Reconciling Multiple Riverine Surveys in a Single Charting Product Database

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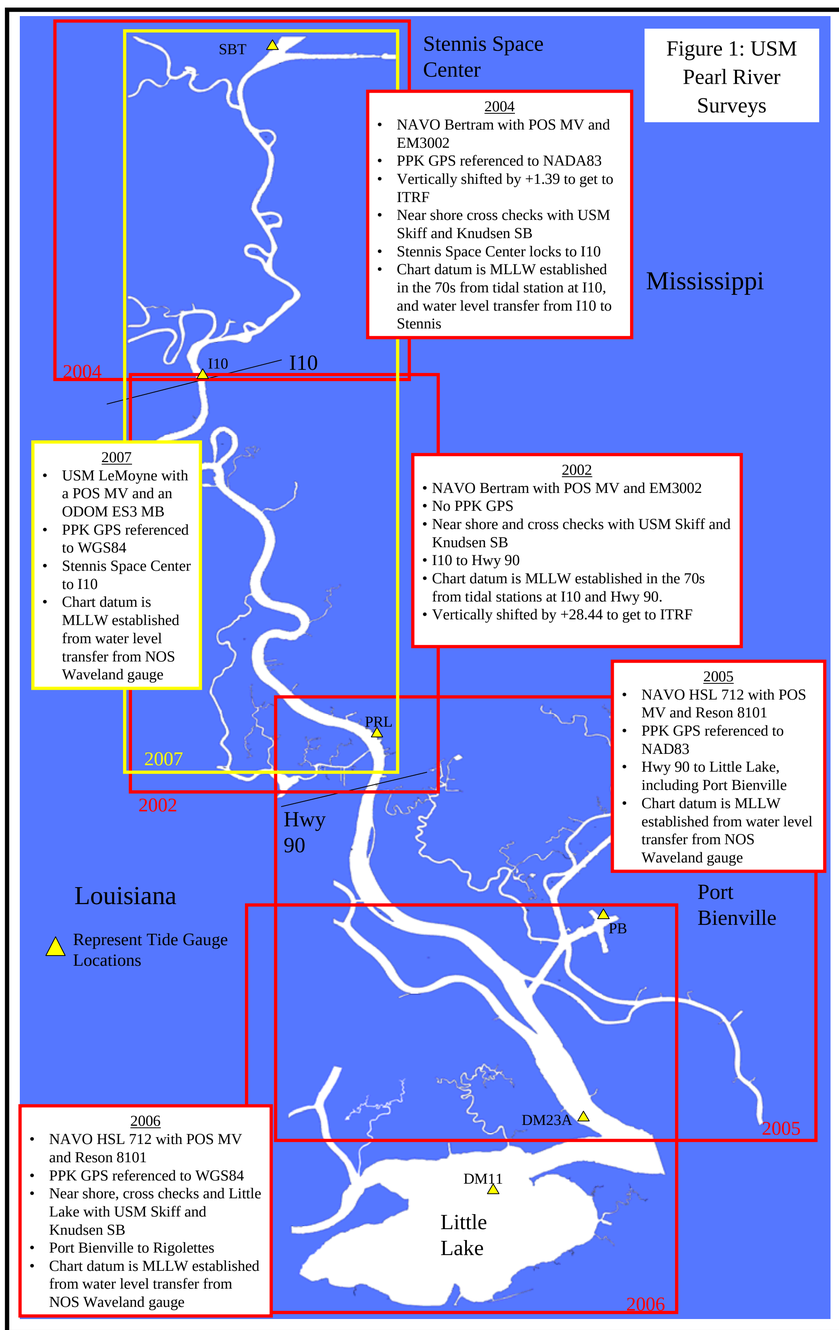


Figure 1: USM Pearl River Surveys

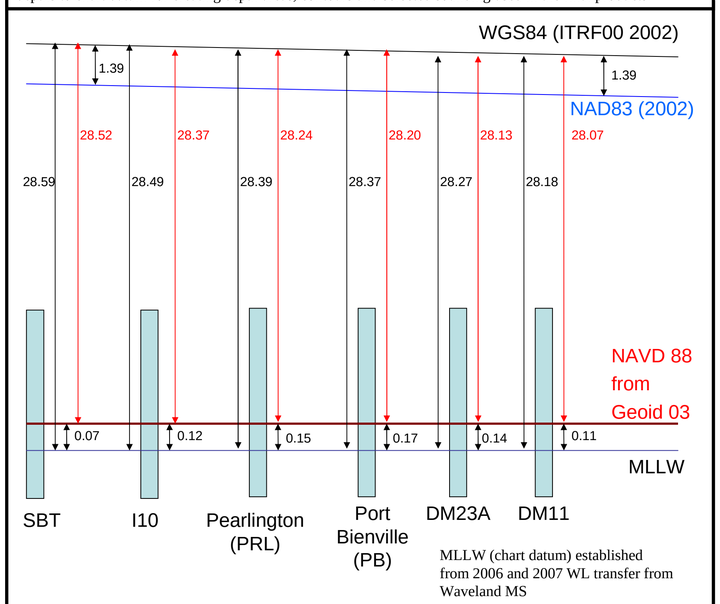
Abstract

Over the past six years, students from the Hydrographic Science program, at The University of Southern Mississippi, have conducted five bathymetric charting surveys on the Pearl River in Mississippi (see Figure 1). The surveys were conducted over various portions of the river; which, when combined, resulted in complete coverage from the Stennis Space Center to the mouth, a distance of approximately thirty kilometers. Each of the five surveys was conducted as a final field project for that year's graduating class. Surveys were executed with some information from the previous years, such as project extents and lessons-learned. Each class went through the process of establishing a survey datum from water level observations for depth reductions. Thus, a lack of continuity is evident in vertical datum development. The current class (of 2008) combined all of the depth data and has established a single ENC (IENC) and paper chart database using information from all of the previous years.

This Poster looks at the processes used to combine the five years of disconnected surveys into a single product database for ENC and paper chart production. It discusses the issues arising from using different vertical datums, in a tidally influenced riverine environment, and how using a GPS based reference ellipse is used to resolve them (see Figure 2). It also looks at how the depth surfaces, developed from each survey, were combined to create a continuous contour and depth-area dataset. The upper section of the poster contains some background on the hydrographic science program as well as an overview of the survey projects that generated the original data used for this poster. The lower section contains a chart that depicts the processing flow (see Figure 3), surrounded by images and descriptions of the various steps.

Figure 2: Vertical Datums

Figure 2 displays the vertical relationship (in meters) between chart datum (MLLW), NAVD88 (Geoid 03), WGS84 and NAD83, at several tide gauge locations along the Pearl River. The locations are plotted on Figure 1. Chart datums were derived from water level transfers from the Waveland, MS gauge. WGS84 and NAD83 heights were established through GPS observations and OPUS processing. NAVD88 was established through GEOID 03. Chart datum to WGS84 offsets for each tide gauge location were used to translate WGS84 reference depths to chart datum for creating depth areas, contours and selected sounding used in the final products.



MLLW (chart datum) established from 2006 and 2007 WL transfer from Waveland MS

Hydrographic Science Program

The University of Southern Mississippi Hydrographic Science Graduate Program started as a joint venture between the Department of Marine Science and the Naval Oceanographic Office. Southern Miss contributes the academic environment including faculty experienced in the field of hydrography, as well as research, educational facilities and equipment. NAVOCEANO contributions include fieldwork support in the form of equipment loans and a multibeam data collection platform; and experienced personnel as instructors, tutors, guest lecturers and students. The program received Category A certification from the International Congress of Surveyors/ International Hydrographic Organization's International Advisory Board on Standards of Competence for Hydrographic Surveyors in April, 2000 and graduated its first class in August, 2000. To date, the program has awarded a total of 86 master's degrees in hydrographic science. Since its inception, the program has progressed from 100% student enrollment through NAVOCEANO, both uniform and civilian, to a diverse mixture of students from NAVOCEANO, the National Geospatial-Intelligence Agency, the U.S. Army Corp of Engineers, the Naval Research Laboratory, the National Oceanic and Atmospheric Administration, the private sector, as well as foreign navies and hydrographic offices (Australia, Canada, Ecuador, India, Mexico, Nigeria, Peru, Slovenia, Sweden., Tonga, Tunisia, Turkey, and the United Kingdom).

Most students follow the accelerated one-year track, which includes two semesters of theory and one semester of application, combining for about 50 continuous weeks of study. Students can choose to complete the program in two years and conduct research with the Electronic Chart Display and Information Systems Laboratory of the Hydrographic Science Research Center. The degree awarded is a non-thesis masters in hydrographic science.

The practical portion of the program is essential for rounding out the educational experience. The Hydrographic Science Field Project consumes the last six weeks of the program. Although the actual project is conducted at the end, many of the practical exercises completed during the year for supporting courses are directed towards the area where this project will be executed. The project is comprised of a complete nautical charting hydrographic survey from planning (developing hydrographic survey specifications (HSS) for the project) data collection, processing, evaluation and development of final products, including paper filed charts and an ENC.

Options for data collection for the summer project include a NAVOCEANO multibeam training vessel as well as Southern Miss's 21' and 30' research vessels. The NAOCEANO multibeam system gives the students exposure to state-of-the-art technology and processes, while the Southern Miss vessels give the students the opportunity to build a fully functioning singlebeam, multibeam and sidescan survey platforms using vessels of opportunity. The final charts and report of survey are submitted to the National Ocean Service for evaluation and assessment. If deemed acceptable, the information is used to update existing nautical charts.

More information on the program can be found at http://www.marine.usm.edu/hydro/index.html

Background Information

Project Implementation

Data Process Overview

The ultimate goal of this poster project is to set up a process whereby the USM hydrographic science class can function as a hydrographic office. This process flow is shown in Figure 3. Each class will be responsible for updating, validating and maintaining the bathymetric and product source databases. They will be tasked to collect new data and to add that information to the existing databases, validate the new information in the office and field and produce paper charts and ENCs. The current plan is to deal specifically with the Pearl River, with a goal of supporting Port Bienville and the Stennis Space Center, in an unofficial (not for navigation) capacity, as well as amassing data for sediment transport evaluation (see Figure 7).

Bathymetric Surfaces

The Multibeam and Singlebeam data collected during the various surveys were cleaned as part of the class summer project. For all but the 2002 survey, dual frequency GPS observations were collected on all survey platforms and used to compute depths relative to the ellipse (either NAD83 or WGS84). Cube surfaces were generated from the multibeam data and ASCII text files were generated from the singlebeam data using CARIS HIPS (Version 6.1).

All surfaces and singlebeam soundings were evaluated in CARIS Bathy Editor (Version 2.1) and, where necessary, shifted to the WGS84 ellipse. In the case of the 2002 data, the average difference between the 2002 surface and the 2007 surface (2007 encompassed the 2002 area, as shown in Figure 1) was computed and applied to the 2002 data to shift it to WGS84. The averaged shift value was computed to be within 4 cm of the chart datum to WGS84 offset for the I10 tide gauge, which was established at the time of the 2002 survey. 2002 data were only used to fill-in near shore areas where 2007 data did not exist. Three dimensional surface evaluations and comparisons were performed using Fledermaus. Final shifted surfaces and singlebeam depths were transferred to the Bathy Surface Database (See Figures 4, 5, 6 and 7).

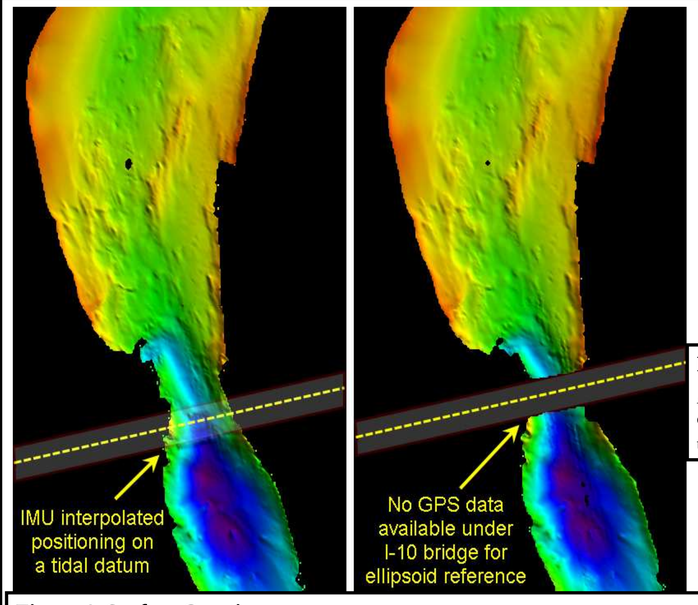


Figure 4: Surface Creation

All data was imported and cleaned in CARIS HIPS. Each survey was referenced both to a tidal (chart) datum and the ellipsoid (NAD83 or WGS84). Surfaces were then generated using the CUBE algorithm at a 1m resolution.

During evaluation, it was noted that different surveys were referenced to different ellipsoids (WGS84 / NAD83). To reconcile these differences a block shift was applied in CARIS Bathy Editor.

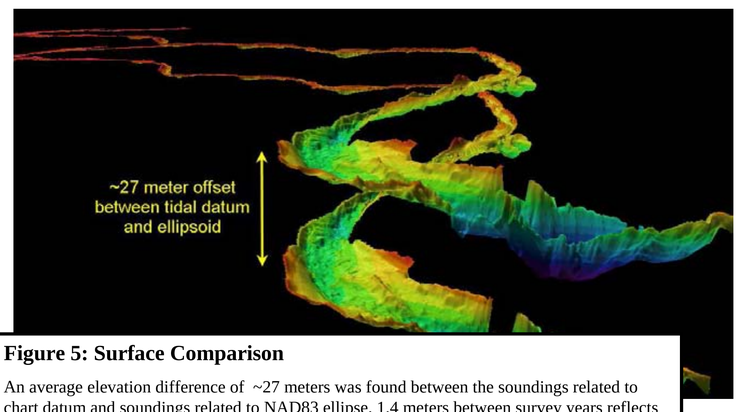


Figure 5: Surface Comparison

An average elevation difference of ~27 meters was found between the soundings related to chart datum and soundings related to NAD83 ellipse. 1.4 meters between survey years reflects the errors induced by referencing different ellipsoids.

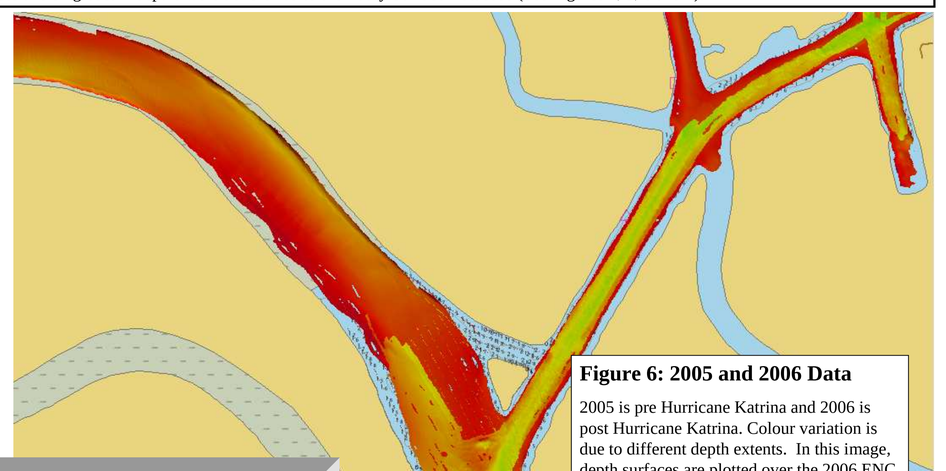


Figure 6: 2005 and 2006 Data

2005 is pre Hurricane Katrina and 2006 is post Hurricane Katrina. Colour variation is due to different depth extents. In this image, depth surfaces are plotted over the 2006 ENC

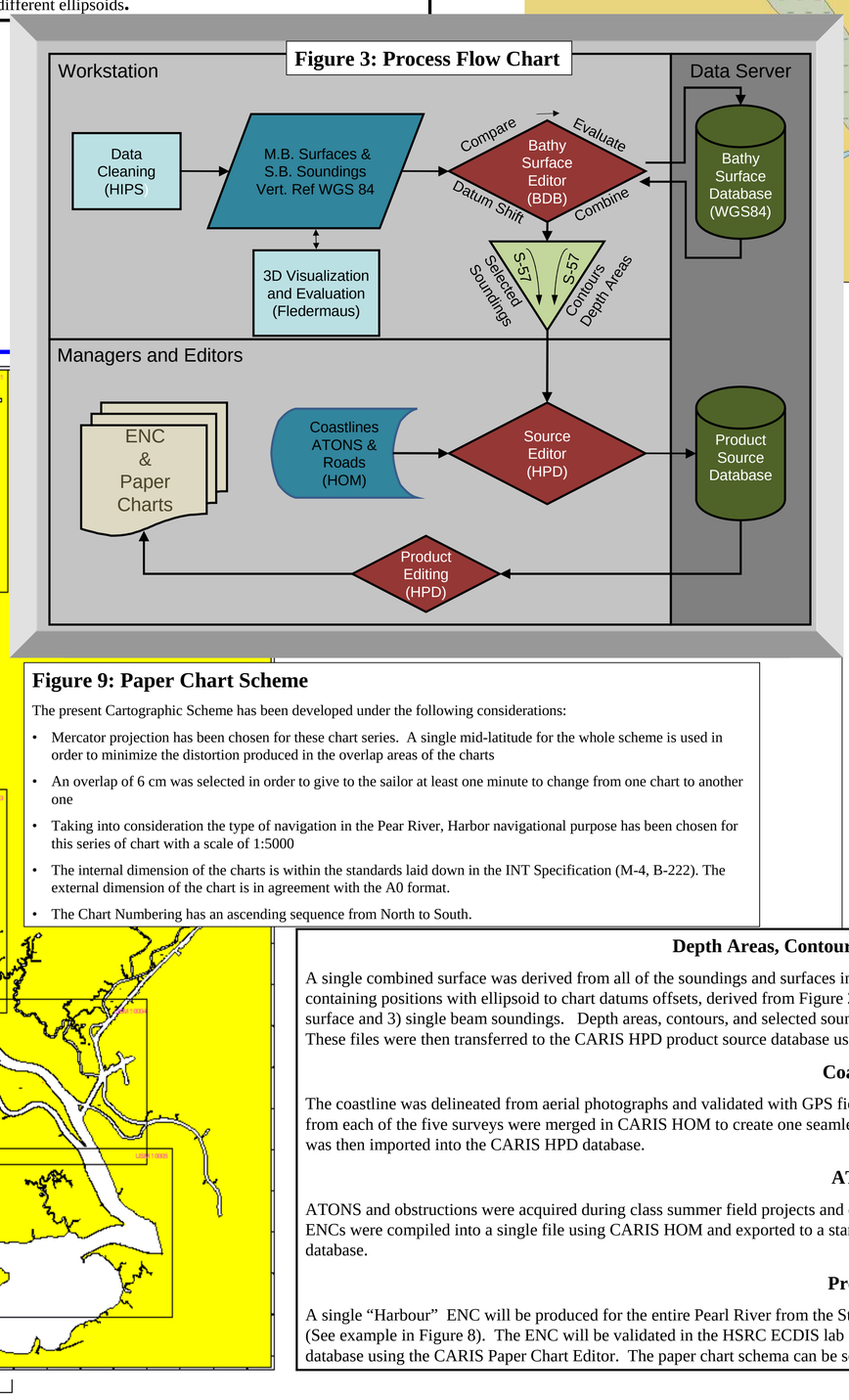


Figure 3: Process Flow Chart

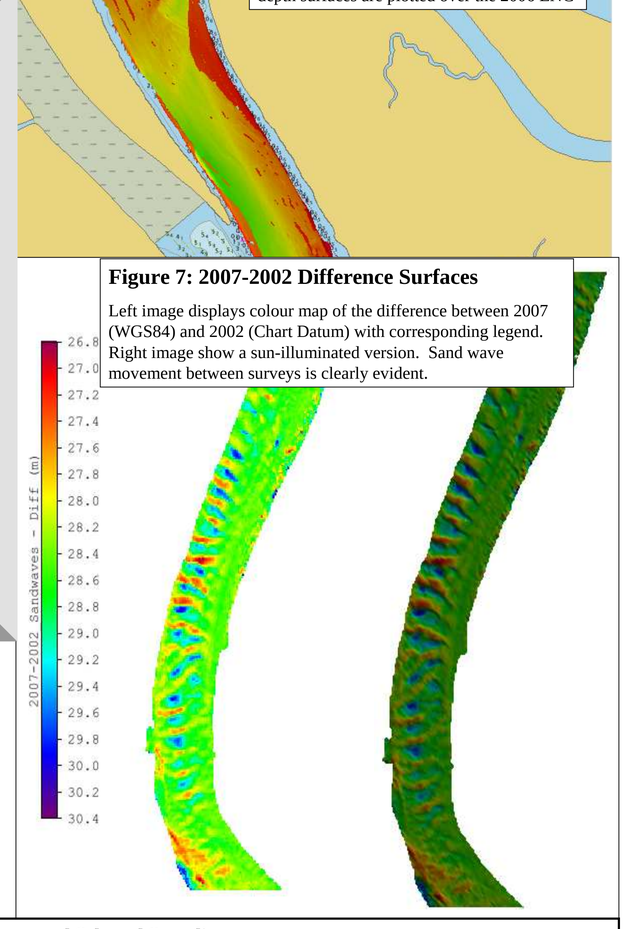


Figure 7: 2007-2002 Difference Surfaces

Left image displays colour map of the difference between 2007 (WGS84) and 2002 (Chart Datum) with corresponding legend. Right image show a sun-illuminated version. Sand wave movement between surveys is clearly evident.

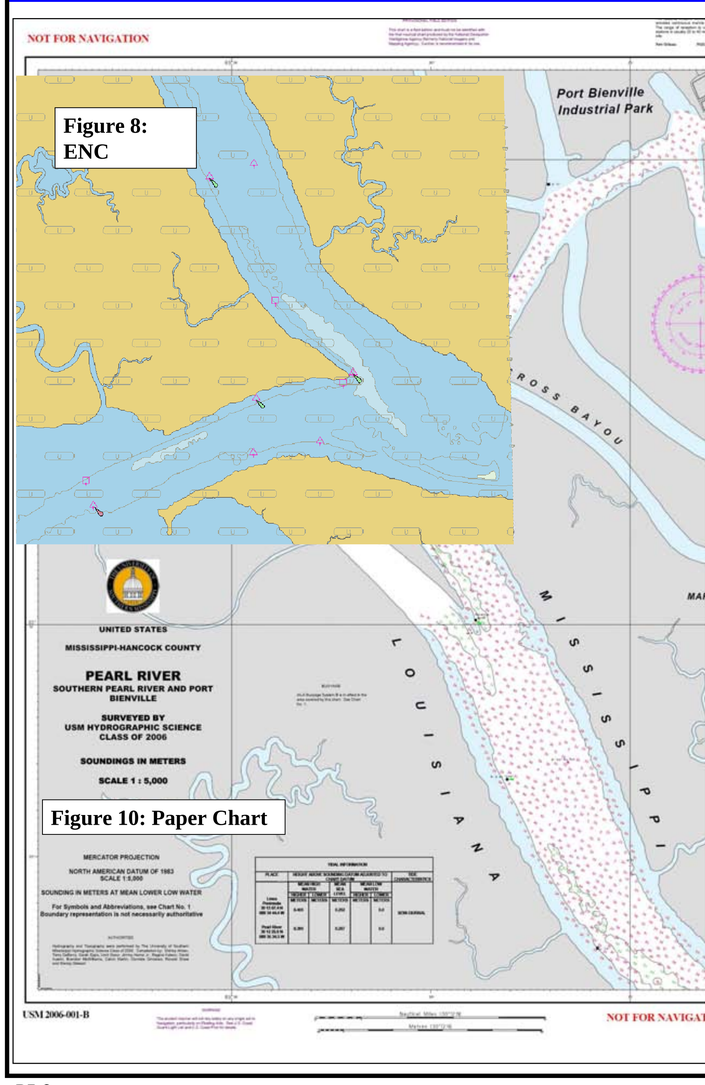


Figure 8: ENC

Figure 10: Paper Chart

Figure 9: Paper Chart Scheme

The present Cartographic Scheme has been developed under the following considerations:

- Mercator projection has been chosen for these chart series. A single mid-latitude for the whole scheme is used in order to minimize the distortion produced in the overlap areas of the charts
- An overlap of 6 cm was selected in order to give to the sailor at least one minute to change from one chart to another one
- Taking into consideration the type of navigation in the Pear River, Harbor navigational purpose has been chosen for this series of chart with a scale of 1:5000
- The internal dimension of the charts is within the standards laid down in the INT Specification (M-4, B-222). The external dimension of the chart is in agreement with the A0 format.
- The Chart Numbering has an ascending sequence from North to South.

Depth Areas, Contours and Selected Soundings

A single combined surface was derived from all of the soundings and surfaces in the Bathy database. This surface was translated to chart datum via a file containing positions with ellipsoid to chart datums offsets, derived from Figure 2. Surface overlap priority hierarchy was based on 1) age of survey, 2) multibeam surface and 3) single beam soundings. Depth areas, contours, and selected soundings were derived from this surface and saved as stand alone CARIS HOB files. These files were then transferred to the CARIS HPD product source database using the HPS source editor.

Coastlines

The coastline was delineated from aerial photographs and validated with GPS field observations. Attribution followed S-57 standards. The digitized coastlines from each of the five surveys were merged in CARIS HOM to create one seamless coastline, which was then exported as a stand alone CARIS HOB file. This file was then imported into the CARIS HPD database.

ATONS

ATONS and obstructions were acquired during class summer field projects and compiled into digital paper charts and ENCs. All of the S-57 features from the ENCs were compiled into a single file using CARIS HOM and exported to a stand alone CARIS HOB file. This file was then imported into the CARIS HPD database.

Products

A single "Harbour" ENC will be produced for the entire Pearl River from the Stennis Space Center to the Rigolettes and the East Pearl entrance into Lake Bourne (See example in Figure 8). The ENC will be validated in the HSRC ECDIS lab and in the field. Paper charts for the Pearl River will be produced from the HPD database using the CARIS Paper Chart Editor. The paper chart schema can be seen in Figure 9 and a sample paper chart product can be seen in Figure 10.