CHAPTER 1

"It would appear that on some [of the Marshall Islands]…these charts were considered so precious that they might not be taken to sea. This was partly because they might be damaged in the canoes and partly, perhaps, because the people might never come back, in which case the tribe's precious property would be lost for ever." [Emphasis added.]

Collinder

Introduction

Background

Marine transportation is crucial to the United States economy: according to data published by the U.S. Bureau of the Census, in 1991 approximately 99 percent of all U.S. trade by weight (48 percent by value) was waterborne. And safe operation is essential to marine transportation. Accidents result in injuries, cost lives, and increase insurance rates. Moreover, as the *Amoco Cadiz, Argo Merchant, Exxon Valdez,* and *Torrey Canyon* cases vividly demonstrated, accidents have the potential to cause significant environmental damage (Cahill, Keeble, Marriott, Nalder, Petrow, Winslow). Fortunately, the operational safety of ships, measured in terms of marine casualties (including ship losses, tonnage lost, and volume of oil spilled), has increased over the past several decades [*National Research Council* (NRC) 1994 b].

Accurate and up-to-date nautical charts are the most basic navigational aid—so basic, in fact, that carriage of corrected charts is a legal requirement for certain classes of vessels. The need for accurate charts was recognized early in the history of the United States. The situation in the early days was described by one observer (Stanley 1976):

> "Moreover, young America at the turn of the 19th century was experiencing a tremendous growth in maritime commerce. Heavily laden cargo vessels and passenger ships with their precious burdens were entering and departing American ports for all parts of the world... Charts then in existence consisted chiefly of those produced by the British Admiralty of Colonial America for use prior to and during the American Revolution. These charts were based upon vague and incomplete reports and sketches, and were totally inadequate for needs of the times."

In 1807, Congress passed the Organic Act authorizing President Thomas Jefferson "… to cause a survey to be taken of coasts of the United States, in which shall be designated the islands and shoals, with the roads or places of anchorage, within 20 leagues [approximately 60 miles] of any part of the shores of the United States; and also the respective courses and distances between the principal capes or head lands, together with such other matters as he may deem proper for completing an accurate chart of

every part of the coasts within the extent aforesaid." In 1834, the Survey of the Coast, since renamed the Coast Survey (in 1936), the Coast and Geodetic Survey (in 1871), the National Ocean Survey (in 1970), and the National Ocean Service (in 1982), completed its first hydrographic survey of Great South Bay, Long Island, NY. The first U.S. Government produced nautical chart, a black-and-white print made from a stone engraving of Bridgeport Harbor, CT, was issued in 1835. Charts were not routinely produced until 1844, a year in which 169 copies were sold (Stanley 1974). Chart sales grew to 50,000 copies about the time of the Civil War, and 100,000 copies by the year 1900.

Schooners were employed as survey ships in those days, leadlines (a line, marked at graduated intervals, with a lead weight attached at one end) were cast at intervals to gather data on water depths, and *dead reckoning* (DR) and celestial navigation methods were used to fix the survey ship's position when out of sight of land. Primitive as these systems were, the results were useful and the charts based upon these surveys contributed substantially to safe navigation.

Hydrographic surveys were often dangerous in the early days, as often the survey ship ran into the very object their charts sought to warn of. Such was the case with the British Admiral Francis Beaufort, then a young man, who was aboard the *Vansittart* (a vessel of the East India Company) when it ran aground on a shoal being surveyed off the Sumatra coast causing all hands to abandon ship. The sinking provided dramatic evidence of the value of an accurate nautical chart (Wilford) and indirectly advanced the cause of nautical cartography because Beaufort later became one of the premier hydrographers.

Over the years, new technology advanced the state of the art for surveying, chart compilation, and publishing. To cite a few examples:

- Survey ships are now diesel powered, electronic depth sounding methods (e.g., side scan sonar) are used to survey the ocean bottom, and modern electronic navigation systems, such as Loran–C and the satellite-based *Global Positioning System* (GPS), are used to fix the survey ship's position.

- Most survey vessels now tow side scan sonars. This enables the hydrographer to survey a swath of the bottom, usually about 100 to 200 meters along the towfish track. Objects on the bottom, such as wrecks, rocks, and obstructions, cast a large shadow on the sonargram, which permits the approximate height of the object to be computed (*Nautical Charting Program*).

- Land areas depicted on nautical charts are surveyed with aircraft and other platforms, computers are used extensively in chart compilation and printing, and electronic charts based upon digital data are becoming commonplace.

- Printing techniques evolved as well, the stone engraving was soon replaced by the copperplate engraving, and this in turn by photo-lithography (Stanley 1974). In the near future, electronic charts will become commonplace, and the television monitor will replace the paper chart.

Although there is room for improvement as budget shortfalls have taken their toll in these days of government austerity (NRC 1994 a, NRC 1994 b, Queeney), U.S. Government nautical charts are recognized as being among the best in the world.

Technology has also reduced the cost of producing charts. As the opening quotation indicates, in some countries at least, charts were so valuable that they were not allowed to be taken to sea—a colossal irony. Now modern compilation and printing methods have so reduced the cost of charts that these have evolved from precious documents to working tools. Mariners of old would be astounded that courses are routinely *plotted* on charts, rather than calculated laboriously by mathematical methods.

The NOAA Ship *Surveyor* is One of a Fleet of Survey Ships Used to Gather Hydrographic Data

The Nautical Chart User's Manual

Even the best chart is of little value if the mariner is not thoroughly familiar with the various conventions and symbols used in its compilation. This manual was written to explain the symbols and conventions employed on U.S. nautical charts and to show how and why charted information is relevant. A listing of the various chart symbols with pictures of the specialized icons and other information is provided in *Chart No. 1, United States of America, Nautical Chart Symbols, Abbreviations, and Terms, Ninth Edition*, generally referred to simply as Chart No. 1.[1] Chart No. 1, described below and throughout this manual, provides a valuable compilation of chart symbols and conventions. However, Chart No. 1 is very compact—important definitions and explanatory material are omitted in the interests of brevity. Moreover, neither this chart nor the numerous excellent texts on navigation provide a comprehensive discussion of nautical chart conventions and their relevance to the mariner. Specialized publications, such as the *Nautical Chart Manual*, do address many of the topics covered here, but are written for a more technical audience and not widely available.

This Chart User's Manual supplements and expands upon the contents of Chart No. 1.

[1]Other nations publish a similar product (e.g., Carte No. 1, Chart 5011) to explain their charts.

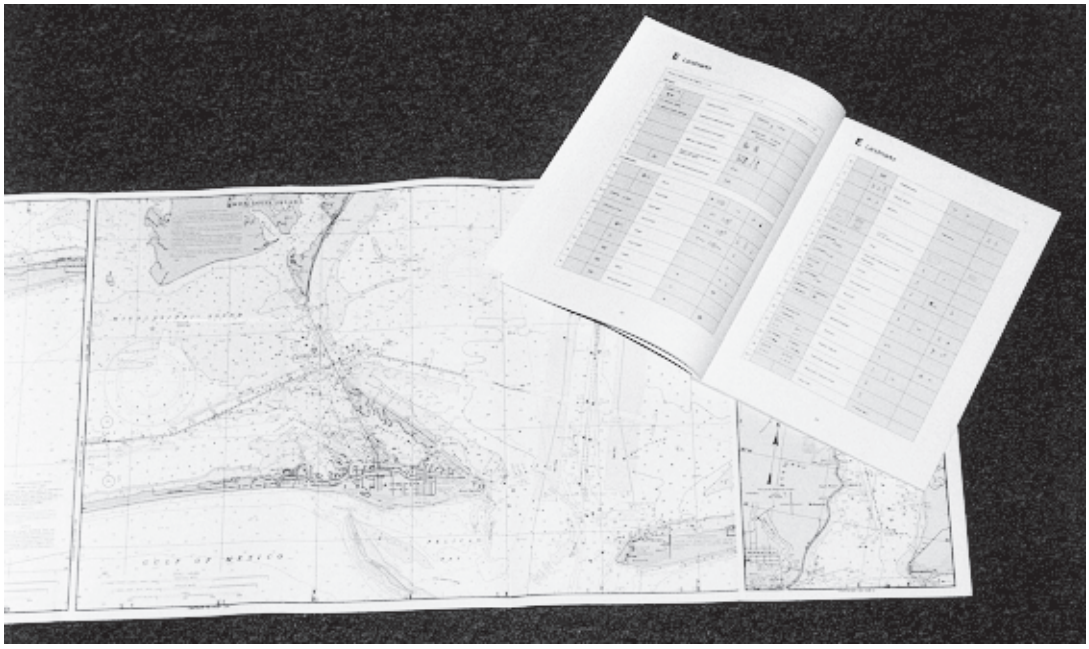
The manual not only identifies the chart symbols and conventions, but also explains the importance of the various charted features to safe and efficient navigation and the underlying cartographic philosophy embodied in the modern nautical chart. For example, Chart No. 1 identifies the chart symbol used to depict a restricted area, but does not inform the reader what this means nor where to find more about the regulations applicable to specific areas (see Chapter 7 for details). As a second example, Chart No. 1 shows the symbols used to depict landmarks, but does not state why only certain objects are charted as landmarks nor why some landmarks might be better than others for determining the vessel's position (topics explored in some detail in Chapter 6).

This manual is intended to be a "reader-friendly" synopsis of a great deal of technical information—organized in an easy-to-understand format suitable for self-study or inclusion as a supplemental text in courses on navigation or boating safety. This manual is not a textbook on navigation *per se*, but does provide essential background to help the reader understand why certain objects are charted and how the various features depicted on the nautical chart are potentially important to the navigator. References at the end of this chapter explore navigation more thoroughly.

Recreational boaters and professional mariners alike should find this manual interesting and relevant.

Organization of this Manual

Chapter 1 provides a general overview and introduction to the nautical chart and related publications. Chapter 2 provides additional general information about nautical charts together with specific material about the schematic layout of the chart, projections, type and scales of charts, chart overlap, vertical and horizontal datums, and other chart conventions. Chapters 3 through 7 provide a detailed exposition of various features found on the nautical chart. Chapter 3 shows how topography and many land-based features (e.g., buildings, roads, urban areas) are charted; Chapter 4 presents the same information for hydrographic features (depth curves, soundings, wrecks, shoals, obstructions and other hazards); Chapter 5 provides information on *Aids to Navigation* (ATONs), such as lights, ranges, and buoys; Chapter 6 discusses landmarks; and Chapter 7 covers areas, limits, and routes as depicted on the nautical chart. This manual is intended to be a companion to Chart No. 1, so the organization is deliberately similar. Space



This Manual Should Be Read with a Copy of Chart No. 1 and a Illustrative Nautical Chart Handy

constraints do not permit incorporation of Chart No. 1 in its entirety, but relevant excerpts are included where appropriate. Likewise numerous excerpts from actual nautical charts are furnished to illustrate key points in the text. It is recommended that the reader have Chart No. 1 and a typical nautical chart at hand when studying this manual. *Any excerpts included in this manual are for illustrative purposes only and are not to be used for navigation*. (For reasons discussed below and throughout this manual, charts and related material are revised periodically. The latest revisions may not be included in this manual. Even though specific charted features may change, the illustrations have generic value.)

Each chapter in this manual contains a list of references that contain additional relevant detail, or useful general information. Names or brief titles inserted in parentheses (e.g., Bowditch) refer to sources listed at the end of the chapter. Inclusion of a reference does not mean that any agency of the U.S. Government endorses the contents or any products mentioned therein. Indeed, some references are cited to present an alternative perspective.

Appendix A provides a glossary of specialized terms used in this manual and appendix B provides a list of abbreviations used in this manual, on nautical charts, or in related publications, such as the *Notice to Mariners* (NM) or the *Light List*.

Relevant Facts, Statistics, and Products

Table 1–1 provides salient facts and statistics regarding nautical charts of U.S. waters. The U.S. NOS, a part of NOAA, under the Department of Commerce, is the agency responsible for charting the national and territorial coastal waters of the United States, including the Great Lakes, Puerto Rico, U.S. Virgin Islands, U.S. Trust Territories, and other islands in the Atlantic and Pacific Oceans. (Hereinafter, these are referred to in this manual as "NOAA" charts. Specific chart numbers are referred to as "NOS Chart No. xxxxx.") Another agency, the *National Imagery and Mapping Agency* (NIMA) *formerly the Defense Mapping Agency* , part of the *Department of Defense* (DOD), is responsible for publishing U.S. charts of other areas of the world. Charts of inland lakes and waters are also produced by the U.S. Army Corps of Engineers (USACE), working cooperatively with NOAA.

As can readily be imagined, the overall process of gathering relevant data (e.g., from aerial photographs, hydrographic surveys, reports of chart corrections sent in by mariners, other government sources such as the *United States Coast Guard* (USCG), and volunteer organizations such as the *United States Coast Guard Auxiliary* (USCGAUX) or the *United States Power Squadrons* (USPS)), compiling charts and checking, printing and distribution is a substantial undertaking. A

Table 1-1. Facts and Statistics Relevant to NOAA Products

Area of Charting Responsibility	The U.S. National Ocean Service (NOS) is responsible for charting the national and territorial coastal waters of the United States, including the Great Lakes, Puerto Rico, U.S. Virgin Islands, U.S. Trust Territories, and other islands in the Atlantic and Pacific Oceans.
Number of NOS Charts:	Approximately 1,000.
Area of NOS Chart Coverage:	Approximately 3.4 million square nautical miles.
Miles of Tidal Shoreline:	Approximately 100,000 nautical miles.
Products:	Canoe Charts, Catalogs of Charts and Publications, Conventional Charts, Dates of Latest Editions, Geophysical Maps, Marine Boundary Charts, Regional Tide and Current Tables, Small-Craft Charts, Special-Issue Charts, Tidal Current Charts, Tidal Current Tables, Tide Tables, and United States Coast Pilots.

few statistics are revealing. NOAA maintains approximately 1,000 charts in its inventory. These charts cover approximately 3.4 million square nautical miles of water and contiguous land area, including approximately 100,000 miles of tidal shoreline. In addition, NOAA maintains a small fleet of research vessels which conduct and revise hydrographic surveys to determine depths, and locate and identify natural (e.g., rocks, shoals, ledges, etc.) and artificial (e.g., wrecks, pipelines, cables, unexploded ordnance) hazards to navigation.

Charting is a dynamic, rather than static, activity. Over time, charts need to be revised. For example, the NOAA ship *Rainier* recently completed a thorough side-scan sonar survey in the vicinity of the offshore oil loading facility in Estero Bay, CA (Richards). This survey discovered 22 previously uncharted and potentially significant dangers to navigation. This is not an isolated example. Hurricanes and earthquakes literally raze the landscape; currents scour and fill areas, disturbing the pattern of depths; dredging activities straighten and deepen rivers; new ports and waterfront facilities and other construction activities alter landmarks, change bridge clearances; and myriad other natural and human activities gradually render present charts obsolete and ultimately potentially unsafe to use. The number of new or revised charts published annually by NOAA varies from year to year, but is measured in hundreds.

For reasons discussed at length in this and the following chapters, no one type of chart of an area serves all users. Therefore, NOAA produces an integrated series of charts and related products (see table 1–1 and below). This manual focuses upon chart products, but the content, role, and utility of related products (published by NOAA and other agencies of the U.S. Government) are too important to be ignored. These other publications are explained below and in appropriate sections of this text.

As shown in figure 1–1, the principal NOAA chart/map products (discussed in some detail in Chapter 2) include small-craft charts, marine facility charts, conventional charts (further subdivided, based upon chart scale and other attributes, into *Intracoastal Waterway Charts* (ICW), harbor charts, coast charts, general charts, sailing charts, and international charts), and training charts. Although many of NOAA's charts are used by all mariners, each of these products is designed to serve the interests of particular segments of the user population (see below) including both navigational and non-navigational consumers. For example, as the names imply, small-craft charts and marine facilities charts are intended principally for the recreational boater, and the content is customized to provide relevant information to this group. (In some areas, however, small-craft or marine facility charts are the only charts available and other users, such as operators of commercial vessels, have no alternative but to use these charts.) Conventional charts are used by all groups. Training charts are inexpensive products with a description of symbols and conventions printed on the back of the chart that are ideal

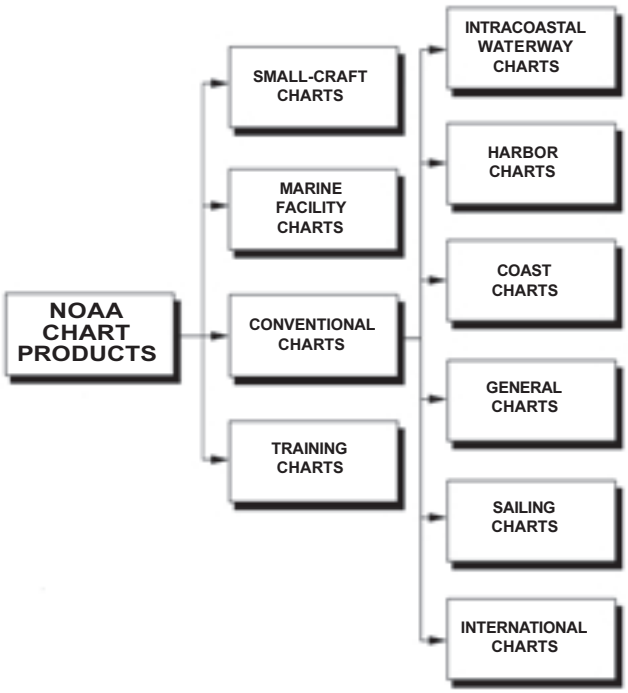


Fig. 1-1. Principal NOAA Chart/Map Products

for teaching navigation. Space and scope constraints preclude a detailed discussion of chart uses for purposes other than marine navigation.

Purpose of the Nautical Chart

In brief, the principal purpose of the nautical chart is to provide information necessary to promote safe and efficient marine navigation. The time-honored application of a chart is to provide data that can be used by the navigator to fix the vessel's position, for example, by taking visual bearings on charted natural and artificial features or ATONs. The fix might be used directly, or as a check on the vessel's position determined by other means, such as an electronic fix read from a Loran–C or GPS receiver.

As important as nautical charts are for position fixing, the real utility of a chart lies elsewhere—in *orienting* the mariner. A position fix merely answers the question, "Where am I?" But often a much more relevant question is, "What does it mean to be here?" From an decision theoretic perspective, "here" should not be described by the conventional coordinates of latitude and longitude, but rather in terms of the relevant features of the surroundings and their implications for underway decision making. Charts help answer numerous key questions. Is "here" in the vicinity of rocks, shoals, ledges, reefs, tide rips, sunken wrecks, or other potential hazards to navigation that should be avoided? Is "here" in the vicinity of a danger area, prohibited area, *traffic separation scheme* (TSS), or other regulated area? Is "here" near a planned turn point, waypoint, or destination? Is "here" a place that I can anchor safely, and if so, which anchor should I use to maximize holding power? Is "here" along my intended route, or should I make course adjustments to get back on track? And if "here" is on the desired track, am I on/ahead/behind schedule? If, as a result of some unforeseen contingency (e.g., medical emergency, mechanical problem, fuel shortage), I needed to select an alternate destination, how could I reach this alternate efficiently? In short, nautical charts furnish information critical to *enroute decision making.*

Nautical charts also provide information essential to *voyage planning;* figuring out how to get from "here" to "there" safely and expeditiously. Nautical charts are useful for voyage planning for many reasons; to cite just a few, these charts

- enable the identification of safe routes which are efficient in terms of total distance, but avoid known hazards,
- facilitate the determination of the true/magnetic courses and distances for each leg of the route (all key inputs to determining the estimated time enroute, estimated time of arrival, and fuel requirements),
- provide information on landmarks, ATONs, and other features that can be used to fix the vessel's position and track progress of the voyage,
- identify regulated areas and, in some cases, the specific regulations applicable to each area, and
- contain key information on facilities, such as repair services, fuel availability, piers, wharves, and marinas.

How Does a Nautical Chart Differ from a Map?

The words "chart" and "map" are often used interchangeably, but incorrectly, by the layman. Although certainly related, charts differ from maps. Reduced to its essence, the key difference between a nautical chart and a map is that the chart provides information relevant to marine navigation, whereas the map is oriented to the terrestrial user.[2] The focus of the nautical chart is on water areas, providing data on water depths, ATONs, hazards, etc. Contiguous land areas are also shown, but the features depicted are limited to those that are particularly relevant to marine navigation (e.g., shoreline, near shore topography, landmarks, piers, wharves). As noted in the *Nautical Chart Manual*,

> "The nautical chart differs considerably from the topographic map in its treatment of the coastline. The topographic map emphasizes the land forms and the representation of relief, with shoreline as an approximate delineation of the waterline at mean sea level. In contrast, the nautical chart has such a unique requirement for detailed and accurate representation of the coastline and water forms that it must be considered in a separate category from topographic maps in any discussion of coastal geography."

–An Illustrative Chart

Figure 1–2 contains an excerpt from NOS Chart No. 12314 (Delaware River, Philadelphia to Trenton) showing a portion of the Delaware River in the vicinity of Riverside, NJ. Depth contours, channel boundaries, soundings, lights, buoys (cans, nuns, and bifurcation buoys), ranges, wrecks, shoals, obstructions, piers, piles, ramps, cable and pipeline areas, bridges (with vertical and horizontal clearances), harbors, and other features important to navigation are found on this chart. Bottom characteristics (e.g., mud, grass) are also shown. To be sure, topographic features, such as roads, are also charted. But the emphasis is clearly on features relevant to marine navigation. The few structures depicted in figure 1–2, including buildings, tanks, and stacks, are landmarks (see Chapter 6) useful for taking visual bearings. Elsewhere on this chart (not shown in the excerpt in figure 1–2) information is presented on anchorage areas, tides and tidal currents, latitude and longitude scales, distance scales, and other related features. Were this chart of an open ocean or bay, Loran–C *time differences* (TDs) might be overprinted to provide the mariner with position information. Yet other features that would be shown include restricted areas, prohibited areas, danger areas, seaplane landing areas, TSS routes, etc. Distances measured on the chart are in exact proportion to actual distances between locations, and directions measured relative to parallels of latitude, meridians of longitude, or conveniently placed compass roses (see Chapter 2) equate to actual courses between points.

The land area depicted in the chart excerpt in figure 1–2 is relatively flat and so does not illustrate how topography is handled on a nautical chart. Some brief comments on the depiction of topography (discussed at length in Chapter 3) on the nautical chart are pertinent. As noted in the *Nautical Chart Manual*,

[2]Likewise *aeronautical charts* depict information relevant to the aviator.

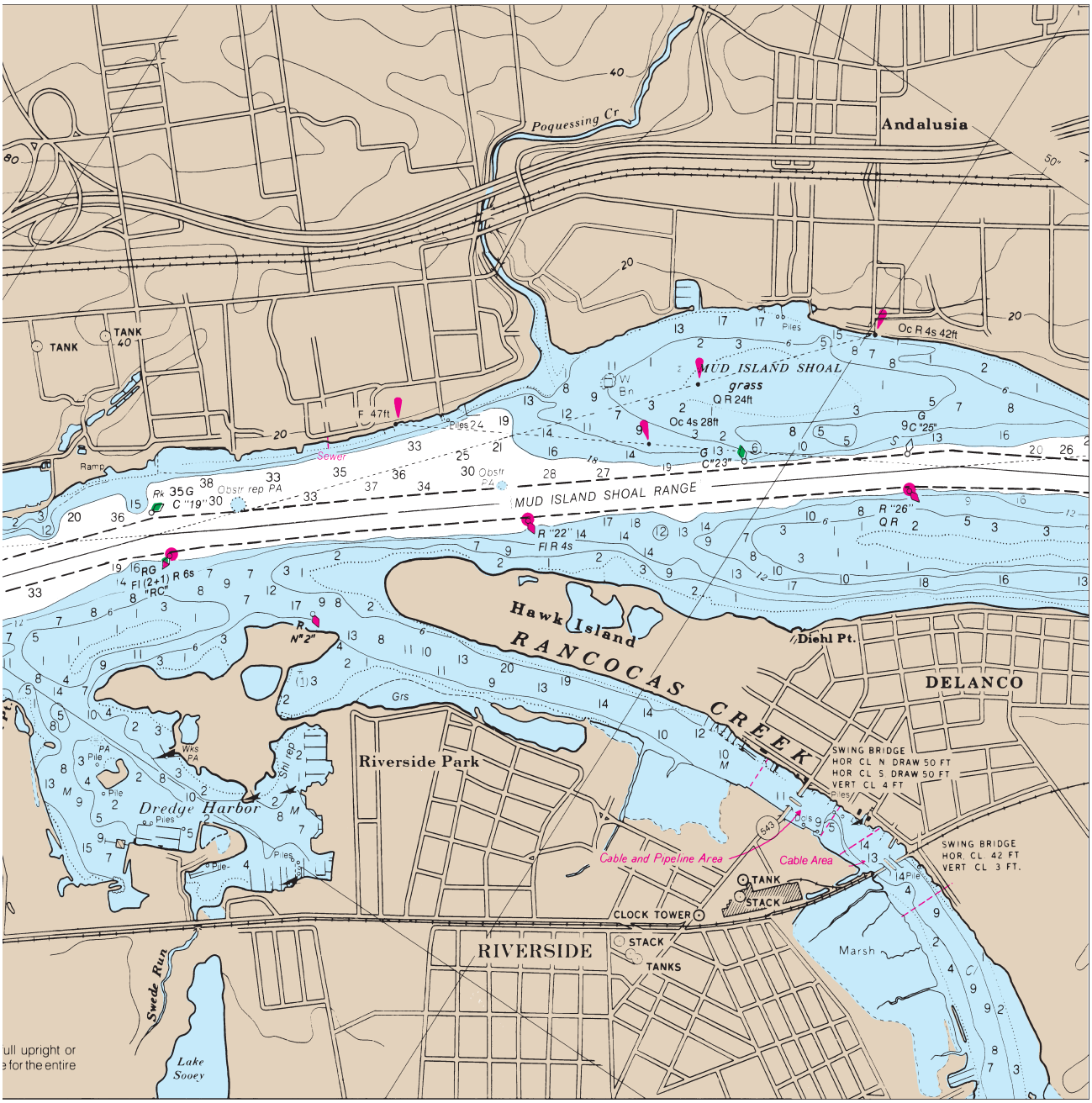


Fig. 1-2. Excerpt from NOS Chart 12314 (Delaware River, Philadelphia to Trenton) Showing Portion of Delaware River in the Vicinity of Riverside, NJ, at a Scale of 1:20,000

> "…although topographic contours are undeniably valuable to the mariner on charts of some areas for radar reflection, visual profiles, and identification for relative position locating, their inclusion on other charts causes an amount of work out of proportion to their value. The drafting of standard rules covering particular features often leads to a misguided attempt to give a chart uniform treatment throughout, whereas an essential element of successful chart compilation is that different considerations apply as a compiler works from inshore to offshore areas, or along an open coast toward a shoal-encumbered estuary, or inland from the coastline."

As an obvious, but revealing example, there is little value in charting topography that cannot be seen from the water. Likewise, charting cultural features, such as buildings, roads, etc., that cannot be seen (or otherwise detected)[3] from the water is unproductive—and continually so, because this detail must either be updated or consumers may lose confidence in the product.

–An Illustrative Map

Contrast figure 1–2 with figure 1–3, showing the same area, drawn to nearly the same scale, taken from a U.S. Geological Survey quadrangle map. Figure 1–3 shows much more nautical detail (e.g., depth curves, shoals) than would typically be found on a highway map, for example. Nonetheless, the focus of this map (figure 1–3) is clearly on the land, rather than the river. Town, county, and state boundaries, buildings, schools, churches, hospitals, street names, etc., are prominently displayed. A highway map of the same area, which is not shown to avoid copyright issues, would omit all nautical detail, and add such items as service stations. Maps are made for a variety of other purposes, such as showing land-use patterns, crop distributions, population characteristics, consumer demographics, etc. (Lewis, Makower, Monmonier, Wood). But all share a terrestrial focus unrelated to marine navigation.

Charts generally also differ from maps in terms of accuracy requirements. For most maps, if a feature were charted at a point several hundred feet from its actual location, the consequence would be small indeed. This same error in a nautical chart of a confined waterway strewn with rocks and shoals could be the difference between a safe and uneventful voyage and a shipwreck.

User Groups

As noted, the user population for NOAA charts is diverse. Figure 1–4 illustrates a typology of nautical chart users (NRC 1994 a). *Navigational users* include navies of the world, marine transportation, commercial fishing fleets, and recreational boaters and fishermen. *Non-navigational users* include those interested in coastal land development, research and exploration, conservation, and coastal zone planning. Non-navigational users and uses are described elsewhere (NRC 1994 a).

Even among navigational users, there is substantial diversity. To some degree the diverse needs and interests of navigational users can be accommodated by the different

[3]Airports are typically charted (see Chapter 3) even if they cannot be seen from the water, because the mariner can observe the rotating beacon, arriving and departing aircraft, or other clues to their existence.

Fig. 1-3. Excerpt from United States Geological Survey Map of Beverly Quadrangle (Beverly, NJ—PA) Showing Portion of Delaware River in the Vicinity of Riverside, NJ, at a Scale of 1:24,0000

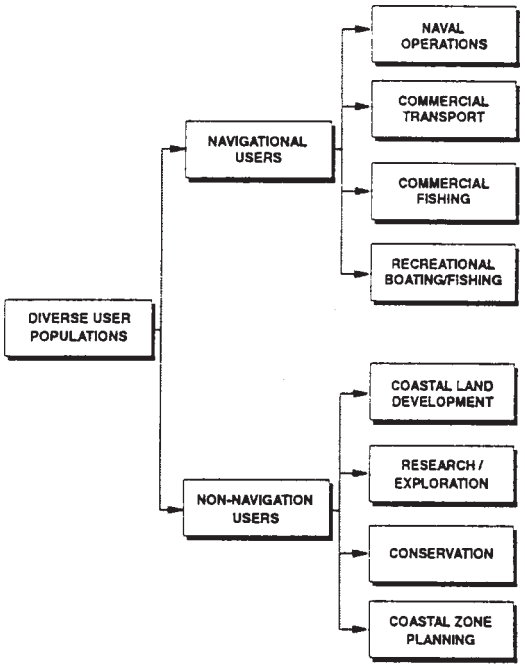


Fig. 1-4. A Typology of Nautical Chart Users

types of charts produced by NOAA. However, it would be wasteful to provide duplicate coverage for all areas. This means that the design of many nautical charts is, at least to some degree, a compromise. Consider depth information, for example. Most recreational boaters operate vessels with drafts less than about 6 feet (approximately 2 meters). To avoid recreational vessel groundings, it might be perfectly acceptable to produce a nautical chart with depth curves and soundings marked to say, 18 feet, and delete anything deeper. Although some utility would be denied the recreational boater by this action (e.g., the opportunity to use depth curves or soundings to establish position), the resulting chart would still be quite satisfactory. Operators of deep-draft vessels (and submarines for that matter) would find this simplified chart entirely unacceptable. These heavy-iron drivers would be more than happy to sacrifice charted depths and soundings less than their draft (all the shallow water detail) in the interests of chart simplification. And so it goes. Fishermen have unique interests, as do divers, offshore rig operators, tanker skippers, etc. Nautical charts are designed to strike a balance among the sometimes conflicting needs and interests of diverse user groups.

In a survey of user needs, NRC (NRC 1994 a) determined that, "the professional mariner uses the chart as a navigation tool and, therefore, generally wants uncluttered charts, believing that information which is available elsewhere (such as marina facilities) should not be included on nautical charts." Professional mariners wish to have all "extraneous information," by which is meant "anything that can be found anyplace else," deleted from the chart.

The recreational boater, according to this same survey, "generally has less storage and working space on board as well as fewer crew members and frequently prefers that as much planning information as possible be printed on the chart. While having the most current chart is generally important to the recreational boater, chart update information is generally not a critical requirement." In a phrase, recreational boaters want charts to offer "user-friendly, one-stop shopping."

The electronic chart of the near future (see below) will enable users to "customize" their charts to display only the information desired. However, paper charts do not offer this flexibility.

Efficiency of Chart Compared to Text

There is an old saying to the effect that a picture is worth a thousand words. As the example given below indicates, nautical charts are probably far more efficient than this comparison suggests. Imagine having to take all the information given on the nautical chart, convert it to text, and produce a detailed book describing the chart. Leaving aside the question of how the information can be effectively conveyed with the written word, even the information storage requirement would be massive. For example, NOAA's recently produced Delaware Bay electronic chart requires approximately 3.8 million bytes of storage. (NOAA uses a very efficient way of storing chart data—so efficient, in fact, that the compression method has been patented. Storage of the digital chart data in more conventional formats is estimated to require

more than 100 million bytes.) For comparison, storage of written text using typical word processing software requires approximately 1,400 bytes per page of single-spaced text. Figured at this exchange rate, the Delaware Bay chart would be equivalent to approximately 2,700 pages of single-spaced text using the efficient storage method! Other quantitative assumptions might lead to somewhat different ratios of pages per chart, but all would support the conclusion that a nautical chart offers an extraordinarily compact presentation of the information presented.

It is interesting to note that, historically, the material now represented on nautical charts is believed to have been originally presented in the form of *sailing directions*; written accounts of harbors, courses, seasonal weather conditions, etc. (Dutton's, Williams). In other words, the nautical chart was a technological evolution of sailing directions (as might now appear in the *U.S. Coast Pilot*). This said, some information is more efficiently presented in written form than on the chart. NOAA products in written form are discussed below.

Chart Distribution—Where to Purchase Charts

NOAA charts are sold both through mail order and by a distribution network of authorized chart agents.

–Mail Order Sales

Customers wishing to purchase charts directly from NOAA should send a list of the charts requested, together with a check or money order (in U.S. funds) payable to NOS, Department of Commerce, to the following address.

Distribution Branch, (N/ACC33)
National Ocean Service
Riverdale, Maryland 20737–1199.

Charts can also be ordered from NOAA by telephone 1-800-638-8972. Credit cards (VISA or Mastercard) are accepted for telephone purchases. At the end of this manual are several blank order forms that can be used to request selected NOAA products.

–Authorized Chart Agents

Mariners who purchase NOAA charts from authorized chart agents do so for several reasons, including convenient locations, rapid service from available inventories, being able to view the charts before purchase, and to take advantage of the (often considerable) expertise of the agent. Some agents offer value-added features, such as providing a computer generated list of the NM, containing all the chart corrections as of the date of purchase—a particularly worthwhile service. As of this writing, there are approximately 2,200 nautical chart sales agents worldwide, varying in size from small marina operators to large map stores and ship chandlers (NRC 1994 a). The addresses and telephone numbers of all authorized chart agents are given in the *Nautical Chart Catalog*.

–The Nautical Chart Catalog

The *Nautical Chart Catalog* is a four-volume NOAA publication, ideal for identifying the charts required for a voyage. It may be obtained without charge from NOAA or from an authorized chart agent. Volume 1 covers the Atlantic and Gulf Coasts, including Puerto Rico and the Virgin Islands. Volume 2 covers the Pacific Coast, including Hawaii, Guam, and Samoa Islands. Volume 3 covers Alaska. Finally, Volume 4 covers the Great Lakes and adjacent waterways. Each volume of the chart catalog contains a map of the overall area on which are superimposed the outlines of each of the charts published for this area, color coded by type of chart. Tables within each catalog provide additional data on the chart number, chart title, scale, whether or not Loran–C or Omega *lines of position* (LOPs) are superimposed, and other information. As noted above, a complete list of authorized chart agents is printed in the chart catalog.

Chart Prices and Related Matters

Some mariners—particularly recreational boaters—complain about the purportedly high prices of government nautical charts. And, indeed, NOAA chart prices have increased significantly in recent years; from $5 per chart in 1983 to $14 per chart in 1996 (*The Boat Show Briefing Book*). However, over the long term,

The *Nautical Chart Catalog* Provides Ordering Information for NOAA Charts.

chart prices have increased only modestly in real (that is, constant dollar) terms. In 1939, for example, the average price of a NOAA nautical chart was $.75. But, in this same year (according to the November 1939 issue of the *National Geographic* magazine) the price of a single room at Boston's Copley–Plaza hotel was $4/night, one at New York's Barbizon was $2.50/night, and one at Washington's prestigious Hay Adams hotel was $3/night. In 1939 you could buy the best steak dinner in Buenos Aires for $.35, admission to most major league ball parks in the United States for $.50, an annual subscription to the *National Geographic* magazine for $3.50, and a Studebaker Commander automobile for $660!

In short, the prices of most things have increased since 1939. The relevant question is whether chart prices have increased more than consumer prices generally. Over the years from 1939 to 1995, NOAA chart prices have increased at a compound average rate of approximately 5.4 percent per year—only slightly more than the 4.4 percent per year increase in the consumer price index over this same period.

Another way of looking at price data is to calculate how many hours of labor it takes to earn the money to purchase a particular item, and track this statistic over time. For example, consider the case of a typical employee in the manufacturing sector of the economy; the average hourly wage in manufacturing was $.63 in 1939 (U.S. Department of Labor, Bureau of Labor Statistics, *Labstat Series Report*), so this employee had to work ($.75/$.63) = 1.19 hours in 1939 to earn the money necessary to purchase a nautical chart. By August 1994, manufacturing wages had risen to $12.03 per hour. The hours required to earn the money necessary to purchase a chart in 1994 were ($14/$12.03) = 1.16— actually slightly less than in 1939. Measured by these yardsticks, a NOAA nautical chart is still a good buy. Can you imagine the reaction of Columbus or Magellan if they could have purchased an accurate chart for the equivalent of 1.16 hours of labor!

Moreover, today's nautical chart is much more accurate and comprehensive than those produced in 1939. Although it is true (see Chapter 4) that some of the soundings data shown on today's charts are based upon hydrographic surveys conducted as far back as the 1930s—when the leadline was used extensively, much of the data used on the modern chart is based upon more recent and accurate hydrographic surveys, using modern technology. Shorelines are depicted based upon aerial photographs, computers are used extensively for chart compilation and

production, and other technological innovations have been exploited. As well, the number of charted features has grown substantially, as waterfronts have been developed, new buildings constructed, additional ATONs placed, etc. Loran–C and Omega (radio navigation systems) didn't exist in 1939, now Loran–C TDs and Omega navigation data are shown on many charts. In short, the modern nautical chart is a significant improvement over those produced more than half a century ago. So today's mariner is able to buy a demonstrably better product for a comparable real price.

Most mariners are unaware that NOAA nautical chart prices are controlled by legislation (Public Law [PL] 99–272) and include only those costs attributable to data base management, compilation, printing, and distribution. Costs attributable to the acquisition or processing of data, such as hydrographic surveys, are not recovered in the chart price. In effect, nautical chart users are being subsidized by the government. Even at today's prices, the government recovers only about 60 percent of the cost of producing a nautical chart.

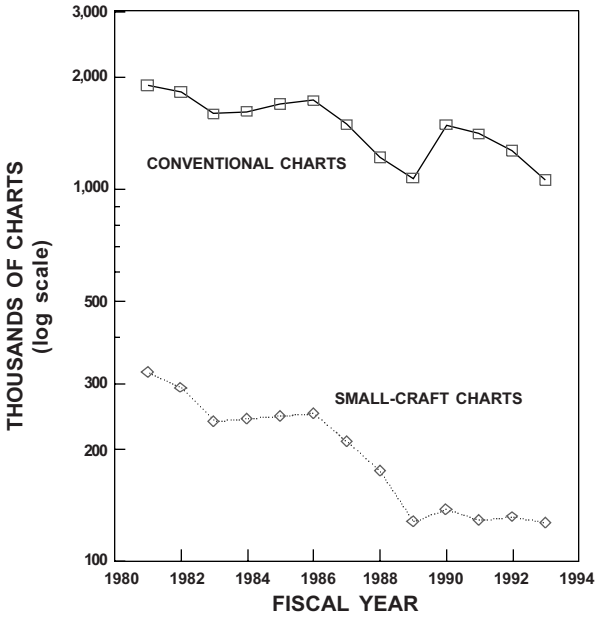
In recent years, about a dozen U.S. companies have begun to reproduce NOAA charts and sell these in a variety of formats, including waterproof paper, smaller paper size, and in chart books containing several charts for a region—often at prices lower than comparable NOAA charts. NOAA charts are not copyrighted as a matter of policy (17 *United States Code* [USC] 105), so this practice is perfectly legal. Chart reproduction can be profitable for commercial companies at lower prices than charged by NOAA because their only costs are for paper, copying, and distribution. No royalties or other costs are paid to cover the costs of chart compilation. The lower prices charged for nautical charts by commercial firms, therefore, are not necessarily a reflection of any greater economic efficiency of the private sector, but rather the fact that valuable chart data are provided to these firms without cost.

Commercial chart companies also attempt to escape liability costs by including such disclaimers as "not to be used for navigation" on their products—as though we should assume that mariners purchase these copies only for place mats, wall decorations, or boating safety classes! Court interpretations of the Federal Tort Claims Act have tended to hold the U.S. Government liable for damages due to incorrectly charted information. Reproducers of NOAA charts may be subject to similar liabilities.

The NRC, a part of the *National Academy of Sciences* (NAS), has offered several suggestions (NRC 1994 a) for cost recovery for NOAA data through royalties, licenses, and user fees, so the present situation may not continue.

Chart Demand

Customers for NOAA charts include government agencies, commercial navigators, and recreational boaters. Figure 1–5 (Source: NRC 1994a) shows a time series of sales of NOAA charts (conventional and smallcraft) from 1980 to 1993 (plotted on a logarithmic axis to emphasize percentage changes). As can be seen, total sales of NOAA charts have declined over these years. Sales of small-craft charts have decreased by approximately 61 percent (–7.5



SOURCE: NATIONAL RESEARCH COUNCIL

Figure 1-5. Recent Sales History of NOAA/NOS Nautical Charts: A Reflection of Evolving Technology or an Ominous Trend?

percent per year compound annual average) over this time period and sales of conventional charts have decreased by about 44 percent (–4.5 percent per year average annual). Factors accounting for this trend include increased prices for NOAA charts, the decrease in the number of U.S. flag ships, and the emergence of competitive commercial products (including variants of paper charts and electronic chart products).

Although exact sales data are unavailable, it is estimated (NRC 1994a) that sales of commercial charts are substantial and certainly exceed NOAA's sales volume.

Assuming, for argument's sake, that commercial sales were twice those for NOAA, sales of nautical charts would be only about 3 million charts per year—of which approximately 900,000 are used by government agencies—leaving approximately 2 million sold to commercial mariners and recreational boaters. However, according to estimates made by the USCG, there are more than 20 million recreational boats operating on U.S. waters (*Boating Statistics*). To be sure, many of these are very small craft operating in circumstances that may not require the use of a nautical chart—for example, 51 percent of the 11.3 million numbered recreational boats are under 16 feet in length. Nonetheless, there is a substantial gap between the estimated number of boats and the annual chart sales, suggesting that many recreational boaters purchase charts infrequently, if at all. Considering the wealth of essential information given on the typical nautical chart (see below and other chapters in this manual), this is evidence of false economy—could it be that some of today's mariners are subscribing to the ancient Marshall Islander's theory that charts are too valuable to be carried on board?

ECDIS, The End of the Paper Era?

Many mariners, including both recreational boaters and those from the commercial sector, now use some form of electronic chart system—more formally called *Electronic Chart Display and Information Systems* (ECDIS). These systems receive position information from onboard navigation systems, such as GPS, *Differential Global Positioning System* (DGPS), or Loran–C receivers, and display this information on an electronic reproduction of a chart. For highest accuracy, DGPS is the navigation system of choice.

Some electronic charting systems offer only a low-detail monochrome display, but the more advanced (which require personal computers) present faithful reproductions of nautical charts in color. The system allows a user to enter a course as a series of waypoints with intervening straight line legs that is superimposed on the electronic chart. Real time position information is provided with a vessel icon, showing its position with respect to the intended track. Often this system is integrated with an autopilot which, in navigation mode, automatically makes rudder corrections to maintain the vessel on the intended track. Details of this system, with legal, institutional, and charting implications, can be found in several sources (NRC 1994a, NRC 1994 b).

To support these systems, NOAA is engaged in a project to digitize existing charts and provide digital data to vendors designing and marketing ECDIS products. Digitizing chart products offers other advantages, not the least of which is a radical simplification of the chart correction process. For example, if a buoy is moved, this change can be noted in the digital data base and all charts which depict this buoy can be electronically updated.

However, full implementation of ECDIS requires additional survey work with modern hydrographic equipment to complement the data base development effort. It is literally true that the integration of DGPS and ECDIS provides the mariner with the ability to navigate with greater accuracy (3 to 5 meters) than was available to the surveyor who collected the data in the first place—at least for many areas. At present, the indicated position of a hazard on a nautical chart may be more uncertain than the vessel's position. Source diagrams, explained in Chapter 4 and in the *U. S. Coast Pilot*, provide the mariner with information on the survey date and scale supporting each nautical chart.

Chart No. 1 Provides Essential Information on symbols and Conventions Used on NOAA and NIMA Charts

Chart–Related Publications

Despite its comprehensiveness, the nautical chart is not a "stand-alone" publication. Rather it is part of an integrated series of publications by NOAA and other government agencies. Nautical chart users should be aware of the content of these companion publications. These are briefly described below.

–Chart No. 1

Chart No. 1 is published jointly by NOAA and NIMA. As noted, Chart No. 1 provides a compendium of chart symbols and other valuable data helpful in interpreting the nautical chart. Terms, symbols, and abbreviations are numbered in accordance with a standard format recommended by the *International Hydrographic Organization* (IHO). The layout of Chart No. 1 is described more fully in Chapter 2.

–Chart Catalogs

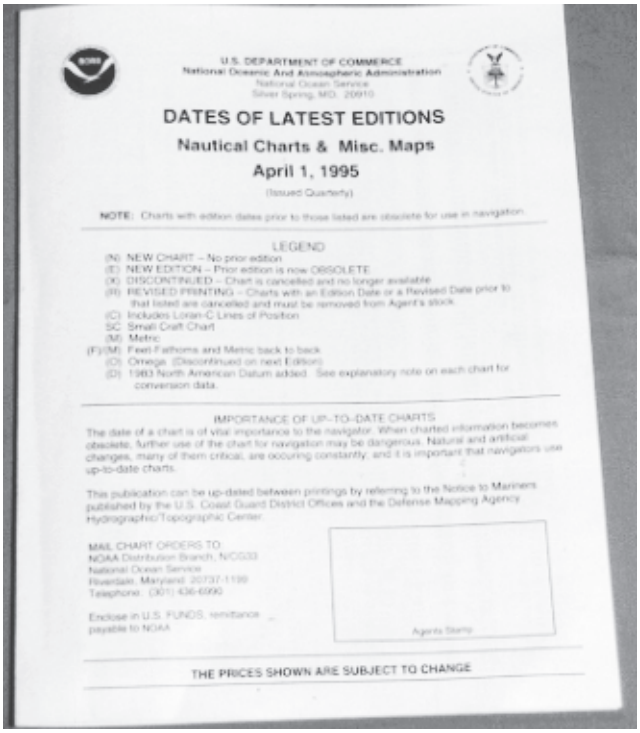
As noted, the *Nautical Chart Catalog* provides ordering information for NOAA charts and related products.

–Dates of Latest Editions

This pamphlet is published quarterly by NOAA and identifies the date of the latest edition of each nautical chart and other relevant information. Mariners can consult this publication to verify that they have the latest chart on board.

–Notice to Mariners

The NM, issued weekly, is prepared by NIMA with input from NOAA and USCG. The NM is of primary interest to navigators of deep-draft vessels; it presents information on changes to channels, ATONs, locations of wrecks, changes to depth curves and soundings, and other information necessary for updating the nautical charts and other publications produced by these agencies. In cases where the changes are too extensive to be listed in written form, NOAA prepares chartlets (page-sized, black-and-white portions of nautical charts) for inclusion in the NM. An illustrative chartlet is shown in Chapter 4. The NM is presently available in two forms, a weekly pamphlet containing corrections listed in order of chart number, together with


U.S. DEPARTMENT OF COMMERCE
National Oceanic And Atmospheric Administration
National Ocean Service
Silver Spring, MD. 20910

DATES OF LATEST EDITIONS
Nautical Charts & Misc. Maps
April 1, 1995
(Issued Quarterly)

NOTE: Charts with edition dates prior to those listed are obsolete for use in navigation.

LEGEND
(N) NEW CHART – No prior edition
(E) NEW EDITION – Prior edition is now OBSOLETE
(X) DISCONTINUED – Chart is cancelled and no longer available
(R) REVISED PRINTING – Charts with an Edition Date or a Revised Date prior to that listed are cancelled and must be removed from Agent's stock.
(C) Includes Loran-C Lines of Position
SC Small Craft Chart
(M) Metric
(F)(M) Feet/Fathoms and Metric back to back
(O) Omega (Discontinued on next Edition)
(D) 1983 North American Datum added. See explanatory note on each chart for conversion data.

IMPORTANCE OF UP-TO-DATE CHARTS
The date of a chart is of vital importance to the navigator. When charted information becomes obsolete, further use of the chart for navigation may be dangerous. Natural and artificial changes, many of them critical, are occuring constantly, and it is important that navigators use up-to-date charts.

This publication can be up-dated between printings by referring to the Notice to Mariners published by the U.S. Coast Guard District Offices and the Defense Mapping Agency Hydrographic/Topographic Center.

MAIL CHART ORDERS TO:
NOAA Distribution Branch, N/CG33
National Ocean Service
Riverdale, Maryland 20737-1199
Telephone: (301) 436-6990

Enclose in U.S. FUNDS, remittance payable to NOAA

Agents Stamp

THE PRICES SHOWN ARE SUBJECT TO CHANGE

Dates of Latest Editions is an indispensable aid to the mariner.

```
                          AUTOMATED NOTICE TO MARINER                    3/11/95
                        CHART CORRECTION QUERY SYSTEM
                    EXTRACT ALL CORRECTIONS TO SELECTED CHARTS
                           THRU CURRENT NTM 12/95

S  12314 28Ed.10/17/92 NEW EDITION            (NOS; CL1126/92)           4/93
         Add        Purple dashed lines joining
                       40deg 06min 15.5sec N   74deg 49min 56.5sec W
                       40deg 06min 13.0sec N   74deg 50min 14.0sec W
                       40deg 05min 56.0sec N   74deg 50min 26.0sec W
                       40deg 05min 50.2sec N   74deg 50min 24.0sec W

                           between
                       40deg 05min 51.0sec N   74deg 50min 14.0sec W
                       40deg 06min 05.3sec N   74deg 50min 03.0sec W

                    Legend "Cable Area''
                       40deg 06min 07.0sec N   74deg 50min 12.0sec W
                    (Previously published 46/92)

         Add        Tabulation of controlling depths
                    from back of Section I

   12314 28Ed.10/17/92 LAST NM 04/93                      (NOS)          14/93
         Change     Characteristic of range light,
                       front to Oc R 4s
                           40deg 07min 18sec N   74deg 46min 42sec W
                       rear to Oc R 4s
                           40deg 07min 18sec N   74deg 46min 41sec W

S  12314 28Ed.10/17/92 LAST NM 14/93               (30/93 CG5)           36/93
         Add        Buoys, each Y, Fl Y 6s (Priv maintd)
                       "N''
                        40deg 02min 01.2sec N   74deg 59min 40.0sec W
                       "S''
                        40deg 02min 00.0sec N   74deg 59min 41.6sec W

S  12314 28Ed.10/17/92 LAST NM 36/93                (CL978/93)           40/93
         Add        Tabulation of controlling depths
                    from back of Section I

S  12314 28Ed.10/17/92 LAST NM 40/93               (CL1268/93)           8/94
         Add        Tabulation of controlling depths
                    from Subsection I-2

S  12314 28Ed.10/17/92 LAST NM 08/94               (22/94 CG5)           28/94
         Change     Legend to
                        "Q 21ft (Day), QR 21ft (Night)''
```

Figure 1-6. ANMS Output for NOS Chart No. 12314

an identifier indicating the number of any prior NM affecting each chart, and a computer service, called the *Automated Notice to Mariners System* (ANMS) which provides several access and sort options. Figure 1–6 shows ANMS output for chart corrections for NOS Chart No. 12314 (the chart illustrated in figure 1–2). The ANMS updates are made continuously, so this system provides the most current information available. The ANMS can be accessed with an appropriate terminal (e.g., a personal computer with a modem) from anywhere in the world that data-grade telephone service is available, which means that vessels can obtain the latest corrections while enroute to a destination. Contact NIMA for details on this system and a user identification.

CHART/PUB. CORRECTION RECORD DMAHC-8660/9 (11-74)

CHART/PUB. NO.	PORTFOLIO NO.	EDITION NO./DATE	CLASS	PRICE	CORRECTED THRU N. TO M., NO./YR. OR PUB. CHANGES

TITLE

APPLICABLE NOTICE TO MARINERS

N/M YR	PUB. PAGE NO.	CORRECTION MADE DATE	CORRECTION MADE INITIAL	N/M YR.	PUB. PAGE NO.	CORRECTION MADE DATE	CORRECTION MADE INITIAL	N/M YR.	PUB. PAGE NO.	CORRECTION MADE DATE	CORRECTION MADE INITIAL	N/M YR.	PUB. PAGE NO.	CORRECTION MADE DATE	CORRECTION MADE INITIAL

CHART/PUB. NO.

Figure 1-7. Form for Recording NM Corrections

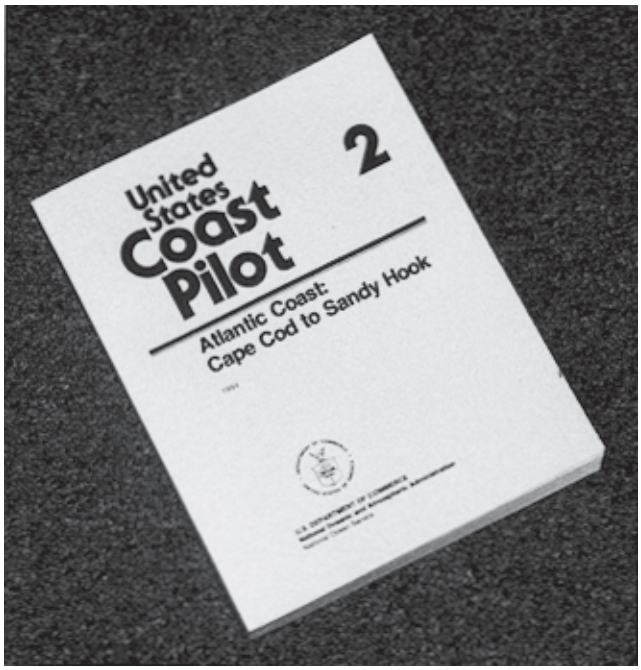
Besides listing chart corrections, the NM contains corrections for other publications, such as the *U.S. Coast Pilot* and *Light List* (see below). Figure 1–7 shows a convenient form for recording NM corrections.

Correcting charts is often a tedious and time-consuming job, particularly if the number of corrections is large, but essential nonetheless. In cases where carriage of charts is legally mandated (see Chapter 2), these charts are required to be corrected to the latest NM.

–Local Notice to Mariners

The NM presents worldwide information relevant to deep-draft vessels. Similar information on waters not navigable by deep-draft vessels, as well as temporary changes to published data, are not included in the NM. The *Local Notice to Mariners* (LNM), published by the USCG, provides this information. Small-craft owners using intracoastal and other waterways and small harbors that are not normally used by deep-draft vessels require the LNM to keep charts and related publications current. The LNM is available from each USCG District on a subscription basis. The number of subscribers to the LNM is very small compared to the number of registered boats, however, which means that the vast majority of recreational boaters do not subscribe to the LNM and are missing out on a valuable opportunity. Moreover, as noted by one observer (Dutton's),

> "Failure to have on board and use the *latest* charts and other publications, *and to keep them corrected*, may adversely affect a mariner's legal position should he have a grounding, collision, or other mishap in which chart or publication information in involved." [Emphasis in original.]



The *United States Coast Pilot* Provides A Wealth of Additional Information

–Coast Pilot

The *U.S. Coast Pilot* is a nine volume series (organized geographically) of nautical books published by NOAA that provide a wide variety of information important to mariners. This publication originated in 1796 with a commercial product, called the *American Coast Pilot*, published by Edmund March Blunt *(Coast Pilot Manual)*. The copyright was later sold to the United States in 1867.

Although there is some overlap with material presented on the nautical chart, most of the contents of the *U.S. Coast Pilot* cannot be shown graphically on the nautical charts and is not readily available elsewhere. For example, the general and specific federal regulations applicable to restricted and prohibited areas, along with other federal regulations are provided in Chapter 2 of each *U.S. Coast Pilot*.

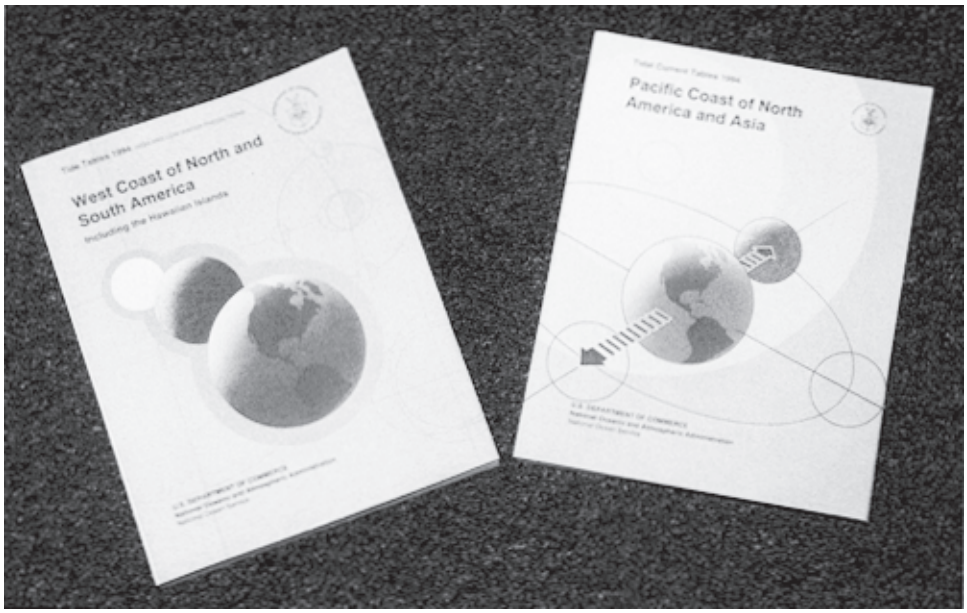
The subjects presented in the *U.S. Coast Pilot* include channel descriptions, anchorages, bridge and cable clearances, currents, tide and water levels, prominent features, pilotage, towage, weather, ice conditions, wharf descriptions, dangers, routes, TSSs, small-craft facilities, and federal regulations applicable to navigation. Revisions to the *U.S. Coast Pilot* are printed in the NM or LNM as appropriate. A related publication, the *Coast Pilot Manual*, provides valuable supplemental information relative to the *U.S. Coast Pilot*.

The Coast Pilot is a user-friendly publication. Reading it is rather like having a conversation with a master mariner with abundant local knowledge. The contents of the *U.S. Coast Pilot* are discussed in detail in other chapters of this manual.

–Light List

The *Light List* is a seven-volume series (organized geographically) published by the USCG and available from the U. S. Government Printing Office in Washington, DC, and authorized sales agents. This list, published annually, provides more complete information concerning ATONs than can be shown on charts. The term, light list, is actually somewhat of a misnomer, since the publication includes many unlighted ATONs. Specifically, the *Light List* contains detailed information on ATONs, including lights, fog signals, buoys, daybeacons, radiobeacons, *RAdar beaCONs* (RACONs), and Loran stations, in a tabular form. Entries in the tables include the *Light List Number* (LLNR), name and location of the ATON, position (latitude and longitude), characteristic, height, range, structure, and pertinent remarks (e.g., if replaced with a seasonal buoy, horn characteristics, RACON characteristic, light sector's arc of visibility, radar reflector, emergency lighting, etc.). Although some of this information is also shown on the nautical chart, the *Light List* provides additional details, such as the appearance of the structure, not found in any other source. The introduction to the *Light List* is particularly interesting, offering a wealth of general information on the ATON system.

The *Light List* contains a list of all federally maintained ATONs as well as so-called Class I and Class II privately maintained ATONs. Class III privately maintained ATONs (located in waters not ordinarily used by general navigation), USCG mooring buoys, and some buoys having no lateral significance, such as special purpose, anchorage, fish net, and dredging buoys are not listed. Corrections to the *Light List* are published in the NM.



Tide Tables and Tidal Current Tables, Issued Annually, Provide Daily Tide and Tidal Current Information

–Tide Tables and Tidal Current Tables

Tide Tables are published annually in four volumes by NOAA and give the predicted times and heights of high and low waters for each day in the year for approximately 200 of the most important harbors, designated as reference stations. These tables also provide additional data for interpolating tidal predictions at thousands of subordinate stations. Estimated tide heights can be used to adjust charted depths (and vertical clearances).

Tidal Current Tables, also published by NOAA, provide information in a similar format for estimation of the predicted times of slack, flood, and ebb, and the strength of the current at any time. Predicted tidal currents are used for estimating the vessel's speed over the bottom, requisite course corrections to maintain a specified track, and the most favorable times to transit certain areas. (Note, NOAA has announced that the Tide Tables and Tidal Current Tables will be printed by the private sector in the future.)

The Track Ahead

This concludes the general overview of U.S. nautical charts and related products. The following chapters are more specific and detailed. Gather a copy of Chart No. 1 and a familiar chart of local waters and see how to get the most out of the nautical chart.

"What can be more difficult than to guyde a shyppe engoulfed, when only water and heaven may be seen?"

Martin Cortes, 1551
Quoted in Heinl

"The position and extent of any shoal or danger discovered, especially of one upon which a vessel has struck or grounded, should be determined, if practicable, by five horizontal sextant angles between well selected objects."

Admiralty Manual of Navigation

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