NAVIGATION WORKBOOK

18465 Tr

For Power-driven and Sailing Vessels

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INTRODUCTION

Scope

These exercises are designed to help small-craft navigators hone their skills in both routine and special circumstances. They are practical exercises in chart reading and plotting, position fixing, dead reckoning, compass work, and the use of special publications such as Chart Catalogs, *Tide Tables*, *Current Tables*, *Light Lists*, Notices to Mariners, *Chart No. 1*, *Navigation Rules*, and *U.S. Coast Pilots*.

These exercises can be incorporated into an ongoing navigation course or used by individuals on their own. This book along with a text book of choice would then make up a self-study course. The chapters of this workbook correlate with those of the book *Inland and Coastal Navigation, 2nd edition* by David Burch, but other books can also provide the necessary background.

The level of these exercises is about that required in the USCG Masters license exam for 100 GT, which in turn is about the same as that used in coastal navigation certification exams from the U.S. Sailing Association, American Sailing Association, Royal Yachting Association, and the Canadian Yachting Association.

Chart 18465 Tr

The exercises in this book that require a chart use NOAA chart 18465 Tr, Strait of Juan de Fuca, Eastern Part. This is one of several NOAA training charts. This one is frozen in time to 1998, but is otherwise similar to the standard navigation chart of this region (No. 18465), which is updated weekly, as are all NOAA charts now that they are all Print on Demand (POD). For training exercises, it is best to use the training chart version 18465 Tr, so all details match the exercises.

The 18465 Tr is available at most NOAA chart dealers and from several online outlets (see Appendix A3.). This chart is used by many schools in the Pacific Northwest, but the basic navigation training does not depend on the specific chart used.

Except for this paper chart, which must be purchased separately, all other resource materials are provided in the Resources section, which includes excerpts for all publications needed.

You can also work the exercises with an electronic version of 18465 Tr, and for that solution we have an extended discussion in Appendix A1, which includes a source for the echart. We encourage mariners to solve the charting exercises using both paper charts and electronic charts. Also provided are a few tips on the use of ECS (electronic charting system) for solving navigation problems.

Terminology

All references to miles are nautical miles. Sometimes this is stated as miles other places as nmi. One nautical mile is about 6,000 ft. (Exact is 1 nmi = 1852m = (1852x100/2.54)/12 ft, which is about 6076.115 ft.)

General phrases like "north of" or "due east of," etc, always refer to true directions unless otherwise specified. Wind directions are labeled by the source of the wind, i.e. north wind flows from north to south, sea breeze blows from the sea toward the land. Wind waves and currents, on the other hand, are labeled with the true direction they flow toward. (Swells, as opposed to wind waves, are labeled by the direction they come from.)

Magnetic Variation

The magnetic variation on the 18465 Tr chart (frozen in 1998) covers magnetic variations that vary from 19.5° E to 19.75° E. To simplify the exercises, however, we use a fixed value of 20.0° E for all locations of the chart, and for all exercises.

Tides and Currents

Because the design of the NOAA *Tide Tables* and *Tidal Current Tables* have changed very little since the time of the 18465 Tr chart, we have chosen to keep the original versions we used in the first edition of this book. Tide and current data provided are from 1999. The procedures for using the newest tables are the same as with these older ones.

Tools of the Trade

These are the basic plotting tools used in marine navigation. There are many alternatives, but these are the most common by far, worldwide, on all vessels.

Dividers

Dividers are used to measure the distance between two points, and also to help align parallel rulers or plotters. There are several styles. Shown here is a type of "speed bow." You can interchange one of the points with a pencil lead for drawing circles of position or other arcs.

A "bow" is a tool that will hold its point separation once set, and it is set by a rotating knob in the center of the tool—as opposed to conventional dividers which are just pulled open or squeezed closed. A "speed bow" is one that you can pull open or close by hand without having to use the center knob. In other words, you can override the fine control of the center knob by firmly pulling or pushing on the legs themselves.

This particular model has become the dividers of choice for the vast majority of professional navigators worldwide because of its ease of use and accuracy. This economic model is called (appropriately) "ultra light dividers."

Parallel Rulers

This is a tool that lets you draw one line parallel to another, some distance away from it. To use it, align one edge of the rulers with the base line, and then holding down that side of the tool, move the other side to the location of the new line. If the new location cannot be reached in one step, then you walk the rulers across the page to the destination.

It takes a bit of practice to manipulate these without slipping, but after some practice it is quite easy. There are numerous styles and sizes of these. A simple design, in clear plastic with small cork anti-slip pads, 15 inches long is a popular and functional option.

Weems Plotter

An alternative to parallel rulers is a rolling tool called a parallel plotter, or more specifically, the Weems parallel plotter, named after its inventor. These are designed to roll without sliding, which they generally do fairly well, with little practice. Unfortunately, rolling plotters do not work well near the edges of charts or over folds in the chart. A solution is always also carry parallel rulers underway and use the Weems plotter whenever possible, but immediately switch to parallel rulers if need be. On a large chart table (or kitchen table) many navigators find this tool faster and easier to use than parallel rulers.

Triangles

The most accurate chart plotting is often done with two matching navigation triangles. They take a bit more practice to master, but the larger protractor scale and more positive positioning does enhance the accuracy. They are popular with professional mariners.

Three-Arm Protractor

Other applications are possible, but the main function of this tool is to plot a fix from two horizontal sextant angles, which is faster than the compass and ruler plotting.

For more Help

Check starpath.com/18456tr for news and resources related to this book as well as contact with the authors. Comments and suggestions will be much appreciated and addressed promptly. Training aids are available as well as links to navigation schools and navigation certification associations around the world that offer basic and advanced training in marine navigation.

Plotting tools. *Dividers, parallel rulers, Weems Plotter, triangles, 3-arm protractor*

2-26. Read the notes on the chart (always a good idea) to answer these questions: (A) What does the green "NWR" mean on the NE shore of Protection Island? (B) What part of the chart has the most accurate (latest) soundings measurements? (C) What is the copyright status of NOS nautical charts? (D) Running our dingy along shore about 5 miles due east of Smith Island (not shown on the chart) we see a series of red flags and lights. What do they mean?

2-27. (A) What is the true bearing from the Smith Island Light to the FL G 4s light at Davidson Rock? (B) What is the distance between the two?

2-28. There is a rock shown about one quarter of a mile west of Smith Island. (A) What is the depth at the site of that rock? (B) When the tide height is about 0 feet in that area, describe what the water will look like around that rock and between it and the island.

2-29. On Kulakala Pt (48° 06', 123° 04') there is something marked "E COR HO." What is that?

2-30. We call this the US Shore Route. It proceeds generally eastward from the Pacific Ocean toward Pt Wilson. We'll pick it up about Crescent Bay:

Waypoint	Location
1	0.25 miles N of Crescent Bay Buoy 2
2	Angeles Pt. Buoy 4
3	New Dungeness Buoy 2
4	Pt. Wilson Buoy 6

What is the compass course and distance of leg (A) 1 → 2, (B) 2 → 3, (C) 3 → 4?

2-31. What distinguishes BELL, GONG, WHISTLE, and HORN sounds?

2-32. Considering that a hand span is about 7 inches, and on a 1:10,000 scale chart that covers about 1 miles distance, what distance is covered by a hand span on a 1:40,000 scale chart?

2-33. One handspan on a 1:80,000 scale chart is about how many miles?

2-34. Is a 1:10,000 harbor chart a LARGER scale or a SMALLER scale chart than 1:1,000,000 oceanic chart?

2-35. For close inshore navigation, which chart scale, large or small, would better allow presentation of rocks, kelp beds, and other items of localized concern?

2-36. What is the echart type called that when displayed on an electronic chart plotter allows the user to see an exact copy of a paper chart?

2-37. List at least 4 major differences between ENC and RNC echarts.

2-38. What is the document that a navigator consults to amend and update a paper chart to the latest information, allowing him/her to pencil in buoy, hazard, and other corrections?

(A) Coast Pilot.
(B) Local cruising guides.
(C) Local Notice to Mariners.
(D) Tides and Current tables.

2-39. Explain what the following light and buoy labels mean. (A) RW "NA" Mo (A) WHISTLE, (B) Fl G 4sec BELL, (C) G "31" FL G 4s GONG, (D) F R 25 ft "8", (E) FL 4sec 30ft 8M "2".

2-40. Which of the following statements concerning buoy location and number sequence is correct?

(A) Can be counted on as accurate and sequential, with no missing numbers.
(B) Is usually sequential, but may occasionally be missing numbers of the sequence.
(C) Can always be relied on for accurate location even though numbering may be off.
(D) Can always be relied on for sequential numbering even though position may be off.

2-41. When tracking a range indicated by painted boards and lights, which board and light set is the set closest to your vessel, the upper or the lower set?

2-42. Ranges can be very accurate aids to navigation but they are not always ahead of us where we need them. What must we do to follow a charted range if the range signals are astern of us?

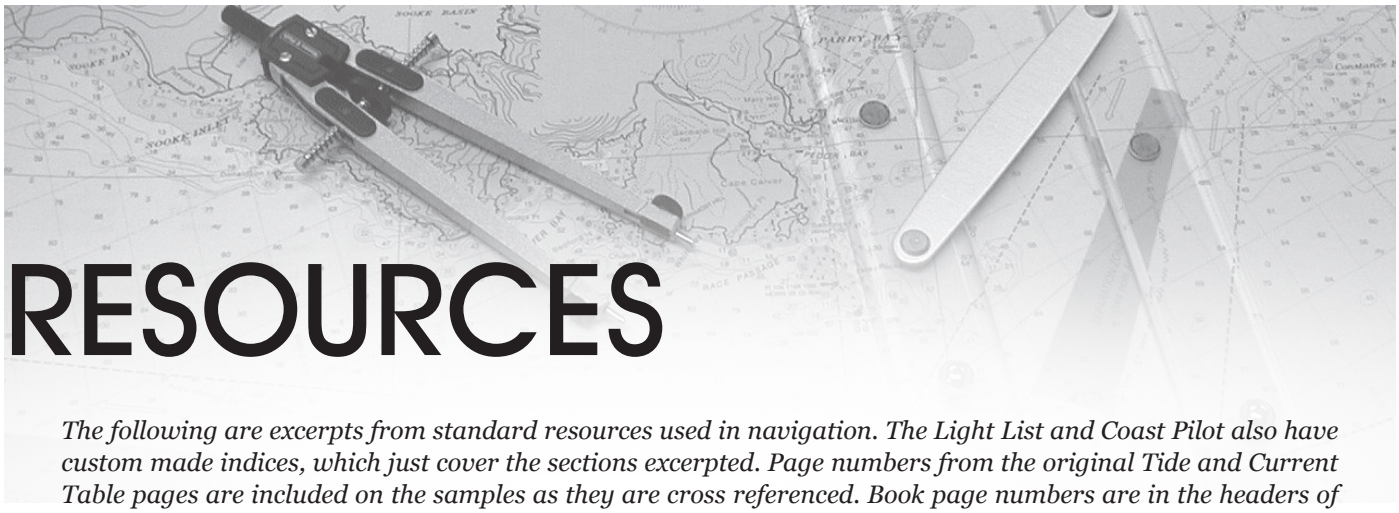
2-43. Approaching the entrance to a harbor from offshore in restricted visibility you sight a buoy with vertical red and white colors, possibly with a white light atop. On which side must or may you leave this buoy as you pass it?

2-44. Regulatory markers are used for important communications, such as speed limits, no wake zones, etc. What does it indicate when you see a regulatory buoy with a crossed diamond on it?

2-45. What do the following navigation abbreviations mean? (A) C, (B) H, (C) R & B, (D) COG, (E) CMG, (F) Trk.

2-46. What are the definitions of the following terms: (A) Course, (B) Heading, (C) Bearing, (D) Course Over Ground, (E) Course Made Good, (F) Track.

2-47. A mark with two black spheres atop, typically black with red horizontal bands indicates what?



RESOURCES

The following are excerpts from standard resources used in navigation. The Light List and Coast Pilot also have custom made indices, which just cover the sections excerpted. Page numbers from the original Tide and Current Table pages are included on the samples as they are cross referenced. Book page numbers are in the headers of each page.

Current Tables

Admiralty Inlet (off Bush Pt.), Washington, 1999

F–Flood, Dir. 180° True E–Ebb, Dir. 005° True

July

	Slack		Maximum		Slack		Maximum	
	h m	h m	knots		h m	h m	knots	
1 Th	0217	0334	0.3F	16 F	0232	0428	1.0F	
	0450	0930	3.1E		0623	1025	3.3E	
	1310	1626	2.6F		1357	1707	2.9F	
	1953	2300	2.1E		2023	2339	2.7E	
2 F	0302	0417	0.3F	17 Sa	0328	0524	0.9F	
	0532	1009	2.9E		0720	1115	2.8E	
	1347	1702	2.5F		1443	1750	2.5F	
	2026	2339	2.2E		2100			
3 Sa	0347	0505	0.3F	18 Su		0026	2.7E	
	0623	1053	2.7E		0426	0623	0.8F	
	1427	1741	2.4F		0822	1208	2.3E	
	2059				1532	1835	2.0F	
					2135			
4 Su		0021	2.3E	19 M		0115	2.7E	
	0433	0600	0.4F		0524	0726	0.8F	
	0728	1142	2.4E		0934	1307	1.8E	
	1511	1822	2.2F		1625	1921	1.6F	
	2133				2210			
5 M		0106	2.5E	20 Tu		0204	2.7E	
	0520	0702	0.6F		0620	0832	0.9F	
	0848	1241	2.0E		1056	1413	1.5E	
	1602	1909	1.9F	◐	1725	2010	1.2F	
	2209				2244			
6 Tu		0154	2.7E	21 W		0255	2.7E	
	0607	0810	0.8F		0711	0938	1.1F	
	1021	1349	1.8E		1222	1525	1.2E	
○	1701	2000	1.7F		1833	2103	0.9F	
	2247				2320			
7 W		0245	3.0E	22 Th		0345	2.8E	
	0654	0920	1.2F		0758	1039	1.3F	
	1158	1505	1.6E		1341	1637	1.2E	
	1810	2057	1.4F		1948	2159	0.7F	
	2329				2359			
8 Th		0338	3.3E	23 F		0434	2.9E	
	0742	1026	1.7F		0841	1133	1.6F	
	1327	1622	1.6E		1447	1741	1.3E	
	1924	2156	1.2F		2059	2254	0.6F	
9 F	0015	0432	3.6E	24 Sa	0040	0520	3.0E	
	0830	1127	2.3F		0920	1220	1.9F	
	1444	1733	1.7E		1540	1835	1.4E	
	2038	2257	1.1F		2201	2345	0.5F	
10 Sa	0104	0525	3.9E	25 Su	0123	0603	3.1E	
	0917	1223	2.7F		0957	1302	2.2F	
	1548	1836	1.9E		1625	1921	1.6E	
	2146	2356	1.1F		2253			
11 Su	0156	0617	4.1E	26 M		0032	0.5F	
	1005	1315	3.1F		0206	0644	3.2E	
	1644	1934	2.1E		1032	1340	2.4F	
	2249				1705	2003	1.8E	
					2338			
12 M		0053	1.1F	27 Tu		0116	0.5F	
	0249	0708	4.2E		0250	0722	3.2E	
	1052	1404	3.4F		1106	1416	2.6F	
●	1734	2027	2.3E		1740	2040	2.0E	
	2347							
13 Tu		0148	1.1F	28 W	0017	0157	0.6F	
	0342	0758	4.2E		0332	0759	3.3E	
	1138	1452	3.5F		1140	1451	2.7F	
	1821	2117	2.5E	○	1814	2116	2.1E	
14 W	0042	0241	1.1F	29 Th	0054	0237	0.6F	
	0435	0847	4.0E		0416	0837	3.2E	
	1225	1538	3.4F		1215	1524	2.7F	
	1904	2205	2.6E		1845	2150	2.3E	
15 Th	0137	0334	1.0F	30 F	0130	0317	0.7F	
	0528	0936	3.7E		0502	0915	3.2E	
	1311	1623	3.2F		1250	1558	2.6F	
	1945	2252	2.7E		1914	2225	2.4E	
				31 Sa	0208	0400	0.8F	
					0551	0955	3.0E	
					1327	1633	2.5F	
					1944	2301	2.6E	

August

	Slack		Maximum		Slack		Maximum	
	h m	h m	knots		h m	h m	knots	
1 Su	0248	0447	0.9F	16 M	0331	0548	1.2F	
	0646	1039	2.7E		0811	1141	2.2E	
	1407	1710	2.3F		1505	1752	1.6F	
	2014	2341	2.7E		2037			
2 M	0333	0539	1.0F	17 Tu		0022	2.7E	
	0748	1129	2.4E		0422	0642	1.1F	
	1452	1751	2.0F		0912	1234	1.8E	
	2046				1556	1834	1.2F	
					2107			
3 Tu		0025	2.9E	18 W		0107	2.6E	
	0422	0638	1.1F		0516	0742	1.1F	
	0900	1227	2.0E		1021	1335	1.4E	
	1544	1836	1.7F	◐	1656	1922	0.9F	
	2122				2138			
4 W		0113	3.0E	19 Th		0157	2.5E	
	0516	0743	1.3F		0611	0846	1.1F	
	1023	1334	1.7E		1139	1446	1.2E	
◑	1645	1929	1.4F		1811	2017	0.6F	
	2201				2214			
5 Th		0208	3.2E	20 F		0252	2.5E	
	0613	0854	1.6F		0705	0952	1.3F	
	1153	1451	1.5E		1257	1601	1.2E	
	1759	2029	1.1F		1935	2120	0.4F	
	2247				2258			
6 F		0307	3.3E	21 Sa		0349	2.5E	
	0710	1004	1.9F		0756	1051	1.5F	
	1318	1611	1.5E		1404	1709	1.3E	
	1920	2136	0.9F		2050	2223	0.3F	
	2340				2352			
7 Sa		0408	3.5E	22 Su		0443	2.6E	
	0806	1109	2.3F		0841	1143	1.8F	
	1432	1724	1.7E		1459	1805	1.5E	
	2038	2244	0.9F		2147	2321	0.4F	
8 Su	0040	0508	3.6E	23 M	0051	0533	2.8E	
	0900	1208	2.7F		0923	1228	2.0F	
	1534	1827	1.9E		1545	1850	1.8E	
	2146	2348	0.9F		2229			
9 M	0143	0605	3.8E	24 Tu		0012	0.5F	
	0951	1300	3.0F		0150	0618	3.0E	
	1626	1922	2.2E		1002	1307	2.3F	
	2243				1623	1929	2.0E	
					2305			
10 Tu		0047	1.0F	25 W		0056	0.7F	
	0244	0659	3.9E		0244	0700	3.1E	
	1039	1349	3.1F		1040	1344	2.4F	
	1711	2011	2.5E		1657	2005	2.2E	
	2335				2338			
11 W		0141	1.2F	26 Th		0138	0.9F	
	0343	0749	3.8E		0335	0740	3.2E	
	1126	1434	3.1F		1116	1419	2.5F	
●	1752	2056	2.7E	○	1728	2038	2.5E	
12 Th	0023	0232	1.3F	27 F	0009	0219	1.1F	
	0439	0837	3.7E		0425	0820	3.2E	
	1210	1516	3.0F		1152	1452	2.5F	
	1830	2138	2.8E		1757	2111	2.7E	
13 F	0109	0321	1.3F	28 Sa	0043	0300	1.3F	
	0532	0923	3.4E		0515	0901	3.1E	
	1254	1556	2.8F		1230	1526	2.5F	
	1904	2219	2.8E		1826	2145	2.9E	
14 Sa	0155	0409	1.3F	29 Su	0119	0342	1.5F	
	0624	1008	3.0E		0606	0943	3.0E	
	1336	1635	2.4F		1309	1602	2.3F	
	1937	2259	2.8E		1855	2222	3.0E	
15 Su	0242	0458	1.3F	30 M	0159	0428	1.7F	
	0716	1054	2.6E		0701	1029	2.7E	
	1419	1713	2.1F		1352	1640	2.0F	
	2007	2340	2.8E		1925	2301	3.1E	
				31 Tu	0244	0519	1.8F	
					0801	1120	2.4E	
					1440	1722	1.7F	
					1959	2346	3.2E	

September

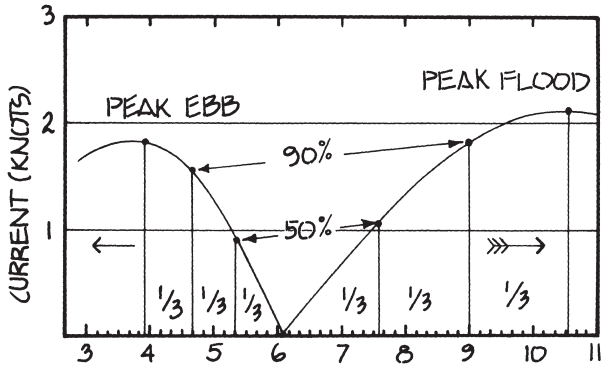
	Slack		Maximum		Slack		Maximum	
	h m	h m	knots		h m	h m	knots	
1 W	0335	0616	1.8F	16 Th		0009	2.5E	
	0908	1218	2.0E		0408	0652	1.4F	
	1537	1810	1.4F		0950	1303	1.5E	
	2036				1644	1836	0.5F	
					2025			
2 Th		0037	3.2E	17 F		0057	2.4E	
	0432	0720	1.8F		0503	0751	1.3F	
	1023	1327	1.7E		1056	1412	1.3E	
◑	1646	1907	1.0F	◐	1811	1935	0.3F	
	2119				2057			
3 F		0136	3.1E	18 Sa		0154	2.2E	
	0535	0831	1.9F		0601	0857	1.3F	
	1145	1445	1.6E		1207	1527	1.3E	
	1808	2014	0.8F			2045	*	
	2213							
4 Sa		0242	3.1E	19 Su		0258	2.2E	
	0640	0943	2.1F		0700	1001	1.4F	
	1304	1605	1.7E		1313	1634	1.5E	
	1934	2130	0.7F			2157	*	
	2319							
5 Su		0351	3.1E	20 M		0402	2.3E	
	0744	1051	2.3F		0754	1057	1.6F	
	1412	1716	1.9E		1407	1728	1.7E	
	2048	2244	0.7F		2129	2259	0.4F	
6 M	0034	0458	3.2E	21 Tu	0027	0500	2.4E	
	0843	1150	2.5F		0842	1145	1.9F	
	1508	1814	2.2E		1452	1812	2.0E	
	2145	2349	1.0F		2159	2351	0.7F	
7 Tu	0148	0558	3.4E	22 W	0140	0551	2.6E	
	0936	1242	2.7F		0927	1227	2.1F	
	1555	1904	2.5E		1530	1849	2.3E	
	2234				2228			
8 W		0046	1.2F	23 Th		0036	1.0F	
	0254	0652	3.4E		0242	0637	2.8E	
	1026	1328	2.7F		1008	1305	2.2F	
	1636	1948	2.7E		1603	1924	2.6E	
	2317				2257			
9 Th		0137	1.5F	24 F		0119	1.4F	
	0354	0741	3.4E		0339	0721	3.0E	
	1112	1410	2.7F		1049	1341	2.3F	
●	1713	2028	2.9E		1634	1957	2.9E	
	2358				2328			
10 F		0223	1.6F	25 Sa		0200	1.8F	
	0447	0827	3.2E		0432	0803	3.0E	
	1155	1449	2.5F		1129	1416	2.2F	
	1745	2106	3.0E	○	1703	2031	3.2E	
11 Sa	0037	0307	1.7F	26 Su	0002	0241	2.1F	
	0537	0910	3.0E		0523	0847	3.0E	
	1237	1525	2.2F		1210	1453	2.1F	
	1814	2141	3.0E		1733	2107	3.4E	
12 Su	0116	0349	1.8F	27 M	0039	0325	2.3F	
	0625	0952	2.7E		0616	0932	2.9E	
	1317	1600	1.9F		1254	1531	1.9F	
	1841	2216	3.0E		1804	2145	3.5E	
13 M	0155	0430	1.7F	28 Tu	0120	0411	2.5F	
	0712	1033	2.4E		0710	1021	2.6E	
	1359	1634	1.5F		1342	1612	1.7F	
	1907	2251	2.9E		1837	2226	3.6E	
14 Tu	0236	0513	1.6F	29 W	0206	0501	2.5F	
	0800	1117	2.0E		0808	1114	2.4E	
	1445	1710	1.2F		1436	1657	1.4F	
	1932	2328	2.7E		1913	2313	3.5E	
15 W	0320	0600	1.5F	30 Th	0258	0557	2.4F	
	0852	1206	1.7E		0911	1214	2.1E	
	1538	1750	0.8F		1541	1750	1.0F	
	1958				1954			

Time meridian 120° W. 0000 is midnight. 1200 is noon.
* Current weak and variable.

Current Sailing Resources

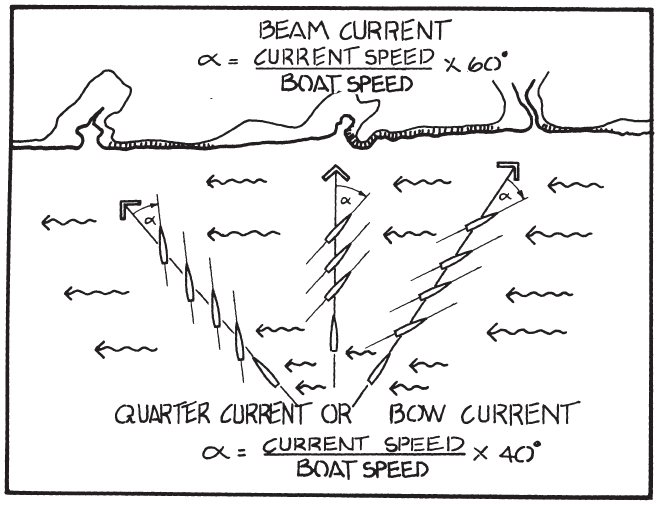
These resources are from the text *Inland and Coastal Navigation, 2nd edition* (Starpath Publications, 2013)

The 50-90 Rule for figuring current speeds between slack and peak flow



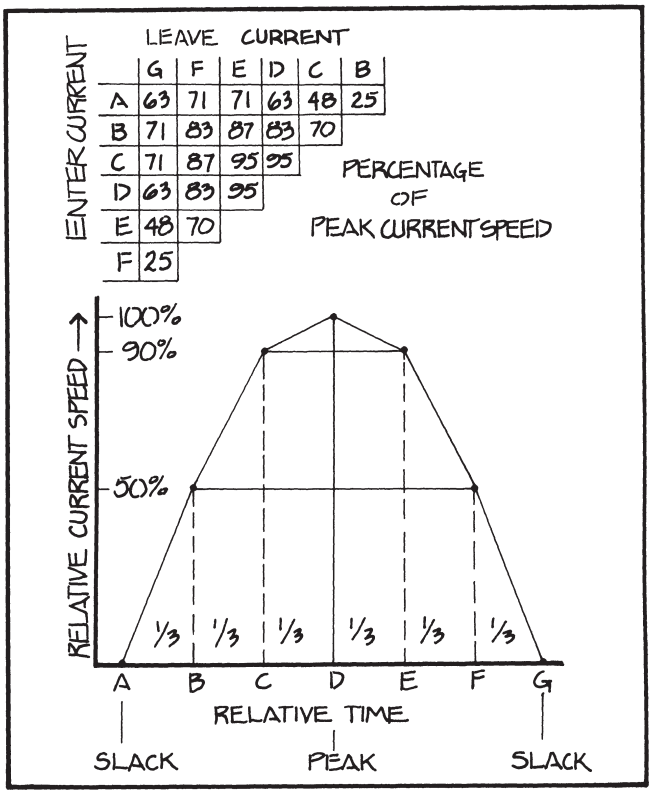
Divide the time between slack water and peak flow into three steps. In many cases, each step will be approximately one hour long. During the first step the current increases to 50 percent of its maximum value, and during the next step it increases to 90 percent of its maximum value. The same procedure will reproduce the fall in current speed after maximum flow.

The 40-60 approximation for estimating current set



The rule works adequately well for set angles up to 42° or so, which is equivalent to limiting its use to currents that are less than some three quarters of your boat speed. In most cases, knowledge of current speed and direction is not accurate enough to justify precise vector solutions. This formula is useful and easy to remember. Bow and quarter currents take less of a correction, but they are the same in each case. The only difference is the resulting SMG. Bow currents slow you down, quarter currents speed you up. Bow, beam, and quarter current directions are defined for this application with the boat pointed toward the destination, as in the starting position shown on each route.

Use of the 50-90 Rule to estimate the effect of a changing tidal current on net progress



Divide the duration of the cycle into six parts, then use data from the inset to find the constant current speed that is equivalent to the changing current of the cycle. Sailing in a current with a peak speed of 3 knots from relative point B to point E, the current would be increasing from 1.5 knots to 3 knots and then decreasing to 2.7 knots during this time. From the inset, you can assume that this will move the boat as if in a constant current of 0.87 times 3, or 2.6 knots. Note that staying in a current from slack to peak (A to D) or slack to slack (A to G) is equivalent to sailing in a constant current of 0.63 times the peak current speed.

Slow Water Rule for Estimating Duration of Slack

You can estimate the time period that the current will flow at 0.5 kts or less on either side of a slack using the peak value of the current on either side of the slack.

The rule is the current stays less than 0.5 kts for about 60 minutes divided by the peak current speed in kts. Thus if the peak current is 2 kts, we expect that on that side of the slack the current will be less than 0.5 kts for 60/2 = 30 min. To this we must then add the period computed for the other side of slack based on the peak current on that side.