U.S. COAST AND GEODETIC SURVEY NAUTICAL CHARTS: A CARTOGRAPHIC HISTORY

by

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A THESIS

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"U.S. Coast and Geodetic Survey Nautical Charts: A Cartographic History," a thesis prepared by Jonathon L. McConnel in partial fulfillment of the requirements for the Master of Arts degree in the Department of Geography. This thesis has been approved and accepted by:

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Title: U.S. COAST AND GEODETIC SURVEY NAUTICAL CHARTS: A CARTOGRAPHIC HISTORY

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The first century of nautical chart publication by the U.S. Coast and Geodetic Survey was a period of much change and innovation in map production. However, the charts published by the agency have not been methodically studied to understand what the changes were, and the reasons they occurred.

This thesis identifies and describes the changes made to the design and content of nautical charts published by the U.S. Coast and Geodetic Survey during the first century of the agency's publishing history, from 1844 to the mid 1940s. For context and relevance, this thesis also offers an explanation of the reasons for the described changes, referring to advances in scientific instruments, the changing needs of maritime navigation, changes in publishing technology, and changes in the bureaucracy of the federal government. It compares forty editions of six charts, accompanied by layouts of clippings from the charts created to facilitate comparison.

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The idea for this project came about while working at the University of Oregon's MAP Library. The collection of nautical charts needed some attention, and my interest in their history was piqued when trying to learn about their organizational scheme.

This project could not have happened, at least it could not have been so inclusive, without having a large store of digital images of nautical charts available. I would like to acknowledge the National Oceanic and Atmospheric Administration's Historic Map & Chart Project (http://historicals.ncd.noaa.gov/historicals/histmap.asp), which supplied the majority of the digital images used here. Other images were acquired from the New York Public Library's collection American Shores: Maps of the Middle Atlantic Region to 1850 (http://www.nypl.org/research/midatlantic/), and from the David Rumsey Historical Map Collection (http://davidrumsey.com/). I would also like to acknowledge the NOAA Central Library Data Imaging Project (http://docs.lib.noaa.gov/rescue/cgs/data_rescue_cgs_annual_reports.html), which makes available online many of the annual reports of the Coast and Geodetic Survey.

Thank you also to my family, friends, co-workers, and employer, who believed that I could finish this project while working full-time in Seattle.

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CHAPTER I
INTRODUCTION

In 1844, the United States Coast Survey published its first official nautical chart. It was the result of an immense amount of manual topographic and hydrographic surveying, manual drafting, manual engraving on copper printing plates, and manual intaglio printing (using black ink from copper plates).

In 1939, the United States Coast and Geodetic Survey (C&GS) published its first nautical chart that included isobaths as the primary representation of the seafloor rather than individual depth soundings. Data for the isobaths were collected by a recording echo sounder, while topographic revision was performed from aerial photographs. The production process included manual and mechanical scribing on wet-plate glass negatives; additional chart compilation using photography to merge in standard elements; photographic transfer to aluminum lithographic printing plates; and printing in multiple colors on a powered rotary offset press.

This thesis looks at the history of changes to the design of C&GS nautical charts from their first publication in 1844 through the World War II era. This period of time spans several transitions: from copperplate engraving and printing, to scribing on glass and plastic and photolithographic printing; from lead-line depth soundings at points to echo sounding and air photo interpretation for determining depth contours; from printing with black ink to printing with multiple color inks; from designing charts for use by sailing ships to designing them for steam and then diesel powered ships; and others.

The thesis focuses on the design of chart elements, what information was included/excluded from the charts, and chart marginalia such as chart identification numbering systems and edition statements. The objective is to understand how incremental changes so transformed C&GS nautical charts during the first century of the

agency's publishing history. The reason for choosing this objective is to better understand this period in the history of cartography, in particular how technological and societal changes influenced changes in cartography. A subsidiary goal is to help map librarians and historians understand the continuity of charts as they went through changes in design and numbering systems. The beginning of the full transition away from the last of the original techniques began in 1939 when the first chart was published that fully incorporated the possibilities for different symbology offered by the vast quantities of data created by recording echo sounders. Charts continued to evolve after 1939, entering a new phase around 1980 based on internationally approved symbology, but the greatest changes are evident by 1939.

CHAPTER II

LITERATURE REVIEW

Dramatic changes occurred in the nautical charts published by the U.S. Coast Survey/U.S. Coast and Geodetic Survey between 1844 and 1940. These changes have not been systematically described or discussed.

The literature that is relevant to this project can be broken into two primary components: writing about nautical charts, and writing about printing techniques & technologies.

Nautical Charts

Woodward suggests in a commentary that there has been little analysis of the graphic design of "workaday maps—the huge topographic map series or detailed reference atlases" that are in everyday use (1985). Nautical charts are included in this category.

Typical histories of nautical charts dwell on early charts, from antiquity up to around the year 1800. Portolan charts have received the most attention and authors either conclude their studies at the creation of the major national surveys—the French Dépôt des Cartes et Plans des Marines in 1720, the British Hydrographic Office in 1795, the U.S. Coast Survey in 1807, and U.S. Naval Hydrographic Office in 1830—or merely deal with them in a cursory manner (Blake 2004; Taylor 1951; Robinson 1952). Robinson's short paper from 1952 on English nautical charts is an example of the former, but it does at least provide an example of a format on which to expand. One author has written on early U.S. Coast Survey topographic mapping (Allen 1998), but the article does not discuss charts published after 1861. The authors of two secondary works that touch on C&GS charts mention the lack of other research on their topic (Cook 2002; Allen 1998).

Morris' 1986 article, "Paper Chart to Digital Chart - Possibilities and Problems," offers a paragraph-each discussion of the design of five British nautical charts. The charts cover the same area through time, published in 1800, 1859, 1916, 1964, and 'current' (the 1980s). The bulk of the article discusses the coming transition to electronic charts, and provides only a limited example of chart comparison.

To date, the majority of writing about C&GS charts has been by agency staff (U.S. Treasury Department et al. 1900a; Tittmann 1912; U.S. Department of Commerce et al. 1916c, 1921b; Jones 1924; U.S. Department of Commerce et al. 1936a; Shalowitz 1957; Wraight et al. 1957; Shalowitz 1964; Theberge 1989). Of that literature, only Shalowitz has made any contribution to delineating changes to published charts, and his work was explicitly focused on using historic charts for legal purposes (1964). However, he did not place changes in any kind of larger context.

There have also been a few articles published in the popular press regarding C&GS charts. They seem to have been part of efforts for agency survival in the nineteenth century, but each was a static portrait, more laudatory than analytical (Hoffman 1847; Davis 1849; Davidson 1880; Powell 1892a, 1892b; Harris 1898; Claudy 1908).

The British Admiralty's transition in chart design that took place from about 1968 to 1970 was the occasion for a couple articles describing either the before, the after, or comparing the two designs (Magee 1971; Kitching 1974). It seems that the British charting agency was even more conservative than the C&GS when it came to changing chart designs and production techniques. While their first use of printed color came at about the same time as the C&GS, in the first decade of the twentieth century, the use of a blue tint for shoal water was not fully put into practice until about 1945 (Magee 1971, 7-8).

Kerr and Anderson of the Canadian Hydrographic Service published a paper entitled "Communication and the Nautical Chart" in 1982. Originally a lecture at a conference, it focuses on changes in navigation and shipping up to their time, and broadly discusses changes to chart design in reaction. Their work provides few specifics about

chart designs, references no specific charts, and concludes as a manifesto to start from scratch.

Printing Techniques and Technology

In his 1975 essay "Mapmaking and Map Printing: The Evolution of a Working Relationship," Robinson differentiates four time periods in the history of the relationship between cartographers and printers. He identifies the period 1790-1940 as one of mechanization and innovation, marked by "great change and variety in printing methods (Robinson 1975, 4)." Throughout this time cartographers and printers slowly begin working more closely together, and around 1940 enter a new period, one of symbiosis. This idea of change around 1940 fits well the choice of World War II as a break in past practice for examining the C&GS charts' design.

Karen Severud Cook (neé Pearson) has written a series of articles on cartography and printing in the nineteenth century (Pearson 1980, 1983; Cook 1995, 2002). In her 1983 article examining area symbols on maps published in nineteenth century geographic journals, she intertwines advances in printing technology with changes in production processes, methods and technologies.

One of the advances she notes is the shift from printing maps in black to printing in multiple colors. Color applied by hand to intaglio-printed sheets was largely decorative and confined to highlighting point and line symbols. A major cartographic advance she notes is the shift to using printed color for area symbols, and color becoming integral to carrying information rather than supplementary. This was made possible by advances in lithographic printing (Pearson 1980, 9-11). She notes that the major shift is that maps "were being conceived in colour (16)," and they would be incomplete without the color plate(s). This quickly led to development of conventions for what information to place on which color plate, "i.e. black for base information and lettering, blue for hydrography and brown for terrain (16)."

These changes she observes were seen in a survey of maps printed in scientific journals, and she notes that most of these maps would have been "executed 'from

scratch'(9)" specifically for an article. Creating new maps offers less "technological inertia (Pearson 1983, 1)" to resist change in production methods than existing map series. This implies freedom on the part of the map creator to incorporate technological advances. National surveys, with their large investment in methods and plate stock, would have faced much larger hurdles in adopting novel production and printing methods. It is not surprising to find that the Coast Survey was late to adopt many of the advances she mentions.

CHAPTER III

METHODOLOGY

In order to survey a sample of charts representative of the style and content of the U.S. Coast and Geodetic Survey's published charts over time, multiple charts must be compared, preferably from different chart series[1]. For this thesis, images of common components of multiple editions of six charts were extracted from digital versions of the original charts. These images were compiled into several large layouts, grouped by theme, to facilitate comparison of the charts' features. This chapter details the steps leading to the creation of these layouts.

Choosing Charts

The choice of charts determines what comparisons can be made as well as impacting the breadth of conclusions that can be drawn. Among the factors that could be compared if appropriate charts are selected:

- Differences due to scale (how were features represented at different scales?)
- Differences due to intended purpose (how were charts different when they were intended for mariners to use them for off-shore navigation as opposed to in-shore navigation?)
- Differences due to geographic area (were different parts of the coast represented differently?)
- Differences due to time (what changes were made to the design and content of charts over time?)

Regarding scale, the Coast Survey and other authors typically recognize four main divisions based on the intended type of navigation (see Appendix B: Scale Divisions for a detailed breakdown of scales used for nautical charts and the common names given to

[1] A *chart,* or *navigational chart,* is a single printed sheet consisting of at least one main map having navigation as its intended purpose. A *chart series* uses multiple charts to cover an area that cannot fit on a single printed sheet, and all of the main maps typically share a single scale and design. Multiple *editions* of a chart can be published over time.

these scales). The names typically used to refer to the four most common ranges of scale are Sailing Chart, General Chart of the Coast, Coast Chart, and Harbor Chart. Sailing Charts are for plotting long courses across hundreds of miles of open water. Coast Charts are for navigating offshore but within sight of land. General Charts have a scale in-between Sailing Charts and Coast Charts. Harbor Charts are used for inland waters, especially when carefully maneuvering into bays and up to docks.

The survey's scheme of scale divisions was explained in the agency's annual reports for 1856 and 1857 (see Table 1). Coast Charts would be at 1:80,000; Preliminary[2] Coast Charts would be 1:200,000; and General Coast Charts would be 1:400,000 (U.S. Treasury Department et al. 1856b, 1858). In the 1863 annual report, mention was made that Sailing Charts were planned to be 1:1,200,000 (U.S. Treasury Department et al. 1864b). Larger scale charts were to be provided at varying scales, as required by the situation.

Table 1. U.S. Coast Survey original charting scheme

	East & Gulf Coasts	West Coast
Sailing Charts	1: 1,200,000	1: 1,200,000
General Coast Charts	1: 400,000	1: 200,000
Preliminary Seacoast Charts	1: 200,000	1:
Coast Charts	1: 80,000	1:
Harbor Charts	1: >80,000	1: >80,000

There is a hitch in this scheme, however. These were all for the Atlantic and Gulf coasts of the country. For the Pacific coast, plans were different. There is no mention of plans for series at 1:80,000 or 1:400,000 for the Pacific coast. A compromise scale of 1:200,000 was instead provided. Even though the 1:80,000 Coast Charts were one of the most important chart series covering the Atlantic and Gulf coasts, the series was not continued on the Pacific. It seems likely this was due to a combination of finances and the relative lack of in-shore navigating done along this rocky coast.

[2] Preliminary charts were engraved on copper plates, but were not finished to the same degree of detail as Finished charts. The 1:200,000 Preliminary charts were considered a temporary product to provide stop-gap information until the 1:80,000 Finished chart of an area became available.

To examine the question of chart differences due to the location of the chart coverage, and to provide a balanced basis for comparison between the Atlantic and Pacific, examples of Atlantic or Gulf of Mexico 1:80,000 Coast Charts are not included in this thesis. Instead, one Harbor Chart, one General Chart, and one Sailing Chart from both the east and west coasts were selected, for a total of six different charts under consideration.

The next task was to choose which six charts. While the best option would be to pick three charts from each coast that fully overlap, nesting the extents of the larger-scale charts fully inside the smaller-scale charts, another criteria was found to be more important—availability of enough editions to make a complete temporal comparison. To aid the process of selection, several resources were consulted in concert.

The Office of the Coast Survey (OCS), part of the National Ocean Service (NOS), which is part of the U.S. Department of Commerce's National Oceanic and Atmospheric Administration (NOAA), has an online archive of digital images as part of its Historical Map and Chart Collection[3]. The OCS is the modern-day successor to the U.S. Coast Survey's chart making.

Using this collection of free images, the public can view and download scanned editions of maps and nautical charts published by NOAA and its precursor charting agencies, the U.S. Coast Survey and the U.S. Coast and Geodetic Survey. For the sake of convenience, a spreadsheet containing all of the records for the time period of interest was built by searching the archive's online catalog one year at a time. A cross-tab of the spreadsheet was used to see which charts had the largest number of editions available for download.

NOAA is the source of another tool used in the selection process. In the fall of 2003, the University of Oregon's MAP Library acquired a spreadsheet from NOAA listing all of the charts it currently publishes. The author was the MAP Library's contact with NOAA, and he kept a copy of the spreadsheet for use in this project. This database was consulted primarily because each record includes the chart's scale, a field that is

[3] http://historicals.ncd.noaa.gov/historicals/histmap.asp

missing from records in NOAA's Historical Map and Chart Collection image catalog. By sorting the spreadsheet on scale, one can quickly see which current charts are of each scale, and by their titles ascertain the general location they cover.

The information gleaned from this listing of current charts had to pass through a translation before it could be used to see how many chart editions from the time period of interest to this thesis are available for download from the archive. The primary method of identifying NOAA charts is by number, with title's a secondary identifier. This is complicated by the fact that the chart numbering system has changed several times (and in some cases, so have the chart names). The numbers used today to identify charts of U.S. waters were assigned in 1974. To find out the prior number of a chart, which is the number needed for this project, there are at least two different strategies available: consult a conversion table, or view an edition of the chart that has the current number. A third option is to use a 1974 edition of NOAA's *Chart No. 1.* This bound volume is supposed to include a full conversion list, but a copy could not be consulted to confirm it.

To help chart users keep track of the change to the chart numbering system, for a short time following the conversion the following statement was included underneath each instance of the new number:

(formerly C&GS [####])

Between 1976 and 1977 this was reduced to single version of the statement, located at the center of the top of the chart, just above the neatline. Today the statement at top center reads in the form:

Formerly C&GS [####], 1st Ed., [Mon. YYYY] [code]

For example:

Formerly C&GS 6152, 1st Ed., July 1913 G-1953-826

If a current copy of chart is not at hand to look up the former C&GS chart number, at least two former number/current number conversion tables are available from libraries at the University of Oregon (UO) and Stanford University. The University of

Oregon's MAP Library has a list of it Historic and Superseded Nautical Charts collections. An incomplete version lacking the older numbers is available online[4], but the original file includes both current and prior chart numbers. The author of this thesis created the file and has a copy of it. The other source is the Branner Earth Sciences Library and Map Collections of Stanford University. It has online the Superseded U.S. Coast and Geodetic Survey Nautical Chart Conversion Table[5], a resource developed by that library. Neither of the lists at these libraries are 100% complete, but between them and viewing a recent edition of the chart online from the NOAA's image archive, all prior chart numbers needed for this project were found.

Using the older chart number, either the spreadsheet of charts built from the NOAA image catalog or the catalog itself was consulted to see how many editions of the chart are available from NOAA. This information was used in conjunction with the UO MAP Library collection list to establish how many different editions were readily available—the more editions, the better. Based on availability, the six charts illustrated in Figure 1 and detailed in Table 2 were selected for use in this project.

[4] http://libweb.uoregon.edu/map/naut/nautical_ss.htm
[5] http://library.stanford.edu/depts/branner/collections/nautical_old.html

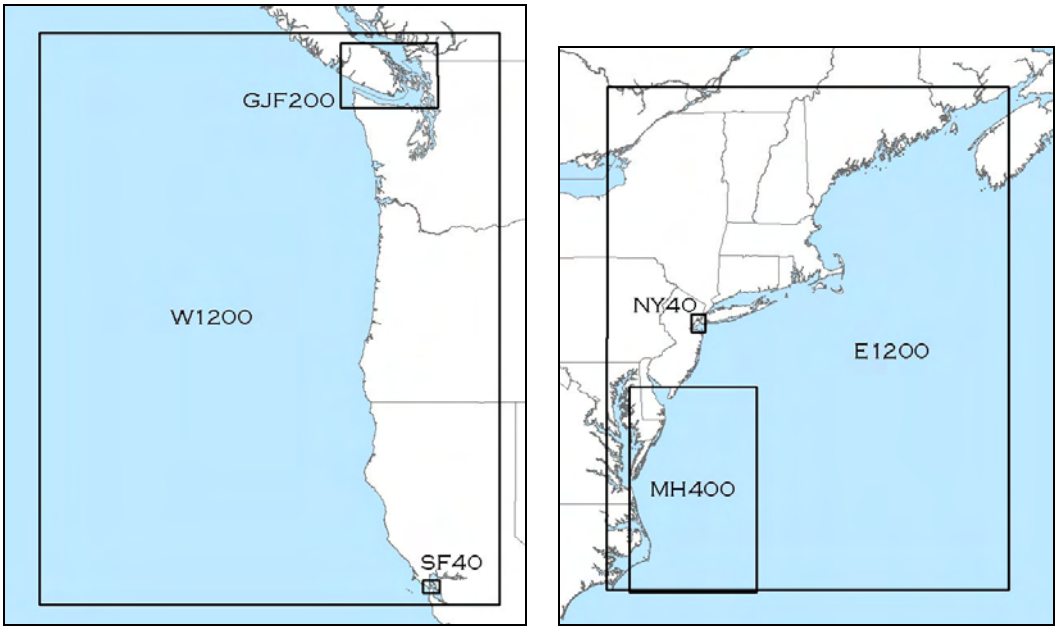

Figure 1. Chart locations

Further research was conducted to determine all the former names and numbers of charts covering the six areas at the scales being used. In all cases older charts with different titles and identification numbers were discovered. Most of these have some difference in scale and/or geographic coverage, but are the best match to the later charts. Editions of these older charts are included in the project. Table 2 includes these older numbers followed by the current five-digit number for reference.

From here forward the six charts will be referred to primarily by the alphanumeric codes leading each cell in the table. The older editions with slightly different scales, names and ID numbers are still identified by these codes because they are the in the same family line, so to speak.

Table 2. Charts used in this project.

Chart Type	East Coast	West Coast
Harbor	***NY40***: 7 / 369[(2)] / 369 / 12327 New York Entrance / New York Harbor, 1:40,000	***SF40***: 621 / 621[a] / 5581 / 5532 / 18649 San Francisco Entrance, 1:40,000
Coast	***MH400***: 9 / 1109 / 12200 Cape May to Cape Hatteras, 1:416,944	***GJF200***: 28 / 6300 / 18400 Georgia Strait and Strait of Juan de Fuca, 1:200,000
Sailing	***E1200***: 24 / A / 1000 / 13003 Cape Sable to Cape Hatteras, 1:1,200,000	***W1200***: 603 / 602 / 5052 / 18007 San Francisco to Cape Flattery, 1:1,200,000

Acquiring Chart Images

After deciding which charts to compare, the next task was to acquire scans of the charts. All but six of the editions used in the project were acquired from the NOAA archive. Three other sources were also used: the University of Oregon's Map and Aerial Photography (MAP) Library, David Rumsey's website, and the New York Public Library's website.

NOAA's online collection was the primary source, providing nearly all of the charts. Searches in the image catalog return records with a link to a file that contains a scan of the chart referenced in the record. Clicking the link allows one to save the file. All editions of the project's six charts that NOAA has available were downloaded.

Three charts from the UO MAP Library's Nautical Chart Collection were scanned using the library's 11-inch by 17-inch flatbed scanner. Several scans of different parts of each of the three charts were taken and saved as uncompressed .tiff files. Only parts that were to be used in the comparison phase of the project were scanned, not the entire

charts. Each chart edition's various scans were joined into a single image using Adobe Photoshop.

Two other sources were also used to acquire scans of editions of the six charts. One was David Rumsey's website[6]. He is a map enthusiast who has acquired a large collection of historic maps and atlases and has created digital images of many of them. Versions of these files are available for both viewing and download from his website. He lives in San Francisco and his collection is strong on the history of the western United States. Two files were acquired from his collection. One is a scan of all six sheets of the first chart engraved and published by the U.S. Coast Survey, that of the area in and around New York City and its harbor. The sheets were published in 1844 and 1845 at a scale of about 1:30,000. Also used is a scan of SF40 from 1926.

The New York Public Library also has collections of digital images online. One of the collections is American Shores: Maps of the Middle Atlantic Region to 1850[7]. This collection includes a scan of three of the six sheets of the aforementioned chart of New York City and its harbor. The library also has online in its general digital collection a scan of the second chart engraved and published by the Coast Survey. It is a reduction to 1:80,000 of the New York City chart, also originally published in 1845. These four images are included in the project.

Table 3 shows which editions of the charts are being used in this project. Not every chart used in the project has the same number of editions, but each chart chosen offered the best balance of appropriate scale, location, and number of editions.

[6] http://www.davidrumsey.com/
[7] http://www.nypl.org/research/midatlantic/

Table 3. Year of each edition of the charts

Time Period	NY40	SF40	MH400	GJF200	E1200	W1200
1	1844					
	1845					
2	1853	1859/77				1855/64
	1870		1862/72	1862	1863	
3	1878	1883			1881	1888
4	1902	1901		1895	1900	
5	1914		1916			
	1917					1917/26
6	1926	1926	1922	1922	1927	
7	1936		1938	1933	1938	1932
8	1944	1947a	1942	1941/48	1943	
		1947b/57	1951		1948	1945/54
9	1989	1989	1986	1989	1986	1986

In Table 3 the numbers on the left identify nine time periods that will be considered co-temporal for this project. This is a scheme based on decades but informed by the availability of chart editions. The intent was to have one edition of each chart for each time period. A few time periods have two editions of a chart. This was done to include charts seen to introduce significant changes. Some of the edition dates are joint (ex. 1945/54), which will be explained in the introduction to Chapter 4. The ninth time period lists the most recent edition available from the NOAA historical image collection, as of summer 2005. They are not used for design comparison, and are listed only for reference should the reader wish to make their own comparisons with current charts. The first time period only includes editions from a single location, but these are critical for understanding the early cartographic practice at the Coast Survey. The other five charts do not have corresponding editions from the 1840s. Their first editions were published later, as shown in Table 4.

Table 4. Year of first edition

Chart	Year	Available ?	Title of First Edition
NY40	1844	Y	New York Bay & Harbor, Sheet 1
	1844	Y	New York Bay & Harbor, Sheet 2
	1844	Y	New York Bay & Harbor, Sheet 3
	1844	Y	New York Bay & Harbor, Sheet 4
	1845	Y	New York Bay & Harbor, Sheet 5
	1845	Y	New York Bay & Harbor, Sheet 6
SF40	1857	No	San Francisco Entrance
MH400	1862 [P]	Y[1]	General Coast Chart No. IV, from Cape May to Cape Henry
GJF200	1862 [P]	Y	Reconnaissance of Washington Sound and Approaches, Washington Territory
E1200	1863 [P]	Y	Atlantic Coast of the United States (in four sheets) Sheet No. II, Nantucket to Cape Hatteras
W1200	1854 [P]	No	Alden's Reconnaissance, Western Coast, No. 2, middle sheet, San Francisco to Umpquah river
	1855 [P]	Y[2]	Reconnaissance of the Western Coast of the United States (Northern Sheet) from Umpquah River to the Boundary

[P] indicates Preliminary Edition

[1] Corrected to 1872

[2] Corrected to 1864

Working with .sids

Except for the uncompressed .tiff files resulting from the maps that were scanned at the UO, all the charts acquired are in .sid format, also known as MrSID. MrSID is a proprietary file format featuring a compression algorithm that provides very efficient, yet lossless, compression of raster files. The .sid files available from NOAA are 50:1 compressions created from scans of charts saved as .tiffs, yet offer resolution identical to the original file. MrSID files can be viewed with a browser plug-in called ExpressView, available for free from the company that owns the MrSID format, LizardTech[8].

Manipulating these files in their compressed state, for example saving out portions of an image as a separate file, requires the use of a different piece of software called GeoExpress. It is available for purchase from LizardTech (but is expensive). This project's methodology requires working with files in a way that can only be done on MrSID files using GeoExpress. Performing these actions on the MrSID files would

[8] http://www.lizardtech.com/

require purchasing that software. LizardTech does provide another option: MrSID files can be decompressed into other formats such as .tiff using a command-line program called "mrsiddecode.exe," which is available for free[9]. It decompresses the files to their original size with no loss in detail. The downside is that the resulting files are decompressed. When a .sid downloaded from NOAA is 10 MB, the uncompressed version of the file will be 500 MB, which is unwieldy for many computers to deal with. It is, however, economical, since software able to manipulate .tiff files is less expensive and more readily available.

The next step, then, was to use mrsiddecode.exe to decompress each of the downloaded .sid files. Because there were a substantial number of them to decompress (over 50 were processed), a way to simplify the use of mrsiddecode.exe was desired. A search discovered that someone had posted some code on the Internet for a batch file to run mrsiddecode.exe automatically[10]. Using this code as an example, a new batch file was written to run mrsiddecode.exe on an entire directory of MrSID files downloaded for this project.

Several conditions must be met for mrsiddecode.exe to work, and several steps were needed to get the files ready to be processed.

1. mrsiddecode.exe is easier to use when it is resident in the directory of the files being decompressed, so it was copied to the same directory as the files. Doing so allows the .bat file to be written without including the full path of both source file and destination file in each command. This makes the .bat file both shorter and simpler to write.
2. mrsiddecode.exe cannot process any command that includes a space in the target file's name or directory path. The .sid files were downloaded before learning this, and spaces were used in all of the file names and the directory structure. To fix this problem a shareware file manager called Total Commander[11] was used to do batch replacement of each space in the file and directory names with an underscore.
3. To save the time it would take to type in each file name when creating the batch file, the command 'dir' was used at the Windows command line to list the

[9] http://www.lizardtech.com/download/dl_options.php?page=tools
[10] http://www.geocities.com/ctesibos/voynich/sid-to-tiff.txt
[11] http://www.ghisler.com/

contents of the directory containing the MrSID files and write the list to a file[12]. An example of the syntax used to write the list:

```
dir D:\NauticalCharts\Charts\RIP\ /b > D:\NauticalCharts\Charts\RIP\Charts.txt
```

resulting in a text file looking something like:

```
1845_NY_Bay_Harbor10-00-1845.sid
1853_shoals_NY_Bay_cp766c.sid
1870_NYEnt_369-00-1870.sid
1870_NYEnt_7-00-1870.sid
1870_NYEnt_CP1167C_369-1870.sid
1874_NY_Bay_Harbor_CP2370C_369_1874.sid
…
```

4. The batch file could then be created from the list of filenames. Notepad was used to modify each entry to read something like:

```
D:\NauticalCharts\Charts\RIP\mrsiddecode.exe –i 1845_NY_Bay_Harbor10-00-
  1845.sid -o 1845_NY_Bay_Harbor10-00-1845.tif -of tifg
```

where [–i] gives the input file, [-o] names the output file, and the output format [-of] of the file is specified as geo-TIFF [tifg]. This switch embeds location information in the image, if any is provided with the MrSID file. The switch [-progress TIMER] was added after the last entry to show the progress of the conversion on-screen as the batch runs.

With the complete file saved as `SIDDECODE.BAT`, it was ready to run. Upon executing the batch file, the computer worked for several hours to complete the list of decompressions. It did not actually complete the job because the drive ran out of space with about 4 files left to process. As mentioned previously, the MrSID format is highly efficient at compressing image files. The smallest of the .sid files decompressed in the first batch was 889 kb and the largest a little over 12 MB. After being decompressed back into .tiffs at their original size and resolution, the smallest was 17.7 MB and the largest 796 MB. It was not realized that so many of them would be so large, and there was not enough room for them on the destination drive. Upon discovering the problem, free space was made on the drive, and the .bat file was edited and re-run to finish the

[12] For instructions on the command ‘dir’, see http://www.windowsdevcenter.com/pub/a/windows/2005/01/04/print_directories.html or http://www.computerhope.com/dirhlp.htm

decompressions. At this point the images of the charts were in a format that could be manipulated using software already at hand, Adobe Photoshop.

Not all of the images used in the project were decompressed at this time. Other relevant files were discovered after this initial run. The above process was repeated for each new group of .sids that was to be included in the project.

Choosing What to Clip

The next decision to make was which chart components to compare in order to best understand the changes that were made to their design and content. This decision would inform choices about which sections of each chart edition should be clipped out and assembled into displays of like sections to ease comparison.

Several sources provided inspiration in deciding what chart features to compare. Morrison et al. in *Charting the Chesapeake* (1990) offer considerable textual comparison of chart features, albeit in a non-academic way. Specifically noted in this work are the design of hydrography (stippling changed to tinting, contour lines) as well as its content (current arrows, location of channels), the content of topography ("buildings, woods, roads, cropland, docks, towers, and other features, (88)"), and the movement of information on and off the charts. Textual notes on navigation were moved to the *Coast Pilot*, also, published by the C&GS, for example.

Fillmore's work *The Chartmakers: The history of nautical surveying in Canada* (1983) is another popularizing work that includes some chart dissection. It mentions the standardized symbology on contemporary Canadian nautical charts such as navigational aids, hydrography (deepwater channels, hazards, depths by contour lines), place names, and cultural features (roads, streets, buildings, railways).

In tracing the history of engraving at the U.S. Geological Survey, Phillips (1997) provides some discussion of map design that is relevant to this project. Representation of topography was a particularly important decision for the USGS, especially the establishment of standard symbols and lettering, which the agency did in 1885. Standardization of chart symbols, including topography, was something the C&GS also

did. While some guidance was given early on regarding representation, the first set of standard symbols published by the C&GS did not come out until 1860, 16 years after the first charts were published (Allen 1998; U.S. Treasury Department et al. 1861).

Robinson directs much of his discussion in "The Evolution of the English nautical chart" (1952) to changes in technology that led to more accurate charts over time. His temporal comparison is not systematic, however—for each snapshot in time he focuses on one or two changes that may or may not have been discussed previously in the article. His work is also more of a general history than a cartographic critique. Of interest to this thesis is the way he includes figures showing side-by-side comparison of charts to facilitate reader understanding.

Magee's 1971 article on the changes to the design of British Admiralty nautical charts includes several paragraphs on the choice of fonts as well as a short history of the addition of more and deeper depth contours as the draft of ships increased (7-10). His is a general discussion that does not make a methodical comparison of multiple editions of charts.

An article from 1974 also looks at the new Admiralty charts (Kitching 1974). It is a critique of the design rather than an introduction. The author describes the following chart components for a single sheet at a single point in time:

- Projection
- Sheet size
- Chart division and ordering (geographic overlap)
- "Graticule of meridians and parallels"
- Compass rose w/ magnetic information
- "Titling and marginal information"
  - Main title and sub title
  - Dates of surveys
  - Representative fraction
  - Height, depth, and projection information
  - Source and date of publication
  - Notes of revisions and corrections
  - Conversion tables for feet, meters, and fathoms
  - Sheet number
  - Notes on navigation and reference to other info.
- Method of topographic relief
- Discussion of cultural symbols
- Hydrographic features:
  - Depth, type of representation
  - Bottom characteristics
  - Navigation hazards like drying rocks
  - Tide and current information
- Representation of coastline
- Navigational aid symbols
- Color/tinting
- Lettering
- Gestalt

More like this thesis is the first half of Morris' "Paper Chart to Digital Chart: Possibilities and problems (1986)." The author discusses three different British charts from five time periods:

1. Houat Island, 1800 [the first chart published by the office of the Hydrographer of the Navy]
2. Approaches to Plymouth, 1859
3. Approaches to Plymouth, 1916
4. Approaches to Plymouth, 1964
5. Approaches to Plymouth, 1986
6. Chart 1610 (Dover Strait and the Southern North Sea), current (1986)

The comparison of the charts discussed:

- Degree of detail
- Specifics of topography, hydrography
- Extra text (sailing directions, warnings, radio and pilot information, etc)
- Statements on surveys
- Titling
- Chart date and survey date
- "Rules" – designated areas, and regulations
- Signal lights
- Color

From these examples and also from the discussion of chart components by C&GS authors at various times, the following list of chart items was selected for comparison in this thesis:

- Production and Printing
  - Copperplate engraving vs scribing on glass, plastics
  - Copperplate printing vs lithographic printing
  - Color
- Navigation-related
  - Design and role of bathymetric contours
  - Bottom surface description
  - Shoal water representation
  - Relative density of soundings, channels vs elsewhere
  - Navigation aid symbols (buoys, bells, lightships)
  - Compass rose and magnetic variation information
  - Topographic information
  - Cultural information
  - Notes and explanatory information
- Design and organization:
  - Numbering system
  - Typography
  - Neatline format
  - Title and Short Title
  - Statement of Responsibility format
  - Movement of information from inside to outside of neatline
  - Standardization of chart marginalia

The chart components selected for capture and analysis were chosen for different reasons:

- **Color** is used as an important marker of changes in printing technology. Lithographic printing allowed for multiple-plate color separations. This increased the amount of color that could be added to charts compared to hand-coloring copper-plate prints. The expanded scope in the use of color offered new options for symbology.
- The **representation of shoal water** is used as an example of changes in engraving, printing and overall chart design, and is also tied to ship propulsion methods.
- The **density of soundings** and delineation of channels were chosen because changes in ship-building, in particular the advent of mechanical propulsion and the subsequent increases in ship draft, size, speed and steerability, prompted changes to the way hydrographic surveys were performed as well as changing the focus of the information collected about the sea bottom. It is also used as an example of advancements in the technology of hydrographic surveying.
- **Aids to navigation** are included to demonstrate increasing standardization of chart elements, as well as changes to symbolization from several causes, from the changing needs of ship captains to increasing international contact and cooperation among mapping and charting agencies.
- The **compass rose**, sometimes called compass card, was chosen as another example of the application of mechanical engraving aids. The compass also is an indicator of progress in the understanding of terrestrial magnetism. The C&GS was one of the most important researchers into the earth's magnetic field, in particular the change in **magnetic variation** at different locations over time.

- Representation of **topography** and **cultural features** are included to show how the idea of what constitutes a nautical chart has evolved. It is also a proxy for advances in surveying technology.
- **Chart numbers** are included to illustrate the adoption of standards and systems within the operation of the survey. As a large bureaucracy, management methods were developed and strengthened over time, and as internal systems became organized, so were the charts. Several different systems of chart organization were in place over the time period of this study.
- **Typography** had attention paid to it in waves over the years, and lettering was performed using several different methods and technologies.
- The **neatline** is used as an example of changes in the engraving technology used by the C&GS. Over time the Engraving Division increasingly relied on mechanical aids to help engrave repetitive or simple portions of chart. Engraving the neatline was among the first tasks so assisted. It is also a proxy for standardization of chart elements.
- **Title, short title,** and **statement of responsibility** are included as further examples illustrating the adoption of standards and systems within the agency, as well as for engraving methodology, and for the standardization of chart elements.

Together, these all contribute to an understanding of the pressures, whether internal or external to the C&GS, leading to the dramatic changes in the agency's published charts during the century examined here.

Having decided the intellectual component of the comparisons, practical considerations came up. Making visual comparisons requires a reasonable degree of proximity for the items being compared, and spatial proximity is preferred to temporal proximity for such comparisons. The limitations of screen resolution make spatial proximity of comparable elements of multiple large digital files impractical, and temporal proximity (flipping between images) for such large files is rendered infeasible due to limitations in computer memory—the .tiff files of the charts total over 30 GB of data.

Likewise, the physical difficulty of shuffling several dozen large-format printouts of the digitally-sourced charts would preclude acceptable spatial and temporal proximity.

In the face of this, it was decided that the most practical way to achieve proximity and to ease comparisons would be to create layouts containing digital clippings from each chart of only the elements of highest relevance for making desired comparisons. Small sections of charts, collected in close spatial proximity, would make comparisons practical either on-screen or in a limited number of large-format printouts.

From the list of chart items selected for comparison (above) a plan was prepared detailing exactly which sections of the charts contain the content to be compared. These common sections could then be compiled into layouts. Each clipping would be copied out into its own file, and then assembled into a layout with all of the other clippings of the same character, one (or two) from each relevant chart. Below is the list of sections selected for compilation. A brief explanation tying the chart sections to the components to be compared is included with each entry, where necessary:

1. Upper left corner: neatline, numbering system
2. Title, including logo and representative fraction
3. One compass rose, preferably one without much topography/hydrography inside: compass rose, magnetic declination
4. One section of shoal water
5. One section of a channel: bottom surface description, sounding density
6. One section of deeper soundings: bottom surface description, sounding density
7. One section of urban topography: cultural features
8. One section of non-urban topography: topographic information
9. Examples of color, if present
10. A representative section of notes (may be one or more, depending): notes and explanatory information
11. A representation of aids to navigation
12. Bottom center: movement of information from inside neatline to outside
13. Lower left: numbering system, chart standardization
14. Lower right: titling, numbering system, chart standardization, representative fraction
15. Full charts: reference

Copy, Save, and Assemble

With the task of deciding what to examine complete, the next task was to prepare the collections of clippings that would aid in performing the comparisons.

The first step was to create a directory structure in which to organize the files. The six charts each had from five to eleven editions totaling 40 separate edition dates (some charts had multiple editions of the same year). With around 14 files copied out from each original, the 560 resulting files would be difficult to manage without a pre-defined organizational structure.

Six subdirectories were made within a primary `\Charts\` directory, one for each of the six charts. Each chart edition, as shown in Table 3, then had a subdirectory created for it. The result was 40 subdirectories with paths looking like this example:

```
\Charts\MH400\1916\
```

To create the saved sections of a chart edition, the .tiff file was opened in Photoshop. This could take as long as five minutes for each of the largest files. Four of the fourteen clips did not require any decision-making—Upper Left, Lower Left, Lower Right, and Bottom Center were pre-decided and did not have to be sought out. Two other clips were obvious (Title, and Compass Rose) but had varied locations. The other seven (Shoal Water, Channel, Deep Water, Urban Topography, Non-urban Topography, Notes, Color, and Aids to Navigation) were more abstract and took longer to find and complete. Decisions had to be made for each chart as to which section of a symbol (for example, shoal water) out of the total area of that symbol on the chart best shows how that chart symbol was designed and printed. A conscious effort was made to select areas common to all editions of a chart and to clip the same area from all the editions. Doing so aids in identifying changes to that location and to the symbols used there.

Notes were taken for each edition while working with them in an effort to capture other information, especially oddities and inconsistencies, of which there were many. One example was that two charts (NY40 1902 and E1200 1881) were scans of only half a chart—the top or bottom sheet of a two-sheet chart for which a copy of the other half could not be found. A bit stranger was SF40 1947A. The scan was missing about two

inches on both the left and right sides. All these instances meant that one or more of the planned clips could not be made. Unfortunately, the small-scale charts (E1200 and W1200) had almost no representation of anything that could be termed a 'channel.' The scale does not permit representation of such a small feature, and mariners should not use a Sailing Chart to navigate inshore channels. The Channel clip is therefore mostly absent for these charts.

Aside from these few examples, the work went smoothly. The procedure for saving each clip into its own file was as follows:

1. Using the Select tool in Photoshop, draw a rectangle defining the area of the image to be saved.
2. Copy the selected area to the Clipboard (`Crtl+c`).
3. Create a new document (`Ctrl+n`), naming it following a naming convention.
4. Paste the contents of the Clipboard into the new file (`Ctrl+v`).
5. Save the new file (`Ctrl+s`) to the appropriate subdirectory.
6. Close the new file (`Alt+F4`).

Once files of all the editions had all been processed, the next step was to organize the clips into layouts to facilitate comparison. The displays were created in Adobe InDesign, a desktop publishing program. InDesign is similar to software such as Quark and Microsoft Publisher. It specializes in bringing together in a single document multiple files in multiple formats in order to print complicated page layouts. The advantage of using a page layout program over a word processing program for this task is its greater control over placement of images, and the fact that files imported into a page are, by default, linked rather than embedded. Linking means that the program does not make a copy of the placed file inside the layout file. Rather, it merely displays the file, and all that is saved in the layout document is a reference to the linked file. This makes for a smaller file size for the layout, which is quicker to open and easier to work with.

To begin, a layout template was built. The page size was set at 36 inches wide by 72 inches tall—a large layout was deemed optimal for displaying the high-resolution .tiffs in case they are ever printed. A six-column by nine-row grid was drawn—columns for the six charts, rows for the nine time periods, which is the same layout as Table 3.

Text blocks were inserted to label the rows and columns, and each of the edition years shown in Table 3 were named by a text block placed appropriately.

At this point the first display was saved as `01_UpperLeft.indd`. All of the clips of the upper left corner, one from each of the 40 editions, were placed in the page layout in or near the proper cell for its chart and time period. They were sized to be as large as possible, and arranged to avoid interfering with any of the other images on the page.

Fourteen other displays were then created, based on the first. Because the files appearing in the image frames in each InDesign document are merely linked, not embedded, it is simple to change which image is displayed. The program has a Links palette just for maintaining links to outside files. Select an object (in this case an image frame) in the list of links and the file displayed in that image frame can be changed to a different one by browsing the directory structure and selecting a new file. Changing the source of each image frame from one image to another took very little time.

After changing the links, it was necessary to manipulate the frames to fit each new source image. The command "Fit Frame to Content" (`Ctrl+Alt+C`) changes the shape and size of the frame to reflect the actual aspect ratio and resolution of the source file. After fitting, most all of the frames would then have to be resized manually to once again fit properly with the images around it.

Most of the 15 displays have instances where more than one clip was saved for a single edition. This was most prevalent for the Notes display, which was more loosely defined than the others. All efforts were made to fit in any additional clips deemed relevant. This was helped by the previously mentioned fact that some of the scans were missing parts and therefore certain of the clips could not be made, leaving space open in the displays where the missing image would have gone.

When the 15 displays were finished, each was converted to a .pdf. Doing so makes the files viewable on computers that do not have Adobe InDesign installed. It is assumed that .pdf files will be able to be read by more computers, and for a longer time, than the original .indd files. These .pdfs have been copied to a CD-ROM that can be

found in an envelope at the back of this document. An 11-inch by 17-inch print of each layout is also included in Appendix D.

With the displays complete, the pieces were in place to examine the history of design changes for the first century of U.S. Coast and Geodetic Survey charts.

CHAPTER IV

COMPARISONS OF CHART ELEMENTS

This chapter systematically examines and compares the chart images collected in the 15 layouts described in Chapter 3. It uses the list of chart elements on page 21 as a guide. In lieu of using page-space to show each graphic being discussed, please refer to the printed page layouts provided in Appendix D, or to the .pdf files provided on the included disc.

Before beginning, however, it necessary to discuss the dates used to identify the chart editions. While seemingly straightforward, identifying a chart by a single year is often troublesome. A table listing many details discussed below is found in Appendix C: Chart Details. Charts have several different dates associated with them, and the terms used to refer to the dates have in some cases had more than one meaning over the course of C&GS history. There are dates for publication, edition, printing, issue, and 'corrected to.' In addition, nearly all charts have a date for the magnetic variation shown on the compass roses, and many list multiple dates for the surveys on which the chart was based. Navigators are most concerned with the 'corrected to' and survey dates, while librarians are most interested in date of publication, for purposes of bibliographic control.

Most charts include a publication date, and this was used to identify the date of the charts used in this project, where feasible. However, seven of the 40 charts are identified with a dual date. For detail as to which type of date is used to identify each chart, Appendix C: Chart Details highlights each date used to identify the charts.

At various times charts have also included a date of 'issue.' For many years charts were engraved on copper plates, and each chart's plate would be corrected and added to for many years. For the life of any particular plate, the chart would maintain a single publication date, the date the plate first completed. After each correction to the plate,

however, the date of issue was changed. The edition SF40 1859/77 is an example of this practice. The plate was completed and the chart first published in 1859, but the edition scanned and used in this project had corrections and additions applied many times, and most likely several editions were issued between 1859 and the edition at hand. Is it an 1859 chart, or an 1877 chart? The design of the chart and the base information on the plate is best related to the earlier date, but the important navigation-related information is updated to be current as of the later date. The answer is ambiguous, so the identifying date includes both. From the perspective of cartographic design, however, the date of initial chart construction is most important.

By the turn of the twentieth century charts carried one or more 'print' dates (all in a row at the lower left corner) and sometimes an 'Edition' date. 'Edition' carries the same meaning as 'Issued' did in the 1870s, and 'Issued' now had a new meaning. By 1900 it represented the date the chart was distributed from the C&GS stock of printed charts. Corrections made to plates were also made by hand to all of the printed copies still in stock, so charts were 'corrected to date of issue.' After being issued, it was up to the new owner to correct it by hand based on information published in one of the editions of the *Coast Pilot* (U.S. Treasury Department et al. 1900a). Such charts have been identified by the publication date except in instances when there were many years difference between it and the print date.

A few of the editions used here are missing all dates typically used to note publication. For some editions the dates were simply not included on the printed charts. In other instances, incomplete scans have made the dates unavailable. In these types of cases the survey and magnetic variation dates were consulted. The date for the magnetic variation on the compass roses is usually one or two years after the print/issue date. With such a small difference it seems reasonable to use it for identification when no other date can be found.

Since the 1960s, charts have been given only one date related to publication. Each time any change is made to the chart it receives a new edition number and a new edition date. Today's charts do not have separate publication, corrected to, or issue dates. Charts

are no longer corrected by hand up to the point of sale—that responsibility has been shifted to the purchaser (Calder 2003).

Production and Printing

Production Methods

For most of the time period under consideration, the C&GS produced finished nautical charts as copperplate engravings. However, the agency underwent a gradual transition from copperplate engraving to engraving on glass negatives in the years leading up to World War II, as illustrated in Figure 2. Finished charts were held to a higher standard than Preliminary charts, which were simply early editions of what would become Finished charts after detail work was completed. Expediency, not beauty, was the drive behind Preliminary charts.

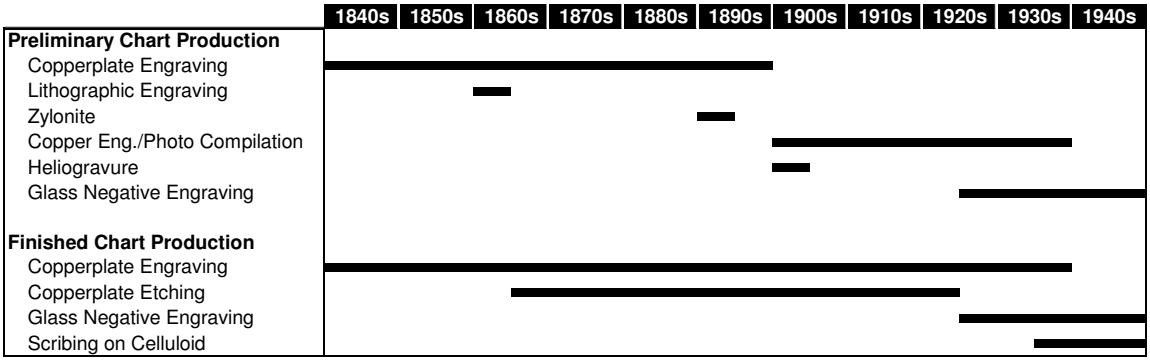

Figure 2. Chart production method timeline.

Determining the production method of a chart from a printed copy is complicated by the fact that the final product of different production methods can be printed using the same method. For example, during the transition from copperplate engraving to glass negative engraving, lithographic presses, not copper plates, printed some copperplate engravings. Proof prints were created from the copper plates, and those prints were used as the basis for generating photolithographic printing plates.

Between 1900 and 1940 it is unclear which charts were produced using which methods. Before 1900 all finished charts were engraved on copper, and after 1930 (or so) the practice was phased out, disappearing once the scribing on plastic was adopted.

Engraving

The engraving staff at the Coast Survey initially engraved entirely manually, even though machines for engraving lines and parallel lines were widely adopted in the early nineteenth century (Pearson 1983, 7). Over time mechanical aids were added to the toolset of the engravers at the Coast Survey, as were additional techniques for speeding production.

A mechanical engraving tool was first mentioned in the annual report for 1845. Constructed for the engravers were a ruling machine and other tools (U.S. Treasury Department et al. 1846, 33). The Engraving Office began using punches[13] for engraving numerals, particularly for soundings on second-class charts, following experiments in 1860 (U.S. Treasury Department et al. 1861, 222; 1864b, 124). This method was manual, but still much faster than engraving each numeral. It was also more consistent, if less elegant. Roulettes[14] for sanding work were not in use in 1854, but their use was under consideration (U.S. Treasury Department et al. 1855). They were in use by 1869, when a study of how to improve their use was undertaken (U.S. Treasury Department et al. 1872, 59).

In 1863, the pantograph was introduced to the office for use with scale reduction. The agency noted that, "Much time and expense … will be thereby saved…(U.S. Treasury Department et al. 1869a)." Success in using pantographs was found after importing two high-quality devices from Denmark in 1865 (U.S. Treasury Department et al. 1869b).

---

[13] Punches for conventional topographic symbols were standard engraver's tools as early as 1751 (Verner 1975).

[14] Manual engraving tools for which the cutting surface is on a wheel attached to a handle. Rolling the tool across the blank surface cuts the symbol.

The 1869 annual report also mentions etching as a technique for engraving the symbol for woods (59). In the 1884 report, etching is listed as one of the steps in the engraving process (U.S. Treasury Department et al. 1885, 115). The annual report of 1906 reports success with "a process of etching copper plates from transfers of drawings …(U.S. Department of Commerce and Labor et al. 1906, 14)," which was a substantial advance on the prior technique. The charts produced in this manner were all large-scale charts that did not require fine lines, and were of locations outside the continental U.S.

The U.S. Naval Hydrographic Office created a Section of Mechanical Engraving under the supervision of Vincent Le Comte Ourdan, who invented and patented several different mechanical engraving machines and tools (Anonymous 1901). Among these are:

- Sounding engraving machine
- Tinting/border-engraving machines
- Border subdividing machines
- Border and scale-shading machine
- Compass engraving and lettering machine
- Multi-point divider

Three of these time-saving aids were put into use in the C&GS in 1901: the sounding engraving machine, the border cutting and tinting machine, and the compass cutting machine (described as "improved", implying there was an earlier compass cutting machine in use) (U.S. Treasury Department et al. 1902, 216). The sounding engraving machine was later modified to allow a single person to operate it (U.S. Department of Commerce and Labor et al. 1908, 67).

The annual report for 1908 also described using a combination of engraving for base chart elements and photolithography for lettering to produce preliminary charts more quickly.

In 1916, a manual on chartmaking published by the C&GS notes that most charts are produced as drawings on "tracing cloth" to be printed by lithography, rather than by copper engraving. The reason cited is that the chart will be published more quickly when traced (1916c, 14). This contradicts a later C&GS report, which states that mechanical

aids available to engravers make engraving quicker than tracing by hand (Jones 1924). This difference meant that a "modern chart, with its simplified topography … could be engraved more cheaply than it could be drawn (26)." Copper also had advantages over other early media, specifically that it is permanent, "not subject to change in varying atmospheric conditions, not easily damaged, and on which old work can be erased and changes made…(U.S. Department of Commerce et al. 1920b, 83)." In fact, the copper plates were considered the "permanent record of the completed work (U.S. Department of Commerce et al. 1916b, 16)."

Copperplate was also given additional life in the lithographic printing era by development in the early 1920s of a technique to pull transfer prints from the copper plate that did not have appreciable distortion (U.S. Department of Commerce et al. 1925b). A transfer print must always be made from the engraving, so the black ink can be photographed. The photograph is finally transferred to the printing plate. The main source of inconsistency was in the transfer print, which for many years suffered distortion from shrinkage when the dampened paper dried. The improved technique was to back the paper with glue, and stick a sheet of heavy blotting paper to it before running the joined pair through the press. The blotting paper stays dry and forces the thinner sheet to dry in place, with unappreciable shrinkage (U.S. Department of Commerce et al. 1921a, 24). This change made it more practical to print engravings by lithography, with the attendant economies that printing method provides. The accuracy of the charts also improved, because the chart paper did not have to be dampened for lithographic printing.

This same advance also led to further development of engraving on glass negatives. Negative engraving, or scribing, on wet-pate glass negatives was developed by the C&GS initially as a way to touch-up charts in between chart compilation and lithographic printing (Shalowitz 1957). As lithography became the dominant and then the only printing method in the agency, more effort was put into working with negatives. Corrections that previously had to be applied to the copper plates could instead be made to the glass negatives from which the printing plates were created. Instead of making corrections to the 'standard sheet' and then to the copper plate before each reprinting,

corrections would only be applied to the copper plates when very extensive, while the copper provided insurance against the glass negative being damaged (U.S. Department of Commerce et al. 1921a, 24). It was only a short leap from there to engraving directly on negatives from the start, which is mentioned as one of the two options for chart creation in the 1929 annual report (U.S. Department of Commerce et al. 1929, 8).

In 1935, tools specifically for engraving on glass negatives were developed. Until then the engravers simply used tools developed for engraving on copper (Shalowitz 1957). However, even in 1936 the C&GS was engraving "a large percentage of the new or completely reconstructed charts" on copper (Adams 1936, 94). The base chart was engraved on copper, while elements more likely to change, or easier to produce using photographic techniques (titles, notes, aids to navigation, compass roses, etc.), were applied to the glass negative. When reprinted, edits were made to the negative, not the copper plate (Adams 1936). These techniques were in use within the C&GS by 1928 (U.S. Department of Commerce et al. 1928b). By 1936 it was "one of the leading processes of this bureau (U.S. Department of Commerce et al. 1936a, 79)."

At the same time, work was being done on expanding the versatility of mechanical aids for chart creation. A new sounding engraving machine was designed and built by the survey's Instrument Division in 1925 to replace a larger, older machine that was designed to work specifically with copper. The new machine could work on both copper and glass (U.S. Department of Commerce et al. 1925a, 50). By the mid-1930s, a projection ruling machine was in use that could work not only on copper and glass, but also on paper. The machine in use for creating the border and neatlines could now do both at the same time (U.S. Department of Commerce et al. 1936a). Also in use by the mid-1930s were rub-off standard chart symbols, and a Ben-Day stippling machine. Charts were still engraved on copper in 1935 (U.S. Department of Commerce et al. 1936b, 136).

Then in the late 1930s, a dimensionally stable, clear plastic film (celluloid) was invented that could be used as the base for cartographic production. This was first used by the C&GS for chart compilation in 1939, and widely adopted in the 1940s for scribing

in place of glass negatives, although glass was still being used in 1949 (U.S. Department of Commerce et al. 1940, 110; Monmonier 1985; U.S. Department of Commerce et al. 1950).

Other Production Techniques

Another technique used to produce charts was engraving on lithographic stones, although it was only used for preliminary charts. A Lithographic Office was established in 1861 to quickly produce maps and charts related to the Civil War. The finished products were printed by lithography and were not finished to the high-degree of detail expected of finished nautical charts. In 1862, this office was producing maps printed in color (Morrison et al. 1990, 114). The Lithographic Office was dissolved between 1866 and 1867 with no mention in annual reports.

In 1891, the Drawing Division made an experiment of using a clear material called zylonite, made of cellulose nitrate, for tracing, engraving, printing, and electrotyping a finished drawing. It could take the place of tracing paper and copper plates. Deemed an initial success that warranted further investigation, the material was not mentioned again (U.S. Treasury Department et al. 1892, 124).

Heliogravure is mentioned in the 1902 report as a method of "reproducing negatives on copper plates," and one chart was created used this process. The experiment was deemed successful, but probably most useful for preliminary charts because the result looks more like photolithograph (U.S. Treasury Department et al. 1903, 202).

When the lithographic presses were switched from stones to aluminum plates, there was hope that drawings could be transferred to the aluminum plates via "[t]he 'direct process,' by which a photoprint is made on a sensitized aluminum plate from the chart drawing, replacing the glass negatives and prints on transfer paper…(U.S. Department of Commerce et al. 1914, 120)." They relied on sunlight for illumination at that time, which made the process inconsistent.

Printing Method

The C&GS began its chart printing using original engraved copper plates. Experiments with electrotyping[15] by C&GS staff member George Mathiot lead to full integration of the technique into the production process, so that original plates were used only as data storage, and printing was done using copies. Lithography was the only printing method used in 1940.

The charts used here appear to have been printed using the methods noted in Table 5. "CP" stands for copperplate printing, and "Lith." stands for lithographic printing. The distinction is made entirely by which charts have colored area fills.

Table 5. Print method: copperplate or lithography

Time Period	NY40	SF40	MH400	GJF200	E1200	W1200
1	CP					
	CP					
2	CP	CP				CP
	CP		CP	CP	CP	
3	CP	CP			CP	CP
4	CP	CP		CP	Lith.	
5	Lith.		CP			
	Lith.					Lith.
6	Lith.	Lith.	Lith.	CP	Lith.	
7	Lith.		Lith.	Lith.	Lith.	Lith.
8	Lith.	Lith.	Lith.	Lith.	Lith.	
		Lith.	Lith.		Lith.	Lith.
9	Lith.	Lith.	Lith.	Lith.	Lith.	Lith.

The first chart here seen to be printed by lithography, E1200 1900 has a note in the lower left corner that it was printed by "JULIUS BIEN & CO. LITH. NY". It is a 1903 print of the 1900 chart, as noted by a stamp in the lower right corner.

Context

The Coast Survey first purchased and installed a flatbed press in 1842 for intaglio printing from copper plates (U.S. Treasury Department et al. 1843). In 1851 a hydraulic

[15] A method of copying engraved copper plates using vats of electrolyte solution, dissolved copper, and electricity.

flatbed press was purchased. See Figure 3 for a timeline of the printing methods used by the C&GS for its charts.

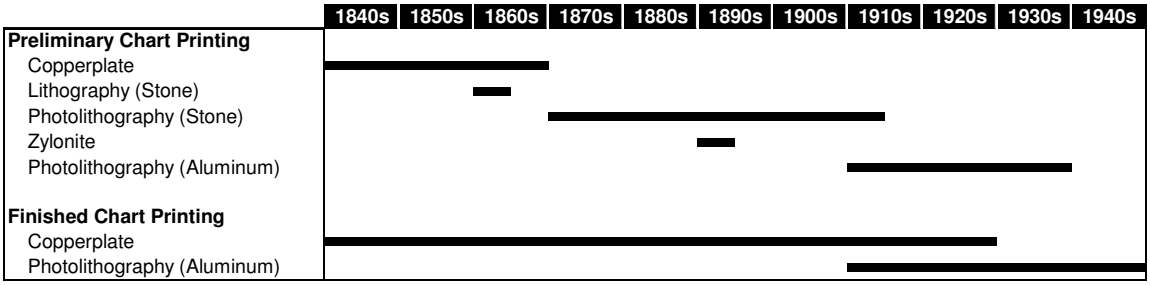

Figure 3. Printing method timeline

In these early years, charts were printed from the original engravings. Electrotyping was seen as a possibility for reproducing charts to extend the life of the original engravings as early as 1851. So much effort was put into each original engraved plate—$3,000-$6,000 over three to four years—that spending $200 to create an electrotype copy was an economical choice (U.S. Treasury Department et al. 1852). Once experiments with electrotyping had successfully demonstrated its value, the Coast Survey began printing only from electrotype copies.

In response to the outbreak of the Civil War in 1861 the survey established a Lithographic Division to quickly produce war-related maps and charts (U.S. Treasury Department et al. 1862). Two lithographic presses were in use by the Division in 1862, and some maps were printed in color (U.S. Treasury Department et al. 1864a). The war material was engraved on stone, but the Division also printed some charts by transfer from copper plates. This included some experiments with printing preliminary charts and sketches "by reproducing gradations of soundings, land, sand-banks, &c., by a system of light coloring (151)." In 1864 several such charts were published, while the war maps were being published in up to five colors (U.S. Treasury Department et al. 1866, 112). One of the two lithographic presses was disposed of in 1865, but the other retained for printing preliminary charts and sketches by transfer from copper (U.S. Treasury Department et al. 1867).

A larger copperplate press was purchased in 1881, and a second added in 1884. An addition was built to expand the press room 1885, allowing the new 38-inch press to fit along with the existing two presses (U.S. Treasury Department et al. 1886, 107). A fourth press was in use in the summers of 1888 and 1889, staffed by temporary labor, due to increasing demand for charts (U.S. Treasury Department et al. 1889b, 120; U.S. Treasury Department et al. 1890, 121). Requests were made to add power to the existing presses in 1888, 1889, and 1890; and two additional presses were requested in 1889 and 1890. Both requests were approved in 1891 (U.S. Treasury Department et al. 1892, 5). A new, larger press room location was found, and in 1892 the new location was in use with its two new powered presses, one older press that had been converted to power, another that was being converted, and a new powered calendar press[16] was installed (U.S. Treasury Department et al. 1893, 135).

In 1904 the survey acquired a lithographic press of its own (U.S. Department of Commerce and Labor et al. 1904, 175). It was used to print preliminary editions via photolithography.

Aluminum printing plates replaced stones in the lithographic presses in 1912 (U.S. Department of Commerce and Labor et al. 1913a, 96). Once this change was made, the survey began to print some of its high-demand finished charts by photolithography instead of using the slower copperplate presses (U.S. Department of Commerce and Labor et al. 1913b, 93). Other charts were still printed from copper plates, though (U.S. Department of Commerce et al. 1916c, 14). The aluminum plates were initially used in the existing flatbed lithographic press, but a rotary offset press was acquired in 1917, greatly increasing the number of sheets that could be printed in a given period of time (U.S. Department of Commerce et al. 1918, 28; U.S. Department of Commerce et al. 1976). In 1931 the survey received an appropriation to purchase three new lithographic presses for its new office building (U.S. Department of Commerce et al. 1931, 8-9). An additional offset press was added in 1935 (U.S. Department of Commerce et al. 1936b,

[16] A press that applies immense pressure to dried, printed sheets in order to harden and glaze the surface of the paper.

137). Pictures of C&GS presses dated circa 1935[17] show five offset lithographic presses, two of which can print five colors in a single pass.

Color

Color on the charts is a direct consequence of the abilities of the printing method in use. Until lithography was employed for the nautical charts, clerks in the Washington DC office applied any color on a chart by hand after the charts were printed by a single impression of the copperplate press using black ink. Analysis of early color is limited by scans of most early charts (before about 1920) being gray-scale or black and white.

This section refers to Layout 09—Color, which only includes clips from scans that are in color. It excludes the color scan of NY40 1844 because this chart is known to have no color applied.

The first chart used here that was printed in color and scanned in color is from **time period four**, E1200 1900. Two colors are seen in the clip: yellow, for land, and orange to highlight beacons and lighthouses. It is not clear if the orange circles were printed or applied by hand. Buoys are not colored.

In the **fifth time period**, NY40 1914 has buoys and sector markings that are either red or magenta in addition to yellow fill for land area. Either way, the color applied to the chart represents red. Red completely fills the red buoys, while the red sector arcs are applied over the black plate. The red arcs do not obscure black text. A close examination of the arc in the clip shows that the right-most segment, between the dotted line and the "15" is slightly off-set from the rest of the arc, and that the whole of the arc is not as perfectly a segment of a circle as the printed dashed line is. This suggests the color was hand-applied, since it is unlikely this was intentional, and such an error would probably have been caught in the plate production process if the red was applied via another pass through the lithographic press.

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[17] Available from the NOAA Photo Library's *Historical Coast and Geodetic Survey Collection*, http://www.photolib.noaa.gov/cgs

NY40 1917 has one addition over the 1914 edition: text referencing larger-scale charts, in red. The clip shows one example, "(chart 541", where a closing parenthesis was omitted. The strokes are inconsistent enough (some square, some pointed; some darker at the ends) that they may have been applied by hand.

W1200 1917 has similar color features: yellow land, red buoys and text references to other charts, and orange circles highlighting lighthouses and beacons.

The **sixth time period** provides one big innovation. MH400 is the first chart here to add a cyan plate to represent shallow water as blue. Waters shallower than three fathoms are shown as cyan with sanding that is heavy at three fathoms but becomes less dense based on distance from the line (not based on depth). It also has the other color features present on the charts in the previous time period. The other editions in the sixth time period do not have the cyan plate.

In the **seventh time period** one of the charts adds cyan for shallow waters, but one loses it. MH400 1938 has had its cyan removed. Present for the 1922 edition, it is gone for the 1930 edition (not shown) and is also not present on the 1938 edition used here. The sanding remains, as does the red buoys and chart references, and orange highlights for lights. One addition is magnetic variation lines that are shown in orange. These would have been printed, not applied by hand.

NY40 1936 is the chart that has had cyan fill for shallow waters (everything inside three fathoms) added since the previous time period. Today the color is a flat shade of blue-gray on the scan; it is not known if this the original shade, or if time has caused the color to shift. Another change to the chart is many more navigational aids (buoys, beacons, etc.) having orange highlights overlaying the black object. There is also additional use of red/magenta. Cable and pipeline areas are defined by a dashed outline in red/magenta, and labeled in the same color.

The other change worth noting is that E1200 1938 has also added magnetic variation lines that are shown in orange, as did MH400 1936. The other charts with clips in this time period (GJF200 1933 and W1200 1932) do not have changes to note.

Time period eight saw additional color added to nearly every chart. NY40 1944 uses a new technique for showing marsh areas: cyan is printed over yellow to create a pastel green. There are distinctly different magenta and red colors on this edition. References to other charts are printed in magenta, while cable and pipeline areas still marked and labeled in red. Some buoys are also filled with red. Lights and beacons that were highlighted in orange on the previous edition are now either enclosed within the outline of an unfilled magenta circle, or overprinted with a filled magenta circle. New danger areas, related to the World War II, are outlined with a dashed magenta line, and labeled with magenta text both on the chart face and in notes.

The green line shown in the clip appears to have been drawn by hand. There is a green square in the center of the chart, and at each corner faint lines that appear to be pencil extend outside for a short distance. It looks like the green lines are traced over a darker line in a thin, translucent green ink. A label printed in magenta just outside the square near bottom center suggests that the square is the outline of "*(chart 541)*". It could merely be coincidence, though

SF40 1947A shares NY40 1944's color scheme, with the addition of cyan and magenta since the 1926 edition. It also uses the cyan-over-yellow method of showing marsh. Red marks buoys and cable areas, while magenta marks lights and restricted areas. Numbers in circles (in magenta) apparently refer to notes, but the scan is incomplete and the notes are not present.

SF40 1947b/57 has switched cable and pipeline areas to magenta, while some buoys are still shown in red. The missing notes from 1947A are present on this later edition, and they refer to Anchorage Areas, some of which have restrictions on their use.

For MH400 1942, the cyan plate returned. There appears to be two tints of cyan, or possibly one of cyan and one of blue, in fact. The darker is used for water less than five fathoms, and the lighter is used for water between five and ten fathoms. The cyan does not overprint yellow to show marsh in green as the larger-scale charts do, though. Much of the frequently-changing navigational information (compass rose and lines of magnetic variation, references to other charts, highlights for lighthouses and beacons,

etc.) are printed in magenta, except for red filling some buoys, all of which are outlined in black.

GJF200 1941 is the only chart edition in this time period that does not use cyan to show shallow water. Yellow, magenta, and red are used as they are on the other charts, however.

For W1200 1945, the only use of color that is not seen on the other charts in this time period is that of a magenta line along the coast showing a “track line”, a preferred route for powered ships. It is visible in the clip passing through the word “Blanco”.

E1200 1943 uses the same printed scheme as others charts of this time period. The chart that was scanned has the addition of a more detailed set of latitude and longitude lines drawn in a dark blue colored pencil around the entrance to Delaware Bay.

E1200 1948 has, in addition to yellow, cyan, and magenta, three additional colors that each provide an overlay related to LORAN navigation systems. Hyperbolic lines for triangulating positions are overprinted on the base chart in brown, green, and dark blue. Text relating information about the lines is also printed in the same color as each of the lines.

MH400 1951 also has a LORAN overprint. It has two sets of hyperbolic lines, one in magenta, one in green.

Context

Printing in multiple colors requires the ability to register the print across the multiple impressions. This is not possible when printing from copper plates because the paper has to be damped for each impression, allowed to dry, then dampened again for the next pass through the press. The drying creates inconsistent shrinkage of the paper (Magee 1971). Color was instead applied by hand to charts printed from copper plates. At the C&GS, buoys were hand-colored on printed charts as early as 1847 (Wraight et al. 1957, 21). This was in keeping with using hand color as decoration for points and lines, as noted by Pearson (1980).

Maps were printed by the Coast Survey in up to five colors using lithography during the Civil War (Wraight et al. 1957, 21). Lithography does not require wetting the paper, which makes registration easier. But, due in part to fact that the detail possible through lithography at that time was not as fine as that of copperplate printing, and partly due to copper plates being the primary data storage mechanism, the practice was not continued by the survey after the war.

Color lithography was again tried through contract with private printers starting early in the first decade of the twentieth century. The first edition of San Francisco Entrance, Chart 5532, to be printed in color by photolithography was in 1903 (U.S. Department of Commerce and Labor et al. 1903, 174, 177). A digital version is not available.

A two-color offset lithographic press was purchased and installed in Washington by the survey in 1917. In the 1930s a five-color offset lithographic press was purchased.

A change in standards for coloring was enacted in 1934, soon after the multi-color presses were installed. Instead of highlighting lights and beacons by hand, color highlights could now be printed in yellow. Radio-navigation related features were to be highlighted by a purple ring. Sanding was to be supplanted by a blue tint (U.S. Department of Commerce et al. 1934, 10).

More changes were made in 1935, including the addition of "[t]rack lines for full-powered steamers, printed in red on general charts of the Pacific coast," and "[i]sogonic lines in purple, on certain sailing charts (U.S. Department of Commerce et al. 1936b, 141)."

A method for printing multiple tints of a color on a single pass through the press was developed in 1938, and it was thought likely applicable on the blue shoal water (U.S. Department of Commerce et al. 1939, 139). This process probably explains the two tints of cyan on MH400 1942.

Design and Organization

Numbering System

Layout 01—Upper Left Corner is the place to begin an examination of the chart numbering systems used by the Coast and Geodetic Survey. See Table 2 on page 13 and Table 6 for summaries of the chart numbers shown on the charts, and Appendix C: Chart Details for chart numbers in context with other identifying information.

Table 6. Chart Numbers

Time Period	NY40	SF40	MH400	GJF200	E1200	W1200
1	-					
	-					
2	-	621				603
	7 / 369		9	28	24	
3	369[(2)]	621[a]			A	602
4	369	5581		6300	1000	
5	369		1109			
	369					5052
6	369	5532	1109	6300	1000	
7	369		1109	6300	1000	5052
8	369	5532	1109	6300	1000	
		5532	1109		1000-L	5052
9	12327	18649	12200	18400	13003	18007

The first charts published by the U.S. Coast Survey were not numbered. The oldest chart editions used in this project are all of New York Bay and Harbor and the surrounding area, published in 1844, 1845, and 1853. These have no text outside the neatline framing the upper left corner.

It is not until well into the **second time period**, 18 years after the first charts were published, that numbers are first seen. The earliest charts that do have text in this spot are both from 1862, MH400 and GJF200. They are numbered ‘No. 9’ and ‘No. 28,’ respectively. The earliest three-digit number is found on W1200 1864, ‘No. 603.’ Two separate editions of NY40, both published in 1870, have different numbers, ‘No. 7’ and ‘ No. 369.’. The last edition in the second time period, SF40 1859/77, shows an addition to

the text in the corner, 'PRICE 75 CENTS'. This is the first instance seen where a price is printed outside the neatline on the charts being compared.

Moving forward to the **third time period**, all of the editions have chart numbers, but all of them are different from the numbers seen in the previous period. The differences are slight, however. Two have an addition of a superscript to the last number seen in time period two. NY40 1878 has become 'No. $369^{(2)}$' and SF40 is now 'No. 621^{a}'. The Sailing charts have also changed. E1200 1881 is 'SAILING CHART A (2 Sheets)', while W1200 1888 is now 'No. 602'. E1200 is the only chart identified by a text phrase rather than a number, and the letter identifier was first seen in the annual report of 1877 (U.S. Treasury Department et al. 1880).

The **fourth time period** continues to show substantial change. Of the three charts that have useful clips of the upper left corner, all three have chart identifications different from previous edition. The numbers are now all four digits long. SF40 1901 seems to be engraved in a thicker font, using block serifs, instead of the more delicate lettering done on other editions. It also appears to have a typo in the price, 'PPICE 50 C(ENTS)'. There is a slight possibility both artifacts are due to bad scans. GJF400 1895 has become 'No. 6300', while E1200 1900 is now "Sailing Chart No. 1000' with a change to lower case type for the identifying text phrase.

Time period five offers several changes from prior editions. MH400 1916 is only the second edition of this chart, and there is a minimum of 44 years between the editions, so signficant change should be expected. The chart is now 'No 1109' with no period after 'No'. Two editions of NY40 are included and there is a major change between 1914 and 1917. For at least 12 years the chart was printed on two sheets. In 1917 it is once again printed on a single sheet, with a drop in price from 75 cents for the two sheets in 1914 to just 50 cents for the one sheet in 1917. The chart number reverted to what it became with the second edition of 1870, 'No. 369'—the superscript numeral two has been removed. There is also a difference in the text's placement in relation to the corner of the neatline. Until the 1950s chart numbers are all left justified flush with the outermost edge of the

neatline. NY40 1917 is the only chart seen that violates this practice. It is indented past the second part of the neatline.

Chart W1200 1917/26 also has changes to the chart number during the fifth time period. It most likely changed during the fourth time period along with so many other charts, but no proof is available to confirm it. The version shown here is from the UO MAP Library and the number has also been manually updated to the post-1974 number scheme.

Time period six has very few changes between its five charts. SF40 1926 has a new chart number, and four of the five charts have a price increase to 75 cents. The typography of NY40 1926 and E1200 1927 is a little different than the type of SF40 1926, MH400 1922, and GJF200 1922. The characters used in the former are drawn with much less difference in thickness between the main stroke and the hairline strokes. They also use a version of slab serifs, while the other three use a form of bracketed serif. The letters to appear bolder, possibly more modern, than the thin, delicate and classic look of the other three. Scan resolution might again contribute to these apparent differences.

Time period seven only has one change from period six. The price of GJF200 has finally caught up to the others, increasing to 75 cents.

Time period eight begins to hint at some major changes taking place. The earliest change is between E1200 1943 and E1200 1948. The title changes from “Sailing Chart No. 1000” to “Loran Chart No. 1000-L,” and the price has been removed. The price is also absent on W1200 1945/54 and SF40 1947b/57 but still seen on MH400 1951. The final change is to both the placement of the text and what is placed. On SF40 1947b/57 the chart ID has moved from above the top neatline reading left-to-right to now residing at the left side of the neatline, left-justified with the top of the line, reading top to bottom. The wording has changed from “No. 5532” to simply “5532” and the price is absent, as mentioned above. One last typographic change seems to be a change to a zero that is more oval than in previous time periods. In all cases the zero takes up less horizontal space while maintaining its height, relative to the other characters.

Context

The C&GS has used several different numbering schemes for its published charts during its history. In the first decade of publishing there was no system, and charts were primarily identified by title. Where the survey was publishing several charts of a particular region at a single scale, the titles of the charts would include numbers ("New York Bay and Harbor, Sheet 1"; "Chesapeake Bay No. 2, Magothy R. to Hudson R."). Any other identification numbers seen on charts of this time period are likely on charts printed in reports such as the annual report to Congress. Charts lithographed for inclusion in the annual report to Congress of the superintendent of the C&GS were numbered by their order in the Appendix.

Even reference to the charts in the annual report to Congress was ad hoc for many years. The first year in which finished charts were listed in geographic order was 1855 (U.S. Treasury Department et al. 1856a). The numbered list, from north to south along the east coast, did not correspond to any numbers on the charts, however.

In the 1856 report, the progress sketches (maps created to demonstrate to Congress the work of the Survey) were placed on a single scale for the first time (U.S. Treasury Department et al. 1858). The office had also finished laying out the extents of a series of 32 charts covering the east & gulf coasts at a scale of 1:200,000, 18 charts covering the same area at 1:400,000, and was working on laying out a series of 1:80,000 charts. This was completed in 1858 with a plan for 113 charts at this scale (U.S. Treasury Department et al. 1859). Numbers were assigned to the charts, but only in relation to the series they were in—for example, "Seacoast of the United States, No. 3, Maine, New Hampshire, and part of Massachusetts," at 1:200,000 published in 1858.

In 1870 the plan for the 1:80,000 series was changed somewhat to reflect information gained in the course of surveys after the previous scheme was laid out (U.S. Treasury Department et al. 1873, 1). Some time later charts were renumbered for purposes of the catalogue of charts published by the agency. For the charts used here, SF40 1859/77 and MH400 1862/72 carry numbers dating from after the reorganization.

In the annual reports, charts continue to be referred to by the pre-1866 numbers until the 1880 report begins noting their catalogue numbers. It mentions that, during the past fiscal year (July 1879 through June 1880), "Special attention was given … to the publication of an edition of the catalogue of the charts embodying a number of improvements, and to a study of the forms best adopted to secure clear and concise expression in the titles of publications (U.S. Treasury Department et al. 1882, 51)." The 1867 scheme was as follows:

- *Atlantic & Gulf Coasts*
  - Sailing Charts (1:1,200,000): 1-5
  - General Coast Charts and Preliminary Coast Charts (1:400,000 & 1:200,000): 6-31
  - Coast Charts (1:80,000): 101-213 (100 was added to the chart series number)
  - Harbor Charts: 300-528
- *West Coast, CA–WA*
  - All classes of chart: 601-657
- *West Coast, north of WA* (beginning 1868)
  - All classes of chart: 700-

A change was made to this scheme in 1892. Four-digit numbers were assigned to west coast charts, leaving enough room in the numbering scheme for all coasts so that a unique identifier could be assigned to each chart, and never be reused if the chart was retired (U.S. Treasury Department et al. 1893, 138-39). This included changing the projection of a chart. For example, Chart A became Chart 1000 when it was converted from polyconic projection to Mercator projection in 1900 (U.S. Treasury Department et al. 1901, 93).

A plan for modernizing charts was approved in 1909. It included retiring out-dated charts with new editions featuring a single unit for soundings, placing charts on the Mercator projection, making all charts have a north/south orientation, and including less detail, particularly topographic detail (U.S. Department of Commerce and Labor et al. 1911, 11-12).

During the years when charts were engraved the most likely place for a typographical to survive to be printed was the upper left. The number was often the last thing engraved because it changed based on the destination of the print, and in some cases were stamped onto the charts by hand (U.S. Treasury Department et al. 1889b, 129; Shalowitz 1964, 90).

Neatline

Coast and Geodetic Survey charts have been created with a wide variety of formats for their neatline. There have always been two main parts of their neatline—an outer section consisting of at least one thick and one thin black line, and an inner section of one or more thin lines. The two sections are separated by a broad white space containing, among other things, latitude and longitude number labels. The design of the inner section has varied more than the outer.

Four of the layouts consistently show portions of the neatline: 01–Upper Left Corner, 12–Bottom Center, 13–Lower Left Corner, and 14–Lower Right Corner. In this section these layouts will be referred to as UL, BC, LL, and LR. See also Table 7 and Table 8 for summaries of neatline formatting.

Table 7. Neatline format: number of outer and inner lines

Time Period	NY40	SF40	MH400	GJF200	E1200	W1200
1	4, 2					
	2, 3					
2	3, 1	3, 2				3, 3
	3, 1		2, 3	3, 2	3, 3	
3	3, 1	3, 1			3, 3	2, 3
4	3, 1	3, 1		2, 2	2, 3	
5	3, 1		2, 3			
	2, 1					2, 3
6	2, 1	2, 1	2, 3	2, 2	2, 3	
7	2, 1		2, 3	2, 3	2, 3	2, 3
8	2, 1	2, 1	2, 3	2, 3	2, 3	
		2, 1	2, 3		2, 3	2, 3
9		2, 1				

The two charts in **time period one** have subtle differences in the design of their neatlines. The outer section of six-sheet NY40 1844/45 consists of (from the outside to the inside) four lines and three white spaces:

1. a black hairline
2. a medium-width white space
3. a black line two to three times thicker than the white space
4. another medium-width white space
5. a second black hairline
6. a double-width white space
7. a third hairline

Inside this is a white space slightly wider than the entirety of the outside section. It is populated by latitude and longitude numbers. Just below or to the left of each of these numbers are lines of latitude or longitude extending to the outer edge of this white space. Bounding it to the inside is the inner section of the neatline. It has two hairlines a medium width apart, and the interior space is divided into sections measuring 1/6 of a minute (10 seconds) of longitude (on the top and bottom) or 1/6 of a minute of latitude (on the left and right sides). These divisions are created by ruling every other 10-seconds of width with a large number of fine lines connecting the inner and outer bounding line. On some scans this shows as a patch of grey, but on higher resolution scans individual lines are discernable. It appears the rules are spaced so as to divide the 10 seconds into 60 sections of equal width, alternating black and white, each thereby covering 1/6 seconds of latitude or longitude.

Table 8. Neatline format: from the left edge in

Time Period	NY40	SF40	MH400	GJF200	E1200	W1200
1	HvTvHwH W Hw(f)H					
	TvH W Hw(f)HwH					
2	HvTvH W H	HvTvH W HwH				HwTwH W Hw(B)HwH
	HvTvH W H		TvH W Hw(f)HwH	HvTwH W HwH	HvTvH W Hw(B)HwH	
3	HvTvH W H	HvTvH W H			HwTvH W HwHwH	TwH W Hw(B)HwH
4	HvTvH W H	HvTvH W H		TvH W Hw(f)H	TvH W Hw(B)HwH	
5	HvTvH W H		TwH W Hw(B)Hw(b)H			
	TwH W H					TwH W Hw(B)HwH
6	TwH W H	TwH W H	TwH W Hw(B)HwH	TwH W Hw(f)H	TvH W Hw(B)HwH	
7	TwH W H		TwH W Hw(B)Hw(b)H	TwH W Hw(B)HwH	TvH W Hw(B)HwH	TwH W Hw(B)HwH
8	TwH W H	TwH W H	TwH W Hw(B)Hw(b)H	TwH W Hw(B)HwH	TwH W Hw(B)HwH	
		TwH W H	TwH W Hw(B)Hw(b)H		TwH W Hw(B)HwH	TwH W Hw(B)HwH
9		TwH W H				

T = Thick line
H = Hairline
W = Wide white space
w = Medium white space
v = Thin white space
(f) = Fine-line shading for dividers
(B) = Medium-weight cross-bar for dividers
(b) = Light-weight cross-bar for dividers

NY40 1845 was drawn and engraved at the same time as the larger-scale version of the same location but has small differences from its sibling chart, the format of the neatline being no exception. Its outer section has only two black lines, a thick one on the outside and a hairline just inside. The white space separating the outer from the inner section contains latitude and longitude numbers and lines the same as the other chart, but it also has another series of lines extending perpendicular from the outside hairline halfway across the white space. These are only on the top and bottom of the chart, not the two sides. The inner section of the neatline has three equidistant hairlines, and the white space created by the outer two is apportioned by areas of tightly ruled lines. These alternating areas of white and shading are each one minute wide, and every fifth minute is labeled.

A statement at the top center of the chart, just inside the neatline, identifies the second set of lines as representing “Longitude West of Greenwich.” The Greenwich Meridian had not yet been officially established as the standard zero meridian. That did not take place until 1871 (Monmonier 1985, 31). The primary grid on this chart uses

"Longitude from the Meridian of New York City Hall" to measure distance east/west, as identified at the bottom of the chart to the left of center, inside the neatline. The larger scale map of New York also sets its prime meridian at City Hall, and states that it is 74°.00'.41" West of Greenwich observatory, or "in time $4^{H}.56^{m}.02^{s}.7$." The addition of this second set of longitude indicators probably stems from comments made by mariners who used British Admiralty charts, which at that time were the most accurate charts for most of the world. These charts used Greenwich as the prime meridian and navigators were familiar with it.

Moving into the **second time period**, the eight chart editions shown on the UL layout can be grouped into four neatline formats. The three editions of NY40 share one; SF40 1859/77 and GJF200 1862 share one; the two sailing charts share one; and MH400 1862/72 has its own format.

NY40 1853 is an anomaly to this project. It is a chart showing only a small portion of New York Harbor: Romer Shoal and Flynn's Shoal. The 1853 edition is preliminary, meaning it was not engraved to the same high standard as the other charts of New York Harbor. The neatline is much less elaborate than the first two New York Harbor charts, but this plainer style is more like later charts. Also there is no indication of latitude or longitude; the chart seems to have no geodetic control apart from a statement on the location of the Sandy Hook Lighthouse in the Notes area.

The NY40 editions now have an outer section made up of three lines: a thick central line flanked by equidistant hairlines enclosing a medium-width white area. Compared to NY40 1844 it is missing the innermost of that chart's three hairlines, and the two remaining are the same distance from the central line rather than having a slight difference. The inner section has been simplified down to a single hairline. The broad expanse of white between the two section still houses latitude and longitude numbers and lines for the 1870 editions, but the 1853 preliminary edition has no grid or identifying numbers. The 1870 editions (and all subsequent editions of all the charts examined here) use Greenwich for their prime meridian, and there is a line and label for every two minutes of both latitude and longitude. The lines again start at the inner hairline of the

outer section, but only extend past the inner section's hairline for a length approximately half the width of the space between the inner and outer neatline parts. Instead of having a grid run over the entire chart, the intersection of every other minute of distance is marked with a small '+'.

SF40 1859/77 and GJF200 1862 share with the NY40 editions the three-line outer section of neatline. They differ in that the inner section uses two hairlines set apart by a white space approximately the same width as the thick black line in the outer section. Latitude and longitude are labeled in the space between the two parts of the neatline but their lines do not extend past the innermost hairline. These charts have a full grid of lines across the face of the chart, interrupted only by notes and views. Also unlike the NY40 charts, longitude is only labeled on the bottom of the chart, not the top. Latitude is labeled on both sides.

E1200 1863 and W1200 1855/64 also share the triple-line design for the outer portion, but their inner portion is a design not seen before. It is made from three equidistant hairlines, as with the inner section of the first two New York charts, and are also divided, but using a different method. The two white spaces created by the three lines are divided into twelve parts (five minutes) per degree of latitude or longitude, by a thin line connecting the inner and outer of the three hairlines. Every sixth such line, marking 30 minutes, extends into the chart by a length equal to the width of the inner portion of the neatline. Each degree line extends from the inner line of the outer portion of the neatline all the way across the chart. The numbers labeling the longitude lines are centered on the line, subdivided by it. Latitude line labels sit just above their respective lines. The outer half of the inner section of the neatline emphasizes the five-minute divisions by extending a medium-width line from divider to divider in every other section. The inner portion is subdivided by lines marking every minute of distance. It is worth noting that the projection of the chart is polyconic[18], which creates a grid where

[18] For polyconic projections, each map has its own unique projection. The central meridian is straight and true to scale; all other meridians are curved. Each parallel of latitude is a curved line (actually a non-concentric circular arc) with true scale that emanates from the map's central meridian.

every line of longitude, except the central meridian, is curved. The lines marking off minutes of longitude are each angled to match the curve of the arc.

The fourth design seen among the chart editions in the second time period is used only on MH400 1862/72. It appears to use the same design as NY40 1845 except that the shaded divisions in the outer half of the inner section of the neatline are each five minutes wide. Scan resolution does not allow counting the number of lines per shaded area.

Time period three shows the beginnings of some design stability. NY40 1878 has no changes from 1870. SF40 1883 changes only to conform to the same design as NY40. W1200 1888 has three small changes: the outer section has lost its outermost hairline; the projection grid lines extend through to the inner hairline of the outer portion; and the longer divider line marking 30 minutes now out of instead of into the chart, into the middle white space. E1200 1881 has its outside hairline still, but is missing the one- and five-minute- divisions of the inner section. This absence makes it look almost unfinished.

It regains its finished look by 1900, however. It uses nearly the same format as W1200 1888, which returns the minute divisions first seen in E1200 1863. The main difference is that the grid lines for the projection no longer extend through the neatline's center expanse. These lines now stop with the inner portion of the neatline. The only lines in the inner white space are the 30-minute lines, which are now a little shorter. One other change is seen on the right third of the bottom. A 'border break' is included where the chart content has been drawn to extend into the neatline (U.S. Department of Commerce et al. 1997, 2-19, 2-21). It can be seen on layout 00–Full Sheets. This is the earliest chart used in this thesis that features this design decision.

Other chart editions from the **fourth time period** include NY40 1902 and SF40 1901, neither showing any change from the third period. GJF400 1895 has lost the outside hairline from the outer portion of the neatline, but has added internal divisions to the two hairlines of its inner portion. The divisions are one minute wide, and while they look solid black in reproduction, a close look at the scan shows they are once again an indeterminable number of finely ruled lines. Every 10 minutes of distance there is a

numeric label and a line spanning the white space between the two portions of the neatline. Halfway between each of these is a line extending out from the inner portion, half the width of the white space. While the 1862 edition of GJF200 had a full grid over the chart, this 1895 edition has only the lines and labels in the neatline area. It has adopted the '+' convention of the harbor charts. One final change is that, like GJF200 1895, E1200 1900 has a border break near the lower left corner where the chart content has been extended into the neatline area.

During the **fifth time period** NY40 loses the outside hairline from the outer portion of the frame. NY40 1914 still has the three outer lines inaugurated with NY40 1844/45, but with the 1917 edition there remain only two. Projection lines change from existing primarily between the two sections of neatline to being a full grid over the chart that does not project into the neatline area at all. Latitude/longitude labels did not change, nor did the single hairline making up the inner portion of the neatline.

There is an addition to the lower left of NY40 1914 that does not seem to reappear on any other NY40 editions, but does appear on other charts. A set of numbers reading `972.$_6$-1212.$_6$' is just below the horizontal and left justified with the vertical lines of the inner portion of the neatline. Their meaning is not immediately obvious, but present-day charts list the inner dimensions of the neatline in metric units. SF40 1989 includes the statement '(inner neatline 108.22cm. N.S. x 82.93cm. E.W.)'. If represented in millimeters they would be fairly close to the numbers on NY40 1914.

MH400 1916 adds the same type of numbers to the lower left, `768.$_6$-1093.$_6$', but places them in a slightly different location, probably due to interference from a longitude label. This edition also introduces a new format for its inner neatline. The outer portion only changes to add a bit of space between the heavy and hairline rules so as to be consistent with NY40, GJF200, E1200 and W1200. The inner portion, however, is completely new. As with the Sailing Charts there are three equidistant hairlines. Of the two white spaces thus formed, the outer one is divided into sections five minutes wide using the same strategy as the Sailing Charts: a medium-width line joins divider to

divider in every other section. Due to the scale difference the sections are significantly longer on the smaller-scale General Chart. The extra width allows a different design for the division of the inner white space. The hairlines defining this space are connected every half-minute (30 seconds) by a thin line, rather than one every minute. Minutes are indicated by a bar spanning every other minute, joining three half-minute lines and then skipping one before reappearing. This edition also begins the use of a larger font for numerals representing degrees than for numerals representing minutes. The other Harbor and General charts pick up this change sooner or later, but MH400 appears to have a larger difference between the two fonts than the other charts.

W1200 1917/26 is the representative of Sailing Charts for the fifth period. There are very few differences between it and both W1200 1888 from the third and E1200 1900 from the fourth time periods. The main difference from the east coast Sailing Chart is a smaller width for the space between the inner and outer portions of the neatline. The main difference from the 1888 version of the west coast Sailing Chart is having the grid lines stop at the inner section instead of continuing through the interior space. One small change is the absence of a decorative line in each corner that connected the three hairlines of the inner portion at a 45-degree angle.

The **sixth time period** offers evidence that standards were phased in rather than being applied to all charts at once. NY40 1926 has no differences from 1917, but SF40 1926 only shows about half of the changes implemented to NY40 by 1917. SF40 is significantly changed from its last example in 1901, but is still not fully coordinated with the Harbor Chart from other coast. The changes it did make toward standardization include dropping the outermost hairline, removing grid lines from the neatline interior white space, and adding grid tics that extend into the chart area marking every other minute. A feature that did not change to coordinate with NY40 is continuing to show only the intersections of grid lines instead of the full lines. It also has one example of formatting that appears only on this chart—the numerals used for the latitude/longitude labels are sans serif and have equal thickness throughout the glyphs. Other sans-serif fonts are used for these numbers on other charts and editions, but all use glyphs with

unequal thickness. An italic sans-serif equal-weight font is used on SF40 1859/77 (and all but one subsequent occurrence on all charts) for the phrase '*U.S.C.& G.S.*' at the lower right corner, and beginning with MH400 1916 such a font is used for soundings on most editions of the charts, but nowhere else is it used for the latitude/longitude labels. It is possible this was an experiment in using the same engraving machine used to engrave soundings.

MH400 1922 dropped a feature that had been added to its neatline for the 1916 edition. The lines that set off one-minute increments among the half-minute dividers in the innermost section of neatline are missing. In a major contrast to the east coast General Chart, GJF200 1922 had not yet been modernized—the same base plate was used as that of the 1895 edition, complete with the many fine lines creating shaded areas to divide the inner portion of the neatline into minutes. Added to it are the cryptic numbers shared by NY40 and MH400 (`968.7-687.5´), and the body of the chart has other additions, but it is still the same base chart. The final chart edition of time period six is E1200 1927. There appear to have been no design changes to the neatline from the 1900 editions. The only visible change is an increase in the amount of detail in the border break in the lower left corner. Additional chart details are present, and the innermost neatline looks to have been extended partially across the break instead of being fully blocked as it was in 1900.

Moving on to the **seventh time period**, NY40 1936 shows a single change from 1926. The grid tics marking minutes that had extended into the chart from the innermost neatline since the 1844 edition have been reflected over the innermost hairline for the 1936 edition. Starting with this edition they extend into the center of the neatline area from the innermost hairline. Tics formatted this way were first seen on W1200 1888, GJF200 1895, and E1200 1900, and they became standard for all charts in the eighth time period.

MH400 1938 similarly only shows a single change from the previous edition, 1922. The lines marking one-minute increments among the half-minute dividers in the innermost section of neatline are back, returning to the design of the 1916 edition. E1200 1938 shows two changes from its previous edition, 1927. First, grid tics extending out

from the chart area into the central portion of the neatline are added for each degree, joining tics for each half-degree that first appeared with the 1900 edition. W1200 1932 does not yet have the one-degree tics, but rather the half-degree tics. Its only change is the addition of the first instance seen here where the interior of the neatline contains a statement referring the user to another chart. The text appears near bottom center and reads, '*(JOINS CHART 5002)*'. E1200 1938 adds a similar statement.

GJF200 is the last chart of the six to migrate from the look of copperplate engraving to lithography. GJF200 1933 is the first edition with the new look, including the design of the neatline. It finally joins the other General and Sailing Charts in having an interior neatline made of three equidistant hairlines. The inner two are subdivided by half-degrees, as is MH400 1922. The outer pair are divided by single degrees, and every other degree is crossed by a medium-weight bar—unlike MH400, which divides its corresponding space in five-degree increments.

The **eighth time period** shows much consolidation toward standards. NY40 1944 has several changes from the 1936 edition, including: a new font style for latitude/longitude labels; a change to the relative size of the numerals used in those labels for degrees versus minutes; and the addition of a section near bottom center where a minute is subdivided into five-second sections by tics extending into the interior of the neatline. Every third tic is both labeled and slightly longer and heavier than the others. The font used for latitude/longitude labels on both of the SF40 editions, 1947a and 1947b/57, is the same used on NY40 1936. They also have the same style for grid tics that NY40 began to show with 1936, plus the additional five-second tics and labels seen with NY40 1944. Aside from SF40 editions using the older font, the SF40 neatline is formatted the same as NY40. The former has also regained a full grid on the chart face, replacing the grid intersection marks ('+') that NY40 moved away from by 1917.

MH400 also becomes more standard during the eighth period. The 1942 edition neatline has one discernable difference from 1938—the loss of the cryptic numbers at lower left. The 1951 edition appears to use a subtly different font within its neatline, one a bit taller, with less weight contrast within each glyph, but this could also be an artifact

of the scan. There is no doubt about it implementing grid tics pointing into the neatline interior, however. GJF200 1941/48 includes the same change to its grid tics, but continues to differ from MH400 by not marking five-minute sections. This should be due to the scale difference and not seen as a lack of standardization. GHF200 1941/48 also adds at least two statements inside the neatline referring the user to other charts. They read '*(CONTINUED ON CHART 6401)*' at lower right and '*(CONTINUED ON CHART 6102)*'at lower left, which is the first instance seen where such a reference says 'Continued'.

Despite the enormous change involved with adding LORAN lines to E1200, the neatline of the chart has almost no change during this period. Between 1938 and 1943 the chart face drops every other grid line, and increases both the size of the numbers used to label the lines and the length of the grid tics inside the neatline. Only with the change in the size of the numbers is a change in the font style. The new font is swoopier, with bracketed serifs instead of thin slabs, and many more curves. E1200 1943 and 1948 are the only charts seen to use this font. The only difference noted between 1943 and 1948 is a slight reduction in the length of the grid tics, which returns some white space between the tics and labels. The format must have been considered quite robust at this point to require no other changes when the LORAN lines were added to the chart.

W1200 1945/54 has switched from having tics into the neatline interior only at half degrees to having them only at degrees. E1200 has interior tics at each degree and half-degree. W1200's font for grid labels is larger on 1945/54 than 1932, but does not change faces.

Context

Early in the history of the survey neatlines were engraved by hand. Very soon, however, machines were developed to partially automate the engraving of this chart feature. See the discussion of chart production methods earlier in this chapter for a history of the adoption of mechanical engraving tools.

Dropping the decorative line from the corners of W1200 1917/26 is evidence of the survey's move from emphasizing the rightness of a traditional design for its aesthetics to emphasizing utility and ease-of-use. Removing superfluous decorative touches was also part of the move toward standardized designs, under the belief that it made charts easier to use.

Removing the grid lines from the interior white space of the neatline accomplished two things. First, it removed a possible obscurant to the latitude/longitude labels. Second, it allowed the latitude labels to be centered with the grid line instead of offset slightly above. Placing the identifier directly in line with the item it labels should improve the accuracy of plotting courses when eyeballing the chart. Both changes should make the chart easier to read at a glance, for example at the helm of a pitching ship.

Title, Short Title, and Statement of Responsibility

As with most other aspects of the C&GS charts, names used to identify the charts changed substantially during the early years, then later become stable, formalized, and consistent. See Table 9 (and Appendix C: Chart Details) for a truncated version of the title of each edition as it appears on the chart in the title area. See Table 11 for the short title, found outside the neatline on the lower right.

Title

Early charts had long, descriptive titles that included the statement of responsibility for their creation, including the two charts in the **first time period** (refer to Layout 02—Title Area). The full title on the map/chart of the New York area published in six sheets in 1844 and 1845 is:

> MAP of NEW-YORK BAY AND HARBOR AND THE ENVIRONS. Founded upon a Trigonometrical Survey under the direction of F.R. HASSLER Superintendent of the SURVEY OF THE COAST OF THE UNITED STATES Triangulation by JAMES FERGUSON and EDMUND BLUNT Assistants, The Hydrography under the direction of THOMAS R. GEDNEY Lieutenant U.S.Navy The Topography by C. RENARD and T.A.JENKINS Assist^{s}. Published in 1844, *Verified by* [signature of ?.M. Eakin, assistant], *Variation of the* Magnetic Needle *at Sandy Hook in January 1844, 5°51' West.* [seal of U.S. Coast Survey Depot], *Longitude of* New York City Hall *West of Greenwich observatory, 74°00'41"; in time* $4^{H}56^{m}02^{s}7$.

The single-sheet version of the same area published the following year has a similar title:

> MAP of NEW-YORK BAY AND HARBOR AND THE ENVIRONS. Founded upon a Trigonometrical Survey under the direction of F.R. HASSLER Superintendent of the SURVEY OF THE COAST OF THE UNITED STATES Triangulation by JAMES FERGUSON and EDMUND BLUNT Assistants, The Hydrography under the direction of THOMAS R. GEDNEY Lieutenant U.S.Navy The Topography by C. RENARD, T.A.JENKINS & B.F.SANDS Assist[s]. Published in 1845. A.D.Bache Superintendent. Scale 1/80,000, Verified by Lieut. A.A.Humphries, Assistant U.S.Coast Survey, [seal of U.S. Coast Survey Depot], Price 75 cents.

The titles were typographically complex. The statement on the six-sheet map is broken into 13 lines, and the single-sheet is arranged in 15 lines. The former uses nine font and style combinations, and the latter uses 10. It should be noted that both of these first works published were titled Maps, not charts. They have more information about the topography and cultural features of the land than the topography of the waters, which may have led the survey to name them as they did.

Table 9. Titles

Time Period	NY40	SF40	MH400	GJF200	E1200	W1200
1	Map of New-York Bay and Harbor and the Environs.					
	Map of New-York Bay and Harbor and the Environs.					
2	Romer's and Flynn's Shoals: New York Bay	Entrance to San Francisco Bay, California				Reconnaissance of the Western Coast of the United States (Northern Sheet) from Umpquah River to the Boundary
	New York Entrance		General Chart of the Coast No. IV, From Cape May to Cape Henry	Reconnaissance of Washington Sound and Approaches, Washington Territory [Preliminary]	Atlantic Coast of the United States (in four sheets) Sheet No. II, Nantucket to Cape Hatteras	
3	New York Entrance	San Francisco Entrance, California			Atlantic Coast: Cape Sable to Cape Hatteras (Northern Sheet)	Pacific Coast from San Francisco Bay to the Strait of Juan de Fuca
4	*Missing from scan*	San Francisco Entrance, California		Gulf of Georgia and Strait of Juan de Fuca, Washington	Atlantic Coast: Cape Sable to Cape Hatteras	
5	New York Bay and Harbor		United States - East Coast: Cape May to Cape Hatteras			
	United States - East Coast: New York Harbor					Pacific Coast: San Francisco to Cape Flattery
6	United States - East Coast: New York Harbor	United States - West Coast: San Francisco Entrance, California	United States - East Coast: Cape May to Cape Hatteras	United States - West Coast: Georgia Strait and Strait of Juan de Fuca, Washington	Atlantic Coast: Cape Sable to Cape Hatteras	
7	United States - East Coast: New York Harbor		United States - East Coast: Cape May to Cape Hatteras	United States - West Coast, Washington: Georgia Strait and Strait of Juan de Fuca	Atlantic Coast: Cape Sable to Cape Hatteras	Pacific Coast: San Francisco to Cape Flattery
8	United States - East Coast: New York Harbor	United States - West Coast, California: San Francisco Entrance	United States - East Coast: Cape May to Cape Hatteras	United States - West Coast, Washington: Georgia Strait and Strait of Juan de Fuca	Atlantic Coast: Cape Sable to Cape Hatteras	
		United States - West Coast, California: San Francisco Entrance	United States - East Coast: Cape May to Cape Hatteras		Loran Chart - Atlantic Coast: Cape Sable to Cape Hatteras	United States - West Coast: San Francisco to Cape Flattery
9	United States - East Coast, New York - New Jersey: New York Harbor	United States - West Coast, California: San Francisco Entrance	United States - East Coast: Cape May to Cape Hatteras (Loran -C Overprinted)	United States - West Coast, Washington: Strait of Georgia and Strait of Juan de Fuca	Atlantic Coast: Cape Sable to Cape Hatteras	United States - West Coast: San Francisco to Cape Flattery

The **second time period** sees similar title and statement of responsibility wording and formatting. The small 1853 chart of a critical entrance to New York Bay was named:

> U. S. COAST SURVEY, A.D.BACHE Superintendt., ROMER AND FLYNN'S SHOALS, NEW YORK BAY, By the Hydrographic Party under the command of Lieut. M.WOODHULL, H.R.N. Asst., Scale 1/40,000, 1853.

This chart had the publisher and author above the geographic area covered by the chart, although typography again leads the reader quickly to the name of the area of interest.

The second edition of NY40 in this time period is also the latest published, in 1870. It shows evidence of a deliberate shortening of the content in the title area:

> U.S.COAST SURVEY, BENJAMIN PIERCE SUPERINTENDENT, NEW YORK ENTRANCE, Scale 1/40.000, 1870, [seal of U.S. Coast Survey Office],

The first edition of SF40, from 1859/77, follows a similar format as the first New York area maps and charts. All of the chart responsibility information is in the title area along with the geographic area of interest:

> ENTRANCE TO SAN FRANCISCO BAY CALIFORNIA, From a Trigonometrical Survey under the direction of A.D.BACHE Superintendent of the SURVEY OF THE COAST OF THE UNITED STATES. Triangulation by R.D.CUTTS Asst. & A.F.RODGERS Sub-Asst. Topography by R.D.CUTTS Asst. A.M.HARRISON & A.F.RODGERS Sub-Assts. Hydrography by the Party under the command of Lieut.Comdg. JAMES ALDEN U.S.N.Assist. Scale 1/50,000, 1859, Aids to Navigation corrected to 1867, [seal of United States Coast Survey], *Issued October 1877 C.P.PATTERSON Superintendent, Verified, J.E.Hilgard Assistant in charge of Office*, PRICE 75 CENTS

The earliest MH400:

> GENERAL CHART OF THE COAST No. IV, FRM CAPE MAY TO CAPE HENRY, From a Trigonometrical Survey under the direction of F.R.HASSLER and A.D.BACHE Superintendents of the SURVEY OF THE COAST OF THE UNITED STATES, Published 1862, A.D.BACHE Superintendent, Scale 1/400.000, [seal of U.S. Coast Survey Office], *Verified, J.E.Hilgard, Assist. Coast Survey, In charge of Office.*

The earliest GJF200:

> U.S.COAST SURVEY, A.D.BACHE Supdt., RECONNAISSANCE OF WASHINGTON SOUND AND APPROACHES, WASHINGTON TERRITORY, Triangulation and Topographry by G.DAVIDSON Asst. and J.S.LAWSON Sub-Assistant, Hydrography by the Parties under the command of Comdr. J.ALDEN and Lieut.R.M.CUYLER U.S.N.Assists., Scale 1/200,000, 1862, [seal of U.S. Coast Survey Office], *Verified,* [signature of J.E.Hilgard]*, Assist. Coast Survey, In charge of Office.*

The earliest E1200:

> [seal of U.S. Coast Survey Office], U.S.COAST SURVEY, A.D.BACHE Supt., ATLANTIC COAST OF THE UNITED STATES (in four sheets) Sheet No.II, NANTUCKET TO CAPE HATTERAS, Scale 1/1200 000, 1863

The earliest W1200:

> [seal of U.S. Coast Survey Office], PRICE $1.30, *Verified, H.W.Benham, Dept. of Eng^{ng}, Asst. C.S. In Charge of Office,* U.S.COAST SURVEY, A.D.BACHE Superintendent, RECONNAISSANCE OF THE WESTERN COAST

OF THE UNITED STATE (NORTHERN SHEET) FROM UMPQUAH RIVER TO THE BOUNDARY, By the Hydrographic Party under the command of Lieut. JAMES ALDEN U.S.N. Assistant, Geographical Positions by G.DAVIDSON, Scale 1/1,200,000, 1855, Corrected to 1864

One can see evidence of lack of standardization between titles at this time. Even where certain features were attempted to be made standard, details were still implemented differently between charts. One standard that appears as early as 1853 is to lead the responsibility statement with the name of the agency, and the name of the Superintendent. This format was not followed for MH400 1862, however, and the title associated with the superintendent is presented in four different forms on six charts:

- Superintendt. (NY40 1853)
- Superintendent (W1200 1855/64, MH400 1862, NY40 1870)
- Supdt. (GJF200 1862)
- Supt. (E1200 1863)

Other inconsistencies include: abbreviating/not abbreviating first names; order of elements (topography before hydrography and vice-versa); commas/no commas in the scale representative fraction; font size for words such as “of the”; phrasing (“Hydrography by…” versus “By the Hydrographic Party…”); including the signature of the Assistant in Charge of Office or just the name; and placement of the seal (see Table 10).

The **third time period** has further movement toward standardization. NY40 1878 is the last example with extensive responsibility information in the title area. This information had been made visually distinct by aligning it to the left instead of center, and putting it in italics. As can be seen, it was becoming too detailed to remain in the title area:

[seal of United States Coast and Geodetic Survey], NEW YORK ENTRANCE, Scale 1/40.000, 1875, Aids to Navigation corrected to 1883, *Triangulation by Edmund Blunt Assistant in 1855. Topography by H.L.Whiting S.A.Gilbert A.M.Harrison C.M.Bache Assistants and F.W.Dorr Sub-Assist. Between 1855 and 1864. Hydrography by Lieuts.Comdg.T.A.Craven R.Wainwright and T.R.Gedney U.S.N.Assists. in 1842,1855 and 1856. The Main and Swash Channels from re-surveys by H.Mitchell and F.F.Nes Assists.in 1863 and 1874. Issued February 1878. C.P.Patterson Superintendent. Verification by J.S.Hilgard Assistant in charge of Office.* PRICE 50 CENTS

Table 10. Location of seal relative to title

Time Period	NY40	SF40	MH400	GJF200	E1200	W1200
1	bottom center					
	bottom right					
2	no seal	bottom right				top left
	bottom right		bottom left	bottom right	top center	
3	top center	top center			top center	top center
4	*Missing from scan*	top center		top center	top center	
5	top center		top center			
	top center					top center
6	top center	top center	top center	top center	top center	
7	top center		top center	top center	top center	top center
8	top center	top center	top center	top center	top center	
		top center	top center		top center	top center
9	top center	top center	top center	top center	top center	top center

SF40 1883 moves most of the responsibility information out of the title area into a new section called "Authorities." This section details the persons who performed the Triangulation, Topography, Hydrography, Astronomical observations, Magnetic observations, and Verification of Hydrography, and their related dates. The only responsibility remaining in the title area are the seal of the United State Coast and Geodetic Survey; the name and title of the Superintendent; date of issue; and "Verified: R.D.Cutts, Assistant in charge of Office". This leaves the title more distinct and easier to identify completely—less confusion is possible about what to consider part of the chart's title.

The Sailing charts also slimmed down the title area during the third time period. E1200 1881 became:

> [seal of United States Coast and Geodetic Survey], ATLANTIC COAST, CAPE SABLE TO CAPE HATTERAS, Scale 1/1200 000*, Issued February 1881 C.P.PATTERSON Superintendent, Verification by J.E.Hilgard Assistant in charge of Office,* PRICE ONE DOLLAR, SOUNDINGS IN FATHOMS

while W1200 1888 became:

> [seal of United States Coast and Geodetic Survey], PACIFIC COAST FROM SAN FRANCISCO BAY TO THE STRAIT OF JUAN DE FUCA, Scale 1/1200000, *Issued December 1888 F.M.Thorn Superintendent. Verified: B.A.Colonna Assistant in charge of Office.* PRICE 50 CENTS, ALL SOUNDINGS IN FATHOMS

The primary difference between these two is the word "From" in the Pacific Coast title, which is missing from the Atlantic Coast title. Meanwhile the Scale statement for E1200 has a space in the denominator between the thousands digit and the hundreds digit, while W1200 does not.

Time period four offers several changes to note. GJF200 1895 has a new title that is not seen again:

> [seal of United States Coast and Geodetic Survey], GULF OF GEORGIA AND STRAIT OF JUAN DE FUCA, WASHINGTON, Scale 1/200000, *Published 189[?] W.W.DUFFIELD, Superintendent. Verified: O.H.Tittmann, Assistant in charge of the Office. J.F.Moser Lieut. Comdr. U.S.N.Hydrographic Inspector.*

E1200 1900 adds several clarifications regarding bureaucratic provenance:

> [seal of United States Coast and Geodetic Survey], TREASURY DEPARTMENT, ATLANTIC COAST, CAPE SABLE TO CAPE HATTERAS, (Mercator Projection), ALL SOUNDINGS IN FATHOMS, *Published at Washington, D.C., April, 1900, BY THE U.S. COAST AND GEODETIC SURVEY, O.H.Tittmann Superintendent.*

The bureaucratic identifier "Treasury Department" is placed just underneath the seal of the U.S. C.&G.S. at top center. The projection is named in the title area for the first time [(Mercator Projection)], and the word "ALL" is placed before "SOUNDINGS IN FATHOMS". Also new to the title area is "*Published at Washington, D.C.*"

SF40 1901 shares the new features, with "Treasury Department" at the top, "*Published at Washington, D.C.*" toward the bottom, and the projection named "(Polyconic Projection)". One additional new item is at the very bottom of the title area, "*(Date of first publication 1895)*".

The **fifth time period** sees further refinement of standards and consistency across charts. Two of the charts in the group, NY40 1914 and W1200 1916/26, are more like the charts in the fourth time period than the other two fifth period charts, NY40 1917 and MH400 1916. The latter two are more like charts of later periods.

NY40 1914:

> [seal of the Department of Commerce], NEW YORK, BAY AND HARBOR, Scale 1/40000, *Published at Washington, D.C., May 1914, BY THE COAST AND GEODETIC SURVEY, O. H. Tittmann, Superintendent*

MH400 1916:

> [seal of the Department of Commerce], UNITED STATES – EAST COAST, CAPE MAY TO CAPE HATTERAS, SOUNDINGS IN FATHOMS, AT MEAN LOW WATER, *(For offshore navigation only)*

The publication and responsibility information for MH400 1916 and all later charts is located at bottom center, outside the neatline. This edition is also the first among the examples used here to have the title formation that would become standard for Harbor and General charts for many decades: seal of the Commerce Department at top center, above a geographic identifier that narrows down from country (UNITED STATES) to coast (EAST, WEST, or GULF) before stating the proper title of the chart. For charts that covered only a single State, the State name was included after the proper title during time period six, but there are no examples of single-State charts in time period five. It is possible that this format was present during this time period, but it cannot be confirmed. Also included in the standard title area is identification of the unit of measurement for depths, and what tidal datum the soundings are measured against. Scale was included for Harbor charts and some General charts.

A standard for titles is appreciable during this time period. The title is now constructed according to this standard as one or more specific places, either connected by "AND" or "TO" depending on if the named places are area features (GEORGIA STRAIGHT AND STRAIGHT OF JUAN DE FUCA) or point features (CAPE SABLE TO CAPE HATTERAS).

One last novel feature of MH400 1916 is the addition of a disclaimer to the title area: "*(For offshore navigation only)*".

NY40 1917 follows the new formulation of the title area:

> [seal of the Department of Commerce], UNITED STATES – EAST COAST, NEW YORK HARBOR, Scale 1/40000, SOUNDINGS IN FEET, AT MEAN LOW WATER

However, it took many years to convert all charts to the new format, as evidenced by W1200 1917/26, which does not include the Country/Coast/State statement:

> [seal of the Department of Commerce], PACIFIC COAST, SAN FRANCISCO TO CAPE FLATTERY, SOUNDINGS IN FATHOMS, *(Not intended for inside navigation)*

In fact, the Sailing Chart examples used here did not see the Country/Coast/State statement until W1200 1945/54, instead simply using the Coast/place-to-place construction.

The **6th time period** saw continuing adoption of the standard introduced during the previous period. NY40 1926 was exactly the same as NY40 1917; it had already been converted. SF40 1926 had nearly the same format, the only difference being the addition of the State just after the main title:

> [seal of the Department of Commerce], UNITED STATES – WEST COAST, SAN FRANCISCO ENTRANCE, CALIFORNIA, Scale 1/40000, SOUNDINGS IN FEET, AT MEAN LOWER LOW WATER

MH400 1922 had not changed from 1916.

The main difference between GJF200 1895 and GJF200 1922 is the addition of the additional geographic identifiers "UNITED STATES – WEST COAST" between the seal and the main title, and "WASHINGTON" between the main title and the scale. The seal is updated, and the unit of measurement and sounding datum for depths were added. One unique aspect of the title is what looks like a typo, but which is actually a representation of Mt. Moriarty, in between "DE" and "FUCA":

> [seal of the Department of Commerce], UNITED STATES – WEST COAST, GEORGIA STRAIGHT AND STRAIGHT OF JUAN DE[Mt. Moriarty]FUCA, WASHINGTON, Scale 1/200000, SOUNDINGS IN FATHOMS, AT MEAN LOWER LOW WATER

This is the only edition of the chart to have the title placed around this mountain.

E1200 1927 lost the "TREASURY DEPARTMENT" note below the seal of the U.S. C&GS on the 1900 edition:

> [seal of the Commerce Department], ATLANTIC COAST, CAPE SABLE TO CAPE HATTERAS, *(For offshore navigation only),* SOUNDINGS IN FATHOMS

The note about projection had also been moved out of the title area. And the word "ALL" was removed from the statement about unit of depth measurements.

The **seventh time period** saw a change in the title format: the movement of the State from below the main title to above (see GJF200 1933). It also introduced an inconsistency in the font used for the phrase "FOR OFFSHORE NAVIGATION ONLY" on one chart. E1200 1938 is the only edition of any chart to have this phrase in all capital letters, Roman face. It also did not have parentheses around it on this edition. In nearly every other instance this statement was in sentence case, italic face, with parentheses.

In the **eighth time period**, NY40 had no format changes from the prior, showing how the format used had become standard. The only visible difference between NY40

1944 and NY40 1936 is a different dash in the phrase "UNITED STATES – EAST COAST". It is thicker and placed slightly lower in the later edition.

The two editions of SF40 have several differences.

SF40 1947a:

> [seal of the Commerce Department], UNITED STATES – WEST COAST, CALIFORNIA, SAN FRANCISCO ENTRANCE, Scale 1/40 000, (Polyconic Projection), SOUNDINGS IN FEET, AT MEAN LOWER LOW WATER

SF40 1947b/57:

> [seal of the Commerce Department], UNITED STATES – WEST COAST, CALIFORNIA, SAN FRANCISCO ENTRANCE, Polyconic Projection, Scale 1:40,000

The order of the notes about scale and projection are reversed, and in the latter edition, both are found to the right rather than centered with the rest of the title.

For MH400, the only difference between the two editions in this time period is a different dash, like SF40. MH400 1951 has a shorter and thicker dash than does MH400 1942.

GJF200 1941/48 had no differences from 1933.

E1200 1943's only difference from 1938 was the return of parentheses around the phrase "FOR OFFSHORE NAVIGATION ONLY". The 1948 edition saw three changes: a reversion to an italic face for the aforementioned phrase; a swap in font size among the geographic locator phrase "ATLANTIC COAST" and the title "CAPE SABLE TO CAPE HATTERAS"; and the addition of the clarifier "LORAN CHART" between the seal and the geographic locator.

W1200 1945/54 is the first Sailing Chart to include the geographic locator formation that the Harbor and General Charts had established late in the second decade of the twentieth century:

> [seal of the Commerce Department], UNITED STATES - WEST COAST, SAN FRANCISCO TO CAPE FLATTERY, SOUNDINGS IN FATHOMS, *(For offshore navigation only)*

The last phrase had also changed to conform with usage on other charts, away from *(Not intended for inside navigation).*

Short Title

Short Title is a reference to the version of the chart title that was printed outside the neatline at the lower right corner for many years. This convention helps locate charts

in piles or rolls—instead of having to lift up or roll back the majority of a stack of charts to find the title area on a given sheet, users could tab through just the one outside corner. In recent years titles have also been printed along other edges, but for the period of interest to this thesis, the lower right has primacy. Please refer to Layout 14—Lower Right Corner, and to Table 11.

Table 11. Short title

Time Period	NY40	SF40	MH400	GJF200	E1200	W1200
1	-					
	-					
2	-	*(San Francisco Bay, Middle)*				-
	-		-	-	-	
3	-	-			Missing from scan	*(San Francisco to Strait of Juan de Fuca)*
4	*(New York Bay and Harbor; 1-40000)*	*(San Francisco Harbor)*		*(Gulf of Georgia and Strait of Juan De Fuca)*	*(Cape Sable to Cape Hatteras)*	
5	*(New York Bay and Harbor, 1-40000)*		*(Cape May to Cape Hatteras)*			
	(New York Harbor)					*(San Francisco to Cape Flattery.)*
6	*(New York Harbor)*	*(Entrance to San Francisco Bay)*	*(Cape May to Cape Hatteras)*	*(Geogrgia Strait and Strait of Juan De Fuca)*	*(Cape Sable to Cape Hatteras)*	
7	*(New York Harbor)*		*(Cape May to Cape Hatteras)*	Missing from scan	*(Cape Sable to Cape Hatteras)*	*(San Francisco to Cape Flattery)*
8	*(New York Harbor)*	*(Entrance to San Francisco Bay)*	*(Cape May to Cape Hatteras)*	*(Georgia Strait and Strait of Juan de Fuca)*	*(Cape Sable to Cape Hatteras)*	
		(Entrance to San Francisco Bay)	*(Cape May to Cape Hatteras)*		*(Cape Sable to Cape Hatteras)*	*(San Francisco to Cape Flattery)*
9	New York Harbor	*(Entrance to San Francisco Bay)*	*(Cape May to Cape Hatteras)*	Strait of Georgia and Strait of Juan De Fuca	*(Cape Sable to Cape Hatteras)*	*(San Francisco to Cape Flattery)*

The first example of a short title seen here is on SF40 1859/77, in **time period two**. This is the Edition of 1877, and the short title likely dates from this edition rather

than from original edition in 1859. The text is in parentheses, in an italic face. This format has been maintained to the present day.

The next example is seen on W1200 1888 in **time period three**. No charts from the east coast have short titles in time periods two and three.

Finally, in **time period four** a short title is seen on east coast charts, starting with E1200 1900. NY40 1902 also has a short title, as does GJF 1895. It appears that placing a short title on the chart started with charts of the west coast and only later were included on east coast charts.

Following full implementation of short titles there were few changes or inconsistencies. The short title changed to match the main title as they evolved, but those were fixed by the end of time period five. The only inconsistency after that point was whether or not a space was placed between the title words and surrounding parentheses. Finally in time period nine there is a formatting change as some charts lost the parentheses and changed from italic to Roman font face, but this did not affect all charts, at least not immediately.

Navigation-Related

Compass Rose and Magnetic Variation

A compass rose has been a part of Coast Survey nautical charts since the very first chart was published. The purpose of including a directional marker on charts is two-fold. First, it provides information about magnetic variation that must be taken into account when navigating by compass. The Coast Survey was instrumental in scientific advances that lead to an understanding of the earth's shifting magnetic field, and those advances were seen in its published charts. Second, it orients the chart for the user, important for charts that are not oriented square with the cardinal directions.[19]

The discussion below is based on Layout 03—Compass Rose. A single compass rose was clipped from each chart, even though later charts include multiple compass

[19] Some Coast Survey nautical charts were published that were not oriented north-south. However, all of the editions of the charts used in this projects are oriented north-south.

roses. The intent was to have compasses from as near as possible to a single location on the chart.

The magnetic variation arrow and compass roses created in the **first time period** are quite crude compared to later version. NY40 1844 and NY40 1845 each include only a single visual indicator of magnetic variation. The 1844 version does not include what can be called a full compass rose. Instead it has single arrow and the phrase "Var. 5°51' West". The arrow is centered on the intersection of the graticule lines marking 40°24' North and 0°9' East (from the Meridian of New York City Hall) so the reader can see the variation of the arrow in relation to the graticule. The northern point of the arrow is barbed, and the southern end is a crescent. The shaft of the arrow varies in width, widest at the middle where a small hollow circle is slightly offset from the intersection of the graticule, tapering to the top and bottom. The right side of the shaft is wider than the left, and is printed darker. The two features combine to make the arrow appear offset from the intersection of the graticule. The overall result is that the arrow looks to be an afterthought that was applied with less-than perfect care and execution. The arrow and text are supplemented by a statement in the title area: "Variation of the Magnetic Needle at Sandy Hook in January 1844, 5°51' West ."

The 1845 version of NY40 supplements the graticule with a rudimentary compass rose centered at the same place as the magnetic variation arrow. Three line weights create a compass centered on true north divided in 32nds of a circle, with the lines for 8ths heavier than those for 16ths, and 16ths heavier than 32nds. The lines create a circle the same diameter as the magnetic variation arrow, with a small empty circle in the center. The arrow indicating magnetic variation is of the same design as that for NY40 1844.

The **second time period** begins with only small differences from the first charts, but major changes are made later. NY40 1853 has a design similar to NY40 1845 for its single compass rose. Centered at a juncture of the graticule, the compass is divided into 32nds using three line weights, with each line the same length as the variation arrow, and originating at the common center point. The arrow's top and bottom are a barbed point and a crescent as before, but the shaft is now a simple straight line with no interior

shading. A five-pointed star centered on the graticule, above the compass rose, reinforces the direction of true north.

GJF200 1862 introduces several changes to the compass rose. The biggest change is the doubling in the number compass divisions to 64. A second change is to make each division (1/4, 1/8, 1/16, 1/32, and 1/64) a different length. The lines continue to be different weights, and the additional 1/64ths lines are dashed to make them lighter than the 1/32nds . A third change is the absence of the 5-pointed star to indicate true north. A fourth change is to the top and bottom of the magnetic variation line. The top no longer has a barbed point, but instead has a stylized pike symbol on only the left side of the shaft. The bottom of the shaft now has feathers, on the right side only. A small change is made to the statement of variation: the name of the direction 'E.' is abbreviated rather than spelled out completely. One last difference is that the compass is not centered on the intersection of any of the graticule lines.

MH400 1862/77 marks a departure in the compass design. Instead of being designed as burst of lines radiating from the center, the new design is of a dial, aligned with local magnetic north instead of with the graticule, with shorter lines that are justified to the outside of the circle's circumference. The different divisions (1/4, 1/8, 1/16, 1/32, and 1/64) are each a different length, but there is less difference in line weight: 1/4 and 1/8 appear to be the same weight, and the three smaller divisions a lighter weight. This design communicates more clearly while applying less ink on the chart. The example shown on the layout is centered on a graticule line of longitude, as is one of the other two compasses on the chart. The third is centered on a graticule intersection. Apparently there were no hard and fast rules about the practice of placing the compass roses in relation to the graticule. Another change is that the magnetic variation line has no decoration at either top or bottom. One last small change is that the center of the compass rose is a dot. The other examples on the layout from time period two use this same design.

Time period three starts with no changes on NY40 1878 or E1200 1881, but sees a significant introduction on SF40 1883 with the first instance of Annual Increase shown on a compass rose. This additional information is shown parallel to the shaft of the

magnetic variation pointer: "Var'n. 1884 16° 34' E. Annual increase 0'3". This is also the first instance of the abbreviation "Var'n.", and the first time the date of the variation is seen on the compass rose. Also, the pike/feather decoration has returned to the magnetic variation pointer.

The compass rose on W1200 1888 is a complete redesign that provides four major innovations: the double compass rose, 180 divisions of the compass, numeric labels, and isogons.[20] This construction has an outer compass aligned with true north that is divided into 180 segments. The lines for every 2° are very short compared to the lines on earlier designs. The 10° lines are just little longer than the 2° lines, and every 30° away from north/south there is a label. The largest value labeled is 90°, marking east/west. The inner circle of the redesigned compass is for magnetic variation. It is an improvement on the previous design, marking out 128ths with varying line lengths justified to the outside of the circle instead of only 64ths.

In the **fourth time period**, GJF200 1895 has incorporated the double compass (180/128), but with some differences. The outer compass for true north does not have numeric labels, but the lines marking 30° are much thicker than other lines. True north and true south are marked with the five-pointed star has, and south is decorated with a crescent.

E1200 1900 has a compass that may have been an experiment—its design was not repeated in any of the other examples seen here. It has a quadruple compass. The center two rings mark the true directions, with the innermost ring divided into 128ths, and an outer ring divided into 360ths. The two outer rings mark magnetic variation direction, also the 128ths and 360ths. Each level of division is still a different length, including the newest (and shortest), those marking single degrees. True directions are still decorated with a star and crescent, although they are located between the two sets of rings. The magnetic variation from true north is marked with pike and feathers as before, but this is the first example seen with decoration on a variation to the west of north. The pike and feathers are still only on one side of the shaft, but they are on opposite sides.

[20] Lines of equal magnetic variation.

SF40 1901 has no changes in its compass design from SF40 1883.

NY40 1902 is another unique design, not seen on any other chart. It has a double ring with 128ths inside and 360ths outside, but both are aligned to magnetic north. The only indication of true north is a single line through the compass with the star and crescent decoration on it. Numeric labels for 30°, 60°, 90° away from north have returned, but are used to label magnetic variation. There are also changes to the text detailing the magnetic variation and annual increase. The text is in a Roman face, not italic as previously. It is also now arranged in a circle inside the compass, aligned with the magnetic variation. The year has moved to the end of the variation phrase: "VAR'N 8° 40' W. IN 1902".

With the beginning of the **fifth time period**, the major features of the compass rose are fixed. NY40 1914 is the earliest example. It consists of an inner ring aligned to magnetic north, divided into 128 sections; and an outer ring aligned to true north divided into 360 sections, and labeled from 0 to 360 in 30-degree increments inside the outer ring. The lines of equal division are primarily distinguished by length, not weight (except for the 30° lines). The crescent decoration formerly marking true south is gone, but the star for true north remains. The period is dropped from the abbreviation for the direction of magnetic variation: "VAR'N 9°45' W IN 1912".

MH400 1916 has one difference that is the first example of an inconsistency that later occurs elsewhere: "VARN 6° 20'W IN 1917" does not have an apostrophe in "VARN" as in all earlier instances.

In **time period six** only one of the examples has changes. E1200 1927 introduces new designs for the lines of the rings, the magnetic variation arrow, and the center point. The lines that comprise both the inner and outer compass rings have been made longer, and now, instead of having different lengths for odd and even divisions, different lengths are reserved for lines marking 5s and 10s. The effect is for the outer ring of the compass to look heavier than it did in the previous design. The line indicating magnetic variation from true north has lost the feathers on the south, and the one-sided pike design for the pointer has been replaced with a simple curved line on both sides, creating an arrow

point. Last, the single dot in the center of the compass has been replaced with a small cross to indicate true north/south and east/west.

MH400 1922 and GJF200 1922 both lack an apostrophe in the text statement of magnetic variation: "VARN". NY40 1926, SF40 1926, and E1200 1927 both have an apostrophe.

Time period seven had no changes to the design of the compass rose.

The **eighth time period** saw design experiments that led the way to a new standard design. While NY40 1944 has no changes from earlier editions, MH400 1942 has two new features. First, the outer ring (true direction) has labels every 10 degrees instead of every 30. Second, the entire compass rose is printed in magenta ink rather than black.

E1200 1943 has the same labeling of the outer ring every 10 degrees. The compass rose is printed in black but the entire chart is overlain with magenta isogons. It is the first chart with a new formulation for the text statement of magnetic variation: "VAR 13°00' (1943)", where the year is in parentheses, and "VARN/VAR'N" has lost the "N". One other change is that the cross at the center of the circle is larger.

GJF200 1941/48 has a new design that seems to be the new standard. It is a triple ring, printed in black, with a closely-spaced inner pair aligned to magnetic north, and an outer ring aligned to true north. The innermost ring, with six line lengths justified to the outside of the circumference, is divided into 128ths and has no number labels. The middle ring is divided into 180ths, made of three line lengths, justified to the inside, and has labels on the outside every 30 degrees from zero to 330. The outermost ring is divided into 360ths using three line lengths, and is justified to the inside. It also has labels on the outside every 30 degrees from zero to 330.

SF40 1947A uses this design in black.

E1200 1948 uses it in magenta with the addition of more labels on the outermost ring (every 10 degrees).

MH400 1951 uses the E1200 1948 design in black.

SF40 1947b/57 uses the GJF400 1941/48 design in magenta.

W1200 1945/54 drops the two inner circles marking magnetic variation. In their place is a single arrow. The chart also features magenta isogons.

Context

Magnetic variation was noted on a compass rose as early as 1529 (U.S. Department of Commerce et al. 1997, 2-27).

For details of the history of engraving at the C&GS, including advances in the engraving of compass roses using mechanical aids, see the end of the Chart Production section earlier in Chapter 4. It appears that the rule for the pike and barbs on the compass arrows was to only appear on the side of the shaft away from the line marking true north.

Aids to Navigation

Navigational aids are man-made objects placed on shore or in the water to help mariners safely make their way. They are represented on nautical charts to help mariners determine their location and to help avoid hazards. This section describes how the aids have changed in specific locations on the example charts. Refer to Layout 11—Aids to Navigation for the referenced images.

NY40 1844 is here represented by two clippings, one of the northern tip of Sandy Hook, New Jersey, and the other of the North and South Channels through the shoals connecting The Narrows and Raritan Bay to Long Island Sound. Sandy Hook is shown with several labeled pictographs representing aids—all of the labels on both clippings are in an italic face. The “Light H.” is shown with a little drawing of a lighthouse radiating light. Details on the symbol include a door and three windows. A “Telegraph” is drawn and labeled because it is a tall structure that would be visible at sea. “Old East Beacon not lighted” is drawn in place where Sandy Hook used to end. Just north of this is the new “East Beacon”. The “West Beacon” is also shown. All three of the beacons are represented using the same symbol, a tepee-like triangle with a glowing light on the top. Meanwhile, the clipping of the North and South Channels offer two aids to navigation,

both buoys. They use the same symbol, an inverted triangle with a semicircle on top, labeled “Black Buoy” and “White Buoy”.

NY40 1845 is represented by two clips of Gedney’s Channel and part of the North and South Channels. One of clips is from a reproduction of Electrotype Copy Number 1 (ECN1) (re-published by NOAA as BiC-10 in 1976), and the other is a scan of Electrotype Copy Number 7 (ECN7), made available by the New York Public Library. Both show buoys in the channel area, but ECN7 has many more buoys. Unfortunately, the scans of both are too light to accurately discern the designs of the buoy symbols. ECN1 looks to have the same buoys as NY40 1844, since the same labels are in the same place. On ECN7 it appears that the buoy symbols are different, and each is labeled in a font that appears to be a sans-serif Roman face, with “BUOY [single letter].NO.[#]”, for example “BUOY R.NO.4”. A sentence added at bottom of the Notes area of ECN7 explains this: “*In the description of buoys H.S. signifies horizontal stripes,P.S. perpendicular stripes, B. black, and R. red.*”

Time period two shows the beginning of standardization for aid symbols.

NY40 1853 shows two aids—a bell boat, and a buoy. The boat is shown with a pictograph of a 3-masted boat with 5 short lines emanating up in a semi-circle from the center mast. It is labeled in an italic font. The buoy, which is not discernable, is labeled in the same font and format as those on NY40 1844 ECN7: “BUOY B.NO.5”

MH400 1862/72 has two labels for aids that are barely legible: “BEACON”, and “LIGHT” in a sans-serif Roman face. The aids they refer to are not visible in the clip.

GJF200 1862 has a lighthouse symbol on the island labeled “Smith or Blunt’s I.” The symbol is similar to the lighthouse on NY40 1844, but is shorter, with a door and one window instead of three windows. It is labeled as “Lt.Ho.” in a serifed, Roman font.

W1200 1855/64 also shows a single lighthouse on an island. Again the scan is poor, but there appears to be a black dot that is associated with the same label as on GFJ200 1862: “Lt.Ho.”

On E1200 1863 there is a single dot where there should be a lighthouse at Cape Hatteras, but no light is labeled.

The latest charts in time period two, NY40 1870 and SF40 1859/77, both have buoy symbols that are different from earlier charts. No longer labeled "Buoy" (but still numbered), there is a standard shape, similar to an upside down bowling pin, with a dot at the base at the buoy's actual location and the body of the symbol generally projecting north from it. The body is either an outline, fully filled-in with black, or has a single vertical or horizontal stripe, depending on the buoy's color and meaning. The scheme is explained in the notes section of the charts. Special buoys have additional text explanation and symbols: on NY40 1870, the buoy labeled "*No.6 PERCH & SQUARE"* has a flag-like symbol attached to the top of the body of the buoy symbol. SF40 1859/77 also has a light marked on Alcatraz Island, but the symbol is a black dot with sunburst rays radiating about it in all 360 degrees. The label "ALCATRAZ LIGHT" is in a sans serif, Roman face, but the descriptor "Fog Bell" just below the other label is in an italic face with serifs.

Time period three saw some additions to the labeling of aids. NY40 1878 has the same buoy design as NY40 1870, but buoy No. 6 has a more descriptive label: "*(Perch & square day mark)*". It again is in sans serif italics, but has changed to sentence case from all capital letters.

E1200 1881 and W1200 1888 both have a new feature: lights are identified by bracketed numbers, which refer to a description in a table elsewhere on the chart. The symbology on the chart is a black dot in these scans, but a note with the tables on both charts indicate that "the principal sea-coast lights are colored". This would have been hand-coloring performed by clerks in the C&GS chart office. The E1200 also shows a "Whistling Buoy" and the "Lt. Ship" at Sandy Hook, as do the larger-scale charts of that area. W1200 has a novel feature, though. Marked on the chart is an arc centered on the light at Cape Flattery that shows how far the light should be visible. The arc is labeled "*Vis. 19 m.F.W.R. ray"*which stands for "Visible 19 nautical miles, Fixed White Red ray," according to the table on the chart. On the inside of the arc, tics point toward the lighthouse.

In the **fourth time period**, the clip for NY40 1902 shows a section of harbor just inside the channels (the scan was poor and the detail of the channels was obscured). This clip shows the West Bank Light, and marks out the red and white sectors with dashed arcs and text arrayed along the arcs; ships needed to stay in the white sector. A note accompanying the light indicates there is a "(SIREN)" for a fog signal.

The clip chosen for SF40 1901 shows a northern section of the bay, off Point San Pablo. Representation of buoys has remained consistent since SF40 1883, but there are several additional buoys shown.

E1200 1900 is the first chart available in a color scan, and it shows how the major sea-coast lights were colored. A circle of orange highlights the major lights. The light ship at Diamond Shoal is symbolized as a ship radiating light from its center (marked by a dot), and the scan shows several lines below the ship, providing a waterline and perspective. The symbol is also highlighted in orange.

Beginning with the **fifth time period**, nearly all of the scans are in color. NY40 1914 shows how Gedney Channel into New York Bay is now lined with pairs of buoys, and the color scheme is discernible on the color scan. New to this chart, the location of each buoy is marked with a dot that is now surrounded by a circle of seven rays. According to the notes on the charts, this signifies a lighted buoy. Also new, the buoys have a different labeling scheme: a single number, with a single letter in parentheses: for example, "4(R)".

For NY40 1917, both of those changes were refined. The seven rays around the point of each lighted buoy locator are longer, making the location more predominant. The buoy labeling scheme is also new, with lighted buoys having a short description of the light in parentheses, followed by the buoy number in quotation marks: (OccR) "2". Buoy "4" is missing the closing parenthesis on the light's description.

MH400 1916, a black and white scan, has a new symbol for the light ship at Diamond Shoal. It appears to be a 2-masted boat with a circle at the top of each mast. A protrudance from the bottom of the ship symbol marks it as having a submarine bell. There is also a new symbol for the lighthouse at Cape Hatteras. Instead of largish black

dot, there is now a small black dot surrounded by six short triangles. This may make it possible to mark and measure the location of the lighthouse more accurately.

W1200 1917 is again in color, and important lights are colored in orange, as with E1200 1900. It still has arcs marking where lights become visible, but they have dropped the inward pointing tics. Additional lights (for example, Neah Bay) are shown, and a lighted buoy is shown between Cape Flattery and Neah Bay. The lights have a lot of new descriptive text on the chart, taking much of the information that had only been in the table of information and placing an abbreviated version of it directly on the chart. Information about the light is presented first, with information about audible fog signals following within parentheses.

A very important new aid is shown at the entrance to the Columbia River, on the second clip for W1200 1917. The abbreviation "(RFS)" stands for Radio Fog Signal, according to the notes on the chart. A table in the notes gives further information on the details of the signal sent out by the Columbia River Light Vessel. This chart was issued in 1922, so the RFS information could have been added in the five years since the chart was first printed.

Changes in the **sixth time period** are minimal, and mostly have to do with changes in the aids, rather than to the design of chart elements. NY40 1926 has the same symbolization as NY40 1917, but the number of buoys in Gedney Channel has dropped from eight to six. On SF40 1926 the design of aids and explanatory content matches that of the other charts of the time period. Compared to SF40 1926, the light at The Brothers still has a fog whistle but for part of the year it uses a bell. The only apparent change to MH400 1922 since 1916 is the addition of a symbol for a sunken wreck due north of the Diamond Shoal light ship, between the two closest sets of shoal water. It is labeled "*PD*", meaning Position Doubtful. GJF200 1922 has added an Echo Board at Smith Island. As with SF40 1926, the design and content of the descriptive text has been updated from the previous example, 1895. E1200 1927 shows an updated symbol for the light vessel at Diamond Shoal. It has a single mast, compared to the two-masted symbol on MH400 1922 and W1200 1917.

Seventh time period

The example clip for NY40 1936 once again shows the West Bank light. Compared to the 1902 edition, there is much more information provided about the characteristics of the light (Occ ev 5 sec 69ft vis 14 m), and the sectors of the light are more clearly shown through a full circle, rather than intersecting arcs.

On MH400 1938, orange rings now note the location of radiobeacons and Naval radio direction finder stations (see NRC at Cape Hatteras), while lights are still highlighted with a circle of orange. Also, minor lights are shown as five-pointed stars, while major lights are shown as six-pointed stars.

E1200 1938 also gained orange circles around radiobeacons (RBn) and Naval radio direction finder stations.

The **eighth time period** sees the end of the orange highlight, to be replaced by magenta rings (in most instances). NY40 1944 shows lights within New York Harbor, marked by the magenta rings around the six-point stars.

With MH400 1942 an increase in administrative rules is shown on the charts. There are areas marked off with dashed lines, or labeled "DANGER AREA", for example. It is also the earliest example of the big magenta ring that symbolizes radiobeacon. When a light or lightship is also a radio source, it now receives two magenta rings, creating a bull's-eye effect.

SF40 1947A and 1947b/57 both have examples of administrative areas—"Cable area" and "RESTRICTED".

E1200 1948 and W1200 1945/54 both show LORAN stations, although only the former is overprinted with LORAN lines.

Context

The charts provide not only a record of where navigational were located at a given time, but also what types of aids were in use. Over the time period covered here there were many changes to the types of aids being used in U.S. waters. It is almost a side note that there were changes to how particular aids were represented.

A system for representing buoys through a set of standard symbols was tested in 1869 and quickly implemented. This system replaced the previous practice of having a single symbol plus text labels describing each buoy's characteristics (U.S. Treasury Department et al. 1872, 59).

Shoal Water

Dangerous shallow waters, or shoal water, are represented with two different techniques over the course of the first 100 years of the C&GS. Such waters are set-off with a distinct representation to warn navigators to stay clear of places dangerous for them to have their vessel. Please refer to Layout 04—Shoal Water for references in this section.

NY40 1844 is a fine example of the first mode of representation, sanding. Sanding is created by engraving a multitude of dots to create continuous-tone swaths on the chart, with each range represented by a different size or density of dots. The transition between different ranges is shown by a band of dots heavier than the other dots in the range. NY40 1844 uses sanding to represent four depth ranges, as expressed in the notes area: "The dotted surfaces represent the bottom at the respective depths of 6, 12, 18, & 21 feet." The text in the center of the clip, just above the "East Bank" label, reads "Dry at low Water". The shape of the shoal has much more detail than the available soundings show.

NY40 1845 also has four different gradations for sanding the shoal water. This is the last chart seen to have sanding for four different depth ranges. Beginning with NY40 1853 and continuing through NY40 1926, all editions of this chart have three gradations of shoal water represented by sanding, with divisions at 1, 2, and 3 fathoms. SF40 shares this design for shoal water over the same time period. The design of the sanding does change some, however. NY40 1917 includes sanding that fades completely out in large expanses. More than other charts, the sanding is heavier at the transition lines between depth ranges, and gradually fades out to white. Older charts have less emphasis on the transition lines between the depths, and do not fade out completely.

The second method of representing shoal waters is to print a blue tint inside a certain depth curve. NY40 first sees this method of representation in the seventh time period on the 1936 edition.

MH400 1916 includes sanding only for outside waters less than 3 fathoms. Waters inside the barrier islands, and other bays, are left free of sanding. This is a choice not seen on other editions of this or other charts. Even the Sailing Charts of the East Coast have a representation of danger for inside waters.

MH400 1922 presents another unique representation, both sanding and a blue tint inside 3 fathoms. MH400 is the only chart examined that combines sanding with color—the other five charts drop sanding when color is added. This chart is particularly anomalous because the next edition seen, MH400 1938, drops the blue tint but leaves the sanding. The two later editions of MH400, 1942 and 1951, again add blue tint over sanding, but the blue expands to 10 fathoms, while the sanding remains at three fathoms.

GJF200 is the only chart to not receive the blue tint for shoal waters in any of the editions examined for this project. It is also the only chart aside from NY40 with variation as to which fathom lines received sanding. When the chart was reconstructed between the 1922 and the 1933 editions, sanding lines were dropped for 1 and 2 fathoms, and instead marked everything inside 3 fathoms with a single band of sanding. For the 1941/48 edition, however, the 1 fathom line was brought back.

As for the Sailing Charts, both represent shoal water first with sanding in side 3 fathoms, then with blue tint in later editions.

Table 12 shows whether or not chart editions have shoal water represented by sanding or other methods, and what depth divisions are shown (in fathoms). The Harbor Charts consistently have sanding for the 1, 2, and 3 fathom lines for time periods two through six, after which they transitioned to a ribbon of blue inside the shallow water line. This line changed from 3 fathoms to 6 fathoms for the last SF40 examined here.

Table 12. Shoal water represented by sanding or color, in fathoms

Time Period	NY40	SF40	MH400	GJF200	E1200	W1200
1	1, 2, 3, 3½					
	1, 2, 3, 3½					
2	1, 2, 3	1, 2, 3				none
	1, 2, 3		3	none	none	
3	1, 2, 3	1, 2, 3			3	3
4	1, 2, 3	1, 2, 3		1, 2, 3	3	
5	1, 2, 3		3			
	1, 2, 3					3
6	1, 2, 3	1, 2, 3	3 (<3 blue)	1, 2, 3	3	
7	none (<3 blue)		3	3	3	3
8	none (<3 blue)	none (<3 blue)	3 (<10 blue)	1, 3	none (<10 blue)	
		none (<6 blue)	3 (<10 blue)		none (<10 blue)	none (<30 blue)
9	none (<3 blue)	none (<6 blue)	none (<10 blue)	none (<10 blue)	none (<10 blue)	none (<30 blue)

The smaller scale charts have much less surface area that could be covered by sanding, and are not designed to be used when navigating near shallow water, placing emphasis elsewhere. The General Charts have differences between the two charts based on scale. GJF200 uses the same representation as the Harbor Charts, with sanding at 1, 2, and 3 fathoms on its finished editions through time period six. MH400 includes sanding only at 3 fathoms, matching the Sailing Charts.

With the exception of GJF200, the eighth time period sees all of the charts migrate away from sanding as the representation of shoal water to a ribbon of blue tint. There are differences in which fathom line is chosen for the danger line, based on the type of navigation being done with the chart (Harbor, General, or Sailing), and the type of coast. The west coast, with its steeper bottom topography, apparently requires a deeper danger line to achieve safe navigation and sufficient distance from navigational threats. W1200 1945/54's blue tint is at 30 fathoms, versus 10 fathoms or E1200 1948. SF40 1947b/57's danger line is six fathoms, versus three for NY40 1944.

Context

Sanding is very time-consuming to create by hand, and is therefore very expensive to have on charts. Preliminary charts did not have sanding; this step was

skipped in an effort to get the information out to the public quickly. It was added to the finished charts done in the “finest style”.

When charts began to be reproduced by photolithography, symbols such as sanding could have been applied through etching, or Ben-Day dots. Instead there was a movement in that era to make charts simpler and more legible. The C&GS moved away from representing shallows as a shaded area in black, and instead used the color printing abilities of offset lithography to add a blue tint to dangerous shallows. The color removed the need to shade through sanding, and the representation was dropped from newly constructed charts by the mid-1920s, although it remained on existing charts until reconstructed.

Bathymetric Contours

Another graphic form used to represent the bottom of water bodies is the bathymetric contour. Essentially the same as topographic contours used to represent land surface above the water, bathymetric contours represent the land surface under the water. While the purpose of sanding is to warn of danger, depth contours are more generally applied to aid in navigating, and are present both in shallow water and in waters considered safe to navigate. Their purpose is to communicate the shape of the bottom and, therefore, the depth of water, through generalization. Please refer to Layout 04—Shoal Water, and Layout 06—Deep Water for examples used in this section. Table 13 shows which charts have depth contours for which fathom lines, and how the contours are formed.

Table 13. Bathymetric contours: fathoms marked with depth contours, and the form of the contour line.

Time Period	NY40	SF40	MH400	GJF200	E1200	W1200
1	none					
	none					
2	none	4, 6, 10 Dashes & Dots				none
	none		10, 20, 30, 100 Dashes & Dots	1, 3 Dots	10, 100 Dots	
3	4 Dashes	4, 5, 6 Dashes & Dots			10, 50, 100 Dashes & Dots	none
4	4 Dashes	4, 5, 6 Dashes & Dots		10, 50 Dashes & Dots	10, 20, 30, 40, 50, 100, 1000 Dashes & Dots	
5	4 Dashes		5, 10, 100 Dashes & Dots			
	5 Dots					30, 100 Dashes & Dots
6	5 Dots	5, 6 Dashes	5, 10, 100 Dashes & Dots	10, 20 Dashes & Dots	10, 20, 50, 100, 1000 Dashes & Dots	
7	1, 2, 3, 5 Dots		5, 10, 100 Dashes & Dots	10, 100 Dashes & Dots	10, 20, 30, 40, 50, 100, 500, 1000 Dashes & Dots	30, 100 Dashes & Dots
8	1, 2, 3, 5 Dots	1, 2, 3, 5, 6 Dashes & Dots	5, 10, 20, 30, 40, 50, 100, 500, 1000 Dashes & Dots	10, 100 Dashes & Dots	10, 20, 30, 40, 50, 100, 500, 1000 Dashes & Dots	
		1, 2, 3, 5, 6, 10 Dashes & Dots	5, 10, 20, 30, 40, 50, 100, 500, 1000 Dashes & Dots		10, 20, 30, 40, 50, 100, 500, 1000, 1500 Dashes & Dots	30, 100, 500, 1000 Dashes & Dots
9	1, 2, 3, 5 Lines	1, 2, 3, 5, 6, 10 Lines	3, 5, 10, 20, 30, 40, 50, 100, 500, 1000, 1500 Lines	1, 3, 10, 100 Dashes & Dots	10, 20, 30, 40, 50, 100, 500, 1000 Dashes & Dots	30, 100, 500, 1000, 1500 Lines

The first charts did not have depth contours. Several charts have contours in the second time period but not NY40 or W1200. From those earliest examples it appears there was a different form of dots, dashes, and lines used to construct each depth line. Even though different depths were represented on each chart, the way each depth was represented was consistent. The poor quality of some of the scans of the earliest charts make determining the exact form of some of the contours impossible, but later scans are clearer and distinguishable. For the most part, the system used is as shown in *How To Read a Nautical Chart* (Calder 2003).

On the Harbor Charts, depth contours were used in tight coordination with sanding. On most of the editions of NY40 and SF40, the sanding at 1, 2, and 3 fathoms were continued with contours at 4 fathoms (NY40) or 5 and 6 fathoms (SF40). When sanding was replaced by blue tint, contours were added at the same depths formerly marked by the sanding to continue to provide detail on the overall shape of the bottom.

The two General Charts and the two Sailing Charts show substantial differences between the east and west coasts in how contours were used for bottom representation. The small-scale charts of the west coast, GJF200 and W1200, have very few depth contours—only two depths are represented on the charts (except for W1200 1945/54). In comparison, the small-scale charts of the east coast, MH400 and E1200, have from two to nine different contours, averaging 5.4 for the 12 editions of the two charts. This difference may be due to differences in landforms between the two coasts. The Pacific coast is typically steeper along the shore than the Atlantic, which only gradually declines along the continental shelf to the edge before dropping off. Having numerous contours to represent the bottom would, along much of the west coast, create thick bands of lines that individually provide little value to navigators, who primarily needs to know where the shallows are. The gentle slopes of the continental shelf along the Atlantic are much more amenable to multiple contour lines.

One of the most interesting set of editions to examine for the history of depth contours are MH400 1938, 1942, and 1951. The clip for 1938 on Layout 06 shows a single contour at 100 fathoms running north/south through both an area with many soundings, and an area with few soundings. The 1942 edition has no additional soundings on the chart, but in the area with many soundings, additional contours are present for 20, 30 ,40, 50, 500, and 1000 fathoms. The contours do not continue into the area with few soundings. The 1951 edition shows the contours continuing into the area with few soundings, but again no additional soundings are present.

Context

Bathymetric contours were created by drawing a line of best fit through recorded soundings. This practice was inherently less accurate than topographic contours because the actual surface being drawn was not visible to the surveyor, unlike the land surface. Few depth contours were present on early charts because few soundings were available, and the level of confidence needed to draw in contours was not present. Additionally, technology needed to make many soundings in very deep water was not available. Such information was not needed to keep ships safe, and since most ships did not have the equipment needed to make deep soundings, the information was unnecessary for navigation, as well. An indication of this is that in the early years of the survey, the C&GS referred to bathymetric contours as "Danger Curves", focusing on their importance for navigation in shallow water, not deep water (U.S. Treasury Department et al. 1900a, 9).

As technology improved and deep soundings were more practical with the invention of mechanical sounding machines, more soundings were taken in deep water. Also, shallower areas were resurveyed and additional soundings were taken, filling in knowledge about the bottom and allowing greater detail.

The echo sounder was a major advance in hydrographic surveying, leading to vast increases in the amount of data the survey had available with which to compile charts. Suggested as early as 1807, it was not until the Submarine Signal Co. tested a machine to warn of icebergs (after the *Titanic* disaster) in 1914 and discovered return signals showing the bottom of the sea that a working device was created (Theberge 1989). The C&GS's first use of a sonic depth finder was in 1923, and by 1928 all soundings in waters over 15 fathoms were being taken with such devices (U.S. Department of Commerce et al. 1923, 1928b; Theberge 1989). By 1939 the survey was using recording echo sounders to collect 200 times as many soundings in a given period of time as could be done in deep water using mechanical methods (Kerr et al. 1982; Theberge 1989). A shallow water sounding device, the Dorsey Fathometer, came into testing in 1935, and a

refined version found wide use by 1937 (U.S. Department of Commerce et al. 1936b, 136; 1938, 138).

Even the echo sounder had limitations, however. Before the advent of multibeam and side-scan sonar, echo sounders could only provide a trace of the bottom directly under the survey vessel. Since the distance between survey tracks varied with the perceived threats posed by the hydrography of the area being surveyed, wide tracks could still let navigational hazards go undiscovered (Craig 1996).

The best soundings are of no value in charting unless the location of the survey vessel is known. Advances in positioning were just as dramatic and important as advances in sounding. Before the advent of electronic positioning aids, soundings taken out of sight of land were located using dead reckoning (Shalowitz 1957). The C&GS was a leader in developing the technique of 'radio acoustic ranging' (RAR) in the 1920s. With RAR, an explosive device was tossed into the water, and the sound of the explosion would travel through the water to distant hydrophones connected to wireless transmitters. Upon picking up the explosion, these units would transmit a radio signal back to the ship. The differential timing of radio signals received on the ship from multiple hydrophones allowed a triangulation calculation to locate the ship at the time of the explosion. This technique was used until more advanced, fully electronic positioning systems were developed during WWII.

A major innovation for the C&GS came in March 1939 with the publication of a new edition of Chart 5101, designated 5101A (U.S. Department of Commerce et al. 1940, 99; Shalowitz 1964). It marked the beginning of a new role for bathymetric contours. It was the first chart designed for ships that have their own echo-sounders on board. Recording echo sounders allowed the survey to collect orders of magnitude more information about landforms at the bottom of water bodies. Continuing to place primary responsibility for representing this information with the point data that soundings represent did not do justice to the richness of the data now available. Instead of playing a subsidiary role to the soundings on the chart, contours could now play the same role as topographic contours, that of being the primary representation of the land surface. This

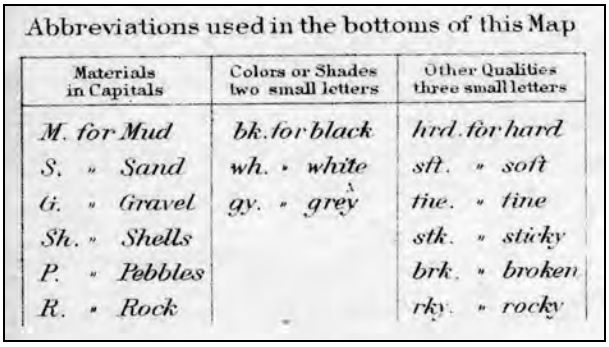
change in role can be seen in such chart editions as MH400 1938, 1942, and 1951, and E1200 1927, 1938, and 1948. As these series progress, contours gain significant detail, while soundings either remain as they were or, as in E1200 1948, are dramatically reduced.

Bottom Characteristics

Another feature of the charts that is useful for navigational purposes is the characterization of the material that comprises the bottom at various locations. This information has been present on the charts from the first, and is still present today. It is relevant to navigation through the use of a sounding lead that picks up a sample of the material from the bottom. Matching a distinctive material like black sand to a bottom-surface description on a chart could help a lost ship determine its location, especially when combined with depth soundings. Examples of bottom-surface descriptions can be seen on Layouts 04, 05, and 06.

On NY40 1844 and 1845, bottom description text was in nearly plain text and did not need an explanatory key. On Layout 04 examples include “Grey Sand” and “Gr. Sand”. Layout 05 has “Gr.Sand & Br.Shells” and “Gr.Sand Y.Specks” in addition “Sand”. Layout 06 shows “Fine Grey Sand” and “Black & White Sand”. The text is formatted as title case, in italics with serifs, and is the same size as the soundings. NY40 1853 has no bottom description text, and is the only chart seen here without.

In the second time period, the other charts began to see standardized abbreviations for the bottom description text. Somewhere on the map, a note would be placed as a key to the abbreviations. See Figure 4 for an example of this key from GJF200 1862. It categorizes the descriptors as ‘Materials’, ‘Colors or Shades’, and ‘Other Qualities’. Adjectives are divided into two categories by the practice of abbreviating Colors with two letters and Other Qualities with three. The text in the key is in italics, as is the text on the chart.

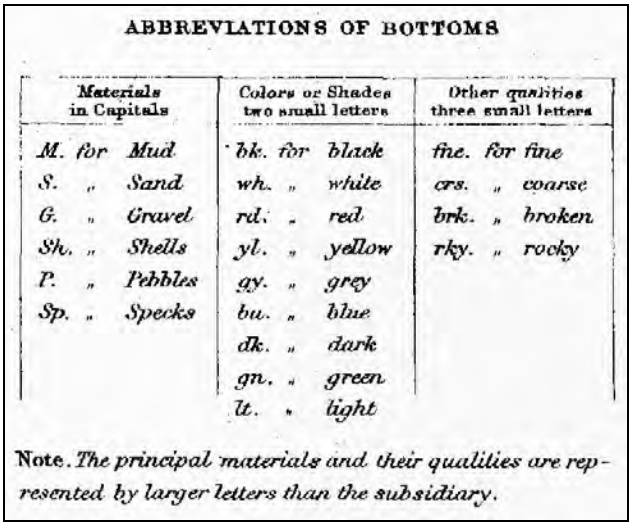


Abbreviations used in the bottoms of this Map

Materials in Capitals	Colors or Shades two small letters	Other Qualities three small letters
M. for Mud	bk. for black	hrd. for hard
S. " Sand	wh. " white	sft. " soft
G. " Gravel	gy. " grey	fine. " fine
Sh. " Shells		stk. " sticky
P. " Pebbles		brk. " broken
R. " Rock		rky. " rocky

Figure 4. Key to abbreviations, GJF200 1862

The abbreviations in the key apparently were specific to that chart so that codes not used on the chart were not in the key. Another example of a key from the second time period is shown in Figure 5, from E1200 1863. While the list of Materials is the same as that on the key for GJF200 1862, the key for E1200 1863 has an additional four colors and two qualifiers, 'dark' and 'light'. It has two fewer Other Qualities listed, but includes one not on the GJF list, 'coarse'. The keys also have different headings, and only the 1863 version's title is in all capital letters. It also has an additional note below the table explaining how materials can be characterized as "principal" and "subsidiary", apparently meaning that both are present at a single location, but that one makes up a majority of the sample.



ABBREVIATIONS OF BOTTOMS

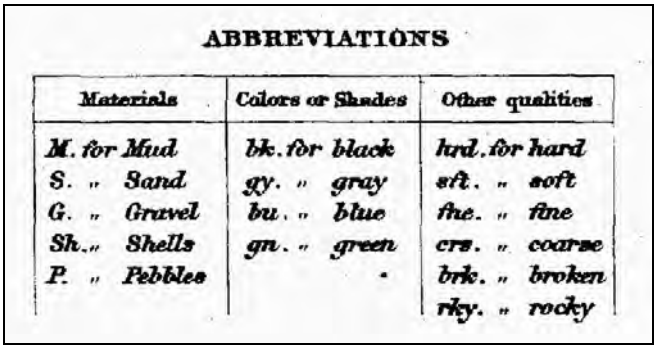
Materials in Capitals	Colors or Shades two small letters	Other qualities three small letters
M. for Mud	bk. for black	fine. for fine
S. " Sand	wh. " white	crs. " coarse
G. " Gravel	rd. " red	brk. " broken
Sh. " Shells	yl. " yellow	rky. " rocky
P. " Pebbles	gy. " grey	
Sp. " Specks	bu. " blue	
	dk. " dark	
	gn. " green	
	lt. " light	

Note. *The principal materials and their qualities are represented by larger letters than the subsidiary.*

Figure 5. Key to abbreviations, E1200 1863

In the second time period, the size of the bottom description text on all of the charts was decreased to be somewhat less than the size of the text for the soundings.

GJF200 1895 has an abbreviation key with the same format, as shown in Figure 6, although the title has been shortened. Each column has one difference from the 1862 edition. 'Rock' is absent from Materials, but in Colors or Shades, the color "green" has been added. In Other Qualities, 'sticky' has been replaced by 'coarse.

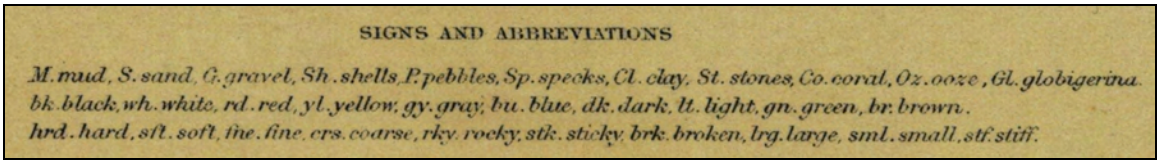


ABBREVIATIONS

Materials	Colors or Shades	Other qualities
M. for Mud	bk. for black	hrd. for hard
S. " Sand	gy. " gray	sft. " soft
G. " Gravel	bu. " blue	fne. " fine
Sh. " Shells	gn. " green	crs. " coarse
P. " Pebbles		brk. " broken
		rky. " rocky

Figure 6. Key to abbreviations, GJF200 1895

E1200 1900 has a major change in the key to abbreviations. Abbreviations are no longer in a table but rather in a paragraph, and are placed under a single heading along with other signs and abbreviations. Figure 7 shows the title and uppermost section of this part of the notes, including all three of the categories of bottom description text. Each of the three has more items listed than the 1863 edition. There are 11 types of materials, 8 colors (plus the two qualifiers), and 10 types of other qualities.



SIGNS AND ABBREVIATIONS

M. mud, S. sand, G. gravel, Sh. shells, P. pebbles, Sp. specks, Cl. clay, St. stones, Co. coral, Oz. ooze, Gl. globigerina.
bk. black, wh. white, rd. red, yl. yellow, gy. gray, bu. blue, dk. dark, lt. light, gn. green, br. brown.
hrd. hard, sft. soft, fne. fine, crs. coarse, rky. rocky, stk. sticky, brk. broken, lrg. large, sml. small, stf. stiff.

Figure 7. Key to abbreviations, E1200 1900.

This new strategy of moving the key from a table to just three lines was eventually applied to other charts. MH400 1916, NY40 1917, W1200 1917/26, GJF200 1922, and SF40 1926 are the first editions where it is seen on the other charts.

Some examples of how the abbreviations are used on the charts include:

- Layout 6, NY40 1870: *fne dk gy wh bk S*
- Layout 6, SF40 1859/77: *fne.S.M.*
- Layout 6, E1200 1863: *gy.&bk. S.rd.G.Sh.*
- Layout 6, W1200 1855/64: *M.*

Abbreviations are mixed and matched to create a properly descriptive statement. Sometimes all that is given is a single letter, while in other cases five or six abbreviations are used. Primary material is described first, followed by secondary material.

In later time periods, changes were made to the form and even the content of the bottom description text. First, the lettering was changed from serif to sans serif at the when soundings were similarly changed, although the italics remained. Second, periods were removed from each abbreviation at that same time. A third change between 1938 and 1940 was more significant. The list of abbreviations was standardized. Before this change each chart had its own unique list of abbreviations, some quite long and using possibly obscure or unclear terms such as ‘globigerina’, ‘ooze’, and ‘stiff’. After 1940 every chart uses the same, shorter, list of abbreviations, an example of which is shown in Figure 8.

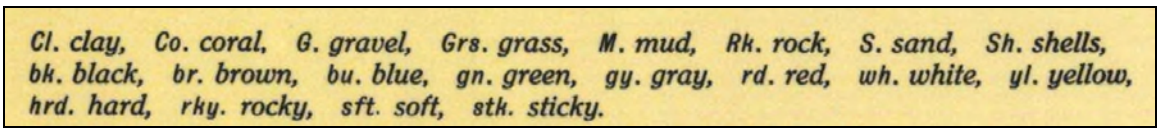

Cl. clay, Co. coral, G. gravel, Grs. grass, M. mud, Rk. rock, S. sand, Sh. shells,
bk. black, br. brown, bu. blue, gn. green, gy. gray, rd. red, wh. white, yl. yellow,
hrd. hard, rky. rocky, sft. soft, stk. sticky.

Figure 8. Key to abbreviations, GJF200 1941/48

Context

With the advent of electronic navigation systems such as Shoran taking primary responsibility for determining the location ships even in poor visibility, and electronic sounding devices to determine depth of the water even while underway, sounding leads

and knowledge of bottom composition became much less important navigational tools. Bottom characteristics were not dropped completely, however, probably to provide backup information should a ship lose all power and, therefore, all electronic navigational aides. The information became less important and subsequently less prominent on the charts.

Soundings

During the 100 or so years covered by the study, soundings on the charts were the primary method of communicating knowledge of the landform under the waters described by the charts. It was not until the very end of this span of time that the burden of primary communication was shifted to bathymetric contours, and even then soundings remained on the chart to provide evidence for the validity of the contours. For all of this responsibility, there are was very little change in the form of the representation of soundings over this time. Soundings can be seen on Layouts 04, 05, 06, and 11. The following descriptions are divided into a section on shoal water using Layout 04, and a section on deeper water using Layout 06.

Soundings have been shown on the charts using three schemes of units of depth measurement:

1. Feet only
2. Feet and Fathoms
3. Fathoms only

Harbor Charts have mostly used feet as the unit measurement, but the mixture of feet and fathoms is used on some editions during time periods two, three, and four. General Charts used feet and fathoms during these same three time periods before being converted to fathoms only. Sailing charts have only used fathoms only. Table 14 provides a summary of the units of measurement used on each chart edition.

Table 14. Units of measurement for soundings

Time Period	NY40	SF40	MH400	GJF200	E1200	W1200
1	Feet					
	Feet					
2	Feet & Fathoms	Feet & Fathoms				Fathoms
	Feet		Feet & Fathoms	Feet & Fathoms	Fathoms	
3	Feet	Feet & Fathoms			Fathoms	Fathoms
4	Feet	Feet & Fathoms		Feet & Fathoms	Fathoms	
5	Feet		Fathoms			
	Feet					Fathoms
6	Feet	Feet	Fathoms	Fathoms	Fathoms	
7	Feet		Fathoms	Fathoms	Fathoms	Fathoms
8	Feet	Feet	Fathoms	Fathoms	Fathoms	
		Feet	Fathoms		Fathoms	Fathoms
9	Feet	Feet	Fathoms	Fathoms	Fathoms	Fathoms

Shoal Water

No significant differences in representation of soundings in shoal water are seen between the different charts. NY40 will be described as the representative chart for differences over time.

NY40 1844 has soundings in feet, and all of the numbers are integers. A close examination shows that each numeral is unique, meaning that all of the numbers were engraved by hand. There are places where the soundings are well-distributed, and other places where they trace lines across an expanse that is otherwise free of soundings.

NY40 1845 has a note stating that "[t]he characteristic soundings only are given on the maps. They are selected from the numerous soundings taken in the survey so as to represent the figure of the bottom." Indeed there are many fewer soundings shown on the chart, and each proportionally covers a larger section of area (recall that this chart is at 1:80,000 while the 1844 version in six sheets is at 1:30,000). The lines of soundings are not noticeable in the shallows. There are still irregularities in the letter forms, however.

As Table 14 shows, NY40 1853 has soundings in both feet and fathoms. Soundings inside the danger line (18 feet) are in feet, while those in deeper water are in fathoms. The soundings in feet are all whole numbers, while some of the fathom soundings include fractions (¼ and ½ are appended to several soundings). Although the scan is not the best, it does appear that the numbers are hand-engraved.

NY40 1870 has all soundings in feet. Fractions are added to some of the soundings (¼ and ½).

No changes are apparent on NY40 1878 and 1902, but for 1914 the letter forms are finally consistent enough to appear to be mechanically engraved. The fractional feet are also gone.

The 1917 edition of NY40 is where a major change takes place for this chart: the switch from serif to sans-serif letters for soundings. The look is cleaner, clearer, and more modern. Less ink is used per numeral. The soundings appear to be chosen and placed according to a grid system, and coverage is more regular than on previous charts.

NY40 1926 shows evidence of some re-survey work, with some additional soundings in places, and other soundings removed. The result is a slightly less regular distribution of soundings.

No changes are seen to the form of the soundings on NY40 1936 or 1944, although small changes are made to the information based on later surveys.

Deep Water

NY40 1844 has a significant difference in the density of soundings between shoal water and deeper water. A gradual tapering of density is seen moving away from the channels through the entrance to the bay. Empty spaces begin to appear, which look to be areas where soundings had not yet been taken.

NY40 1845 maintains the voids in deeper water seen on the 1844 edition.

On NY40 1853, individual lines of soundings appear to be represented. These likely show where a hydrographic sounding crew made a single trip across an area, recording soundings as they went. Sounding density dwindles to nothing in deeper water.

The clip chosen for NY40 1870 has a more regular distribution of soundings in the deep waters than the previous editions. The distribution appears to be very much the same as that of the 1878 edition.

The clips selected for NY40 1902 and 1914 demonstrate that there is still a difference in the density of soundings selected for the charts between shoal water and deeper waters. The coverage of deep water soundings appears to be complete, however, unlike the earliest editions in which there were obvious holes in the coverage.

Looking at the deep water clips for the other charts, it appears that they, too, went through a similar history. The early charts have large gaps in soundings, with entire sections of chart with no soundings at all, and the tracks of individual sounding parties plainly represented. MH400 1916 is an excellent example of this. It appears that multiple runs were taken heading east until a depth of 100 fathoms was reached. On MH400 1938 it appears that a project is shown where a party was asked to make soundings out to 1500 fathoms, but only north of a particular line of latitude.

E1200 shows evidence of the 1500 fathom plan but the 1948 edition is unique in that all deep water soundings have been removed. It is entirely dependent on bathymetric contours for depth information in deep water, although it does have soundings within the blue-tinted danger zone, the 10-fathom line. Removing the soundings makes the LORAN lines more distinct and, therefore, easier to use for navigating with that electronic aid.

Sounding tracks appear on all of the W1200 editions, even the last, 1945/54.

Context

In 1915 a plan was approved to convert all large scale Atlantic coast charts to soundings in feet (U.S. Department of Commerce et al. 1915, 136). See Shalowitz 1964 for a discussion of C&GS standards for depth units (306).

It is clear by examining the charts that soundings have different importance for different mariners at different times. A high density of soundings is necessary for successfully traversing shallows, especially for sailing ships using the wind to tack a zig-zag course. If fog was present and visual aids to navigation unavailable, they would

sound constantly using a lead line to determine depth. With a detailed chart, enough soundings, and good dead-reckoning, a navigator could make it through such dangerous waters.

Making soundings in very deep water, over 100 fathoms, was difficult if not impossible until certain technological and scientific advances came along in the nineteenth century. Steam-powered sounding machines, long metal wire, and mechanisms to drop weights when the bottom was struck, comprised a first generation of advances over dropping a lead weight by hand. The next generation involved better instrumentation, such as pressure tubes, to make more accurate measurements. The twentieth century saw remote sensing technologies, particularly echo sounding for deep water and SHORAN, LORAN, and RADAR for navigation, which revolutionized both data collection and navigation. Dead-reckoning, and later an advanced version termed Precise Dead Reckoning, were used for determining location of soundings for work done out of sight of land or other pre-placed aids until electronic positioning technologies such as RAR were developed in the 1920s.

While C&GS publications from the very earliest tried to reassure mariners that density of soundings on the finished charts did not directly relate to quality of survey, and that the soundings shown were only a miniscule number of representative soundings compared to the large number actually taken, there are instances where blank spaces meant ‘no soundings.’ This was acknowledged in a pamphlet published by the survey in 1900 (U.S. Treasury Department et al. 1900a, 8).

Channels

Channels are interesting both for how they are represented and for what they say about the needs of navigation and the technological abilities of society. Layout 05—Channels is referred to in the following section. It does not include clips from the Sailing Charts (there is only clip for MH400) because those charts are not designed for navigating through channels, and such features are poorly represented if at all.

On NY40 1844 the line on which the words “Main Ship Channel” sit represents the center and deepest line of the channel, the fairway. The line intersecting it at an angle near the “p” in “Ship” represents the fairway of Gedney’s Channel through the outer bar of the harbor. These lines are keyed to sailing directions provided as notes elsewhere on the chart. The line through “Flynn’s Knoll” is a line of latitude. Sanding along the shallows to the north and south provide the boundaries of the Main Ship Channel. The three channels shown on the smaller clip (Fourteen Foot Channel, East Channel, and Swash Channel) are less-preferred routes, and do not have a fairway track shown.

NY40 1845 has similar fairway lines, while NY40 1853 does not. The letters for “Main Ship Channel” are placed along a curve instead of a straight line. The font for this phrase has a taller x-height than the 1844 edition, and it appears less formal and elegant.

NY40 1870 and 1878 have a dashed centerline representing the fairway of the channel, which has had its name shortened to “*MAIN CHANNEL*”. The font used is sans serif but slanted, and the words are in all caps. It is still defined only by the sanding on the adjacent features.

By the 1902 edition of NY40, the channel’s label was moved a bit to the northwest, but the letterforms stayed the same. The channel has slightly more definition with the addition of a dashed bathymetric contour at the 4-fathom line to compliment the sanding inside 3 fathoms.

On the 1914 edition, the fairway is better defined by adding the bearing of the line, “*250°18’ TRUE*”, between the line and the name of the channel. The second clip for 1914 shows that the channel between Fourteen Foot Channel and Romer Shoal has been renamed from East Channel to Ambrose Channel (see NY40 1844). It has also been “*DREDGED TO 40 FEET DEC 1912*” according to the text on the chart. In addition to the 4-fathom line, the outside edges of the dredged channel are represented by a dashed line with a different pitch than the fairway’s dash. Oddly, the name of the channel is placed outside of the actual channel.

In the 1917 edition, the name of the channel has been moved back inside the channel. Also different for 1917 is the form of the dashes defining the outside of the

dredged channel. They are thicker than the dashes representing the fairway, although the pitch is more nearly the same. Another change is that the label noting the channel's depth has been shortened to "*40 FEET JUNE 1916*". For the Main Channel, the name is now placed at a different angle than the fairway line. The bearing label has moved but is still present on the eastern edge of the clip. For both channels an important change is that the 4-fathom line has been replaced with a 5-fathom line made up of sets of five dots.

No representational changes are seen for NY40 1926, but the 1936 edition has a different form of the fairway line. The dashed line uses a longer, heavier dash. Also for 1936, the sanding is replaced with a blue tint, and the 1-, 2-, and 3-fathom lines are shown by distinct lines inside the tinted area.

One change to note for the NY40 1944 clip is a new name, "*SANDY HOOK CHANNEL*", for what used to be the Main Channel. Also, the fairway line has been removed.

The earliest example of a dredged channel is shown on SF40 1859/77. Protruding from the mouth of San Antonio Creek, just south of Oakland, is "*DREDGED CHANNEL 13 FEET DEEP*", noted in italic sans-serif letters. The label is at an angle to the channel itself, marked by solid lines and labeled "*Training Walls*" in title case, italic, with serifs. It appears the channel label is positioned to avoid obscuring the soundings in the channel. This suggests that the labels and the lines were added to the chart after the soundings. There is no date associated with the channel, however. (Note the high level detail in the braided creek north and south of the eastern end of the training wall.)

On SF40 1883 both labels are gone, but the lines that were previously labeled as walls are still present. The channel is deeper in some places. Also, the label for San Antonio Creek has been moved so that most of it is no longer in the channel. (The detail in the braided creek area is absent, but a rail line and wharf are shown at the head of the channel.)

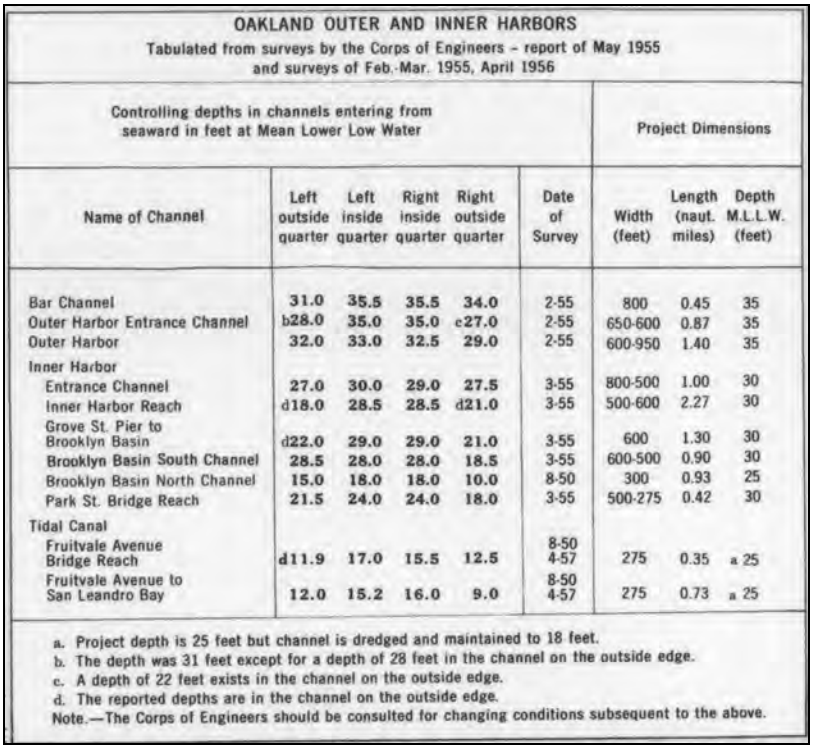
For 1901, SF40 does not have text relating to the channel, but the soundings indicate that it is 3¼ fathoms deep through its entire length. This would require that it was dredged. The lines for the unlabeled training wall are still present. A new rail line

and wharf have been added to the south of the wall. The label for the creek is either moved or absent.

Major changes in landform are evident on SF40 1926 in the area around the channel. Much of the shallows and mud flats have been filled-in, and the training walls now have dry land on both sides of the channel. A new rail line and wharf are shown along the north side of the channel. The channel itself is labeled "26½ FEET APRIL 1927" in Roman sans-serif letters in two places, and "28 FEET APRIL 1927" once. This text appears to be created with an inked stamp rather than printed. Soundings have been removed from the channel, but are present immediately outside of it. The sides of the dredged channel are represented as a dashed line, and areas shallower than 18 feet are sanded, even within the banks of the channel.

SF40 1947A shows additional land area filled-in, and new wharfs built in the vicinity of the channel. The channel is now labeled "*28 FEET MAY 1947*" and "*29 FEET MAY 1947*" in italic sans-serif text that is clearly printed on the chart, not stamped. Longer dashes are used to show the edge of the dredged channel, and with the sanding replaced by blue tint, contour lines mark several depth lines. The dredged part of the channel does not have the blue tint, but the shallows between the dredged area and the channel banks are shown in blue.

The last edition of SF40, 1947b/57, no longer states the depth to which it is dredged. This information has moved to a table elsewhere on the chart (shown in Figure 9). Instead, text in part of the channel provides the label "*INNER HARBOR ENTRANCE CHAN*", and a section further east is set off by a box made of dashes and labeled "*MEASURED NAUTICAL MILE. COURSE 105°32' TRUE*".



OAKLAND OUTER AND INNER HARBORS

Tabulated from surveys by the Corps of Engineers – report of May 1955 and surveys of Feb.-Mar. 1955, April 1956

Name of Channel	Controlling depths in channels entering from seaward in feet at Mean Lower Low Water: Left outside quarter	Left inside quarter	Right inside quarter	Right outside quarter	Date of Survey	Project Dimensions: Width (feet)	Length (naut. miles)	Depth M.L.L.W. (feet)
Bar Channel	31.0	35.5	35.5	34.0	2-55	800	0.45	35
Outer Harbor Entrance Channel	b28.0	35.0	35.0	c27.0	2-55	650-600	0.87	35
Outer Harbor	32.0	33.0	32.5	29.0	2-55	600-950	1.40	35
Inner Harbor								
Entrance Channel	27.0	30.0	29.0	27.5	3-55	800-500	1.00	30
Inner Harbor Reach	d18.0	28.5	28.5	d21.0	3-55	500-600	2.27	30
Grove St. Pier to Brooklyn Basin	d22.0	29.0	29.0	21.0	3-55	600	1.30	30
Brooklyn Basin South Channel	28.5	28.0	28.0	18.5	3-55	600-500	0.90	30
Brooklyn Basin North Channel	15.0	18.0	18.0	10.0	8-50	300	0.93	25
Park St. Bridge Reach	21.5	24.0	24.0	18.0	3-55	500-275	0.42	30
Tidal Canal								
Fruitvale Avenue Bridge Reach	d11.9	17.0	15.5	12.5	8-50 4-57	275	0.35	a 25
Fruitvale Avenue to San Leandro Bay	12.0	15.2	16.0	9.0	8-50 4-57	275	0.73	a 25

a. Project depth is 25 feet but channel is dredged and maintained to 18 feet.
b. The depth was 31 feet except for a depth of 28 feet in the channel on the outside edge.
c. A depth of 22 feet exists in the channel on the outside edge.
d. The reported depths are in the channel on the outside edge.
Note.—The Corps of Engineers should be consulted for changing conditions subsequent to the above.

Figure 9. Key to Oakland Outer and Inner Harbors channel information, SF40 1947b/57

Context

As time passed, the draft of ships increased, and better definition of channels was needed to safely navigate through them. There were also fewer sailing ships needing wide channels to tack back and forth in as ships switched to steam and diesel power. Direct routes were then of most importance, and the deepest direct route at that.

In a report on standard symbology published in 1860, the survey noted that, in contrast to other efforts to reduce the amount of detail on charts, one item that that was to be added to charts was a representation "showing the channel of deepest water…(U.S. Treasury Department et al. 1861, 222)."

Topographic Information

Natural landforms have been represented on the C&GS charts in varying ways. This section examines the depiction of landforms above the shoreline on first the Harbor Charts through time, and then the General and Sailing Charts through time. The

discussion refers to Layout 08—Topography (other). The General and Sailing Charts are represented by fewer clips than Harbor Charts, due to multiple editions with no landforms shown.

Harbor Charts

On NY40 1844, topographic relief is shown with hachures (see Table 15 for a summary of the types of topographic relief depiction on each chart edition).

Table 15. Form of Topographic Relief Depiction

Time Period	NY40	SF40	MH400	GJF200	E1200	W1200
1	Hachures					
	Hachures					
2	none	Hachures				Hachures
	Contours		none?	Mtn. Symbol	none	
3	Hachures	Contours			Mtn. Symbols	Mtn. Symbols
4	Hachures	Contours		Contours, Mtn. Symbols and Hachures	Mtn. Symbols	
5	Contours and Hachures		none			
	none					Mtn. Symbols
6	none	Contours	none	Contours, Mtn. Symbols and Hachures	Mtn. Symbols	
7	none		none	Contours, Mtn. Symbols and Hachures	Mtn. Symbols	Mtn. Symbols
8	none	Contours	none	Contours and Mtn. Symbols	Mtn. Symbols	
		Contours	none		Mtn. Symbols	Mtn. Symbols
9	none	Contours	none	Contours and Mtn. Symbols	Mtn. Symbols	Mtn. Symbols

Wooded areas are filled with small tree symbols, each with its own shadow, as well as other dots for bushes. Agricultural fields are filled with a seemingly endless mix of lines, dashes, and dots running across each field at its own angle. It is not known if this illustrates the actual direction of plowed furrows in each field when it was surveyed, or

merely serves to distinguish them from their neighbors. Fields are separated from each other by what appears to be a symbol for hedgerow, a mix of circles and ovals of different sizes. Marshes are filled with many horizontal rows of small dots. Streams, rivers, and roads are cased by black lines of unequal weight. Smooth, regular, lines for roads maintain a nearly constant width between the lines, with blank interior space. Lines forming water bodies are wavy to a larger degree, the space between the lines varies, and the interior is sanded. Rural residential lots are mostly filled with a smooth gray tone that would have been created with very fine parallel lines, but some are unfilled. Buildings are shown as small black rectangles.

NY40 1845 shows that the 1:80,000 charts began their history with the C&GS with hachures for topographic relief, and fields and woods are distinguished.

In the **second time period**, the first edition of SF40 (1859/77) uses hachures for topographic relief. Roads are symbolized with parallel dashed lines, and fields are divided by single dashed lines. Buildings are shown as small black rectangles. Small streams look to be a single black line until they widen out sufficiently to represented as two solid lines. The scan does not show if pairs of lines for roads and larger water features are unequal weight. The lower clipping on the layout shows that some cultural and some topographic features received labels, such as “Ocean Ho.” and “Merced Lake”. The hachures that show the landform do not extend inland very far. By the scale on the chart, it averages about two miles inland before the chart goes blank.

NY40 1870 uses contour lines for topographic relief, instead of hachuring like the 1844 edition. Woods appear to be shown with the same symbol as before, while fields are divided from one another by a line or dash symbol of some kind. The scan does not have sufficient detail to ascertain what fill symbol is used for fields, or to tell if the lines between the fields are the same symbol used in 1844.

In the **third time period**, topographic relief methods are swapped. NY40 1878 returns to hachuring, while SF40 1883 uses contours. NY40 has elevations for the peaks of some hills: “240”, “260”, and “120” are distinguishable on the clip. One hill has a

symbol like ⊙ at the top labeled "NEW DORP BEACON". Apart from those additions, the rest of the land features appear to be the same as on previous editions.

SF40 1883, as previously mentioned, uses contours to show relief. A note explains that, "[t]he curves of elevation are given for every 20 feet difference of level. The figures on the hills show the height in feet. The Datum line is high water mark." The contours cover the entire peninsula on which San Francisco resides, unlike the hachures on the earlier edition. A few of the figures on the hills are seen in the lower clip. At the same time, engraved patterns are still used to show vegetation type. A stipple pattern is seen over much of the upper clip, while in the lower clip a patch of the woodland symbol is seen near the "Visitation Valley" label. Several cultural features are labeled, too. The upper clip has "Ocean Side House" and in the oval, formed from parallel dashed lines, is the phrase "Ocean House Race Course". The name of the lake noted on the previous edition has been changed to "*LAGUNA DE LA MERCED*", and the lake is filled with waterlining.

In **time period four** the waterlining has been removed from Laguna de la Merced on the upper clip of SF40 1901. On the lower clip, the tightly-spaced horizontal lines along the shore, probably representing marsh area, that appeared on the 1883 edition have also been removed. Apart from those two changes, the topographic representation appears to have been kept static. NY40 1902 uses the same representational approach as NY40 1878.

In the **fifth time period**, however, NY40 makes a major change. The 1914 edition uses a representational vocabulary that is very closely related to earlier editions, but which is not as fine or individualized. There are fewer unique symbol forms, especially area and fill types. Fields are still filled with pattern, but there appears to be only two: a type of stipple for plowed fields, and rows of dots for orchards. Hills are shown with hachures, but they are very regular, more coarse, and do not provide the same quality of appearance, hampering the sense of shading and relief. The primary source of topographic information is now contour lines at 20-foot intervals, rather than the detailed hachures of earlier editions. Some hills still do have their elevations labeled. Barely

visible in the lower clip is one small lake or pond that is filled with waterlining, as are the rest of the lakes on the chart, unlike earlier editions. Some buildings are shown as rectangles, a heavy outline filled with tightly-spaced, fine, parallel lines that appear to be a solid fill at low resolutions.

For NY40 1917, even more dramatic changes are seen. Nearly all topographic information has been removed. The only things left are the marsh symbol and elevations of hills. No contour lines, no hachures, no property lines, and no field or woodland fills are present. Large areas of upland have been cleared of cultural information as well, cutting off the road and rail network within a few miles of the shore, even on Staten Island. All lakes and ponds have lost their waterlining except for those in Central Park (see Layout 00—Full Sheets). Some of the buildings shown on the chart are filled with a cross-hatch, rather than a solid fill or parallel lines.

No edition of SF40 is available for the fifth time period.

In the **sixth time period**, NY40 1926 has a few small changes from the 1917 edition. Some labels for cultural features are given knockouts[21] for area fills, in addition to the knockouts for linear cultural features available on the previous edition. The shoreline has been generalized a bit more than previous, and Pralis Island has had the marsh fill that ringed the shoreline on the 1917 edition removed.

SF40 1926 differs from the 1901 edition primarily in the amount of cultural features present, rather than changes to representational techniques. This change is more due to growth of population on the San Francisco Peninsula than to improvements to the chart. Relief is still shown through contours, although now every fifth contour (100 feet) is a thicker line than the others. Tops of hills are still labeled with elevations, and area fill is still present for several types of vegetation. Some roads are shown with parallel solid lines, a change from the exclusive use of dashed lines for roads. Between Laguna Puerca and Lake Merced on the upper clip, a road is lined with symbols for deciduous trees,

[21] Where a label or other symbol that is placed on top of another symbol has a solid fill that replaces the underlying symbol. This helps the map user distinguish the topmost symbol.

demonstrating that a wealth of detail was still provided for cultural information and topography above the waterline.

For **time period seven**, NY40 1936 appears to have no changes from the previous edition. No edition is available for SF40.

The **eighth time period** does have changes on NY40 1944. The symbol for marsh has changed to an overprint of blue on yellow to create green. It is outlined by a dashed line where not otherwise bounded by other cultural or topographic features (roads, railroads, stream banks, shorelines, etc.) within the two-mile swath of upland detail. It is also repeatedly labeled by the word "marsh" in a lowercase sans serif font face. Labels for natural and cultural features that are placed within the color fill do not knock out the color like they did for the marsh symbol on the previous edition. Buildings are filled with heavier parallel lines. The absence of some sections of the road and rail network appear to be updates to reflect what is built, versus merely platted, as it seems unreasonable for such large sections to be demolished and replaced by marsh in such a short period of time. More natural features, particularly creeks, are labeled—note "*Morse Cr.*" and "*Piles Cr.*"

For SF40 1947a and 1947b/1957, no changes to representation are seen. It is interesting to see the bay between Candlestick Point and Visitation Point progressively filled-in, however. Also, between these two editions, the name "Visitation" was changed to "Visitacion."

General and Sailing Charts

The General Charts and Sailing Charts always had less topographic detail than the Harbor Charts. Starting with W1200 1855/64 in the **second time period** it is clear that the smaller scale charts have very little information on inland landforms. This Reconnaissance Chart does have a thin strip of very generalized topography along the U.S. Pacific coast (but not on Vancouver Island) that is represented as hachuring and vague dotting that has not reproduced well. The clip shown on the layout has less detail

than parts of the coast further south. No topographic or cultural information is shown further inland than the thin coastal strip.

GJF200 1862 is the first example here that represents important mountain peaks within sight of water through the use of a generalized symbol for mountains, labeled with the name of the feature and its height in feet. On this chart it is not a standard symbol, as each is drawn individually with some indication of relative size shown by the size of the symbol. It is a modified hachure-like symbol, created by drawing rays out around a central circular void. The clip on the layout shows "Mt. Constitution 2411 ft." and "Entrance Mt 1120 ft." on Orcas Island. Apart from such peaks, there are no other landforms shown. As with E1200 1863, land is distinguished from water by many parallel horizontal rows of dots that serve to give a gray tint to the land. It only continues a few miles inland from the shore, however. Past the ribbon of dots the land is left blank.

MH400 1862 has areas of detailed landforms, as shown in the clip, but most of the land is left blank. This is the only edition of MH400 with any topographic information at all, and clips are not provided for the other time periods. The clip for the 1862 edition shows Cape Charles at the southern end of the DelMarVA Peninsula just north of the entrance to Chesapeake Bay. It is very marshy, and may have been included with such detail because some of the channels are navigable, or for expediency through unrevised photographic reduction from larger-scale charts. Marsh areas are indicated with a marsh fill symbol, while solid land appears to be filled with a combination of gray dots, and larger circles representing vegetation. It is not clear from the scan if the darker meandering shaded areas are representing actual landforms, or are a generalized symbol. On other parts of the chart (see Layout 00—Full Sheets) land area is represented for a much shorter distance inland.

E1200 1863 has no topographic information at all. All of the land area is shaded with rows of small dots to appear gray and provide contrast to the paper-colored water areas. The only cultural information shown is the dark, heavy patterned area representing the city limits of New York City and Brooklyn.

In the **third time period**, both of the sailing charts use the mountain symbol to indicate navigationally-important peaks. On E1200 1881 "Agamenticus Mt. 728 ft." in Maine is shown, while the nearby "*York R.*" is only labeled, not shown continuing past the tidal zone. Inland areas are not filled with rows of dots as the previous edition was, but are left empty.

W1200 1888 does have its land area filled with a gray tone, although a legend area with a white background sits over much of the land. It also shows all of the important peaks of the Coast Range and Cascade Range. Many but not all include height in feet, and each is symbolized with unique version of the mountain symbol. Several mountains are shown within the legend box ("Mt. Jefferson 10567", Dodson Butte 3045", "Mt. Pitt", "9000 Mt. Scott", and "Thompson"). Heights are in a different lettering face than the names of the mountains.

For the **fourth time period**, GJF200 1895 has a mix of several types of topographic representation. On some areas, particularly within Puget Sound and the San Juan Islands, topography is shown with 100-foot contours (heavier lines every fifth contour) and spot heights, and vegetation types are shown with area fill symbols much like what was being used for SF40 at this time. Elevations are in a different font than names. This level of detail is inconsistently applied, however. Orcas Island, for example, is only partially detailed, with much left blank. Elsewhere on the chart (see Layout 00—Full Sheets) topography is shown with hachures. This is particularly prevalent in areas of the charts showing Canada. Islands along Georgia Straight have the most detail, with less detail present on Vancouver Island. The symbol for mountain is also on the chart, most noticeably on the south side of the Straight of Juan de Fuca on the Olympic Peninsula. Several hills and peaks are shown with the not-quite-full hachuring of the mountain symbol. None are identified with labels.

E1200 1900 is the first chart used here that was lithographed, and as such is the first seen to use yellow ink as a fill for land. No engraved texture is provided, as it has been replaced by the color. As with the previous edition, navigationally-important hills are shown with the symbol for mountain. Heights are now provided in a sans-serif font,

while names are still in a serif font. Inland waters are now shown to continue further away from the coast than in the previous editions.

For **time period five**, W1200 1917/26 still has many mountain symbols, but the style has changed. The radiating lines are now heavier, which is a change similar to the hachuring seen on NY40 1914. The clip shows that some peaks have been joined into groups by other hachures. Some peaks now have heights without labels giving their name, while others still have neither. The only other inland topographic information shown are single lines for some rivers, extending only a short way from the coast.

The **sixth time period** has GJF200 1922 showing detailed topography on Orcas Island. As with the previous edition, landforms are shown with contours and spot heights for peaks, and vegetation is shown with area fill symbols. Contours are now used for the Canadian islands along the Straight of Georgia, although peaks on Vancouver Island are still shown with mountain symbols. Canadian islands along Haro Straight are still shown with hachures. On the Olympic Peninsula, the peaks shown with mountain symbols are now partially set within 200-foot contours drawn with dashed lines. The contours are incomplete and apparently provisional, although no note mentions this. The river systems are now more complete and extend further inland. Small sections of solid-line 100-foot contours with vegetation-symbol fill are also present in a ribbon along the U.S. side of the Straight of Juan de Fuca. Other parts of this shore have hachures instead of contours.

The clip for E1200 1927 shows that it had changed to the new, heavier form of mountain symbol since the previous edition. There is also a bit more detail for inland waters near the coast. The height for Agamenticus Mt. has been changed to "673 ft."

Time period seven

W1200 1932 has no changes from the 1917/26 edition, and E1200 1938 has no changes from the 1927 edition. Of note is the poor registration of the color plates relative to the black plate on E1200 1938.

GJF200 1933 has dramatically different topographic representation than the 1922 edition. The chart was converted from copper plate to lithographic printing, and with the change came a reduction in topographic detail. Vegetation area fill has been removed.

Contour lines, where present, are every 200 feet instead of every 100 feet, in both Canada and the U.S. Meanwhile Vancouver Island and the islands in Haro Straight still have peaks shown with mountain symbols and hills with snaky, rudimentary hachures. On the Olympic Peninsula additional areas are shown with contours, but parts do still have the dashed contours first seen on the previous edition. All hachures along the coast have been replaced by contours.

In the **eighth time period**, GJF200 1941 continues its progression from hachures to contours for Canadian land area, while no changes are made to US topography. The clip of Orcas Island shows no changes to representation, but elsewhere, particularly on Vancouver Island, fewer hills are represented with hachures than the 1933 edition, and those are all inland past where additional contours line the coast.

E1200 1943 has a different representation of the mountain symbol than the 1938 edition. Compared to the previous edition it is much more distinctly two concentric circles made of short lines radiating from the center point. The 1938 edition looks at a glance to be a single circle of radiating lines, while very close inspection reveals two rows that touch.

For W1200 1945/54, the only change in upland information appears to be a switch from upright to italic numbers for spot heights on mountains. The mountains themselves are still shown as mountain symbols.

Engraved Views

One other method of showing landform information that was used on some charts was the **engraved view**. Some of the earliest charts were not only works of art themselves, but had separate, inset landscape engravings included. They were drawn from the point of view of a ship's captain looking toward land, and typically showed entrances to bays, headlands, and other prominent landmarks that would be useful to piloting a ship. They were engraved in the Washington DC office, based on drawings and descriptions provided by the survey crews. Table 16 notes which of the charts used here include engraved views. Layout 00—Full Sheets should be consulted for greater detail.

Table 16. Charts with engraved views

Time Period	NY40	SF40	MH400	GJF200	E1200	W1200
1	Yes					
	Yes					
2	no	Yes				Yes
	no		no	no	no	
3	Yes	no			no	no
4	Yes	no		no	no	
5	Yes		no			
	no					no
6	no	no	no	no	no	
7	no		no	no	no	no
8	no	no	no	no	no	
		no	no		no	no
9	no	no	no	no	no	no

Discussion and Context

NY40 1844 probably has the most landform detail of any charts examined in this project. Part of this can be attributed to it being the largest scale, 1:30,000. But much of the responsibility lies with the decisions of the first Coast Survey Superintendent, Ferdinand R. Hassler. The first baseline surveyed was in the vicinity of New York, and this was the first example of the Coast Survey's work, so undoubtedly extra effort went into it. The survey was not occupied with simultaneously working on nearly as many charts as in later years, and the issue of updating charts as information changes had not been discussed in the agency's annual reports. Later, as more charts were published, updating content took a larger and larger percentage of the survey's effort. Eventually it was decided that topographic detail would be reduced, in part to focus the charts on nautical information, but partly to save effort on updates to the quickly-changing cultural information.

It was recognized within the survey as early as 1854 that hachures may give way to contours. In a report on engraving included as an appendix to the annual report, it is noted that, "The method of hachures has some radical faults, which make its perpetuity only desirable in case nothing better can be substituted. The extent to which it sacrifices the distinctness of the contour lines will, as contours become more universal in surveys,

be felt as a growing objection," and "[i]t seems by no means impossible that ere long some cheap, clear, expressive and tasteful system of hill delineation may supercede hachures with great advantage (U.S. Treasury Department et al. 1855, 211)." It is time-consuming, and therefore expensive, to engrave hachures, and the office was behind in its engraving work for many years due to shortage of skilled engravers (U.S. Treasury Department et al. 1856a, 21, 252).

Contours were used on experimental map created in 1866. They were combined with "shading in crayon" to produce relief, and it was printed in color (U.S. Treasury Department et al. 1869a, 7).

In 1935, the symbol for 'Marsh' was made more distinctive on large-scale charts (U.S. Department of Commerce et al. 1936b, 141).

Cultural Information

The C&GS charts published in 1844 have very different representation of man-made structures and impacts on the landscape than the charts published by World War II. This section refers to clips on Layout 07—Urban Topography. It first looks at the Harbor Charts through time, and then the General and Sailing Charts together.

Harbor Charts

The clips from the NY40 chart focus on a town in New Jersey called Perth Amboy, with supplemental clips for the more urban area of New York City. The smaller town provides a better balance of showing both urban and rural cultural landforms.

NY40 1844 shows how the survey included highly detailed information about cultural features on its charts. Roads are represented as the voids between city blocks within town, and as the void between two parallel lines outside town. It appears that one of the lines casing the roads is usually heavier that the other, giving a look of shaded relief. Within the city blocks individual platted properties are shown, along with alleys. Within properties, structures are depicted as black rectangles that appear to show the building footprint. The town square is depicted with a single structure in the center,

flanked by two rows of four smaller dots that could be trees or small structures. Lots are shaded with different patterns (rough, smooth) and degrees (light, dark) of shading, presumably to indicate type of vegetation and groundcover, as well as if the land has been cleared. Many individual trees are shown, particularly along roads and hedgerows, and in fields. Farmland outside the town is represented with several different types and combinations of dashes and lines, presumably to represent particular types of crops. The town name is provided in proud capital letters placed along on the horizontal, with large serifs and a slight lean to the right.

Somewhat less information is shown for the urbanized areas around New York City. Platted blocks create the outline for the street system but individual buildings are not included. Some roads are shown as wider than other roads, presumably to indicate local importance. The blocks are filled with either of two degrees of shading, with more central blocks shaded darker than peripheral blocks. It may indicate which blocks are inside and outside the city limits. The unequal line weight for the outside of the blocks is most evident on the lightly shaded blocks south of Brooklyn. It gives them an extruded look, creating the appearance that they have height and are sitting on top of a flat ground plane, illuminated from the northwest.

On NY40 1845, this smaller-scale version of the earlier map shows Perth Amboy as a cluster of dark rectangles that end up defining a partial street network through figure/ground contrast. It does not appear that city blocks are shown. Outside town the roads are shown as what appear to be single lines, and the shading of the farm fields is much less pronounced and detailed. The city label is in the same location, but uses thicker lines that are not as elegant, although it is still oriented horizontally with a slight italic lean to the right.

For the **second time period**, NY40 1853 does not show any urban cultural features, and a clip is not provided.

NY40 1870 is a poor scan that obscures the ability to identify if fine detail present on the 1844 edition is still in use. Shaded city blocks still create the road network through figure/ground contrast, but the line weight appears consistent on all sides of the blocks.

Individual structures are shown as before. The town square has a circle inscribed in it, but no structure. There appears to be differing degrees of shading in some places, but the patterns are obscured. Fields are divided into properties by lines of perhaps two weights. The name of the city has moved to an arc oriented mostly north/south. A railroad has been added that runs from the northeast to the southwest as a straight, black line with what may be crossties. The font is more like the thicker font of the 1845 edition than 1844, but does not have an italic slant.

SF40 1877 forms San Francisco using the same technique: outlined city blocks with interior shading create the road network through contrast. Roads vary in width, blocks reflect their actual dimensions, and structures are shown in black in some of the city blocks. Several of the streets jut out into the bay, presumably indicating wharves. The name "City of San Francisco" is placed in an arc from northwest to southeast cutting across the street grid in a font similar to that used for Perth Amboy on NY40 1870.

In **time period three**, NY40 1878 has reduced the amount of detail for the city of Perth Amboy. Roads are depicted as before, but there appears to be less detail for property lines within the blocks, and fewer buildings are included. Again the scan makes distinguishing the finest detail challenging, but there do not appear to be individual trees depicted, either along the roads or in the fields. The railroad is somewhat more distinguishable, particularly the regularity of the crosstie marks. The town square no longer has the circle inside of it.

SF40 1883 has similar scan clarity issues, but changes from the second time period look similar to those of NY40 1878. The relationship of roads and blocks is the same, but fewer buildings are distinguishable, even though the city has grown substantially. The label for the city has moved and is not visible on the clip. Some of the blocks appear to be entirely filled in, as with most urban blocks in Brooklyn on NY40 1844. Some of the streets appear to be black lines, which may show railroad or trolley tracks.

For the **fourth time period**, NY40 1902 has no changes to representation of cultural features, and only a few alterations to the features themselves. A few structures and a few roads have been added. SF40 1901 has the same situation.

Time period five does not have a sample of SF40, but the two examples of NY40 (1914 and 1917) both have changes, the latter more dramatic than the former. On the clip of Perth Amboy on the 1914 edition the base information is largely the same as the 1901 edition, and it is represented in the same way. Two changes stand out, however. First, a standard symbol for a tall structure is shown, which looks like ⊙, and is labeled as a spire. Second, the railroad symbol expands into a larger symbol, perhaps for a trestle, as it nears the water. It appears there is a special symbol for the railroad bridge crossing the water, as well. These are the first examples of emphasis on navigationally significant land features at this location.

On the other clip from NY40 1914 several changes from 1844 should be noted. As with Perth Amboy, the blocks that frame the road system have equal weight lines on all sides, so the effect of relief shading is no longer present. More of the blocks are filled with a dark tone, although some do have a lighter tone—parks or greens, as suggested by the fine path systems shown in two of the blocks. These lightly shaded blocks are also framed with a lighter line. Near the west edge are some blocks that are outlined with the same line, but have no interior shading. The fort on Governor's Island is drawn with a single line instead of a double line, but additional structures are shown as black rectangles. Navy Yard has many structures shown, as well as bare ground.

It is NY40 1917 where the really dramatic changes are seen. The urban features are symbolized very differently, and do not extend as far away from the water's edge. The figure/ground relationship of roads to blocks has been reversed. It is now the few roads that stand out, rather than the blocks. The blocks are no longer shaded and no vegetation or property lines are shown, nor are fields distinguished. There are very few buildings shown, and they are all apparently either large or otherwise visible from the water since they are clustered along the shore. The decrease in cultural information makes the symbol and label for the spire stand out more than on the previous edition,

making them easier to locate on the chart. The railroad tracks are also easier to identify, and all of the feeder and siding tracks are shown, not just mainline tracks. The same symbol is used for the all of the track. The special symbols for 'railroad trestle' and 'railroad bridge' are not seen. One of the mainline tracks is now labeled with the name of the railroad company ("L.V.R.R.", for the Lehigh Valley Railroad). The label for the town name has moved. It is now an arc through the town, rather than being an arc around the town, which better identifies the town's location. The font for the town label is heavier, and the serifs are not as fine. The letters also have a slight halo. The road network is disrupted to make way for the letters, rather than the letters being directly against the ink of the other symbols, as before. The majority of the 'map' information has been removed from the chart, firmly establishing its identity as a nautical chart.

For the **sixth time period**, no representational changes are seen on NY40 1926, although the shoreline has been updated and a few structures added. SF40 1926 still uses the older representational technique as the primary feature of the chart, with shaded and outlined blocks creating the street network. Blocks are divided into properties, and some properties have structures shown. Railroad or perhaps trolley tracks are shown in the middle of some streets. There is more navigation-related information shown within the city, also. New labels are provided for towers and spires, and they knock-out the street network to aid legibility, with "TIME BALL", "FLG. STF.", and "FERRY TOWER" as examples.

For the **seventh time period**, NY40 1936 adds two items of note. First, some further definition is provided to the label for the first spire that was labeled in the town. It now reads "SPIRE(ST.PETERS CH)". The second item of note is the addition of a joined pair of circles denoting "STACKS" near the L.V.R.R. yard in the upper right corner of the clip. Instead of shifting the symbols' locations to make two copies fit, the actual location of both spires are shown with the two small dots, and the surrounding circles are modified to fit. Additional features are labeled, but the symbology has not changed.

For the **eighth time period**, on NY40 1944 the symbol for tall structures has changed to a larger circle, with more interior white space between the outer circle and the

center dot, looking much like ⊙. It seems to be easier to spot at a glance than the smaller symbol used previously. The double circle symbol for the pair of stacks mentioned on NY40 1936 has similarly been enlarged, but the larger outer circles join in such a way that it is more difficult to tell what the symbols are. The text used to identify such structures remains the same font, size, and weight, although the label for the spire has had spaces added to it, taking up more room across the chart. It now reads "SPIRE (ST. PETERS CH)". To allow this longer label to fit, the label for the town name has shifted slightly north, and its letter spacing has been tightened, so it takes up less space on the chart. One last change to note is that the town square now appears to be an oval of road surrounding a central oval.

For SF40 1947A and 1947b/57 almost no changes to the urban landform representation are seen. Both have larger circle symbols for tall landmarks than the 1926 edition has, as does NY40 1944. While nearly all roads are formed as the spaces between city blocks, a bridge and its off-ramps are first shown in 1947A as the inside of a pair of lines that pass over city blocks.

General and Sailing Charts

For the General and Sailing charts, cultural features and urban forms receive much less importance than do those features on the Harbor Charts. They begin in the **second time period**, where there is little consistency in typography or representation seen. Poor scans impair the ability to compare many of the fine features. The clip for MH400 1862/72 has no urban features, but is shown as a comparison for later editions.

GJF200 1862 has two cultural features. A representation of the layout of the town of "Port Townshend", Washington, is shown as a grid of lines along the shore. It is unclear if this slightly uneven 2 by 6 grid of lines represents the actual street layout at that time, or if it is purely representational. The historic downtown of Port Townsend today does have a similar orientation. The second cultural feature shown on this clip is an unnamed "*Military Post*", rendered in a neat, italic, slab-serif cursive (the 'i-l-i-t-a' of 'Military' are all joined).

E1200 1863 shows New York City and Brooklyn as either a dark mass, or more likely a tight grid (the scan is poor). No label is visible for New York City, although it could be hidden in the dark mass. The 'B' of "Brooklyn" is hidden, while the rest of the label extends horizontally to the east of the city.

W1200 1855/64 shows a label for the city of Astoria, Oregon. A symbol for the city is not distinguishable on the scan. The label arcs away from the location of the town to the southeast.

The **third time period** only has two editions with clips, one each for the Sailing Charts. E1200 1881 shows the city of New York now labeled in all-capital letters, while Brooklyn uses the title-case letters seen on the earlier edition. The poor scan shows only a few weak lines.

W1200 1888 sees the label for Astoria placed on the horizontal below and to the right of what appears to be a symbol for the town. The symbol is just a smudge in the scan, and no details are visible.

Time period four also has two scans, GJF200 1895 and E1200 1900. The former shows a larger grid of streets for Port Townsend, as well as the modern spelling of the town's name in title case, placed horizontally. The scan for E1200 1900 has sufficient detail to show a fine grid of streets for New York and Brooklyn, as the previous charts probably also showed. The lettering for the labels of New York, Brooklyn, and Jersey City (new to this edition) are all the same, while the town of New Brunswick, New Jersey (also new to this edition of the chart, and also shown as a grid of streets), is in title case. The label for New York has moved to the northeast of Manhattan, at an angle, while the other labels are horizontal.

The **fifth time period** has examples of the other two small scale charts, MH400 1916 and W1200 1917/26. MH400 has street grids for three towns: Cape May, Hollybeach, and Anglesea. All three are shown with the same type of street grid as other small-scale charts, and all are labeled in title case on the horizontal. In addition, the chart shows train tracks, including spurs. The two main lines are labeled with the name of their

railroad companies: P. & R.R.R. (Philadelphia and Reading Railroad), and W.J.& S.R.R. (West Jersey and Seashore Railroad).

On W1200 1917, Astoria is shown by the standard small street grid, again showing in a high-quality scan what was perhaps present on the earlier charts, although illegible on the scans. The town label has switched back to being placed along an arc running to the southeast, but is still in title case.

Time period six shows no changes to the form of the urban landscape representation on any of the three example charts. For MH400 1922 the only change of note is the name change for the two adjacent towns of Hollybeach and Anglesea, which on this chart are combined into a single name, Wildwood. On GJF200 1922 the street grid has grown, and there may be a railroad entering town along the shore from the south, but there are no representational changes. For E1200 1927 the same can be said, with the caveat that an additional town is shown. Elizabeth, New Jersey, has been added as another small street grid labeled the same way as Jersey City and Brooklyn. Meanwhile, New Brunswick is still labeled in title case, rather than all caps.

The **seventh time period** has examples of all four charts. MH400 1938 shows no representational changes, although the street grid has grown. For GJF400 1933 the author's scan did not include Port Townsend, so a clip of a different urban locale is shown. Victoria, British Columbia, is shown with a street plan that apparently represents all major streets in the city as they are actually laid out. Navigationally important features ("DOME", "STANDPIPE") are represented the same way as they are on the Harbor Charts, with a ⊙, although the size of the circle and dot symbol is small relative to the size of the label for the feature. The city name is in a slab-serif font, all caps, while the smaller nearby town of Craigflower is in title case.

E1200 1938 has one addition to note. At least two radio towers have been added. They are represented by the ⊙, and labeled with "R.T.", plus their call letters are included in parentheses: "(WOR)", and "(WEAF)". For W1200 1932 no changes are seen for Astoria, but a symbol for a tall structure has been added at Pt. Adams. The ⊙ appears to

be placed over the ‘s’ in “Adams”, and the label “NRC” appears to be stamped on, indicating the chart has been updated by hand after printing.

The **eighth time period** has six clips for the four charts. MH400 1942 no longer shows a spur line connecting Wildwood to the mainline tracks along the shore, but otherwise has no changes. MH400 1951 shows only a single mainline railroad at Cape May, the P.R.S. R.R. (Pennsylvania-Reading Seashore Lines Railroad). In addition, a canal is now shown connecting a harbor to the east of the town of Cape May, through the peninsula to Delaware Bay.

On GJF200 1941 there is definitely a railroad south of Port Townsend, but it does not appear to go all the way to the town. No representational changes are seen.

E1200 1943 appears to slightly change the representation of the urban street grid. The grid looks like it is more generalized than in previous editions. While oriented correctly, the pitch of the lines appears to be equal for all of the cities in the area, which suggests that it does not exactly represent the location of the streets, but is instead a standardized area fill symbol. Two other changes appear: first, a shift in the labels for the New Jersey cities from being placed on the horizontal, to an arc from the northwest to southeast; second, the abbreviation for ‘Radio Tower’ is now “R.Tr. ” instead of “R.T.” For E1200 1948, no representational changes are seen, but an additional major town, Newark, is present. Other changes include a different line type for state lines, and a switch from sans-serif text on the horizontal to serif text along an arc for state labels (see Layout 08—Topography (other)).

For W1200 1945/54, the label for Astoria has changed back to being placed on the horizontal. To make it fit it has been displaced away from the street grid representing the town. This grid is slightly smaller than the previous chart, as a line or two are missing from the west edge of town. The tall structure stamped on the previous edition is absent, but a new radio tower is located on the west edge of town. It is labeled “ R TR (KAST)”, which is a slightly different construction for the abbreviation than the radio tower labels on E1200 1943 and 1948.

Context

It is clear that a major change was developed over time in the conception of the Harbor Charts. They began with the purpose of helping navigators safely make harbors, but also for the military to wage war. No other accurate maps of the country had been created that were tied into a geodetic system, making any topographic and cultural information on these map/charts new and important to the country. Later, the role of topographer for the country was handed to the U.S. Geological Survey, and most of the topographic information that had been included was no longer needed on the nautical charts. At the same time the needs of navigators were changing. Their vessels had deeper draft and were faster, moving under their own propulsion. Additional navigational aids were installed and maintained by the U.S. Coast Guard and the Light-House Board, making navigation simpler.

Competition with other agencies (and private map publishers) eventually led to other map series that provided land-side information. The C&GS could then focus the charts on being nautical charts, and not imagine they would be re-purposed. For example, no intercity roads were shown on later maps.

As the C&GS published more charts, greater effort had to go into maintaining the accuracy of the charts already published. Removing information was a way to save money, since it would no longer have to be updated.

CHAPTER V

ANALYSIS

The changes to the Coast and Geodetic Survey's published charts that occurred during the 100 years chronicled in the preceding chapter were enacted for many reasons. A large number of small changes made for unique reasons added up to wholesale change over time. This chapter identifies and explains the most important of the reasons, and attempts to loosely tie those reasons to specific changes noted in Chapter 4.

Technological Change

While not the only cause, and in many cases only a proximate cause (not an underlying driver), changes in technology played a crucial role in the changes to the chart end-products. Many of the changes would not have been possible without specific technological breakthroughs.

Shipping and Boating

Changes to the size, draft, and speed of ships were an important driver for changes to the charts. As Kerr and Anderson note, there was only evolutionary change in the design, construction, and capabilities of ships between the thirteenth century and the first half of the nineteenth century (1982, 440). These modest changes led to a doubling in length and draft over the course of 600 years. It was not until the widespread adoption of both powered ships and iron and steel construction that the needs of navigators began to change. Weber, writing in 1923, provides a succinct explanation:

> In the days of sailing vessels, when the draft of merchant vessels did not exceed twenty feet, when sailing vessels often had to beat back and forth across the harbor in order to enter it, these was no need for one deep, clearly defined

> channel, but it was necessary to know the location of the dangerous shoal areas over the entire harbor, and surveys were made accordingly.
>
> With the introduction of steam vessels and the increase of draft which now requires a depth of forty feet from some of them, it became necessary to seek out in each harbor the deepest channel available…. This necessitated resurveys, not so much of the entire harbors, but close examination to locate and define these channels. (Weber 1923, 21)

Other contemporary writers made the same points, including C&GS annual reports in 1909, 1914, 1915, 1917, and 1929 (U.S. Department of Commerce and Labor et al. 1909; U.S. Department of Commerce et al. 1914; U.S. Department of Commerce et al. 1915, 1917; U.S. Department of Commerce et al. 1929); Representative J. Hampton Moore in a speech commemorating the centennial of the C&GS (U.S. Department of Commerce et al. 1916a, 59); an agency report on nautical charts (Jones 1924, 4, 8); and Figure 10 (a version of which is found in the 1917 annual report).

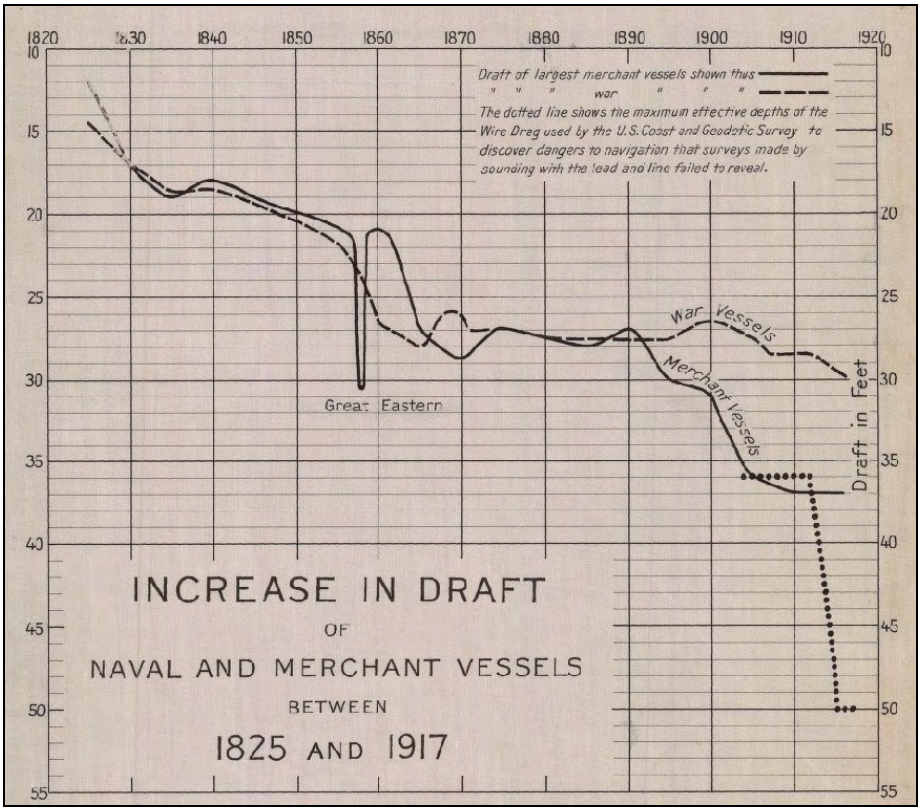


Figure 10. Increase in draft of naval and merchant vessels between 1825 and 1917. NOAA Historical Map & Chart Project, 0_B-00-0000.sid.

The change in the motive power of ships from wind to fuel, and the increase in draft that came with the increase in overall size that became possible with the advent of iron and steel ship construction, led to a change in focus for hydrographic surveying and the charts that were their end product. Initially surveyors focused on finding the hidden dangers everywhere, and charts focused on tidal currents and sailing directions that would help a sailor navigate along shore and into harbors with only the limited control that sails provided. With the changes in shipbuilding technology came a focus on finding the safest route for deep-draft vessels and charting the safest routes in the clearest manner. Resurveys were required.

It was the increase in the speed of ships, however, which had the greatest impact on chart design (Kerr et al. 1982). Deeper drafts requiring deeper clear zone and dredged

channels had a greater impact on surveying than on the finished charts. Increases in ship speed, however, required the navigator to be able to identify navigationally important chart features more quickly. Around the year 1900, American warships could achieve 18 knots. In 1943, the battleship Iowa hit 35 knots (Kerr et al. 1982). These changes to the needs of military navigators led to pressure to simplify charts and make navigational information more prominent.

Among the design changes noted in Chapter 4 that relate to the changing needs of navigators are the reduction in landside detail, outlining the sides of channels, changing navigational aids to make them more prominent, and the fact that the danger line kept getting deeper.

Submarines also contributed to the need for more accurate and detailed hydrographic surveys. Around the time of the First World War the military began to require charts to have accurate hydrography down to 100 meters or more (U.S. Department of Commerce et al. 1915, 9). No longer just useful for determining location for lost ships, knowledge of these depths was required for submarines to operate safely.

Another change in maritime activity was the rise of population of boating in small craft. The advent of gasoline-engine powered recreational motorboats led to a major part of this class of use, and recreational yachting and commercial fishing comprised most of the rest (U.S. Department of Commerce et al. 1923, 21; U.S. Department of Commerce et al. 1950). An increase in free time, discretionary spending, and improved land transportation predicated the recreational uses, according to the survey (U.S. Department of Commerce et al. 1923, 23). Noted as a new source of chart users in 1911, the agency responded by creating additional large-scale charts to serve the needs of recreational boaters (U.S. Department of Commerce and Labor et al. 1912, 12). It also began to publish charts pre-folded instead of rolled, so as to better fit in small boats. While not necessarily affecting the content of the charts, these new users pushed up demand on the agency's resources in the 1920s, adding to the pressure to speed up chart production while reducing costs. Among the agency's responses was the decision to remove non-essential topographic information from the charts, freeing some staff time.

Data Acquisition

Scientific advances between 1844 and the start of WWII brought efficiencies to topographic and hydrographic surveying, increases in the amount of data collected, and increases in data precision and data accuracy. New materials such as invar steel; new machines and devices like electric motors, gasoline engines, airplanes, aerial cameras, lanterns, the telegraph, wireless radio, and recording acoustic depth finders; and new methods such as wire-drag surveys, photographic surveys, and radio-acoustic ranging, all helped the survey do more, and do so more accurately, in less time, and at a lower unit cost.

As noted by Robinson, "instrument development … acted as an indirect stimulant to the production of more accurate charts (Robinson 1952, 368)." As instruments developed greater accuracy, precision, and speed, charts kept up. Shalowitz also ties together charts and technology, stating that, "[p]rogressive improvement in the nautical charts is, in the main, coextensive with the development of systematic surveying and of surveying techniques, including instrumentation and equipment (1957, 292)."

The C&GS has always been relatively quick to adopt technological advances. As one annual report explains,"[w]e have found by long experience that our work can be done better, quicker, and cheaper almost in proportion as we keep abreast of scientific research in metallurgy, electricity, optics, etc., and appropriate to our use such advances as will be of benefit (U.S. Department of Commerce et al. 1926, 5)." One example of this is the rapid adoption of long-distance communication tools for improving the speed with which the survey was able to make longitude determinations for new locations. The survey first used the telegraph to determine longitude in 1846 when it began sending time signals between telegraph stations (U.S. Treasury Department et al. 1847, 32). The Trans-Atlantic telegraph cable was successfully used for determining longitude across the ocean, with the result applied to the survey's charts in 1877 (U.S. Treasury Department et al. 1880, 64). Very soon after wireless telegraphy was invented, it was also used by the survey in tests for longitude determination (U.S. Treasury Department et al. 1903, 12).

All of these advances served to generate data with greater accuracy in less time than previous methods.

Even inventions like the electric light and invar steel helped increase the speed and accuracy of data acquisition. The 1887 annual report noted that a battery-powered electric light was acquired for use by field surveyors. It was expected to improve night-time readings of micrometers (U.S. Treasury Department et al. 1889a, 90). Use was limited until dry cell batteries could be used instead of liquid batteries (U.S. Department of Commerce and Labor et al. 1905, 100). Invar steel, which expands and contracts less due to temperature changes than regular steel, was invented in 1896 (Collier 2002). It was quickly adopted by the C&GS in topographic surveying for measuring tapes, which led to more accurate distance measurements in less time (U.S. Department of Commerce and Labor et al. 1906, 101).

Electricity provision improved during the course of the survey's first 100 years. Its first use in the survey was in supplying current for electrotyping via wet cell batteries. Electric light was later used in photography (replacing sunlight for photolithography) and general illumination of the survey's offices. Florescent tubes were installed in the engraving division's light tables in the mid-1930s. Electricity also came to power the survey's presses.

Remote measurement was also made possible by electricity. In 1901, the survey first installed tide gauges that could send readings over a wire to a remote recording device, instead of only recording on-site (U.S. Treasury Department et al. 1902, 223). This reduced the cost of collecting such measurements and made the information available more quickly.

Photography for data acquisition was also adopted by the survey relatively quickly. A boundary survey for Alaska was sped to completion in the 1890s using photography, for example. The C&GS began using aerial photography as a source of information for chart revision in 1919 and for surveying wetlands in 1924 (U.S. Department of Commerce et al. 1920a, 86; Collier 2002). The C&GS also designed and was the first to use a nine-lens aerial camera, seeing good results from its first use in 1936

(Landen 1952). It served to reduce the need for ground control in areas that were difficult to access, particularly wetlands in the southeast.

Technology also advanced hydrographic surveys, not just topographic surveys. Mechanical soundings machines using piano wire, in use by 1875 (Theberge 1989), increased the speed with which soundings could be made in deep water, and allowed soundings to be taken in mid-ocean for the first time. Pressure-tube sounding devices were a further improvement by 1890 (Theberge 1989). These advances increased the amount of data available to the survey, but did not lead to changes in chart design.

The wire-drag, however, did lead to chart design changes. Following examples from other agencies, the C&GS began experimenting with a "channel and harbor sweep" in 1902, dragging a pipe below the water at a set depth to make sure there were no obstructions (U.S. Department of Commerce and Labor et al. 1903, 1007). In a few years, this had been modified into a wire up to 15,000 feet long, supported by buoys (U.S. Department of Commerce et al. 1916b, 36). It created the necessity of adding, to some charts, a way of showing what areas had been swept, and to what depth. Obstructions that are found are shown as usual, but on some charts the cleared areas are overlain with green (U.S. Department of Commerce et al. 1924, 36).

The advances mentioned are only a tiny handful among many such improvements that allowed the survey to increase the rate and accuracy of data acquisition. Not all of the new technologies led directly to changes on the survey's finished charts, but the necessity of dealing with the subsequent increase in volume of raw data did eventually force the C&GS to make changes to the charts.

Chart Creation

The methods and techniques used in the Washington office to create nautical charts from the survey data also were also impacted by technological changes. While the Drawing Division only had to deal with the increase in the quantity and accuracy of survey data (and learn to incorporate photographic input, particularly aerial photos), the artisans who create the finished charts had to transition from engraving on copper, to

extensive use of chemical etching, then to engraving on glass negatives, and then to scribing on plastic.

Chart production began as two separate tasks. At first, the cartographers would draw the chart on paper, with the engravers creating a finished version of the chart on copperplate. The drawings were not considered finished products because they did not have the fineness of artistry and detail that the engravers put into the work, and at times the drawing staff did not completely fill in areas. Gradually, however, the work became more closely intertwined as reproduction methods became more flexible and quality prints could be created from drawings.

One technical advance mentioned in the 1845 annual report was the ability of electrotyping to make a joined copy of multiple smaller copper plates, allowing the engraving of a single chart to be distributed to multiple engravers (U.S. Treasury Department et al. 1856a, 369). An advance reported in 1877 was that of creating inset maps by transferring harbor charts onto smaller scale charts in the same way that multiple plate pieces were joined to create a whole (U.S. Treasury Department et al. 1880, 2), as seen on E1200 1881.

The office began to use photography to reduce the scale of drawings by 1854, but it was not put into full production until 1859 (U.S. Treasury Department et al. 1855, 1860). Survey sheets came to the drawing office at a large scale, and were compiled into completed drawings. These were typically at a larger scale than final charts. For example, a chart drawn at 1:10,000 could be reduced to a publication scale of 1:40,000 before being sent to the engraving room. Using photography to reduce the scale of drawings saved the Drawing Office many hours of manual re-drawing and was also more accurate (U.S. Treasury Department et al. 1861; Theberge 2001).

All of these new techniques, and others, served to decrease the length of time it took to create a new chart, as well as its cost. In the earliest years a finished chart could take up to four years to be engraved, at a cost of $3,000-$6,000 in nominal dollars (U.S. Treasury Department et al. 1852). For charts completed in 1920, the average time in

production was 27 months at a cost of $1,771. In 1926 it was 8 ½ months and $1,395 (U.S. Department of Commerce et al. 1926, 4).

Figure 11 shows the relatively constant rate of growth in the number of nautical chart titles available for sale by the C&GS, as noted in the annual reports (data was not available in all reports). There is an inflection around 1860 where the rate of increase grows slightly, but overall the chart shows remarkably constant growth throughout this time period. The total number of charts available is the number of separate chart numbers or titles listed for sale in the agency's chart catalog. It is affected by the addition of new finished charts, and retirement of older charts.

Figure 11. Number of chart titles available, 1844-1945. (Annual Reports)

Typography

In the early days of the survey, all lettering on the charts was engraved by hand (in reverse). Rules were established in the office and standard lettering specimens created

by 1854 (U.S. Treasury Department et al. 1855, 207). The author of a report on engraving in the Coast Survey mentions that the French War Depot has established instructions for lettering maps, providing the suggestion that the survey's rules are based on the French rules (U.S. Treasury Department et al. 1855, 207).

In anticipation of the widespread adoption of photographic reduction, an 1860 report again emphasized the importance of consistent lettering. "A uniform system of lettering, in the size and character of letters used, will tend to a more ready understanding of the maps. The size and style of figures for soundings is a question of mechanical practicability which is already undergoing some tests… (U.S. Treasury Department et al. 1861, 222)." A sketch of the "system and styles of lettering used on the Coast Survey's charts" is included in the annual report for 1871[22] (U.S. Treasury Department et al. 1874, 66).

In the annual report for 1900, one of the draftsmen of the C&GS wrote a report on the *Proportions and Spacing of Roman Letters* (U.S. Treasury Department et al. 1901, 485-94). It is a highly detailed survey of C&GS lettering practice, with recommendations for future practice. It shows the importance placed on quality hand-lettering at the time. Standard specimen sheets were available the following year and in 1902, a standard plate of "slanting Roman letters was completed (U.S. Treasury Department et al. 1903, 198)." Additional plates of both upright and slanting letters were finished in 1903 (U.S. Department of Commerce and Labor et al. 1903, 176). These plates were used to create titles and notes on preliminary charts via photographic transfer, saving the time of manually drawing them on the field sheets. They were also used in wax transfer to the copper plates, saving the engraver the time of creating each letter from scratch every time (U.S. Treasury Department et al. 1903, 200). In a sense, this was the precursor to rub-off letters and paste-up type.

Separately producing the text for charts on a small hand printing press was mentioned in 1928, which "completes in minutes that which formerly required hours

[22] Sketches in annual reports are not currently available from NOAA.

(U.S. Department of Commerce et al. 1928a, 6).” By 1936, all hand-engraving of lettering on copper had ceased (U.S. Department of Commerce et al. 1937, 127).

One C&GS staffer noted in 1936 that “[c]loser attention has been given in recent years to the art of lettering maps by the use of special types for different features. The use of variations in Roman and italic or light block letters as designed for the better presses, has contributed both to the classification of unrelated groups of material, and to the artistic effect of the map or chart (U.S. Department of Commerce et al. 1936a).” Lettering was still done either by hand or through the photographic manipulation of standard alphabets. Either way, the lettering was supposed to be standardized, with particular styles used for particular kinds of information.

This history of lettering and typography on C&GS charts demonstrates another venue where technological advances were adopted to speed chart production while reducing unit cost. After a period where artistry was a primary goal, a decision point was reached within the survey were artistry gave way to usability and standardization, and standardization was abetted by mechanical and photomechanical aids. This helps understand the details of typography noted throughout Chapter 4, with introductions of new production methods having an impact on the lettering. There were more opportunities for inconsistencies between engravers before rules were established, and especially before standard lettering plates were developed to pre-form the letters for the engravers. With the adoption of photographic methods and use of a press for creating text, opportunities for inconsistency of letterforms decreased further, although decisions about abbreviation and capitalization still had to be made.

Printing

Over the course of the first one hundred years of chart production by the C&GS, their method of printing charts made a transition from intaglio printing of engraved copper plates using a hand-powered flatbed printer, to powered rotary offset photolithographic presses (see Table 5 on page 37), speeding production up from, at best, a dozen impressions per hour to several thousand impressions per hour.

Lithography was initially dismissed as giving unsatisfactory printing results—specifically, the detailed lines of copperplate engraving did not reproduce clearly. The annual report of 1857 deplored the fact that the maps in the report had to be lithographed due to lack of manpower in the engraving office, calling the technique the "most undesirable mode (U.S. Treasury Department et al. 1858, 202)." Rather than adjust the content to fit the capabilities of the printing method, the C&GS instead, for many years, used lithography only for printing preliminary charts, reserving the slower but higher-quality intaglio printing for finished charts (U.S. Treasury Department et al. 1900a, 5-6). It is not clear if the finished/preliminary dichotomy applied to color lithographic printing done on contract by commercial printers, or just to printing done with the C&GS's single-color lithographic press, used prior to the acquisition of a two-color press in 1917.

Limitations in the production capacity of copperplate printing and lithography's superior ease of printing in color (and the impact this had on area fill symbols) led the agency to slowly adopt lithographic printing for finished charts. A major chart re-design in the second decade of the twentieth century took advantage of lithography's strengths: multiple colors and applying ink to areas, not just lines. By 1924, the Superintendent reported that "…the Coast and Geodetic Survey has completed a gradual transition from copper plate to lithographic printing (Jones 1924, 26)." Some very low-demand charts were still printed from copper as late as 1930, though (Adams 1936).

Figure 12 shows the survey's record of printing and distribution of nautical charts, as reported in annual reports. Charts printed by copperplate press are distinguished from those printed by lithography, where information is available. Charts distributed to outside users (sales agents, other military branches, and free distribution to libraries, etc.) are shown as an overlay. Aeronautical charts, printed by the C&GS after 1927, are not included.

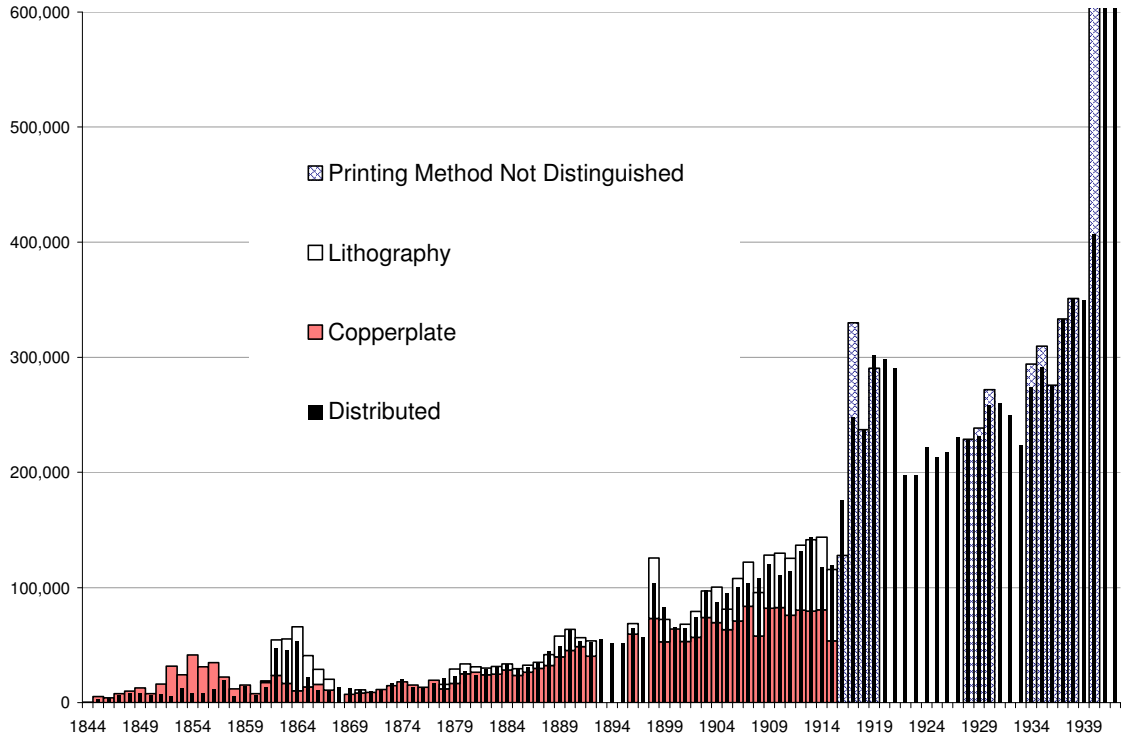


Figure 12. Nautical charts printed and distributed, 1844-1942. (Annual Reports)

The graph shows the impact to printing and distribution that wars have had. The Civil War provided the first spike in distribution, abetted by the adoption of lithographic printing for war-related maps. The lead-up to Spanish-American War in 1898 also created a short spike in volume, which immediately followed a spike in demand for charts of Alaskan waters caused by the Yukon gold rush earlier that same year (U.S. Treasury Department et al. 1899, 123). By the time the U.S. entered the First World War, normal yearly production had passed that 1898 spike, and again the increase in volume came primarily from lithographic printing.

In 1915, copper plate presses were the source for "a large proportion" of the C&GS charts (U.S. Department of Commerce and Labor et al. 1915, 43). Printing from copper plates was reduced after 1916, with the technique "being discarded … as rapidly as the transition to lithography printing can be effected," and over 94 percent of chart production came from lithography in 1920 (U.S. Department of Commerce et al. 1920b,

83, 85). Printing from copper came to be confined to very low-demand charts, and reportedly the last production printing from copper plates was done in 1930 (Adams 1936).

After 1912, the annual reports rarely broke printing down by type. Printing and distribution continued to increase at fairly constant rate until World War II, which produced another spike in production. Output passed one million sheets distributed in 1942. It was the shift to powered rotary offset lithographic presses that allowed such an increase to happen. The first was acquired during World War I. Later, several five-color Harris presses were installed in the mid-1930s, which provided exponentially more capacity than previously available within the survey.

One reason cited for switching to lithographic printing was the distortion imparted to the paper by intaglio printing. Printing from copper plates requires the paper to be slightly damp when the impression is made. The paper will necessarily shrink to some unknowable degree after printing, and each sheet's final dimensions will be unique (U.S. Treasury Department et al. 1900a, 10). When the goal is precise navigation, this can cause problems. Lithography does not require damp paper, and therefore switching over served to increase the accuracy of published charts.

Administrative/Bureaucratic

Technological advances were not the only agents of change working on the C&GS. Social pressures were significant, in particular a constant pressure from Congress to economize. With increases in the U.S. land area through purchase and imperial expansion, the responsibilities of the C&GS expanded many times from its original mandate, although funding was not always commensurate with the increase. It also officially gained responsibility for studying terrestrial magnetism and gravity. Its name was changed to Coast and Geodetic Survey in 1878 to reflect these expanded responsibilities.

Civilian Versus Military

One of the biggest influences on the C&GS in the nineteenth century was the repeated battle over whether the activities of the survey should be under civilian or military control (Manning 1988). Apart from the argument that the survey was producing charts too slowly, proponents of military control argued that the charts being produced were too detailed, particularly the topographic information. As long as there was question about the final home of the survey, the agency would have resisted removing topographic detail for fear of proving their opponents correct. The question was finally settled in 1903 by transferring the survey from the Treasury Department to the Department of Commerce and Labor. Soon after, the C&GS began to revisit the content of the charts, including simplifying topography (Tittmann 1903, 1912). While they were being externally challenged they could not afford to give in to their critics, who wished not simply for different results, but a different structural authority. The different results may have been warranted, but the survey could not risk conceding those points while their existence was imperiled.

Funding and Economy

Another source of pressure on the survey came from Congress' power of the purse and fiscal oversight. Throughout the agency's annual reports to Congress is a recurring theme of economization of funds and how making certain investments in new equipment will lower costs.

There is defensiveness in the reports and a sense that every decision is predicated on making the most of every dollar. Superintendent Hassler noted in his report for 1834 that "…every thing is arranged in the most strictly economical manner … so as to produce … perfectly accurate results in the shortest space of time; for in this principle lies the true economy of the work…(Hassler 1836b, 69)." Even this early in the work of the survey, the Superintendent felt the need to defend the work on the basis of its efficiency and economy.

Funding pressures in 1851 "forced the closest scrutiny of the organization, progress, results, economy – in short, of every particular relating to the coast survey…

(U.S. Treasury Department et al. 1852).” One economizing decision the survey made was to engrave some charts on thin paper, particularly those that had to be mailed long distances or bound into books (U.S. Treasury Department et al. 1855). Continued pressures were evident in the 1878 annual report, with Superintendent Patterson emphasizing economizing measures on page 1: “As heretofore the aim has been steadily maintained of limiting the outlay for each party to the least sum consistent with its efficiency. All items in estimates for outfit and for monthly expenditures in field work and hydrography have been closely scanned, and it is gratifying to add that the assistants have cheerfully sustained all arrangement for promoting economy (U.S. Treasury Department et al. 1881a, 1).”

Another ostensibly economizing decision was that of purchasing a calendar press in 1883 for finishing and hardening paper. Part of the reasoning for this purchase was that it might allow the use of paper made in America, “which would be a step favorable to economy,” as well as quieting any critics who would deplore the government buying foreign goods (U.S. Treasury Department et al. 1884, 93). However, the survey saw several years of struggle finding a consistent supply of chart paper, particularly 1885 and 1886.

Even the adoption of computing machines in the Washington Office was worth noting in the annual reports. These new machines allowed the Computing Division to “increase[e] the output … with consequent reduction in cost (U.S. Department of Commerce and Labor et al. 1907, 57).”

Some of the external pressure that eventually led to changes in the amount of detail present on the charts came from complaints by economy-minded members of Congress that detailed topography was not necessary on nautical charts. The Allison Commission, set up in 1885 to examine the role and finances of the C&GS, solicited testimony from private chart publishers and others as to the necessity of providing such detailed topography (Manning 1988). The commission was part of an economy movement in Washington, led by Democrats in Congress and President Grover Cleveland, who wished to shrink the size of the federal government and reduce the tax

burden. The first Cleveland administration sacked superintendent Hilgard in 1885, ostensibly to fight waste, fraud, and shady accounting, but the survey's practices were vindicated by the Allison Commission's report. Such inquiries had to be on the mind of the survey when it later redesigned charts to simplify topography, however.

One change that happened immediately after the Allison Commission was hiring women in the Washington Office. Three were hired in 1886 to work in the Miscellaneous Division. They initially worked on hand-coloring printed charts (U.S. Treasury Department et al. 1887, 133). It seems likely this could have been an economizing measure, because it is likely the women were paid less than men for the same work.

Several economic crises had impacts on the agency's finances, as well. Panics caused recessions in 1857-60, 1873-77, 1884, and 1893, several of which lead to rollbacks in appropriations.

Another external push for economy came during the Taft administration. The President's Commission on Economy and Efficiency was active from 1910-1913, and the Commission's information requests took "a large amount of the time of officers and employees…" of the C&GS during those years (U.S. Department of Commerce and Labor et al. 1913a, 19; 1913b, 19).

The spirit of economy had become entrenched in the survey by the mid-1920s, when the Director felt it worth noting that, "…to make one dollar do the work of two, has become traditional and is accepted as a matter too commonplace to justify comment (U.S. Department of Commerce et al. 1926, 2)."

The work projects of Roosevelt's early Depression budgets gave the survey several new tools. Among their temporary hires were instrument designers who designed a 9-lens aerial camera that would take 35" by 35" photographs (one planar image, eight oblique images, all on the same negative) and an echo sounder that could work in shallow water (U.S. Department of Commerce et al. 1934, 8-9). Both these tools increased the survey's efficiency.

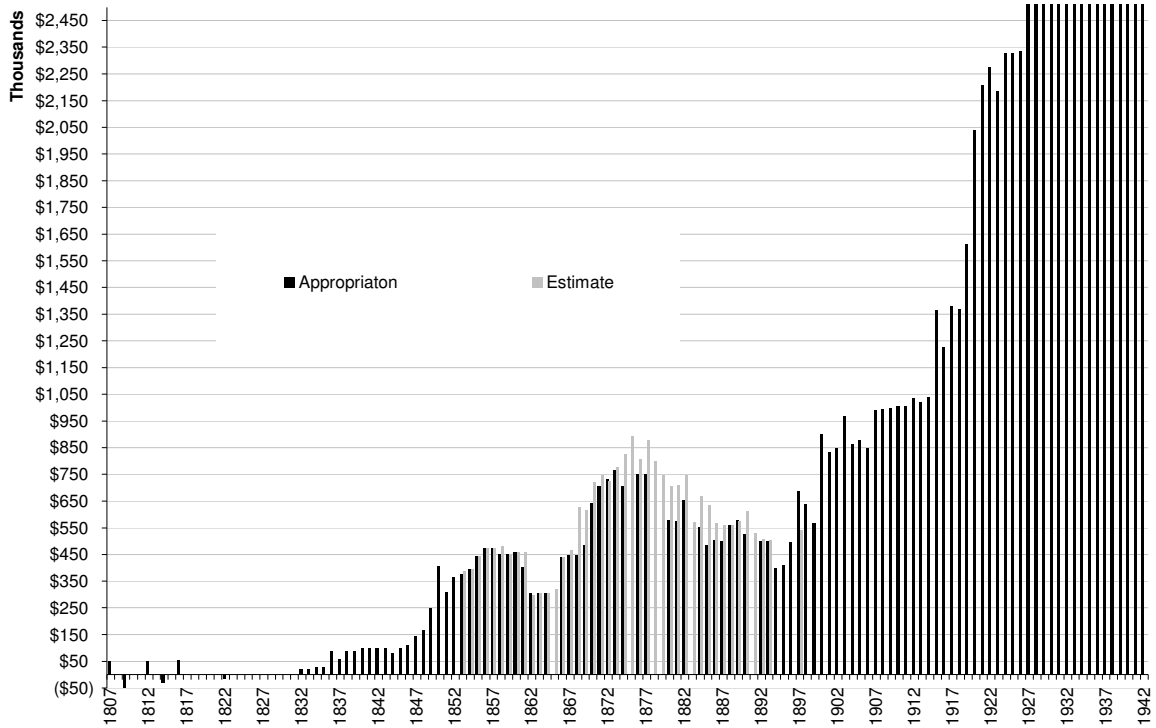


Figure 13. Appropriation and budget estimate (request), 1807-1942. (Annual Reports and other C&GS publications)

As with many, if not most, federal agencies, the C&GS had trouble receiving the funding it felt necessary to fulfill its mandate. Figure 13 illustrates that there were times when funds requested (the 'Estimate', which was included in the annual report for many years) were not fully appropriated, while at other times it received more than it requested. At various times, particularly between the late 1850s and 1900, funds were reduced from previous appropriations. The Civil War years saw several years of reductions, and economic and political troubles in the last 25 years of the century brought other periods of budget cuts. After the Spanish-American War brought another small decrease, annual appropriations grew substantially up to and through WWII, apart from several years during the Great Depression in the 1930s.

Figure 14 and Figure 15 offer slightly different views of the agency's appropriation history from 1807 to 1945. Using two different methods, appropriations

reported in annual reports[23] (and other agency publications) are adjusted to constant 2005 dollars. Figure 14 uses the Consumer Price Index (CPI), while Figure 15 uses a calculation of the Gross Domestic Product (GDP) to determine each appropriation's relative share of GDP.

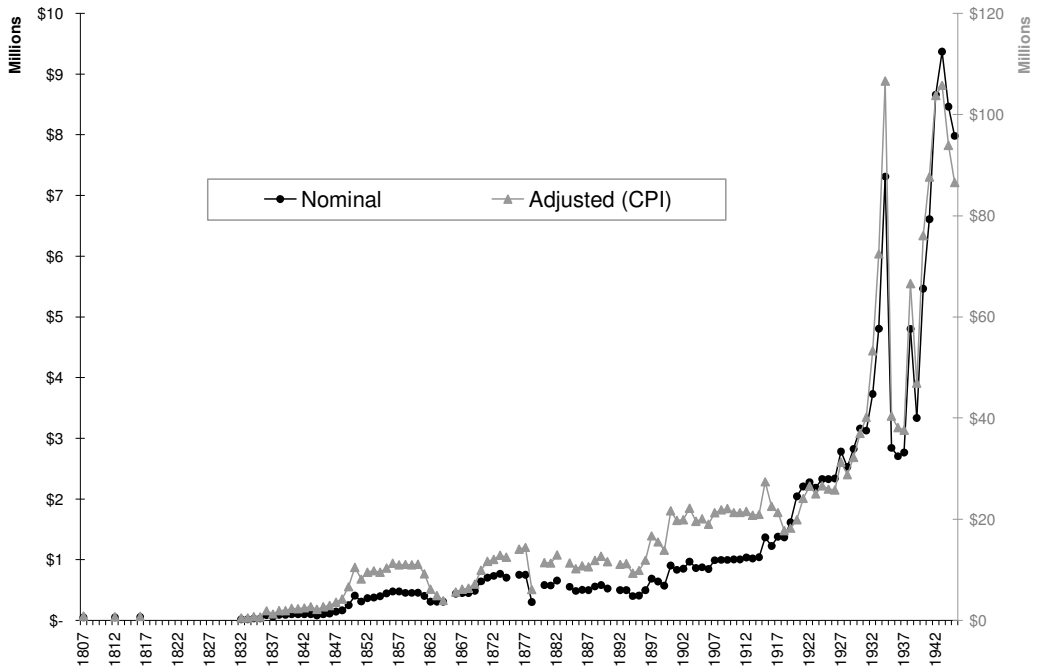


Figure 14. Appropriation, nominal and adjusted (Consumer Price Index), 1807-1945. (Williamson 2006)

The CPI measure largely tracks the nominal value of the appropriation. There are only a few areas of appreciable difference. One example is between 1870 and 1877, where the adjusted value grew at a faster rate than the nominal value. Another is seen in the period between 1900 and WWI, where the adjusted value remained flat while the nominal value grew consistently.

[23] Appropriation values are not available in annual reports for all years.

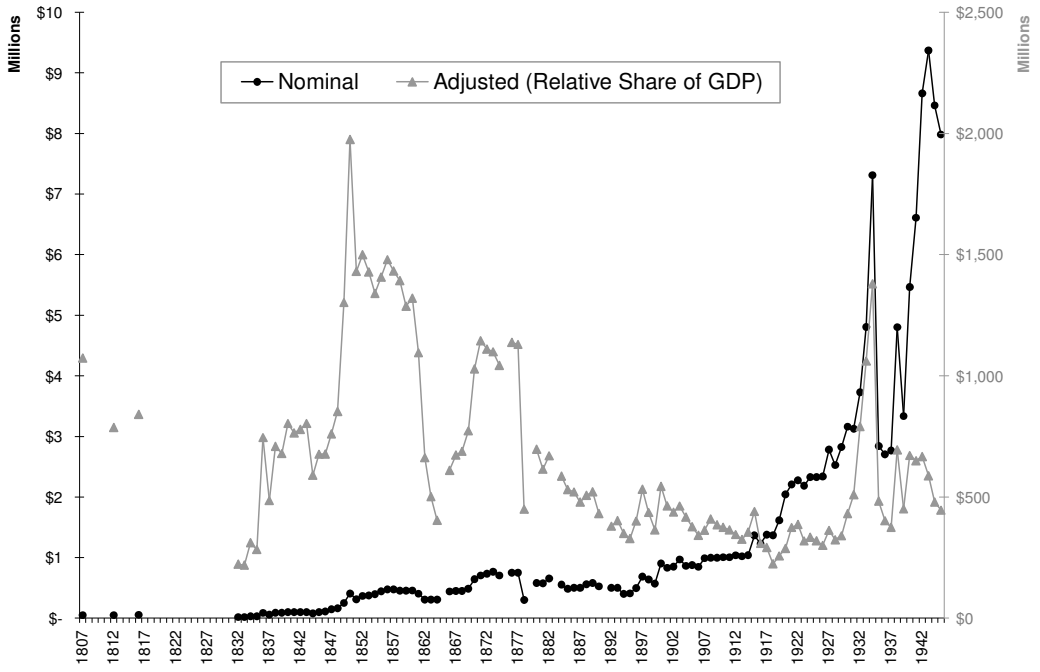


Figure 15. Appropriation, nominal and adjusted (relative share of GDP), 1807-1945. (Williamson 2006)

The comparison in Figure 15 is less consistent, and the author of the conversion series warns that values before 1930 are only valid to two significant digits and should not be used for time-series comparison (Williamson 2006). Still, this measure shows an interesting pattern after 1930. The Roosevelt budget for 1934 provided a large increase in both nominal dollars and share of GDP, after which both dropped for a few years before WWII. The war years, on the other hand, saw an even larger nominal increase in funds for the C&GS, but no concomitant increase in share of GDP. In fact, during the war, its share was entirely within the historical range seen since 1880 (with the exception of the Depression years).

The two ways of calculating constant dollars provide very different pictures of the funds available to the agency. This is not the place to provide a comparison of such methodology, but it provides an interesting look at the agency's financial fortunes all the same.

Corrections

Once the first survey of entire U.S. coast and those of the U.S. territories and possessions was complete, the agency faced a new challenge: keeping the charts current. Natural changes to shorelines, harbors, and magnetic variation continued. With increased population and increased economic activity came increased human impacts on the shoreline. Larger and deeper ships led to additional dredging by the Army Corps of Engineers, as evidenced on both the SF40 and NY40 Harbor charts over time. The Lighthouse Board and the Coast Guard continued to move and change navigational aids to meet current needs.

All such changes had to be incorporated onto the charts when new editions were printed. The frequency with which new editions were printed ranged from less than once every five years for lightly-used and lightly-populated areas with rocky shorelines and no nearby rivers dumping sediment (such as parts of Alaska); up to six times per year for busy ports with a high demand for charts and sandy harbors that constantly shifted (such as New York Harbor). At various times, including 1889 and the second decade of the twentieth century, every draftsman and engraver in the C&GS was working on revisions. This worked was deemed the highest priority of the agency, taking precedence over creating new charts (U.S. Treasury Department et al. 1890, 134; U.S. Department of Commerce et al. 1922, 30).

This realization was in stark contrast to initial promises that the Coast Survey would only need to exist until all of the shoreline was surveyed and charts published. It turned out that the office work to maintain the existing charts took more labor than the initial creation, so that each new chart published became an additional drain on resources.

There were, in fact, two meanings for ‘correction’, referring to two different activities in the Washington office. The first definition refers to updating the stock of printed copies of charts before they leave the agency for sale. Charts were printed in batches of several hundred per print run. Updates were made by hand to printed copies in stock prior to their being sold to sales agents. The second meaning of ‘correction’ refers to bringing the original copper plate (and in later years, glass negative) up-to-date prior to

a new print run. The discussion here refers to the second meaning unless otherwise specified.

The work of correcting charts was first noted in the annual report for 1877 (U.S. Treasury Department et al. 1880, 65). In 1882, correction work was increased due to better communication between the C&GS, the Lighthouse Board, and the Hydrographic Inspector. It was hoped that this information sharing arrangement this would, in a few years, decrease the number of needed corrections (U.S. Treasury Department et al. 1883, 102). This would not be the case.

The pressure of keeping the catalog of charts up-to-date was starting to show by the mid-1880s. In 1885 came the first articulation that maintaining the existing charts is more important than making new ones: "the work of engraving new charts has … given way to the more pressing necessity of making corrections to charts already published …(U.S. Treasury Department et al. 1886, 95)." A system of tracking chart corrections was adopted in 1899. Corrections were first to be made on a print, termed the 'standard proof' of a plate, and only transferred to copper when all of the corrections have been made, just before reprinting (U.S. Treasury Department et al. 1900b, 110).

By the middle of the first decade of the twentieth century, corrections were again starting to dominate the work of the engraving office. It was noted in 1906 that "the work of engraving was principally confined to making necessary changes in existing plates to bring them up to date (U.S. Department of Commerce and Labor et al. 1906, 14)." By 1912, the survey had begun to simplify the charts' content in order to minimize the amount of revision work that would later be required to maintain each chart (Tittmann 1912). The number of charts published was also studied, which resulted in a reorganization of the chart scheme and a small reduction in the total number of charts (Tittmann 1912).

Chart correction was still a factor in the mid-1920s, however. To minimize the issue of hand corrections to printed sheets, "we print small editions … frequently (U.S. Department of Commerce et al. 1926, 2)." As for correcting the originals, "the time of our chart force is devoted primarily to the correction of existing charts, and only such

time as remains from this task can be devoted to the production of new charts or the extensive reconstruction of existing ones (3)."

The volume of information coming into the survey from other organizations (primarily other federal agencies) had become so large by the early 1930s that in 1932, further simplification of topography was instigated. Applying all available corrections to the land areas of the charts was not possible with the staff available, so the practice stopped (U.S. Department of Commerce et al. 1932, 3).

Contracting

At various times in its history, the survey used outside labor to complete some of its chart creation and printing tasks. This was almost always due to pressures to either economize or increase production. Early contracts for copperplate engraving were essentially forced on the survey by complaints about how long it was taking the charts to get published. The agency faced such a shortage of skilled engravers that the engraving office was a bottleneck in production. The remedy was to contract with private persons, and later, companies, to do some of the engraving work.

The 1846 annual report notes that the output capacity of the engraving room was five or six charts, including three to four harbor maps engraved , in part, by contractors (U.S. Treasury Department et al. 1847). The contractors were used largely to help clear out the large backlog of work. There were complaints, however, about contractors not finishing work on time, and a lack of consistent quality (36-7).

The practice did continue, from time to time, as noted in annual reports. "Portions of several charts have been engraved on contract…" in 1854 (U.S. Treasury Department et al. 1855). Some views of entrances to harbors were engraved on contract in 1872 (U.S. Treasury Department et al. 1875, 51). In other years, it was hard to find contractors willing to do the work. For example, the survey was only able to expend 25 per cent of its budget for contract engraving in 1891 (U.S. Treasury Department et al. 1892, 124).

Printing was also contracted, particularly lithographic printing in the years before the survey had its own powered offset presses. There were frequently times when the in-

house presses were not able to keep up with demand, so contracts were let. This appears to have begun during the Civil War when, in 1864, 10,200 sheets were printed by "other printing offices (U.S. Treasury Department et al. 1866, 112)."

Dissatisfaction with the work of contract lithographic printers, as well as likely concerns about the safety and security of copper plates, led the Engraving Division to begin pulling its own transfer proofs from copper plates for printing on lithographic presses (U.S. Treasury Department et al. 1884, 103). The same year it was noted that publication of the 1881 annual report was delayed by the failure of contract lithographers to deliver their work (U.S. Treasury Department et al. 1884, 107).

During the crisis in 1885 when the Cleveland administration forced new management on the survey, contracts for photolithography printing were examined by the new management. It was discovered that the price of the existing contracts were appropriate after trying several low bidders and receiving unacceptable results (U.S. Treasury Department et al. 1887, 116).

A report on "Processes Employed In Chart Production" in the 1898 annual report notes that, "[l]ithograph charts are usually printed by contract in editions of 300 copies…(U.S. Treasury Department et al. 1899, 97)." After the survey bought its own lithographic press in 1904, the amount of contract lithography quickly declined. In 1905, only one-third of the lithographic printing was contracted out, and none in 1906 (U.S. Department of Commerce and Labor et al. 1905, 14; 1906, 99). E1200 1900, printed in 1903 by the Julius Bien Co., was apparently among the last charts lithographed on contract, then.

Standards

Another influence on the chart's changing content was a continuing process of standardization. This refers both to the content of the charts and the influences. There were initially internal standards and later there were external standards for chart symbology.

Standard symbology for the Coast Survey's charts was first mentioned by Superintendent Hassler in the annual report of 1834. He notes that "there has been established for all such works an universally understood conventional language of signs, and manner of distinguishing the objects, which appears not yet much known in this country, and which it is necessary to adopt, in order to be properly intelligible for every body…," in the expectation that the survey's charts will use this language (Hassler 1836b). Hassler did issue instructions for topographic surveyors in 1840 ("Instructions for Chiefs of Plane Table Parties"(Allen 1998)) which reportedly included a sample sheet of standard symbols, but how this applied to the engraving staff is not known.

Sample sheets of hachures and other topographical details were drawn and distributed in-house in 1845 (U.S. Treasury Department et al. 1846). The instructions were updated and re-issued as a printed manual in 1860, "Rules for Representing Certain Topographical and Hydrographical Features on the Maps and Charts of the United States Coast Survey." It included standard symbols for surveyors to use (U.S. Treasury Department et al. 1861; Guthorn 1984). Again, its relationship to the engraving staff is not known.

The survey is known to have adopted the Lehmann system of topographical drawing by 1849, which includes representing slope through systematic hachures (Davis 1849; U.S. Treasury Department et al. 1855; Thrower 1996). The 1860 annual report includes a report on the results of a comparison of several modifications to the Lehmann system and issues instructions on which modifications to follow in drawing hachures (U.S. Treasury Department et al. 1861). While the standardization efforts in the mid-1840s were related to ensuring that the work of different drafters and engravers was consistent, the impetus for the 1860 standards was the use of photographic reduction. The staff needed guidance on how to draw for the purposes of later scale reduction. Very much on their minds was to "free the charts from an excess of detail (U.S. Treasury Department et al. 1861, 222)."

These 1860 rules were largely to guide the field surveyors in the inking of their original pencil field sheets with the goal of consistency in the face of possible

photographic *reduction*. With the advent of possible photographic *reproduction* of the original sheets, it was felt that even greater consistency was needed. This idea was advocated in the 1872 annual report (U.S. Treasury Department et al. 1875, 5). In 1879, the inking of field sheets was transferred to the drawing room, and another set of standards was issued. They primarily consisted of a set of eight sample drawings (U.S. Treasury Department et al. 1881b). A further eight sample drawings were prepared and published in the 1883 annual report (U.S. Treasury Department et al. 1884). The 1887 report includes a memo to the surveyors detailing the notes they are required to submit along with their drawings (U.S. Treasury Department et al. 1889a, 211-215). Reporting good results, the survey nonetheless issued another set of conventional signs in 1891, "in the interest of securing for the field still greater uniformity than heretofore in the use of conventional signs on original charts (U.S. Treasury Department et al. 1892, 576)." This four-page set was formatted as a legend, and was probably more useable than the previous sample chart samples.

Standard plates were prepared for the lettering used in notes, as well as standard scale bars, compass roses, and seals, in the years around 1900 (U.S. Treasury Department et al. 1903, 199). These were used in the printing of preliminary charts, saving time by combining the chart base from the original copper plate with the standard items from their copper plates. The different originals were combined into a single chart using photography. The resulting glass negatives were used to expose lithographic printing plates. When the drafting force was reduced in 1919, a plate of the symbol for 'marsh' was prepared for the same purpose (U.S. Department of Commerce et al. 1919, 27).

The 1939 annual report noted that a "comprehensive tabulation of nautical chart symbols was prepared, to standardize the symbols used (U.S. Department of Commerce et al. 1940, 110)."

The U.S. Geological Survey (USGS) faced similar issues of standardization. Established in 1879, the USGS chose to use copper for chart production because "illustrations on stone … tended to 'deteriorate over time'(Phillips 1997, 8)." The same

report notes that standard lettering and symbology for finished maps had been established.

After 1890, there were efforts within the federal government to standardize mapping and map symbols. One of the first was a Topographical Conference in 1892. It was convened by the C&GS but included other federal agencies (Larsgaard 1984). Another effort came in 1906 when President Roosevelt charged the Board of Geographic Names (later renamed the United States Geographic Board) with unifying the symbols and conventions used on maps (Shalowitz 1964, 204). In 1911, the Board published a set of conventional symbols covering the topographic and hydrographic symbols to be used on maps and charts published by the U.S. government. The C&GS was represented on the Board and much of the symbolization practice of the survey was included in the new federal standard (Shalowitz 1964, 206).

At about the same time, C&GS Superintendent Tittmann ordered an internal Board to review the charts, with particular attention to choice of projection. The Navy had been requesting that charts be published using the Mercator projection instead of the C&GS's traditional polyconic projection. The Board returned a recommendation to convert all chart with scales of 1:100,000 and smaller to the Mercator projection. For charts larger than 1:100,000, new charts should use the Mercator projection, but existing charts should only be converted when they were completely revised. Shalowitz notes that this second part of the project was nearly complete in 1963 (302).

The Federal Board of Survey and Maps had some input to map design from its establishment in 1919 to its abolishment in 1942, when its functions were transferred to the Bureau of the Budget (Larsgaard 1984). Use of this Board's standards is confirmed in a C&GS publication from 1936 (U.S. Department of Commerce et al. 1936a, 78).

This history is, at least to some degree, evident in the history of the charts as described in Chapter 4. Examples include the symbols for navigational aids changing to become simpler as the standard symbols evolved. NY40 1844 shows lighthouses as little towers with doors and windows, the 1870 version uses a black circle, the 1926 version uses a black star, 1936 a black star with an orange highlight, and 1944 shows lighthouses

as a black star surrounded by a magenta circle. The symbol for lightship also went through a process of simplification as can be seen through the editions of E1200, and labeling for navigational aids was simplified over time. Topographical relief changed from hachures to contours (see Table 15 on page 105). Tying specific features on chart editions to particular sets of standards is complicated by the time lag between adoption of rules and updates to any given chart, but the changes seen on the charts do appear to parallel the changes to standards.

User Needs

A major change within the survey that had a significant impact on chart design was a change in how the survey saw its mission. In the early years, Superintendent Hassler focused on The Best: the best method of surveying, the best method of creating charts, the best method of printing, etc. Engravers and their work were graded, and only the best quality was allowed on finished charts. Even the "best quality" drawing paper and "best quality" copper plates were acquired for the survey (Hassler 1840).

This focus led to published charts with particular design characteristics, which were well received by many (but not by all). In 1847, one writer noted:

> The highest praise is due to the admirable execution of the Charts, for the distinct and beautiful minuteness of detail, and for the excellence of the engraving in all respects. They may be advantageously compared with the Maps of the British Ordnance Survey, and even with the highly finished maps of the French Survey. (Hoffman 1847)

It was the other surveys' charts that the Coast Survey's charts were being compared to. Another writer offered similar praise in 1849: "The charts which have been issued from the office of the Coast Survey are very beautiful specimens of topographic drawing and engraving, and in the highest degree creditable to the office…(Anonymous 1849, 143)." Even the staff spoke of the charts in this manner. In a 13-page report on the agency's engraving that appeared in the 1854 annual report, E.B. Hunt declared that "it is not too much to claim a higher finish and more perfect elaboration for the best Coast Survey charts than is exhibited in any others of which we have any knowledge (U.S. Treasury

Department et al. 1855, 203).” He sees the charts as works of art, which the finest engravers imbue with life: “The engraver who ignores art can only accumulate topographical lines and dots in spiritless ranks by literal copyism from his drawing, or in unreasoning conformity to conventional rules (204).”

Superintendent Hassler also made the point that Coast Survey was doing work in such a way that the information could be put to any conceivable use (1836a, 21). In particular he was thinking of coastal defense, which required accurate knowledge of topography, roads, and other cultural features. Such information was not available from any other source at the time. It was not until the USGS took responsibility for topographic mapping of the county off the hands of the C&GS that the focus could afford to shift away from all-inclusiveness.

By the early 1900s, the survey was thinking only of navigators. This came to the forefront in the 1920s. It is not that the quality of the finished product was allowed to be less than “best,” it is instead that the charts were being judged by a different set of measures. Changing opinions were taken into account, as noted by the Superintendent in 1909. With the first round of surveying complete, he had the office undertake a review of the charts. Early charts were judged to have “a great amount of detail … which under modern conditions is not considered necessary (U.S. Department of Commerce and Labor et al. 1911, 11).” The solution was a plan to replace the old-style charts with a smaller number of new charts formed with current standards.

In the 1915 annual report, the Chart Construction Division of the survey describes its aim to be that of showing current navigation information “on the charts in a manner by which it can be most clearly read and easily comprehended (U.S. Department of Commerce et al. 1915, 141).” This is first time user understanding of information on the charts is noted in survey publications. It also notes that simplification of the information on charts has been underway for five years: “The old series of charts show a number of details, such as fences, woods, farm roads, individual houses, etc., which are not of importance to the navigator and are of a transitory character (141).” These details are most evident on NY40 1844, but nearly all of the early editions have such features.

Omitting this detail speeds chart construction, but also "show(s) more clearly the prominent land marks needed by the navigator. In addition, on new charts, both the hachured land area and sanded water areas have been simplified, with the result that the original drawing and engraving is reduced and subsequent corrections more easily made (141)."

In 1916, a manual on chartmaking published by the C&GS emphasized which topographic features are noted in topographic surveys and why: "All objects of prominence which can be seen from the water areas, such as lighthouses, beacons, range marks, church spires, towers, etc., are carefully plotted on the drawing (U.S. Department of Commerce et al. 1916c, 13)." These are all navigationally important features. Those features that are not of use to mariners were not emphasized. Since the charts had begun to be "designed primarily for the navigator (Jones 1924, 22)," information that did not directly support navigation was "generalized or omitted altogether if they in any way interfere with, or cloud, data of navigational value (22)." The changes between NY40 1914 and NY40 1917 show how this was implemented. The cultural topography was dramatically simplified as figure/ground was reversed for roads; most vegetation fill and topography was removed; only large buildings visible from the water were shown; and the standard symbol for navigationally-important features was revised and relabeled. In 1925, the survey saw its charts as "a diagram for practical use by navigators" from which "unnecessary details are studiously avoided (U.S. Department of Commerce et al. 1925b, 97)."

By the end of the first century, there was a recognition among the cartographers at the C&GS that graphic techniques could be used to help navigators focus on the important information. "The proper procedure is to bring out the essential characteristics in a clear light, without entering deeply into incidental features which have no reference to the professed purpose of instruction," and if the chart is not properly designed, the chart's user "… *is led to fix equal attention* on all its parts, though many are superfluous (U.S. Department of Commerce et al. 1943, 81)." The stated goal of a chart was then seen to be "simplicity," which "is the golden mean between *too little* and *too much* (81)."

The survey made a transition from producing accurate, detailed, and beautiful charts, to producing accurate, simple, and legible charts. This change in attitude about the agency's goals is a significant shift to user-centered thinking that in turn contributed to major changes in chart design.

Competition

Prior to the C&GS adopting color lithography, the USGS had adopted the method and was producing high-quality results. Its technique was to engrave charts on copper plates but transfer them to lithographic printing plates for three-color printing (Monmonier et al. 2000). All three colors (black, brown, and blue) were printing points and lines, not flat tints. By 1914, however, a fourth color, green, was being used for area fills. Seeing the USGS succeed with these processes must have provided some impetus for the C&GS to reexamine its policy of printing in a single color from copper plates.

Another source of competition was for labor, specifically engravers. The survey took years to build up a cadre of engravers in the early years and by 1920 was again having difficulty finding workers willing to make a career of the art. The initial problem was that the U.S. was not training topographic engravers and no one was available to teach the skill. During the period between the Civil War and 1900, there was salary competition from the private sector that reduced the pool of applicants for positions. By 1920 the art was commercially dead except for banknote engraving. The Director of the C&GS noted that this situation made hiring for the engraving room extremely difficult, which was exacerbated by retirements (U.S. Department of Commerce et al. 1920a, 17-18). No one was entering into a career in topographic engraving.

Other Publications

Another change that should not be overlooked is the movement of information off the charts themselves and into several periodicals: the various *Coast Pilot* books, tide-tables, and *Notice to Mariners*. These publications became the repository for detailed navigation information and engraved views (later photographs) that were originally available on the survey's charts.

Coast Pilots for the Atlantic seaboard were originally published by the Blunt Company beginning around 1850, but were purchased by the Coast Survey in 1867 (Morrison et al. 1990, 103). The *Pacific Coast Pilot* was first published by the Coast Survey in 1858 (U.S. Treasury Department et al. 1872, 7). The publication *Notice to Mariners* started as occasional bulletins published by the U.S. Light-House Board, but were taken over by the Coast Survey and became regularly printed. They provide up-to-date information about navigational hazards and aids, which often require chart owners to manually update their chart to reflect the new information. They began regular publication in 1876, going to monthly publication in 1887. In 1908, responsibility for publishing them was transferred back to the Lighthouse Board.

When the *Coast Pilots* were published, detailed information on tides, currents, navigation along particular routes, and images of what a pilot would see from particular locations were removed from the charts. The text could then be typeset and both the text and views could be printed by lithography, avoiding the need to engrave them on finished charts. Lithography was also a less expensive printing method.

CHAPTER VI
CONCLUSION

The topics of this thesis were chosen to help map librarians and historians understand the continuity of Coast & Geodetic Survey charts as they went through changes to design and numbering systems, and to better understand the period of transformation from manual to photomechanical production and reproduction in the history of cartography. From a bibliographic control perspective it is clear the charts are problematic, particularly in the early years of the survey. After years of publishing charts with either no identification number or a context-specific number, three numbering systems were developed and used between 1858 and 1892. After 1892 the numbering is, for the most part, problem-free.

Titles, however, continued to change into the 1940s, although the most dramatic changes had been enacted by 1900. Titles were changed from long and florid to short and terse before additional geographic descriptors were added to place them in a locational hierarchy. Publication dates are problematic throughout the first 100 years. There were inconsistencies regarding what dates were provided on the charts, issues with the cartographic base remaining static while navigational information is updated, and the problem of multiple printings from the plates.

The information provided here is helpful context for librarians and historians, but the high degree of inconsistency suggests that generalizing between charts is not appropriate. The details provided should help a person know what to look for, but does not provide enough information to give answers for any specific chart.

Regarding this period in the history of cartography, the primary insight this thesis provides is that inconsistency is the rule rather than exception for the charts produced by

the C&GS. Despite concerted efforts at providing standards for the surveyors, cartographers, and engravers to follow, published charts that are the work of so many different people are extremely difficult to make perfectly consistent. Even after the advent of mechanical aids and photographic compilation techniques using standard elements, inconsistencies abound. Wording, typography, capitalization, topography, bathymetric contours, and use of color all have some inconsistencies in their application during the 1940s.

Parts of the inconsistencies appear to be due to ad hoc choices made while the chart was constructed. Some are due to mistakes, such as obvious typographical errors. Mistakes are inevitable and will also slip through no matter the level of proofing available. Ad hoc choices are not, and must be seen differently. Some are probably due to a spirit of invention, giving staff the freedom to advance the products through experimentation, particularly during times when new production techniques were being implemented. New methods were variously tried and abandoned, tried and adjusted, or tried and adopted, leading to differences when experiments broke with the past (particularly when they were not widely adopted and so became design orphans). Other inconsistencies probably slipped through unnoticed due to lack of oversight. It is probably not possible to distinguish which errors stem from which types of sources from this distance in time.

Just as important to the level of inconsistency is the inertia of the survey's body of work. When a decision was made to change a design element, the several hundred existing charts did not immediately update themselves to match the new expectation. It took years of work for a change to cascade through the charts one at a time as they were corrected (for minor changes) or reconstructed (for major changes). Simply put, reality could not keep pace with rhetoric. It is much simpler to change the message about the work by announcing a design change than it is to make those changes to such a vast body of work. Changes were always phased in over time, so one cannot tell by looking at a single chart what the policies of the survey were at the time of publication. A chart may carry all of the current design elements and be produced and printed with the most up-to-

date methods, or it may be a holdover from past practice. Users of these charts today need to keep these facts in mind when judging them as design examples and as sources of historical information.

This thesis is an amalgamation of two projects. One project details changes to C&GS charts, and the other details the history of the C&GS as it relates to those charts. The latter was conducted to provide context and explanation for the former. Precisely joining the context to the details remains elusive primarily because the amount of detail is so vast. In its depth of detail on the minutia of C&GS charts, this document is unprecedented. The context sections are not all-encompassing, but do provide significant breadth. It is hoped that the work of studying these charts so intently will provide some usefulness to other scholars and map enthusiasts.

APPENDIX A

CHARTS USED IN THIS PROJECT

Except where otherwise noted, images of charts were obtained from the Image Archives of the Historical Map & Chart Collection/Office of Coast Survey/National Ocean Service/NOAA, http://historicals.ncd.noaa.gov/historicals/histmap.asp.

1a. NY40 1844: "Map of New-York Bay and Harbor and the Environs." (Sheets 1, 2 & 3 of 6 sheets), 1844. ca 1:31,000. U.S. Treasury Department, U.S. Coast Survey: Washington, DC. Electronic reproduction: New York Public Library[24], 434640.sid

1b. NY40 1844: "Map of New-York Bay and Harbor and the Environs." (Sheet 5 of 6 sheets), 1845. 1:30,000. U.S. Treasury Department, U.S. Coast Survey: Washington, DC. Electronic reproduction: SHEET5.sid

1c. NY40 1844. "Map of New-York Bay and Harbor and the Environs." (Sheets 1, 2, 3, 4, 5, and 6 of 6 sheets), 1844 and 1845. ca.1:30,600. U.S. Treasury Department, U.S. Coast Survey: Washington, DC. Electronic reproduction: David Rumsey Collection[25], 2491000.sid.

2a. NY40 1845: "Map of New-York Bay and Harbor and the Environs," 1845. 1:80,000. U.S. Treasury Department, Survey of the Coast of the United States: Washington, DC. Electronic reproduction: New York Public Library[9], 434585.sid

2b. NY40 1845: "Map of New-York Bay and Harbor and the Environs," 1845. 1:80,000. U.S. Treasury Department, Survey of the Coast of the United States: Washington, DC. Reproduction edition: BiC-10, 1976. U.S. Dept. of Commerce, National Oceanic and Atmospheric Administration, National Ocean Service: Washington, DC. Electronic reproduction of BiC-10: 10-00-1845.sid

[24] http://digitalgallery.nypl.org/nypldigital/dgadvsearch.cfm, section "Search Keywords in Fields," keywords [coast survey], field [Name].
[25] http://www.davidrumsey.com/

3. NY40 1853: "Romer and Flynn's Shoals, New York Bay," 1853. 1:40,000. U.S. Treasury Department, U.S. Coast Survey: Washington, DC. Electronic reproduction: cp766c.sid

4a. NY40 1870: "New York Entrance," Chart 7, 1870. 1:40,000. U.S. Treasury Department, U.S. Coast Survey: Washington, DC. Electronic reproduction: 7-00-1870.sid

4b and 4c. NY40 1870: "New York Entrance," Chart 369, 1870. 1:40,000. U.S. Treasury Department, U.S. Coast Survey: Washington, DC. Electronic reproduction: 369-00-1870.sid and CP1167C_369.sid

5. NY40 1878: "New York Entrance," Chart 369$^{(2)}$, Published 1875, Issued Feb. 1878. 1:40,000. U.S. Treasury Department, U.S. Coast & Geodetic Survey: Washington, DC. Electronic reproduction: 369_2-2-1878.sid

6. NY40 1902: "New York Bay and Harbor," Chart 369 (Lower Half), 1902 [date from magnetic variation date]. 1:40,000. U.S. Treasury Department, U.S. Coast & Geodetic Survey: Washington, DC. Electronic reproduction: 369-00-0000.sid

7. NY40 1914: "New York Bay and Harbor," Chart 369, May 1914. 1:40,000. U.S. Dept. of Commerce, U.S. Coast & Geodetic Survey: Washington, DC. Electronic reproduction: 369_5-1914.sid (Upper Half) and 369_5-1914-2.tif (Lower Half)

8. NY40 1917: "United States – East Coast: New York Harbor," Chart 369, May 16, 1917. 1:40,000. U.S. Dept. of Commerce, U.S. Coast & Geodetic Survey: Washington, DC. Electronic reproduction: 369_5-1917.sid

9. NY40 1926: "United States – East Coast: New York Harbor," Chart 369, Jan. 9, 1926. 1:40,000. U.S. Dept. of Commerce, U.S. Coast & Geodetic Survey: Washington, DC. Electronic reproduction: 369_1-1926.sid

10. NY40 1936: "United States – East Coast: New York Harbor," Chart 369, Dec. 5, 1936. 1:40,000. U.S. Dept. of Commerce, U.S. Coast & Geodetic Survey: Washington, DC. Electronic reproduction: 369_12-1936.sid

11. NY40 1944: "United States – East Coast: New York Harbor," Chart 369, June 17, 1944. 1:40,000. U.S. Dept. of Commerce, U.S. Coast & Geodetic Survey: Washington, DC. Electronic reproduction: 369_6-1944.sid

12. SF40 1859/77: "Entrance to San Francisco Bay, California," Chart 621, Published 1859, Issued Oct. 1877. 1:50,000. U.S. Treasury Department, U.S. Coast Survey: Washington, DC. Electronic reproduction: 621-00-1859.sid

13. SF40 1883: “San Francisco Entrance, California,” Chart 621[a], Dec. 1883. 1:40,000. U.S. Treasury Department, U.S. Coast & Geodetic Survey: Washington, DC. Electronic reproduction: CP1532C.sid

14. SF40 1901: “San Francisco Entrance, California,” Chart 5531, July 1901. 1:40,000. U.S. Treasury Department, U.S. Coast & Geodetic Survey: Washington, DC. Electronic reproduction: CP1829C.sid

15. SF40 1926: “United States - West Coast: San Francisco Entrance, California,” Chart 5532, Dec. 22, 1926. 1:40,000. U.S. Dept. of Commerce, U.S. Coast & Geodetic Survey: Washington, DC. Electronic reproduction: David Rumsey Collection, 3481000.sid

16. SF40 1947a: “United States - West Coast, California: San Francisco Entrance,” Chart 5532, 1947. 1:40,000. U.S. Dept. of Commerce, U.S. Coast & Geodetic Survey: Washington, DC. Electronic reproduction: 5532_1-1949.sid

17. SF40 1947b/57: “United States - West Coast, California: San Francisco Entrance,” Chart 5532, 26th Edition, July 7, 1947, Revised Oct. 28, 1957. 1:40,000. U.S. Dept. of Commerce, U.S. Coast & Geodetic Survey: Washington, DC. Electronic reproduction: 5532_10-1957.sid

--. SF40 1986: “United States - West Coast, California: San Francisco Entrance,” Chart 18649, 53rd Edition, May 6, 1989. 1:40,000. U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Ocean Service: Washington, DC. Electronic reproduction: 18649_5-1989.sid

18. MH400 1862/72: “General Chart of the Coast No. IV, From Cape May to Cape Henry,” Chart 9, 1862. 1:400,000. U.S. Treasury Department, Survey of the Coast of the United States: Washington, DC. Electronic reproduction: cp924c.sid

19. MH400 1916: “United States - East Coast: Cape May to Cape Hatteras,” Chart 1109, Published Oct. 1914, Reissued Oct. 1916. [1:416,944]. U.S. Dept. of Commerce, U.S. Coast & Geodetic Survey: Washington, DC. Electronic reproduction: 1109_A-00-0000.sid

20. MH400 1922: “United States - East Coast: Cape May to Cape Hatteras,” Chart 1109, May 20, 1922. [1:416,944]. U.S. Dept. of Commerce, U.S. Coast & Geodetic Survey: Washington, DC. Electronic reproduction: 1109_5-1922.sid

21. MH400 1938: "United States - East Coast: Cape May to Cape Hatteras," Chart 1109, Mar. 1, 1938. [1:416,944]. U.S. Dept. of Commerce, U.S. Coast & Geodetic Survey: Washington, DC. Electronic reproduction: 1109_3-1938.sid

22. MH400 1942: "United States - East Coast: Cape May to Cape Hatteras," Chart 1109, Sept. 25, 1942. [1:416,944]. U.S. Dept. of Commerce, U.S. Coast & Geodetic Survey: Washington, DC. Electronic reproduction: 1109_9-1942.sid

23. MH400 1951: "United States - East Coast: Cape May to Cape Hatteras," Chart 1109, 14th Edition, Mar. 26, 1951. [1:416,944]. U.S. Dept. of Commerce, U.S. Coast & Geodetic Survey: Washington, DC. Electronic reproduction: 1109_3-1951.sid

24. GJF200 1862: "Reconnaissance of Washington Sound and Approaches, Washington Territory," Chart 28, 1862. 1:200,000. U.S. Treasury Department, U.S. Coast Survey: Washington, DC. Electronic reproduction: scans of University of Oregon MAP Library's copy performed by the author

25. GJF200 1895: "Gulf of Georgia and Strait of Juan de Fuca, Washington," Chart 6300, Published "189_," 1895 [date from latest survey date]. 1:200,000. U.S. Treasury Department, U.S. Coast & Geodetic Survey: Washington, DC. Electronic reproduction: CP2119C.sid

26. GJF200 1922: "United States - West Coast: Georgia Strait and Strait of Juan de Fuca, Washington," Chart 6300, 1922 [date from magnetic variation date]. 1:200,000. U.S. Dept. of Commerce, U.S. Coast & Geodetic Survey: Washington, DC. Electronic reproduction: P_3678-00-0000.sid

27. GJF200 1933: "United States - West Coast, Washington: Georgia Strait and Strait of Juan de Fuca," Chart 6300, Published June 1933, Printed July 2, 1934. 1:200,000. U.S. Dept. of Commerce, U.S. Coast & Geodetic Survey: Washington, DC. Electronic reproduction: scans of University of Oregon MAP Library's copy performed by the author

28. GJF200 1941/48: "United States - West Coast, Washington: Georgia Strait and Strait of Juan de Fuca," Chart 6300, 11th Edition, Published Sept. 1941, Printed July 5, 1948. 1:200,000. U.S. Dept. of Commerce, U.S. Coast & Geodetic Survey: Washington, DC. Electronic reproduction: 6300_7-1948.sid

29. E1200 1863: "Atlantic Coast of the United States (in four sheets) Sheet No. II, Nantucket to Cape Hatteras," Chart 24, 1863. 1:1,200,000. U.S. Treasury Department, U.S. Coast Survey: Washington, DC. Electronic reproduction: CP936C.sid

30. E1200 1881: “Atlantic Coast: Cape Sable to Cape Hatteras (Northern Sheet),” Sailing Chart A, Issued 1881. 1:1,200,000. U.S. Treasury Department, U.S. Coast & Geodetic Survey: Washington, DC. Electronic reproduction: CP1357C.sid

31. E1200 1900: “Atlantic Coast: Cape Sable to Cape Hatteras,” Chart 1000, April 1900. 1:1,200,000. U.S. Treasury Department, U.S. Coast & Geodetic Survey: Washington, DC. Printed by Julius Bien & Co. Lith., N.Y. Electronic reproduction: 1000_4-1900.sid

32. E1200 1927: “Atlantic Coast: Cape Sable to Cape Hatteras,” Chart 1000, Feb. 16, 1927. 1:1,200,000. U.S. Dept. of Commerce, U.S. Coast & Geodetic Survey: Washington, DC. Electronic reproduction: 1000_2-1927.sid

33. E1200 1938: “Atlantic Coast: Cape Sable to Cape Hatteras,” Chart 1000, Dec. 5, 1938. 1:1,200,000. U.S. Dept. of Commerce, U.S. Coast & Geodetic Survey: Washington, DC. Electronic reproduction: 1000_12-1938.sid

34. E1200 1943: “Atlantic Coast: Cape Sable to Cape Hatteras,” Chart 1000, Jan. 27, 1943. 1:1,200,000. U.S. Dept. of Commerce, U.S. Coast & Geodetic Survey: Washington, DC. Electronic reproduction: 1000_1-1943.sid

35. E1200 1948: “Loran Chart - Atlantic Coast: Cape Sable to Cape Hatteras,” Chart 1000-L, 1948 [date from magnetic variation date]. 1:1,200,000. U.S. Dept. of Commerce, U.S. Coast & Geodetic Survey: Washington, DC. Electronic reproduction: 1000L_12-1948.sid

36. W1200 1855/64: “Reconnaissance of the Western Coast of the United States (Northern Sheet) from Umpquah River to the Boundary,” Chart 603, Published 1855, Issued 1864. 1:1,200,000. U.S. Treasury Department, U.S. Coast Survey: Washington, DC. Electronic reproduction: 603_00-1855.sid

37. W1200 1888: “Pacific Coast from San Francisco Bay to the Strait of Juan de Fuca,” Chart 602, Issued 1888. 1:200,000. .S. Treasury Department, U.S. Coast & Geodetic Survey: Washington, DC. Electronic reproduction: 602_12-1888.sid

38. W1200 1917/26: “Pacific Coast: San Francisco to Cape Flattery,” Chart 5052, Published Oct. 1917, Printed Jan. 22, 1926. 1:1,200,000. U.S. Dept. of Commerce, U.S. Coast & Geodetic Survey: Washington, DC. Electronic reproduction: scans of University of Oregon MAP Library’s copy performed by the author

39. W1200 1932: “Pacific Coast: San Francisco to Cape Flattery,” Chart 5052, Nov. 1932. 1:1,200,000. U.S. Dept. of Commerce, U.S. Coast & Geodetic Survey: Washington, DC. Electronic reproduction: 5052_8-1933.sid

40. W1200 1945/54: “United States - West Coast: San Francisco to Cape Flattery,” Chart 5052, 13th Edition, Published April 1945, Printed May 24, 1954. 1:1,200,000. U.S. Dept. of Commerce, U.S. Coast & Geodetic Survey: Washington, DC. Electronic reproduction: 5052_4-1945.sid

APPENDIX B

SCALE DIVISIONS

Scale divisions

Date	Author	# of divisions	2,500	5,000	10,000	20,000	40,000	50,000	60,000	75,000	80,000	100,000	150,000	200,000	300,000	400,000	600,000	1,000,000	1,200,000	3,600,000	>
1856	Coast Survey	3		Harbor							Inshore or Coast					General Coast, or Off-shore Chart					
1856/1984	Guthorn	3		Harbor							Inshore or Coastal					General Coast Chart					
1857	Coast Survey	4		Harbor							Coast maps (in-shore)		Preliminary Seacoast Chart			General Coast Chart					
1858	AAAS Report	3		Harbor							Inshore or Coastal					General Coast Chart					
1863	Coast Survey	5		Harbors, Bays, Anchorages, &c.							Coast		Preliminary Sea-Coast			General Charts of the Coast			Sailing		
1900	C&GS	4		Harbor							Coast		General Chart of the Coast			General Chart of the Coast			Sailing		
1903	Tittmann*	3																			
1905	C&GS: Atlantic & Gulf*	4																			
	C&GS: Pacific*	3																			
1924	Jones: Atlantic	4		Harbor							Coast				General Charts of the Coast				Sailing		
1964	Shalowitz	4		Harbor				Coast				General					Sailing				
1967	Magee	6		Harbor							Approach			Coasting				Landfall		Ocean Passage	Route Planning
1979	Schmidt*	6																			
1982	Kerr & Anderson*	4																			
1982	Whitmore	4		Harbor						Approaches			General		General			Sailing			
2000	Monmonier & Puhl	4		Harbor							Coast			General Charts of the Coast			Sailing				
2003	Calder	4		Harbor					Coastal				General				Sailing			International	
2005	**McConnel**	**3**					**Harbor**							**General**		**General**			**Sailing**		

* States scale divisions without specifying values. See below for detail.

Tittmann 1903	Sailing charts
	General charts of the coasts
	Harbor charts
C&GS: Atlantic & Gulf 1905	1st series: "Sailing charts"
	2nd series: "General charts of the coast"
	3rd series: "Coast charts"
	4th series: harbor charts
C&GS: Pacific 1905	1st series: Sailing charts
	2nd series: alongshore navigation, scale about six times as large as the first
	3rd series: Harbor charts
Schmidt 1979	Overseas navigation
	Coasting
	Approach
	Entrance
	Channel navigation
	Port navigation
Kerr & Anderson 1982	general charts
	coastal chart
	open harbors and approaches
	large-scale port charts

APPENDIX C

CHART DETAILS

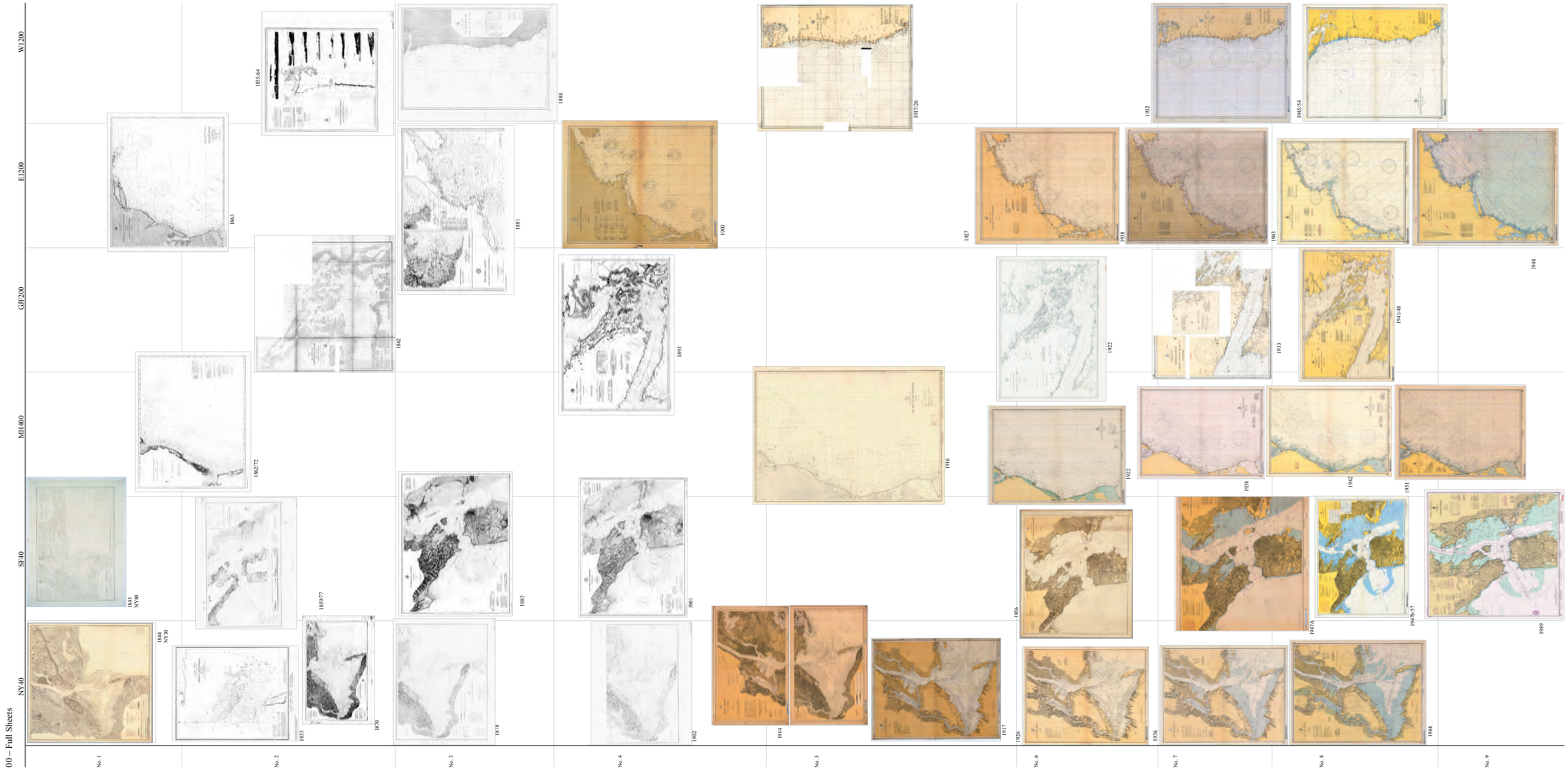
Chart Details

Series	Yr.	Number	Title	Scale	Published	Edition	Print	Plate	Correct to	Issued	Survey	Compass	Var.	Price	Short Title	Projection	Soundings	Sanding (fathoms)	Depth Curves (fathoms)	Copper?	Electrotype Copy #	Lithographed?	Color?
NY40	1844		Map of New-York Bay and Harbor and the Environs	30,000	1844, 1845								5' 51" W				Feet	1, 2, 3, 3.5	none	y	-	n	n
NY40	1845		Map of New-York Bay and Harbor and the Environs	80,000	1845						1841		5' 54" W	$0.75			Feet	1, 2, 3, 3.5	none	y	1, and 7	n	n
NY40	1853		Romer's and Flynn's Shoals New York Bay	40,000	1853				1854			1854	6' 00" W				Feet & Fathoms	1, 2, 3	none	y	1	n	n
NY40	1870	7 / 369	New York Entrance	40,000	1870				1873		1869		7' 14" W	$1.50			Feet	1, 2, 3	none	y	-, and 2	n	n
NY40	1878	369[(2)]	New York Entrance	40,000	1875			1304	1883	1878	1874		7' 45" W	$0.50			Feet	1, 2, 3	4, Dashes	y	1	n	n
NY40	1902	369	New York Bay and Harbor	40,000				2617				1902	8' 40" W		(New York Bay and Harbor)		Feet	1, 2, 3	4, Dashes	y	missing	n	n
NY40	1914	369	New York Bay and Harbor	40,000	1914			3385/3341		1914	1914	1912	9' 45" W	$0.75	(New York Bay and Harbor)		Feet	1, 2, 3	4, Dashes	y		y	y
NY40	1917	369	United States - East Coast: New York Harbor	40,000	1917		1917		1917		1916	1919	10' 05" W	$0.50	(New York Harbor)		Feet	1, 2, 3	5, Dots	y		y	y
NY40	1926	369	United States - East Coast: New York Harbor	40,000	1926		1926		1926		1925	1925	10' 30" W	$0.75	(New York Harbor)		Feet	1, 2, 3	5, Dots	y		y	y
NY40	1936	369	United States - East Coast: New York Harbor	40,000	1936		1936		1936			1936	11' 15" W	$0.75	(New York Harbor)		Feet	none (<3 blue)	1, 2, 3, 5, Dots	n		y	y
NY40	1944	369	United States - East Coast: New York Harbor	40,000	1944		1944	4485-4486		1944		1944	11' 15" W	$0.75	(New York Harbor)		Feet	none (<3 blue)	1, 2, 3, 5, Dots	n		y	y
NY40	1989	12327	United States - East Coast, New York - New Jersey: New York Harbor	40,000	1989	82	1989	C-1941-540		1989	1989	1989	13' 00" W		(New York Harbor)	Mercator	Feet	none (<3 blue)	1, 2, 3, 5, Lines				
SF40	1859/77	621	Entrance to San Francisco Bay, California	50,000	1859		1877	818	1887	1877	1877	1877	16' 30" E	$0.75	(San Francisco Bay, Middle)		Feet & Fathoms	1, 2, 3	4, 6, 10, Dashes & Dots	y	3	n	n
SF40	1883	621[a]	San Francisco Entrance, California	40,000	1883			1532		1883		1884	16' 34" E	$0.50			Feet & Fathoms	1, 2, 3	4, 5, 6, Dashes & Dots	y	-	n	n
SF40	1901	5581	San Francisco Entrance, California	40,000	1901			1829				1902	17' 00" E	$0.50	(San Francisco Harbor)	Polyconic	Feet & Fathoms	1, 2, 3	4, 5, 6, Dashes & Dots	y	1	n	n
SF40	1926	5532	United States - West Coast: San Francisco Entrance, California	40,000	1926		1926	3772		1927	1926	1928	18' 10" E	$0.75	(Entrance to San Francisco Bay)		Feet	1, 2, 3	5, 6, Dashes	?		y	y
SF40	1947a	5532	United States - West Coast, California: San Francisco Entrance	40,000	1947	26		C-1910-86		1949		1950	17' 45" E		(Entrance to San Francisco Bay)	Polyconic	Feet	none (<3 blue)	1, 2, 3, 5, 6, Dashes & Dots	n		y	y
SF40	1947b/57	5532	United States - West Coast, California: San Francisco Entrance	40,000	1947	26 Rev.	1957	C-1910-86	1957			1958	17' 15" E	$1.00	(Entrance to San Francisco Bay)	Polyconic	Feet	none (<6 blue)	1, 2, 3, 5, 6, 10, Dashes & Dots	n		y	y
SF40	1989	18649	United States - West Coast, California: San Francisco Entrance	40,000	1989	53	1989					1988	16' 15" E		(Entrance to San Francisco Bay)	Mercator	Feet	none (<6 blue)	1, 2, 3, 5, 6, 10, Lines	n		y	y
MH400	1862/72	9	General Chart of the Coast No. IV, From Cape May to Cape Henry	400,000	1862				1872			1863	3' 30" W	$2.00		Polyconic	Feet & Fathoms	3	10, 20, 30, 100, Dashes & Dots	y	-	n	n
MH400	1916	1109	United States - East Coast: Cape May to Cape Hatteras	[416,944]	1914	1916	1916	3395			1913	1917	6' 20" W	$0.50	(Cape May to Cape Hatteras)	Polyconic	Fathoms	3	5, 10, 100, Dashes & Dots	?		y	n
MH400	1922	1109	United States - East Coast: Cape May to Cape Hatteras	[416,944]	1922		1922	3619		1922		1917	6' 20" W	$0.75	(Cape May to Cape Hatteras)	Polyconic	Fathoms	3 (blue <3)	5, 10, 100, Dashes & Dots	?		y	y
MH400	1938	1109	United States - East Coast: Cape May to Cape Hatteras	[416,944]	1938		1938	3818		1938	1936	1939	7' 15" W	$0.75	(Cape May to Cape Hatteras)	?	Fathoms	3	5, 10, 100, Dashes & Dots	?		y	y
MH400	1942	1109	United States - East Coast: Cape May to Cape Hatteras	[416,944]	1942		1942	3818		1942		1940	7' 15" W	$0.75	(Cape May to Cape Hatteras)	?	Fathoms	3 (blue <10)	5, 10, 20, 30, 40, 50, 100, 500, 1000, Dashes & D	n		y	y
MH400	1951	1109	United States - East Coast: Cape May to Cape Hatteras	[416,944]	1951	14	1951	C-1913-123				1950	7' 30" W	$0.75	(Cape May to Cape Hatteras)	?	Fathoms	3 (blue <10)	5, 10, 20, 30, 40, 50, 100, 500, 1000, Dashes & D	n		y	y
MH400	1986	12200	United States - East Coast: Cape May to Cape Hatteras (Loran -C Overprinted)	416,944	1986	37	1986	C-1913-123 526		1989		1986	11' 45" W		(Cape May to Cape Hatteras)	Mercator	Fathoms	none (<10 blue)	3, 5, 10, 20, 30, 40, 50, 100, 500, 1000, 1500, Lin	n		y	y
GJF200	1862	28	Reconnaissance of Washington Sound and Approaches, Washington Territory [Preliminary]	200,000	1862							1858	21' 50" E			?	Feet & Fathoms	none	1, 3, Dots	y	missing	n	n
GJF200	1895	6300	Gulf of Georgia and Strait of Juan de Fuca, Washington	200,000	189_			2119			1895	1896	23' 20" E	$0.50	(Gulf of Georgia and Strait of Juan de Fuca)	?	Feet & Fathoms	1, 2, 3	10, 50, Dashes & Dots	y	-	n	n
GJF200	1922	6300	United States - West Coast: Georgia Strait and Strait of Juan de Fuca, Washington	200,000				3678			1916	1922	25' 10" E	$0.50	(Georgia Strait and Strait of Juan de Fuca)	?	Fathoms	1, 2, 3	10, 20, Dashes & Dots	y	-	?	n
GJF200	1933	6300	United States - West Coast, Washington: Georgia Strait and Strait of Juan de Fuca	200,000	1933		1934	3945			1931	1934	24' 15" E	$0.75	(Georgia Strait and Strait of Juan de Fuca)		Fathoms	3	10, 100, Dashes & Dots	n		y	y
GJF200	1941/48	6300	United States - West Coast, Washington: Georgia Strait and Strait of Juan de Fuca	200,000	1941	11	1948	C-1927-280	1949			1949	24' 00" E	$0.75	(Georgia Strait and Strait of Juan de Fuca)	Mercator	Fathoms	1, 3	10, 100, Dashes & Dots	n		y	y
GJF200	1986	18400	United States - West Coast, Washington: Strait of Georgia and Strait of Juan de Fuca	200,000	1986	35	1986	C-1927-280		1986		1986	21' 30" E		(Strait of Georgia to Strait of Juan de Fuca)	Mercator	Fathoms	none (<10 blue)	1, 3, 10, 100, Dashes & Dots	n		y	y
E1200	1863	24	Atlantic Coast of the United States (in four sheets) Sheet No. II, Nantucket to Cape Hatteras	1,200,000	1863							1865	6' 00" W			Polyconic	Fathoms	none	10, 100, Dots	y	-	n	n
E1200	1881	A	Atlantic Coast: Cape Sable to Cape Hatteras (Northern Sheet)	1,200,000				1357		1881			14.25' W	$1.00	Sailing Chart A	Polyconic	Fathoms	3	10, 50, 100, Dashes & Dots	y	3	n	n
E1200	1900	1000	Atlantic Coast: Cape Sable to Cape Hatteras	1,200,000	1900		1903	2636				1900	10.25' W	$0.50	(Cape Sable to Cape Hatteras)	Mercator	Fathoms	3	10, 20, 30, 40, 50, 100, 1000, Dashes & Dots	y		y	y
E1200	1927	1000	Atlantic Coast: Cape Sable to Cape Hatteras	1,200,000	1927		1927	3868				1929	11' 20" W	$0.75	(Cape Sable to Cape Hatteras)	Mercator	Fathoms	3	10, 20, 50, 100, 1000, Dashes & Dots	?		y	y
E1200	1938	1000	Atlantic Coast: Cape Sable to Cape Hatteras	1,200,000	1938		1938	3868		1938		1939	12' 15" W	$0.75	(Cape Sable to Cape Hatteras)	Mercator	Fathoms	3	10, 20, 30, 40, 50, 100, 500, 1000, Dashes & Dots	n		y	y
E1200	1943	1000	Atlantic Coast: Cape Sable to Cape Hatteras	1,200,000	1943		1943	4557-4558		1943		1943	13' 00" W	$0.75	(Cape Sable to Cape Hatteras)	Mercator	Fathoms	none (blue <10)	10, 20, 30, 40, 50, 100, 500, 1000, Dashes & Dots	n		y	y
E1200	1948	1000-L	Loran Chart - Atlantic Coast: Cape Sable to Cape Hatteras	1,200,000				4557-4558				1948	14' 15" W		(Cape Sable to Cape Hatteras)	Mercator	Fathoms	none (blue <10)	10, 20, 30, 40, 50, 100, 500, 1000, 1500, Dashes	n		y	y
E1200	1986	13003	Atlantic Coast: Cape Sable to Cape Hatteras	1,200,000	1986	37	1986	C-1943-587 2156		1986		1985	13' 45" W		(Cape Sable to Cape Hatteras)	Mercator	Fathoms	none (<10 blue)	10, 20, 30, 40, 50, 100, 500, 1000, Dashes & Dots	n		y	y
W1200	1855/64	603	Reconnaissance of the Western Coast of the United States (Northern Sheet) from Umpquah River to the Boundary	1,200,000	1855				1864		1864		20' 00" E	$1.30		Polyconic	Fathoms	none	none	y	6	n	n
W1200	1888	602	Pacific Coast from San Francisco Bay to the Strait of Juan de Fuca	1,200,000				1908		1888		1888	16.75' E	$0.50	(San Francisco to Strait of Juan de Fuca)	Polyconic	Fathoms	3	none	y	-	n	n
W1200	1917/26	5052	Pacific Coast: San Francisco to Cape Flattery	1,200,000	1917		1926	3836		1926		1927	19' 30" E	$0.75	(San Francisco to Cape Flattery)	Mercator	Fathoms	3	30, 100, Dashes & Dots	y		y	y
W1200	1932	5052	Pacific Coast: San Francisco to Cape Flattery	1,200,000	1932		1933	3836		1934	1931	1933	19' 15"	$0.75	(San Francisco to Cape Flattery)	Mercator	Fathoms	3	30, 100, Dashes & Dots	n		y	y
W1200	1945/54	5052	United States - West Coast: San Francisco to Cape Flattery	1,200,000	1945	13	1954	C-1897-20	1954			1952	18' 45" E	$1.00	(San Francisco to Cape Flattery)	Mercator	Fathoms	none (blue <30)	30, 100, 500, 1000, Dashes & Dots	n		y	y
W1200	1986	18007	United States - West Coast: San Francisco to Cape Flattery	1,200,000	1986	27	1986	C-1897-20	1986			1986	17' 45" E		(San Francisco to Cape Flattery)	Mercator	Fathoms	none (blue <30)	30, 100, 500, 1000, 1500, Lines	n		y	y

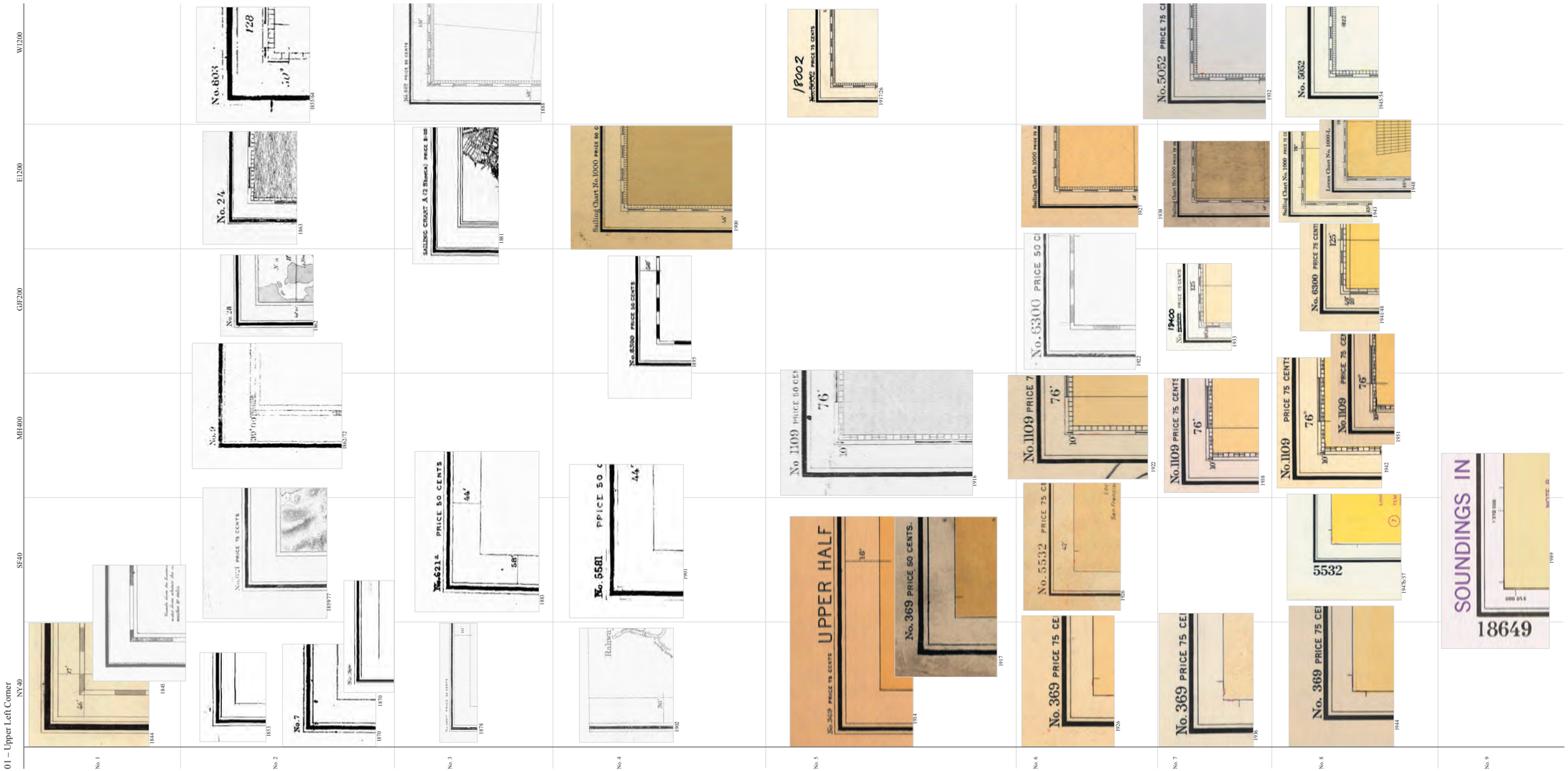
APPENDIX D

LAYOUTS

Layout 00—Full Sheets



Layout 01—Upper Left Corner



02 – Title Area

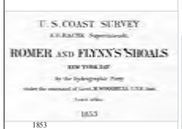
NY40 SF40 MH400 GJF200 E1200 W1200

No. 1

1844


1845

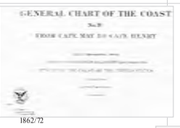
No. 2



1853


1870

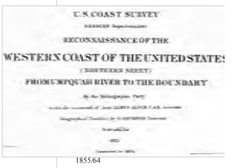
1859/77



1862/72

1863

1862



1855/64

No. 3

1878

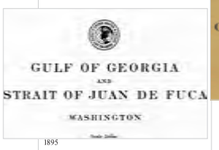
1883

1881

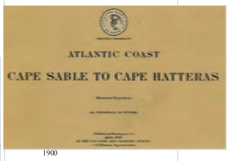
1888

No. 4

1901



1895



1900

1902

No. 5

1914

1917/26

1916

1917

No. 6

1922

1926

1926

1922

1927

No. 7

1936

1938

1933

1938

1932

1943

1947A

No. 8

1944

1942

1941/48

1947b/57

1951

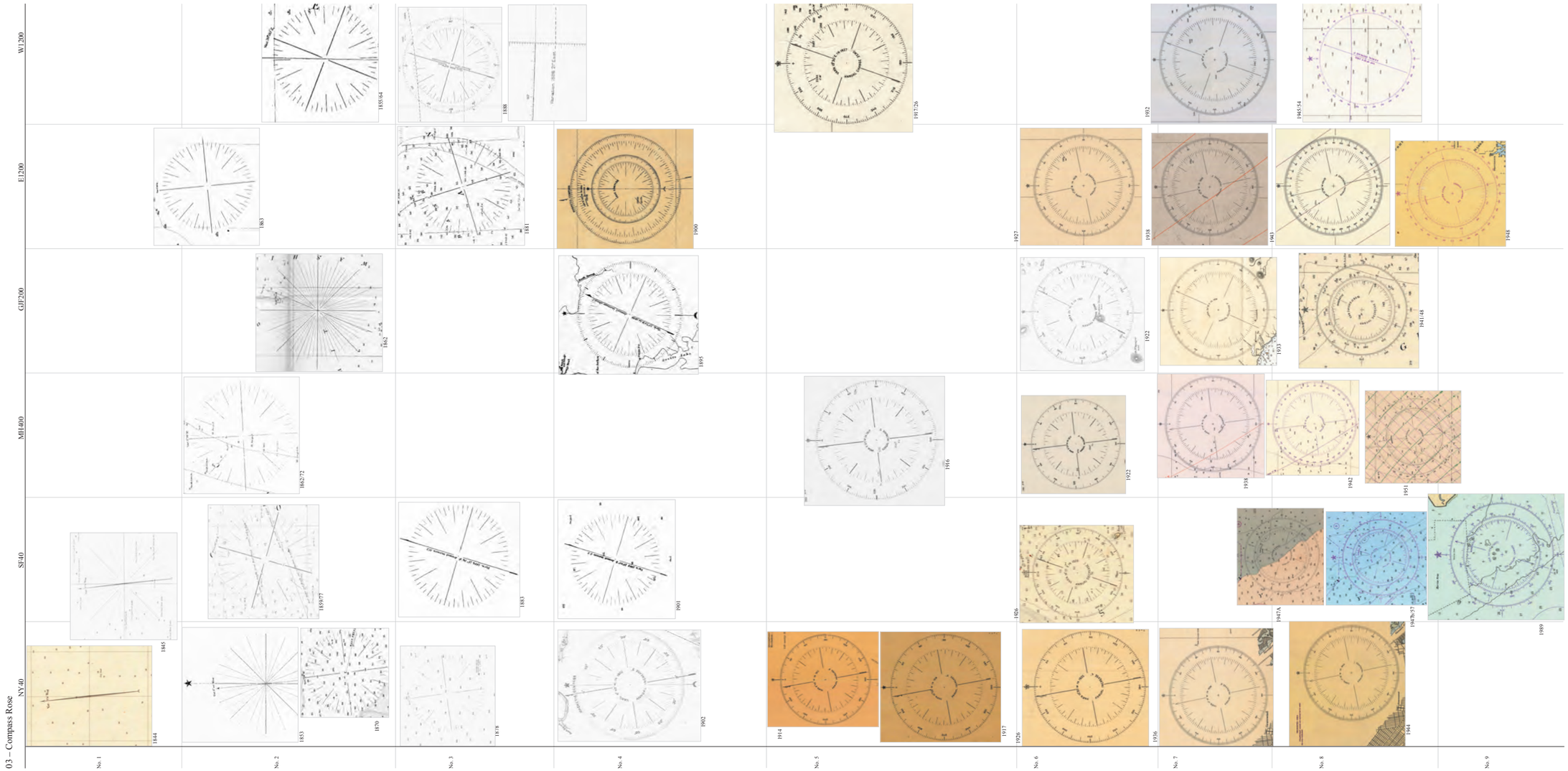
1948

1945/54

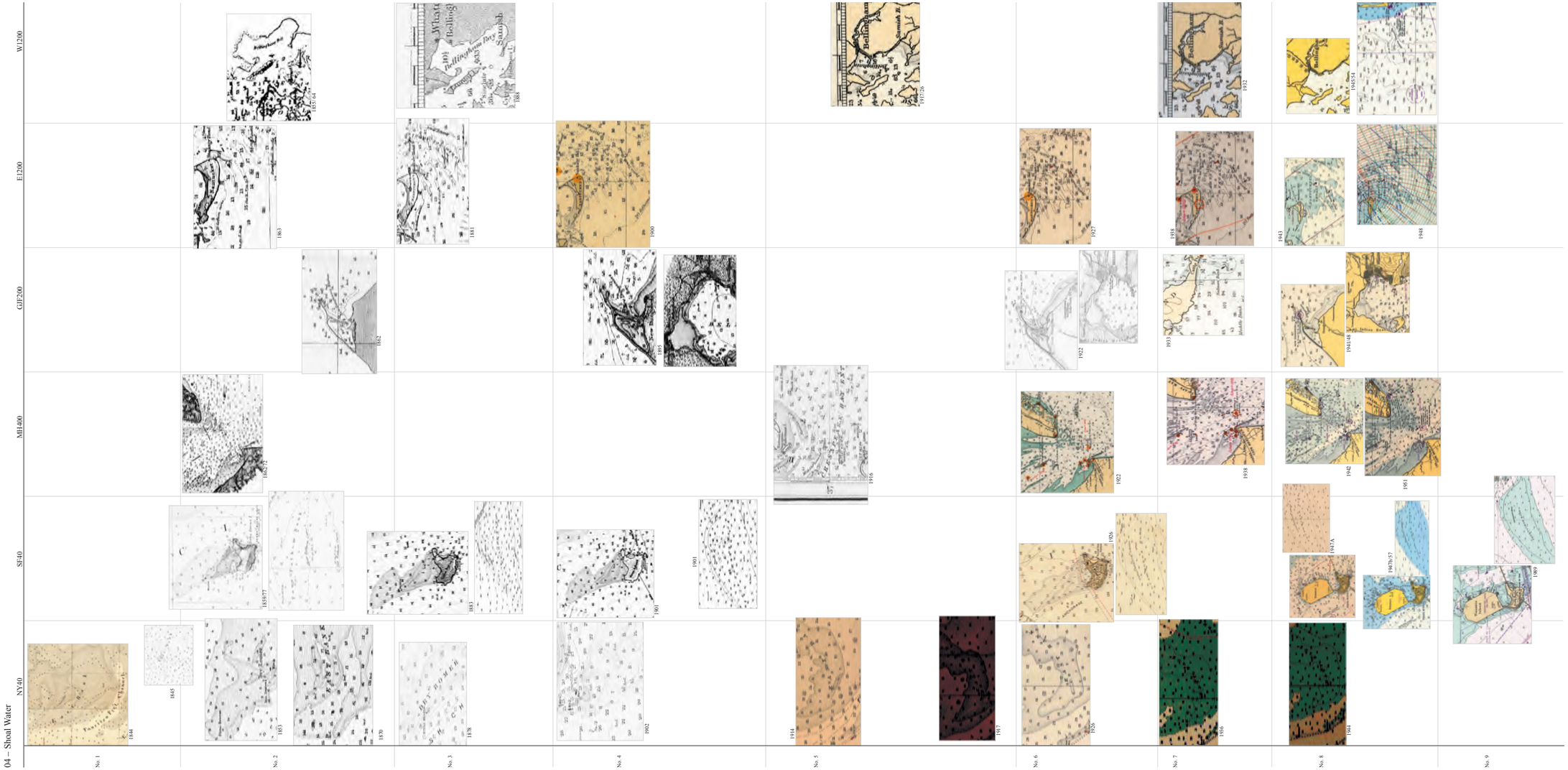
No. 9

1989

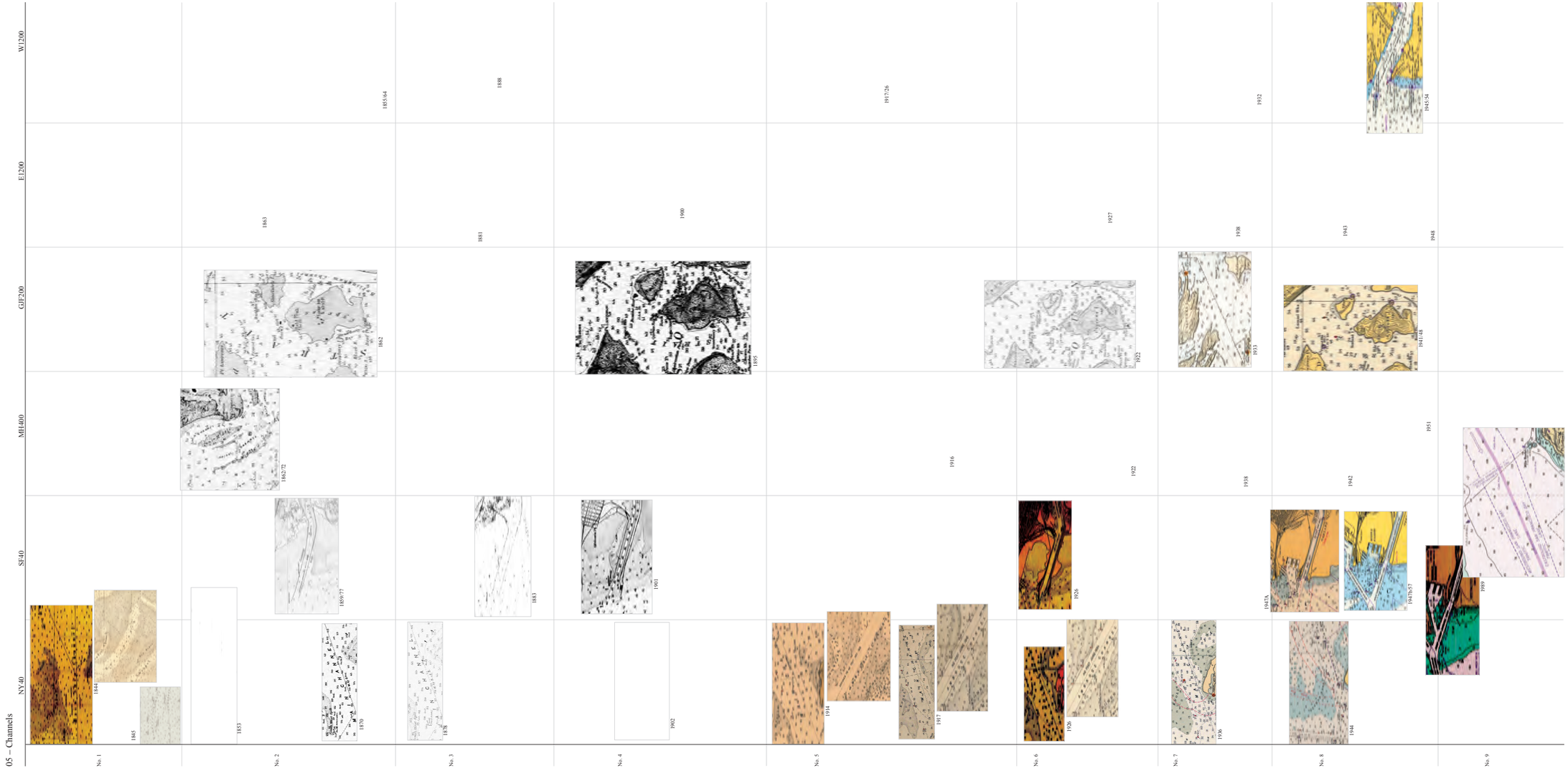
Layout 03—Compass Rose



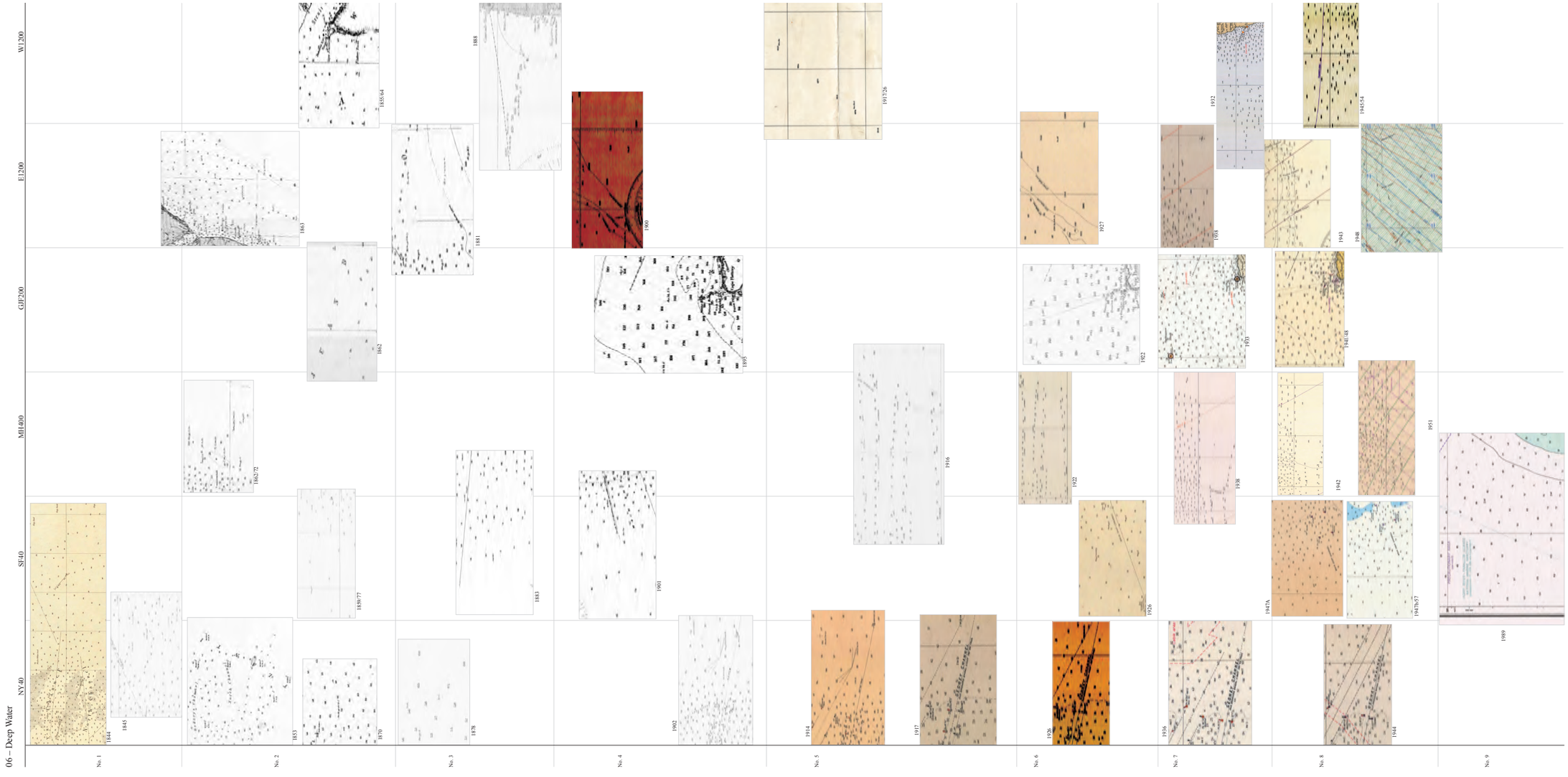
Layout 04—Shoal Water



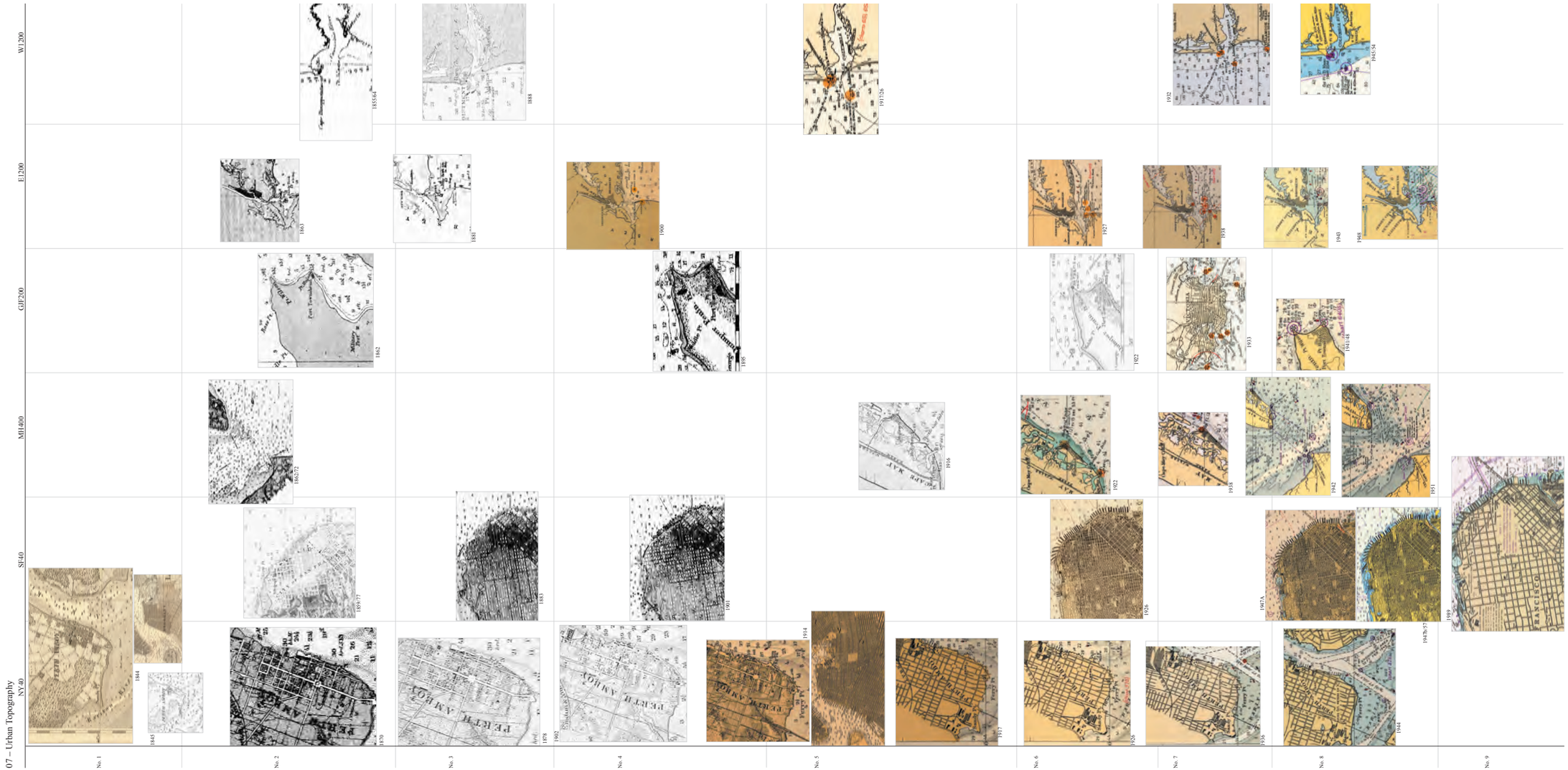
Layout 05—Channels



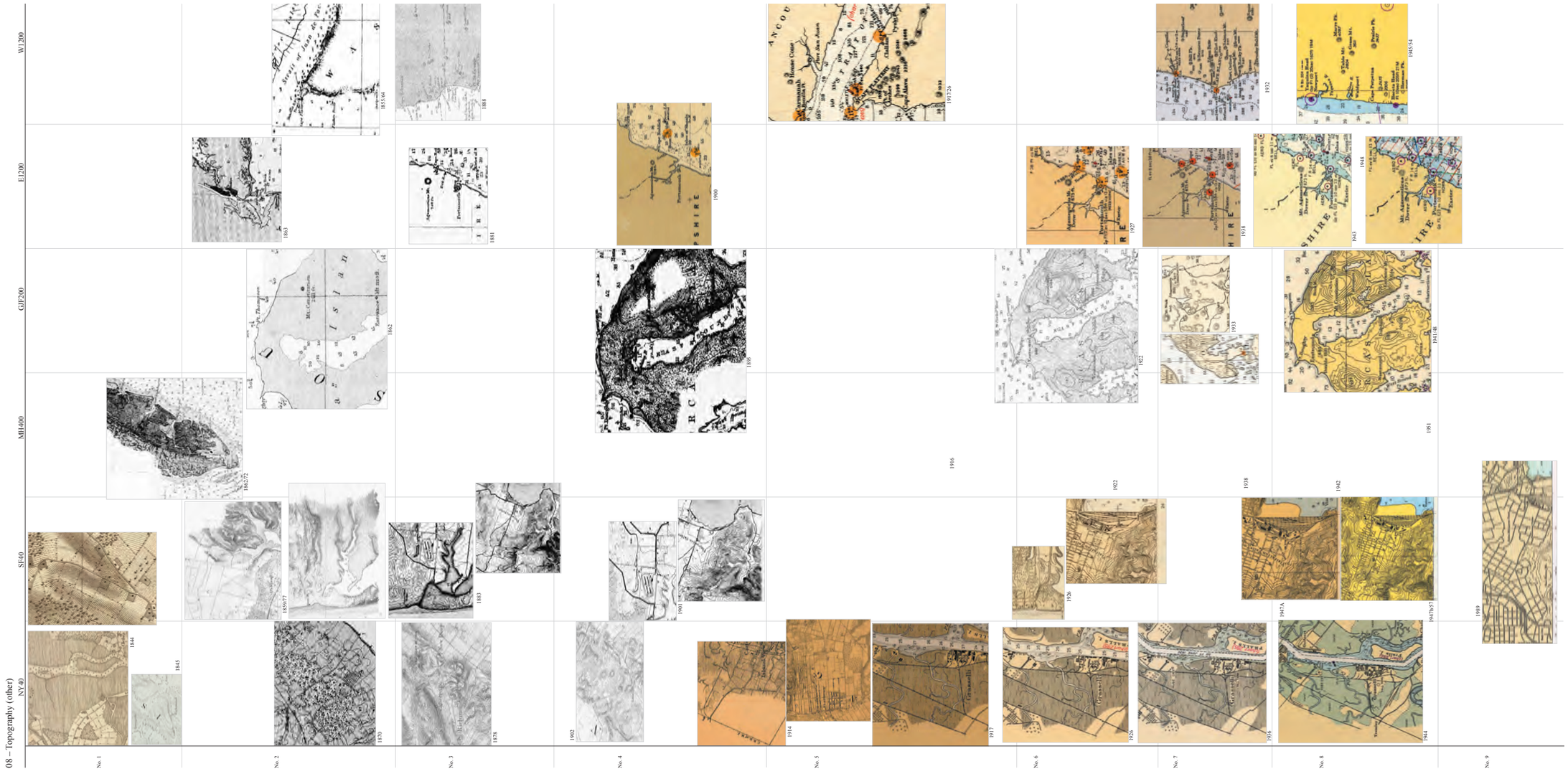
Layout 06—Deep Water



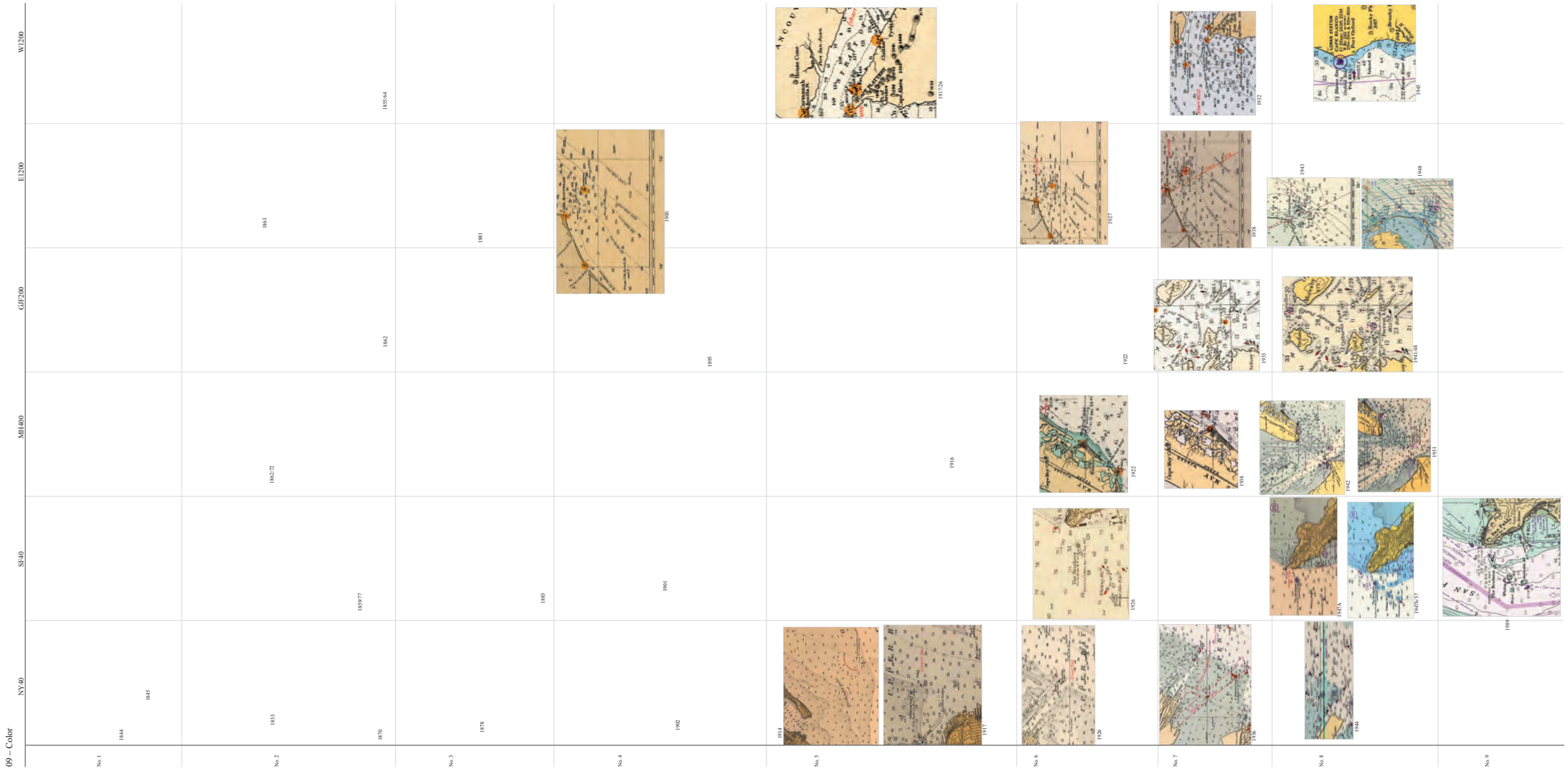
Layout 07—Urban Topography



Layout 08—Topography (other)

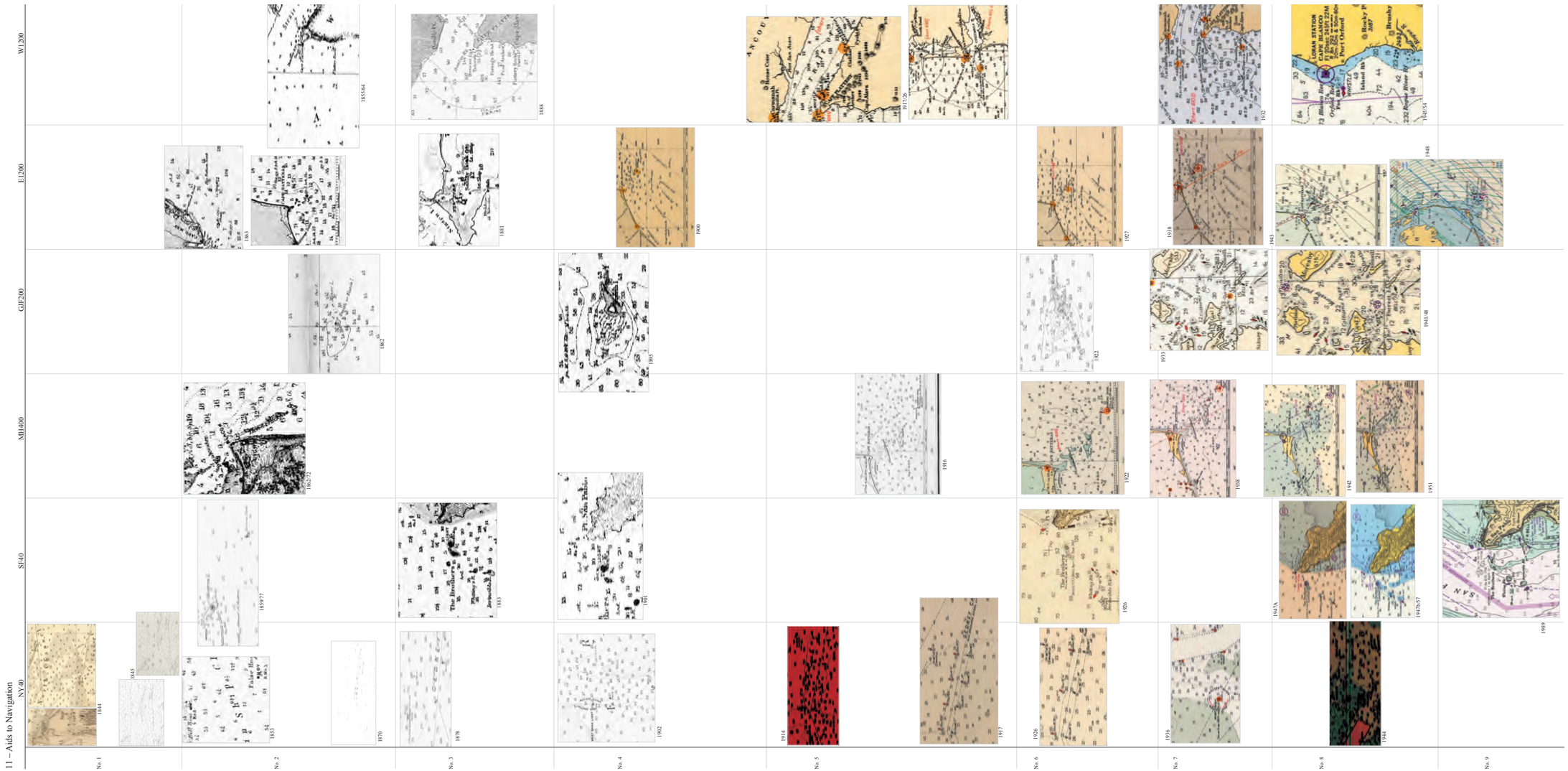


Layout 09—Color

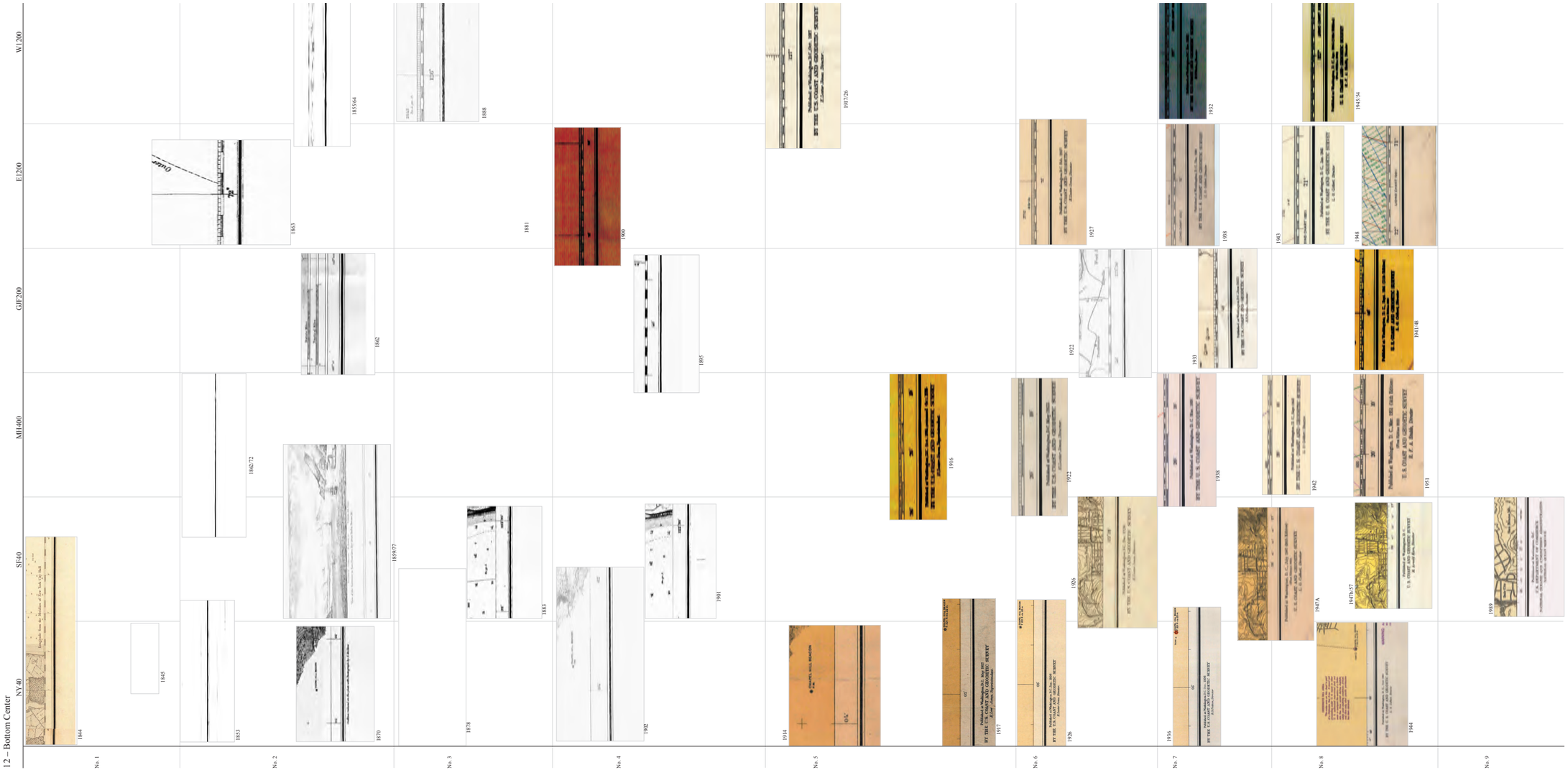


Layout 10—Notes

Layout 11—Aids to Navigation

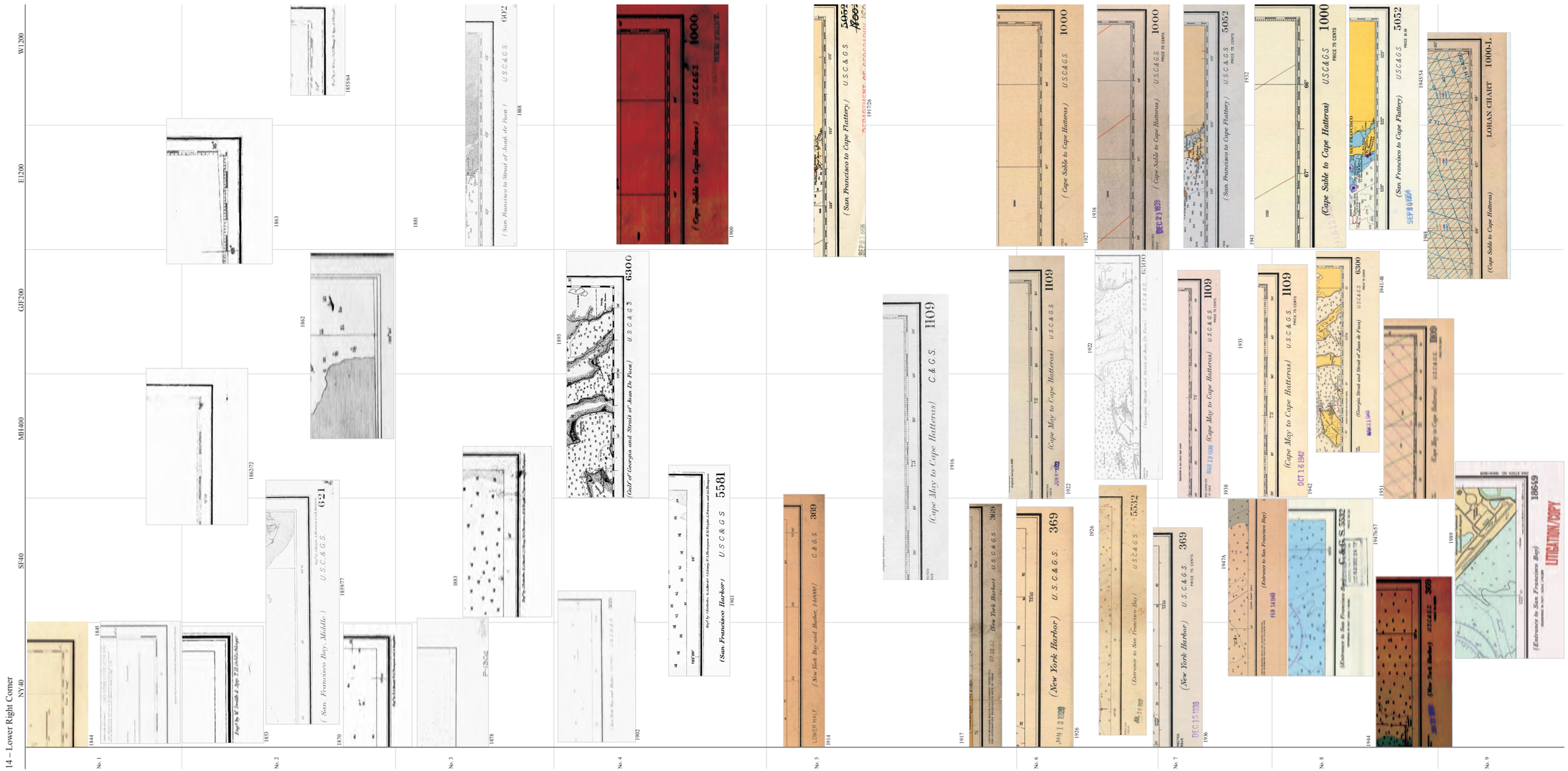


Layout 12—Bottom Center



Layout 13—Lower Left Corner

Layout 14—Lower Right Corner



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