Transforming the NOAA ENC®

Implementing the National Charting Plan

This document has been superseded by a new Nautical Charting Plan, available at:
https://www.nauticalcharts.noaa.gov/publications/docs/nautical-charting-plan.pdf

Office of Coast Survey
National Oceanic and Atmospheric Administration

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Cover photo: Getty Images

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Introduction

A draft National Charting Plan was released for public comment in February 2017 and a final version incorporating feedback from professional mariners, recreational boaters, and other stakeholders, was released in July 2017. This document, "Transforming the NOAA ENC®: Implementing the National Charting Plan," provides additional details on how the NOAA ENC® product suite is being enhanced. This document is intended to stand on its own, although a review of the National Charting Plan could be helpful.

Importance of Nautical Charts for Maritime Commerce

The Office of Coast Survey within the National Oceanic and Atmospheric Administration (NOAA) maintains nautical charts for U.S. coasts and the Great Lakes. These charts support the 1.3 billion metric tons of cargo valued at $1.8 trillion that comes in and out of U.S. ports every year. Coast Survey maintains over a thousand paper nautical charts and over twelve hundred electronic navigational charts that cover 95,000 miles of shoreline and 3.6 million square nautical miles of within U.S. coastal waters and its Exclusive Economic Zone.

ENC Related Regulation Changes

In 2018, the International Maritime Organization (IMO) requirement for most commercial ships on international voyages to use ECDIS and ENCs came into full effect.[1] In 2016, the U.S. Coast Guard started allowing commercial ships on domestic voyages in U.S. waters to use ENCs in lieu of paper nautical charts.[2] Both of these factors have contributed to the significant decline in the use of paper nautical charts and the rise in use of ENCs.

ENC-First Chart Production Strategy

Like many other chart producing national agencies, NOAA has recognized a change in mariners' preference for (and in some cases, required use of) ENCs over paper nautical charts and has adopted an “ENC-First” production process . That is, ENCs are recognized as being the "first" or the primary nautical chart product produced by NOAA.

Critical corrections, such as newly discovered shoals and other dangers to navigation are applied to ENCs first, followed shortly after by application to paper and raster nautical charts. However, new routine source data, such as hydrographic and shoreline surveys, are now only being compiled into NOAA's production database to support the output of NOAA ENCs. As time goes by, traditional paper raster nautical charts will fall more out of synch with their corresponding ENC products.

Gridded ENC Product Scheme

The layout of the extents or footprints of ENC charts is called a scheme – a term meaning a systematic configuration. ENC rescheming is a major component of the charting plan and is the means by which many other aspects of the plan will be implemented – such as compiling depth contours in metric intervals.

The current ENC scheme is based on the extents of the paper nautical charts from which ENCs were originally digitized. Rescheming will replace this puzzle-piece layout with a rectangular grid of ENCs, often providing larger scale and more detailed coverage than the existing paper charts. The existing and new gridded layout of NOAA ENCs in the Great Lakes in approach usage band 4 are shown in Figure 1.

[1] As specified in the International Convention for the Safety of Life at Sea (SOLAS), Chapter V, Regulation 19, "Carriage requirements for shipborne navigational systems and equipment."

[2] USCG Navigation and Vessel Inspection Circular No. 01-16 (NVIC 01-16), "Use of Electronic Charts and Publications in Lieu of Paper Charts, Maps and Publications."

The new scheme for all usage bands is shown on the Gridded NOAA ENC Cell Creation Status web map service at https://distribution.charts.noaa.gov/ENC/rescheme. This web map service also shows the progress being made in creating new ENC coverage in the new scheme.

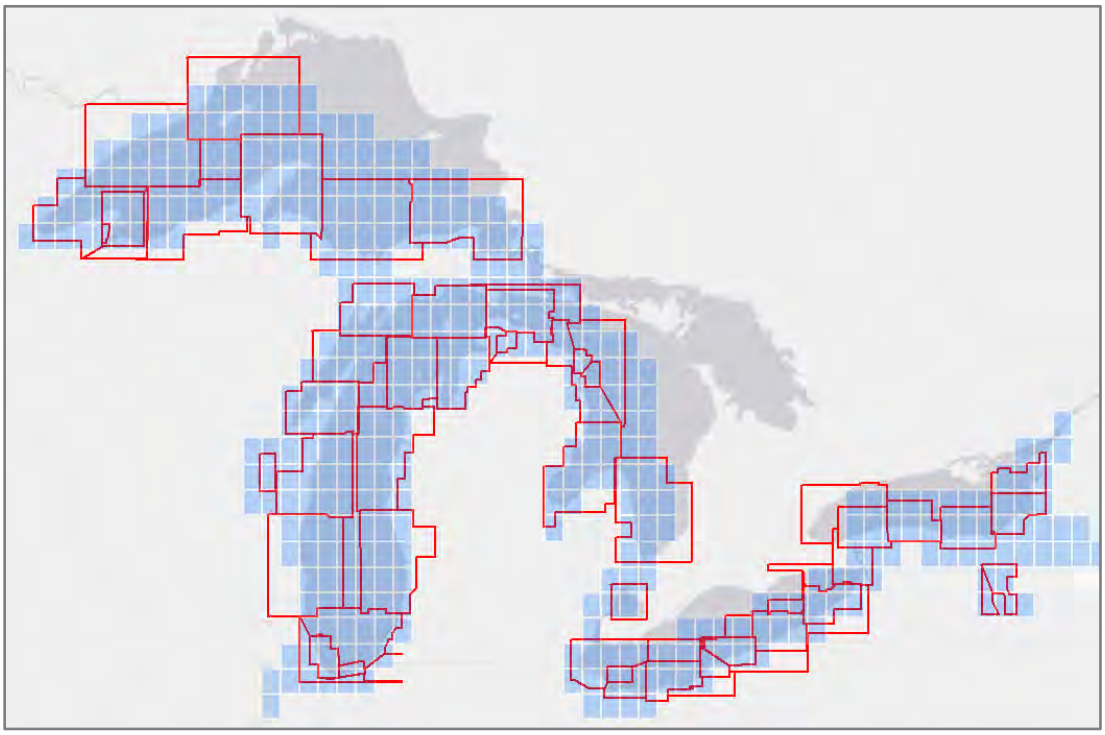

Figure 1 Approach scale ENC coverage in the Great Lakes.
Red outlines show existing ENCs. Blue rectangles show planned reschemed 1:40,000 and 1:80,000 scale coverage.

All reschemed ENC cell boundaries follow lines of longitude and latitude and will appear rectangular in a Mercator projection. Progressively larger scale usage band cells nest within smaller scale (larger size) cells (see Figure 2). The cell dimensions are the same for both of the two standard scales in each usage band, and the size accommodates the IHO restriction for ENC file sizes being 5 MB or smaller.

To account for the convergence of lines of longitude at the poles, the widths (latitudinal extent) of ENC cells are extended for cells beyond 48˚ and again for cells beyond 64˚ (see Figure 3 and Table 1).

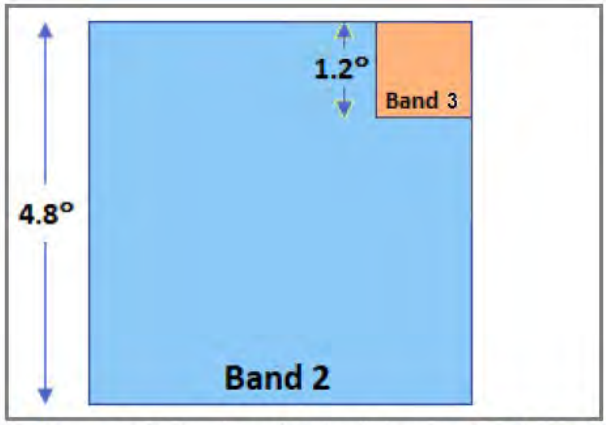

Figure 2 Relative sizes of ENC cells in usage bands 2 and 3

Width Zone	Latitude Extent
III	64˚N - 80˚N
II	48˚N - 64˚N
I	0˚ - 48˚N
	Equator
	0˚ - 48˚S
II	48˚S - 64˚S
III	64˚S - 80˚S

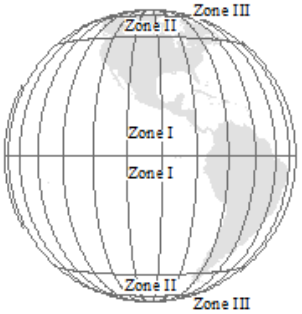

Figure 3 ENC cell latitudinal width zones

Usage Band	Navigational Purpose	Compilation Scales	Height	Width Zone I	Width Zone II	Width Zone III
1	Overview	1:5,760,000 1:2,560,000	19.2˚	19.2˚	38.4˚	76.8˚
2	General	1:1,280,000 1:640,000	4.8˚	4.8˚	9.6˚	19.2˚
3	Coastal	1:320,000 1:160,000	1.2˚	1.2˚	2.4˚	4.8˚
4	Approach	1:80,000 1:40,000	0.3˚	0.3˚	0.6˚	1.2˚
5	Harbor	1:20,000 1:10,000	0.075˚	0.075˚	0.15˚	0.3˚

Table 1 ENC Cell Dimensions in Decimal Degrees

Enhancements Implemented in New ENCs

As new gridded ENCs are created, a number of improvements to the quality and consistency of the data will be implemented. This includes the items listed below, details for which are provided in separate sections.

- Larger, standard scale coverage
- Depth contour metrification
- Resolution of discontinuities and other edge matching issues
- Minimum channel depths on ENCs

Larger, Standard Scale Coverage

The current suite of NOAA nautical chart products maintained by Coast Survey are compiled in 131 different scales. The new ENC scheme uses only a dozen scales, two for each of the six standard ENC usage bands. Table 2 shows a comparison of the scale ranges in the old ENC scheme and the 12 new standard scales for each of the ENC usage bands. Although the 1:2,500 scale is reserved for use in band 6 coverage, it is anticipated that all new band 6 ENCs will be compiled at the 1:5,000 scale.

The standard scales follow a binary system in which each successively smaller scale is half of the preceding scale. As a result, 16 cells of any scale fit neatly into the same footprint as one cell of the next smaller scale, as shown in Figure 2 above. Binary scales simplify the display of charts in different systems and web-services, and generalization rules are simpler when the scales are linearly aligned with each other.

ENC Usage Band	Navigational Purpose	Current (2019) NOAA ENC Scale Ranges	Reschemed NOAA ENC Scales
1	Overview	1:587,870 – 10,000,000	1:5,120,000 1:2,560,000
2	General	1:240,000 – 1:1,534,076	1:1,280,000 1:640,000
3	Coastal	1:150,000– 1:600,000	1:320,000 1:160,000
4	Approach	1:25,000 – 1:150,000	1:80,000 1:40,000
5	Harbor	1:5,000 – 51,639	1:20,000 1:10,000
6	Berthing	1:2,500 – 12,000	1:5,000 1:2,500

Table 2 New Standard ENC Compilation Scales

Depth Contour Metrification

All but a handful of NOAA's 1,000-plus raster nautical charts show depths in feet or fathoms; however, IHO ENC product specifications state that all depths must be encoded in meters. When NOAA digitized paper charts in the 1990s to create the first NOAA ENCs, depth values for soundings, depth curves, and other features with depths were converted from fathoms or feet into meters to populate the ENC database.

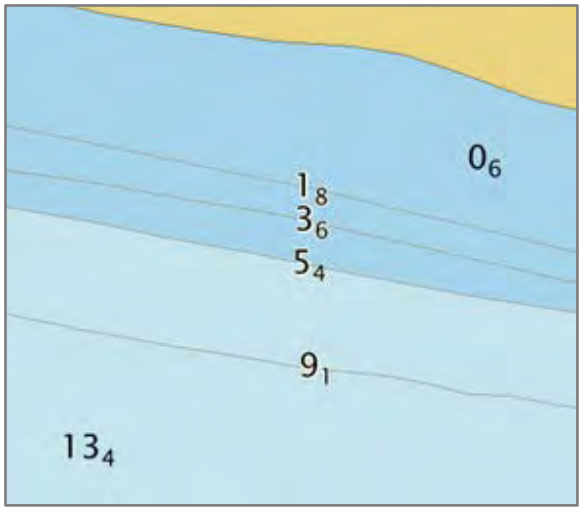

Figure 4
Depths, compiled in feet and encoded in meters

As a result, soundings and depth areas in the current suite of NOAA ENCs are compiled in fathoms and feet, but stored and displayed in ECDIS in decimal metric values, as shown in Figure 4.

1 fm	6 ft	1.8 m
2 fms	12 ft	3.6 m
3 fms	18 ft	5.4 m
5 fms	30 ft	9.1 m

This presents mariners with a rather unwieldy set of depth contour values to decipher when viewed in an ECDIS.

Table 3 shows the standard set of whole meter depth values into which new gridded ENC depth contours will be compiled. These are based on depth intervals specified in the IHO S-101 ENC Product Specification[3]. Areas that have extremely flat or steep bathymetry may use a modified set of values.

Usage Band	Navigational Purpose	Compilation Scale	Depth Contours (meters)
1	Overview	5,760,000	100 200 300 400 500 ...
		2,560,000	50 100 150 200 300 400 500 ...
2	General	1,280,000	50 100 150 200 300 400 500 ...
		640,000	20 50 100 150 200 300 400 500 ...
3	Coastal	320,000	20 30 50 100 150 200 300 400 500 ...
		160,000	10 20 30 50 100 150 200 300 400 500 ...
4	Approach	80,000	5 10 15 20 30 50 100 150 200 300 400 500 ...
		40,000	2 5 10 15 20 30 50 100 150 200 300 400 500 ...
5	Harbor	20,000	2 5 10 15 20 30 50 100 150 200 300 400 500 ...
		10,000	2 3 4 5 6 7 8 10 15 20 30 50 100 150 200 300 400 500 ...

Table 3 New Standard Metric Depth Contour Intervals

Resolution of discontinuities in adjacent ENCs

The legacy of the original paper charts from which ENC data was digitized lives on in the current suite of ENCs. Adjacent paper charts, even with the same navigational purpose (harbor, approach, coastal, etc.) are often compiled at different scales to accommodate different chart orientations, paper sizes, or a desire to "stretch" a chart to include harbors or other features at either side of a chart. Different depth contour intervals are often

[3] These depth intervals are specified in the "Depth area" section of IHO S-101, Electronic Navigational Chart Product Specification, Annex A, Data Classification and Encoding Guide.

used on different scale charts, and the techniques for "edge matching" adjacent ENC cells of different scales can be challenging. Figure 5 shows an example of three adjacent band 4 ENC cells of different scales with the type of discontinuities that exist in the current suite of ENCs.

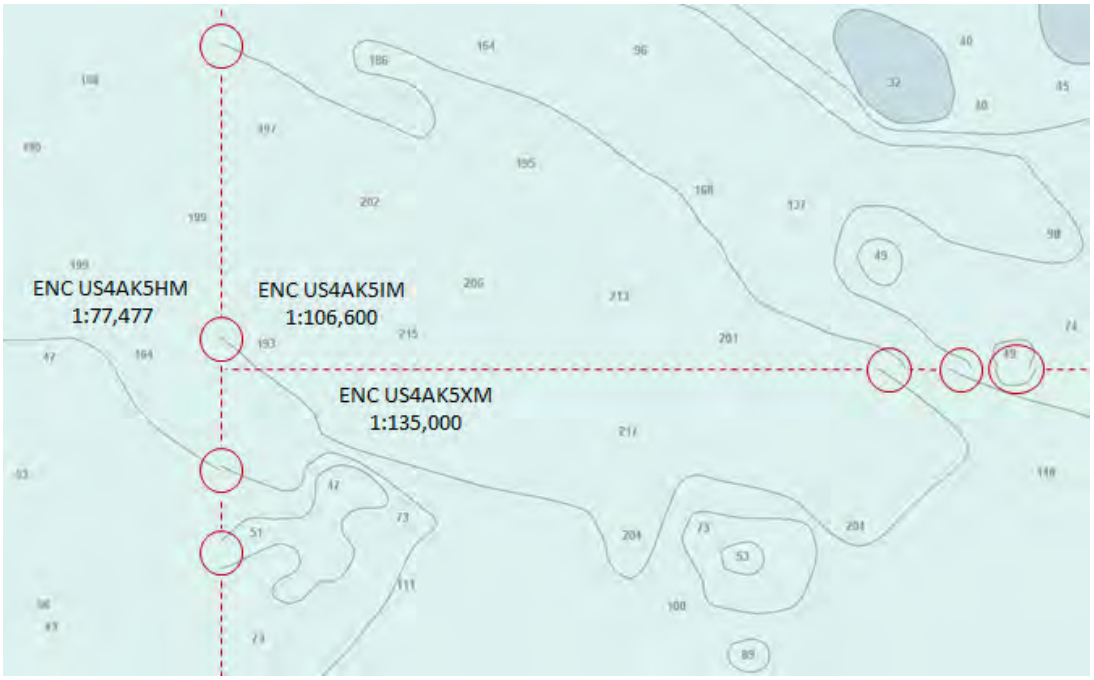

Figure 5 Examples of discontinuities in three adjacent approach usage band 4 ENC cells

As new ENC cells are created for the gridded layout they will be recompiled with standard depth contour intervals that match across ENC cell boundaries within the same standard scale. Similar alignment errors among other area and linear features will also be fixed as new ENC cells are created.

Minimum Channel Depths on ENCs

Project depths and controlling depths defined

Federally maintained channels are broken into a series of individually named sections called “reaches.” There are two different depths associated with each reach that are reported by the US Army Corps of Engineers (USACE) - project depth and controlling depth. Project depths are the depths which a channel reach was designed to be dredged when constructed by the USACE. Reaches may or may not be maintained to the project depth by dredging after completion of the channel. In other words, the actual depth of the channel may be shoaler than the project depth, such as Reach B in Figure 6. Controlling depths, or minimum depths, are the least depths within the limits of a channel reach. These depths are updated with new USACE hydrographic survey data and restrict the safe use of a channel to ships with drafts less than the minimum.

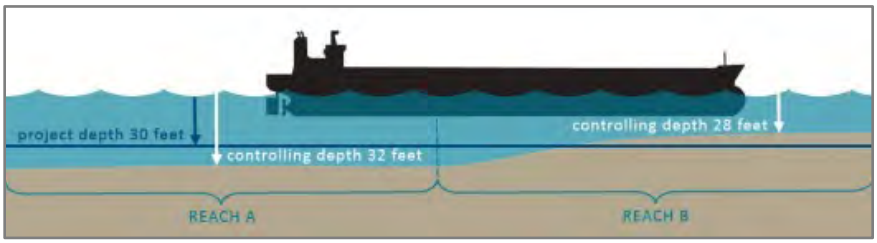

Figure 6 Example of a federally maintained channel with a project depth of 30 feet. Reach A has a controlling depth of 32 feet and Reach B has a controlling depth of 28 feet.

An Issue of Timing

Controlling depths are collected by the USACE during periodic sonar surveys of federally maintained navigational channels. Typically, the USACE is able to post new controlling depth information on their website before Coast

Survey is able to update and publish the changes on paper nautical charts. This inconsistency between the USACE website and NOAA charts – both of which are consulted by mariners and pilots – can to lead to confusion.

To eliminate inconsistencies, NOAA is transitioning paper nautical charts to show only project depths for each channel reach. Project depths can give mariners a general idea of the depth for which each section of a channel was designed, but not the most recent survey's controlling depths. ENCs will continue to show controlling depths and mariners transiting federally maintained channels are encouraged to use ENCs for this reason.

Mariners transiting federally maintained channels are encouraged to use ENCs, which show controlling depths, in lieu of paper charts, which only show project depths.

Comparative Ease of Updating ENC Data

Updated ENC revision files are available weekly. When ENC revision data is loaded, ECDIS, and some other navigation systems, apply these updates automatically. Mariners using paper nautical charts must apply USCG Local Notices to Mariners (LNM) and NGA Notices to Mariners (NM) corrections by hand to keep their paper charts up to date.

Precision navigation and High Definition Charts

In Aug 2016, Office of Coast Survey Director, RDML Shepard Smith, discussed the need for new products to support today's navigational needs :

> "As clearance margins are squeezed by larger ships and limited dredging budgets, we are challenged to provide more precise measurements and predictions of water depth, tides, currents, salinity and waves. Putting data on websites is not enough. We need to distribute them in standard formats to charting systems, portable pilot units and port information systems to allow users to quantifiably manage navigation risk."[4]

The NOAA High Definition (HD) Chart product is part of NOAA's commitment to supporting the precision navigation environment described by RDML Smith. HD Charts are band 6, 1: 5,000 scale, ENC cells that will be compiled with high resolution bathymetry. Areas selected for HD coverage will consist primarily of navigational channels in major ports used by large commercial vessels. HD Chart ENC cells will show high resolution "depth area" features (intervals up to one-half meter) and depth soundings within channels, unlike standard band 6 ENCs which depict a minimum depth within individual "dredged area" features. Figure 7 shows a one-meter resolution HD Chart covering a portion of the Mississippi River south of the Sunshine Bridge.

The first HD Charts will be produced for selected channels within New York Harbor and the Ports of Los Angeles/Long Beach, followed by portions of the lower Mississippi River.

[4] Hydro International, On the Cusp of a New Hydrographic Era," at: https://www.hydro-international.com/content/article/on-the-cusp-of-a-new-hydrographic-era, accessed 6 may 2019.

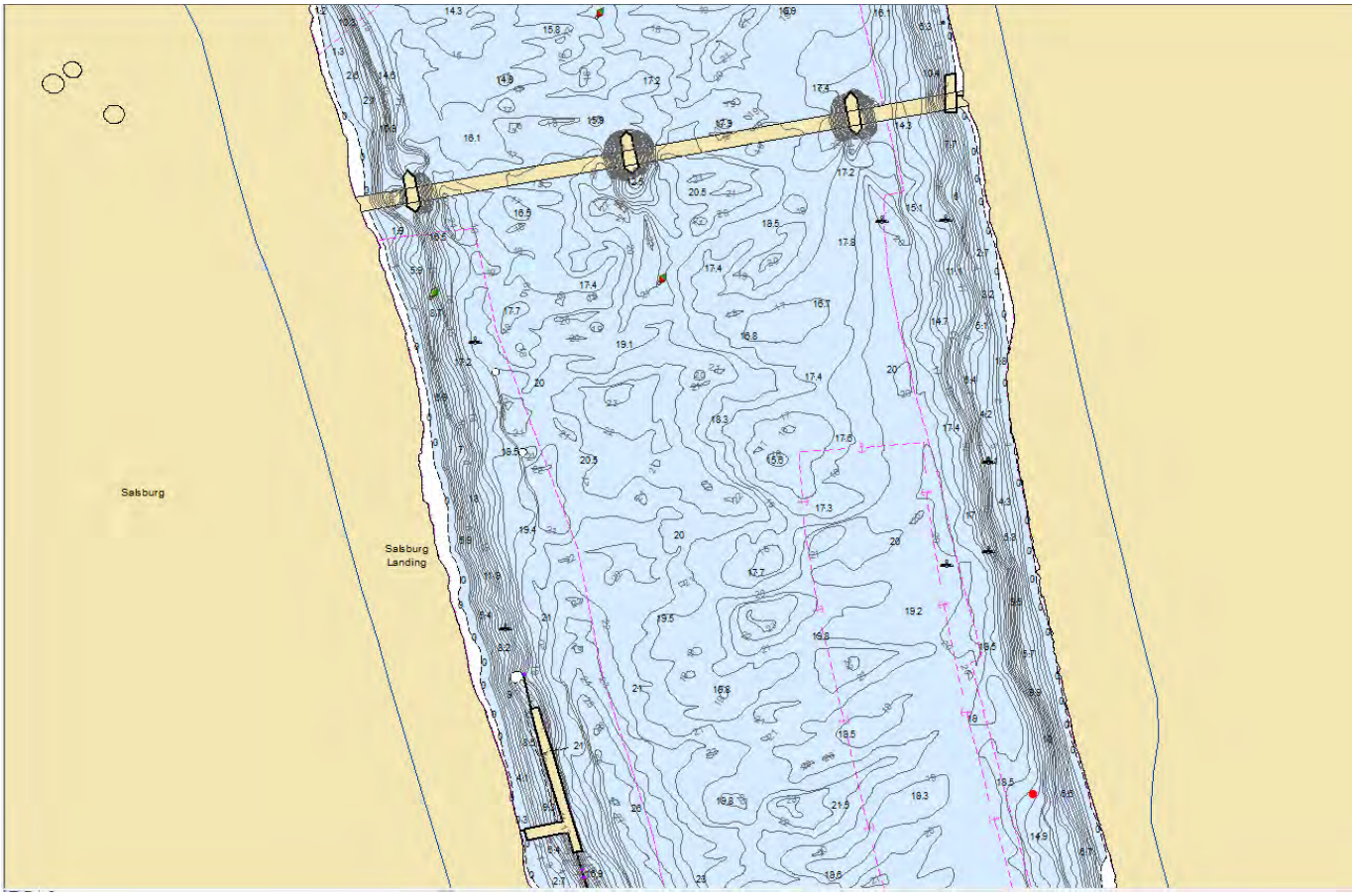

Figure 7 HD Chart showing one-meter resolution depth contours in the Mississippi River south of the Sunshine Bridge – about half way between Baton Rouge and New Orleans.

Estimated ENC Rescheming Schedule

Figure 8 shows the estimated schedule to complete the new ENC gridded layout for approach scale usage band 4. New harbor scale usage band 5 ENCs will be completed approximately two to three years after the completion of band 4 coverage of an area.

Unforeseen events, changing priorities, and the availability of source data are likely to drive changes to this estimated schedule. Up to date status of NOAA ENC rescheming for all usage bands will always be available online at:
https://noaa.maps.arcgis.com/apps/webappviewer/index.html?id=ab6ad790ac3f411f8ef96cb26d0c4868.

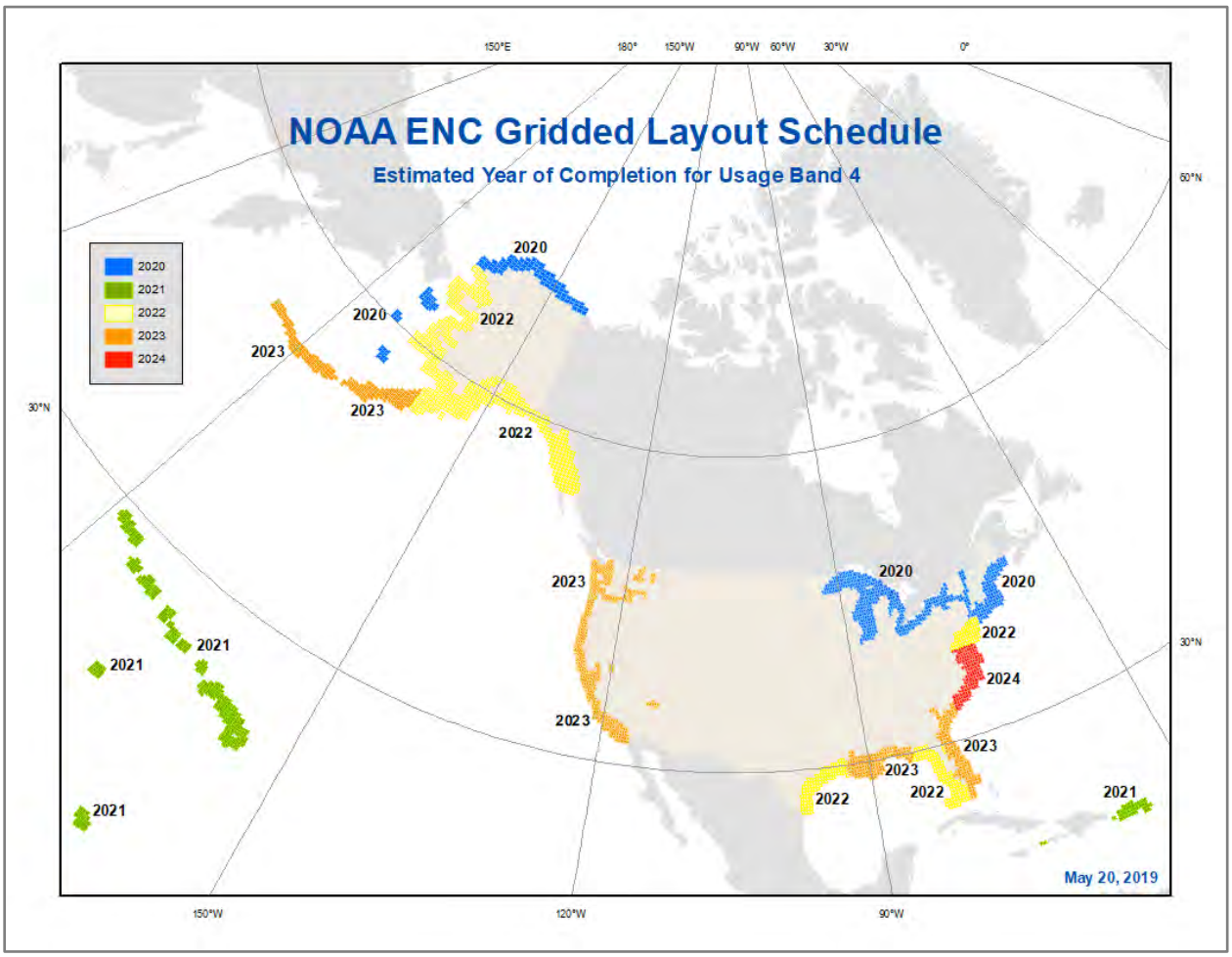

Figure 8 Estimated schedule to complete the new ENC gridded layout for ENC approach scale usage band 4.

Glossary[5]

ECDIS (Electronic Chart Display and Information System) A navigation information system which with adequate back-up arrangements can be accepted as complying with the up-to-date chart required by regulations V/19 and V/27 of the 1974 SOLAS Convention, as amended. Use of ECDIS is now mandatory by most SOLAS vessels on international voyages.

ECS (Electronic Chart System) A navigation information system that electronically displays vessel position and relevant nautical chart data and information from the ECS data base on a display screen, but does not meet all IMO requirements for ECDIS, and does not satisfy SOLAS Chapter V requirement to carry a navigational chart.

ENC (Electronic Navigational Chart) The database, standardized as to content, structure and format, issued for use with ECDIS on the authority of government authorized hydrographic offices. The ENC contains all the chart information necessary for safe navigation and may contain supplementary information in addition to that contained in the paper chart (e.g. sailing directions) which may be considered necessary for safe navigation. The format and encoding of ENC data is specified by the S-57 *IHO Transfer Standard for Digital Hydrographic Data*. The recently developed S-101 *ENC Product Specification* will eventually be phased in to replace S-57 based ENCs.

ENC Rescheming The layout of the extents or footprints of ENC charts is called a scheme – a term meaning a systematic configuration. The development of a new layout of the extents is called rescheming. In the case of the NOAA ENC rescheming, new ENC cell extents are being created in a rectangular grid in a standard set of twelve scales.

Paper nautical chart or paper chart A printed chart specifically designed to meet the requirements of marine navigation, showing the depth of water, nature of bottom, elevations, configuration and characteristics of coast, dangers and aids to navigation.

Raster chart A printed paper nautical chart, a scanned image of a paper chart, the digital image from which a paper chart is made, or other digital representations of a "traditional" nautical chart stored as rows and columns of color pixels. Raster charts include both paper charts and digital charts that use a raster format, such as raster navigational charts.

RNC (Raster Navigational Chart) A digital facsimile of a paper chart originated by, or distributed on the authority of, a government-authorized hydrographic office. It is either a single chart or a collection of charts. RNCs may be used in ECDIS (in Raster Chart Display System mode) where ENCs are not available at all or are not of an appropriate scale for the planning and display of the ship's voyage plan.

[5] Definitions are adapted from the International Hydrographic Organization (IHO) Hydrographic Dictionary (S-32) at http://iho-ohi.net/S32/index.php, accessed May 7, 2019 and the IHO Nautical Cartography Working Group, "Preliminary Report on Future of the Paper Nautical Chart," at http://www.iho.int/mtg_docs/com_wg/HSSC/HSSC11/HSSC11_2019_05.4B_EN_Future%20of%20the%20Paper%20Nautical%20Chart_v1.pdf, accessed May 7, 2019.