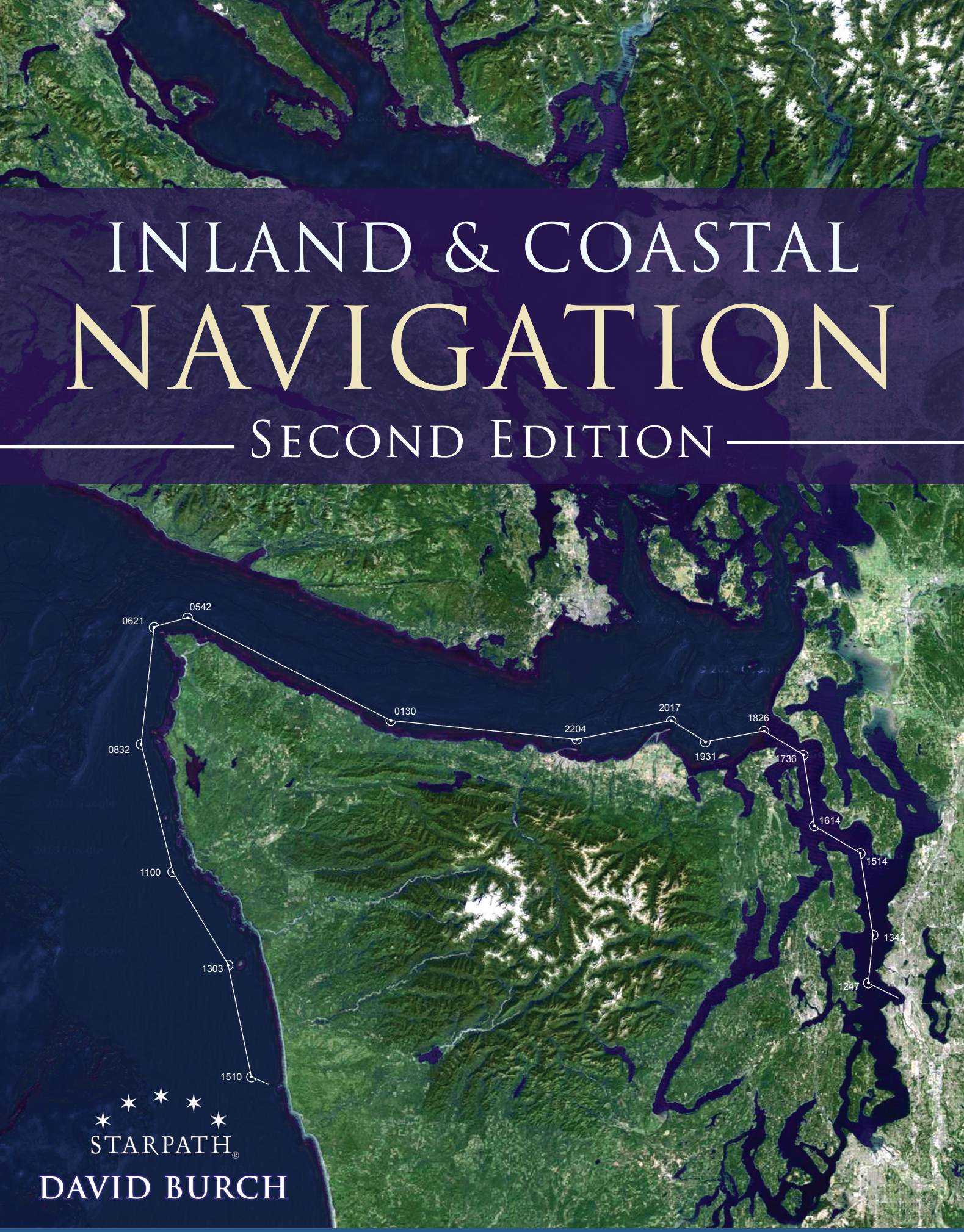
INLAND & COASTAL NAVIGATION

SECOND EDITION



STARPATH®

DAVID BURCH

For Power-driven and Sailing Vessels

Inland and Coastal Navigation

Second Edition

BY

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Preface to the first edition

This book has been used for many years in classroom courses on small-craft navigation. It is equally applicable to power or sailing vessels, kayaks or ships. The fundamental principles of marine navigation are the same to all, just as the Rules of the Road apply to all vessels. The subject matter is described as small-craft navigation simply because we cover techniques and routes that do not apply to large ships.

These days GPS is the mainstay of the navigation of any vessel, but it is both legally and practically not prudent to rely on just this one source for navigation. Furthermore, the GPS cannot tell you the safest, most efficient route from where you are to where you want to go. That you must decide yourself, taking into account the lay of the charted waterway, the depth of the water, the wind, currents, sea state and visibility, the Navigation Rules, the time of day, the performance of your vessel, the crew on board, and more. In short, choosing the best route takes the knowledge presented in this book.

Another value of this background in the traditional methods of hands-on navigation is the ability it then gives you to easily spot check the GPS as you proceed. These position checks, along with good logbook and plotting procedures, will keep you on top of the navigation at all times. Not only does the continuous process of GPS checking assure your safety, it keeps you in tune with your environment. With this process you will know the names of landmarks around you, and you can identify features on the distant horizon, and you know who has the right of way as you approach another vessel, and you know ahead of time that the current will start setting you strongly to the right, and so on. The GPS cannot answer these things; you must rely on your knowledge.

A thorough background in navigation fundamentals will also make your time on the water more enjoyable as it removes unnecessary anxiety, and adds another dimension to your sport. You then remain in command and are not dependent on electronics. Modern marine electronics are generally very dependable, but they are not guaranteed. The hallmark of good seamanship is to look ahead and be prepared.

Preface to the second edition

The second edition has been fully updated to include new resources now available, as well as changes in terminology and even such basics as the types of nautical charts we now use–or will very shortly. The important new role of mobile devices and electronic charting systems in general are addressed as well as ways to keep up to date with anticipated developments.

We have also taken the opportunity to readdress the main topics of traditional navigation throughout the book with a new outlook in some cases. Contact information for the several federal agencies we count on for navigation data were updated, and we have established an online link for further updates, as they will certainly change again.

There have also been changes in terminology over this period related to electronic navigation. The technology of typical marine and handheld GPS receivers has improved over the past several years, but the risks of relying on GPS alone have not changed.

For our powerboater and paddler readers, please do not be distracted by our use of the word "sailing." We use it in its basic maritime sense of any vessel underway–as when the *Navigation Rules* refer to Steering and Sailing Rules, or as standard navigation references are called Sailing Directions. When matters specific to sailboats are addressed, we refer to when under sail. This book does contain information specific to navigation under sail, but the vast majority of the content applies to "any description of watercraft used for transportation on the water."

We have also redone the Glossary completely, adding the terms to the end of the chapters in which they first appear. This should facilitate both home study and classroom use.

Contact with the author, further resources, and news related to the text can be found at starpath.com/navbook. Comments and suggestions are always appreciated.

Acknowledgements

It is a pleasure to once again thank Starpath instructor Larry Brandt for his careful review of the text, which led to many helpful suggestions. This book has much benefited from his insights into both the practice and the teaching of navigation, in addition to his sharp eye as an editor.

Many illustrations from the first edition were drawn by Stephen Davis. Several of these have been adapted from the originals. Many new illustrations have been added to the second edition by Tobias Burch, who also did the book and cover design. I remain grateful for his skill and good work on this book and others.

Chapter 1
The Role of Navigation

1.1 Introduction

Navigation means knowing where you are and choosing a safe, efficient route to where you want to go. These two skills are mandatory for long trips into unknown waters and are often valuable for shorter trips in well-known waters. For the most part, navigation skills learned and practiced in one area apply to other areas as well; the fundamental techniques of navigation are universal. Safety, efficiency, and enjoyment are the main reasons to learn navigation. As opposed to wilderness hiking or ocean sailing—where actually getting lost might be a safety concern—inland navigation focuses more on avoiding hazardous areas that could be an immediate threat to a boater's safety: waters with strong currents, strong winds, big waves, or big ships. Discerning these hazards and knowing how to avoid them is part of navigation.

All boat trips must be planned. A proposed trip must fit into the number of days you have allotted, and a day's run must fit into a day. If you do not make your destination by nightfall or in time for favorable currents at the anchorage, the arrival could be more of an adventure than you want at the end of a long day. In extreme cases it could be dangerous. A wrong turn made when sailing downwind might take a long hard sail against the wind to correct. Poor navigation can turn a relaxed sightseeing outing into an adventure. With the basic navigation skills of nautical chart reading, keeping track of position, and predicting currents, an itinerary can be set up and checked off underway that will help keep the experience in line with your intentions. Under any circumstances, however, the key to good navigation during the trip is thorough navigation planning before the trip.

Once underway on a well-planned route, navigation consists of keeping track of where you are along that route. The challenge of this task depends on prevailing conditions. When sailing along a shoreline on a clear day, keeping track means little more than just looking around. As one headland is passed, the next comes into sight. By identifying the next headland on the chart, you know where you are (see Figure 1-1). After passing a few prominent points, and noting the time it took to get from point to point, it is easy to figure out how fast you are actually progressing (regardless of what your knotmeter might say) and decide how far or how long to continue on that day.

At night, in the fog, or when crossing large open waters, there is much less to see. Under these conditions, the value of practiced navigation skills is more apparent. If the only visible landmarks are far off, they will not help much in locating your position. In these cases, course direction must be read from a compass, and progress along that course reckoned from knotmeter speed and predicted current flow. It is indeed true that these skills are not often called upon for much of our daily boating (especially with a functioning GPS), but your time on the water will always be more relaxed if you are confident that you can navigate this way if need be. It pays to prepare for fog, significant currents, or nighttime sailing.

Even thorough planning, however, cannot cover all the navigational decisions a mariner confronts underway, even on a simple route along a shoreline. Should you, for example, sail point to point, straight across each bay you meet or follow the longer but less exposed concave route along the shoreline? And how should the point itself be approached: close in along the beach, or passed wide well away from waves and currents at the point? These and many other important decisions ultimately must be made underway, in the prevailing conditions of wind, waves, and current. Although navigation covers a broad range of topics, all navigation decisions depend on knowing where you are. You cannot pick the best route to where you want to go without knowing where you are at the time. Good navigation and the safety it affords always boil down to knowing where you are at all times—and from a practical point of view, that means being able to look at a chart and point to your position on the chart.

...In Depth

12 Special Topics

Throughout this book you will find these **...In Depth** links or references to sections in Chapter 12. They present details or side topics related to the present discussion.

Please take a look at Chapter 12 to see how these are organized. In the paper edition these are just references; in the electronic version of this book they are links.

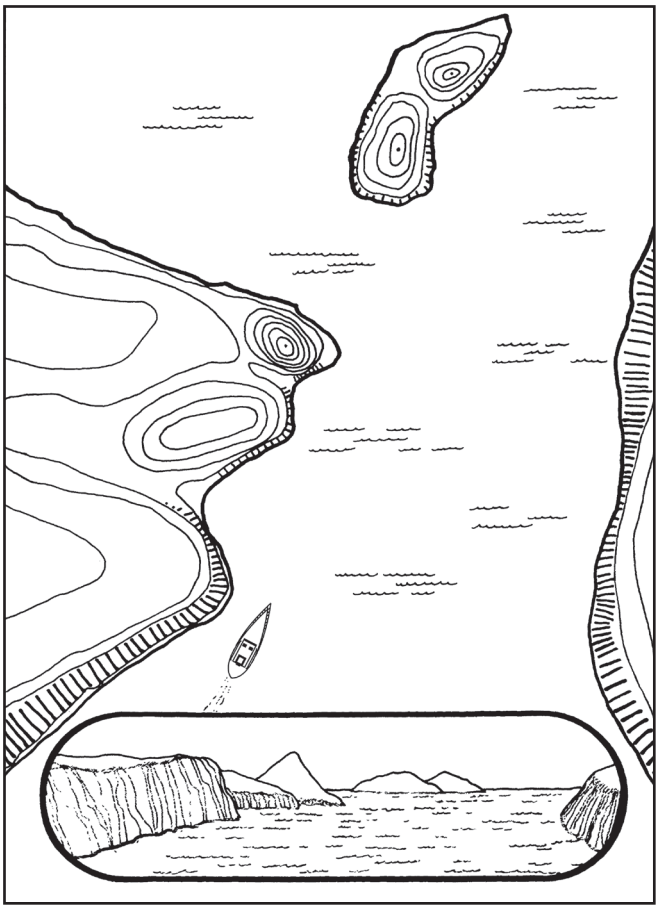

Figure 1-1. *Navigation from point to point. The inset shows the perspective from an elevated view. From the lower perspective of the cockpit of a small boat, the bases of the land masses appear more along a single straight line because the close horizon blocks the true view of the shorelines (see inset Figure 2-8).*

Crossing a shipping lane is one obvious example of how important it is to know where you are. Some waterways routinely traveled by large ships are divided into inbound and outbound lanes, which all large shipping traffic must follow. Though clearly marked on charts, the lane boundaries are not at all discernible from the water. They are effectively mile-wide invisible streets, which might lie a mile or more off the shoreline. If you detect an approaching ship while crossing the lanes, you have a quick navigation decision to make, but any choice of action must start with knowing where you are relative to the lane boundaries. These days, we have various aids such as radar, GPS and electronic charting that might make this an easy observation in some cases, but the prudent navigator will always know how to do these things without these aids if need be.

1.2 Types of Navigation

Finding and keeping track of position is done by one of two ways: piloting or dead reckoning. Piloting is the formal name for the usual way of getting around, using known landmarks. Sailing past a buoy, you know where you are as soon as you can find that buoy on the chart. The same is true near any prominent landmark.

Well away from landmarks, on the other hand, it is not as simple to pinpoint your position on the chart by just looking. To find position with only one distant landmark in sight requires a compass direction to the landmark and a measure of how far away it is. With two charted landmarks in sight, position can be found from the intersection of the two compass bearings plotted on the chart. This and other piloting techniques are explained later.

With no identifiable landmarks in sight, position must be figured from speed, course, and time. The procedure is called *dead reckoning*. It is an unusual name, but it was commonly used and listed in nautical dictionaries in the 1600s. To navigate by dead reckoning, a present position is deduced from the distance and the direction sailed away from a known location. Sailing at a rate of 6 miles per hour toward due north, you can deduce that in thirty minutes you should be 3 miles north of where you started. With the known starting point shown on the chart, you can draw this route on the chart and point to where you think you are.

Although it may not be thought of in these formal terms, the navigation of any trip proceeds as a sequence of piloting fixes, with navigation by dead reckoning between the fixes (see Figure 1-2). Starting from a known position, you set off in the direction of your destination at some estimated speed. From this you can deduce how long the trip should take and where you should be at various intermediate times. Once underway along this route, whenever you suspect that winds or currents or any other factor might be influencing your progress, you take a position fix using piloting. Sometimes this takes no more than a careful look around and a quick note on the chart.

Other times it might require compass bearings and drawing a few lines on the chart. In any event, once you find out where you are, you mark it on the chart with the time of the fix and then figure the route that will take you from there to where you want to go. The several steps of this process are the subjects of this book.

...In Depth

12.1 Traditional Skills in the Satellite Age

There is a tendency in these modern times to think that GPS and other high tech electronics have taken all the vinegar out of navigation... see here why this is not the case and what to do about it. This is a key article on how to relate what we are learning here with other instrumentation and daily procedures.

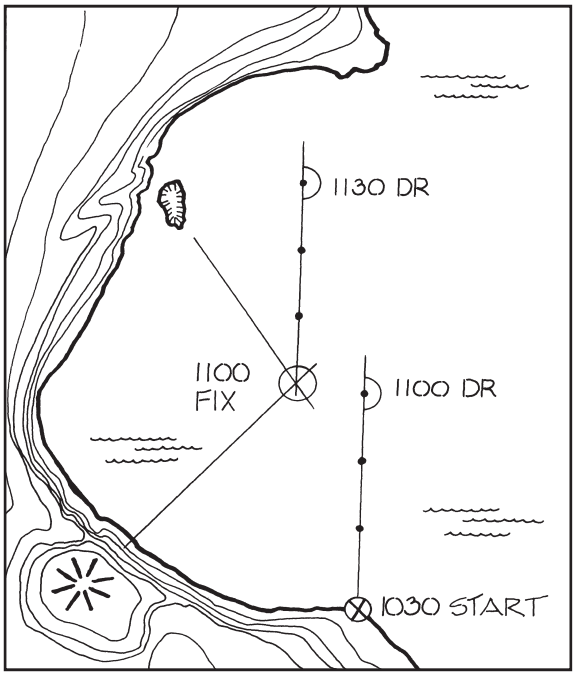

Figure 1-2. *Navigation by dead reckoning (DR) and piloting. Using estimated speed, compass course, and time underway, the navigator thought he was at the 1100 DR position shown. He was actually located at the 1100 fix position as found from compass bearings to the island and peak.*

Navigation skills are often distinguished by the waters sailed. Offshore navigation usually refers to navigation out of sight of land, as opposed to inshore navigation, which refers to navigation in sight of or in close proximity to land and to established aids to navigation. The terms, however, are relative to vessel size and weather conditions. The centers of large bays, straits, or inland sounds can present conditions similar to those many miles offshore in the ocean, despite the visibility of land on either side. The distinction fades even more at night and in the fog. Furthermore, in sight of land is relative to the height of the land, as explained in Chapter 6. A low coastline will slip below the sea horizon at a few miles offshore, whereas a coastal mountain range might be seen at 30 miles off on a very clear day.

For practical matters of small craft navigation and seamanship, a vessel is effectively offshore in any waters whenever the nearest land is more than few miles off; this is, in part, because from this distance off, many lights, buoys, and other aids designed for the inshore navigation of larger vessels are simply not in view from the low perspective of many small craft. On the other hand, only skippers of smaller vessels can usefully distinguish the region of *close-inshore* navigation, meaning right along the shore in and out of off-lying rocks and shoaling—a water realm of unique navigation and often unique joys—reserved for small shoal-draft vessels. (See Figure 1-3.)

1.3 Navigation as a Hobby

There are two distinct aspects to navigation: knowing where you are and choosing the best route to where you want to go. The fundamental task of finding position is more or less straightforward. The techniques of piloting and dead reckoning are readily learned and mastered with little practice. Planning the best route through various waterways and conditions, on the other hand, is not always so easy. This distinction is even more dramatic when using the electronic aids covered in Chapter 7. With them, determining accurate position is simply a matter of pushing a button and reading a dial, whereas practical route selection is scarcely benefited at all from that information.

The elusive factors that boaters must always bear in mind when route planning are wind and current and their effects on waves. Big steep waves are potentially dangerous to a vessel, and strong winds make big waves. Current flowing against waves steepens them even more, a lot more. So not only do adverse winds and currents hinder progress along some routes, their interactions are often an even larger threat to progress and safety.

Planning the best route, therefore, involves more than choosing the shortest distance between two points on the chart. You must consider which way and how strong the wind is blowing, now and later in the day, and which way and how strong the currents are flowing, now and later in the day. You must consider how winds are influenced by the shape of the land, and how currents are influenced by the shape of the waterway. You must learn how waves are made by the wind and how the shape and depth of the waterway affect its waves. Getting from one place to another in a small vessel is often as much a question of the oceanography and meteorology of the area as it is a question of

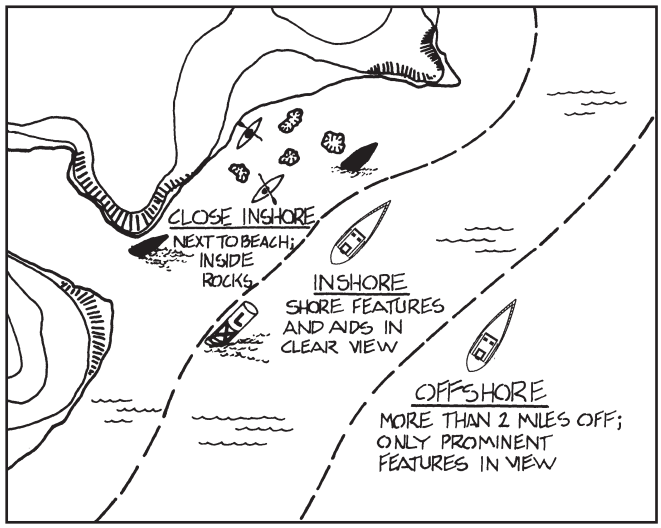

Figure 1-3. *A way to distinguish navigation regions in terms of the available aids to navigation. The terms and associated safety and navigational considerations are relative to the nature of the waterway and shore as well as the prevailing visibility and the size of the vessel.*

simple geographic navigation. This diverse but interrelated knowledge is best obtained by treating navigation and all it entails as part of boating itself, rather than something that must be learned in order to go boating.

Add a new dimension to the sport—a knowledge of the wind and the sea and the orientation skills that good navigation practice instills. Treat navigation itself as a hobby, not just the means of getting from point A to point B. Take pride in finding out where you are by different navigation methods. Practice it as a game in clear weather from a known position. Figure how long each leg of a trip should take and check your work, even when there is no need to predict the times. Predict the currents in all waters you cover and check your work. Practice listening to weather reports and watch the skies to compare surface winds with cloud patterns. Then when you need these skills, and they are not a game, you are prepared.

Keep notes of what you learn on each outing. Navigation skills progress much faster with a notebook. With good records, you can learn in one season what it takes years to learn without keeping records. On each trip, a navigator is exposed to a barrage of navigational experiences and details. But it takes written records to remember more of these than you forget. Eventually local knowledge compiled from individual trips begins to jell. Lessons learned in one place can be applied to another, and the watery part of the world accessible to you begins to expand.

1.4 How to Navigate Today

This course covers the traditional methods of navigation by chart and compass and log, as if we did not have any electronics at all, but the reality is that it is almost negligent these days not to have a GPS, at least an inexpensive handheld model. Not only does it make your navigation easier and more accurate, but it can be used to learn skills needed to navigate without it.

With that in mind, please at this point skim through section 12.1 on the role of what we are learning and how it will fit into our actual navigation in practice. You can come back to that article for a more in-depth reading later on, but it will be helpful to know what is there and where we are going. Several of the tricks and procedures we study later are outlined in the article.

Later on we will discuss the concept of waypoints and how to use them, but you can also at this point take a look ahead to section 12.2 on Keeping Track of Course and Position Underway. It will also show where the skills we will learn here fit into the overall navigation practice, with more specific discussion of their application in an actual voyage.

The content of these two articles should give you a way to start practicing some of the basic ideas and procedures right away, without having to wait till we have covered each topic in detail.

Both of these sections are still in the In-Depth category because they include terms and ideas which we have not yet covered in this Chapter 1. You can be confident, though, that these ideas will be explained in the later chapters of this course book.

1.5 What is a Small Craft?

In the past, small craft was defined as vessels under 65 ft, which can probably be traced to the 20-meter length limit used in some of the Rules of the Road. But this definition is rarely used now as it is way too general when it comes to weather and navigation. The National Weather Service (NWS) solves the problem (after stating there is no precise definition) with this nugget “Any vessel that may be adversely affected by Small Craft Advisory criteria should be considered a small craft.”

A 16 foot skiff, or a 25-foot cruiser is definitely a small craft, but a high powered 25-footer may be much less challenged by some navigation situations than is a 74-footer with low power. Typical sailing vessels are usually small craft, and generally in most navigation situations vessels up to 70 feet or so would be considered small craft.

Sailboats in light air are all effectively small craft. They are low-powered in these conditions, and they are very susceptible to the wind and current conditions we cover. There is, however, not really a distinction between power and sail when it comes to basic navigation, and for that matter, most of the standard or traditional navigation skills are the same in a kayak as they are in a ship. The main distinction has to do with what equipment you have and what power is available–and it will depend on the circumstances.

The vast majority of the material in this book would apply to the navigation of any vessel, although we concentrate on the equipment available on smaller boats. We do not, for example, cover use of gyro compasses, but what any navigator might do with the bearing data once obtained by gyro would be pretty much the same if obtained with an inexpensive bearing compass. On the other hand, we do devote more detail to the effects of current and wind, because these are far more important more often to low-powered small craft than they are to ships or other large vessels.

...In Depth

12.2 Keeping Track of Course and Position

Once underway on a well planned route, navigation reduces to keeping track of where we are along that route. This note covers some of the ways to do this.

Chapter 1 Glossary

bearing. The numerical value of the direction to an object (0° to 360°). It can be specified as relative to true north, magnetic north, or the bow of the boat.

charts. Maps of the waterways used for navigation. They include depth data, topographic features of the shoreline, and magnetic variation, as well as aids to navigation such as lights and buoys.

close-inshore. Close to beach, in and out of rocks and surf and pocket bays. In oceanography, called the littoral zone.

compass. Instrument to measure direction, usually using the magnetic field (mechanical or electrical) or on some large ships using a gyro.

current. Horizontal flow of the surface water, can be driven by the tides or other sources.

dead reckoning. Estimating your position based on distance (log) and direction (compass) run from your last known position, corrected for current, leeway, and helm bias as needed.

GPS. Global Positioning System, a worldwide, all-weather satellite navigation system that provides highly accurate position on land and sea. From these accurate positions, course and speed over ground can be derived.

gyro. An electronic device used on larger vessels to determine accurate vessel heading. It is based on gyroscopic principles and does not depend on the earth's magnetic field.

inshore. Not far from the shore, in sight of land in clear weather, usually in 100 fathoms of water or less, but away from the hazards of the close-inshore region.

knotmeter. A boat's speedometer, it measures speed in knots, usually by means of a spinning propeller below the hull.

log. (1) A boat's odometer, counts miles through the water, usually using the same propeller as the knotmeter. (2) To record something in the logbook. (3) Another name for the logbook itself. (4) The process of covering some distance underway, as "We logged 10 miles this morning."

navigation. Finding and keeping track of your position on a chart and from there figuring a safe efficient route to where you want to go.

Navigation Rules. (1) The international set of rules and regulations designed to prevent collisions at sea. Also called COLREGS (Collision Regulations). Canada and the US each have modifications to the International COLREGS that apply to their inland waters. (2) The book published by the USCG that presents the Rules.

offshore. Ocean or coastal location, out of sight of land, usually without soundings.

piloting. Finding or keeping track of position using charted landmarks for references, such as compass bearings. Piloting can be relative, such as following a channel or point to point along a shore, or used specifically to determine a position fix on the chart.

position fix. A known position of the vessel on the chart at a particular time determined by some form of piloting or by electronic navigation using GPS or radar.

radar. An electronic navigation aid that measures line-of-sight range and bearing to landmarks or other vessels. It can be used for piloting, position fixing, or collision avoidance.

Rules of the Road. A common name for the *Navigation Rules*.

sailing. (1) To make way in a sailboat under the power of the wind. (2) More generically, the movement of any vessel, as used in Sailing Directions, or referred to in the *Navigation Rules*, Part B, Steering and Sailing Rules, which apply to all vessels, power and sail. (3) A routing option based on map projections and other factors, such as rhumb-line sailing, great-circle sailing, mid-latitude sailing. The full set of options are referred to as the sailings.

shipping lanes. Official or unofficial routes taken by commercial traffic through a waterway. Official lanes controlled by the USCG are referred to as Vessel Traffic Safety (VTS) lanes. Rule 10 in the *Navigation Rules* addresses navigation in or near VTS lanes.

shoaling. Means shallow water. Also called shoals or shoal water.

small craft. An unofficial term meaning a vessel, whose size or design limits its performance in some conditions. At one time it was considered to be all vessels less than 66 ft (20 m), but this definition is no longer used. The *Navigation Rules* apply to "Any description of watercraft used for transportation on the water," so vessels such as sail boards, paddle boards, kayaks, row boats, dinghies, and jet skis would also be in this category, just as a 100 ft houseboat might be, or a 70 ft yacht could be as well.

waypoints. Specific checkpoints (Lat and Lon) on a chart that are chosen to mark progress points or turning points along an intended route. They are best chosen to be points that are easily identified (visually or with radar) by prominent nearby landmarks or aids to navigation such as buoys or lights.

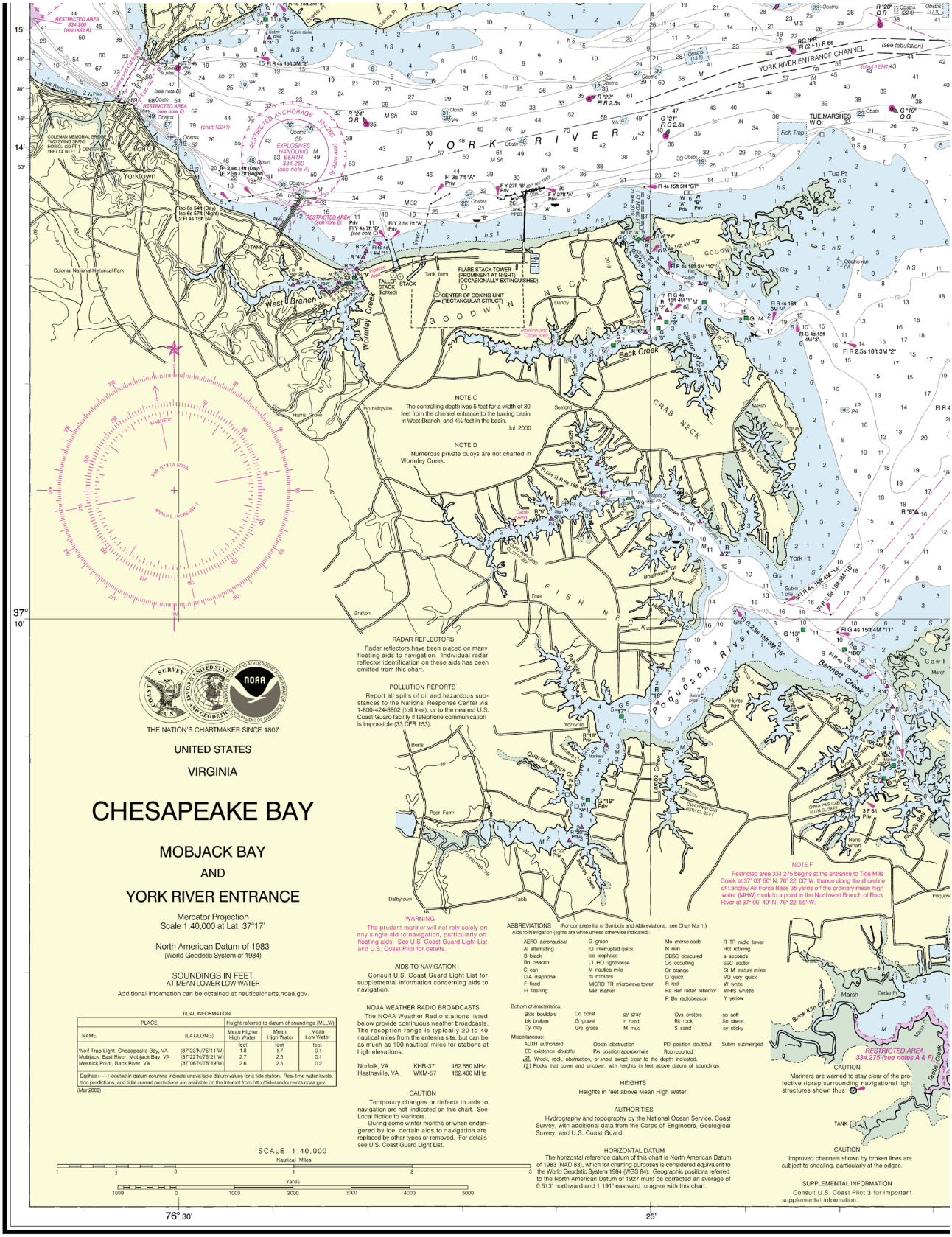

Figure 1-4. *Section of a new NOAA pdf chart (free online downloads), showing correction dates as well as a print scale. Bottom left line should be 6" long when printed to proper scale.*

Chapter 2

Nautical Charts and Chart Reading

2.1 What is a Nautical Chart?

The first step in navigation is having the proper nautical chart on board. Nautical charts are maps of waterways designed specifically for marine navigation. They show water depths, shoreline composition, extent of the tidal range on the shore, inshore rocks, aids to navigation (lights, buoys, daymarks), the direction that compasses point to in the charted area, and other aids to navigation such as shoreside buildings, structures, and terrain that are visible from the water. Most mariners distinguish the name chart from map when referring to these, but this is certainly not important—it is a maritime tradition similar to calling a rope a line when it is on a boat.

Charts come in various sizes (some are big sheets, some are smaller sheets), and they are made to various scales, although U.S. issues cost the same regardless of these distinctions. Areas covered by individual charts range from single bays to entire oceans. Two charts of the same sheet size that depict areas of different sizes must have different scales. The most detailed charts cover single bays or harbors. A harbor chart scale of 1 to 10,000 (written 1:10,000) means that 10,000 inches of the harbor appears as 1 inch on the chart. It takes some trickery, however, to interpret 10,000 inches.

Considering a handspan to be just over 7 inches, chart scales can be converted to nautical miles per handspan to get a quick feeling for what they mean. A 1:10,000 scale is equivalent to 1 mile per handspan. Chart scales of 1:40,000 cover 4 miles for each handspan on the chart. To figure miles per handspan for any scale, drop the last four digits of the scale factor and what is left is the number of miles per handspan. To calibrate your handspan for this purpose, stretch your hand out along the mile scale of a 1:40,000 chart to see what fingertip is 4 miles from your thumb tip. This handspan is then the one to use to interpret all chart scales.

The terms large scale and small scale are frequently used to describe charts. As with high and low gears on a bicycle, however, the logic of the names is not apparent. Large refers to the chart scale written as a fraction: 1/10,000 is larger than 1/80,000. Consequently, large-scale charts cover small areas; small-scale charts cover large areas. A specific island, for example, would appear large on a large-scale chart and small on a small-scale chart. Ocean chart scales might be as small as 1:1,200,000. The handspan trick keeps this in perspective. On this chart a handspan is 120 miles. For the purposes of small craft navigation, large-scale means 1:40,000 or larger.

2.2 Choosing Charts

Nautical charts are readily available for all navigable waters of the United States and most other parts of the world as well. Charts of American waters are prepared by the National Ocean Service (NOS), a division of the National Oceanic and Atmospheric Administration (NOAA)—see nauticalcharts.noaa.gov. American charts of foreign and international waters are published by the National Geospatial-Intelligence Agency (NGA). The larger NOS chart dealers will also carry the NGA charts. Many countries have charting services of their own, which are usually coordinated by a hydrographic office. Some of these foreign charts are carried by American dealers, but most are not. See any chart catalog for specific information on obtaining charts. Of special interest to North American sailors are the excellent charts of Canadian waters produced by the Canadian Hydrographic Service.

The best way to select charts for American waters is through NOAA's Nautical Chart Catalogs (see Figure 2-1). These free pamphlets (also available online) show maps of the cataloged region with the individual charts available outlined on it. Each chart has a specific name, number, and scale. The catalogs also list authorized chart dealers in the region. Authorized dealers are obligated to sell only the latest editions and charge only the official price. Canadian and NGA chart catalogs are similar.

Close maneuvering in small anchorages, for example, calls for the most detailed (largest scale) charts available. Hazards close to the shoreline such as rocks, shoaling (that might enhance waves or currents), kelp beds, and details of the shore itself (sand or rocks, steep or flat) are not discernible from small-scale charts. Access to the shore through off-lying rocks can only be judged, if at all, from detailed charts. A small island on a large-scale chart can appear as a rock on a small-scale chart (see Figures 2-2a and b).

For close inshore navigation, the larger the chart scale the better. As a rule, 1:40,000 is the smallest scale useful for reading features needed for landing or navigation along a rocky shoreline. One to 20,000 or larger would be even better, but they are not always available or more detailed. On the other hand, long trips call for some compromise in chart selection since a 1:20,000 chart can be just 10 miles across. The series of large-scale charts needed for a long trip makes an unwieldy stack of paper. Furthermore, long trips require at least one small-scale chart (1:80,000 or smaller) for planning the overall route–to locate, for example, the public lands in the area. It is tedious at best to plan

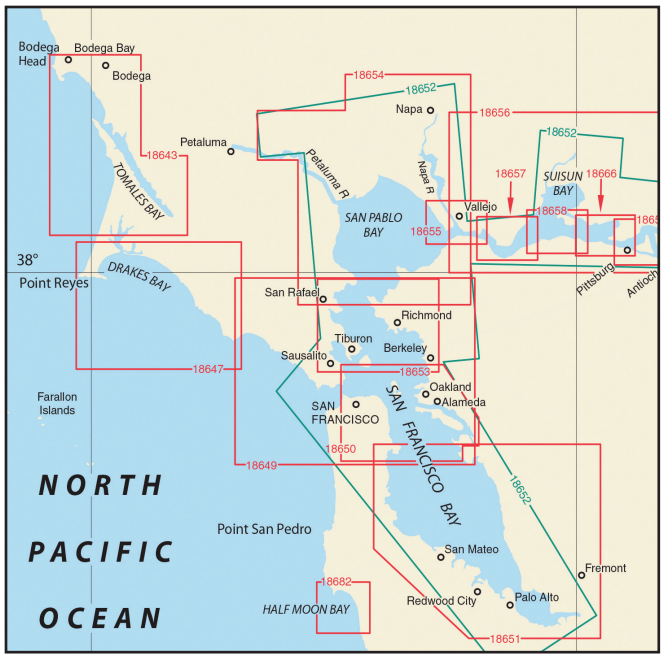

Chart Number	Title	Scale
18643	Bodega and Tomales Bays	1:30,000
18647	Drakes Bay	1:40,000
18649	Entrance to San Francisco Bay	1:40,000
18650	San Francisco Bay—Candlestick Point to Angel Island	1:20,000
18651	San Francisco Bay—Southern part.	1:40,000
	Redwood Creek	1:20,000
	Oyster Point	1:20,000
18652 SC	San Francisco Bay to Antioch	1:40,000; 1:80,000
18653	San Francisco Bay—Angel Island to Point San Pedro	1:20,000
18654	San Pablo Bay	1:40,000
18655	Mare Island Strait	1:10,000
18656	Suisun Bay	1:40,000
18657	Carquinez Strait	1:10,000
18658	Suisun Bay—Roe Island and Vicinity	1:10,000
18659	Suisun Bay—Mallard Island to Antioch	1:10,000
18660	San Joaquin River—Stockton Deep Water Channel	
	Antioch to Medford Island	1:20,000

Figure 2-1. *Section of a NOAA* Nautical Chart Catalog. *Each chart has a unique number, name, and scale, although some charts contain large-scale insets of specific areas, as indicated in the list of chart titles. This chart catalog is also online.*

long routes across several charts. Also, once underway it is difficult to identify islands on the horizon and other distant features when they are not on the same chart you are using. This is one potential disadvantage to NOAA's special folio charts, called small-craft (SC) charts, or to the commercial chart packets available for some areas.

Whenever possible, it is best to select charts by actually looking at them at the chart dealer. This way you can compare different scales of the same areas to see if the extra information provided on the large-scale charts is required for your intentions in the area. If you are only transiting a featureless shoreline, the larger-scale charts might not add significant detail to justify the extra expense and gear.

Unfortunately, chart agents with a large stock of optional charts for you to peruse might soon be a thing of the past, as NOAA is switching in 2014 to all print-on-demand (POD) charts, which already account for about 75%

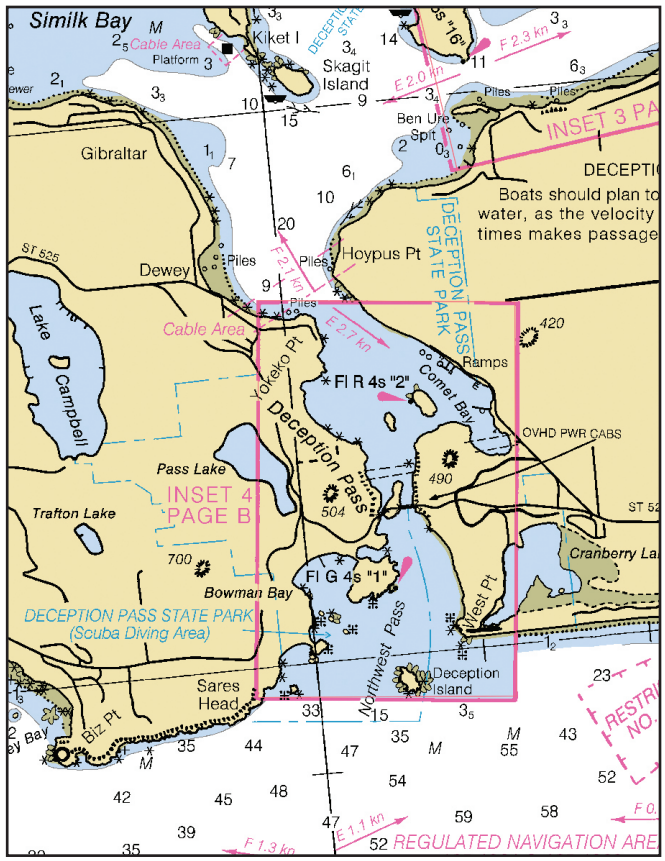

Figure 2-2a. *Sections of two charts of the same area having different scales. The smaller scale (2.2a) is 1:80,000; the larger scale (2.2b) is 1:25,000. Each is from a small-craft chart that has north to the left of the page.*

of paper chart purchases. Fortunately, however, the NOS nautical chart website is excellent, making it easy to find the charts available, with convenient viewers that can be zoomed in to see details. They also offer now new options in charting such as the BookletCharts, which break up the chart into individual panels, as well as new high resolution pdf images of the full chart. Charting and the distribution of charts is changing at the moment, so we need to keep an eye on the options and how the agents and other commercial outlets will be responding.

...In Depth

12.17 POD and pdf Charts

NOAA has announced that they will discontinue printing traditional lithographic charts in April, 2014, after which all paper charts will be Print-on-Demand. This note discusses this transition with pros and cons to look out for.

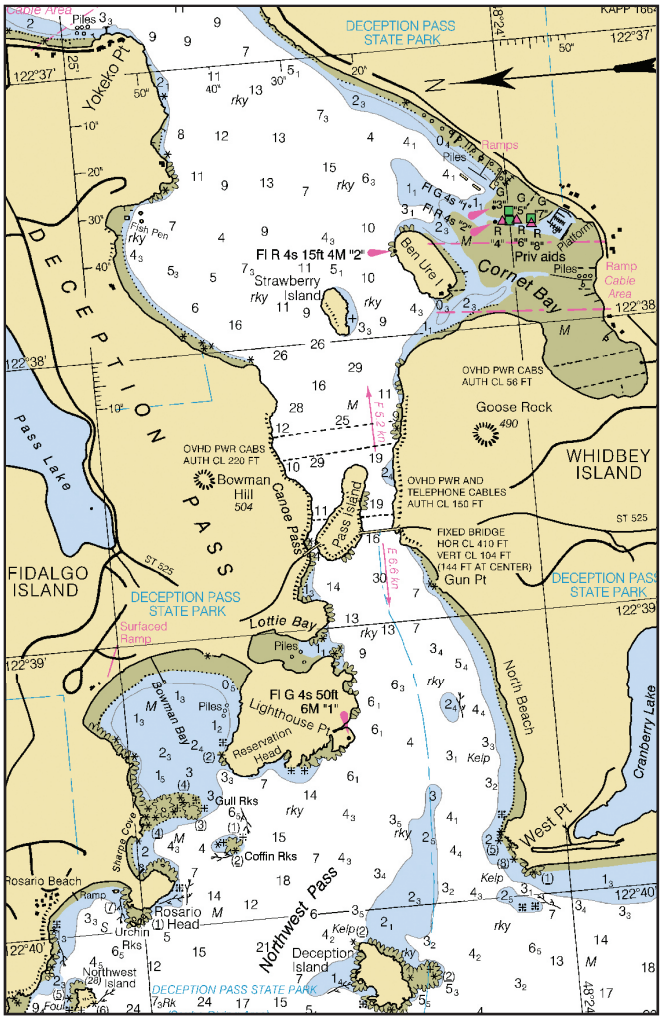

Figure 2-2b. *Sections of two charts of the same area having different scales. The smaller scale (2.2a) is 1:80,000; the larger scale (2.2b) is 1:25,000. Each is from a small-craft chart that has north to the left of the page.*

2.3 Electronic Charting

Nautical charts and topographic maps are available online. They can be viewed online in convenient viewers or downloaded to be viewed in your own electronic charting software. US nautical echarts are all free. Some topo maps are free; others are commercial products. See starpath.com/getcharts. There are two basic formats for nautical charts, vector charts (called ENC for electronic navigation charts) or raster charts (called RNC for raster navigation charts). The latter are direct reproductions of the paper charts into digital images and usually the preferred format when you have the option.

The NOAA chart site has a list of free echart viewers. These programs have convenient, versatile display options and let you lay out and plan a trip completely on the screen. You can enter waypoints with the click of a button, label them, and then have the program label the course line for each leg of the voyage with the distance and compass bearing between waypoints. The annotated chart segments of interest can then be selected, cropped, and printed out in full color for a trip. Whatever method you might use to protect your paper charts can be applied, including lamination, which is often very inexpensive.

The general term for navigation with an echart program using GPS input to track your position across the chart is called using an Electronic Charting System (ECS), and the associated software can be called ECS software. Several of these programs include very convenient tide and current options, so not only can you visualize the trip on any chart scale you choose at the click of a button, you can also display and print both the tide height and current speed and direction in that region. With practice, ECS is certainly the most convenient and thorough means of planning a trip, but you should still spot-check a few of its results the old-fashioned way by using paper charts and plotting tools. And, needless to say, this computerized approach to navigation planning will not appeal to all sailors. If it fits your lifestyle and resources, then it will be a boon; if not, you can always do this the tried and tested way that it has been done for hundreds of years with chart and pencil.

Bear in mind that as with much wonderful new technology, you often must go backward for a while before going forward. And this is just as true with the ECS revolution. There is a learning curve to crawl up before the fun ride down the other side. It could well take longer to carefully plan a trip by computer than by hand the first couple times you do it, but if you do a lot of extended sailing that calls for navigation, then this equipment and approach to planning will prove to be very worthwhile. It could be especially valuable to schools and clubs that are providing trip planning for their members.

Many commercial and recreational vessels use ECS not only for planning but also underway with direct input to the computer from their GPS satellite navigation system. This arrangement then shows their precise position right on the nautical chart (on the computer screen or mobile device) at all times and leaves a trail of dots showing where they have been. If they are drifting off course into danger it is obvious at a glance. At the click of a button they can take range and bearings to charted landmarks or compute new courses to any destination, all with a mouse click.

With mobile devices like smartphones and tablets, we have to address the waterproofing issue, but there are numerous options on the market. We have just seen one popular mini-tablet come out in a waterproof version, and there will likely be more, and there are many companies making protective covers.

Also, many modern radars now include a plotter option that is directly linked to the GPS. With these you can view on the same screen a chart view, radar view or both, or one overlaid on top of the other.

In any event, these types of developments can indeed be hazardous to navigation, since with their amazing con-

venience there is a tendency to not learn basic navigation, or to get so many things showing on the screen that it is confusing—so we let this topic go for now and get on with learning the basics that we must ultimately depend upon.

2.4 Latest Editions and Corrections

The date on a chart does not always tell whether it is the latest edition of that chart. Some charts are reissued every year, some only as often as every three or four years. The decision to reissue a chart depends on the number and seriousness of the changes that must be made. The latest issue of a chart can be checked by contacting the Coast Guard or any authorized chart dealer. They in turn will refer to a quarterly USCG publication called *List of Latest Editions*. A chart with the present year's date is probably the latest edition. One dated more than four years ago is probably outdated. The *List of Latest Editions* is online or available from official chart dealers.

The important things that are likely to change on new chart issues are locations of buoys and lights, flashing characteristics of lights, locations of shipping lanes, and the layout of structures on land. Much of the remainder of what charts show does not change with most new issues, but this cannot be counted on. Valuable shoreline information obtained from recent surveys might be missed if you go with outdated charts. Old charts often can be updated adequately by hand after comparing them with new ones or with lists of known chart corrections discussed below. Nighttime navigation calls for up-to-date data since it relies on proper light identification.

The latest chart data, including temporary as well as permanent chart alterations and other news of interest to marine navigation, are compiled weekly in the Coast Guard's Local Notice to Mariners (see Figure 2-3). These are kept on file at Coast Guard offices, marinas, chart dealers, and some libraries, and they are all online for very convenient review. A long trip into unfamiliar waters with planned nighttime sailing, or any other anticipated dependence on charted navigation aids, calls for going this extra mile in chart preparation. A quick survey of recent notices could reveal interesting information. Buoys can be dragged away by currents or collisions with ships; the only light for miles might be temporarily out of order; or an announced Navy bombing run might clarify what is meant by a Restricted Area marked on the chart. Important notices also are broadcast daily on VHF marine-radio frequencies.

Once a year, all permanent chart changes that pertain to lights, buoys, and other aids to navigation are compiled and printed in another Coast Guard publication called the *Light List*. If a *Light List* is newer than the latest issue of a particular chart, the data it contains supersedes that printed on the chart.

For example, suppose, early some August, you plan a trip for the end of the month. The most recent chart of the area you plan to visit is two years old. This chart claims the Cape Hazard Light flashes every six seconds and can be seen from 12 miles off. Your current *Light List*, however, states that this same light flashes every four seconds and can be seen from 10 miles off. The *Light List* supersedes the chart, so its information is what to expect and what should be written in ink on this chart next to that light. Checking the latest Local Notice to Mariners (dated August 2) you discover that this light is reported to be "operating at reduced intensity," meaning it cannot be seen from as far as it should. This calls for a pencil note on the chart and a check on the next several notices when available. It might even take a telephone call to the Coast Guard or a check of their Web site just before leaving to verify the status of this light. The visible range of lights and how this is determined from the *Light List* and charted light data are fundamental to nighttime navigation. US and Canadian Light Lists are online.

This level of preparation might seem excessive when compared to navigation practice in hiking or driving. You would not, for example, call the Highway Department before a cross-country drive to verify whether the street light in Podunk was working. The difference lies in the consequence of a wrong turn. A wrong turn in Podunk will not lead to a roller coaster ride that eventually turns the car over and fills it with water. A wrong turn in a boat in some places can rain on your parade—not often, but possibly.

2.5 Symbols and Soundings

Chart reading takes practice. There is a wealth of information on nautical charts, much of which is presented in symbolic or abbreviated terms. Once the symbols and conventions are learned, a nautical chart becomes a wonderful resource that is easy to use. If a picture is worth a thousand words, a chart is worth a book.

The primary guide to the interpretation of chart symbols is an inexpensive booklet called *Chart No. 1* (see Figure 2-4) published jointly by NOAA and NGA and available from most chart dealers. *Chart No. 1* lists all chart symbols and their meanings, although quite tersely at times. Rock and shoreline symbols, especially important to small craft navigation on close in routes, are explained below, but the booklet should be referred to for further details and practice. To learn the symbols, pick any chart and use *Chart No. 1* to identify symbols at random. Any marking on the

...In Depth

12.26 How to Fold Charts

For longer trips that require multiple charts, it is almost impossible to stress how important it is to have your charts organized...

U. S. COAST GUARD
LOCAL NOTICE TO MARINERS

I. SPECIAL NOTICE

SPECIAL WARNING NO. 69 - WEST COAST OF AFRICA - WESTERN SAHARA -

1. Unprovoked attacks on shipping off the coast of the Western Sahara by Polisaro front guerrillas using machine guns, grenades, and mortars continue to occur resulting in the loss of life and property. Polisario spokesmen have been quoted as stating that any vessel in Western Sahara territorial waters, which the Polisario considers to be a war zone, would be the target of attack.

II. DISCREPANCIES - DISCREPANCIES CORRECTED

The following is a list of aids to navigation that are not watching as advertised in the Light List Volume VI, Thirteenth District section:

LL #	Aid Name	Status	Chart	BNM	LNM
755/16135	Strait of Juan de Fuca Traffic Lane Separation Lighted Buoy J	Off Station	18400	0174-87	5/87
9120	Coos River Channel Light 8	Damaged/TDBN	18587	2194-85	1/86
9935	Clatsop Spit Lighted Bell Buoy 8	Missing	18521	0155-87	4/87
9970	Clatsop Spit Lighted Whistle Buoy 14	Improper characteristic	18521	0257-87	7/87
10050	Astoria Pier 3 East Light	Extinguished	18521	0222-87	6/87

III. TEMPORARY CHANGES - TEMPORARY CHANGES CORRECTED

The following is a list of aids to navigation that have been temporarily changed as advertised in the Light List Volume VI, Thirteenth District section:

LL #	Aid Name	Temporary status	Chart	BNM	LNM
None	Columbia River Entrance Test Lighted Buoy	Established	18521	1042-86	27/86
		Relocated		0130-87	4/87
9100	Coos River Entrance Light 1	Discontinued	18587	0959-86	25/86
None	Coos River Entrance Temporary Daybeacon 1T	Established	18587	0959-86	25/86

VI. ADVANCE NOTICE OF CHANGES IN AIDS TO NAVIGATION

OREGON AND WASHINGTON - COLUMBIA RIVER - HARRINGTON POINT TO CRIMS ISLAND - Aids to Navigation - Changes -
Pancake Point Dike Light 59 (LLNR 10480) will be discontinued.
Pancake Point Temporary Lighted Buoy 59T, a green buoy show a flashing green light every 6 seconds with a nominal range of 4 miles, will be permanently established in approximate position 46°08'58.8"N. 123° 22'20.5"W.
Chart 18523.

VIII. GENERAL

OREGON AND WASHINGTON - COLUMBIA RIVER - NAVIGATION LOCKS - Closures -
The navigation locks at Bonneville, The Dalles, John Day and McNary Dams across the Columbia River at river miles 145, 191, 216, and 292 (respectively) will be closed to navigation from 0700 local 8 March 1987 until 0800 local 22 March 1987 for annual maintenance.
Charts 18531, 18533, and 18535.
LNM CG Seattle 1, 2, 3, 4, 5, and 6 of 1987.

Figure 2-3. *Sample contents of the Local Notice to Mariners. Such notices are published by each U.S. Coast Guard District and they are online at the USCG web site. There are samples of US and Canadian notices in the Chart Problems book.*

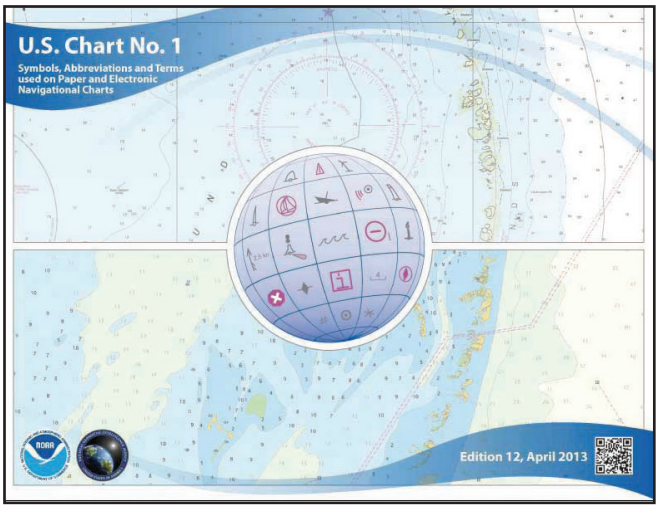

Figure 2-4. *Cover of the pamphlet called* Chart No.1*, which lists all nautical chart symbols and abbreviations. See section 12.5 for more discussion of this publication and related products.*

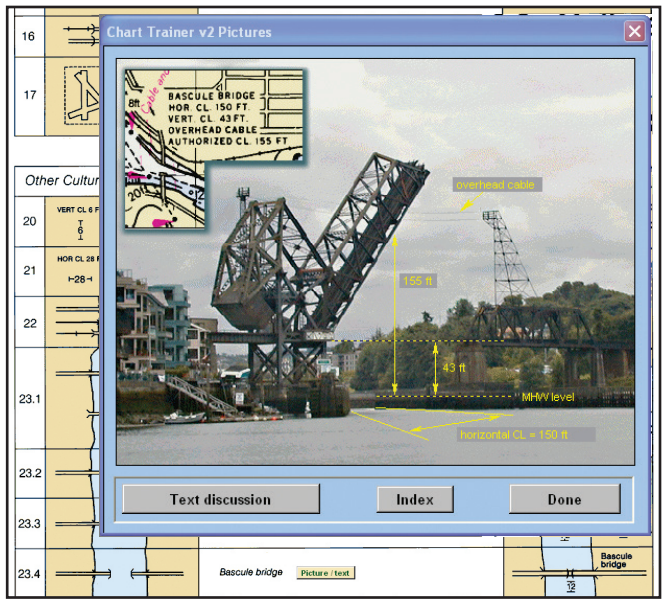

Figure 2-4a. *Screen shot of the annotated and enhanced* Chart No. 1 *section of the Starpath Chart Trainer software program.*

chart that is not listed in *Chart No. 1* is probably an actual structure built in the shape of the mark, or the work of a passing insect. Canadian chart symbols are similar to American ones, but there are enough minor distinctions to justify having a copy of the Canadian counterpart (also called *Chart No. 1*) when using Canadian charts, although the US edition does have columns defining international symbols.

The numbers scattered across the waters on charts are actual measurements of water depths called soundings. The units of the soundings vary from chart to chart. They will be either feet, fathoms, or meters. One fathom is 6 feet. One meter is just over 3 feet (3.28). The international trend is to convert all charted depths and heights to meters, but NOAA is not rushing into this and there are few complaints about it. Canadian charts are in meters. Depth units on U.S. charts are noted in bold purple print on the chart border.

With one exception, the same units are used for all soundings on any one chart. The exceptions occur in the shallower depths of some charts that use fathoms. A sounding with a subscript on these charts, such as 3_2, is a mixed notation meaning 3 fathoms and 2 feet, or 20 feet. When this convention is used, the chart is labeled "SOUNDINGS IN FATHOMS—FATHOMS AND FEET TO 11 FATHOMS." Other charts using fathoms do not follow this convention, but instead mark this same depth with a $3_{1/3}$, meaning 3 and one-third of a fathom. On charts using meters for soundings, the symbol 3_2 means 3.2 meters.

It is important to know what is meant by these charted depths. They cannot represent the actual depth of the water at all times, since depths change 10 or 20 feet each day in some places as the tides rise and fall. At any point on the chart, the tides go up and down twice a day, and books are available that tell the height of the tide at any time at that place. Tide books are made by the same agency (NOS/NOAA) that makes the charts, so they use the same reference level for both, and that reference level is the one marked on charts by soundings and shoreline boundaries.

Suppose a tide book states that at noon today the tide height at Seal Rock will be 5 feet. This means the depth of the water at noon at Seal Rock will be 5 feet above the reference level printed on the chart. If charted soundings around Seal Rock all read 20 feet (meaning the sea bottom is 20 feet below the reference level), the depth to expect at noon at Seal Rock is 25 feet. The depth of the water at any point on a chart is just the charted depth plus the tide height at that time read from a tide book.

The reference level (officially called the chart datum) could be at any height above the sea bottom, but the actual level used is not chosen arbitrarily. It is always taken to represent the depth of the water at the average value of the lowest tides. In other words, charted depths represent the shallow end of the tidal range at any particular spot. This means that tide heights listed in tide books are mostly positive numbers, and the actual water depth at any point and time will most likely be greater than that printed on the chart. The only time the water will be shallower than charted is during a negative tide—meaning the tide height printed in tide books is prefaced with a minus sign (-). From a practical point of view, this occurs only for a few hours each month, and even during these periods it is rare to find a tide more than 1 or 2 feet negative. Canadian tide tables use a slightly lower chart datum (*lowest normal tides*), which results in fewer negative tides than U.S. tables.

To a chart-reading navigator in some waterways, however, the tide's effect on the exposed shore is more important than it is on the actual water depths. For some shoal-draft vessels, a small change in tide height can open or close water routes over low-lying lands. Areas with large tidal range can appear remarkably different at high and low wa-