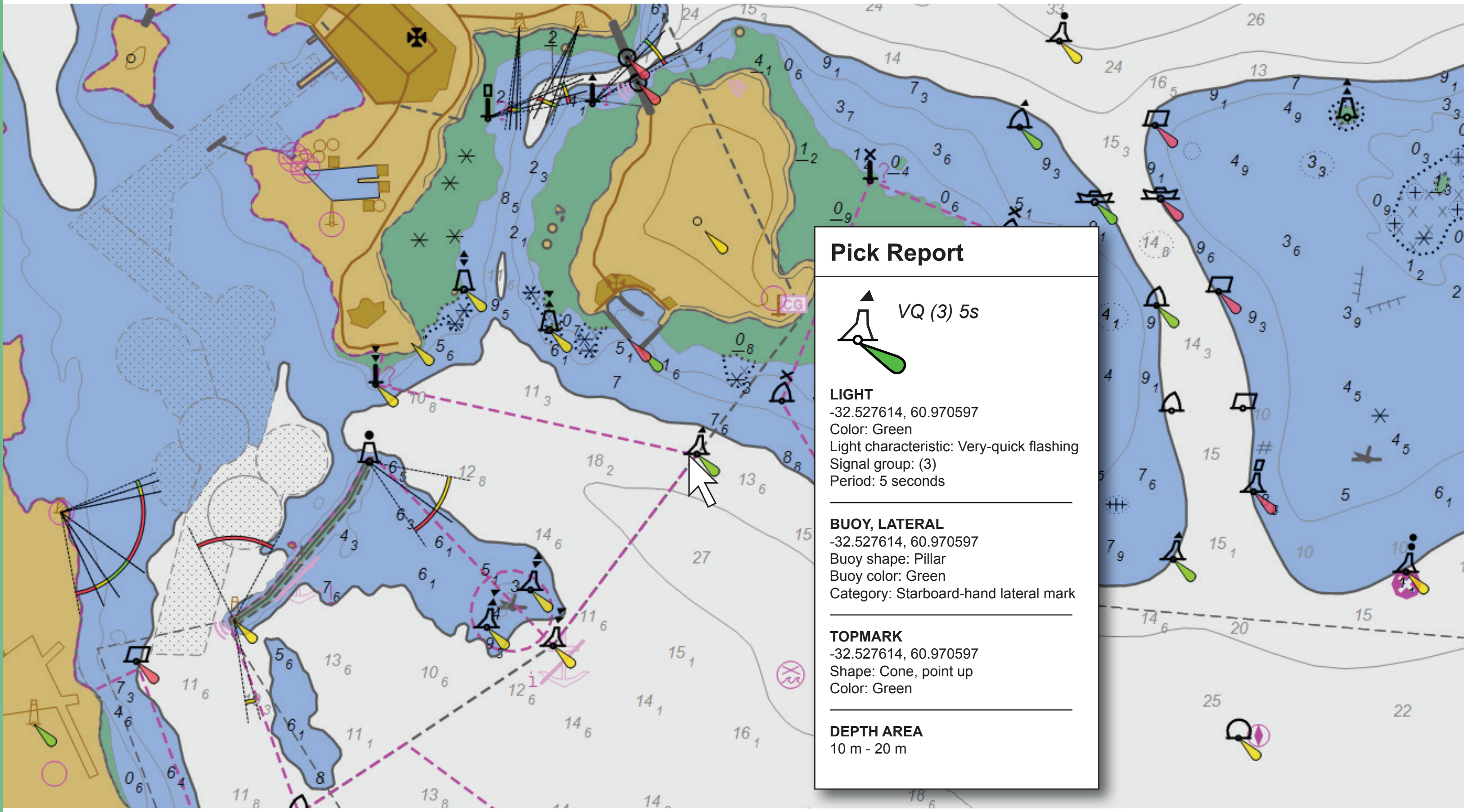
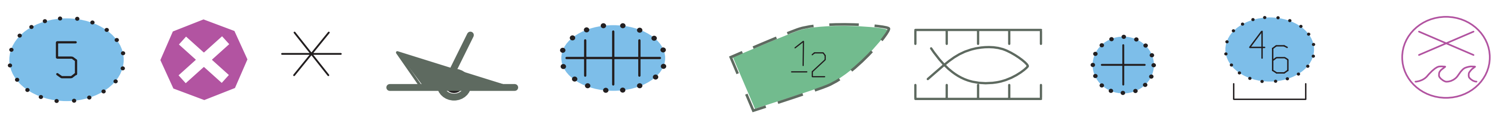
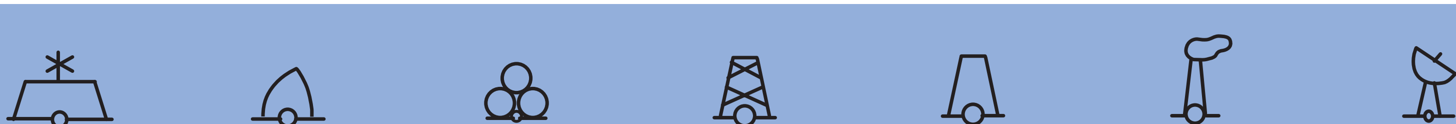
Introduction to

Electronic Chart Navigation

With an Annotated ECDIS Chart No. 1







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Contents

Nomenclature and Sources

Historically, documents called "Chart No. 1" have actually been *printed booklets* that include all the chart symbols, along with their explanations. At the time of inception of this convention, charts were indeed paper, and Chart No. 1 was in effect a folded up paper chart of symbols alone, no land or water, and hence, for effective chart use, it would be the first "chart" you would want to look at. Traditional forms of Chart No. 1 are available from most nations that produce and distribute charts from their respective hydrographic offices.

The International Hydrographic Organization (IHO) document called "ECDIS Chart No. 1" is an extension of that traditional paper chart concept into the age of electronic charts. ECDIS stands for electronic chart display and information system. The IHO edition of "ECDIS Chart No. 1" is actually a set of special electronic navigational charts (ENC) made up of just the chart symbols, and, as with standard ENCs, you find out what a symbol means by clicking it on the computer screen. This set of nine, 1:14,000 electronic charts, when installed into a charting program, is positioned in the desert of central Mali, near 15 N, 5 W.

This special set of ENCs is available from the IHO, primarily for navigation program developers, so they can confirm their rendering of the symbols on the screen. It seems not to have been intended for public use, and indeed it would not be particularly beneficial to mariners underway using ENC. If they want to know the meaning of a symbol on an ENC in front of them, they would just click it; they would not need a separate chart of symbols.

Nevertheless, there remains a valuable role for a comparison of the electronic chart symbols and their corresponding paper chart symbols. NOAA recognized this early on, and in May of 2013 published the 12th edition of *U.S. Chart No. 1*, which, for the first time, showed the ECDIS standard electronic chart symbols and the paper chart symbols side by side. *U.S. Chart No. 1* is in effect another "ECDIS Chart No. 1," returning to the historic (printed) sense of the title. *U.S. Chart No. 1* is available as a free PDF download, or in print from several commercial outlets.

Chapter 4 of this book is based on the ECDIS symbols section of *U.S. Chart No. 1*, which we have reformatted, annotated, and cross referenced to other sections of this book. This book is not, however, intended as a substitute for *U.S. Chart No. 1* on any level. We do not include paper chart symbols and we have abbreviated the ECDIS parts as well. We strongly recommend that not just every vessel, but indeed every mariner, have a copy of *U.S. Chart No. 1*. You can go to the NOAA web site and download the PDF to your phone!

The British Admiralty publication N5012, *Admiralty Guide to ENC Symbols used in ECDIS* (1st edition, June, 2012) is also in effect an "ECDIS Chart No. 1," but that name is not used. We have chosen to call our Chapter 4 "Annotated ECDIS Chart No. 1." In principle it could be called "Annotated ENC Chart No. 1," or "Annotated Electronic Chart No. 1," but the actual symbols discussed are those specified by the ECDIS standard, which is what all electronic chart programs use as a guide, so it seems fair to us to shake that name loose from its esoteric origins.

In addition to *U.S. Chart No. 1*, our other primary resources have been the IHO publications *S-57, IHO Transfer Standard for Digital Hydrographic Data*, and *S-52, Specifications for Chart Content and Display Aspects of ECDIS*. In essence, the purpose of this book is to translate into useful terms those parts of those resources that are most relevant for routine navigation using electronic charts.

IMPORTANT NOTE

Every effort has been made to confirm the veracity of the content of this book. This is, however, a broad subject, open to interpretation in some cases, and potential errors in all cases. The author and publisher cannot warrant it is free of errors or omissions.

The book includes symbols and explanations used on electronic navigational charts, but it does not provide an exhaustive representation of all scenarios that might be encountered.

The selection and choice of screen shots from various sources does not reflect a preference or promotion of any particular charting program manufacturer.

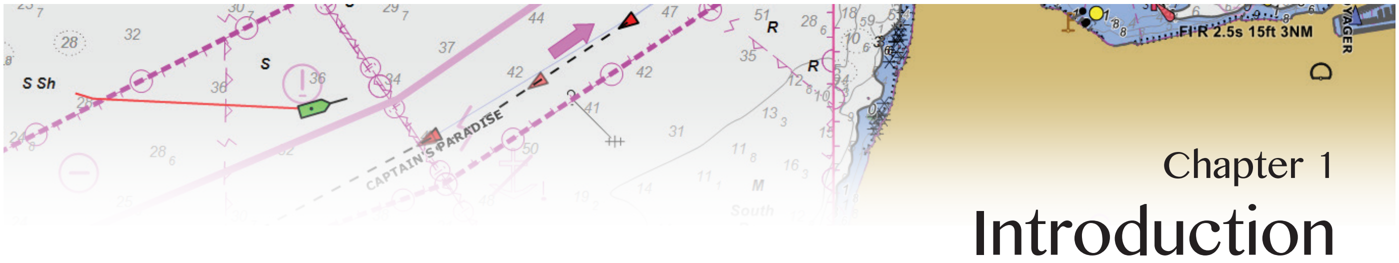
Acknowledgments

First and foremost I thank Tobias Burch for his collaboration on all phases of the book. Beside creating all of the graphics, he designed the text and cover, and provided invaluable editing on both text and graphics. This project literally would not have been possible without his participation. I am also pleased to thank Starpath instructor Larry Brandt for once again applying his sharp editor's eye, finding needed corrections and clarifications throughout.

The NOAA Office of Coast Survey invites queries and comments on their products, and we have benefited immensely from that service. Many individuals there helped us understand the nuances of electronic charts, which has improved several aspects of this book. We thank them again here and remain grateful for their assistance.

During our study of electronic charts we benefited from the use of several navigation programs, and we remain grateful to these companies for the support they offered during the process. These include in alphabetic order: Coastal Explorer (Rose Point Navigation), ENC Online (NOAA), Expedition (Expedition Marine), MacENC (GPSNavX), OpenCPN, PolarView (Polar Navy), SeeMyENC (SevenCs), and TZ Navigator (Nobeltec).

I am also pleased to thank Brian Voss, Librarian at the NOAA Regional Library in Seattle. He has many times shown us the irreplaceable value of a real library and real librarian in the age of the internet. Thanks again for all your help over the years.



Chapter 1

Introduction

Our goal with this publication is to help mariners make the transition from traditional navigation using paper charts and associated printed publications to the use of an electronic charting system (ECS) that relies on some digital form of nautical charts.

An ECS is a software program that incorporates GPS signals and other sensor data so as to display a vessel's moving position on a digital chart, along with crucial derived parameters such as course over ground (COG) and speed over ground (SOG), among others. In it's simplest form, it can be a handheld GPS with a rudimentary base map; in its most sophisticated form it can be a complex system that meets the highest international standards of safe, efficient ship navigation. The type of ECS in use plays a key role in how we read and interact with digital charts.

There are two broad categories of digital charts, both of which are widely used internationally. They are distinguished by the nature of the digital files that represent the charts. The two chart file types are *raster charts* and *vector charts*.

1.1 Raster Charts

A raster chart is a graphic image of a region of the earth. They are photographic images that have been georeferenced, meaning each pixel location on the image has associated with it the corresponding latitude and longitude of the point shown in the image.

A raster chart can be made from an image of a street map, topographic map, or satellite image. A cellphone app following your position across a satellite image is an ECS using raster charts. For the discussion at hand, the most important type of raster chart is one made from a photographic image of an official paper nautical chart. Electronic charts made from official paper charts are called *raster navigational charts* (RNC).

On the display screen of an ECS, an RNC looks just like the paper chart it was made from, except that in this digital format the image can be zoomed, panned, rotated, and digitally annotated to carry out traditional navigation plotting. Thus a key point in the use of RNCs is that the chart symbols, labels, and chart notes are identical to those of traditional paper charts, because they are indeed just georeferenced pictures of the paper charts.

When using only RNCs, the navigator's transition from using paper charts to using digital charts is wholly a matter of learning the use of the navigation software that displays the charts, which is generically referred to here as the ECS. For example, how do we download and install the electronic charts; input our GPS signals to follow our vessel across the chart; how to use electronic range and bearing tools; how to set up waypoints and routes; and how to monitor our progress along that route using the electronic tools in the software.

Another factor that remains the same when going from paper charts to RNCs is our dependence on related navigation publications, such as the *U.S. Coast Pilot* and *Light List*. These documents contain crucial navigation information that is not shown on paper charts, and consequently not included in the RNC.

Since digital versions of these crucial navigation publications are readily available, some ECS programs have incorporated access to this supplemental data from within the software. This is one of the virtues of using electronic navigation in the first place, regardless of the chart type in use.

For example, place names in the *U.S. Coast Pilot* often include the Lat-Lon of the location, so an ECS program can include *U.S. Coast Pilot* data in such a way that a user could search on a place name, or mouse-click a specific place on the chart, and *U.S. Coast Pilot* information for that region will show up on a supplemental screen. This type of functionality is an asset to that ECS product, but it is not related to the chart in use. This extra information has been included by the ECS software manufacturer; it is not part of the RNC itself. Likewise, many ECS programs include tide and current overlays that can be displayed on the chart. These are a great asset to navigation, both when planning and when underway.

Of the many types of raster charts we might use, it is good policy to reserve the name "RNC" to those made specifically from the official paper charts issued by a national hydrographic office. The International Hydrographic Organization (IHO) website lists the member nations. A georeferenced satellite image, or other raster chart provided by third parties, would not be called an RNC.

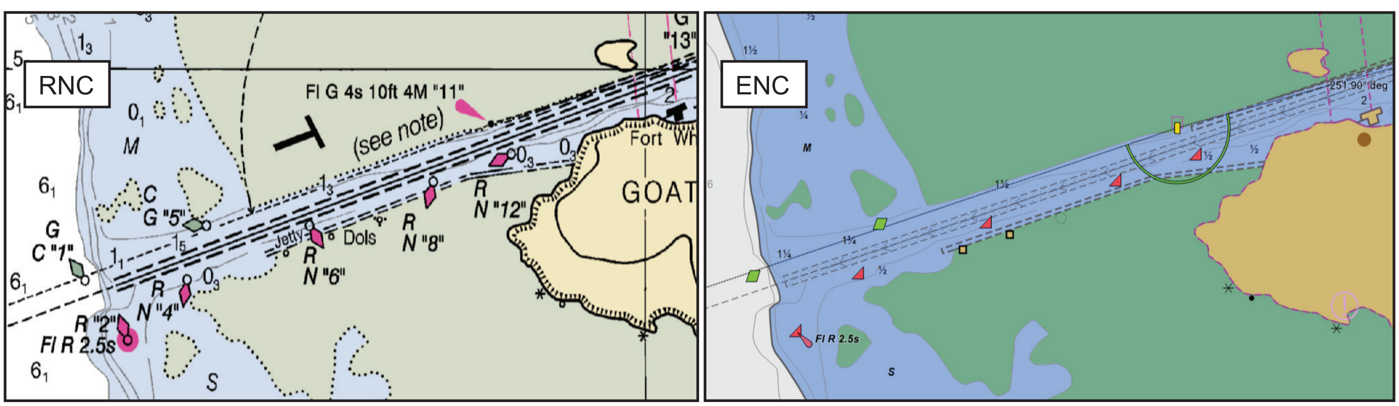
1.2 Vector Charts

In contrast to the static images of a raster chart, a *vector chart* is a dynamic depiction of the charted area that is created by the ECS software program from a database of nautical chart data and then drawn on the ECS display. A vectorized depth contour, for example, is not a picture of the depth contour shown on the paper chart, it is a curved line that is drawn on the screen each time the user displays the chart region that includes it, or changes the zoom level. A curved contour on a vector chart is a series of connected straight-line segments from one point to the next along the contour. The contour is stored as a table of Lat-Lon positions along that depth. The size of the steps along the line is determined by the scale of the chart so the curve appears a smooth line at the working scales. Likewise, land boundaries, and other areas on the chart are created on the wing from database entries. Even the symbols themselves are drawn out individually each time they are needed.

Because the entire chart is just a database of text and numbers, vector charts are inherently smaller file sizes than the corresponding high resolution graphic images of a raster chart. As such, a mariner can have a tremendous number of vector charts at hand for any voyage on a single CD, thumb drive, or plug-in chip for their ECS. Likewise, portable GPS devices can include very large areas in high detail using vector charts.

Most of the console navigation units used on vessels rely on vector charts, often in a proprietary format unique to the manufacturer. The main virtue of the vector format, however, is not the file size, but their ability to include many layers of information about the charted objects and the ability of the ECS to let mariners customize the display to varying degrees. With an RNC you have the option to change the display color palette in some ECS programs to best meet ambient light conditions (daylight, dusk, night), but that is about it. With vector charts you can not only change the display palette, you can choose the depth contour patterns, show or hide labels, and even simplify the symbology used for the aids to navigation (ATON). More sophisticated programs have more sophisticated options.

More importantly, you can view very detailed information about every object shown on the chart with a mouse click (called *cursor pick*) that pops up a table listing the properties (attributes) of the object. These crucial data are often more in-depth than can be found on the corresponding paper chart.



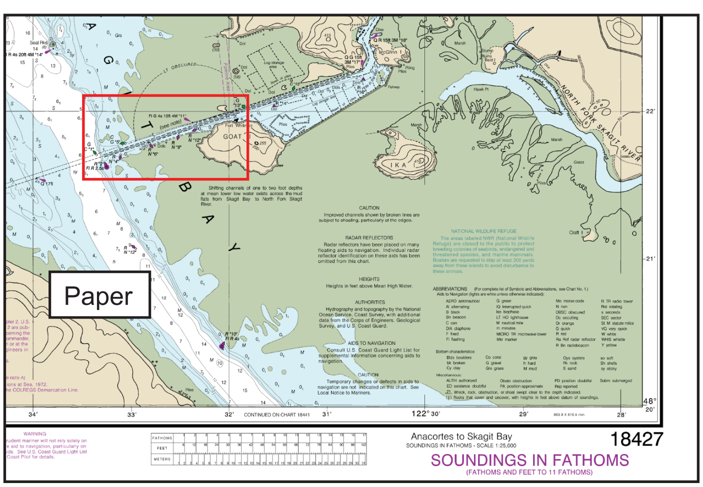


Figure 1.2-1. *A segment (red) of a paper chart (bottom left), shown as an RNC (top left), and ENC (top right). The RNC display is the same as the paper chart. The ENC is a vectorized presentation. Notable distinctions discussed later include customization of the ENC display regarding depth contours, labels, boundary and symbol styles, and more, along with the absence of terrain details on the ENC.*

But just as there are different types of raster charts, there are different types of vector charts as well. Many commercial companies create their own proprietary vector charts. These are all based on official government charts to some level, but it is only market competition that dictates how thorough, accurate, and up-to-date they are. In this book, however, we are only addressing official vector nautical charts produced by national hydrographic offices. Official vector charts all adhere to the same standard of content prescribed by the IHO called *S-57, IHO Transfer Standard for Digital Hydrographic Data*. Vector nautical charts produced to this standard are called *electronic navigational charts* (ENC). The name "ENC" applies only to S-57 adherent charts.

1.3 RNC versus ENC

In a sense, the use of RNCs is a traditional approach to electronic chart navigation, whereas ENCs are the future of electronic chart navigation. The many advantages of ENCs are not limited only to those already mentioned (more information and user customization). Since the software knows where you are, and it knows what is on the chart in front of your vessel icon, you can define anti-grounding zones in the direction of your COG (course over ground) to warn you of approaching hazards or shallow water. You can also highlight the visible arc of navigation lights in the vicinity to aid your visual navigation. There are numerous safety and efficiency features available to the navigator using an ENC.

Beyond that, because an ENC is a database, it is much easier and economical to update and distribute than the graphic or paper products are. An ENC can be updated in seconds. The more mariners rely on this form of charting, the more efficient the process becomes, which is a benefit to both mariners and producers. With all the layers of information the ENC contains, the description of each ATON (aid to navigation) and geographic object on the chart improves over time.

An ENC, for example, will always tell us the height of a light above mean high water, just as an RNC would do. But, even if the latest ENC does not tell us that this particular light is on a 80-foot-tall, black-and-white-striped, cement tower, which itself is on a hill that is 45 feet above mean sea level, as the producing agency learns more about the object—with the help of mariners who know it well and take the trouble to report their observations—the information will eventually make it into the ENC. There is a limited amount of information that can be put onto a paper chart (RNC) within its own standards of production, whereas there are extensive attribute options for objects on an ENC. The United Kingdom Hydrographic Office (UKHO) already has a popular app for mobile devices, designed for mariners to make quick reports of charting discrepancies or additions they find underway. NOAA has a similar online service. Both respond promptly to all submissions.

As a further example, there are numerous lights or lighted buoys on RNCs whose labels do not include the nominal range that is crucial to predicting the visible range. In some cases, that is because it is not known. In other cases, however, this range is known and presented in the *Light List;* it is just not on the RNC. The latest edition of an official ENC, on the other hand, should include within it all *Light List* information that is known about that light, and thus we get this information directly from the ENC, when we could not get it from an RNC. For U.S. products, the

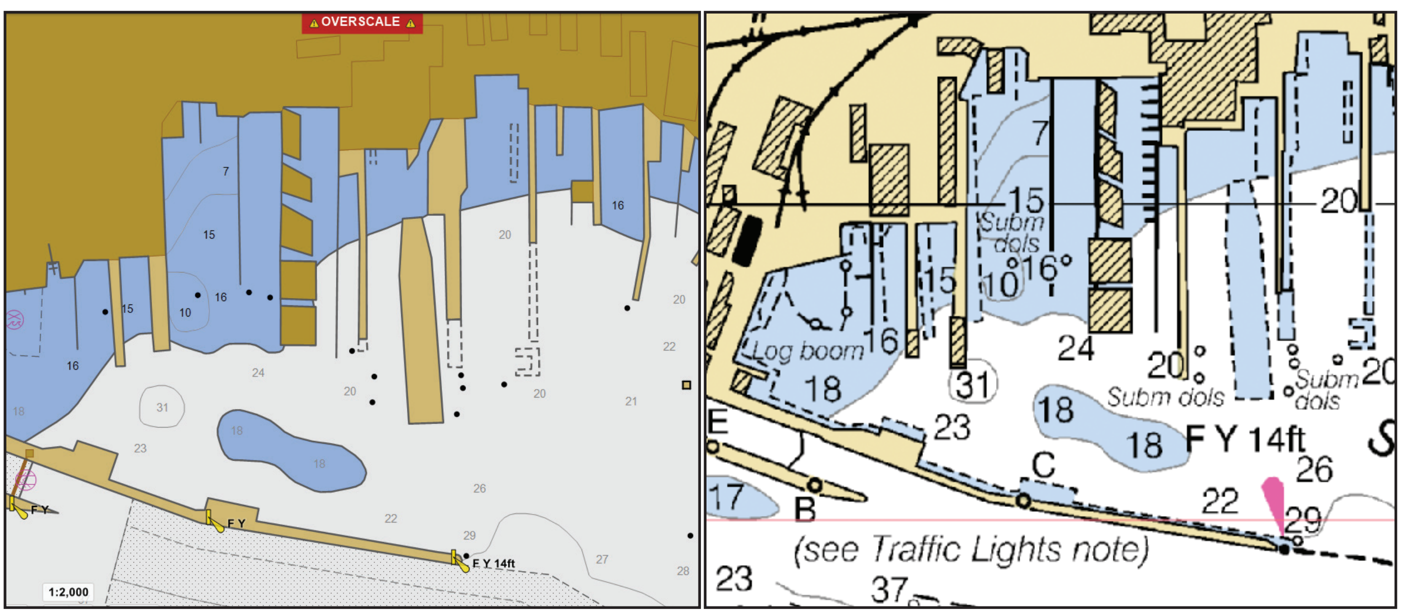


Figure 1.3-1. *ENC (left) and RNC (right) of the same docks area. Note breakwater lights shown on the ENC are relegated to a chart note in the RNC—an advantage of the ENC that also applies to some bridge lights.*

the definitions of the attribute categories (samples are shown in Table 1.7-3). In principle, this type of interactive presentation could be included in an ECS or ECDIS program, but we have not seen it done.

Cursor Pick Reports

Chart reading on an ENC is an interactive process, a step into modernization of navigation. On a paper chart we see all there is to know from the chart by looking at it. Looking at an ENC, we see only a fraction of the information it includes. In numerous cases, we must click the chart just to learn what we would know at a glance from the corresponding paper chart—but then, almost certainly, learning a lot more. We might compare a person sitting motionlessly reading a traditional printed book to someone reading an illustrated ebook in an electronic device. The latter is likely panning and zooming images for the best display, highlighting sections, clicking words to look up their meanings, book marking, adding notes, and so on. Modern ENC reading now is done as much with the hands (on a mouse or track ball) as with the eyes.

When we click an object on an ENC (a cursor pick) we get back a list of all objects at that point (a pick report), along with sublists of all the attributes that apply to each object. How this report is formatted and displayed on the screen depends on the ECS in use. In fact, it also depends on the ECDIS in use, because this display varies among all navigation programs. We can be certain that a type-approved ECDIS will include *all* the possible data, whereas most ECS choose edit the list of objects and attributes on some level. There can be a dozen or more object layers on some pick reports, not all of which are crucial to typical navigation concerns.

ECS pick reports appear in one of three formats, they use acronyms only, acronyms and plain language, or plain language only. A sample of the latter is shown in Table 1.7-4 for the cursor pick of a lighted buoy, showing all the underlying layers that we might see—the image of the buoy was added. Symbols are sometimes shown in pick reports, but not often. The objects and attributes shown are discussed later in the book.

Cursor pick examples

There are more practical details in Chapter 2, but for an introduction to what we can learn from an ENC, we look at the cursor pick of the light shown in Figure 1.7-1. The results are presented in Table 1.7-5 with annotations. When we cursor pick that light symbol we get a list of everything located at that point. There is a prescribed order, but that order is not always followed by all ECS; in any event, we usually get all the key information. In this discussion we are looking at the top four objects, namely a light, a beacon, a fog signal, and the land these are sitting on.

Notice that each of the three point objects has its own symbol (a flare, a thin rectangle, and a sound wave symbol). If you carefully made the cursor pick on any one of

Table 1.7-4 Sample Pick Report*

US5VA20M		36° 58.26' N, 076° 06.297' W
Buoy, lateral		
	Shape	Pillar
	Category	Port-hand lateral mark
	Color	Green
	Name	Thimble Shoal Channel Lighted Buoy 7
Light		
	Color	Green
	Exhibition condition	Night light
	Characteristic	Flashing
	Group	(1)
	Period	2.5 s
	Sequence	00.3+(02.2)
Restricted area		
	Information	Regulated navigation area, 33 CFR165.501: Navigation regul ations are published in Chapter 2 of the U.S U.S. Coast Pilot for
this		geographic area.
	Restriction	Entry restricted
Navigational system of marks		
	Marks system	IALA B
Fairway		
	Name	Thimble Shoal Channel
	Traffic	Two-way
Magnetic variation		
	Reference year	2015
	Annual change	-1'
	Variation	-11°
Quality of data		
	Zone of confidence	A1
	Source date	20110800
	Text description:	US5VA20D.TXT
Depth area		
	Contours	10.9 m - 36.5 m
Dredged area		
	Sounding	14.5 m
	Name	Thimble Shoal Channel LOQ
Nautical publication information		
	Usage	Harbour
	Compilation Scale	20000
	Source date	20110800
	Source	US,US,graph,Chart 12254
	Text description	US5VA20A.TXT

** This is an example of clicking an object where a lot is going on at that location, ten layers of objects. Objects and attributes shown in this report are explained in later sections.*

them, away from their overlapping center point, you could get (depending on the ECS) a report for just that object plus the land under it. This behavior is important to remember because, unlike RNCs, when we zoom into an ENC, it is only the line and area objects that zoom; point objects, i.e., the chart symbols, remain at their specified sizes, which are pretty small on some screens. Also the fog signal (sound wave) symbol color is specified as magenta, which is not very prominent when shown on top of tan land or a water shade, and this varies with the ambient lighting. Thus we might click a light hoping to learn all about it, but miss the fog signal. (We see later that ECS programs do not all respond to cursor picks of related objects like these in the same manner.)

The pick report tells us all that is in the ENC for these objects, but we must rely on our own experience with ENCs, or a list of attributes, to learn what might be known but is not given. In this example we learn what we would most likely need about this light, but there could be more, meaning valid attributes of the object that are not known. This light, for example, has a name according to the *Canadian Light List*, so it could have the attribute *object name* (OBJNAM) of "Race Rocks Light," but that is not given. More practically, we could want to know if this light is on during the daytime. That would be the attribute *exhibition condition of light* (EXCLIT), which can be: always on, daytime only, fog only, or night only. At this point in time, that is not known for this light.

Looking at Figure 1.7-2 and the beacon report in Table 1.7-5, we see more that could usefully be included in the ENC. This is a conspicuous object, meaning the attribute *visually conspicuous* (CONVIS) is clearly applicable. CONVIS does not apply to object LIGHTS, but it does apply to beacons, and it is not there in this case. Also this light is in both the U.S. and the Canadian Light Lists, so it would be nice to have both Light List numbers. Other lights along this shared waterway do have both.

Indeed, this object (Figure 1.7-2) could be identified in the ENC as an object *landmark* (LNDMRK), both historically and visually. The object LNDMRK could then have attribute *category of landmark* (CATLMK) = "tower"; attribute *function* (FUNCTN) = "light support"; attribute *vertical length* (VERLEN) = "80 ft." And then those, along with attribute *visually conspicuous* (CONVIS) = "yes" could be applied to the beacon object.

In short, a virtue of the ENC is that the format is all in place to add new information about any of the charted objects. The symbols are not going to change, they are fixed in both size and design, but the characterization of the object and the list of attributes can expand to cover more of what we would learn from the *Light List*, *U.S. Coast Pilot*, or local knowledge. However, despite not having reached full potential with this symbol's description, the ENC still provides much more information than does the RNC for the same light.

For completeness, we might note that even though this light tower was not listed as a landmark, we do get some hint of its value to navigation from the beacon symbol itself. Within ENC terms, towers, prominent lattice structures, and large pile structures are called *major beacons*, whereas stakes and poles are called *minor beacons*. Major and minor beacons have slightly different symbols, as shown in Figure 1.7-3. They are similar, but noting this adds to chart reading skill. Minor beacon symbols are thinner and taller. This is an example of the interplay between the S-52 and S-57 standards. The ENC (S-57) does not specify a beacon as major or minor, but S-52 specifies a major or minor beacon symbol depending on the value of its beacon shape attribute (BCNSHP).

Furthermore, S-52 specifies two styles of symbols be available to the user: one called "simplified," which we have been using so far, and one called "paper chart," which emulate those of traditional paper charts. The distinction between major and minor beacons is more prominent in the latter style (see insert to Figure 1.7-3). Optional symbol

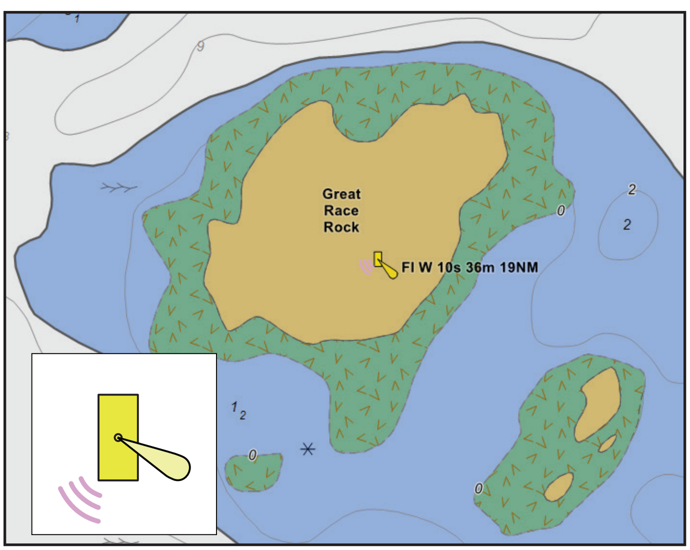


Figure 1.7-1. *ENC presentation of a lighted beacon with simplified symbols and light label showing. From CA570101.*


Figure 1.7-2. *Race Rocks Lighthouse was established in 1860 and manned until 1996.*

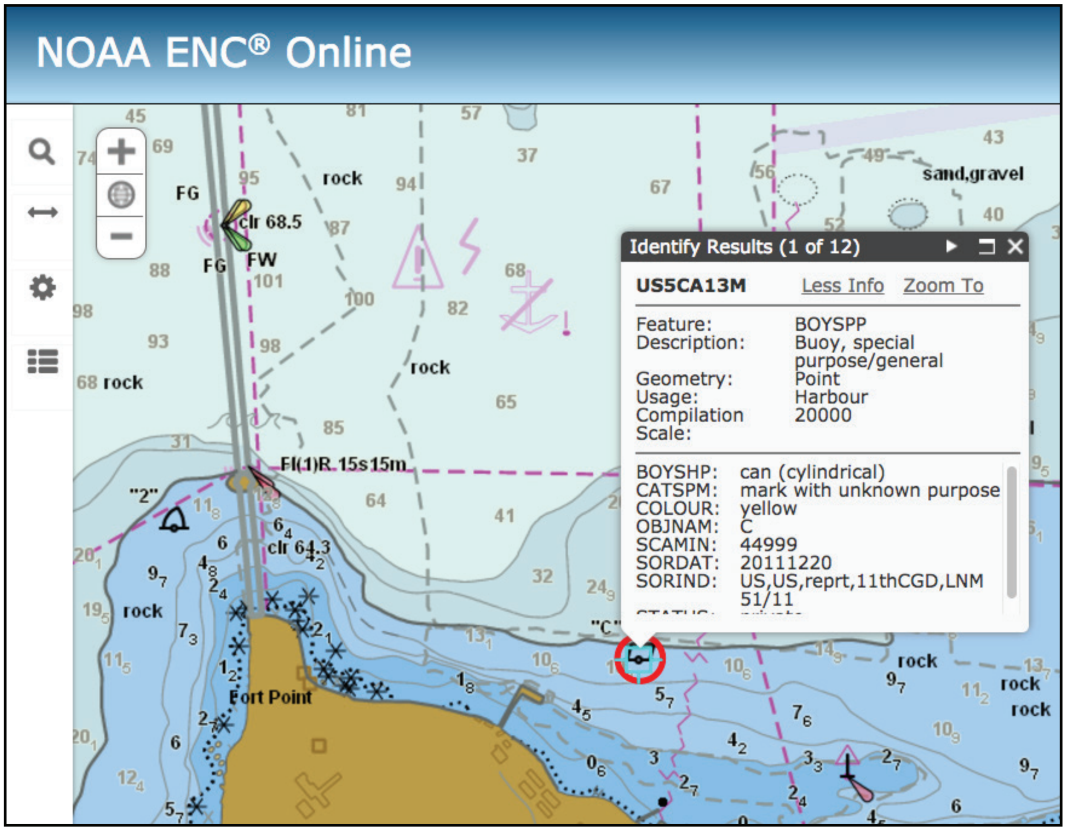


Figure 1.8-1. *Sample screen from the NOAA online ENC viewer. Symbols follow closely the ECDIS standard as do the content of the pick reports, i.e., we see everything that is encoded at that location. Use of attribute acronyms alone is not standard, but these are all listed in Appendix 4. The sample shown has 12 layers of objects, which are accessed with the step button, top right. Typical display options and contour controls are present for a realistic ECDIS example of ENC viewing. Measurement tools and search options are included. The ENC cell outlines can also be shown to learn where charts are available. There is another sample of this viewer in Figure 2.13-1.*

This service is also a way to quickly view any NOAA ENC without having to download and install the chart in your own ECS. Even with the RNC of a location in hand, this interactive view of the corresponding ENC can provide more information about the chart and charted objects. Figure 1.8-2 shows a very informative feature of the NOAA Viewer that lets users overlay the ENC on any of a number of base maps.

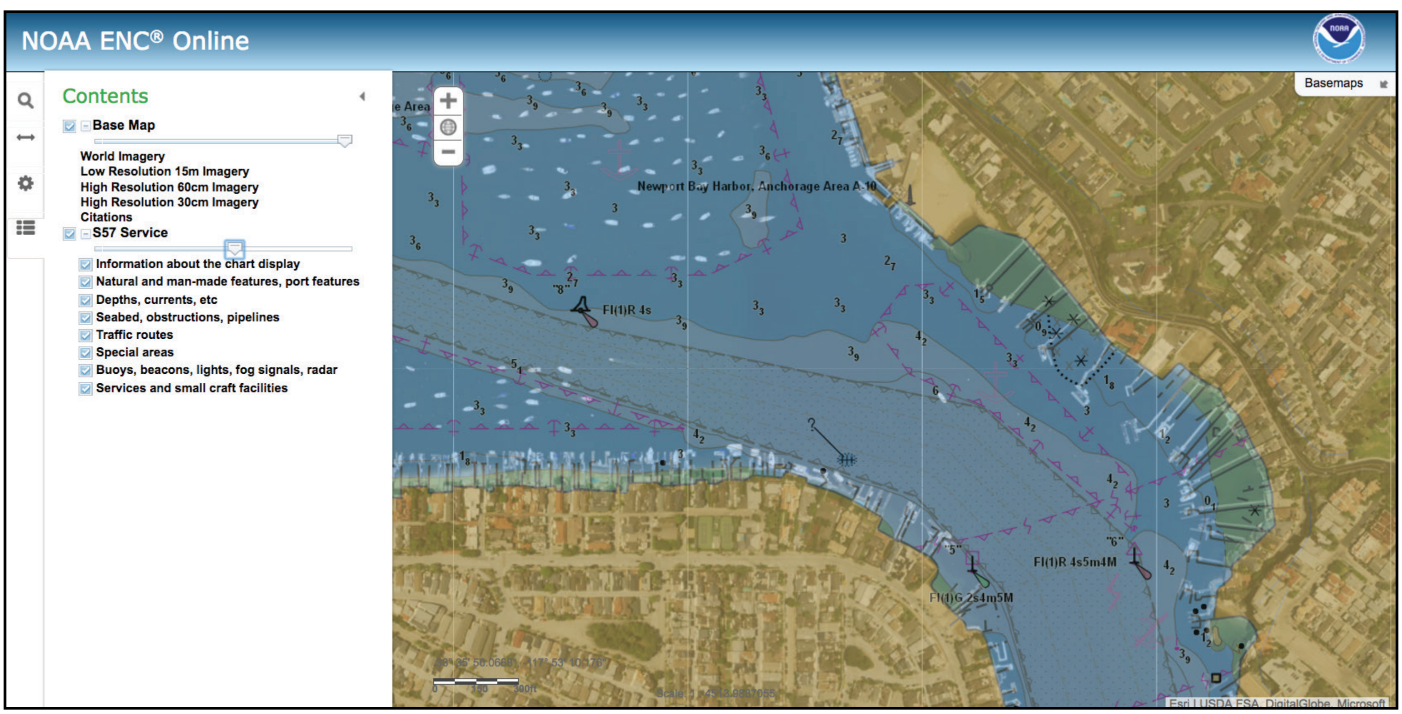
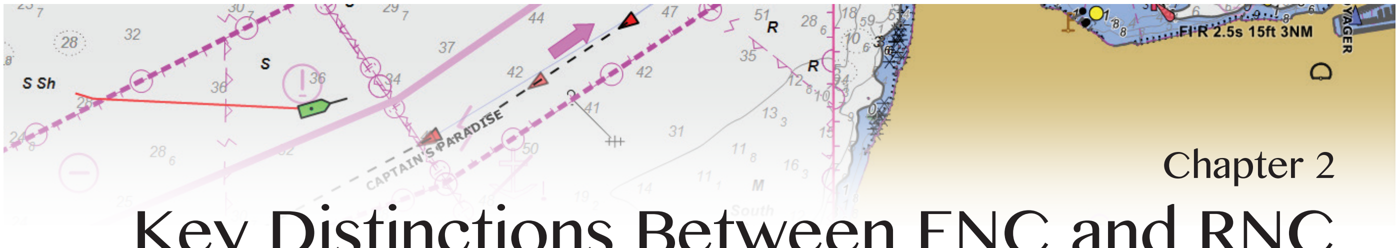


Figure 1.8-2.*Newport Beach ENC over a satellite image with transparency control. The topo map base is also very useful for understanding some charts. The transparency level of the ENC can be varied for the overlay.*



Chapter 2

Key Distinctions Between ENC and RNC

2.1 Introduction

We have already covered several generic differences between raster navigational charts (RNCs) and the corresponding electronic navigational charts (ENCs), such as file sizes, nomenclature and boundaries, obtaining crucial content by cursor pick, and their respective places in nautical chart evolution. In this chapter we look into details that affect our usage of ENCs, focusing on the changes RNC users face when transitioning to ENC usage.

One notable difference is when ENCs are zoomed, only the land and water areas change size. Individual chart symbols stay the same size, specified in the S-52 standard (see Figure 2.1-1). This can appear counterintuitive to RNC users at first, but it becomes more understandable with practice. This feature leads to a cleaner display of a congested region of a chart when zoomed, but it remains the user's obligation to keep in mind the limitations of over-zooming discussed later.

The primary philosophical difference between RNCs and ENCs is the variability of ENC appearance. That they are notably different looking charts to begin with is not so much a challenge as the fact that the appearance of any one ENC can change. We are accustomed to the invariance of RNCs. They pretty much look the same from one to the other, and any one of them never changes as we use it. This has been the policy in nautical charting for a hundred years. ENCs, on the other hand, purport the virtue of user customization of the chart display, and we look at these options in following sections.

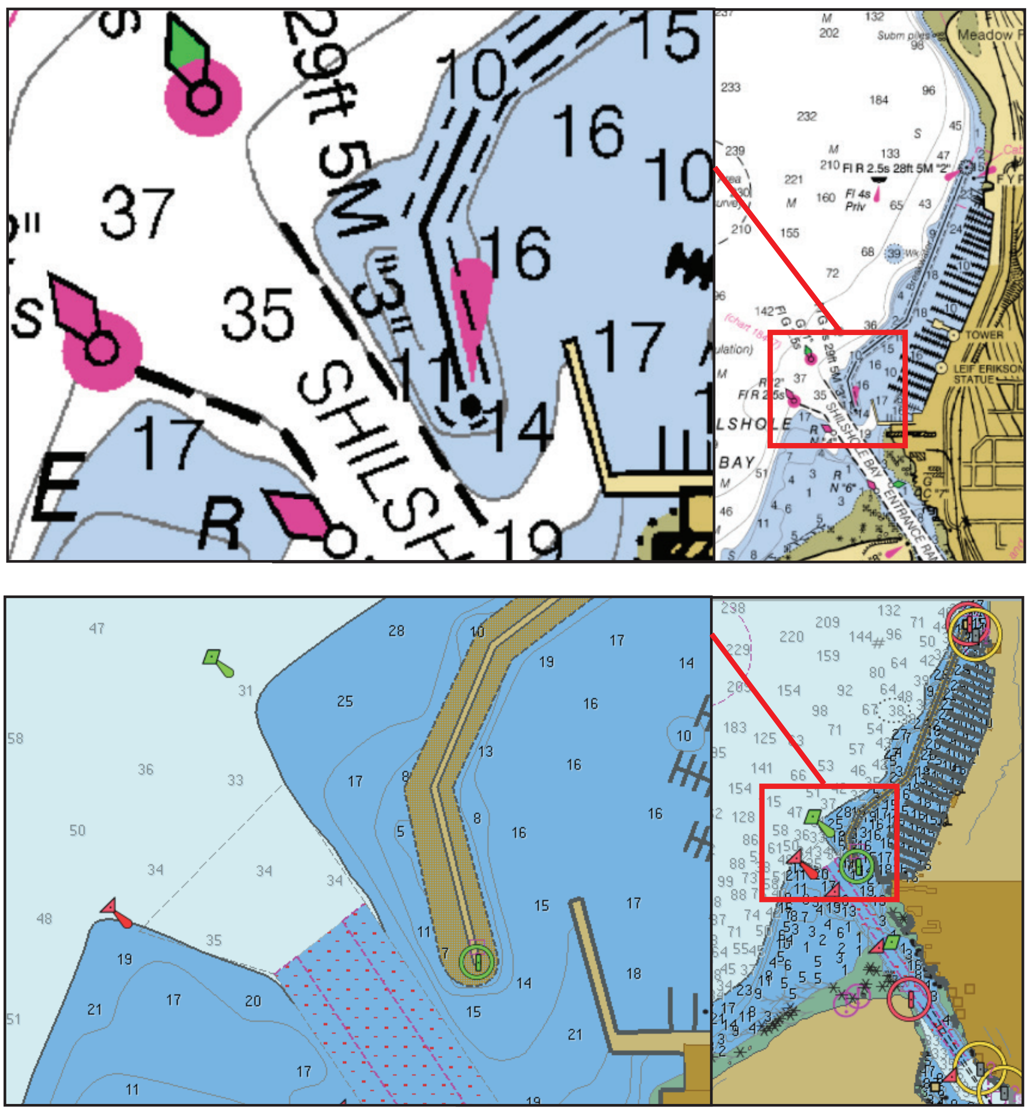


Figure 2.1-1. *Right side shows1:25,000 chart segments viewed at x1; on the left, each is zoomed to x6. Top is an RNC; bottom is the same chart as ENC. Symbol and text sizes do not change in the ENC.*

The most conspicuous content difference between RNC and ENC is absence of terrain detail on an ENC, which (at present) rarely contain elevation contours, roads, and other structures on the land part of the charts. This issue is addressed in Section 2.10. It is an example of the value of having both RNC and ENC formats installed.

2.2 Optional Display Modes

Both RNCs and ENCs offer color palette options for daylight, dusk, and night viewing, and the changes among the palettes are similar for both types of charts. What is unique to the ENC is a broad array of display options that affect how the chart appears on the screen. Many of these are user controlled, others occur automatically in various display configurations. These display variations are outlined here, with reference to subsequent sections for details on the more consequential options.

To accommodate these options, ECS programs implement some form of the ECDIS requirement of having a *Standard display mode* that can be considered the default (or minimum) combination of settings intended as the starting point for chart viewing. Added to that is a *Base display mode* that turns off many of the Standard options for a truly basic view of the chart, which is usually not adequate on its own for general navigation. In the other direction is the *Custom display mode*, sometimes called *Other* or *All*, which turns on (or gives access to) all of the displayable objects within the ENC. The full Custom display is also not often the best choice for general navigation as the chart will be too cluttered. Figure 2.2 -1 shows samples of these three modes.

The intention of the design is the user starts with one of these modes and then turns objects on or off to create a chart display that best meets the needs at hand. This can be a dynamic process, in that you might change the display as you meet changing conditions—or you might find a combination of settings that meet your needs most of the time and then rarely need to change this.

Besides selecting the underlying display mode from the three choices—which is equivalent to selecting a specific subset of objects from the display All option—you can do further quick display adjustments with several toggle (on/off) controls. This toggle option for specific controls is an ECDIS requirement that is met on varying levels by all ECS. For example, regardless of the choice Base, Standard, or All, you can with one click turn soundings on or off; hide text information in several categories; and hide or show various boundaries, light labels, and buoy labels. There is also usually an option to turn on enhanced sector light displays discussed in Section 2.9. The choices offered (and how they are described and implemented) depend on the ECS manufacturer.

Two additional display controls are also available in all ECS programs, namely the option of showing boundary lines as plain lines or symbolized in a way that indicates the meaning of the lines—albeit using a complex coding system—and there is an even more notable option mentioned earlier of using *simplified symbols* versus *paper chart symbols*. Choosing plain boundaries cleans up the chart view notably, but a change of symbols style can be a more significant change to many users. Chapter 4 shows how each of the symbols appear in each style. Examples are also in Section 2.9 on Lights.

The appearance of the water colors and selection of defined depth contours can also be changed by the user in consequential ways. These are covered in Section 2.4. The choice of these depth settings also changes how hazard symbols (rocks, wrecks, obstructions) appear, depending on their individual soundings. Their standard symbols will be automatically replaced with an *isolated danger symbol* whenever their soundings are shallower than the user selected safety depth (also covered in Section 2.4).

There is another unique aspect of ENC display with no counterpart at all in RNCs, namely many objects on the ENC have a *scale minimum* attribute (SCAMIN) that determines which view scales they will be shown on. This is again motivated to provide users with the cleanest possible chart display consistent with safe navigation. This is an

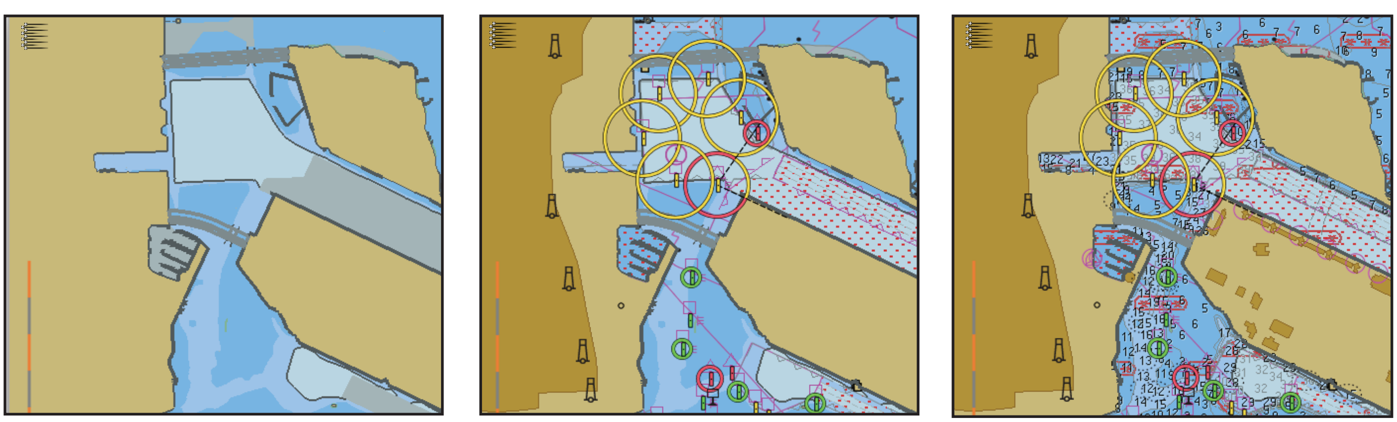


Figure 2.2-1. *Base (left), Standard (center), and All (right) display modes as presented in one particular ECS.*

Table 2.2-1. ENC Display Variations
User Controlled
• Underlying configuration
Base, Standard, or All
• Depth contours and colors
Shallow, Safety, and Deep
Two colors or four colors
• Boundary lines
Plain or Symbolized
• Symbols style
Simplified or Paper Chart
• Toggle on/off
Soundings
Chart text (several categories)
Light and buoy labels
Enhanced sector-light display
Cable areas
Plus others... (ECS dependent)
Automated changes
• Active chart in view
Depends on scale and ECS policy
• Hiding of symbols
Depends on scale and ENC specs
• Isolated danger symbols
Depends on user-set Safety Contour

automatic change in the display; the attribute is built into the ENC. The end effect is when you zoom out on a region, some objects will disappear. This feature is discussed in Section 2.3.

Table 2.2-1 summarizes the principle ways a user can change the appearance of the chart, plus automated changes the user does not control. The active chart issue included there is discussed in Section 2.3.

Although not related to the charts themselves, there is a significant user interface choice presented by many ECS programs when they implement some form of the ECDIS requirement of providing both a *navigation mode* versus a *planning mode* in the user interface to the chart display. The goal is to have a navigation mode that is restricted to the simplest possible display for safe navigation, usually forced to full-screen display. Thus, route planning or a study of various derived navigation parameters would be done in the planning mode, which allows about any screen configuration the navigator might choose, in contrast to the navigation mode that is restricted to a simple display that should be less confusing when navigating—usually with larger digits for the numerical data that can be seen some distance away from the screen.

Again, this ECS program interface choice does not affect the chart display itself, and typically the user can switch back to the planning mode for actual navigation if the "navigation mode" does not meet their needs. Screen configurations and typical digital display options for navigation are discussed in Chapter 3.

2.3 Chart Scales

Categories of ENC chart scales (usage bands) were discussed in Section 1.6, and unlike paper charts or RNCs, we know the scale range of an ENC from the name of the chart cell, which is indeed helpful. The physical interpretation of chart scale on paper charts is easy to understand, in that a scale of 1:40,000 means 1 inch on the chart is the same as 40,000 inches on the land or water charted.

This is a more nuanced concept when it comes to electronic charts (RNC or ENC) where we can change the scale with zoom tools. There is no longer an invariant proportion that describes the chart we are looking at. One inch on the screen could be 100 yards or 10 miles, depending on the zoom level of the chart. Thus we end up with two scales to keep in mind: one, the native scale of the electronic chart (called its *compilation scale*), and two, the *view scale* we have selected at the moment.

All ECS programs display the present view scale that applies to the full screen, which could be composed of just one ENC cell or several. If the full screen is just one cell, we can think of a "zoom factor" in the usual way. A chart with compilation scale of 1:20,000 viewed at a scale of 1:10,000 would be a zoom factor of x2.0; viewed at 1:40,000, it would be x0.5—we can never avoid the confusion that small scales are large numbers, because they are thought of as fractions!

The view scale can almost always be changed with plus or minus keys, but how that works depends on the ECS. Some have a fixed list of scale options and the keys go up and down that list. In others, the keys are a fixed zoom step, such as x2.0 per key stroke; in some ECS, adding a second key reduces the size of the steps, offering an almost continuous variation of view scales. Those with a fixed list of scale options often have a drop down menu to go to specific scales. Scale display and its control varies notably from one ECS to the next.

A good way to study your own system is to turn off chart quilting and turn on chart outlines, so you can home in one specific chart at a time, to practice changing zoom levels

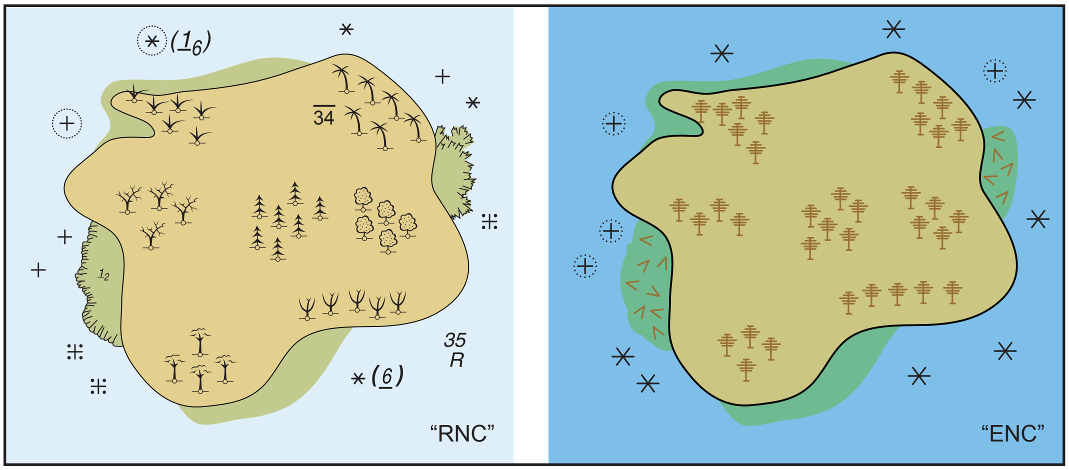


Figure 2.6-2. *Rock and terrain symbols are greatly simplified on ENC charts. Left is a hypothetical RNC (paper chart, INT 1); right is the corresponding ENC. The six or so INT 1 rock symbols used on paper charts are covered in ENC with just two symbols, with detailed attributes found by cursor pick. Likewise the attractive but challenging INT 1 trees notation is replaced with a generic tree and a cursor pick. Using ENCs, navigation schools will have to forgo tricky test questions distinguishing INT 1 coral from rocks, as these two are a single generic symbol on ENC. Click the symbol to find out which. (We leave it as an exercise to decide which is coral and which is rocks in the RNC.)*

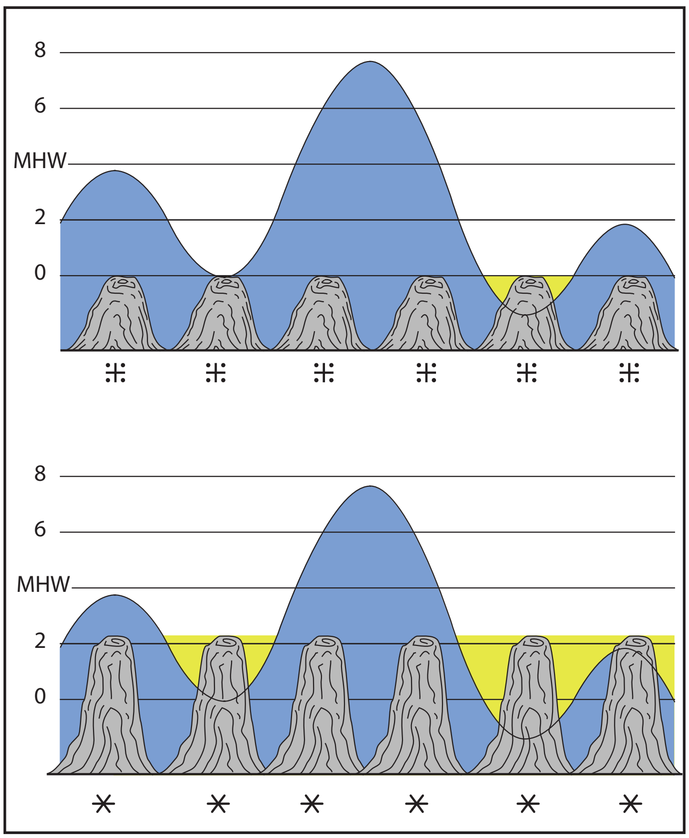


Figure 2.6-3. *An aside to recall why the rock awash had its own symbol in the days of paper charts! Top is a rock awash at chart sounding datum (i.e., tide equals zero), with its corresponding unique paper chart symbol. Bottom is a rock which covers and uncovers; ENCs use the same symbol (an asterisk) for both types of rock. Yellow marks the time span of the tidal cycle during which each is uncovered, to emphasize the greater hazard of the rock with zero or near zero sounding.*

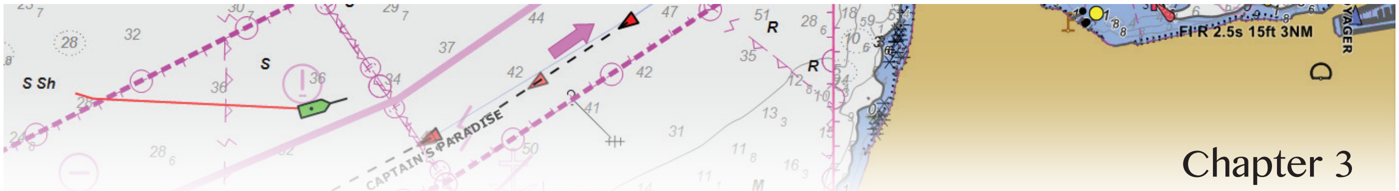
The use and meaning of rock symbols on ENCs are not the same as they are on paper charts. We have gone from seeing some 6 or 7 "rock symbols" that tell us much about the rock from the symbol alone, to seeing just two different rock symbols on an ENC, some of which may not show at all—being replaced by an isolated danger symbol as noted earlier.

Thus we come back to the primary new approach to chart reading when using ENCs; cursor-picking any object we want to know about. This is especially crucial for rocks. ENC rock symbols alone do not convey detailed information.

This change in chart reading practice required when using ENCs can be a challenge, depending on individual experience. Having used paper charts for 30 years, my initial attitude toward these simplifications of the symbols, and rock symbology in particular, was negative, and I was not timid in complaining about it. However, the more I have used ENCs and studied the goals of the IHO in their "new" system (it is actually some 10 years old at this point!), I have changed my opinion on this.

Although we might miss our traditional symbols, there is much virtue in not having to learn all the nuances of the traditional rock symbols in the first place. In fact, many mariners who did not need to know these details to pass a navigation exam may not have been aware of all the information contained in the paper chart symbols. It is not even that transparent when searching *U.S. Chart No. 1,* the official source for paper chart symbols. Part of Section K on rocks is shown in Figure 2.6-1

Note on Terminology
The IHO definition (S-32) of "rock awash" is a rock that is awash at tide height equals zero, whereas the *Bowditch* definition of "rock awash" is a rock that is awash at *any* tide height between zero and MHW. This can be helpful to recall when an ENC pick report describes "Water level affect = awash."



Chapter 3

Electronic Chart Navigation Underway

3.1 Basic Features and Operations

This chapter discusses some basic procedures that can contribute to safe, efficient navigation using electronic charts. Details and some important background are left to other navigation texts and courses which we have listed in the References. Our focus is on small-craft navigators who are new to electronic charting, but the fundamental procedures are much the same for any vessel. And even though this book is primarily devoted to use of ENCs, for those new to *all* electronic charting it could be best to start with RNCs when first learning to use your chosen ECS. Doing so allows you to concentrate on the tools of the navigation program while using familiar charts. Then later you can take advantage of the benefits ENCs can add to the navigation.

We start with a list of basic features and operations that most ECS programs include, and then discuss how these are used in planning and underway.

• It is crucial to master the loading of new charts into your ECS. Study and practice the process, including auto-update procedures if included, and recall that the auto-update function on some ECS programs only applies to full regions and not individually installed charts. Practice changing between RNCs and ENCs.

• Practice with quilted versus not-quilted chart display. The behavior can differ in RNCs and ENCs. A not-quilted chart shows only one full chart at a time. Some not-quilted displays show paper chart border notes; others show the single chart clipped at the chart area as in Figure 3.1-1. The quilted display shows adjacent charts matched at the boundaries as best can be done. Quilted generally works best, but there are exceptions. Note how displays can change at the border of two quilted charts. Check for options on how adjacent quilted charts with different scales are presented.

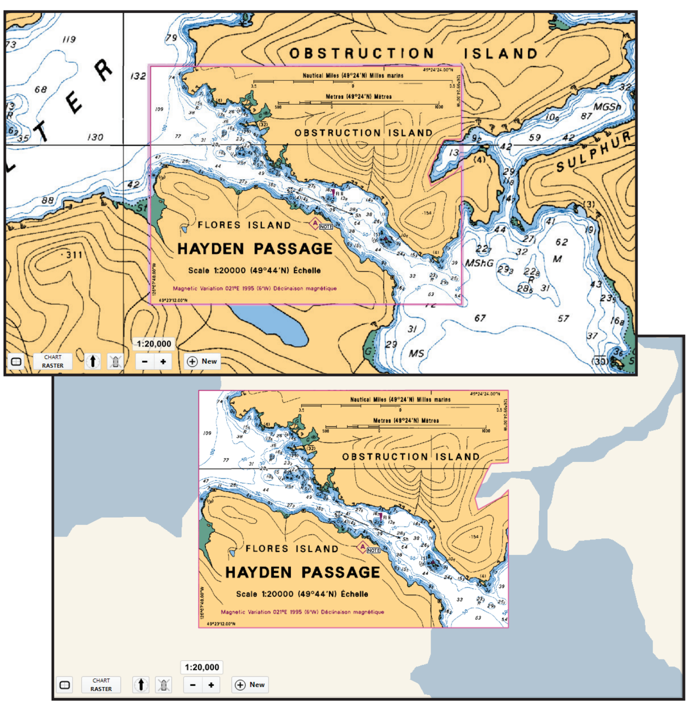


Figure 3.1-1. *Top: Section of Canadian chart 3674 (1:40,000) with a quilted insert of 1:20,000 and chart outlines turned on. Bottom: The not-quilted display of the insert.*

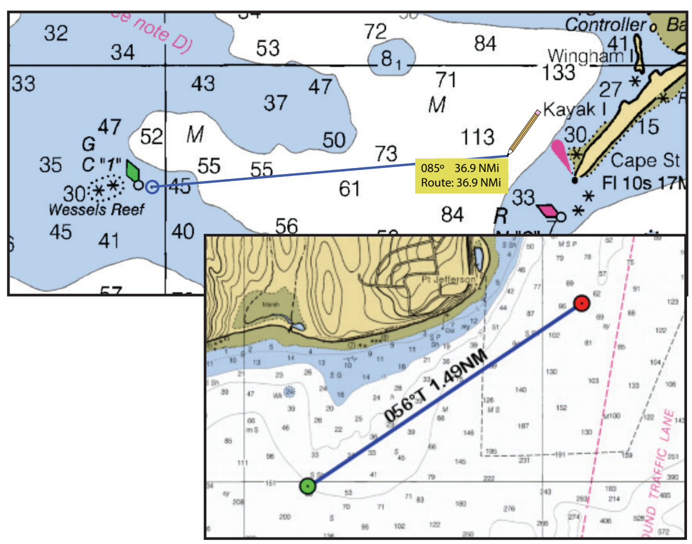


Figure 3.1-2. *Measuring or Range and Bearing tool. Top example is activated by the M key. When an ECS does not offer a specific range and bearing tool, we can always use the new-route tool, which in some cases is preferred as it leaves the data on the screen. Bottom is an example uses the route tool for this type of measurement.*

• Practice measuring range and bearing between two points. Most ECS programs have the option to also measure these from boat to object. We use both tools frequently underway and they are usually two different tools. See Figure 3.1-2.

• Practice setting range rings on marks, waypoints, and the vessel icon itself. There are typically options for the number of rings and the spacing between them. This function has many applications.

• Cursor control in general, and chart zoom and pan control in particular, are fundamental operations. Be sure these are well understood and practiced. In some programs, the mouse works more dependably than a track pad, which means having a place for a mouse on the boat. Also the quality of the mouse itself can affect its operation. Zooming and panning with key strokes might prove to be the safest and most dependable approach underway, so practice with these is valuable, even in light of more convenient mouse control. Learn which, if any, combination of keys can alter the zoom level. A [+] key , for example, could zoom by a factor of 0.2, while [Ctrl] [+] could be a factor of 2 increase. To observe these changes, practice watching the ENC scale bars described in Section 2.7.

• Setting up custom digital data display windows is fundamental to efficient navigation underway. All ECS programs offer options for setting up and saving multiple custom windows for use in different circumstances. The process is more transparent in some systems than others.

• Creating and manipulating user assigned marks and waypoints, and combining these into routes is the backbone of electronic charting. Procedures for setting these up is also one of the things that can differ the most from one ECS to another. Practice is the only solution, including editing by adding or removing points from the middle or ends of the route, reversing the route, hiding or showing marks or routes, and how they are stored or exported, are all key actions that will be done on a daily basis.

• Find the menus that let you do things like change units, and go from Magnetic to True directions. When using Magnetic, it is crucial to check if there is a manual versus automatic setting. The ECS can compute your variation based on the date and your location, but some programs offer the option to enter the variation yourself. When doing that, you have locked in that variation, and if this is done by accident on a long voyage over a notable variation change, you can end up with serious navigation errors. I know of several cases where this threatened the safety of unsuspecting mariners at the end of an ocean passage. It is worth checking once, and setting to automatic.

On ENC cursor pick reports of the variation, the labels E and W are not used. East variation is positive and West variation is negative. (The adage "correcting add east" might serve as a reminder.)

• Remember computer screens can be hard to read in bright sunlight. Practice with a laptop outside in the sunlight to be reminded of this!

3.2 Waypoints and Routes

Using a route made up of a sequence of waypoints is fundamental to navigation. If we are not sailing a route, we are not navigating; we are just out sailing. We may have to deviate from a route without actually changing it, but we must have a route in mind and in the program.

The basic procedure of navigation is to display the course line to the next waypoint, head the boat in that direction, and get underway. Then we monitor the track of the vessel (a bread-crumb trail of past positions) relative to the course line between the last and next waypoint. Our job is to choose the waypoints carefully and then stay on that line, or understand very clearly what we are doing when we leave the line—which we must of course do when tacking under sail. That course line is our guide line to the next waypoint. If the wind or other conditions change, then we can change the waypoints, using as much thought at that stage as when they were first selected.

Sailing in open waters, the route is often just a guide, but we still need it to remain aware of our location relative to the best route we chose earlier. In dangerous waters under power, it can be critical to stay right on the line, zooming in on the screen to detect the first deviation from the course line, and which direction it is in. A visual picture of our actual track deviating from the course line is often a better way to monitor this than just noting differences between COG and the bearing to the next waypoint, or watching a cross track error (XTE) output.

Setting up waypoints is most easily done in stages. First we roughly plot out the general route on a small scale chart showing all or most of the voyage, then we zoom in on a large scale chart to fine-tune the locations. This will entail moving some waypoints and adding others—occasionally using the range and bearing tool to check passing clearances. We obviously want waypoints at each place we change course, but it often helps to add to these with other marks along the route that help monitor progress or to mark specific hazards. Whenever possible, it is best to choose waypoints near some landmark or ATON that is conspicuous, either visually or by radar.

Naming the waypoints is more important than we might guess. Each waypoint name should start with a number, including leading zeros to match the full run in that route. With 15 waypoints, use 01, 02, etc., so that they will sort properly when we transfer them to other devices—or load them into a spreadsheet for archiving or later analysis. Then add a descriptive name to every waypoint. The numbers alone are not enough for safe organization of the route. A sample is shown in Figure 3.2-1.

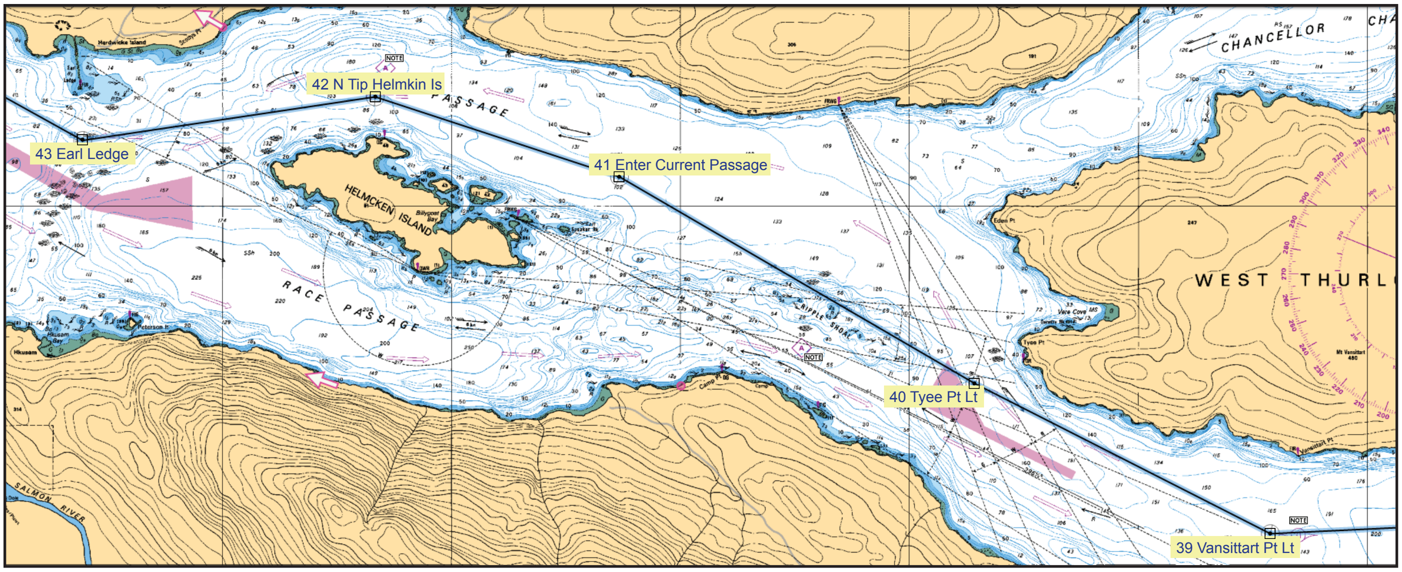


Figure 3.2-1. *Section of a route of waypoints, showing labels with numbers and names.*

Once each waypoint along the route has been named and double-checked as safe and optimum, the waypoint should be locked (an ECS option) so it cannot be moved by mistake.

3.3 Print the Route Plan

Most ECS programs include an option to print out a table of the waypoints that includes not just the name and coordinates of the waypoints, but also the course and distance of each leg of the route. Many include an input for the anticipated speed made good (SMG), and with that, the run time along each leg can be included in the table. With a known departure time, the anticipated clock times at each waypoint can be included. See Figure 3.3-1. Several ECS programs include with this a customized chart image showing the route as well.

These route plans can be printed in the conventional sense (on paper) or they can be printed to a PDF file, which in turn can be transfered to various other computers or mobile devices, including cellphones. The route plan in hand serves as more than a back up; it offers an easy way for multiple users to keep track of the route and look ahead without having to engage the main navigation computer.

3.4 Backup Routes in Mobile Devices

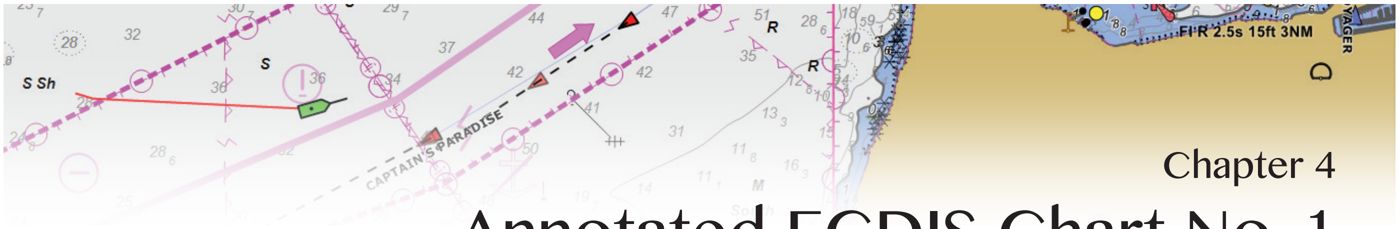
A route plan is a form of backup if the route happens to get corrupted in the main computer, or if the main computer itself has to be replaced. But it would be tedious and slow to enter it all back into the system by hand from a printed list.

A better approach is to export the route in a format that can be directly input to another computer or mobile device. The virtue of having your main navigation route

Victoria to Ketchikan Full
Depart: 2016-06-26 11:00 Total distance: 587.728 nm Total Time: 4 days 1 hour 58 mins ETA: Jun 30 12:58

Leg to	Bearing	Distance	Total	Speed	ETA	TTG	Turn	End Position	Notes
38 Ripple Pt Lt.	303.9° T 286.9° M	2.182 nm	164.895 nm	6.00 kn	Jun 27 14:29	22 mins	36° to port	50°22.485'N 125°34.582'W	
39 Vansittart Pt Lt	267.3° T 250.2° M	6.560 nm	171.455 nm	6.00 kn	Jun 27 15:34	1 hour 6 mins	29° to starboard	50°22.175'N 125°44.856'W	
40 Tyee Pt Lt	297.0° T 279.9° M	1.846 nm	173.301 nm	6.00 kn	Jun 27 15:53	18 mins	3° to starboard	50°23.012'N 125°47.435'W	
41 Enter Current Passage	300.3° T 283.1° M	2.288 nm	175.589 nm	6.00 kn	Jun 27 16:16	23 mins	12° to port	50°24.165'N 125°50.536'W	
42 N tip Helmkin Is	288.2° T 271.0° M	1.430 nm	177.019 nm	6.00 kn	Jun 27 16:30	14 mins	26° to port	50°24.611'N 125°52.668'W	
43 Earl Ledge	261.5° T 244.4° M	1.645 nm	178.664 nm	6.00 kn	Jun 27 16:46	16 mins	37° to starboard	50°24.368'N 125°55.221'W	
44 Hickey Pt Lt	299.1° T 281.9° M	6.835 nm	185.499 nm	6.00 kn	Jun 27 17:55	1 hour 8 mins	17° to port	50°27.689'N 126°04.600'W	
45 Havannah Channel	282.1° T 264.9° M	10.823 ...	196.322 nm	6.00 kn	Jun 27 19:43	1 hour 48 mins	7° to port	50°29.950'N 126°21.233'W	
46 Swaine Pt Lt	274.2° T 257.0° M	8.692 nm	205.014 nm	6.00 kn	Jun 27 21:10	1 hour 27 mins	13° to starboard	50°30.593'N 126°34.862'W	
47 Blinkhorn Lt	288.2° T 271.0° M	7.895 nm	212.909 nm	6.00 kn	Jun 27 22:29	1 hour 19 mins	5° to port	50°33.058'N 126°46.661'W	
48 S Tip Cormorant Is	282.9° T 265.6° M	5.265 nm	218.174 nm	6.00 kn	Jun 27 23:22	53 mins	14° to starboard	50°34.230'N 126°54.740'W	
49 Alert Rk Lt	297.4° T 280.2° M	1.769 nm	219.943 nm	6.00 kn	Jun 27 23:39	18 mins	14° to port	50°35.045'N 126°57.212'W	

Figure 3.3-1. *Section of a route plan. There are many variations of these among ECS programs. They can be printed or exported to a spreadsheet for customizing the display. An average SMG can be used for time estimates, or make several route plans with different SMGs. These can also be updated along the voyage.*



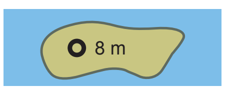
Chapter 4

Annotated ECDIS Chart No. 1

Introduction

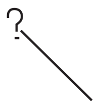
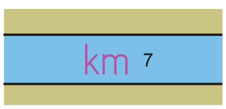
This chapter of the book is essentially a reproduction of the ECDIS part of *U.S. Chart No. 1*, which we have abbreviated in some cases and reformatted. We have then added annotations to clarify some symbols and provided cross references to sections in the text where appropriate. To distinguish what we have added from the original text of *U.S. Chart No. 1*, our annotations appear in *[square brackets, using blue italic font]*.

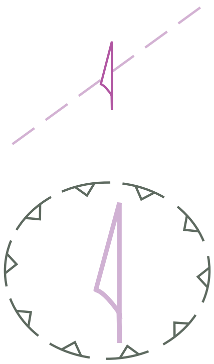
Columns in the body of the Chapter have this format:

Category and symbol	Short description	Paper Chart Equivalent
	Land as a point at small scale	K 10
	Land as an area, with an elevation or control point	K 10
	Rock which covers and uncovers or is awash at low water	K 11, K 12

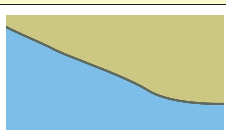
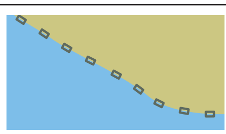
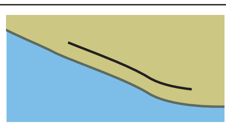
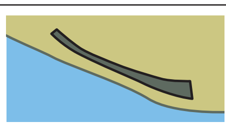
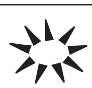
The paper chart equivalents refer to the International Symbols (INT 1) listed in *U.S. Chart No. 1*. When there are multiple references given it means the ECDIS symbol has multiple meanings, as many do. As stressed throughout, a cursor pick is the key to learning the meaning of individual symbols, lines, and areas. Click everything! The main reference for our annotations is IHO S-52 Presentation Library, version 3.4, with awareness of proposed changes in version 4.0 planned to be in effect Sept 1, 2017.

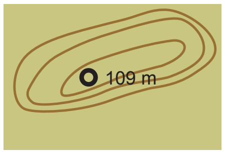
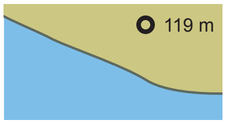
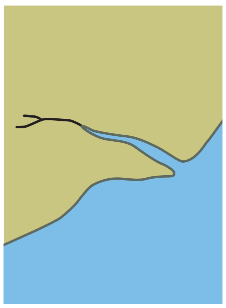
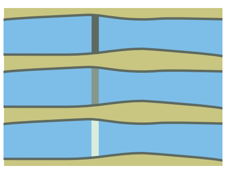
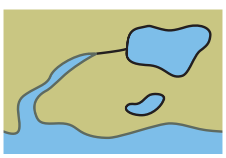
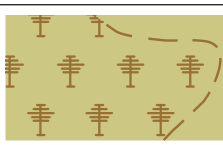
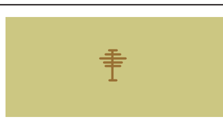
B. Positions, Distances, Directions, Compass

Geographical Positions		
PA	Position approximate	B 7
	Point feature or area of low accuracy	B 7, B 8
	Sounding of low accuracy	B 7, B 8
Control Points		
	Position of an elevation or control point	B 20-24
	Canal and distance point with no mark *[Unmarked distance point along a canal.]*	B 25.1
	Canal and distance point *[Visible distance mark along a canal.]*	B 25.2
Note: ECDIS uses a magenta "km" symbol to represent distance marks. However, the distances shown along waterways on NOAA-produced ENCs are displayed in statute miles. [Rivers, Great Lakes, Intracoastal]		
Symbolized Positions (Examples)		
ECDIS follows the paper chart convention for the position of symbols, except for simplified symbols for buoys and beacons (see Q 1).		B 30, B 31
	Position of a point feature *[Brown when non-conspicuous.]*	B 32
ECDIS indicates approximate position only for wrecks, obstructions, islets and shoreline features.		B 33
Magnetic Compass *[See Section 2.13.]*		
Varn	Magnetic Variation	B 60
	Cursor pick site for magnetic variation at a point	B 68.1, B70

	Cursor pick site for magnetic variation over an area	B 68.1
	Cursor pick site for magnetic variation along a line *[Example shown is 3º West. West is negative; East is positive.]*	B 71
	Cursor pick site for magnetic anomaly along a line or over an area	B 82.1, B 82.2

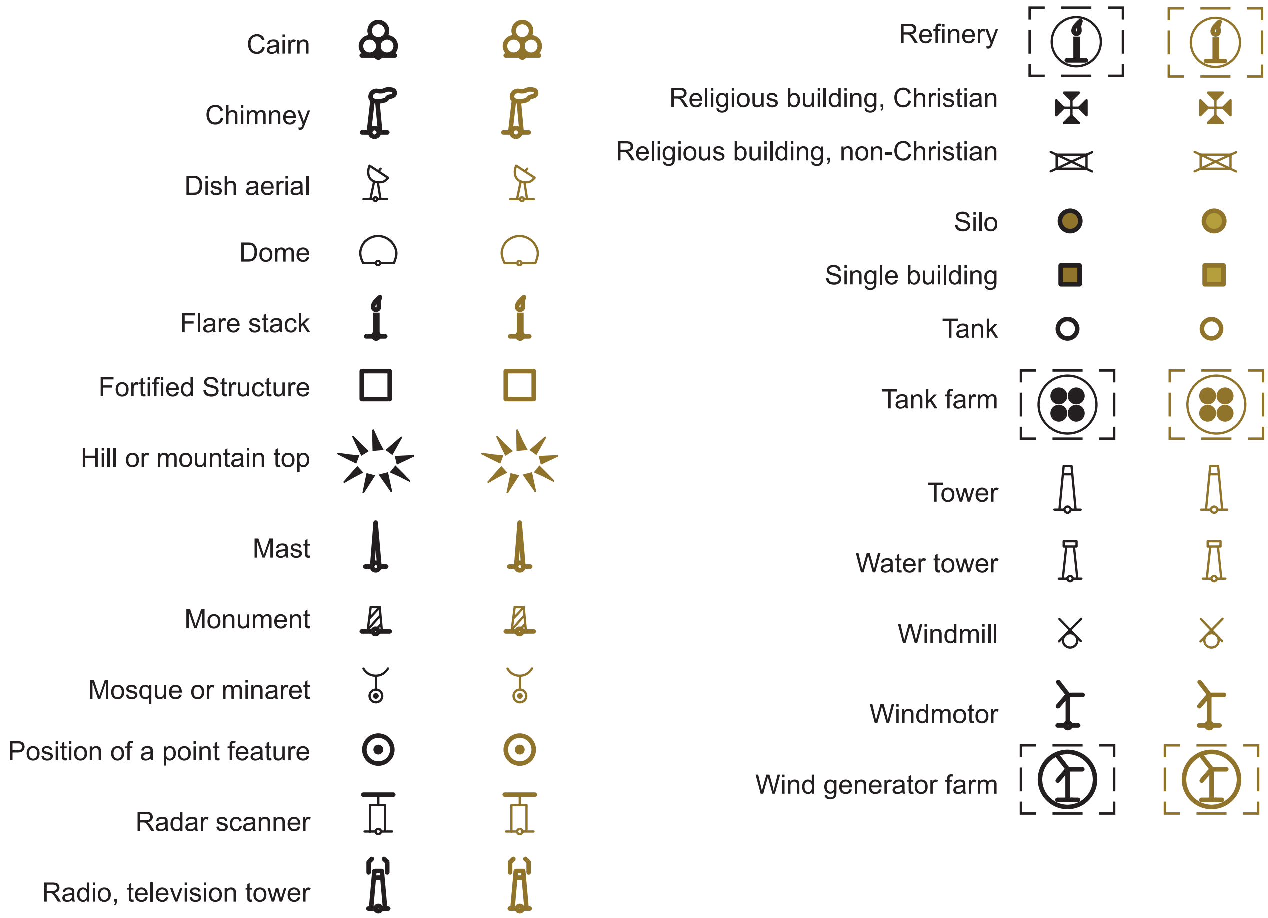
C. Natural Features

Coastline *[See Section 2.10.]*		
	Coastline *[Nature of coastline (cliffs, etc.) is obtained by cursor pick.]*	C 1
	Coastline or shoreline construction of low accuracy in position *[Does not show if accuracy not encoded.]*	C 2
	Sloping ground crest line distant from coastline, radar or visually conspicuous	C 3
	Cliff as an area *[There are more cliff symbols in RNC than ENC.]*	C 3
	Conspicuous hill or mountain top *[Brown when non-conspicuous.]*	C 4, C 8

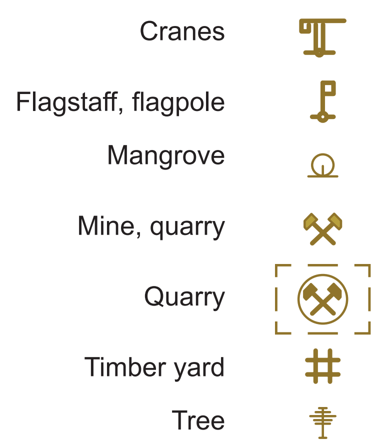
Relief *[See Section 2.10]*		
	Elevation contour with spot height, contour value is obtained by cursor pick *[Many ENCs do not show elevation contours that are depicted on the corresponding RNCs.]*	C 10, C 12-13
	Position of an elevation or control point	C 11
Water Features, Lava		
	River	C 20, C 21
	Rapids Waterfall Waterfall, visually conspicuous	C 22
	Lake *[See Section 2.10.]*	C 23
	Continuous pattern for an ice area (glacier, etc.)	C 25
Vegetation *[See Section 2.6, 2.10.]*		
	Line of trees	C 30, C 31.2, C 31.3
	Wooded area	C 30, C 31.5-8
	Tree *[Height of a tree is sometimes available via cursor pick.]*	C 31.1, C 31.2

ECDIS Conspicuous and Non-Conspicuous Features

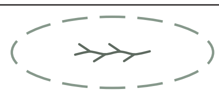
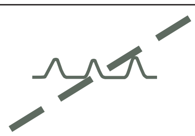
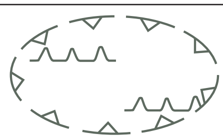
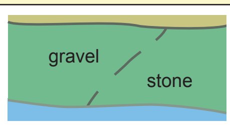
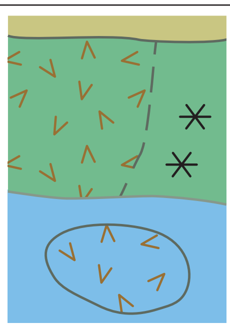
There are 25 features for which ECDIS displays either a black symbol, if the feature is visually conspicuous, or a brown symbol if is not. Only conspicuous landmarks are depicted on NOAA paper charts and ENCs. Therefore, only the conspicuous symbol versions are shown in the symbol tables of U.S. Chart No. 1. Both versions of the symbols for these features are shown on this page. *[These colors are sometimes difficult to distinguish, depending on the ECS.]*



These seven symbols represent features that only have a brown symbol. There is no corresponding black, conspicuous symbol. The brown symbol is displayed regardless of the conspicuousness of the feature.

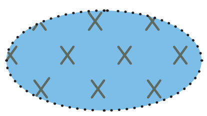
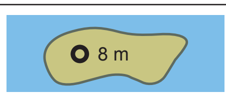
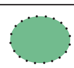
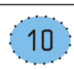
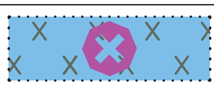
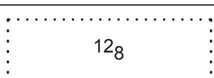
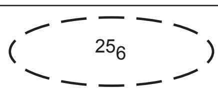


J. Nature of the Seabed

Types of Seabed		
S	Sand *[0.06 mm to 2 mm]*	J 1
M	Mud	J 2
Cy	Clay	J 3
Si	Silt	J 4
St	Stones	J 5
G	Gravel *[2 mm to 4 mm (buckshot to marbles)]*	J 6
P	Pebbles *[4 mm to 64 mm (marbles to golf balls)]*	J 7
Cb	Cobbles *[64 mm to 256 mm (golf balls to soccer balls)]*	J 8
R	Rock	J 9.1
R	Boulder *[bigger than cobbles]*	J 9.2
R	Lava	J 9.2
Co	Coral	J 10
Sh	Shells	J 11
	Weed, kelp	J 13.1
	Weed, kelp as an area	J 13.2
	Sand waves as a point	J 14
	Sand waves as a line	J 14
	Sand waves as an area	J 14
	Spring	J 15
Types of Seabed, Intertidal Areas		
	Areas of gravel and stone *[See Types of Seabed.]*	J 20
	Rocky ledges or coral reef	J 21, J 22

K. Rocks, Wrecks, Obstructions, Aquaculture

[Key attributes of rocks and wrecks and obstructions are: water level effect and value of sounding.]

General *[See Section 2.5.]*		
	Obstruction, depth not stated	K 1, K 16, K 40, K 43
	Obstruction which covers and uncovers	K 1
	Underwater hazard with depth of 20 meters or less	K 1, K 14, K 26, K 41, K 43, K 46.1
	Isolated danger of depth less than the safety contour *[This is activated by safety contour, not safety depth.]*	K 1, K 11, K 12-14, K 16, K 26-28, K 30, K 40-43, K 46
	Foul area, not safe for navigation	K 1
	Swept sounding, less than or equal to safety depth	K 2
	Swept sounding, greater than safety depth	K 2
Rocks *[See Section 2.6.]*		
	Land as a point at small scale	K 10
	Land as an area, with an elevation or control point	K 10
	Rock which covers and uncovers or is awash at low water	K 11, K 12
	Underwater hazard which covers and uncovers with drying height	K 11, K 12
	Underwater hazard which covers and uncovers	K 12
	Dangerous underwater rock of uncertain depth	K 13, K 16
	Underwater hazard with depth greater than 20 meters	K 14, K 15, K 26, K 30, K 41, K 46.2
	Underwater hazard with a depth of 20 meters or less	K 15,
	Safe clearance shoaler than safety contour***	K 16, K 40, K 46.1, K 46.2
	Safe clearance deeper than safety contour	K 16
	Safe clearance deeper than 20 meters	K 16, K 46.2
	Overfalls, tide rips; eddies; breakwaters as a point	K 17
	Overfalls, tide rips; eddies; breakwaters as a line	K 17

ECDIS Traditional (Paper Chart) and ECDIS Simplified Symbols

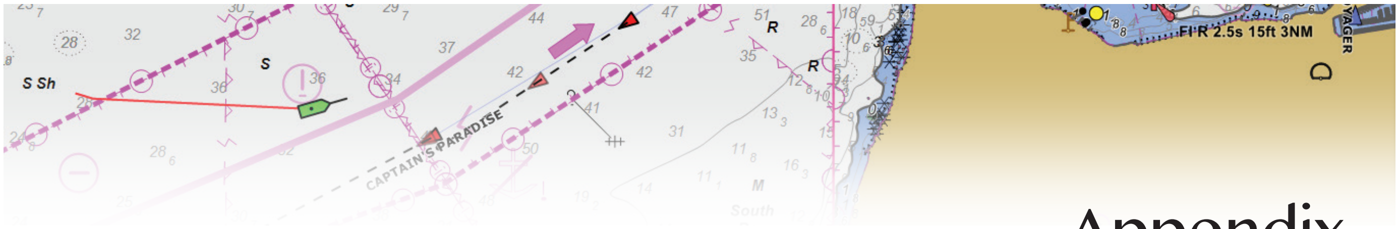
ECDIS can be set to display aids to navigation with either traditional paper chart symbols or what they call "simplified symbols." The two symbol sets are shown here. Some ECDIS color fill the paper chart buoy shapes, but this is not required by IHO ECDIS specifications.

[Simplified cardinal buoy symbols have an IHO specified outline thickness that is twice that of cardinal beacons, but individual ECS or ECDIS displays may not reflect this.]

[On both paper charts and ECDIS displays, floating objects are tilted, whereas fixed beacons are shown vertical—a convention that helps us interpret the symbols. Even the labels are tilted (italics) to support the convention.]

Floating Marks *[See Section 2.7.]*

Paper Chart	Simplified	Simplified Symbol name
*		Cardinal buoy, north
*		Cardinal buoy, east
*		Cardinal buoy, south
*		Cardinal buoy, west
?	?	Default symbol for buoy (used when no defining attributes have been encoded in the ENC)
*		Isolated danger buoy
		Conical lateral buoy, green
		Conical lateral buoy, red
		Can shape lateral buoy, green
		Can shape lateral buoy, red
		Installation buoy and mooring buoy
**		Safe water buoy
		Special purpose buoy, spherical or barrel shaped, or default symbol for special purpose buoy
		Special purpose TSS buoy marking the starboard side of the traffic lane
		Special purpose TSS buoy marking the port side of the traffic lane
		Special purpose ice buoy or spar or pillar shaped buoy
		Super-buoy ODAS & LANBY
		Light float
		Light vessel



Appendix

Appendix 1. Chart Accuracy and Overscaling

Chart accuracy is discussed in Section 2.4 and overscale (also called over-zoomed) is discussed in Section 2.3. This section illustrates these points. This is not a exact cartographic analysis, but just a way to get a feeling for the issue at hand, namely, overscaling can present a chart that appears more accurate than it is. We start by looking at a case where we know something is wrong.

Figure A1-1 shows the two adjacent ENC cells that are the only charts of the coastline shown. There is no ZOC accuracy data in either one, but referring to the RNC counterparts we learn from the source diagrams that the surveys of the narrow strip along the coast are category B3, dated 1940 to 1969. These data have larger uncertainties than modern surveys, and the discrepancies we see in Figure A1-2 are consistent with this. The mismatch could be even larger on other charts.

The point here is, over-zooming on these chart boundaries can illustrate this discrepancy in accuracy, whereas in other places it would not at all be obvious. Figure A1-3 and A1-4 show examples where we would want to take care in heeding the stated charting uncertainties.

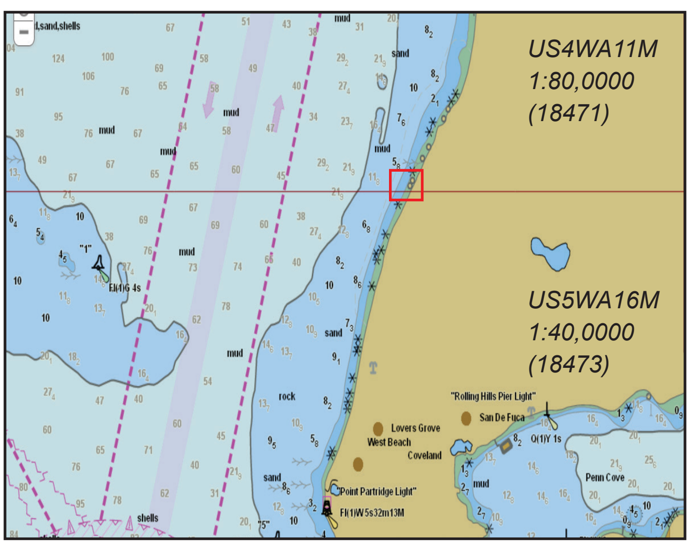


Figure A1-1. *Two adjacent ENC cells. The red box marks the area shown in Figure A1-2.*

Remember, however, that just because chart data has a stated uncertainty of some amount does not mean it is wrong by that amount. Indeed, position measurements in surveys of this "B3 period" were made by horizontal sextant piloting, which can be more accurate than what we might dependably assign to standard GPS (± 20 m). In fact, we will be amazed much more often by NOAA chart accuracy than by a lack of accuracy.

[GPS can be and often is remarkably better than noted above; this "standard" value accounts for situations with no differential corrections (DGPS) and considers the often unaccounted for location of the GPS antenna on the vessel, not to mention that high nearby terrain can limit signal quality. For a practical look at this, when tied up at the dock, turn on your GPS, set the tracking to plot your position every 30 seconds, and let it run overnight. Then zoom in on the results in the morning to see where all you have been and where you were most of the time.]

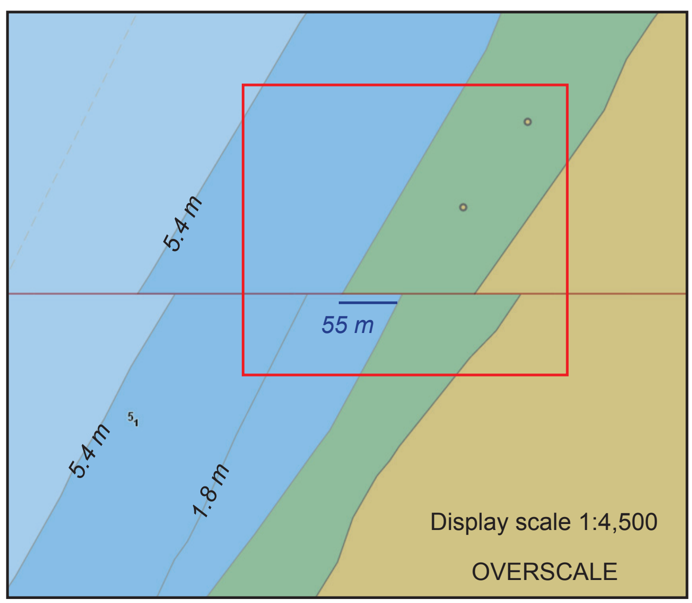


Figure A1-2. *A much overscaled view showing discontinuity at the boundary. The 55 m shown is consistent with the B3 survey shown on both of the RNCs. The top ENC does not include a 1.8 m contour, so that one just ends at the boundary..*

ATTRIBUTE	ACRONYM
Value of annual change in magnetic variation	VALACM
Value of depth contour	VALDCO
Value of local magnetic anomaly	VALLMA
Value of magnetic variation	VALMAG
Value of maximum range	VALMXR
Value of nominal range	VALNMR
Value of sounding	VALSOU
Vertical accuracy	VERACC
Vertical clearance	VERCLR
Vertical clearance, closed	VERCCL
Vertical clearance, open	VERCOP

ATTRIBUTE	ACRONYM
Vertical clearance, safe	VERCSA
Vertical datum	VERDAT
Vertical length	VERLEN
Water level effect	WATLEV
Information in national language	NINFOM
Object name in national language	NOBJNM
Pilot district in national language	NPLDST
Text string in national language	$NTXST
Textual description in national language	NTXTDS
Horizontal datum	HORDAT
Positional Accuracy	POSACC
Quality of position	QUAPOS

Appendix 5. Most Likely Position from 3 LOPs*

In several places in the book, the issue of checking the GPS position (or having to rely on other sources) has come up, as it would in any prudent discussion of navigation. Often we can get by with basic accuracy for these checks, but occasionally we want to do the very best we can. The fixes we can do on our own, however, are always some form of piloting, which means we are finding our position relative to other locations that we have to assume are correct.

Short of celestial navigation, which is limited to about ± 0.5 nmi in good conditions and therefore not often adequate for inland navigation, we cannot find our latitude and longitude independent of the chart we are working on. With trusted landmarks in sight, however, we can do very precise fixes relative to them by several means, competing or exceeding standard GPS accuracy. All high accuracy piloting boils down to interpreting the lines (or circles) of position we measured. Once we have more than two (which is required) they will not intersect in a single point, but rather they will form a triad of three intersections and our task is to interpret that triangle of intersections for the best fix. This is a standard navigation problem that has existed since the inception of charting.

The following solution is readily solved on paper or directly on the ECS screen using electronic plotting tools.

• • •

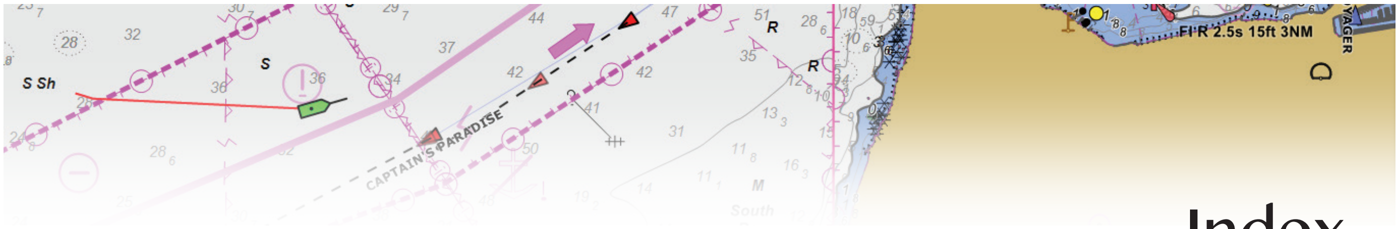
Practicing navigators tend to choose the best position within a triad of intersecting LOPs (cocked hat) as a centroid value of their choice, based on their experience and the actual sights at hand. In most cases this is an adequate solution, but in rare cases we might need to choose the very best location based on all that we know about the three LOPs. These can be celestial sights, or they could be three compass or gyro bearing lines. More to the point, they could be two bearings of standard accuracy and a range line (transit) that can be a very accurate LOP, or equivalently, one very good celestial sight and two that were not as good due to poor horizon or fewer sights in the sequence.

In short, if we are to apply more sophisticated analysis, we need to have enough extra data to justify it, which can be expressed as the individual uncertainties in each sight, called their variances.

It can be shown that if these variances are all the same (no one sight better than another), and there is no systematic error that applies to all of them, then the most likely position is located at what is called the symmedian point of the triangle, which is discussed at length at online math resources. It is frankly fairly tedious to graphically plot this point, but worth noting that it is *not* any of the common centroids we might have considered. This does not distract from the practical solution we usually use underway, because we are fine-tuning the analysis here, and assuming knowledge we do not always have.

Once you are convinced that the variances are not the same, then the symmedian point is no longer correct. For example, if one line (of a terrestrial fix) is a range, then that should bias the fix toward that line, and the other two compass bearings are effectively just showing where you are on that line.

We have developed a solution to the most likely position that accounts for variances in the LOPs that is relatively easy to evaluate by hand, and very easy to solve with a calculator or programmed function.



Index

An In-depth Look at Electronic Charting

There are two types of electronic charts: raster navigational charts (RNC) and electronic navigational charts (ENC). RNCs are exact copies of paper charts and their use underway comes naturally to navigators accustomed to paper charts.

ENCs (also called vector charts), on the other hand, include much more information than an RNC; they allow user-selected display options that enhance safety and efficiency; and they are easier to keep up to date. But they do not look like traditional charts, and they do not behave like traditional charts. Navigation with ENCs is fundamentally different from navigation with paper charts or RNCs.

This book is intended to explain the content and use of ENCs so that these important charts of the future become as familiar to navigators as their paper chart forerunners. Chapter 1 is an overview of electronic charting; Chapter 2 covers the distinctions between RNC and ENC; Chapter 3 reviews basic navigation practice adapted to electronic charts; and Chapter 4 presents a complete library of all electronic chart symbols, which differ in many respects from their paper chart counterparts.

Electronic charting benefits all mariners, professional and recreational, large vessels and small, power and sail, racing and cruising. The unique information in this book should help mariners in any of these categories master the use of ENCs to enhance their safety and performance underway. There are many virtues of vector charts, but to take advantage of these, a new approach to "reading charts" is called for. This book explains and illustrates the process.

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