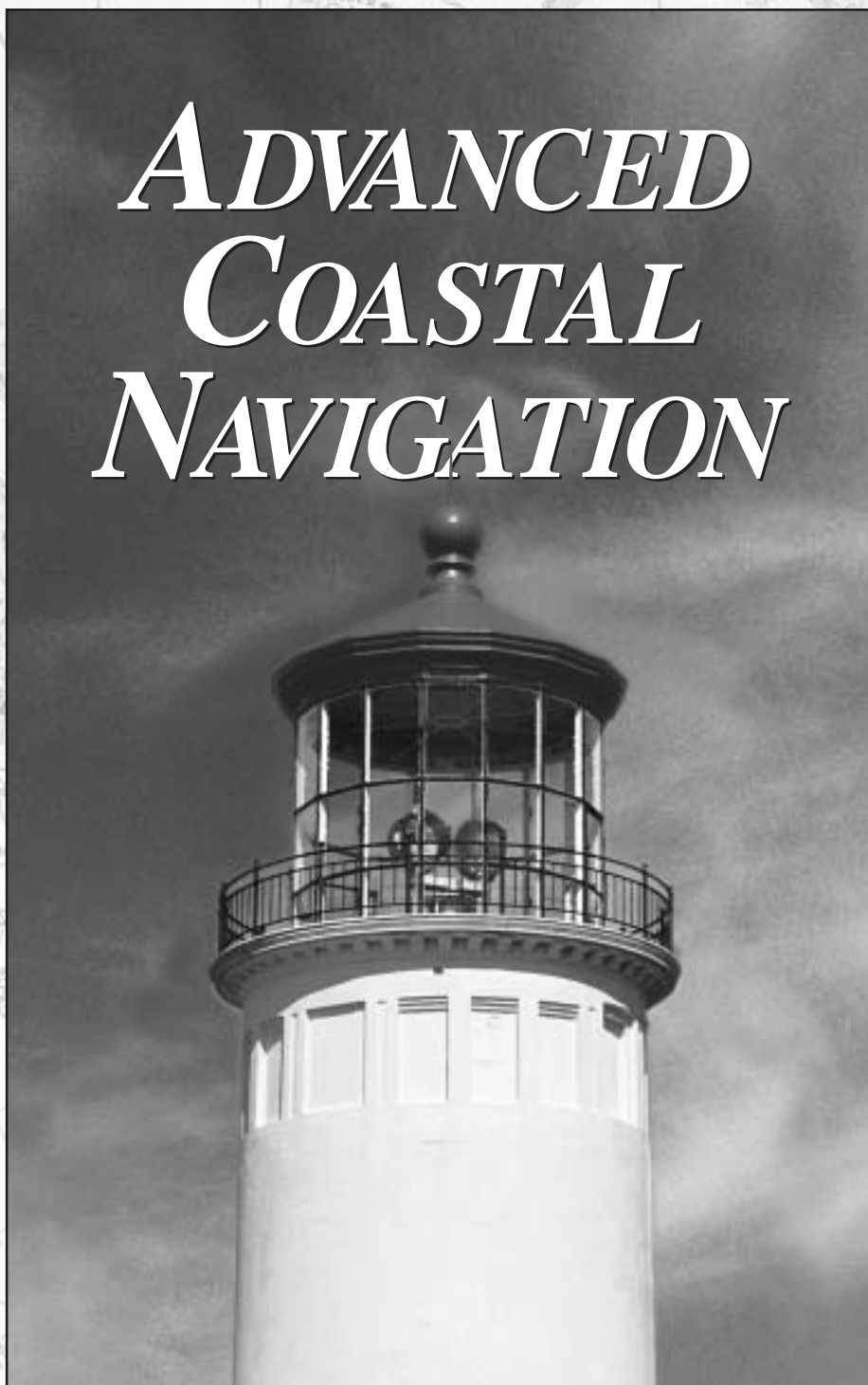




FOURTH EDITION

United States Coast Guard Auxiliary
America's Volunteer LifesaversSM

ADVANCED COASTAL NAVIGATION



AN-2 STUDY GUIDE

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PREFACE

This Study Guide (SG), supplements the text, *Advanced Coastal Navigation* (ACN 4th Edition). It is used in both the BCN, *Basic Coastal Navigation*, and AUXACN, *Auxiliary Advanced Coastal Navigation*, Public Education Courses, as a source of homework study questions and quantitative problems.

The BCN course uses a subset of the material covered in the AUXACN course and is designed to be given in six (6) to eight (8) lessons. The first six chapters together with the material on Navigation Reference Publications from Chapter 10 are included as the “core” lessons, that may be supplemented with two additional sessions. The instructor will tell you what extra lessons will be covered in your scheduled class. The material in this course deletes the topics that are considered to be more advanced, allowing the course to be shortened somewhat.

The SG is divided into eleven lessons, corresponding to those in the text. The twelfth chapter in the text, “Reflections,” is intended for classroom discussion only, and no study questions or practice problems are included. For each lesson, the basic learning objectives are indicated, and a series of study questions and practice problems are included. The reading assignment for each lesson is the corresponding chapter in the ACN text. You are encouraged to consult the references at the end of each chapter for additional perspectives and insights.

The answers to all of the questions and problems are provided in the back of the SG for the benefit of students that wish to check answers in “real time” and for those who wish to use this material as a self-study guide. For the most part, the answers to the practice problems are given without comment. Detailed answers and comments are given to selected problems that are thought to be of particular interest or experience has shown to be particularly difficult. We recommend that you work out the problem to the best of your ability before checking the answer in the back of the book.

The nautical chart 1210-Tr (7th Edition, May 28/62, Revised May 5/90, Loran-C Overprinted) is required for both study questions and practice problems. Do not use other editions of this chart. Additionally, you should

have a set of dividers, a compass, a plotter (e.g., paraline plotter or parallel rulers), protractor, calculator (or nautical slide rule), pencils, and—yes—numerous erasers.

As a general strategy, it makes sense to reread the chapter first, before attempting to answer the questions. Next, read the study objectives in the SG to ensure that you have paid attention to the most important parts of the chapter. The answers to all of the study questions can be found in the text.

Quantitative problems are also supplied in abundance. But, it is not necessary for you to solve each and every problem. Once it is clear that you have mastered that type of problem, move on to those that explore other techniques. However, if you find that you are having difficulty with a given problem type, work out all the problems of this type, and make it a point to ask the instructor to review this material in the next class. It may be that other students in your class are having the same difficulties. Take the time to plot courses, bearings, etc., carefully, and ensure that your answers are within the tolerances given in the ACN text.

Quantitative problems denoted with an asterisk are more advanced and/or address material identified as more technical in the text. Solution of these problems is optional and left to the discretion of the student seeking more advanced knowledge.

Do not allow yourself to get too far behind. The lecture material builds in a logical way on a foundation of earlier material. You can get “lost” (no worse disaster can befall a navigator!) if you do not keep up with the class.

Each chapter introduces some new terms and/or words with specialized meanings. It is a good idea to read through the chapter in search of these terms to ensure that you are familiar with their meanings. If in doubt, consult the glossary at the end of the text.

A cruise exercise problem is included for AUXACN students in Appendix A of this SG. Answers are given in Appendix B of this SG. It is intended to review and integrate the course material. AUXACN students can begin work on the cruise problem upon completion of Chapter 5 and work in parallel with the course.

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LESSON 1.—INTRODUCTION TO NAVIGATION

A. Introduction. *The objectives of this lesson are to enable the student to:*

1. have an overview of the course,
2. understand the names and definitions for the various types of navigation,
3. know the steps of voyage planning and underway navigation,
4. become familiar with the earth's coordinate system and how it is used to specify the location of any point on the earth,
5. understand how direction can be measured on the earth's surface, and
6. be able to convert from one direction (e.g., true, magnetic, relative) to another.

B. Study Questions:

- S1-1. In simple terms, marine navigation is _____
- S1-2. Coastal navigation refers to _____
- S1-3. It is convenient to subdivide navigation into two distinct phases, _____
- S1-4. The steps in voyage planning include: _____
- S1-5. For the purposes of this course, the earth is a _____ with a mean (average) diameter of _____ nautical miles, and a circumference of _____ nautical miles.
- S1-6. The process of predicting the future position of a vessel from knowledge of its present (or starting) position, the course steered, and speed maintained is termed _____
- S1-7. The earth revolves about an axis of rotation, which passes through the center of the earth and intersects the surface at two points, termed the _____
- S1-8. A plane passed through the center of the earth intersects the surface of the earth to produce a geometric figure termed a _____.
- S1-9. On the surface of a sphere, the shortest distance between any two points lies on the _____ connecting these two points.
- S1-10. If a plane is passed through the center of the earth and is perpendicular to the axis of rotation, the resulting great circle is termed the _____.
- S1-11. The upper branch of the great circle passing through both poles and a specific point in Greenwich, England, is called the _____.

- S1-12. A circle contains _____ degrees of angular measure. Degrees are further subdivided into _____ and _____.
- S1-13. _____ (abbreviated Lo) is the angular distance between a position on the earth and the prime meridian measured eastward or westward through 180 degrees along the arc of the equator.
- S1-14. A plane passed through the earth that does not touch the earth's center is termed _____.
- S1-15. The angular distance between a position on the earth's surface and the equator, measured northward or southward from the equator along a meridian, is termed _____ and abbreviated _____ or _____.
- S1-16. Any position on the earth's surface can be defined by specifying its _____ and _____.
- S1-17. One degree of _____ equals 60 nautical miles in length. Not so, however, for _____, except at the equator.
- S1-18. Three common reference points for measurement of direction are: _____, _____, and _____.
- S1-19. When a direction (other than exactly north, east, south, or west) is specified on the earth and followed for any distance, such that each subsequent meridian is passed at the same angle relative to the direction of the geographic north pole, the resulting line is termed a _____ or _____.
- S1-20. The earth has a _____, thought to be generated by the flow of the liquid iron alloy core of the planet.
- S1-21. At the surface of the earth, lines of magnetic force are termed _____, analogous to _____ meridians.
- S1-22. The angular difference between the geographic and magnetic meridians at any point on the earth is called the _____, or simply _____.
- S1-23. Variation is said to be _____ if the magnetic meridian points eastward of the north geographic pole.
- S1-24. Lines of constant variation are termed _____ lines, and the line of zero variation is termed the _____ line.
- S1-25. Conversion from magnetic direction to true direction is simply a matter of _____ easterly variation or _____ westerly variation.
- S1-26. To convert from relative bearing to a true or magnetic bearing, it is necessary to use the equation _____ + _____ equals _____. Of course, if the number of degrees so calculated exceeds _____, it is necessary to subtract this amount from the total.

- S1-27. An object off the stern of the vessel would be said to have a relative bearing of _____ degrees, while one located directly off the port beam would have a relative bearing of _____.
- S1-28. Normally, the _____ of the compass rose on a chart is referenced to _____ north, while the _____ is referenced to _____.
- S1-29. According to this text, within the continental United States, variation ranges from about _____ in northern Maine, through _____ in portions of Florida, to _____ in northern Washington state. In portions of northern Alaska, variation is as great as _____.
- S1-30. A handy rule to remember in converting from magnetic to true directions is “magnetic or compass to true, add _____.”

C. Practice Problems:

- P1-1. You wish to sail due NORTH from L: $34^{\circ} 47.0'N$ to L: $36^{\circ} 51.0'N$. How far do you have to sail, in nautical miles?
Answer: _____
- P1-2. Your LATITUDE is $39^{\circ} 49.6'N$, when a ship passes a point three nautical miles SOUTH of your position. What will its LATITUDE be?
Answer: _____
- P1-3. How far is it in nautical miles from the top to the bottom of the 1210-Tr chart?
Answer: _____
- P1-4. And, how far is it from the east side to the west side of the 1210-Tr chart, measured in nautical miles?
Answer: _____
- P1-5. What is the difference in LATITUDE and LONGITUDE between the respective edges of the 1210-Tr chart?
Answer: L: _____
Lo: _____
- P1-6. Tokyo, Japan, is at L: $35^{\circ} 40.4'N$, and Los Angeles, California, is L: $34^{\circ} 06.8' N$. Which is farther north, and by how much?
Answer: _____
- P1-7. How many compass roses are there on the 1210-Tr chart, and are they all the same?
Answer: _____
- P1-8. The TRUE direction you wish to sail is 090, and the VARIATION is 015 W. What is the MAGNETIC direction?
Answer: _____

P1-9. The MAGNETIC direction is 137 M, and the chart shows that the VARIATION is 005 E. What is the TRUE direction?

Answer: _____

P1-10. The vessel's TRUE heading is 105 when Buoy "B" bearing 072 R is observed. What is the TRUE bearing of the Buoy "B"?

Answer: _____

P1-11. While on a TRUE heading of 105, you observe another vessel bearing 230 R. What is the TRUE bearing of the other vessel?

Answer: _____

P1-12. The TRUE heading of your vessel is 350 when a buoy bears 045 R. What is the TRUE bearing of the buoy?

Answer: _____

Pl-13. The VARIATION is 024 E, and your MAGNETIC heading is 008 M, and you note a boat bearing 280 R. What is the TRUE bearing of the boat?

Answer: _____

P1-14. The TRUE direction is 359, and the VARIATION is 009 W. What is the MAGNETIC direction?

Answer: _____

Pl-15. The MAGNETIC direction is 010 M, and the variation is 012 W. What is the TRUE direction?

Answer: _____

Pl-16. The VARIATION is 013 W. What are the TRUE or MAGNETIC directions for the following?

a. TRUE: 045 MAGNETIC: _____

b. TRUE: 217 MAGNETIC: _____

c. MAGNETIC: 318 M TRUE: _____

d. MAGNETIC: 095 M TRUE: _____

e. MAGNETIC: 045 M
and RELATIVE: 030 R TRUE: _____

f. TRUE: 347
and RELATIVE: 355 R MAGNETIC: _____

LESSON 2.—THE MARINE MAGNETIC COMPASS

A. Introduction. *The objectives of this lesson are to enable the student to:*

1. understand the parts and principle of operation of the marine magnetic compass,
2. understand the concept of deviation, and the distinctions between compass north, magnetic north, and true north,
3. understand how to “swing ship” and prepare a deviation table, and
4. be able to rapidly and reliably solve TVMDC and/or CDMVT computations.

B. Study Questions:

- S2-1. In the modern compass, the north-seeking magnets are attached to a _____ or compass rose.
- S2-2. The dials of most compasses are graduated in degrees, with numbers shown every 30 degrees, and the _____ (N, E, S, and W). Arrows or other marks are sometimes used to denote the _____ (NE, SE, SW, and NW).
- S2-3. The compass dial is supported on a jeweled bearing which turns on a pivot. In turn, the pivot is mounted in a _____, designed to keep the dial level with the horizon if the vessel pitches or rolls.
- S2-4. Fastened to the gimbal is one (or more) _____ against which the dial graduations can be read to determine the direction of the vessel relative to the card.
- S2-5. There are two principal types of compass dial design, the _____ and the _____.
- S2-6. During the mid-1920s an electronic compass termed a _____ compass was developed for aircraft. In recent years this has become available to the mariner.
- S2-7. The modern magnetic compass is highly sensitive and is able to align itself with _____, such as the earth’s magnetic field.
- S2-8. However, the magnetic field aboard a vessel is not solely due to the earth’s magnetic field. Other shipboard magnetic fields are caused by a variety of items, including _____.
- S2-9. These additional fields also affect the compass, with the result that the _____ of the vessel may differ from its _____.
- S2-10. Simply put, _____ is the difference between the direction that the compass actually points, and the direction that it would point if there were no local magnetic fields aboard the vessel.
- S2-11. The mariner has two options for dealing with deviation: _____ any residual error or to correct for deviation.
- S2-12. Unlike variation, which depends solely on the vessel’s position, deviation varies with the vessel’s _____.

- S2-13. The process of developing a deviation curve is often termed _____.
- S2-14. If the compass bearing (i.e., that read over the compass directly, or calculated from the compass heading and relative bearing) of an object is less than the magnetic bearing, as determined from the chart, the deviation is _____.
The simple rule is “_____.”
- S2-15. A device for measuring relative bearings is termed a _____.
- S2-16. The letter sequence TVMDC is used to describe the sequence of starting with a _____ course, correcting for _____ to calculate a _____ course, and finally allowing for _____ to calculate a _____ course.
- S2-17. When converting from a true course to a compass course (i.e., uncorrecting), westerly variation and deviation are to be _____.
- S2-18. When converting from a compass to a true course (correcting), _____ variation and deviation are to be _____ and _____ variation and deviation are to be subtracted.
- S2-19. It is important to remember that compass readings are most accurate only when the vessel is level, _____, and maintaining a constant course.
- S2-20. Otherwise a series of additional compass errors can arise, including _____, _____, _____, and _____.

C. Practice Problems:

- P2-1. The compass heading is 287 C, and the deviation is 029 W. What is the magnetic heading?
Answer: _____
- P2-2. A hand-bearing compass held in a position that is free from local magnetic fields reads 060 at the same heading the vessel's compass reads 056. What is the deviation?
Answer: _____
- P2-3. The compass heading is 045 C, the deviation is 004 W at that heading, and the variation is 009 W in your locality. What is the true heading for this compass course?
Answer: _____
- P2-4. In an area where the variation is 009 W, the true heading of the vessel is 013. What is the magnetic heading?
Answer: _____
- P2-5. For the magnetic heading indicated in P2-4 above, the deviation is 004 E. What is the compass heading?
Answer: _____
- P2-6. For the situations in P2-4 and P2-5 above, a vessel is sighted at 270 R. What is its true bearing?
Answer: _____

For practice problems P2-7 through P2-16, use the values for deviation found in the Deviation Table on page 2-4. Use a variation of 015 E for these problems.

P2-7. A vessel is on a heading of 035 C. What is its true heading?

Answer: _____

P2-8. That vessel changes heading to 135 C. What is its new true heading?

Answer: _____

P2-9. A buoy is observed at 035 R while on a compass heading of 135 C. What is its true bearing?

Answer: _____

P2-10. A course change is made to a new heading of 285 C, and a lighthouse is observed on the starboard beam (i.e., 090 R). What is its true bearing?

Answer: _____

P2-11. For P2-10 above, what is the reciprocal bearing of the lighthouse (True and Magnetic)?

Answer: _____

P2-12. On a heading of 185 C, a prominent smoke stack bears 285 R. What is its true bearing, and its reciprocal true and magnetic bearings?

Answer: _____

P2-13. On a true heading of 110, we want to be aware when buoy “6” is on the port beam. What would the compass bearing of the buoy be?

Answer: _____

P2-14. On a true heading of 200, what would our compass heading be?

Answer: _____

P2-15. On a true heading of 158, what would our compass heading be?

Answer: _____

P2-16. On a compass heading of 323 C, what would our true heading be?

Answer: _____

DEVIATION TABLE
[ALL VALUES IN DEGREES(°)]

COMPASS TO MAGNETIC		MAGNETIC TO COMPASS	
(A) Compass Heading	(B) Deviation	(C) Magnetic Heading	(D) Deviation
000	2E	000	2E
015	3E	015	3E
030	5E	030	4E
045	6E	045	6E
060	5E	060	5E
075	5E	075	5E
090	3E	090	3E
105	3E	105	3E
120	2E	120	1E
135	1W	135	1W
150	2W	150	2W
165	3W	165	2W
180	4W	180	4W
195	5W	195	5W
210	6W	210	6W
225	5W	225	5W
240	4W	240	4W
255	5W	255	5W
270	4W	270	4W
285	3W	285	3W
300	2W	300	2W
315	1W	315	1W
330	1E	330	1E
345	2E	345	2E
360	2E	360	2E

LESSON 3.—THE NAUTICAL CHART

A. Introduction. *The objectives of this lesson are to enable the student to:*

1. understand the important characteristics of nautical charts and, in particular, of the Mercator and polyconic projections,
2. be able to plot positions in terms of latitude and longitude on the nautical chart,
3. know the various chart types/scales and their appropriate uses,
4. have a basic knowledge of the various symbols employed on charts, and where these can be found, and
5. be able to rapidly and reliably measure direction, distance, and location on Mercator and polyconic nautical charts.

B. Study Questions:

S3-1. List ten items of information that can be found by consulting a nautical chart.

S3-2. What goals do various types of chart projections have in common?

S3-3. A projection which preserves correct angular relationships is said to be _____.

S3-4. The spherical surface of the earth projected on a cylinder provides the basis for the _____ projection.

S3-5. The spherical surface of the earth projected on a series of cones concentric with the earth's axis, and tangent to the sphere of the earth, results in the _____ projection.

S3-6. Which projection is conformal and shows a rhumb line as a straight line?

S3-7. In a Mercator projection, the meridians appear as _____.

S3-8. In terms of measuring distance along a course or bearing line, does it matter where this distance is measured on a Mercator chart? _____

S3-9. How are directions measured on a polyconic Great Lakes chart? _____

S3-10. The distance units employed on nautical charts of the Great Lakes are _____

S3-11. At a scale of 1:80,000, one inch equals approximately _____ nautical miles.

S3-12. The basic types of nautical charts available include harbor, _____, _____, and small craft.

S3-13. A large-scale chart offers (more/less) _____ detail than a small-scale chart.

- S3-14. What types of charts have a larger scale than a coast chart? _____,
_____.
- S3-15. Contour lines connect points of equal _____ on the nautical chart.
- S3-16. A type of bottom that generally provides poor holding ground is termed _____ and indicated on the chart by the abbreviation _____.
- S3-17. Clearances of bridges and heights of landmarks are given with respect to _____.
- S3-18. The depth units employed on a chart can be found _____
_____.
- S3-19. As used in the nautical chart, a cupola means _____
_____.
- S3-20. The mere fact that an object is charted does not imply that it is _____
_____.
- S3-21. A circle with a dot in the center is used to denote a landmark that _____
_____.
- S3-22. Where can you find a summary of the chart symbols, abbreviations, and meanings?
_____.
- S3-23. Changes/updates to nautical charts can be found in _____.
- S3-24. In terms of chart convention, the difference between a flagpole and a flagstaff is
_____.
- S3-25. Using a low-water datum is generally conservative, but it is important to remember that _____ values are used in determining the chart datum. At any given time in any location, the actual water depth may be _____ or _____ than the charted depth.

C. Practice Problems:

Chart 1210-Tr (7th Edition, May 28/62; Revised May 5/90, Loran-C overprinted) will be used for the practice problems for Lesson 3. Additionally, the student may wish to consult Chart No. 1, if a copy is available. In any event, ensure that you read the back of the 1210- Tr chart. The student will also need dividers, plotting tool (parallel rulers, aircraft plotter, “paraglide”-type plotter, etc.), straight edge, pencil, and eraser. The precision for these practice problems is: to the nearest 0.1 M, to the nearest degree of direction, to the nearest 0.1 minute of L and Lo, nearest foot for depth of water or height of object.

- P3-1. What is the charted depth of water immediately due west of lighted buoy W Or “A” Fl 4 sec BELL, located approximately 8 M NE of Block Island?

Answer: _____

- P3-2. What is the position of this buoy?

Answer: L: _____

Lo: _____

- P3-3. What is the position of the lighted buoy G “1B1” Fl G 4 sec BELL, located just north of Sandy Pt, on Block Island?
Answer: L: _____
Lo: _____
- P3-4. What is the distance between lighted buoy G “1B1” Fl G 4 sec BELL and lighted buoy W Or “A” Fl 4 sec BELL?
Answer: _____
- P3-5. What are the true and magnetic directions from lighted buoy G “1B1” Fl G 4 sec BELL to lighted buoy W Or “A” Fl 4 sec BELL?
Answer: _____ TRUE
_____ MAGNETIC
- P3-6. Their reciprocals?
Answer: _____ TRUE
_____ MAGNETIC
- P3-7. What is the position of lighted buoy R “2” Fl 10 sec WHISTLE, just south of Pt. Judith?
Answer: L: _____
Lo: _____
- P3-8. What kind of bottom do we find in the vicinity of the buoy in problem P3-7, above?
Answer: _____
- P3-9. What are the characteristics of the light at Pt. Judith?
Answer: _____
- P3-10. What ATON is located at L: 41° 25.6’N, Lo: 71° 23.3’ W?
Answer: _____
- P3-11. What is the object located at a true bearing of 208, 1.0 M from the ATON of problem P3-10 above?
Answer: _____
- P3-12. What are the directions and distances between the object in problem P3-11, above, and the lighted buoy W Or “A” Fl 4 sec BELL of problem P3-17
Answer: _____
- P3-13. What is the depth of water at L: 41° 22.3’N, Lo: 71° 18.5’W, and what can be found there?
Answer: _____
- P3-14. What is located at L: 41° 26.6’N, Lo: 71° 09.6’W, and what are the colors of the ATON there?
Answer: _____

P3-15. Indicate the objects located at the following positions:

- a. L: 41° 31.9'N, Lo: 71° 20.7'W: _____
- b. L: 41° 26.4'N, Lo: 71° 13.6'W: _____
- c. L: 41° 13.8'N, LO: 71° 19.3'W: _____
- d. L: 41° 30.7'N, Lo: 71° 18.6'W: _____
- e. L: 41° 24.2'N, Lo: 71° 11.4'W: _____

P3-16. What are distance (M) and direction (T and M) from the light on Sandy Pt., Block Island (Fl 5 sec, 36 ft 13 M) to BRENTON REEF Light?

Answer: _____

P3-17. What lies between lighted buoys W Or "H" Fl 2 sec BELL and W Or "A" Fl 4 sec BELL on the line south of Conanicut Island?

Answer: _____

P3-18. What are the bottom characteristics at the following positions?

- a. L: 41° 23.0'N, Lo: 71° 09.6'W: _____
- b. L: 41° 25.4'N, Lo: 71° 07.5'W: _____
- c. L: 41° 20.4'N, Lo: 71° 09.1'W: _____
- d. L: 41° 10.4'N, Lo: 71° 24.5'W: _____
- e. L: 41° 16.1'N, Lo: 71° 31.1'W: _____

P3-19. Can the light at Gay Head on the west tip of Martha's Vineyard be seen from a position south of Nomans Land?

Answer: _____

P3-20. Describe the area around the Weepecket Islands, located north of Naushon Island.

Answer: _____

LESSON 4.—THE NAVIGATOR'S TOOLS & INSTRUMENTS

A. Introduction. *The objectives of this lesson are to enable the student to:*

1. become familiar with the tools that the navigator uses in everyday practice,
2. develop basic skills and familiarity with the use of the plotting instruments, and
3. learn how the other instruments and equipment are used in the practice of navigation.

B. Study Questions:

- S4-1. Many of the navigator's tools are relatively inexpensive, particularly in comparison to the obvious benefits of their use. Accuracy depends on good _____, but also upon good _____ in the use of the tool.
- S4-2. The basic purposes of a plotter are to be able to draw _____ on the nautical chart and to measure the _____ of these _____ with respect to either the parallels of latitude or the meridians of longitude.
- S4-3. The purpose of the nautical slide rule is to quickly solve _____ problems _____.
- S4-4. A _____ may be used for taking visual bearings on landmarks and Aids to Navigation.
- S4-5. _____ is one of the basic dimensions of piloting. A reliable _____ is essential. Without a means of telling _____, dead reckoning navigation, running a search pattern, or identifying the proper characteristic of an ATON are all impossible.
- S4-6. A good _____ can be useful in locating and identifying visual landmarks and ATONs. Avoid _____ with more than _____ as these are nearly impossible to hold steady enough by hand alone.
- S4-7. The _____ may be used to ascertain shallow depths of water when the depth sounder is not available.
- S4-8. The _____ is one of the key variables which a navigator considers in safety of navigation. Groundings have accounted for approximately _____ percent of recreational boating incidents in recent years.
- S4-9. Particularly on power vessels the mass of metal in the engine may cause appreciable _____ if bearings are taken with a handheld compass while standing over or near the engine.
- S4-10. The individual navigator must make the choice of which tools are appropriate to their needs and budget. At a minimum, a _____, charts, relevant _____, pencils, _____, dividers, a hand-bearing compass, a _____, portable navigation receiver, and some device for measuring water depth should be onboard.

C. Practice Problems:

Use the 1210-Tr chart for these practice problems. Use the deviation table given in Lesson 2 of this document if deviation is required. The precision expected is: distance to .1 M; direction within 1 degree; latitude or longitude to .1 minute; depth of water or height of objects to within 1 foot.

P4-1. What are the types of bottoms and what kind of flash would a flashing light-type display depth sounder indicate at the following positions?

- a. L: 41° 11.2'N, Lo: 70° 57.4'W: _____
- b. L: 41° 28.9'N, Lo: 70° 53.3'W: _____
- c. L: 41° 30.1'N, Lo: 70° 38.7'W: _____
- d. L: 41° 28.2'N, Lo: 70° 49.8'W: _____
- e. L: 41° 14.1'N, Lo: 70° 49.3'W: _____

P4-2. What is the object located at L: 41° 12.2'N, Lo: 70° 50.0'W?

Per chart notation _____

In plain English _____

P4-3. What is the object located at L: 41° 21.8'N, Lo: 70° 51.9'W?

Answer: _____

P4-4. What is the bearing to the object in P4-2 from the object in P4-3 above?

_____ TRUE

_____ MAGNETIC

_____ COMPASS

P4-5. What is the distance between the objects in P4-4 above?

Answer: _____

P4-6. While at L: 41° 12.2'N, Lo: 70° 50.0'W and steering toward a large object in the distance exhibiting a flashing light, the compass reads 336C. What is the object and what are its position coordinates?

Answer: L: _____

Lo: _____

P4-7. How far away is the object identified in P4-6?

Answer: _____

P4-8. Provide the positions for the following buoys in Buzzards Bay beginning NW of Woods Hole and proceeding southwesterly:

- | | |
|----------------------------|---------------------|
| Answer: a. RG N: | L: _____, Lo: _____ |
| b. R "10" Fl R 4 sec GONG: | L: _____, Lo: _____ |
| c. BW "BB" Mo (A) BELL: | L: _____, Lo: _____ |
| d. R "8" Fl R 4 sec GONG: | L: _____, Lo: _____ |
| e. R "6" Fl R 4 sec BELL: | L: _____, Lo: _____ |

- P4-9. In problem 4-8, above, what are the directions to each end of the line between:
- a. Buoy RG N and Buoy BW "BB" Mo (A) BELL?
Answer: _____ or _____ TRUE
_____ or _____ MAGNETIC
- b. and, using the deviation table given in this guide, the compass courses to steer:
Answer: _____ or _____ COMPASS
- P4-10. What are the depth of water and the bottom characteristic at the position bearing dead ahead from L: $41^{\circ} 26.3'N$ Lo: $70^{\circ} 46.9'W$?
- Answer: a. 6.6M @ 323C? _____
b. 3.5M @ 223C? _____
c. 4.4M @ 251C? _____
d. 5.4M @ 083C? _____
e. 7.6M @ 177C? _____
- P4-11. Identify the objects found at the following positions:
- Answer: a. L: $41^{\circ} 21.3'N$ Lo: $70^{\circ} 44.2'W$: _____
b. L: $41^{\circ} 20.5'N$ Lo: $70^{\circ} 48.8'W$: _____
c. Bearing 260° 4.2M from L: $41^{\circ} 25.4'N$ Lo: $70^{\circ} 40.3'W$

d. Heading $261^{\circ}C$ 7.2M from L: $41^{\circ} 15.7'N$ Lo: $70^{\circ} 41.6'W$

e. Heading $054^{\circ}C$ 9.0M from L: $41^{\circ} 14.4'N$ Lo: $70^{\circ} 58.4'W$

- P4-12. Identify the objects found at the following positions:
- Answer: a. L: $41^{\circ} 25.6'N$ Lo: $70^{\circ} 52.6'W$: _____
b. L: $41^{\circ} 25.2'N$ Lo: $70^{\circ} 56.1'W$: _____
c. Bearing 236° 11.0M from L: $41^{\circ} 30.0'N$ Lo: $70^{\circ} 50.0'W$

d. Bearing $334^{\circ}C$ 7.6M from L: $41^{\circ} 11.8'N$ Lo: $70^{\circ} 53.5'W$

e. Bearing $277^{\circ}C$ 3.0M from L: $41^{\circ} 17.6'N$ Lo: $71^{\circ} 00.1'W$

P4-13. Determine the true and magnetic directions of the following objects from BUZZARDS Light:

Answer: a. Lighted buoy RW "NA" Mo (A) WHISTLE (midchannel in Vineyard Sound between Gay Head and Nashawena Island)

b. Lighted buoy "27" Fl G 4 sec BELL (south side of channel in Vineyard Sound southeast of Naushon Island)

c. SPIRE at Chilmark, on west end of Martha's Vineyard

d. TOWER on Gooseberry Neck (on Massachusetts shore north of Buzzards)

e. WINDMILL on Round Hill Point (midway to New Bedford NNE of Buzzards)

P4-14. Determine the true and magnetic directions of the following objects from the MONUMENT on NASHAWENA Island: (NOTE: *This problem is intended to solely give you practice in measuring directions on the chart. In fact, the monument on NASHAWENA Island is quite difficult to see.*)

Answer: a. Lighted buoy RW "NA" Mo (A) WHISTLE (midchannel in Vineyard Sound between Gay Head and Nashawena Island)

b. Lighted buoy "27" Fl G 4 sec BELL (south side of channel in Vineyard Sound southeast of Naushon Island)

c. SPIRE at Chilmark, on west end of Martha's Vineyard

d. TOWER on Gooseberry Neck (on Massachusetts shore north of Buzzards)

e. WINDMILL, on Round Hill Point (midway to New Bedford NNE of Buzzards)

P4-15. Determine the true and magnetic directions from the following objects to BUZZARDS Light:

Answer: a. Lighted buoy RW "NA" Mo (A) WHISTLE (midchannel in Vineyard Sound between Gay Head and Nashawena Island)

_____ or _____

b. Lighted buoy "27" FI G 4 sec BELL, (south side of channel in Vineyard Sound southeast of Naushon Island)

_____ or _____

c. SPIRE at Chilmark, on west end of Martha's Vineyard

_____ or _____

d. TOWER on Gooseberry Neck (on Massachusetts shore north of Buzzards)

_____ or _____

e. WINDMILL on Round Hill Point (midway to New Bedford NNE of Buzzards)

_____ or _____

P4-16. Determine the true and magnetic directions from the following objects to the MONUMENT on Nashawena Island:

Answer: a. Lighted buoy RW "NA" Mo (A) WHISTLE (midchannel in Vineyard Sound between Gay Head and Nashawena Island)

_____ or _____

b. Lighted buoy "27" FI G 4 sec BELL (south side of channel in Vineyard Sound southeast of Naushon Island)

_____ or _____

c. SPIRE at Chilmark, on west end of Martha's Vineyard

_____ or _____

d. TOWER on Gooseberry Neck (on Massachusetts shore north of Buzzards)

_____ or _____

e. WINDMILL on Round Hill Point (midway to New Bedford NNE of Buzzards)

_____ or _____

P4-17. What are the true directions of the following ranges?

Answer: a. RW "NA" Mo (A) WHISTLE and "29" FIG 4 sec GONG (South Vineyard Sound):

_____ or _____

b. "1" FIG 4 sec BELL and R "2" FI R 4 sec WHISTLE (South of Nomans Land:

_____ or _____

c. G C "5" and G C "3" (North of Nomans Land):

_____ or _____

d. SPIRE on Gay Head and SPIRE at Chilmark:

_____ or _____

e. Qk F1 63 ft 12M and LOOK TR on Cuttyhunk Island:

_____ or _____

P4-18. What Navigation Rules would apply in Buzzards Bay?

Answer: _____

P4-19. What Navigation Rules would apply in the vicinity of Nomans Land?

Answer: _____

LESSON 5.—DEAD RECKONING

A. Introduction. *The objectives of this lesson are to enable the student to:*

1. have a working knowledge of dead reckoning methods including plotting, labeling, measuring and determining dead reckoning (DR) positions,
2. be able to use time, speed, and distance formulas to solve problems involving these quantities, and
3. learn how speed can be estimated using a tachometer with a “speed curve” giving the relationship between engine RPM and speed.

B. Study Questions:

- S5-1. The practice of estimating position by advancing a known position for courses and distances run is called _____.
- S5-2. In the process of dead reckoning, courses are drawn on the chart as solid lines from a known starting position called a _____.
- S5-3. Courses and speeds are appropriately labeled, and DR positions and times are plotted at each _____.
- S5-4. The DR position is labeled by a _____ surrounded by a _____, and the time, using the 24-hour system, is written on the chart at an _____ to the horizontal.
- S5-5. Course (C) is the average _____ and the horizontal _____ in which a vessel is intended to be steered, expressed as the angular distance relative to north, 000 to 359 degrees clockwise from the point of departure or start of the course to the point of arrival. The reference direction is _____ and if so used, need not be labeled. Magnetic courses, if used, are labeled after the three-digit direction with the letter _____.
- S5-6. An improved position based upon the DR position and which may include, among other things, factoring in the effects of wind and current, or a single line of position, is termed an _____ (EP).
- S5-7. The most accurate visual fix is obtained from _____ objects above the horizon _____ to _____ degrees apart in azimuth. *A dead reckoning plot is always renewed (restarted) at a fix or running fix.*
- S5-8. The speed in knots (nautical miles per hour) at which a current is moving is termed _____.
- S5-9. The instantaneous direction of a vessel’s bow is termed _____.
- S5-10. The _____ (SOA) indicates the speed intended to be made relative to the ground along the track line.
- S5-11. A _____ (RFX) is a fix obtained by means of LOPs taken at different times and adjusted to a common time. This practice involves advancing or retiring LOPs as discussed in Chapter 6.

- S5-12. The mechanism used to accomplish calibration of speed logs or tachometers in terms of actual speed through the water is the development of the _____, a graphic plot of observed speed versus RPM.
- S5-13. In solving for distance when speed and time are known, what formula is used?
D=_____
- S5-14. In solving for speed when distance is known and time can be calculated, what formula is used?
S=_____
- S5-15. In solving for time when speed and distance are known, what formula is used?
T=_____
- S5-16. The intended or desired horizontal direction of travel with respect to the ground is termed _____.

C. Practice Problems:

Use the 1210-Tr chart for the practice problems below. *When required, use the deviation table found in Lesson 2 of this study guide.* The precision for these problems is: to the nearest 0.1 M, to the nearest degree of direction, to the nearest 0.1 minute of L and Lo, to the nearest foot for depth of water, and to the nearest minute for time.

- P5-1. Convert the following civil times to corresponding 24-hour system times:

Civil Time	24-Hour Time
a. 10:15 p.m.	_____
b. 9:28 a.m.	_____
c. 9:28 p.m.	_____
d. 1:25 a.m.	_____
e. 10:15 a.m.	_____
f. 1:38 p.m.	_____
g. 8:15 p.m.	_____
h. 7:25 a.m.	_____
i. 12:03 p.m.	_____
j. 12:03 a.m.	_____

- P5-2. For the following departure and arrival times, indicate the time interval between these times in hours and minutes, and in minutes:

DEPARTURE	ARRIVAL	HOURS	MIN	TOTAL MINUTES
a. 0800	0819	_____	_____	_____
b. 0200	1525	_____	_____	_____
c. 0928	2335	_____	_____	_____
d. 0948	1822	_____	_____	_____
e. 1327	1506	_____	_____	_____

- P5-3. Using the forms of the Speed, Time, and Distance formulas, complete the following table:
(Precision: Speed to nearest 0.1 kn, Time to nearest minute, and Distance to nearest 0.1 M)

SPEED	TIME		DISTANCE
(kn)	(hr)	(min)	(M)
a. 8.0	_____	_____	12.5
b. 15.0	2	28	_____
c. _____	0	46	5.0
d. 9.0	_____	_____	15.0
e. 6.0	3	23	_____
f. _____	0	45	9.8
g. 7.0	1	30	_____
h. _____	1	19	23.6
i. 5.0	_____	_____	1.0
j. 8.0	_____	_____	3.0

- P5-4. At 0900, we take departure from Buoy R “16” Fl R 6 sec BELL just south of the entrance to Falmouth Inner Harbor (L: 41° 32.0’N Lo: 70° 36.5’W), and set a course for Buoy R “26” Fl R 4 sec BELL, running at 8.0 knots. Plot this course line, labeling it with course and speed, time of departure, and time expected to pass Buoy R “26” close aboard.
- True Course _____; Magnetic Course _____; Compass Course _____
 - DEP: _____
 - Time at Buoy R “26” _____
- P5-5. We pass buoy R “26” close aboard at 0920, a little late because of some extra maneuvering, and turn to pass close aboard buoy “27” Fl G 4 sec BELL, maintaining our speed of 8.0 knots. What are our new true, magnetic, and compass courses? When do we expect to arrive at buoy “27”? Plot and label the new course and DR plot.
- True Course _____
 - Magnetic Course _____
 - Compass Course _____
 - Time at buoy “27” _____
- P5-6. We pass buoy “27” at 0940, change course for buoy “29” Fl G 4 sec GONG, and bring up our speed to 10.0 knots. Draw and label our new DR plot, indicating true, magnetic, and compass courses, speed, and DR positions for 1000 and 1030. Indicate latitude and longitude for the 1000 and 1030 positions, and the time expected to arrive at buoy “29”.
- True Course _____
 - Magnetic Course _____
 - Compass Course _____
 - 1000 DR L: _____ Lo: _____
 - 1030 DR L: _____ Lo: _____
 - Time at buoy “29” _____

P5-7. After passing buoy “29” at 1039, we turn to a true course of 181° and come up to a speed of 15.0 kn. Calculate our magnetic and compass courses. Construct a DR plot for 1100 and 1130, and indicate the latitude and longitude for these positions. Remember to label the plot with the course and speed, and the DR positions with the time and DR position symbol.

- a. Magnetic Course _____
- b. Compass Course _____
- c. 1100 L: _____ Lo: _____
- d. 1130 L: _____ Lo: _____

P5-8. As we run on C181/S15.0, above, we note a white orange can buoy (W Or C) off our port beam (270R) at 1048. What are its compass (looking over the vessel’s compass while on the above heading), magnetic, and true bearings, and which buoy is it? Draw a line from the buoy along the true bearing and label it with the time on top of the line and the true bearing from the vessel on the bottom of the line.

- a. Compass bearing _____
- b. Magnetic bearing _____
- c. True bearing _____
- d. Chart identification of buoy _____
- e. Bearing line label _____

P5-9. Develop a Speed Table for the following information obtained from a speed trial over a measured nautical mile. Plot a speed curve from the table.

RPM	“Out” Run (min)	“Back” Reciprocal Run (min)
500	—	30.0
1000	60.0	20.0
1500	30.0	15.0
2000	20.0	12.0
2500	12.0	8.6
3000	8.6	6.7
3500	5.5	4.6
4000	4.0	3.5
4500	3.8	3.3
5000	3.7	3.2

Note: In this example, unlike that in the text, the “seconds” have already been converted to decimal minutes. For example, the measured time for the out leg was 8 minutes 36 seconds, or 8 and $36/60 = 8.6$ minutes. The speed for this leg is (from the equation in the text) $60(1)/8.6 = 7.0$ knots.

P5-10.* Your vessel *Mei Toi* is 47 ft. long. You have a crewman drop a small block of wood overboard at the bow and, using a stopwatch, record the number of seconds it takes for your stern to pass the wood. You record 7 seconds. What is your estimate of *Mei Toi*’s speed in knots?

Answer: _____

LESSON 6.—PILOTING

A. Introduction. *The objectives of this lesson are to enable the student to:*

1. understand the Line Of Position (LOP) concept,
2. understand the way a bearing is used to plot the LOP from the charted object,
3. establish a RUNNING FIX by advancing or retiring an LOP,
4. understand the use of danger bearings to avoid unseen but charted hazards to navigation, and
5. know the proper way to plot an Estimated Position or Most Probable Position when the data are lacking for a FIX.

B. Study Questions:

S6-1. What distinguishes PILOTING from other branches of navigation?

Answer: _____

S6-2. Why are LOPs drawn on buoys (floating atons) to be treated with caution?

Answer: _____

S6-3. What is the proper way to label an LOP?

Answer: _____

S6-4. How can a relative bearing be used to plot an LOP?

Answer: _____

S6-5. How can a range be used to obtain an LOP if no bearing was obtained for the range?

Answer: _____

Note: If the range includes a floating ATON (or a fixed ATON or charted landmark that is not absolutely identified), it is recommended that a bearing be obtained to verify the location of the floating aid (or the identity of the charted landmark).

A comparison of the true bearing obtained on a fixed range with the charted bearing also confirms the accuracy of the compass used. Refer to “Spot Checks” in Chapter 2 of the text for further instruction.

S6-6. A circle of position is based on a measurement of distance to the charted object. What methods of measuring distance are generally available to the navigator?

Answers: a. _____

b. _____

c. _____

S6-7. When using the height of an object printed on the 1210-Tr chart, what are the units used and what is the reference (datum) for the measurement?

Answer: _____

S6-8. List six type of FIXES discussed in the text:

Answers: a. _____
b. _____
c. _____
d. _____
e. _____
f. _____

S6-9. What factors can affect the accuracy of an LOP?

Answers: a. _____
b. _____
c. _____
d. _____

S6-10. How are visual FIXES labeled?

Answer: _____

S6-11. List the steps necessary to plot a running fix.

a. _____
b. _____
c. _____
d. _____

C. Practice Problems:

Use the 1210-Tr chart for the practice problems below. When required, use the deviation table found in Lesson 2 of this study guide. The precision for these practice problems is: to the nearest 0.1 M for distance, to the nearest degree of direction, to the nearest 0.1 minute of L and Lo, and to the nearest minute for time. NOTE: The work should be done on the chart. However, to provide a means of verification, the basic labeling of LOPs, course lines, etc., should be entered in the Student Study Guide in the answer space provided. For example, an LOP of 270° established at 5:30 p.m. would be labeled on the chart and in the guide as:

$$\frac{1730}{270}$$

Remember: The convention in this text is that all course and bearing lines on the chart must be indicated as TRUE directions. This is done by showing the bearings, courses, etc., as a three-digit number without an initial.

P6-1. With the object dead ahead (RB 000°), plot and label the following LOPs: (Make the length of the LOP about 5M long.)

OBJECT	TIME	BEARING
a. MONUMENT, CUTTYHUNK I.	6:13 p.m.	330
Answer: _____		
b. CUPOLA, NAUSHON I.(NE)	9:30 a.m.	012C
Answer: _____		

- | | | |
|---------------------------------------|----------------|------|
| c. SPIRE, CHILMARK, MARTHA'S VINEYARD | 1:00 p.m. | 314C |
| Answer: _____ | | |
| d. SPIRE, GAY HEAD, MARTHA'S VINEYARD | 10:53 p.m. | 168C |
| Answer: _____ | | |
| e. WATER TOWER, WOODS HOLE | 10:16 a.m. | 157C |
| Answer: _____ | | |
| f. TOWER, GOOSEBERRY NECK | 7:30 a.m. | 288C |
| Answer: _____ | | |
| g. TOWER, GOOSEBERRY NECK | 8:01 a.m. | 358C |
| Answer: _____ | | |
| h. BUTLER FLATS LIGHT, NEW BEDFORD | 6:25 a.m. | 334C |
| Answer: _____ | | |
| i. NEW BEDFORD R TR (WNBH) | 6:25 a.m. | 324C |
| Answer: _____ | | |
| j. TOWER, WEST ISLAND | 3:28 a.m. | 288C |
| Answer: _____ | | |
| k. SOUTH TIP, PENIKESSE I. | 2:31 p.m. | 039C |
| Answer: _____ | | |
| l. RADAR TOWER, MARTHA'S VINEYARD | 12:00 midnight | 005C |
| Answer: _____ | | |

P6-2. Plot and label the following ranges:

- | TIME | OBJECT (A) | OBJECT (B) |
|---------------|-------------------------------------|--|
| a. 2:15 a.m. | GAY HEAD, SPIRE | GAY HEAD LIGHT
Alt Gp F1 (3) & (1) R 40 sec |
| Answer: _____ | | |
| b. 2:15 p.m. | MARTHA'S VINEYARD
CHILMARK SPIRE | RADAR TOWER |
| Answer: _____ | | |
| c. 3:12 p.m. | MARTHA'S VINEYARD
LOOKOUT TOWER | AERO Rot W & G |
| Answer: _____ | | |

- d. 12:23 a.m.

	DOME	WOODS HOLE	WATER TOWER
--	------	------------	-------------

Answer: _____

e. 7:35 a.m.

	WINDMILL	ROUND HILL POINT	TANK
--	----------	------------------	------

Answer: _____

f. 8:35 p.m.

	MONUMENT	NASHAWENA ISLAND	HOUSE
--	----------	------------------	-------

Answer: _____

g. 11:23 a.m.

	MONUMENT	CUTTYHUNK ISLAND	LOOKOUT TOWER
--	----------	------------------	---------------

Answer: _____

h. 6:28 p.m.

	CUTTYHUNK I. LOOKOUT TOWER	NASHAWENA I. MONUMENT
--	-------------------------------	--------------------------

Answer: _____

i. 9:13 a.m.

	MENEMSHA POND ENTRANCE LIGHT	MARTHA'S VINEYARD RADAR TOWER
--	---------------------------------	----------------------------------

Answer: _____

j. 10:17 p.m.

	TOWER	FALMOUTH	STACK
--	-------	----------	-------

Answer: _____

P6-3. Plot and label the following Circles of Position:

OBJECT	TIME	DISTANCE (M)
a. GAY HEAD Alt Gp Fl (3) W & (1) R 40 Sec 170 ft 17 M Answer: _____	10:15 p.m.	3.1
b. CUTTYHUNK ISLAND LOOKOUT TOWER Answer: _____	7:15 a.m.	2.0
c. MARTHA'S VINEYARD LOOKOUT TOWER Answer: _____	6:25 a.m.	4.2
d. GAY HEAD SPIRE Answer: _____	8:25 a.m.	6.5

e. MARTHA'S VINEYARD AERO Rot W & G 2:28 p.m. 5.0

Answer: _____

f. NOMANS LAND, NORTH TIP 11:38 p.m. 5.2

Answer: _____

g. PENIKESSE I., SOUTH TIP 12:03 a.m. 3.2

Answer: _____

h. WOODS HOLE WATER TOWER 3:15 p.m. 2.6

Answer: _____

i. BUTLER FLATS LIGHT 6:18 p.m. 1.8

Answer: _____

j. GOOSEBERRY NECK TOWER 5:27 p.m. 1.9

Answer: _____

k. BUZZARD'S LIGHT 1:00 p.m. 3.7
Fl 2.5sec 101ft 22M HORN

Answer: _____

P6-4. At 10:30 p.m., while on a course of C231 at 10.0 kn, from Buoy "27" F1G 4 sec BELL, in Vineyard Sound, you note a light flashing every six seconds on the starboard beam (090R) when your heading is 251C.

a. Draw the course line and label it:

Answer: _____

b. Plot the bearing and label it:

Answer: _____

P6-5. While heading 251C, at 7:00 p.m. south of PASQUE Island, you note a flashing green light every four seconds off your port bow (315R). Plot the bearing and label it.

Answer: _____

P6-6. The MONUMENT on NASHAWENA ISLAND can be seen off the starboard bow (045R) while on heading 251C at 9:30 a.m. Plot the bearing and label it.

Answer: _____

P6-7. On another day at 6:25 a.m., while running C262C at S10.0, you sight the CUTTYHUNK ISLAND MONUMENT on the starboard beam over the vessel's compass at 090R. At the same time you note that the MONUMENT and the HOUSE on NASHAWENA ISLAND are in range.

- a. What is the *compass* bearing of the CUTTYHUNK MONUMENT?

Answer: _____

- b. Plot and label the FIX, and determine its latitude and longitude:

Answer: L: _____

Lo: _____

Note: This assumes that the range can be seen from the SW of NASHAWENA Island. Assume this is true for the purpose of solving this problem.

P6-8. Southeast of GAY HEAD on MARTHA'S VINEYARD at 1527, you are barely making way, and you take a bow bearing of 322C on GAY HEAD SPIRE. You then turn the boat toward the AERO Rot W & G beacon at the airport on MARTHA'S VINEYARD and obtain a bearing of 029C.

- a. Plot and label these two LOPs and the resulting FIX:

Answer: _____

- b. What is the position of the FIX?

Answer: L: _____

Lo: _____

P6-9. At 0625 you are between NASHAWENA ISLAND and GAY HEAD and note that the MONUMENT and HOUSE on NASHAWENA ISLAND are in range. You also note that the SPIRE and the light on GAY HEAD (Alt Gp Fl (3) W & (1) R 40 sec, 170 ft 17 M) are in range. Plot these two LOPs and plot and label the FIX they form. What is the position of the FIX?

Answer: FIX label: _____

L: _____ Lo: _____

Note: Assume, for purposes of this problem, that both ranges are visible.

P6-10. At 0715, while on course of C288C at ordered speed of 10.0 kn, you detect a strong PIP on the RADAR at the NW tip of GAY HEAD, range 5.6M. You also notice a good PIP about the center of CUTTYHUNK ISLAND which you decide is the TOWER and measure the range at 5.1M.

Plot and label these two LOPs and the FIX they determine. Answer:

- a. FIX label: _____

- b. Position: L: _____ Lo: _____

- c. Bearing to PIP on GAY HEAD: _____

- d. Bearing to PIP on CUTTYHUNK: _____

Note: "Ordered speed" is a military term used to denote the vessel's speed through the water as requested by the Captain.

P6-11. While underway at 2215 on course C239C, you take a RADAR distance (5.1M) and bearing (082R) on the North tip of NOMANS LAND. Plot and label the LOPs, determine and label the FIX, and provide its position.

Answer: a. FIX label: _____
 b. Position: L: _____ Lo: _____
 c. Range LOP: _____
 d. Bearing LOP: _____

P6-12. While underway on C231/S10.0 from Buoy “27” Fl G 4 sec BELL, approximately three miles southwest of WOODS HOLE entrance in VINEYARD SOUND, you take a bearing on the light at the head of TARPAULIN COVE, NAUSHON ISLAND, Fl 6 sec 78 ft 9 M, at bearing 090R at 5:15 p.m. At 5:33 p.m. you take a bearing on the light at GAY HEAD, Alt Gp Fl (3) W & (1) R 40 sec, bearing 341R while on course.

a. Plot and label the course line: _____
 b. Plot and label the 5:15 p.m. LOP: _____
 c. Plot and label the 5:33 p.m. LOP: _____
 d. Advance the 5:15 LOP to 5:33. Plot and label. _____
 e. Plot and label the RUNNING FIX: _____
 f. Position: L: _____ Lo: _____

P6-13.* Assume all the same facts as in problem 6-12 with the additional information that, over this time period, at 5:30 p.m. a 2.5 kn current is flowing in VINEYARD SOUND toward 231 true.

a. Plot and label the course line: _____
 b. Plot and label the 5:15 p.m. LOP: _____
 c. Plot and label the 5:33 p.m. LOP: _____
 d. Advance the 5:15 LOP to 5:33. Plot and label. _____
 e. Plot and label the RUNNING FIX: _____
 f. Position: L: _____ Lo: _____

P6-14. While underway on C251C/S 10.0 in VINEYARD SOUND, you observe the light on GAY HEAD (Alt Gp Fl (3) W & (1) R 40 sec) bearing 315R at 10:30 a.m. Nine minutes later the light is abeam (270R). Plot and label the RUNNING FIX and determine its position.

Answer: Fix _____
 L: _____ Lo: _____

P6-15.* Continuing from the position determined in 6-14 above, establish a danger bearing using BUZZARDS LIGHT (Fl 2.5 sec 101 ft 22M HORN) to clear the Sow and Pigs Reef by .5 M. What are the true, magnetic, and compass (ship's head) danger bearings on the BUZZARDS LIGHT?

Answers: _____, _____, _____

NOTE: Danger bearings are used by the helm to avoid a danger. Therefore, the practice is to give warning in ship's heading compass reading to the helm. Also, hand-bearing compasses are used to determine the turning angle and most likely will be given to another watch and so should be in magnetic readings. The chart will be plotted in true. Look for easily found marks for use as danger-bearing targets—good ones include island edges or large structures such as the BUZZARDS Texas Tower.

P6-16. Departing at 6:11 p.m. from L: $41^{\circ} 18.8'N$ Lo: $70^{\circ} 51.7'W$, you are underway on C136C/S12.0. At 6:40 p.m. the CHILMARK SPIRE on MARTHA'S VINEYARD is observed to bear 236R while your heading is 136C.

- a. Plot and label the course line: _____
- b. Plot and label the 6:40 p.m. DR: _____
- c. Plot and label the SPIRE LOP: _____
- d. Plot and label an Estimated Position (EP) for the 6:40 p.m. LOP observation and determine its position:
EP _____ L: _____ Lo: _____

P6-17.* Prove that an EP constructed from a DR position and a single LOP is generally closer to the true position than the DR position.

LESSON 7.—CURRENT SAILING

A. Introduction. *The objectives of this lesson are to enable the student to:*

1. have an understanding of what is meant by current, and how it affects the motion of the vessel, and
2. solve various current problems on both the nautical chart and maneuvering board, including:
 - a. the determination of estimated positions, given knowledge of the course steered, speed maintained, and the set and drift of the current,
 - b. the determination of the actual set and drift of the current from knowledge of the course, speed, course made good (SMG), and speed made good (SMG),
 - c. the determination of the course to steer, and resultant speed of advance (SOA), given the set and drift of the current to make good an intended track (TR) and,
 - d. the determination of the course to steer and speed to maintain in order to make good a specified track and SOA, given the current set and drift.

B. Study Questions:

- S7-1. The process of allowing for current in determining the predicted course made good, or in determining the effect of a current on the direction of motion of a vessel is termed _____.
- S7-2. The term current as used in this context refers to three elements:
_____, _____, and _____.
- S7-3. Current is not used in preparing a DR plot; however, a DR position can be corrected for current. This position is termed an _____.
- S7-4. The estimated current is defined as the current _____.
- S7-5. The actual current is defined as the current _____.
- S7-6. The set of a current is the _____.
- S7-7. The drift of the current is the _____.
- S7-8. The current drift angle is the _____.
- S7-9. The difference between the track (COA) and the CMG is that the track refers to an _____ or _____ direction of travel with respect to the ground, whereas the CMG refers to the _____ direction of travel with respect to the ground.
- S7-10. In determining the estimated actual current from the vessel's DR position, the current vector is drawn _____.
- S7-11. Ideally, the actual current is determined by comparing the vessel's actual position with a contemporaneous DR position. However, if no fix is available, an _____ may be substituted for the fix. Such estimates, however, are likely to be less accurate than if a fix were available.
- S7-12. The current correction angle is a function of the _____.

C. Practice Problems:

Use a maneuvering board and/or the 1210-Tr chart to solve these problems. Take your time and plot the answers carefully. As used in these problems, the phrase “course to steer” or “course” refers to a true course. In practice this course would be translated to a compass course using the methods discussed in Chapter 2. Finally, in comparing your answers with those given in the text, you can be more generous in the error margins.

- P7-1. If the course sailed was C000/S10.0, and a FIX after one hour showed the course made good to be CMG000/SMG7.0, what were the SET and DRIFT of the current? Is the current fair or foul?

Answer: a. SET: _____
b. DRIFT: _____
c. (fair) / (foul)

- P7-2. If the course sailed was C090/S6.0, and a FIX after one hour showed the course made good to be CMG092/SMG5.2, what were the SET and DRIFT of the current?

Answer: a. SET: _____
b. DRIFT: _____

- P7-3. Given the course and speed to be C060/S10.0, and the course and speed made good to be CMG045/SMG9.0, what are the SET and DRIFT of the current?

Answer: a. SET: _____
b. DRIFT: _____

- P7-4. Given the course and speed to be C330/S9.5, and the course and speed made good to be CMG315/SMG9.1, what are the SET and DRIFT of the current?

Answer: a. SET: _____
b. DRIFT: _____

- P7-5. Given the course and speed to be C215/S8.0, and the course and speed made good to be CMG210/SMG7.3, what are the SET and DRIFT of the current?

Answer: a. SET: _____
b. DRIFT: _____

- P7-6. Given the course and speed to be C105/S8.5, and the set and drift to be SET240/DRIFT3.0, what are the course and speed made good?

Answer: a. CMG: _____
b. SMG: _____

- P7-7. Given the course and speed to be C105/S8.5, and the set and drift to be SET320/DRIFT1.4, what are the course and speed made good?

Answer: a. CMG: _____
b. SMG: _____

- P7-8. Given the course and speed to be C150/S7.6, and the set and drift to be SET024/DRIFT1.2, what are the course and speed made good?
- Answer: a. CMG: _____
b. SMG: _____
- P7-9. After determining the current vector to be SET000/DRIFT1.5, what course would you steer at a speed of S8.0 to make good an intended track, TR270? What would your SOA be? The time is now 1210, what is your ETA at a point along your TR that is 10.3 miles distant?
- Answer: a. COURSE: _____
b. SOA: _____
c. ETA: _____
- P7-10. After determining the current vector to be SET215/DRIFT2.0, what course would you steer at a speed of S10.0 to make good an intended track, TR083? What would your SOA be? What is your ETE to a point 4.3 miles distant?
- Answer: a. COURSE: _____
b. SOA: _____
c. ETA: _____
- P7-11. After determining the current vector to be SET140/DRIFT2.0, what course would you steer at a speed of S10.0 to make good an intended track of TR020? What would your SOA be?
- Answer: a. COURSE: _____
b. SOA: _____
- P7-12. While running a course of C060 at a speed of 10.0 kn for 1 hour and 10 minutes, you actually cover a distance of 9.0 M with a CMG of 045. What are the SET and DRIFT of the current?
- Answer: a. SET: _____
b. DRIFT: _____
- P7-13. While running a course of C282 at a speed of 10.0 kn for one hour, you actually cover a distance of 7.5 M with a CMG of 294. What are the SET and DRIFT of the current?
- Answer: a. SET: _____
b. DRIFT: _____
- P7-14. While running a course of C060 at a speed of 14.0 kn for one hour, you actually cover a distance of 15.6 M with a CMG of 063. What are the SET and DRIFT of the current?
- Answer: a. SET: _____
b. DRIFT: _____

P7-15. You are in Auxiliary vessel 273007 traveling in a generally southerly direction at the west end of Vineyard Sound. Using a hand-bearing compass, a magnetic bearing of 177M degrees is taken on the light on Gay Head at 1320. A magnetic bearing of 284M is taken on the Buzzards Bay entrance light at this same time. Plot and label the fix. You steer a course of 197 (true) and maintain a speed of 8.0 knots. At 1400 the light on Gay Head bears 074 M, and the Buzzards Bay light bears 331 M. What are:

a. The coordinates of the 1400 fix?

L: _____, Lo: _____

b. The CMG and SMG?

_____, _____

c. The SET and DRIFT of the current?

SET: _____, DRIFT: _____

(Note: use a variation of 015W in this and following problems.)

P7-16. Assuming the results determined in the answers to P7-15 above, suppose that you wished to voyage directly to the Buzzards Bay entrance light and maintain a speed through the water of 8.0 knots. What is (are) the:

a. True bearing and distance to the Buzzards Bay entrance light?

COURSE: _____ DISTANCE: _____

b. Course to steer, and estimated SOA?

COURSE: _____ SOA: _____

c. ETA at the light?

ETA: _____

P7-17. You are sailing in a loran-equipped yacht, *Business*. (This way, when your secretary receives a call, she can legitimately say that you are away on *Business*!) At 0930 you note the latitude and longitude readouts on the loran as L: 41° 20.0' N and Lo: 71° 10.0' W. You steer a course directly for buoy BW "SR" Mo (A) Whistle at the entrance to the Sakonnet River, and maintain a speed of 6.0 knots. After a few minutes it is apparent that you are drifting slightly to the left of the course to the "SR" buoy on your initial heading. At 1020 you again take a loran fix of L: 41° 23.2' N and Lo: 71° 12.7' W. What is (are) the:

a. CMG and SMG?

CMG: _____ SMG: _____

b. SET and DRIFT?

SET: _____ DRIFT: _____

- P7-18. You are in a twin-screw sport fisherman, *Argo*, south of Nomans Land. At 1700 you read the loran and note the latitude and longitude as L: 41° 10.0'N, and Lo: 70° 50.0'W respectively. You maintain a course of 050 (true) and speed of 12.0 knots. Meanwhile, someone inadvertently pours coffee over the loran and it quits. At 1730 you take a bearing on the radar tower on Martha's Vineyard with a hand-bearing compass, obtaining a reading of 005 M.
- What is your 1730 EP?
L: _____, Lo: _____
 - Using the EP just derived, the current set and drift are estimated to be
SET: _____ DRIFT: _____
 - To check your position, you also take a bearing on the light at Gay Head, which bears 332M. Plot the fix. A revised estimate of the actual current is
SET: _____ DRIFT: _____
Is this likely to be a better estimate? _____
- P7-19. During a westerly voyage through Buzzards Bay in the trawler *Equivoca*, you estimate the current set as 060, and the drift as 1.1 knots. This checks (more or less) with the predictions in the *Tidal Current Chart Narragansett Bay to Nantucket Sound*. Now, at 1400, you pass close abeam the Buzzards Bay entrance light enroute to the Sakonnet River, maintaining 6.0 knots. The planned or intended track is direct to buoy BW "SR" Mo (A) Whistle at the entrance to the Sakonnet River.
- What is the intended track? _____.
 - Assuming that the current stays the same as determined above, what are the course and estimated SOA on this leg to reach buoy BW "SR"?
COURSE: _____ SOA: _____
 - Lay out the DR plot. What are the coordinates of the 1500 DR position?
L: _____, Lo: _____
 - At 1500, you take a bearing with a handheld compass on the Tower (Aband LT HO) just southwest of Sakonnet Pt, and read 320 M, and another bearing on the tower at the end of Gooseberry Neck, which reads 073 M. What is your estimate of the current?
SET: _____ DRIFT: _____
- P7-20.* At 1500, while on a compass heading of 075 C (use the deviation table given in Chapter 2 of the ACN text) Auxiliary vessel, 273007, observes Pt. Judith Light (actually, the tip of Pt. Judith) on radar at a range of 2.0 nautical miles and bearing 235R. After taking this fix, the vessel turns to a compass course of 090C, and maintains a speed of 5.0 knots. According to available current information, the likely set is 000, and the drift 2.0 knots. At 1545, you take a bearing on the Brenton Reef Light (Gp Fl (2) 10 sec 87 ft 25 M) using a hand-bearing compass (assumed to be free of deviation) and note a bearing of 331 M. Plot the 1545 EP considering both current and the 1545 LOP. What is the distance from the 1545 EP to the Brenton Reef Light?
Answer: _____

P7-21.* A vessel cruising in an unknown current with drift, D_{ft} (knots), maintains a DR plot and fixes its position every T minutes. The error in the DR position compared to the fix is clearly $(T)(D_{ft})/60$ (nautical miles).

- a. What is the formula for the area of uncertainty, A , in sq. nautical miles?

Answer: _____

- b. If the vessel fixes its position once every 60 minutes and the drift is 2.5 knots, what is the possible area of uncertainty of its DR position?

Answer: _____

- c. Suppose the navigator wishes to ensure that the area of uncertainty is no more than 4 square nautical miles. What is the maximum time between fixes to ensure this accuracy?

Answer: _____

LESSON 8.—TIDES AND TIDAL CURRENTS

A. Introduction. *The objectives of this lesson are to enable the student to:*

1. understand the tidal phenomenon, its causes, and typical tidal variations,
2. appreciate the practical reasons why tides and tidal currents are important to the mariner,
3. know how to use the *Tide Tables* to estimate the height of the tide at any time, and
4. learn how to use the *Tidal Current Tables* to estimate the strength of the current at any time.

B. Study Questions:

- S8-1. Tides and currents arise from the same forces and, although related, are distinct terms. Tide refers to the _____ motion of the water, tidal current to the _____ flow of the water.
- S8-2. The term high water denotes _____ and low water denotes _____.
- S8-3. Tidal range is defined as _____.
- S8-4. There are three principal daily patterns observed for tides: _____, _____, and _____.
- S8-5. In addition to the daily tide patterns, there are more subtle patterns with a longer period. Tides have decreased range when the moon is in _____ and increased range when the moon is in _____.
- S8-6. When the moon and the sun are “pulling together,” larger tidal ranges, termed _____, occur.
- S8-7. Alternatively, when the gravitational force of the sun and the moon are at right angles, tides with smaller range, termed _____, occur.
- S8-8. In the United States and certain other parts of the world, the vertical reference plane or datum is what is termed _____.
- S8-9. Locations for which tidal predictions can be made with the aid of the *Tide Tables* are subdivided into two classes: _____ and _____.
- S8-10. The mean range is defined as _____.
- S8-11. The spring range is defined as _____.
- S8-12. The mean tide level (also termed half-tide level) is defined as _____.
- S8-13. Three common errors made by students in tide height calculations are: a. _____, b. _____, and c. _____.
- S8-14. Three methods for estimating tidal currents include: a. _____, b. _____, and c. _____.

S8-15. Data given in the *Tidal Current Tables* for reference stations include _____.

S8-16. A reversing current is defined as _____.

S8-17. A rotary current is defined as _____.

S8-18. The most important use of *Tidal Current Diagrams* is to determine _____.

C. Practice Problems:

Please refer to the tables contained in Chapter 8 of the ACN text, the worksheets and the computer output attached at the end of this lesson to solve the following problems.

P8-1. Anchorage, AK, has what type of tidal pattern? _____.

P8-2. San Francisco, CA, has what type of tidal pattern? _____.

P8-3. Assuming that the distance from the bow to the waterline of your vessel is 2 ft., you anchor at low tide with a water depth of 6 ft., the tidal range is 4 ft., and you deploy enough line for a scope of 7:1 at low tide, what is the actual scope at high tide? _____.

P8-4. What are the time and height of the first high tide at Newport, RI, on Sunday, 7 March 1999? _____.

P8-5. What are the time and height of the first low tide at Newport, RI on Saturday, 30 January 1999? _____.

P8-6. Over the three month period from January through March 1999, what are the date, time, and height of the highest high water at Newport, RI? _____.

P8-7. Over the same three month period referred to in P8-6 above, what are the date, time, and height of the lowest low water at Newport, RI? _____.

P8-8. What is the range of the tide between 0520 and 1151 on Saturday, 27 February 1999 at Newport, RI? _____.

P8-9. What station is references for Westerly, RI (#1195) in the *Tide Tables*? _____.

P8-10. What is the time of the first high tide at Sakonnet (#1145) on 14 January 1999? _____.

P8-11. What are the mean tidal range and spring tidal range at Cuttyhunk Pond Entrance (#1101)? _____.

P8-12. What are the times and heights of the high and low tides at Pt. Judith (#1187) on 27 February 1999? _____.

-
- P8-13. What is the predicted height of tide at 0600 at Pt. Judith (#1187) on 27 February 1999?
_____.
- P8-14. If the charted depth at Pt. Judith were 4 ft in problem 8-13, what would be the actual depth at 0600 on 27 February 1999? _____.
- P8-15. What is the time and speed of the first maximum ebbing current at Pollock Rip Channel on 27 February 1999? _____.
- P8-16. What is the set of the ebb current at Pollock Rip Channel? _____.
- P8-17. What are the times and currents at Dumpling Rocks (#2091) on 27 February 1999?
_____.
- P8-18. What is the current set and drift at Dumpling Rocks (#2091) at 0900 on 27 February 1999?
_____.
- P8-19. What is the current at New Bedford Harbor (#2106) at 0800 on 27 February 1999?
_____.
- P8-20. What is the estimated current at Ribbon Reef (#2046) at 0800 on 27 February 1999? (You may refer to the attached computer output.) _____.

Substation: _____	Date: _____	Look up these values from Table 2., "Tidal Differences and Other Constants." This section can be omitted if the desired location can be found in Table 1 "Daily Tide Predictions" of the <i>Tide Tables</i> . Height differences denoted with an asterisk are to be multiplied rather than added to reference station height.
Ref. Station: _____	Substation #: _____	
HW Time Diff: _____	Diff of Hgt. At HW: _____	
LW Time Diff: _____	Diff of Hgt. at LW: _____	

Calculations:		Look up heights and times for reference stations in Table 1., Daily Tide Predictions. Add or subtract time differences for substations to Table 1 times for reference Stations. Calculate the height at the substation from the height of the tide at the reference station plus or minus the height difference tabulated above, unless denoted with an asterisk — in which case the tabulated factors should be multiplied by the heights of the corresponding tides at the reference station. Keep in mind that the time differences may place the required reference tide on the day before or after the date in question for the substation. Remember, times given in tables are standard zone time, not daylight savings time. Subtract 1 hour from daylight savings time to calculate zone time.
Ref. Station: _____	Substation: _____	
Condition Time Height	Condition Time Height	
LW _____	LW _____	
HW _____	HW _____	
LW _____	LW _____	
HW _____	HW _____	
LW _____	LW _____	

Height of Tide at Any Time:		
Location: _____	Time: _____	Date: _____
Duration of Rise or Fall: _____	Length of time between high and low tides that bracket desired time	
Time from Nearest Tide: _____	Use the lesser of the times from the last tide, or time until the next tide	
Range of Tide: _____	Difference in height between tides on either side of desired time: re that subtracting a negative number is logically equivalent to addition	
Height of Nearest Tide: _____	Height of tide closest to desired time	
Tabled Correction: _____	From Table 3	
Height of Tide at Time: _____	Add above correction if nearest tide is low water, subtract otherwise	
Charted Depth: _____	Determined from chart	
Depth of Water at Time: _____	Add tide height to charted depth to calculate depth at required time	

▲
TABLE 8-1—Complete Tide Table Worksheet.

Substation: _____ Time Differences: _____ Min. Bef. Flood: _____ Flood: _____ Min. Bef. Ebb: _____ Ebb: _____	Ref. Station: _____ Speed Ratios: _____ Flood: _____ Ebb: _____	Date: _____ Directions: _____ Flood: _____ Ebb: _____	Look up these values from Table 2, "Current Differences and Other Constants." This section can be omitted if the desired location can be found in Table 1, "Daily Current Predictions." Pay careful attention to any footnotes applicable to the station.																								
CALCULATIONS: <table style="width: 100%; border-collapse: collapse;"> <tr> <td style="width: 50%;">Ref. Station: _____</td> <td style="width: 50%;">Substation: _____</td> </tr> <tr> <td>Condition Time Speed</td> <td>Condition Time Speed</td> </tr> <tr><td>Slack</td><td>Slack</td></tr> <tr><td>Ebb</td><td>Ebb</td></tr> <tr><td>Slack</td><td>Slack</td></tr> <tr><td>Flood</td><td>Flood</td></tr> <tr><td>Slack</td><td>Slack</td></tr> <tr><td>Ebb</td><td>Ebb</td></tr> <tr><td>Slack</td><td>Slack</td></tr> <tr><td>Flood</td><td>Flood</td></tr> <tr><td>Slack</td><td>Slack</td></tr> <tr><td>Ebb</td><td>Ebb</td></tr> </table>			Ref. Station: _____	Substation: _____	Condition Time Speed	Condition Time Speed	Slack	Slack	Ebb	Ebb	Slack	Slack	Flood	Flood	Slack	Slack	Ebb	Ebb	Slack	Slack	Flood	Flood	Slack	Slack	Ebb	Ebb	Look up times and speeds for reference station in Table 1. Add or subtract time differences for substations to Table 1 times for reference station (pay attention to date). Estimate the drift at the substation by multiplying the appropriate speed ratio by the drift at the reference station. Remember, times given in these tables are standard time in the 24-hour system.
Ref. Station: _____	Substation: _____																										
Condition Time Speed	Condition Time Speed																										
Slack	Slack																										
Ebb	Ebb																										
Slack	Slack																										
Flood	Flood																										
Slack	Slack																										
Ebb	Ebb																										
Slack	Slack																										
Flood	Flood																										
Slack	Slack																										
Ebb	Ebb																										
VELOCITY OF CURRENT AT ANY TIME: Location: _____ Time: _____ Date: _____ Interval Between Slack and Desired Time: _____ Interval Between Slack and Max Current: _____ Max Current: _____ Tabled Correction: _____ Calculated Velocity: _____ Direction: _____				Time difference between desired time and nearest slack. Time difference between slack and maximum current that bracket desired time. Drift of maximum current (ebb or flood) closest to desired time. From Table 3—be careful to use correct table if more than 1. Multiply correction by max current. Take direction from top data block.																							

TABLE 8-2—Complete Current Table Worksheet.

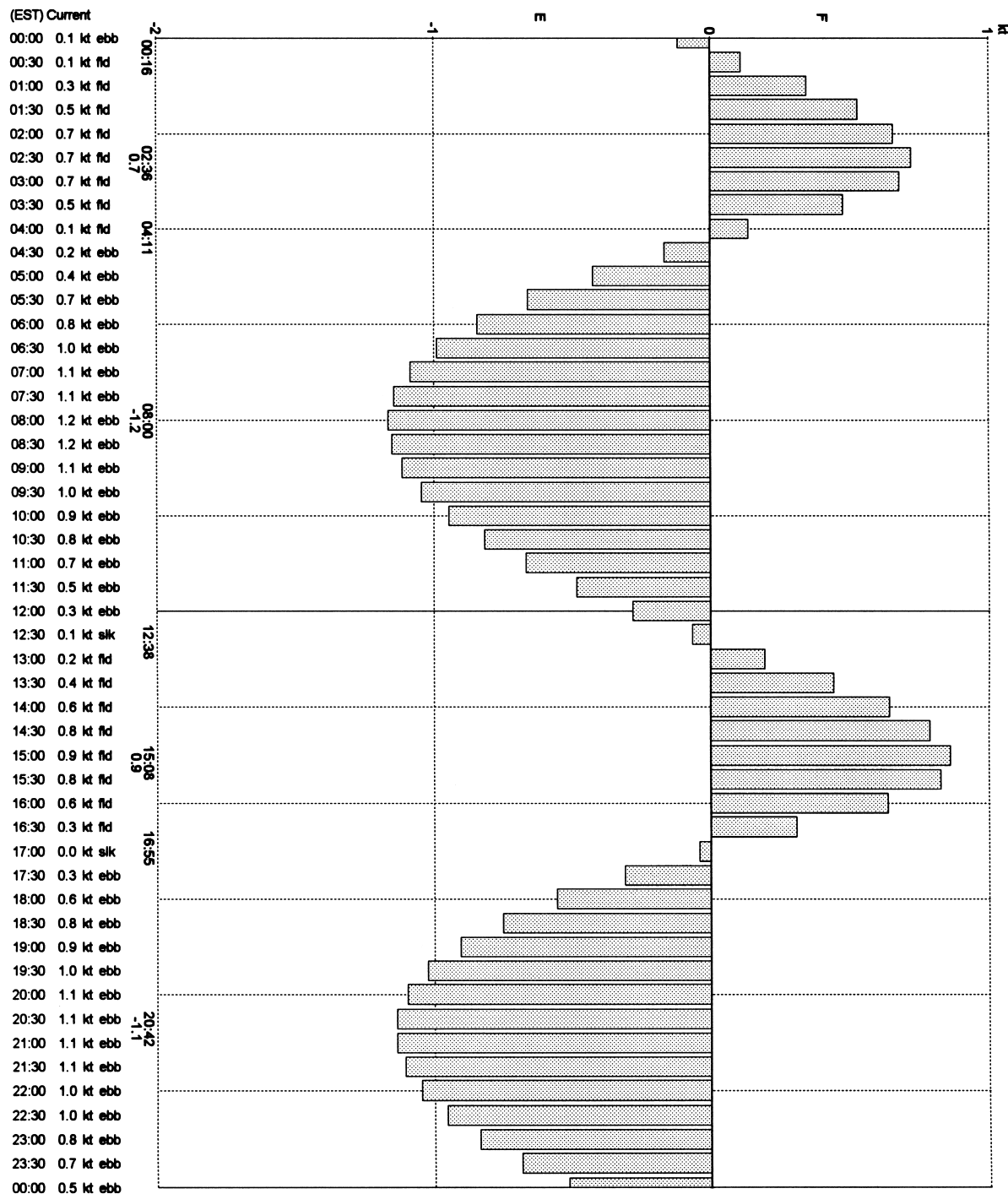
Currents-Ribbon Reef-Sow & Pigs Reef, between

based on Pollock Rip Channel, Massachusetts (NOAA)
41° 25.30 N 70° 58.20 W

Saturday, February 27, 1999

Average Currents
Min Before Flood: 0.0 kt --
Avg Max Flood: 0.8 kt 62°
Min Before Ebb: 0.0 kt --
Avg Max Ebb: 1.2 kt 237°

Slack Max Flood & Ebb
00:16 02:36 0.7 kt 62° fld
04:11 08:00 1.2 kt 237° ebb
12:38 15:08 0.9 kt 62° fld
16:55 20:42 1.1 kt 237° ebb



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LESSON 9.—RADIONAVIGATION

A. Introduction. *The objectives of this lesson are to enable the student to:*

1. understand the principles of operation of Loran-C, GPS and DGPS,
2. know how to use a navigation receiver for coastal piloting,
3. understand radar basics, and
4. know how to plot radar targets.

B. Study Questions:

- S9-1. The absolute accuracy of Loran-C is between _____ and _____ nautical miles.
- S9-2. The components of the Loran-C system include _____ and _____.
- S9-3. Using Loran-C, position is determined as the intersection of _____.
- S9-4. Loran-C LOPs are not printed on most harbor charts because _____.
- S9-5. The *Global Positioning System* (GPS) consists of three segments: _____, _____, and _____.
- S9-6. The principle of operation of GPS is based on satellite _____.
- S9-7. Historically, GPS provided two levels of service: the _____ and the _____.
- S9-8. The stated accuracy of the GPS under S/A (95% of the time) is _____.
- S9-9. A system of improved accuracy based upon additional corrections to GPS is termed _____. The horizontal accuracy of this system is approximately _____.
- S9-10. To ensure best accuracy for GPS receivers it is important to set the _____ to the same as that used on the nautical chart.
- S9-11. A waypoint is an imaginary point that can be _____ in the navigation receiver.
- S9-12. The cross-track error is defined as _____.
- S9-13. An arrival alarm warns the mariner when _____.
- S9-14. The modern radar display screen is known as a _____.
- S9-15. The two principal uses for radar aboard ships are _____ and _____.
- S9-16. Rule 7 of the NAVRULES states that “_____ use shall be made of radar equipment if fitted and operational, including long-range scanning to obtain early warning of risk of collision and _____ or equivalent systematic observation of detected objects.”
- S9-17. Two major radar display types are _____ and _____.

- S9-18. To increase the accuracy of range estimates, most radar units are also equipped with one or more _____.
- S9-19. To increase the accuracy with which relative bearings can be read, most modern radar units have one or more _____.
- S9-20. A CBDR target is one that exhibits _____ and presents a risk of collision.
- S9-21. CPA stands for the _____ and provides a possible indication of collision risk.
- S9-22. The relative motion plot is used to determine the following quantities: _____, _____, and _____.
- S9-23. The vector diagram is used to determine the target's _____ and _____.
- S9-24. Steps in radar plotting include _____, _____, _____, and _____.
- S9-25. ARPA is an acronym for _____.

C. Practice Problems:

Use the 1210-Tr chart, special worksheets, maneuvering boards, and navigator's tools to solve the following problems.

- P9-1. Vessel *Esplendido* is planning a trip from Menemsha Pond to Tiverton on the Sakonnet River. The following waypoints are defined: WP 01 buoy G "29" near the tip of Gay Head; WP 02 buoy RB "VS" near Buzzards Light; WP 03 buoy BW "SR" at the entrance to the Sakonnet River. Assuming these waypoints have been correctly entered into the GPS receiver, what should be the bearing and distance from WP 01 to WP 02? _____.
- P9-2. Assuming that the distance between waypoints 01 and 02 is 6.3 nautical miles and that vessel *Esplendido* makes 17 knots, what should be the time-to-go (TTG) indication for WP 02 as WP 01 is passed? _____.
- P9-3. *Esplendido* is equipped with an integrated Loran-C and GPS receiver. While enroute between WP 01 and WP 02, the Loran-C TDs (GRI 9960) read 14270 for the Whiskey TD and 43905 for the Yankee TD. Based on the position just determined, what is the approximate *cross-track error* (XTE) at this stage in the voyage? What should be the approximate bearing to WP 03? (Assume that the Loran-C receiver has been set up to read bearings in magnetic.)
_____.
- P9-4. *Esplendido* passes WP 02 close aboard. The next waypoint in sequence appears WP 03 (buoy BW "SR") in the display. If the waypoint has been entered correctly in navigation receiver, what should be the bearing and distance? _____.
- P9-5. What action should you take if the indicated distance to waypoint 03 in the navigation receiver were 18.2 miles as WP 02 is passed? _____.
- P9-6. Waypoint 03 is reprogrammed into the navigation receiver. The indicated distance is 10.7 miles. If *Esplendido* maintains 17 knots, what is the TTG? _____.

- P9-7. The horizontal chart datum is now shown in the title notes on all nautical charts produced in the United States. (It is not shown on the 1210-Tr chart.) At present, the majority of charts published by NOAA are on the North American Datum of 1983 (NAD 83), which is very similar to the World Geodetic System of 1984 (WGS 84). What is the relevance of the horizontal chart datum? _____.
- P9-8. A Loran-C TD fix is obtained in TD mode (X-ray and Yankee) as
TD1 = 25655.1
TD2 = 43950.0
As a check, the navigator glances at the depth sounder. Neglecting the state of the tide and assuming that the fix is accurate, what should the gauge read? _____.
- P9-9. A navigator on a route between two waypoints notices that the distance to the destination waypoint decreases steadily at first, then stops decreasing. Assuming that the vessel is being steered in the approximate direction of the waypoint, what are the possible explanations?
_____.
- P9-10. Chapter 9 notes that routes should be planned to allow an adequate margin of safety from navigational hazards (e.g., rocks, shoals) considering the probable accuracy of the navigational system. If the accuracy of the GPS system (SPS) is approximately 100 meters in the horizontal direction, does this mean that courses can be laid out to within 100 meters of charted hazards?
_____.
- P9-11. No Loran-C TDs are shown on the 1210-Tr chart in Narragansett Bay. Can this chart be used for Loran-C navigation in this area? _____.
- P9-12. Sport fisherman *Adrenaline Rush* is equipped with an unstabilized radar, *ship's head up* (SHU) display. Returning to the Harbor of Refuge at Pt. Judith at 0930, it is noted that, while on a heading of 285 compass (assume no deviation), Pt. Judith bears 050 R (using the EBL) at a range of 2.5 miles. Plot and label the fix. What are the coordinates of this position?
_____.
- P9-13. Referring to the position determined in P9-12, a target is observed bearing 014 R, range 1.4 M. What is this target? _____.
- P9-14. Vessel *Alacrity* fixes its position using GPS at L: 41° 10.0' N, Lo: 71° 10.0' W. While on a compass heading of 060 (deviation 5° east, variation 15° west) a target is observed on the PPI (SHU display). The bearing and range are 280 R and 2.2 miles, respectively. Plot the target's position on the 1210-Tr chart. What is the target? _____.

P9-15. A radar-reflective buoy is observed on the PPI (SHU display) as follows:

Time	Range	Relative bearing
XX05	4.0 M	030
12	2.8	040
19	1.8	069
26	1.6	117

What is the relative bearing of our *course made good* (CMG)? _____

What is our *speed made good* (SMG)? _____.

P9-16. Our vessel, *Negocios*, is making a course of 000 true at 10.0 knots.

A target is observed as follows:

Time	Our Heading	Range	Relative Bearing
XX24	000	2.0 M	042
30	000	1.0	017
36	000	0.8	300

What is the target? _____.

What is the CPA? _____.

What is the TCPA? _____.

What are the course and speed of the target? _____.

P9-17. Vessel 273007 is making good a course 305 magnetic at 10.0 knots. Readings on a target vessel (SHU display) are observed as follows:

Time	Heading	Range	Target Bearing
XX16	310	2.5 M	125
22	308	1.6	132
28	312	0.8	147

Prepare a radar plot as shown in the text.

What are the CPA and TCPA? _____.

What is the relative bearing of the CPA? _____.

What are the course and speed of the target? _____.

LESSON 10.—NAVIGATION REFERENCE PUBLICATIONS

A. Introduction: *The objectives of this lesson are to enable the student to:*

1. become acquainted with the important publications available to the mariner, including the *U.S. Coast Pilot*, the *Light List*, and the *Notices to Mariners*,
2. learn how to compute the visibility of a light, considering the height of the light, observer's height, prevailing visibility, and nominal range of the light, and
3. appreciate the importance of up-to-date charts and other publications.

B. Study Questions:

- S10-1. What agency publishes the *United States Coast Pilot*, and how many volumes are there in the series? _____
- S10-2. What are some of the topics covered in the *Coast Pilot*? _____
- S10-3. What agency publishes the *Light List*, and how frequently are these publications revised?

- S10-4. What is the definition of the geographic range of a light? _____
- S10-5. What is the definition of the luminous range of a light? _____

- S10-6. What is the definition of the nominal range of a light? _____

- S10-7. What is the relationship between the actual range at which a light can be seen and the luminous range and the geographic range? _____

- S10-8. What are typical contents of the *Notices to Mariners*? _____
- S10-9. In the LNM the abbreviation W/P means that an ATON is _____
- S10-10. Who publishes the *Local Notices to Mariners*? _____

5. VINEYARD SOUND AND BUZZARDS BAY

harbormaster is at the town-operated Falmouth Marina, on the west side halfway up the harbor; telephone (617-548-9796). The harbormaster monitors VHF-FM channels 16, 12, and 9. A ferry operates in the summer to Oak Bluffs from the wharf at the head of the harbor.

Nobska Point, about 29 miles westward of Monomoy Point, is a bluff with **Nobska Point Light** (41°30.9'N., 70°39.4'W.), 87 feet above the water, shown from a white tower, at the south end. A fog signal is at the light, and a radiobeacon is 50 yards northeastward. **Nobska Point Ledges**, partly bare at low water, extends 150 yards eastward and southwestward from the point.

Charts 13233, 13229.—**Middle Ground**, covered 4 to 17 feet, is the easterly half of a narrow, somewhat shifting ridge that extends for about 9 miles westward from a point about 0.5 mile northwestward of West Chop Light. A buoy is at the northeast end, and a lighted bell buoy off the southwestern end.

Lucas Shoal, covered 12 to 18 feet, is the southwestern end of the ridge. It is separated from the Middle Ground by a natural channel with a depth of 31 feet. A buoy marks the southwestern end of the shoal.

Lake Tashmoo, a landlocked pond on the northwest side of Martha's Vineyard, is entered through a narrow jettied entrance which had a reported controlling depth of 2½ feet in September 1981. The lake, only used by local craft, has general depths of 3 to 10 feet. A private seasonal light marks the east jetty and private seasonal buoys mark the channel through a shoal area just inside the entrance.

A 4 mph speed limit is enforced in the pond. Anchoring is prohibited in the entrance channel.

A small boatyard is on the easterly side of the lake; a flatbed trailer can handle craft up to 30 feet for hull and engine repairs. Guest moorings and limited supplies are available.

Norton Point and **Cape Higgon** are prominent bluffs on the northwest side of Martha's Vineyard about 3 and 8 miles, respectively, southwestward of West Chop Light.

Menemsha Bight, on the northerly side of the western end of Martha's Vineyard 2.5 miles east of Gay Head, affords shelter from southerly and easterly winds in depths of 25 to 60 feet, sticky bottom. (See 110.1 and 110.140 (c) (1) and (d), chapter 2, for limits and regulations for the anchorage area.) There are no dangers in the bight if the shore is given a berth of 0.3 mile.

Menemsha Creek, on the northwestern shore of Martha's Vineyard and about 3 miles eastward of Gay Head Light, is entered from Menemsha Bight through a dredged channel that leads southeastward to **Menemsha Basin**, on the north shore just inside the entrance. From the basin, the dredged channel continues southward through the creek to Menemsha Pond, about 1 mile above the entrance. The entrance to the creek is protected by jetties. The east jetty is marked by a light. A bell buoy, about 300 yards northwestward of the light, marks the channel approach, and buoys and daybeacons mark the channel.

In May 1986, the controlling depth was 8 feet to Menemsha Basin, thence depths of 2 feet could be carried to Menemsha Pond; depths of 6½ to 10 feet were available in the larger northwestern part of Menemsha Basin and 3½ to 5 feet in the smaller southeastern part, except for shoaling to 1 foot in the southeastern corner. The channel south of Menemsha Basin is reported to shoal rapidly after dredging; mariners are advised to seek local knowledge before attempting to go beyond Menemsha Basin.

Menemsha is a small fishing village on Menemsha Basin.

Menemsha Pond, a rectangular basin about 1 mile long and 0.7 mile wide, has general depths of 2 to 18 feet, with the deepest water in the southern half of the pond.

Tides and currents.—The mean range of tide in Menemsha Bight is 2.7 feet. The tidal currents through the entrance have an estimated velocity of 3 knots or more. Slacks are reported to occur 45 minutes after local high and low waters.

Guest moorings are available in Menemsha Basin, and anchoring is permitted in the pond. Berths are also available at the public facilities at Dutcher Dock, on the northeast side of the basin. Commercial fishing and charter boats berth at the dock or at the private piers on the west side of the basin. **Menemsha Coast Guard Station** is on the south side of the basin. The harbormaster controls all berthing and mooring in the basin. The harbormaster has an office at Dutcher Dock and can be contacted by radiotelephone on VHF-FM channel 16 or by telephone (617-645-2846).

Storm warning signals are displayed. (See chart.)

A marina is on the east side of Menemsha Basin. Repairs and hauling of craft to 45 feet can be arranged. Gasoline, diesel fuel, water, ice, launching ramp, and marine supplies are available.

Seasonal bus service is available from Menemsha to Vineyard Haven and other points on the island.

Gay Head, the westerly end of Martha's Vineyard, is a prominent high bluff. It is marked by **Gay Head Light** (41°20.9' N., 70°50.1' W.), 170 feet above the water, shown from a 51-foot red brick tower on the head. A lighted gong buoy is 1.6 miles northwestward of the light.

Devils Bridge is a reef making off 0.8 mile northwestward of Gay Head. The reef has a depth of 2 feet about 0.4 mile offshore and 17 feet at its end, which is marked by a buoy.

Nomans Land, about 5.5 miles southward of Gay Head, is a prominent, high, and rocky island. Except for a small section on its northwestern side, the shore consists of clay and gravel cliffs 10 to 18 feet high with boulders lining the shores. In the interior of the island are many hills, the highest over 100 feet high, with considerable marshy area between the hills. A danger zone surrounds Nomans Land. (See 334.70, chapter 2, for limits and regulations.)

Several sunken rocks and ledges are in the passage between Nomans Land and Martha's Vineyard. **Lone Rock**, covered 8 feet, and **Old Man**, a ledge covered 4 feet, are marked by buoys. A buoyed channel about 0.7 mile wide between the islands may be used by small vessels in the daytime. Shoal water extends 0.5 mile southward of **Squibnocket Point**, the southernmost point of Martha's Vineyard.

Charts 13230, 13229.—**Elizabeth Islands**, including **Nonamesset**, **Uncatena**, **Weepecket**, **Naushon**, **Pasque**, **Nashawena**, **Penikese**, and **Cuttyhunk Islands**, extend about 14 miles west-southwest from the southwest end of Cape Cod. The islands, forming part of the northern shore of Vineyard Sound, separate the sound from Buzzards Bay. They are hilly and partly wooded; the shores are, in general, low bluffs. Westward of Woods Hole are several buoyed channels between the islands, but Quicks Hole is the only one recommended for strangers.

Charts 13235, 13229.—**Woods Hole** is that water area lying between the southwest tip of Cape Cod and **Uncatena** and **Nonamesset Island**, the easternmost of the Elizabeth Islands, with Buzzards Bay on the northwest and Vineyard Sound on the southeast; it includes Great

C. Practice Problems:

Use the luminous range diagram, relevant exhibits given in the text, and the excerpt from the *U. S. Coast Pilot* shown on the opposite page, to answer the following questions.

P10-1. You are on the cabin cruiser *Night Hawk*, with a height of eye of 10 ft. when on the bridge. The prevailing visibility is 5.5 miles. There are two lights that might be used for navigation, light "A," 57 ft. high, with a nominal range of 20 miles, and light "B," 246 ft. high, with a nominal range of 14 miles. Which light is likely to be seen at a greater distance under these conditions?

Answer: _____

P10-2. Again on the bridge of the cabin cruiser *Night Hawk* (see above), what is the geographic range of a light that is 40 ft. high?

Answer: _____

P10-3. If the prevailing visibility were 11 miles, what would be the luminous range of a light identified in the *Light List* as "Al (3) W R 40s 170 W 21 R 17?"

Answer: _____

P10-4. Assuming a height of eye of 10 ft., and other information given in problem 10-3 above, at what range would the light be visible? Another larger trawler (height of eye 20 ft.) is cruising alongside; would an observer see this light before you?

Answer: _____

P10-5. According to the *U. S. Coast Pilot*, how large a berth to the shore should be given to ensure that there are no dangers when cruising in Menemsha Bight?

Answer: _____

P10-6. What is important to know about the channel south of Menemsha Basin?

Answer: _____

P10-7. How does the *U. S. Coast Pilot* characterize the passage between Nomans Land and Martha's Vineyard?

Answer: _____

P10-8. Whom should you contact to arrange for mooring at Menemsha Basin?

Answer: _____

P10-9. What channels are available west of Woods Hole that are recommended for strangers?

Answer: _____

LESSON 11.—FUEL AND VOYAGE PLANNING

A. Introduction. *The objectives of this lesson are to enable the student to:*

1. understand the basics of fuel planning, including the definitions of fuel efficiency, fuel reserve, endurance, and range,
2. understand the factors such as hull design, engine horsepower, throttle setting, condition of bottom, etc., that affect fuel consumption,
3. know how to use and develop fuel consumption curve for a vessel,
4. know how to allow for the effects of current in fuel-planning calculations, and
5. know how to do, prepare, and use a “Howgozit” chart for a voyage.

B. Study Questions:

- S11-1. What is a fuel consumption chart or curve? _____
- S11-2. Define the term *fuel efficiency*. _____
- S11-3. Define the term *range*. _____
- S11-4. Define the term *endurance*. _____
- S11-5. Define the term *fuel reserve*. _____
- S11-6. How does speed affect fuel efficiency and range for displacement or semi-displacement vessels? _____
- S11-7. How does speed affect fuel efficiency and range for planing hull vessels? _____
- _____
- S11-8. What are the factors that affect fuel efficiency? _____
- S11-9. How do fair or foul currents affect fuel efficiency? _____
- S11-10. What is a “Howgozit” chart? _____

C. Practice Problems:

The following problems (P11-1 through P11-4) are based upon the fuel consumption curve given below (assume that the vessel’s fuel capacity is 150 gallons):

Throttle Setting (RPM)	STW (Knots)	Fuel Consumption (GPH)
750	0.8	0.30
1000	1.0	0.43
1250	1.9	0.90
1500	3.3	2.00
1750	5.1	3.50
2000	7.5	5.50
2250	8.5	6.90
2500	9.8	9.50
2750	11.3	13.00
3000	11.5	18.00

P11-1. Assuming that there is no current (fair or foul), complete the table to calculate fuel efficiency (MPG), endurance (hours), and range (miles) at 10% and 20% fuel reserve. What are the endurance and range (at 10% fuel reserve) at throttle settings of 750 RPM and at 3000 RPM?

Answer: _____

P11-2. What throttle setting maximizes the range? Answer: _____

P11-3. Assume a 2-knot foul current. Replicate the above computations. What are the throttle settings that maximize the endurance and range respectively?

Answer: _____

P11-4. What is the effect of the 2-knot foul current on the vessel's maximum range?

Answer: _____

The next series of questions (P11-5 through P11-9) is based on the fuel consumption curve given below for a planing vessel (assume that their vessel's fuel capacity is 200 gallons):

Throttle Setting (RPM)	STW (Knots)	Fuel Consumption (GPH)
1500	8.2	8.1
2000	13.8	15.3
2500	22.5	20.1
3000	31.4	21.8
3500	37.6	27.7
4000	41.5	31.8
4500	47.2	54.9
5000	55.0	71.6
5300	61.0	73.9

P11-5. How does this fuel consumption curve differ from that given for the displacement vessel in the first series of problems?

Answer: _____

P11-6. Assuming that there is no current (fair or foul), complete the table to calculate fuel efficiency (MPG), endurance (hours), and range (miles) at 10% and 20% fuel reserve. What are the endurance and range (at 10% fuel reserve) at throttle settings of 1500 RPM and at 5300 RPM?

Answer: _____

P11-7. What are the throttle settings that maximize the endurance and range respectively?

Answer: _____

P11-8. What is the effect of a 2-knot foul current on optimal throttle settings for endurance and range?

Answer: _____

P11-9. Contrast the effect of current for the two vessels discussed here.

Answer: _____

The final questions (P11-10 through P11-11) are based upon these fuel consumption data for *El Gordo*, a 37 ft. cruiser equipped with twin diesels. The vessel has a 330 gallon fuel capacity in two tanks.

Throttle Setting (RPM)	STW (Knots)	Fuel Consumption (GPH)
700	5.0	3.0
1000	6.5	3.4
1250	8.0	4.4
1500	10.0	8.3
1750	12.0	11.4
2000	14.0	17.5
2250	15.5	25.8
2500	15.8	31.6

P11-10. You plan a trip of 200 miles in this vessel, start off with 300 gallons in the fuel tanks, and wish to maintain a 20% fuel reserve.

- Draw a “Howgozit” chart for this trip. At the end of each of the first two legs of the trip you note the fuel consumed and the distance remaining. After completing 50 miles, you have 220 gallons remaining, after 100 miles, you have 120 gallons remaining. Plot these data on the “Howgozit” chart.

- What are your conclusions?

Answer: _____

- The navigator proposes a reduction in speed to 1500 RPM (10.0 knots). If you wish to arrive in port with a 20% fuel reserve, is this suggestion useful?

Answer: _____

P11-11. A trip of 200 miles is planned for *El Gordo*. Estimate the time required and fuel remaining at destination at various throttle settings assuming that 330 gallons are on board initially. Assume that no current (fair or foul) will affect the vessel. What might be an appropriate throttle setting?

Answer: _____

CRUISE EXERCISE

This cruise exercise is designed to tie together the material presented in the ACN course in the form of a simulated cruise. This cruise exercise differs from the practice problems given earlier in the Study Guide (SG) in that the cruise exercise links together the material presented in separate chapters. The answer format differs also—multiple-choice answers are given as on the final examinations for the course. Additionally a series of “thought questions,” termed “points-to-ponder” are included after the multiple choice questions to stimulate class discussions.

The cruise exercise is divided into three parts. Part 1 is to be done upon completion of Chapters 5 and 6 in the text. Part 2 is to be done upon completion of Chapters 7 and 8 in the text. Part 3 is to be done upon completion of Chapters 9, 10, and 11. Problems in each part include material from the relevant chapters, together with material from the earlier chapters. Problems denoted with an asterisk are more difficult.

Answers to the multiple-choice problems are contained in Appendix B. However, if you encounter difficulties, please meet with your instructor to review any problem(s) and make sure that you understand how to solve the cruise exercise. If you understand all the problems in this cruise exercise, you are well prepared to take the cruise examination.

Necessary tables or other data for solution of these problems can be found in this SG or in the main ACN text. Aside from these, you will need a 1210-Tr chart and the usual navigator’s tools. Use 15 degrees west variation for all problems and the deviation table given on page 2-4 of this SG.

PART 1

The overall scenario is as follows. You and two of your ACN classmates are going on a cruise from Tiverton on the Sakonnet River to “The Harbor” on Block Island in your older twin-engine semi-displacement vessel, *Ajax*, equipped with radar, loran, RDF, GPS, and VHF/FM radio. *Ajax* draws 3 ft. of water, and the transducer for the depth sounder is mounted 3 ft. below the waterline. The date for the cruise is 1 June 1999. This cruise is planned to give you and your classmates the opportunity to put into practice some of

the things that you have learned in the ACN class. You plan to meet another friend for lunch at Block Island and go for a brief cruise to Pt. Judith and back to Block Island. Forecast weather through the morning hours is excellent along the proposed route with generally good visibility and no more than 1 to 2 foot seas. Later in the day, the visibility is expected to decrease to 4 to 6 miles, occasionally 1 to 2 miles in light rain showers as a weak warm front approaches.

1. You take departure from lighted buoy BW “SR” Mo (A) Whistle at the mouth of the Sakonnet River at 0900 eastern daylight time (EDT) and plan your trip to pass close to lighted buoy W Or “A” then direct to the entrance light (Fl G 2.5 sec 33 ft 8 M “1A”) at the breakwater to the Harbor on Block Island. The *compass* course for the first leg from lighted buoy BW “SR” to lighted buoy W Or “A” is closest to:

- (a) 218 C
- (b) 233 C
- (c) 237 C
- (d) 058 C

Point-to-ponder: What is the advantage of a routing from ATON to ATON rather than a direct course?

2. You plan a leisurely cruise speed of 6.0 knots for the trip to Block Island. The coordinates of your 0930 DR position are closest to:
 - (a) L: 41° 24.1’ N Lo: 71° 16.0’ W
 - (b) L: 41° 21.8’ N Lo: 71° 18.4’ W
 - (c) L: 41° 24.2’ S Lo: 71° 15.8’ W
 - (d) L: 41° 23.0’ N Lo: 71° 17.5’ W
3. The estimated time (DR) that you will pass lighted buoy W Or “A” is closest to:
 - (a) 1124
 - (b) 1106
 - (c) 1100
 - (d) 1004

4. The total distance *along this route* from lighted buoy BW “SR” to the entrance light at the Harbor at Block Island is closest to:

(a) 21.7 M
(b) 10.9 M
(c) 21.4 M
(d) 22.1 M

Point-to-ponder: Would you save much distance by a more direct routing?

5. At 1000 you decide to take a position fix. Using a hand-bearing compass, the silo at Sachuest Point (on the southeast tip of Aquidneck Island) bears 043 M, and Pt. Judith Light (Gp Occ (1 + 2) 15 sec 65 ft 16M Horn R Bn 325 • - - • . - - -) bears 280 M. Based upon this fix:

(a) You are 0.8 M from your 1000 DR position in a northwest direction.
(b) You are almost exactly on course.
(c) You are south and slightly east of your 1000 DR position.
(d) The distance to lighted buoy W Or “A” is almost exactly 8.0 M.

Points-to-ponder: What is the crossing angle of this fix? Should you select another reference point for a third LOP? What might be a good reference point?

6. From the fix determined in problem 5 above, you adjust your course to reach lighted buoy W Or “A” as planned. Neglecting any allowance for current, the new compass course to the buoy is closest to:

(a) 212C
(b) 227C
(c) 232C
(d) 241C

7. You change to the new compass course and eventually sight and run directly toward lighted buoy W Or “A”, passing close to this buoy at 1120. Including the effects of all maneuvering, your speed made good (SMG) since you took departure from buoy BW “SR” is approximately:

(a) 5.1 knots
(b) 5.4 knots
(c) 6.0 knots
(d) 6.5 knots

Point-to-ponder: How does this SMG compare to the vessel’s speed through the water? Why are these different?

8. Departing buoy W Or “A” at 1120, you wish to arrive at the entrance light at the breakwater by 1200 so as to arrive in time for your lunch appointment. Neglecting any allowance for current, you calculate that it will be necessary to adjust *Ajax*’s speed to:

(a) 6.0 knots
(b) 11.4 knots
(c) 13.7 knots
(d) 17.1 knots

Note: Speed changes to make up lost time have implications for fuel consumption. Were this a longer trip you might wish to refigure fuel.

9. You make the necessary speed adjustments and proceed on course. At 1140 you take bearings (using a handheld compass) on the light at Sandy Pt. (Fl 5 sec 36 ft 13 M) on the tip of Block Island and the Block Island southeast light (Fl G 3.7 sec 201 ft 21 M). Assuming that your DR plot is an accurate indicator of position, the *magnetic* bearings to these two lights should be respectively:

(a) 290, 235
(b) 280, 220
(c) 270, 235
(d) 285, 233

Point-to-ponder: Why take the time to estimate the magnetic bearings beforehand, when these are to be measured in any event?

PART 2

After a nice (but nonalcoholic) lunch, you plan to go for a short cruise to Pt. Judith (west entrance) and return. Assuming a 1400 departure, *Ajax* and crew could arrive at Pt. Judith at approximately 1500 on 1 June 1999. Before departing, you elect to calculate the tide height and tidal current expected at the Pt. Judith Harbor of Refuge. Necessary tables can be found at the end of this appendix.

10. Which of the following statements are true with respect to prediction of tide heights at Pt. Judith Harbor of Refuge?
 - (a) Pt. Judith is a subordinate station referenced to tide heights at Newport, RI.
 - (b) Pt. Judith is a subordinate station referenced to tide heights at New London, CT.
 - (c) Pt. Judith is a subordinate station referenced to tide heights at The Race.
 - (d) Daily predictions are available for Pt. Judith.
11. Assuming a tide height prediction is wanted at 1500 EDT, the appropriate time as given in the tables would be:
 - (a) 1500 Eastern Standard Time (EST)
 - (b) 1400 Eastern Standard Time (EST)
 - (c) 1600 Eastern Standard Time (EST)
 - (d) None of the above, tide and tidal current data are already corrected for daylight time.
12. The estimated height of tide at 1500 EDT on 1 June 1999 at Pt. Judith Harbor of Refuge is closest to:
 - (a) 0.3 ft.
 - (b) 1.1 ft.
 - (c) 0.2 ft.
 - (d) 2.6 ft.

Point-to-ponder: What depth does your depth sounder read? What is the relation between your charted depth, tide height, and depth sounder reading?

13. Which of the following statements is correct with respect to tidal currents at Pt. Judith (south entrance)?
 - (a) The maximum flood current has a set of 329 degrees.
 - (b) Table 5 (Rotary Tidal Currents) is required for estimation of the current.
 - (c) The maximum flood current has a set of 141 degrees.
 - (d) The currents are repeated as "weak and variable."
14. The estimated current set and drift in the south entrance to Pt. Judith at 1500 EDT on 1 June 1999 are approximately:
 - (a) 151°, 0.4 knots
 - (b) 160°, 0.2 knots
 - (c) 124°, 0.5 knots
 - (d) 141°, 0.5 knots

You take departure from the entrance light (Fl G 2.5 sec 33 ft. 8M) "1A" at 1400 and plan a route directly toward lighted buoy R "2" (Fl 10 sec Whistle) south of Pt. Judith. You adjust your time schedule somewhat and choose a more leisurely speed of 6.0 knots. Lay out a DR track to this buoy.
15. Neglecting possible currents, *Ajax* should arrive at buoy R "2" at:
 - (a) 1450
 - (b) 1500
 - (c) 1520
 - (d) 1540
16. The compass course to buoy R "2" is closest to:
 - (a) 021C
 - (b) 041C
 - (c) 036C
 - (d) 031C

17. At 1500 you use a handheld compass to take a bearing on the light at Sandy Pt. (Fl 5 sec 36 ft. 13M) on Block Island which bears 253 magnetic. You also take a bearing on Pt. Judith light, which bears 307 magnetic. Plot and label this fix. Based upon this fix, the estimated set and drift of the current since departure from Block Island are approximately:

- (a) Set 182, Drift 1.5 knots
- (b) Set 002, Drift 0.8 knots
- (c) Set 191, Drift 1.0 knot
- (d) Set 270, Drift 1.5 knots

Points-to-ponder: Would you use this estimate for the rest of the trip? How does this estimate compare with the relevant data from the *Computer Current Tables*? What do you make of these differences?

You adjust course toward buoy R “2,” intending to continue, but the weather forecast is proving accurate and, by 1530, a light rain begins to fall. You decide to terminate the cruise, and return to Block Island. *Ajax*’s 1530 position, read from the loran, is L: 41° 19.0’ N and Lo: 71° 28.1’ W. Plot and label this fix.

Point-to-ponder: Whenever possible you should cross-check a fix determined with one method (e.g., loran) with other available information. How might you check this fix?

18. Based upon the 1530 loran fix, what is the true direction of the track to return to the entrance light to “The Harbor” at Block Island?
- (a) 200
 - (b) 204
 - (c) 208
 - (d) 215
19. Assuming that *Ajax*’s speed is increased to 8.0 knots and that the current set and drift are estimated to be 080 and 1.5 knots respectively, what are the compass course to steer and the estimated speed of advance (SOA) to the entrance light?
- (a) 213 C, 7.1 knots
 - (b) 233 C, 7.1 knots
 - (c) 193 C, 8.5 knots
 - (d) 223 C, 8.1 knots

20. If *Ajax*’s speed through the water (STW) were increased to 11.0 knots, what would be the required compass course and estimated SOA assuming the same current as given in question 19?

- (a) 230 C, 10.1 knots
- (b) 213 C, 10.1 knots
- (c) 190 C, 9.1 knots
- (d) 223 C, 10.6 knots

Point-to-ponder: What is the relation between the answer to problem 20 and that for problem 19?

PART 3

After returning to Block Island, you and your classmates spend the night, intending to depart for Menemsha on the following morning. The weather forecast is for continued calm seas and intermittent rain showers with visibilities 1 to 3 miles, locally less in areas of precipitation. Although less than ideal, the weather is acceptable and, moreover, should provide an opportunity to practice electronic navigation. A fairly long leg, such as that from Block Island to Menemsha, will provide some opportunity for voyage planning as well. You are looking forward to this trip because none of you have visited Menemsha before.

Points-to-ponder: As the seas are cooperative, reduced visibility is the major weather factor here. Take some time to do careful planning. Consider whether or not you should undertake this trip. Make sure that you have some alternate destinations and plans if “things go south” and visibilities deteriorate more than expected. The vessel is well-equipped for this trip, but are you?

21. A fuel consumption chart for *Ajax* is given below:

Both Engines Operating Throttle Setting (RPM)	STW (knots)	Fuel Consumption (GHI) Both Engines
750	4.8	5.5
1000	6.0	8.0
1250	7.3	11.0
1500	9.0	17.0
1750	11.0	22.0
2000	12.5	26.5
2250	13.5	29.5
2500	14.5	35.0

On departure from Block Island, approximately 230 gal. fuel are on board. Assuming that a 20% fuel reserve is desired, what are the fuel efficiency (MPG) and range (M) at a throttle setting of 1000 RPM?

- (a) 1.33 MPG, 306M.
 (b) 1.33 MPG, 245M.
 (c) 0.75 MPG, 138M.
 (d) 0.75 MPG, 173M.
22. What would be the answer to question 21 assuming a 1.5 knot foul current and a throttle setting of 1000 RPM?
- (a) 0.56 MPG, 129M.
 (b) 0.56 MPG, 104M.
 (c) 1.77 MPG, 409M.
 (d) 1.77 MPG, 325M.
23. What would be the answer to question 21 assuming a throttle setting of 2500 RPM and 1.5 knot foul current?
- (a) 0.37 MPG, 68M.
 (b) 0.37 MPG, 85M.
 (c) 0.47 MPG, 87M.
 (d) 0.53 MPG, 111M.

With all of *Ajax's* electronics, there are numerous safe routes between "The Harbor" at Block Island and Menemsha. You and your classmates elect to make the trip in four "legs." Leg 1 is from the entrance light to "The Harbor" at Block Island to lighted buoy W Or "A" (Fl 4 sec Bell) located at the southern end of the Torpedo Range. Leg 2 is from this buoy to lighted buoy RB "VS" (Qk Fl Whistle) located approximately 1.8 M southeast of Buzzards Bay light, Fl 2.5 sec 101 ft. 22M. Leg 3 is from the "VS" buoy to the lighted midchannel

buoy RW "NA" Mo (A) Whistle just south of Nashawena Island in Vineyard Sound. Finally, leg 4 is from buoy "NA" to the entrance light, Fl 4 sec 25 ft. "3", to the channel to Menemsha Pond.

Point-to-ponder: What are the advantages of this route compared to a more direct route?

24. The estimated distance along all four legs of this trip is approximately:

- (a) 37.6 M.
 (b) 39.8 M.
 (c) 19.9 M.
 (d) 42.3 M.

Point-to-ponder: Based upon the fuel consumption calculations in questions 21 through 23, do you have sufficient fuel on board for the trip?

25. On consulting the appropriate reference, you learn that:

- (a) Fuel is reportedly available at Menemsha Basin but, just to be on the safe side, you could call the Harbormaster at (617) 645 -2846.
 (b) Just beyond the entrance lies Menemsha Basin, and beyond that, Menemsha Pond. Anchoring in Menemsha Pond is feasible for *Ajax*.
 (c) Currents in Menemsha Bight are weak and variable.
 (d) The Harbormaster has an office at Dutcher Dock and can be reached on VHF-FM channel 28.

Point-to-ponder: What are the sources of this information?

Ajax departs the entrance light at Block Island at 0930 EDT on 2 June 1999. A throttle setting of 1500 RPM is selected. Lay out the DR plot with DR positions every 30 minutes and whenever else appropriate.

26. Neglecting any allowance for currents, what is your estimated time of arrival (ETA) at lighted buoy W Or "A" Fl 4 sec Bell?

- (a) 1000
 (b) 1101
 (c) 1047
 (d) 1031

27. As forecast, visibility is generally less than 3 miles, so you plan to define waypoints in the GPS corresponding to each of the turn points at the ends of each leg of the trip. You enter the coordinates of lighted buoy W Or “A” as:

- (a) 9960—W—14457, 9960—Y—43914
- (b) L: 41° 16.6' N, Lo: 71° 23.9' W
- (c) L: 41° 14.5' N, Lo: 71° 23.8' W
- (d) L: 41° 16.5' N, LO: 71° 23.8' E

Note: Check the directions for your GPS. “E,” “W, ... N,” and “S” are generally not entered. Instead +/- is used to denote N or S or E or W.

- *28. The cruise proceeds uneventfully with you and your classmates taking turns at the helm. But instead of following your DR course as originally plotted, you simply adjust the vessel’s heading to keep the course deviation indicator (CDI) on the GPS centered. All works fine, and you arrive at lighted buoy W Or “A” at 1040. The compass course required to keep the CDI centered is approximately 065C. What are your course made good (CMG) and speed made good (SMG)?

- (a) CMG 065, SMG 9.0 knots
- (b) CMG 049, SMG 9.0 knots
- (c) CMG 055, SMG 9.0 knots
- (d) CMG 049, SMG 7.8 knots

Hint: Remember carefully the definition of CMG and SMG.

29. The coordinates of your 1040 DR position (*as steered—not as originally planned*) are closest to:

- (a) L: 41° 18.5' N, Lo: 71° 25.5' W
- (b) L: 41° 16.5' N, Lo: 71° 23.8' W
- (c) L: 41° 16.6' N, Lo: 71° 21.7' W
- (d) cannot be determined from the information given.

Notes: This assumes a throttle setting of 1500 RPM and compass course of 065. Do you see why the original (planned) DR track and the tactical DR plot differ? This question asks you to superimpose the tactical DR plot on the original DR plan. Note that, as a result of the use of GPS for tracking, the CMG is quite close to the original DR track, but the tactical DR plot does not pass through any of the originally planned turn points. This situation occurs quite frequently in practice.

- *30. Based upon the information given in questions 28 and 29, the estimated current set and drift are approximately:

- (a) Set 270, Drift 1.5 knots
- (b) Set 093, Drift 1.5 knots
- (c) Set 270, Drift 1.8 knots
- (d) Set 161, Drift 1.5 knots

Note: Think through this question carefully. Remember that the current vector is drawn *from* the DR position to the fix and not vice versa. You are accustomed to drawing in the DR plot first and then plotting the fix. But, in this case, because you were able to use GPS to maintain the intended track you wind up drawing the DR plot later.

31. You alter course as you begin leg 2 of the trip. The GPS acts up and finally quits, a problem resulting in a blown fuse. (Unfortunately, you installed circuit breakers throughout the vessel and forgot to buy spares for the *internal* GPS fuse—a common error.) But, otherwise, all is well and, in particular, the radar and the RDF are both operating. Although it’s hard to estimate visibility on the open water, you guess that visibility is at most 1 mile. The rain is sufficiently intense that you turn on the windshield wipers. For your 1200 position fix you successively tune in the Brenton Reef and Buzzards beacons. After verifying the Morse Code identifier for each, you obtain relative bearings of 237R, and 345R respectively while on a compass heading of 082C. Assuming that the RDF does not have any deviation, your 1200 position is approximately:

- (a) L: 41° 18.9' N, Lo: 71° 11.9' W
- (b) L: 41° 21.2' N, Lo: 71° 20.3' W
- (c) L: 41° 20.0' N, Lo: 71° 09.4' W
- (d) L: 41° 21.1' N, LO: 71° 11.3' W

Note: This question assumes that these RDF stations are still in service. USCG has phased out nearly all RDF stations. For purposes of this exercise, assume both are in operation.

Points-to-ponder: Because you are measuring relative bearings, it is necessary to know the vessel’s compass heading. Now is not the time to wonder if the deviation table was prepared with the windshield wiper on! If you have any doubt, turn off

the windshield wiper briefly while you read the compass. Because the visibility is poor, you will have to rely on the compass more. Take extra care to clear the area around the compass of any metallic objects—such as the screwdriver you may have used to open up the GPS when you determined the fuse had blown!

Shortly after taking this fix you hear a vessel, *POTR* (Putting on the Ritz), requesting assistance. Apparently *POTR* has some transmission difficulties and cannot engage forward gear. *POTR* reports that it is stopped and slowly drifting at a position defined by the loran TDs 9960-X-25655 and 9960-Y-43951. You offer to assist and ask *POTR* to report the water depth. *POTR* responds, “approximately 40 ft” and, confident of *POTR*’s position, you proceed in that direction. Ultimately you locate *POTR* at 1320 and pass a towline to the vessel. (Another vessel, ‘*Enrietta*, also went to assist *POTR* but had to return to port for additional fuel.)

Points-to-ponder: Why did you ask for the depth information? How could you use this information? Where is *POTR*?

32. As luck would have it, *POTR* is based out of Menemsha, and so you begin towing *POTR* towards that port. At 1430 you pass close abeam buoy RB “VS” and set your course for buoy RW “NA.” While proceeding on a compass course of 088C at 5 knots you observe a target on radar as follows (*Ajax* has an unstabilized SHU radar display):

Time	Relative Bearing	Range (M)
1430	350	9.5
1436	355	7.4
1442	004	5.5

What is the closest point of approach (CPA) of the target?

- (a) 4.1
- (b) 2.9
- (c) 2.1
- (d) 1.4

Points-to-ponder: Is this “miss distance” adequate under the circumstances? What are your responsibilities under the NAVRULES?

33. What are the course and speed of the target?

- (a) 240°, 14.1 knots
- (b) 146°, 17.9 knots
- (c) 220°, 18.0 knots
- (d) cannot be determined from information given

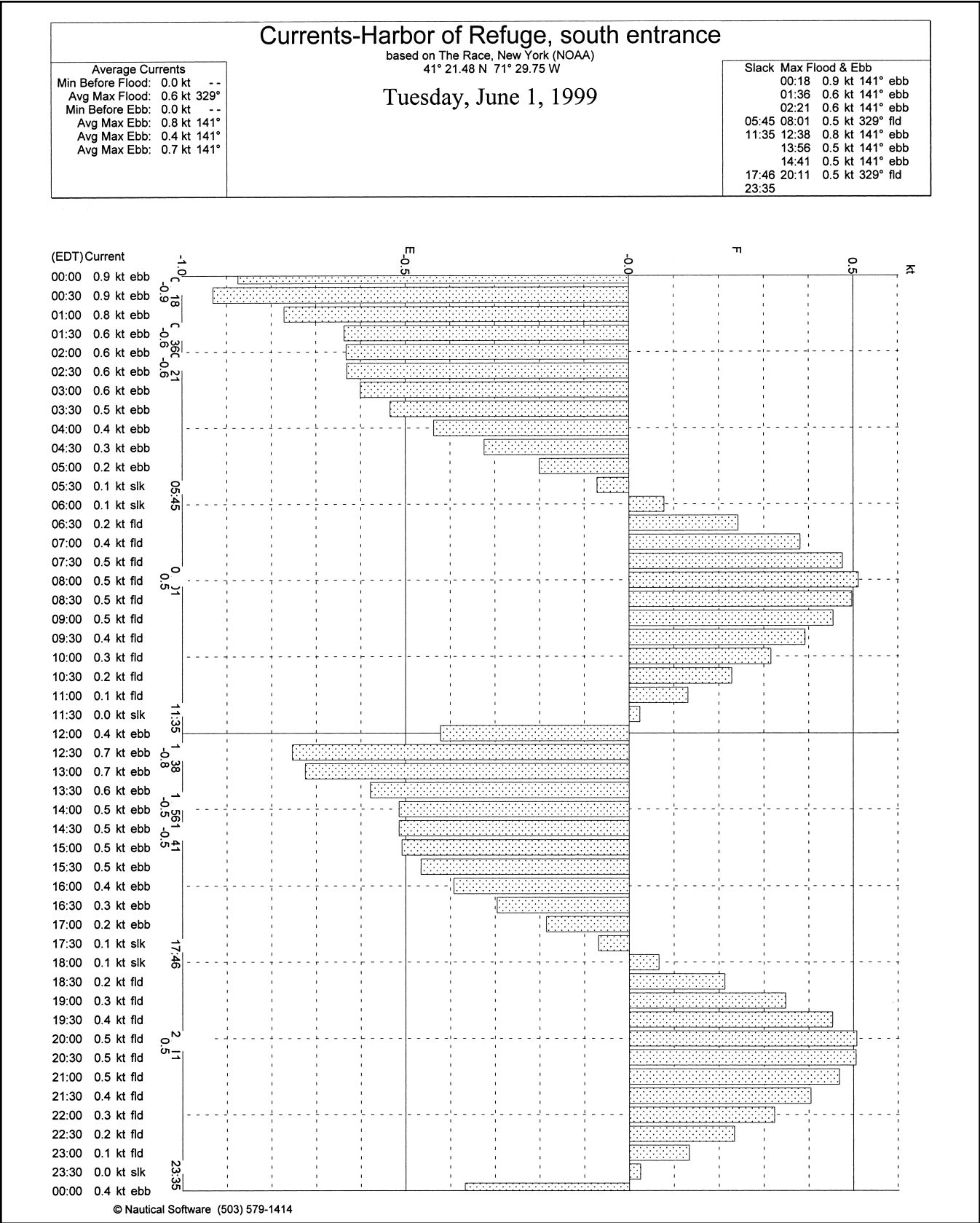
Point-to-ponder: Is this likely to be a safe speed for the target vessel in these conditions?

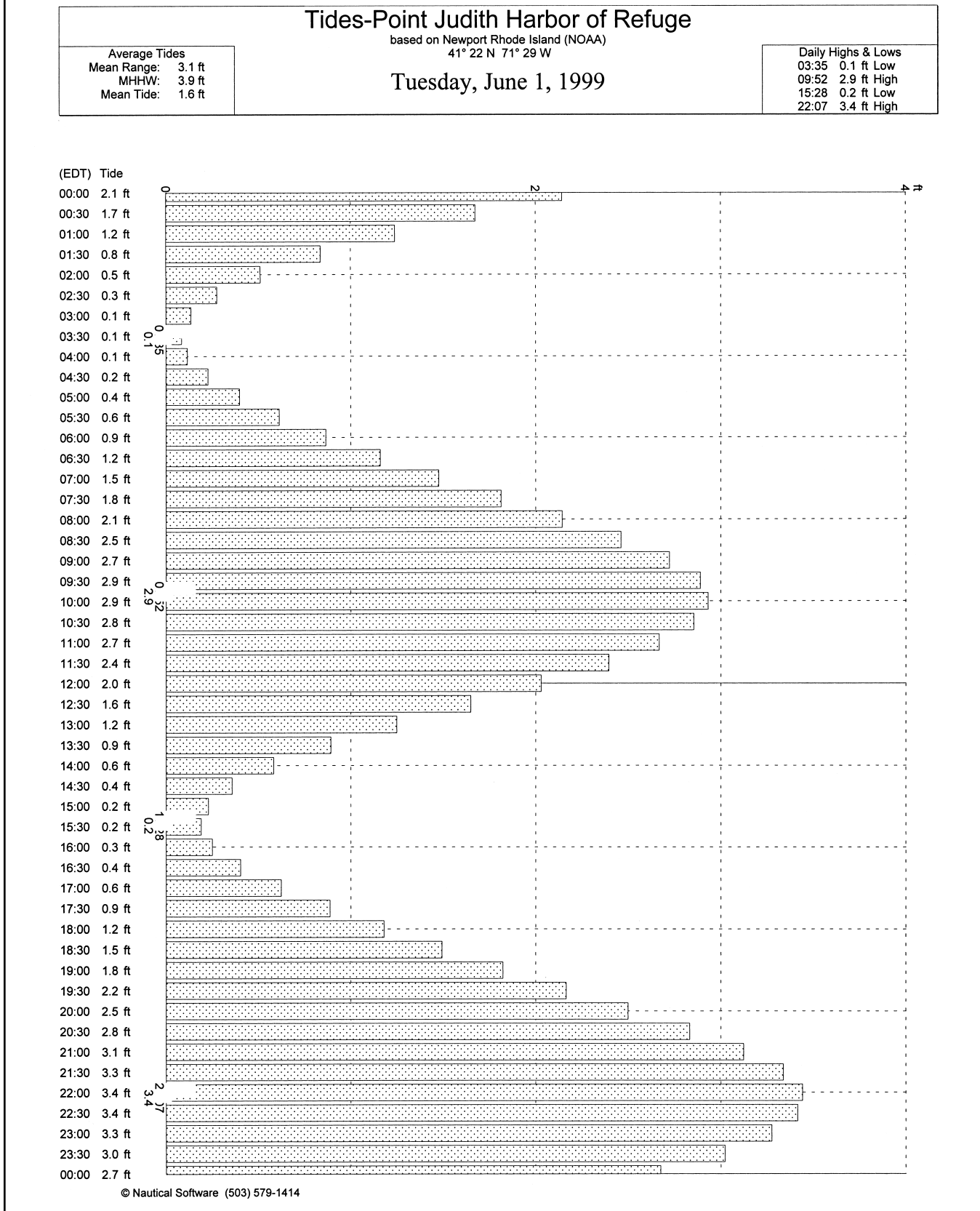
34. At 1600, the fairway buoy RW “NA” is sighted and *Ajax* turns right in the direction of Menemsha. Both Gay Head and the hills to the northeast of Menemsha are clearly visible on *Ajax*’s radar, but the harbor entrance cannot be seen on radar. Visibility has been reduced further in rain showers and may be less than a mile. Considering all factors, the best course of action in this situation would be to:

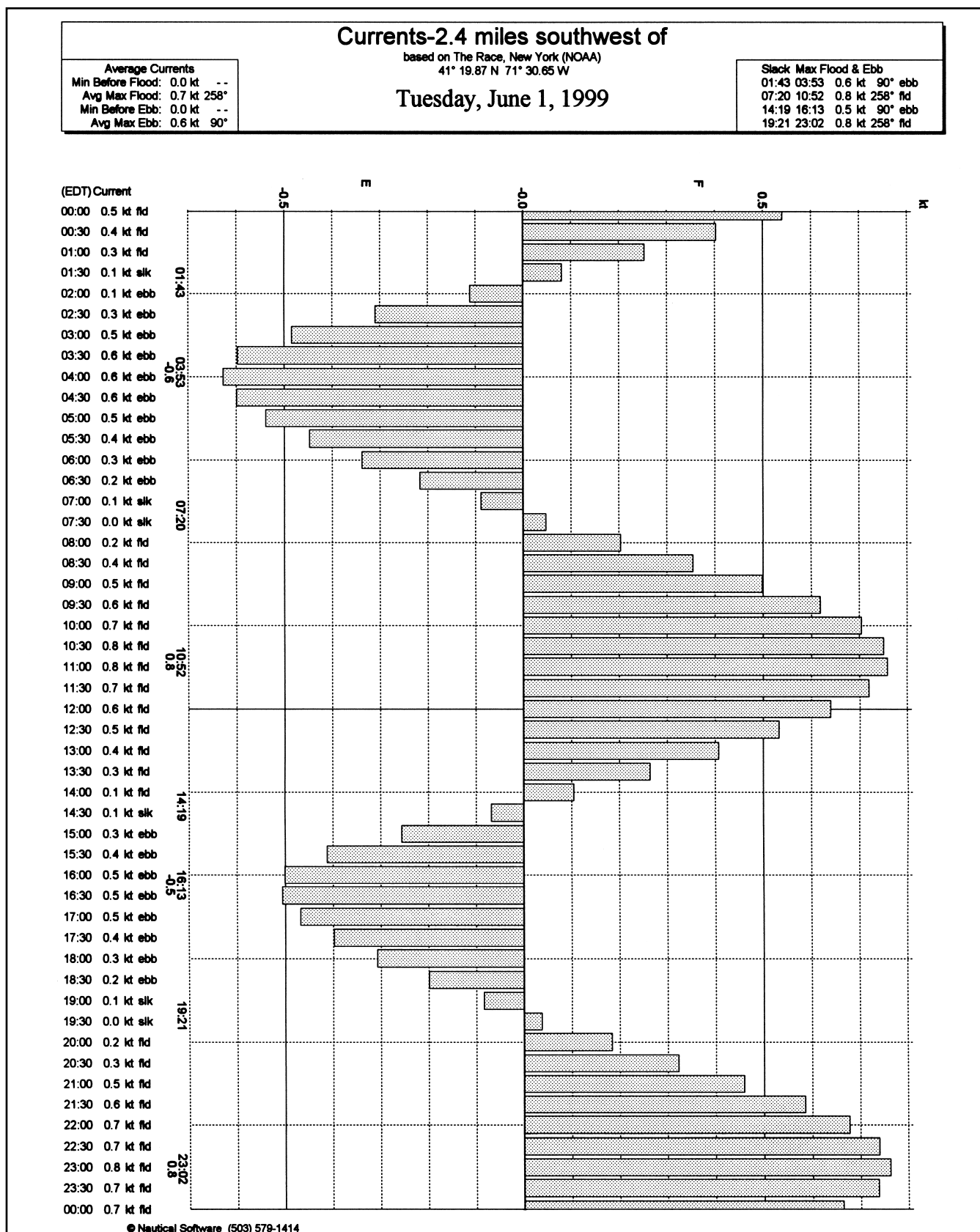
- (a) Continue inbound on the direct course and maintain 5.0 knots,
- (b) Offset your course to the left, using both compass and the radar target of the hills. Slow down when close to land and monitor the depth sounder carefully. When the water depth becomes less than 35 ft. or so, alter course to the right and follow the depth contour. Post a lookout on the bow and stop frequently to listen for the bell buoy.
- (c) Offset your course to the right and follow generally the same procedure as indicated for answer (b).
- (d) Follow the procedure given in answer (b) except transfer someone from *POTR* to *Ajax* to help supply local knowledge. Also, make sure that all persons in both boats are wearing personal flotation devices (PFDs).

Points-to-ponder: At what time are you likely to secure? How does this compare with your original estimates? You have diverted and towed a vessel—what does this do to your fuel burn? Do you see why fuel reserves are important? How confident are you of being able to tow a vessel through an inlet that you have never visited before, in poor visibility? What other options do you have?











Newport, Rhode Island, 1999

Times and Heights of High and Low Waters

January				February				March											
	Time	Height		Time	Height		Time	Height		Time	Height								
	h m	ft	cm	h m	ft	cm	h m	ft	cm	h m	ft	cm							
1 F ○	0001	-0.8	-24	16 Sa	0642	3.9	119	16 Tu ●	0054	-0.6	-18	16 Tu	0633	4.0	122				
	0642	4.8	146		1234	-0.1	-3		0743	4.2	128		1216	-0.5	-15				
	1255	-0.7	-21		1903	3.3	101		1326	-0.6	-18		1854	4.1	125				
	1906	3.9	119		2004	3.9	119		1916	3.9	119								
2 Sa	0054	-0.8	-24	17 Su ●	0028	-0.2	-6	17 W	0139	-0.7	-21	2 Tu ○	0122	-0.5	-15	17 W ●	0037	-0.7	-21
	0732	4.8	146		0724	4.0	122		0826	4.2	128		0740	4.1	125		0718	4.2	128
	1343	-0.7	-21		1311	-0.3	-9		1407	-0.7	-21		1344	-0.4	-12		1259	-0.7	-21
	1956	4.0	122		1946	3.4	104		2048	4.0	122		1959	4.0	122		1939	4.3	131
3 Su	0143	-0.7	-21	18 M	0110	-0.4	-12	3 W	0224	-0.8	-24	3 W	0158	-0.5	-15	18 Th	0124	-0.9	-27
	0821	4.6	140		0806	4.1	125		0911	4.1	125		0822	4.0	122		0803	4.3	131
	1429	-0.6	-18		1349	-0.4	-12		1448	-0.7	-21		1414	-0.3	-9		1343	-0.9	-27
	2045	3.9	119		2028	3.5	107		2134	4.1	125		2040	3.9	119		2024	4.5	137
4 M	0230	-0.6	-18	19 Tu	0152	-0.5	-15	4 Th	0311	-0.7	-21	4 Th	0232	-0.4	-12	19 F	0211	-1.0	-30
	0909	4.4	134		0848	4.1	125		0958	4.0	122		0902	3.8	116		0850	4.2	128
	1512	-0.4	-12		1428	-0.4	-12		1532	-0.7	-21		1442	-0.3	-9		1426	-0.9	-27
	2134	3.8	116		2112	3.6	110		2223	4.0	122		2121	3.8	116		2112	4.5	137
5 Tu	0316	-0.4	-12	20 W	0236	-0.5	-15	5 F	0400	-0.6	-18	5 F	0303	-0.2	-6	20 Sa	0259	-0.9	-27
	0957	4.1	125		0932	4.0	122		1048	3.7	113		0943	3.5	107		0938	4.0	122
	1554	-0.2	-6		1509	-0.5	-15		1618	-0.5	-15		1511	-0.1	-3		1512	-0.8	-24
	2223	3.6	110		2157	3.6	110		2316	3.9	119		2203	3.6	110		2202	4.4	134
6 W	0401	-0.1	-3	21 Th	0322	-0.4	-12	6 Sa	0453	-0.4	-12	6 Sa	0335	0.0	0	21 Su	0349	-0.7	-21
	1045	3.7	113		1018	3.8	116		1143	3.5	107		1024	3.3	101		1029	3.8	116
	1634	0.0	0		1552	-0.4	-12		1709	-0.4	-12		1542	0.0	0		1559	-0.6	-18
	2313	3.4	104		2246	3.6	110		2245	3.4	104		2245	3.4	104		2255	4.2	128
7 Th	0446	0.2	6	22 F	0412	-0.3	-9	7 Su	0013	3.1	94	7 Su	0409	0.2	6	22 M	0442	-0.5	-15
	1135	3.4	104		1108	3.6	110		0553	-0.1	-3		1107	3.0	91		1125	3.5	107
	1713	0.2	6		1639	-0.4	-12		1242	3.3	101		1616	0.2	6		1651	-0.3	-9
					2339	3.6	110		1806	-0.2	-6		2331	3.2	98		2353	4.0	122
8 F	0005	3.2	98	23 Sa	0506	-0.2	-6	8 M ○	0116	3.7	113	8 M	0446	0.4	12	23 Tu	0542	-0.2	-6
	0533	0.5	15		1203	3.4	104		0703	0.1	3		1154	2.8	85		1225	3.3	101
	1226	3.1	94		1730	-0.3	-9		1347	3.1	94		1655	0.3	9		1750	-0.1	-3
	1755	0.4	12		1828	0.5	15		1913	0.0	0								
9 Sa ○	0058	3.1	94	24 Su ○	0202	2.9	88	9 Tu	0221	3.7	113	9 Tu	0021	3.0	91	24 W ○	0056	3.8	116
	0626	0.7	21		0715	0.8	24		0827	0.2	6		0530	0.5	15		0653	0.1	3
	1319	2.9	88		1426	2.5	76		1452	3.1	94		1247	2.6	79		1330	3.2	98
	1841	0.5	15		1924	0.5	15		2032	0.0	0		1740	0.5	15		1902	0.2	6
10 Su	0153	3.1	94	25 M	0138	3.7	113	10 W	0325	3.8	116	10 W ○	0116	2.9	88	25 Th	0202	3.7	113
	0728	0.8	24		0717	0.1	3		0952	0.1	3		0623	0.7	21		0820	0.2	6
	1413	2.7	82		1406	3.2	98		1554	3.2	98		1346	2.5	76		1435	3.2	98
	1933	0.5	15		1932	-0.1	-3		2153	0.0	0		1835	0.6	18		2031	0.2	6
11 M	0247	3.1	94	26 Tu	0241	3.8	116	11 Th	0425	3.9	119	11 Th	0216	2.9	88	26 F	0306	3.6	110
	0841	0.8	24		0836	0.1	3		1059	-0.1	-3		0727	0.7	21		0944	0.2	6
	1508	2.7	82		1509	3.2	98		1651	3.4	104		1446	2.6	79		1537	3.3	101
	2030	0.5	15		2043	-0.2	-6		2301	-0.2	-6		1940	0.6	18		2157	0.1	3
12 Tu	0339	3.2	98	27 W	0343	4.0	122	12 F	0520	4.0	122	12 F	0314	3.0	91	27 Sa	0406	3.7	113
	0949	0.7	21		0955	0.0	0		1151	-0.2	-6		0839	0.6	18		1046	0.1	3
	1600	2.8	85		1610	3.3	101		1744	3.6	110		1543	2.7	82		1633	3.5	107
	2126	0.4	12		2154	-0.3	-9		2356	-0.4	-12		2051	0.5	15		2302	0.0	0
13 W	0429	3.4	104	28 Th	0441	4.2	128	13 Sa	0610	4.1	125	13 Sa	0409	3.2	98	28 Su	0500	3.7	113
	1039	0.5	15		1103	-0.2	-6		1234	-0.3	-9		0947	0.4	12		1134	0.0	0
	1649	2.9	88		1707	3.5	107		1831	3.8	116		1635	3.0	91		1724	3.7	113
	2217	0.3	9		2259	-0.4	-12		2322	-0.1	-3		2158	0.2	6		2351	-0.2	-6
14 Th	0515	3.6	110	29 F	0536	4.3	131	14 Su	0616	3.8	116	14 Su	0459	3.5	107	29 M	0549	3.8	116
	1119	0.3	9		1159	-0.4	-12		1206	-0.1	-3		1043	0.1	3		1212	-0.1	-3
	1736	3.0	91		1800	3.7	113		1838	3.5	107		1723	3.4	104		1809	3.9	119
	2303	0.1	3		2356	-0.6	-18				2257		-0.1	-3					
15 F	0559	3.8	116	30 Sa	0627	4.4	134	15 M	0009	-0.3	-9	15 M	0547	3.8	116	30 Tu	0032	-0.3	-9
	1157	0.1	3		1247	-0.5	-15		0659	4.0	122		1132	-0.2	-6		0633	3.8	116
	1820	3.2	98		1850	3.8	116		1246	-0.4	-12		1809	3.7	113		1243	-0.2	-6
	2346	-0.1	-3						1921	3.7	113		2348	-0.4	-12		1852	4.0	122
16 Sa	0054	-0.8	-24	31 Su ○	0047	-0.7	-21	31 Su ○	0054	-0.6	-18	31 W ○	0106	-0.3	-9	31 W ○	0106	-0.3	-9
	0732	4.8	146		0715	4.4	134		0743	4.2	128		0718	4.2	128		0715	3.8	116
	1343	-0.7	-21		1330	-0.5	-15		1326	-0.6	-18		1259	-0.7	-21		1311	-0.2	-6
	1956	4.0	122		1946	3.4	104		2004	3.9	119		1939	4.3	131		1932	4.1	125

Height of Tide at anytime

	<i>h. m.</i>	Time from the nearest high water or low water														
		<i>h. m.</i>	<i>h. m.</i>	<i>h. m.</i>	<i>h. m.</i>	<i>h. m.</i>	<i>h. m.</i>	<i>h. m.</i>	<i>h. m.</i>	<i>h. m.</i>	<i>h. m.</i>	<i>h. m.</i>	<i>h. m.</i>	<i>h. m.</i>	<i>h. m.</i>	<i>h. m.</i>
Duration of rise or fall, see footnote	4 10	0 08	0 16	0 24	0 32	0 40	0 48	0 56	1 04	1 12	1 20	1 28	1 36	1 44	1 52	2 00
	4 20	0 09	0 17	0 26	0 35	0 43	0 52	1 01	1 09	1 18	1 27	1 35	1 44	1 53	2 01	2 10
	4 40	0 09	0 19	0 28	0 37	0 47	0 56	1 05	1 15	1 24	1 33	1 43	1 52	2 01	2 11	2 20
	5 00	0 10	0 20	0 30	0 40	0 50	1 00	1 10	1 20	1 30	1 40	1 50	2 00	2 10	2 20	2 30
	5 20	0 11	0 21	0 32	0 43	0 53	1 04	1 15	1 25	1 36	1 47	1 57	2 08	2 19	2 29	2 40
	5 40	0 11	0 23	0 34	0 45	0 57	1 08	1 19	1 31	1 42	1 53	2 05	2 16	2 27	2 39	2 50
	6 00	0 12	0 24	0 36	0 48	1 00	1 12	1 24	1 36	1 48	2 00	2 12	2 24	2 36	2 48	3 00
	6 20	0 13	0 25	0 38	0 51	1 03	1 16	1 29	1 41	1 54	2 07	2 19	2 32	2 45	2 57	3 10
	6 40	0 13	0 27	0 40	0 53	1 07	1 20	1 33	1 47	2 00	2 13	2 27	2 40	2 53	3 07	3 20
	7 00	0 14	0 28	0 42	0 56	1 10	1 24	1 38	1 52	2 06	2 20	2 34	2 48	3 02	3 16	3 30
	7 20	0 15	0 29	0 44	0 59	1 13	1 28	1 43	1 57	2 12	2 27	2 41	2 56	3 11	3 25	3 40
	7 40	0 15	0 31	0 46	1 01	1 17	1 32	1 47	2 03	2 18	2 33	2 49	3 04	3 19	3 35	3 50
	8 00	0 16	0 32	0 48	1 04	1 20	1 36	1 52	2 08	2 24	2 40	2 56	3 12	3 28	3 44	4 00
	8 20	0 17	0 33	0 50	1 07	1 23	1 40	1 57	2 13	2 30	2 47	3 03	3 20	3 37	3 53	4 10
	8 40	0 17	0 35	0 52	1 09	1 27	1 44	2 01	2 19	2 36	2 53	3 11	3 28	3 45	4 03	4 20
	9 00	0 18	0 36	0 54	1 12	1 30	1 48	2 06	2 24	2 42	3 00	3 18	3 36	3 54	4 12	4 30
	9 20	0 19	0 37	0 56	1 15	1 33	1 52	2 11	2 29	2 48	3 07	3 25	3 44	4 03	4 21	4 40
	9 40	0 19	0 39	0 58	1 17	1 37	1 56	2 15	2 35	2 54	3 13	3 33	3 52	4 11	4 31	4 50
	10 00	0 20	0 40	1 00	1 20	1 40	2 00	2 20	2 40	3 00	3 20	3 40	4 00	4 20	4 40	5 00
	10 20	0 21	0 41	1 02	1 23	1 43	2 04	2 25	2 45	3 06	3 27	3 47	4 08	4 29	4 49	5 10
	10 40	0 21	0 43	1 04	1 25	1 47	2 08	2 29	2 51	3 12	3 33	3 55	4 16	4 37	4 59	5 20
	<i>Ft.</i>	Correction to height														
		<i>Ft.</i>	<i>Ft.</i>	<i>Ft.</i>	<i>Ft.</i>	<i>Ft.</i>	<i>Ft.</i>	<i>Ft.</i>	<i>Ft.</i>	<i>Ft.</i>	<i>Ft.</i>	<i>Ft.</i>	<i>Ft.</i>	<i>Ft.</i>	<i>Ft.</i>	<i>Ft.</i>
Range of tide, see footnote	0.5	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.1	0.1	0.2	0.2	0.2	0.2
	1.0	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.2	0.2	0.2	0.3	0.3	0.4	0.4	0.5
	1.5	0.0	0.0	0.0	0.1	0.1	0.1	0.2	0.2	0.3	0.4	0.4	0.5	0.6	0.7	0.8
	2.0	0.0	0.0	0.0	0.1	0.1	0.2	0.3	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0
	2.5	0.0	0.0	0.1	0.1	0.2	0.2	0.3	0.4	0.5	0.6	0.7	0.9	1.0	1.1	1.2
	3.0	0.0	0.0	0.1	0.1	0.2	0.3	0.4	0.5	0.6	0.8	0.9	1.0	1.2	1.3	1.5
	3.5	0.0	0.0	0.1	0.2	0.2	0.3	0.4	0.6	0.7	0.9	1.0	1.2	1.4	1.6	1.8
	4.0	0.0	0.0	0.1	0.2	0.3	0.4	0.5	0.7	0.8	1.0	1.2	1.4	1.6	1.8	2.0
	4.5	0.0	0.0	0.1	0.2	0.3	0.4	0.6	0.7	0.9	1.1	1.3	1.6	1.8	2.0	2.2
	5.0	0.0	0.1	0.1	0.2	0.3	0.5	0.6	0.8	1.0	1.2	1.5	1.7	2.0	2.2	2.5
	5.5	0.0	0.1	0.1	0.2	0.4	0.5	0.7	0.9	1.1	1.4	1.6	1.9	2.2	2.5	2.8
	6.0	0.0	0.1	0.1	0.3	0.4	0.6	0.8	1.0	1.2	1.5	1.8	2.1	2.4	2.7	3.0
	6.5	0.0	0.1	0.2	0.3	0.4	0.6	0.8	1.1	1.3	1.6	1.9	2.2	2.6	2.9	3.2
	7.0	0.0	0.1	0.2	0.3	0.5	0.7	0.9	1.2	1.4	1.8	2.1	2.4	2.8	3.1	3.5
	7.5	0.0	0.1	0.2	0.3	0.5	0.7	1.0	1.2	1.5	1.9	2.2	2.6	3.0	3.4	3.8
	8.0	0.0	0.1	0.2	0.3	0.5	0.8	1.0	1.3	1.6	2.0	2.4	2.8	3.2	3.6	4.0
	8.5	0.0	0.1	0.2	0.4	0.6	0.8	1.1	1.4	1.8	2.1	2.5	2.9	3.4	3.8	4.2
	9.0	0.0	0.1	0.2	0.4	0.6	0.9	1.2	1.5	1.9	2.2	2.7	3.1	3.6	4.0	4.5
	9.5	0.0	0.1	0.2	0.4	0.6	0.9	1.2	1.6	2.0	2.4	2.8	3.3	3.8	4.3	4.8
	10.0	0.0	0.1	0.2	0.4	0.7	1.0	1.3	1.7	2.1	2.5	3.0	3.5	4.0	4.5	5.0
	10.5	0.0	0.1	0.3	0.5	0.7	1.0	1.3	1.7	2.2	2.6	3.1	3.6	4.2	4.7	5.2
	11.0	0.0	0.1	0.3	0.5	0.7	1.1	1.4	1.7	2.3	2.8	3.3	3.8	4.4	4.9	5.5
	11.5	0.0	0.1	0.3	0.5	0.8	1.1	1.5	1.8	2.3	2.9	3.4	4.0	4.6	5.1	5.8
	12.0	0.0	0.1	0.3	0.5	0.8	1.1	1.5	1.9	2.5	3.0	3.6	4.1	4.8	5.4	6.0
	12.5	0.0	0.1	0.3	0.5	0.8	1.2	1.6	1.9	2.6	3.1	3.7	4.3	5.0	5.6	6.2
	13.0	0.0	0.1	0.3	0.6	0.9	1.2	1.7	2.2	2.7	3.2	3.9	4.5	5.1	5.8	6.5
	13.5	0.0	0.1	0.3	0.6	0.9	1.3	1.7	2.2	2.8	3.4	4.0	4.7	5.3	6.0	6.8
	14.0	0.0	0.2	0.3	0.6	0.9	1.3	1.8	2.3	2.9	3.5	4.2	4.8	5.5	6.3	7.0
	14.5	0.0	0.2	0.4	0.6	1.0	1.4	1.9	2.4	3.0	3.6	4.3	5.0	5.7	6.5	7.2
	15.0	0.0	0.2	0.4	0.6	1.0	1.4	1.9	2.5	3.1	3.8	4.4	5.2	5.9	6.7	7.5
	15.5	0.0	0.2	0.4	0.7	1.0	1.5	2.0	2.6	3.2	3.9	4.6	5.4	6.1	6.9	7.8
	16.0	0.0	0.2	0.4	0.7	1.1	1.5	2.1	2.6	3.3	4.0	4.7	5.5	6.3	7.2	8.0
	16.5	0.0	0.2	0.4	0.7	1.1	1.6	2.1	2.7	3.4	4.1	4.9	5.7	6.5	7.4	8.2
	17.0	0.0	0.2	0.4	0.7	1.1	1.6	2.2	2.8	3.5	4.2	5.0	5.9	6.7	7.6	8.5
	17.5	0.0	0.2	0.4	0.8	1.2	1.7	2.2	2.9	3.6	4.4	5.2	6.0	6.9	7.8	8.8
	18.0	0.0	0.2	0.4	0.8	1.2	1.7	2.3	3.0	3.7	4.5	5.3	6.2	7.1	8.1	9.0
	18.5	0.1	0.2	0.5	0.8	1.2	1.8	2.4	3.1	3.8	4.6	5.5	6.4	7.3	8.3	9.2
	19.0	0.1	0.2	0.5	0.8	1.3	1.8	2.4	3.1	3.9	4.8	5.6	6.6	7.5	8.5	9.5
	19.5	0.1	0.2	0.5	0.8	1.3	1.9	2.5	3.2	4.0	4.9	5.8	6.7	7.7	8.7	9.8
	20.0	0.1	0.2	0.5	0.9	1.3	1.9	2.6	3.3	4.1	5.0	5.9	6.9	7.9	9.0	10.0

Tidal Differences and Other Constants

No.	PLACE	POSITION		DIFFERENCES				RANGES			Mean Tide Level
		Latitude	Longitude	Time		Height		Mean	Spring		
				High Water	Low Water	High Water	Low Water				
	MASSACHUSETTS—cont. Vineyard Sound Time meridian, 75° W	north	west	n	m	n	m	ft	ft	ft	
				on Newport, p.48							
1085	Nobska Point	41° 31'	70° 39'	+0 41	+2 05	*0.43	*0.43	1.5	1.9	0.8	
	Woods Hole										
1087	Little Harbor	41° 31'	70° 40'	+0 32	+2 21	*0.40	*0.40	1.4	1.8	0.8	
1089	OCEANOGRAPHIC INSTITUTION	41° 32'	70° 40'					1.8	2.3	1.0	
1091	Uncatena Island (south side)	41° 31'	70° 42'	+0 12	+0 22	*1.02	*1.02	3.6	4.5	1.9	
1093	Tarpaulin Cove	41° 28'	70° 46'	+0 11	+1 23	*0.54	*0.54	1.9	2.4	1.0	
	Quicks Hole										
1095	South side	41° 26'	70° 51'	-0 10	+0 09	*0.71	*0.71	2.5	3.1	1.3	
1097	Middle	41° 27'	70° 51'	0 00	+0 10	*0.85	*0.85	3.0	3.7	1.6	
1099	North side	41° 27'	70° 51'	-0 08	-0 08	*0.99	*0.99	3.5	4.4	1.8	
	Buzzards Bay										
1101	Cuttyhunk Pond entrance	41° 25'	70° 55'	+0 01	+0 01	*0.97	*0.97	3.4	4.2	1.8	
1103	Penikese Island	41° 27'	70° 55'	-0 17	-0 16	*0.97	*0.97	3.4	4.2	1.8	
1105	Kettle Cove	41° 29'	70° 47'	+0 09	+0 02	*1.08	*1.08	3.8	4.7	2.1	
1107	Chappaquott Point, West Falmouth Harbor	41° 36'	70° 39'	+0 10	+0 20	*1.10	*1.07	3.9	4.9	2.1	
1109	West Falmouth Harbor	41° 36'	70° 39'	+0 21	+0 18	*1.14	*1.14	4.0	5.0	2.2	
1111	Barlows Landing, Pocasset Harbor	41° 41'	70° 38'	+0 24	+0 18	*1.14	*1.14	4.0	5.0	2.2	
1113	Abiels Ledge	41° 42'	70° 40'	+0 11	+0 16	*1.11	*1.11	3.9	4.9	2.2	
1115	Monument Beach	41° 43'	70° 37'	+0 23	+0 18	*1.14	*1.14	4.0	5.0	2.2	
1117	Cape Cod Canal, RR. bridge <6>	41° 44'	70° 37'	+1 15	- - -	*0.99	*0.99	3.5	4.1	1.9	
1119	Great Hill	41° 43'	70° 43'	+0 12	+0 11	*1.15	*1.21	4.0	5.0	2.2	
1121	Wareham, Wareham River	41° 45'	70° 43'	+0 22	+0 16	*1.16	*1.16	4.1	5.1	2.2	
1123	Bird Island	41° 40'	70° 43'	+0 05	-0 02	*1.19	*1.19	4.2	5.2	2.3	
1125	Marion, Sippican Harbor	41° 42'	70° 46'	+0 10	+0 12	*1.13	*1.29	4.0	4.9	2.2	
1127	Mattapoisett, Mattapoisett Harbor	41° 39'	70° 49'	+0 11	+0 20	*1.09	*1.00	3.9	4.8	2.1	
1129	West Island (west side)	41° 36'	70° 50'	+0 09	+0 08	*1.05	*1.05	3.7	4.6	1.9	
1131	Clarks Point	41° 36'	70° 54'	+0 14	+0 24	*1.06	*1.00	3.6	4.5	2.0	
1133	New Bedford	41° 38'	70° 55'	+0 07	+0 07	*1.05	*1.05	3.7	4.6	1.9	
1135	Belleville, Acushnet River	41° 40'	70° 55'	+0 07	+0 09	*1.08	*1.08	3.8	4.7	2.1	
1137	South Dartmouth, Apponagansett Bay	41° 35'	70° 57'	+0 25	+0 33	*1.05	*1.05	3.7	4.6	1.9	
1139	Dumpling Rocks	41° 32'	70° 55'	+0 01	-0 02	*1.05	*1.05	3.7	4.6	1.9	
	Westport River										
1141	Westport Harbor	41° 30'	71° 06'	+0 09	+0 33	*0.85	*0.85	3.0	3.7	1.6	
1143	Hix Bridge, East Branch	41° 34'	71° 04'	+1 40	+2 30	*0.77	*0.77	2.7	3.4	1.4	
	RHODE ISLAND, Narragansett Bay										
1145	Sakonnet	41° 28'	71° 12'	-0 13	-0 01	*0.88	*0.86	3.1	3.9	1.7	
1147	Anthony Point, Sakonnet River	41° 38'	71° 13'	-0 02	-0 02	*1.09	*1.07	3.8	4.8	2.1	
1149	Beaverfall Point	41° 27'	71° 24'	-0 05	+0 04	*0.99	*1.00	3.5	4.3	1.9	
1151	Castle Hill	41° 28'	71° 22'	-0 05	+0 12	*0.94	*0.93	3.3	4.1	1.8	
1153	NEWPORT	41° 30'	71° 20'					3.5	4.4	1.9	
1155	Conanicut Point	41° 34'	71° 22'	+0 07	-0 06	*1.07	*1.07	3.8	4.7	2.0	
1157	Prudence Island, (south end)	41° 35'	71° 19'	+0 08	-0 04	*1.08	*1.07	3.8	4.8	2.0	
1159	Bristol Point	41° 39'	71° 16'	+0 18	+0 07	*1.14	*1.14	4.0	5.0	2.1	
1161	Bristol Highlands	41° 42'	71° 18'	+0 08	-0 07	*1.18	*1.21	4.2	5.2	2.2	
1163	Bristol Ferry	41° 38'	71° 15'	+0 16	+0 01	*1.16	*1.14	4.1	5.1	2.2	
1165	Fall River, State Pier	41° 42'	71° 10'	+0 19	-0 01	*1.25	*1.25	4.4	5.5	2.4	
	RHODE ISLAND and MASSACHUSETTS Narragansett Bay—cont.										
1167	Fall River, Massachusetts	41° 44'	71° 08'	+0 28	+0 29	*1.26	*1.26	4.4	5.5	2.4	
1169	Taunton, Taunton River, Massachusetts	41° 53'	71° 06'	+1 06	+2 21	*0.79	*0.79	2.8	3.5	1.5	
1171	Bristol, Bristol Harbor	41° 40'	71° 17'	+0 13	0 00	*1.16	*1.14	4.1	5.1	2.2	
1173	Warren	41° 44'	71° 17'	+0 18	-0 01	*1.31	*1.29	4.6	5.7	2.5	
1175	Nayatt Point	41° 43'	71° 20'	+0 09	-0 02	*1.31	*1.29	4.6	5.7	2.5	
1177	Providence, State Pier #1	41° 48'	71° 24'	+0 11	-0 01	*1.28	*1.29	4.5	5.6	2.4	
1179	Pawtucket, Seekonk River	41° 52'	71° 23'	+0 18	+0 09	*1.31	*1.29	4.6	5.8	2.5	
1181	East Greenwich	41° 40'	71° 27'	+0 13	+0 03	*1.14	*1.14	4.0	5.0	2.1	
1183	Wickford	41° 34'	71° 27'	+0 09	+0 02	*1.08	*1.07	3.8	4.7	2.0	
1185	Narragansett Pier	41° 25'	71° 27'	-0 11	+0 11	*0.91	*0.93	3.2	4.0	1.7	
	RHODE ISLAND, Outer Coast										
1187	Point Judith Harbor of Refuge	41° 21.8'	71° 29.4'	-0 01	+0 32	*0.87	*0.54	3.1	3.1	1.7	
1189	Block Island (Great Salt Pond)	41° 11'	71° 35'	+0 02	+0 07	*0.74	*0.71	2.6	3.2	1.4	
1191	Block Island (Old Harbor)	41° 10'	71° 33'	-0 17	+0 12	*0.83	*0.86	2.9	3.6	1.5	
1193	Watch Hill Point	41° 18'	71° 52'	+0 41	+1 16	*0.74	*0.71	2.6	3.2	1.4	
	on New London, p.56										
1195	Westerly, Pawcatuck River	41° 23'	71° 50'	-0 21	+0 03	*1.02	*1.00	2.6	3.1	1.5	
	CONNECTICUT, Long Island Sound										
1197	Stonington, Fishers Island Sound	41° 20'	71° 54'	-0 32	-0 41	*1.05	*1.05	2.7	3.2	1.5	
1199	Noank, Mystic River entrance	41° 19'	71° 59'	-0 22	-0 08	*0.89	*0.90	2.3	2.7	1.4	
1201	West Harbor, Fishers Island, N.Y.	41° 16'	72° 00'	0 00	-0 06	*0.97	*0.97	2.5	3.0	1.4	
1203	Silver Eel Pond, Fishers Island, N.Y.	41° 15'	72° 02'	-0 16	-0 04	*0.89	*0.89	2.3	2.7	1.3	

ANSWERS TO STUDY QUESTIONS AND PRACTICE PROBLEMS

LESSON 1.—INTRODUCTION TO COASTAL NAVIGATION

Study Questions

- S1-1. “getting your vessel from where you are to where you want to go, safely and efficiently.”
- S1-2. navigation in coastal waters, where the opportunity exists to determine or check the vessel’s position by reference to navigational aids and observations of the coast and its features.
- S1-3. voyage planning and underway navigation.
- S1-4. assemble required reference materials; formulate voyage alternatives; evaluate alternatives; select best voyage plan and prepare float plan; complete pre-underway vessel checks, and weigh anchor.
- S1-5. sphere; 6,880; 21,614.
- S1-6. dead reckoning (DR).
- S1-7. north and south geographic poles.
- S1-8. great circle.
- S1-9. great circle.
- S1-10. equator.
- S1-11. prime meridian or Greenwich meridian.
- S1-12. 360; minutes, seconds, or minutes and tenths.
- S1-13. Longitude.
- S1-14. small circle.
- S1-15. latitude; Lat, L.
- S1-16. latitude; longitude.
- S1-17. latitude; longitude.
- S1-18. true, magnetic, and ship’s heading.
- S1-19. rhumb line; loxodrome.
- S1-20. weak magnetic field.
- S1-21. magnetic meridians; geographic meridians;

- S1-22. magnetic variation; variation.
- S1-23. east.
- S1-24. isogonic; agonic
- S1-25. adding; subtracting.
- S1-26. ship’s heading + relative bearing = object bearing; 360.
- S1-27. 180; 270.
- S1-28. outer circle; true; inner circle; magnetic north.
- S1-29. 20 degrees W; zero degrees; 21 degrees E; 35 degrees E.
- S1-30. east.

Practice Problems

- P1-1. 124M.
- P1-2. $L\ 39^{\circ}\ 46.6'N$.
- P1-3. $41^{\circ}45' - 41^{\circ}09' = 0^{\circ}36' = 36\ M$.
- P1-4. As measured at approximate midpoint ($41^{\circ}27'$) of chart 44.3 M.
- P1-5. $L = 36'$.
 $Lo = 71^{\circ}35' \text{ Minus } 70^{\circ}36' = 0^{\circ}59'$.
- P1-6. Tokyo, $1^{\circ}\ 33.6'$, or approximately 93.6 nautical miles.
- P1-7. 3, no, these differ because the variation is different at each.
- P1-8. 105 Magnetic, or 105M. Note that the rule is “magnetic to true, add east.” It follows that in going from true to magnetic you subtract east and, therefore, add west.
- P1-9. 142.
- P1-10. 177.
- P1-11. 335.
- P1-12. 035, $(350 + 045 = 395, 395 - 360 = 035)$.

- P1-13. 312.
P1-14. 008M, (359+009=368, 368-360=008).
P1-15. 358.
P1-16. a. 058M
b. 230M
c. 305.
d. 082.
e. 062.
f. 355M

LESSON 2. THE MARINE MAGNETIC COMPASS

Study Questions

- S2-1. lightweight dial.
S2-2. cardinal points; intercardinal points.
S2-3. gimbal system.
S2-4. lubber's line(s).
S2-5. top-reading compass; front-reading compass.
S2-6. fluxgate.
S2-7. weak magnetic fields.
S2-8. shipboard electronics, windshield wiper motors, compressed gas horns, tachometers, electrical motors, television sets, and other equipment.
S2-9. compass heading; magnetic heading
S2-10. deviation.
S2-11. ignore.
S2-12. heading.
S2-13. swinging ship.
S2-14. east; "compass least, error east."
S2-15. pelorus.
S2-16. true; variation; magnetic; deviation; compass.
S2-17. added.
S2-18. easterly; added; westerly.
S2-19. traveling at constant speed.
S2-20. northerly turning error; acceleration error; oscillation error; and heeling error.

Practice Problems

- P2-1. 258 M.
P2-2. The hand-bearing compass is assumed to have no deviation in this example (free from local magnetic fields). Therefore, the hand-bearing compass provides a *magnetic* bearing of 060. The compass bearing, 056, is 004 degrees *less* than the magnetic bearing. Using the rule "compass least, error east," the deviation is 004E.
P2-3. Get in the habit of writing either CDMVT (+ E), or TVMDC (+ W) for this type of problem and working it through. In this case:
C 045C given
D -004W given (attach correct sign)
M 041M calculated
V -009W given
T 032 calculated
P2-4. 022M.
P2-5. 018C.
P2-6. 283.
P2-7. This is an easy CDMVT problem, except that the deviation has to be taken from the deviation table. Since the sequence is from compass to magnetic, the left half of the table is used. Inspection of the table shows that 035C is an intermediate heading. Therefore, the deviation will have to be interpolated to the nearest degree. The deviation is estimated as $5 + 5/15$ ($6-5$) = 5.33 or, rounded, 005 E. The solution follows,
C 035C
D +005E
M 040M
V +015 E
T 055
P2-8. 149.
P2-9. 184.
P2-10. 027.
P2-11. 207; 192M.
P2-12. 121; 301; 286M.
P2-13. 002C.

P2-14. 189C.

P2-15. 145C.

P2-16. 338.

LESSON 3. THE NAUTICAL CHART

Study Questions

- S3-1. water depths, buoys, geographic features, chart datum, landmarks, unmarked hazards to navigation, land outlines, areas of regulatory significance, distance, and direction.
- S3-2. to balance and minimize the distortions to produce a representation that preserves, to the extent possible, direction, distance, shape, area, and correct angular relationships.
- S3-3. conformal.
- S3-4. Mercator.
- S3-5. polyconic.
- S3-6. Mercator.
- S3-7. straight parallel lines.
- S3-8. yes, the distance should be measured at the approximate midpoint of the course or bearing line. As a practical matter, this is not likely to be important except on very small scale charts.
- S3-9. from the nearest compass rose.
- S3-10. statute miles.
- S3-11. 1.10 nautical miles.
- S3-12. coast, general, sailing.
- S3-13. more.
- S3-14. harbor chart; small craft.
- S3-15. water depth.
- S3-16. sandy; "S".
- S3-17. mean high water.
- S3-18. in the General Information Block of the chart.
- S3-19. a small dome-shaped tower or turret rising from a building.

S3-20. visible from all distances, at all aspects, and at all times.

S3-21. has been accurately located and charted.

S3-22. Chart Number 1.

S3-23. *Notices to Mariners*. (Note: See Chapter 10 for a more complete discussion in the text.)

S3-24. the term *flagpole* is used if the pole is not attached to a building, whereas a flagstaff rises from a building.

S3-25. average; greater; lesser.

Practice Problems

P3-1. 126 feet.

P3-2. L: 41°16.6'N
Lo: 71°24.0'W

P3-3. L: 41°15.5'N
Lo: 71°34.6'W

P3-4. 8.0 nautical miles.

P3-5. 082, 097M.

P3-6. 262, 277M.

P3-7. L: 41°20.0'N
Lo: 71°28.5'W

Note: The 1999 *Light List* shows this buoy as watching at L: 41°19.3'N, Lo: 71° 28.6'W, over 3/4 of a mile away! This change of assigned position illustrates why floating aids are not recommended for position fixing. Accurate updates are difficult to enforce in recreational boating with most boaters assuming the latest edition is "close enough." Using this buoy as the entrance buoy to the "Harbor of Refuge" to the northwest could cause you to miss the entrance altogether!

P3-8. boulders.

P3-9. Gp Occ (1+2) 15 sec 65 ft 16 M Horn R Bn
325 .- -. / . - - -

P3-10. BRENTON REEF LIGHT.

P3-11. Lighted buoy W Or "H", Fl 2 sec BELL.

P3-12. 180, 8.1 M.

- P3-13. 109 ft., Dumping Ground.
- P3-14. Elisha Ledge Can Buoy, Green over Red Horizontal Bands.
- P3-15. a. Gould Island
b. Buoy, BW “SR” Mo(A) Whistle
c. Unexploded depth charges; Dec. 1952, Position Approximate.
d. Tonomy Hill Tower
e. Wreck, 51 ft.
- P3-16. 14.6 M; 035; 050M.
- P3-17. Torpedo Range.
- P3-18. a. rocky
b. hard
c. sticky
d. mud, shells
e. mud, sand, and gravel.
- P3-19. No, see chart annotation “Lt obscured” just south of Nomans Land.
- P3-20. Looks like a good place to give a wide berth to -- the largest of these islands is surrounded by rocks. All of the islands are surrounded by fish trap areas. Tangling with a fish trap can be an expensive proposition.

LESSON 4. THE NAVIGATOR’S TOOLS AND INSTRUMENTS

Study Questions

- S4-1. quality; technique
- S4-2. straight lines; angle; lines
- S4-3. time-speed-distance; quickly and accurately
- S4-4. handheld compass
- S4-5. time; time piece; time
- S4-6. 7x50 mm binocular; binoculars; 7 power
- S4-7. handheld lead line
- S4-8. depth of water; 10
- S4-9. compass deviation
- S4-10. watch; publications; plotter; slide rule or calculator

Practice Problems

- P4-1. a. hrd (hard), Narrow return
b. rky (rocky), Multiple sharp returns
c. stk (sticky), Broad fuzzy return
d. sft (soft), Broad fuzzy return
e. sh (shells), Narrow return
- P4-2. R “2”, Fl R 4 sec WHISTLE.
A lighted starboard-hand red whistle buoy with the number “2” painted on it flashing red once every four seconds. (The whistle is activated by wave action and may not sound when the sea is calm!)
- P4-3. Port-hand buoy “29” Fl G 4 sec GONG, (A lighted port-hand green gong buoy with the number “29” painted on it flashing green once every four seconds.)
- P4-4. 172; 187M; 191C ($172+015W = 187M + 4W = 191C$).
- P4-5. 9.7 M
- P4-6. BUZZARDS LIGHT, L: $41^{\circ}23.8'N$, Lo: $71^{\circ}02.0'W$.
(Flashes once every 2.5 seconds, 101 feet high, visible at 22 miles [if you are high enough to see it, approximately 75 ft. above the water] sounds a HORN in reduced visibility, and has a radio beacon that transmits the morse code letters BB on 314 Khz.)
- P4-7. 14.7 M.
- P4-8. a. L: $41^{\circ}34.1'N$; Lo: $70^{\circ}43.3'W$.
b. L: $41^{\circ}33.1'N$; Lo: $70^{\circ}46.6'W$.
c. L: $41^{\circ}30.8'N$; Lo: $70^{\circ}50.1'W$.
d. L: $41^{\circ}29.0'N$; Lo: $70^{\circ}53.6'W$.
e. L: $41^{\circ}27.9'N$; Lo: $70^{\circ}56.6'W$.
- P4-9. a. 057, 237, 072M, 252M.
b. 067C, 257C.
- P4-10. a. 40-53 ft., stk (sticky).
b. 76 ft., hrd (hard).
c. 88 ft., rky (rocky).
d. 70 ft., hrd (hard).
e. 58-59 ft., S Sh (sand, shells).

- P4-11. a. RADAR TOWER.
 b. SPIRE.
 c. Buoy, BR C (Black over red bifurcation [channel splitting] can buoy.)
Note: Black buoys have been replaced by green buoys over the past decade.
 d. Lighted Buoy R “2” Fl R 4 sec WHISTLE.
 e. GAY HEAD Light, Alt Gp Fl (3) W & (1) R 40 sec 170 ft 17M (Fixed light on GAY HEAD exhibiting alternating equal on and off timing) group flashes of three white **and** one red every 40 seconds 170 feet above mean high water visible for 17 miles in clear weather).
- P4-12. a. MONUMENT.
 b. LOOKOUT TR.
 c. BUZZARDS LIGHT.
 d. Buoy “VS” BW WHISTLE (Black and white vertically striped midchannel whistle buoy with “VS” painted on it. Note it is **not** lighted).
 e. Unexploded depth charge ED (Existence Doubtful) Sept 14 1957.
- P4-13. a. 086, 101M.
 b. 075, 090M.
 c. 104, 119M.
 d. 358, 013M.
 e. 022, 037M.
- P4-14. a. 141, 156M.
 b. 074, 089M.
 c. 130, 145M.
 d. 296, 311M.
 e. 334, 349M.
- P4-15. a. 267, 282M.
 b. 255, 270M.
 c. 284, 299M.
 d. 178, 193M.
 e. 202, 217M.
- P4-16. a. 321, 336M.
 b. 254, 269M.
 c. 310, 325M.
 d. 116, 131M.
 e. 154, 169M.

- P4-17. a. 012, 192.
 b. 039, 219.
 c. 113, 293.
 d. 086, 266.
 e. 063, 243.

P4-18. Inland Navigational Rules.

P4-19. COLREGS (International Regulations for Preventing Collisions at Sea, 1972, amended 1982).

LESSON 5. DEAD RECKONING

Study Questions

- S5-1. dead reckoning (DR).
 S5-2. fix.
 S5-3. course or speed change.
 S5-4. dot; semicircle (or partial circle); time; angle.
 S5-5. heading; direction; true; M.
 S5-6. estimated position.
 S5-7. three; 50; 70.
 S5-8. drift.
 S5-9. heading.
 S5-10. Speed of Advance.
 S5-11. Running Fix.
 S5-12. Speed Curve.
 S5-13. $S T / 60$.
 S5-14. $60 D / T$.
 S5-15. $60 D / S$.
 S5-16. Track (TR).

Practice Problems

P5-1. a. 2215
b. 0928
c. 2128
d. 0125
e. 1015
f. 1338
g. 2015
h. 0725
i. 1203
j. 0003

P5-2. a. 0; 19; 19.
b. 13; 25 805.
c. 14; 7; 847.
d. 8; 34; 514.
e. 1; 39; 99.

P5-3. a. 1; 34.
b. 37.0.
c. 6.5.
d. 1; 40.
e. 20.3.
f. 13.1.
g. 10.5.
h. 17.9.
i. 0; 12.
j. 0; 22 or 23.

P5.4. a. C225; C240M; C244C.
b. 0900.
c. 0918.

P5-5. a. C224.
b. C239M.
c. C243C.
d. 0943.

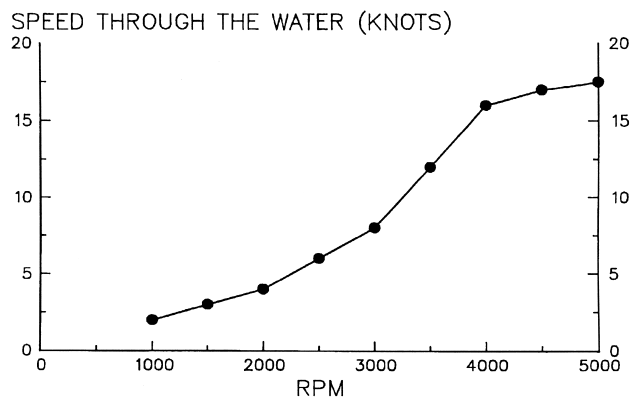
P5-6. a. C231.
b. C246M.
c. C250C.
d. L: 41°26.0'N; Lo: 70°45.0'W.
e. L: 41°22.8'N; Lo: 70°50.2'W.
f. 1039.

P5-7. a. C196M.
b. C201C.
c. L: 41°16.5'N; Lo: 70°51.9'W.
d. L: 41°09.0'N; Lo: 70°52.1'W.

P5-8. a. 111C.
b. 106M.
c. 091.
d. W Or C "AA" Ra Ref
e. 1048/091.

P5-9. The speed curve is shown following. Note that no speed value is plotted for 500 RPM, because no time estimate is available for the "out" leg.

RPM	"OUT" LEG		"BACK" LEG		Average Speed (kn)	Estimated Current (kn)
	Run (min)	Speed (kn)	Run (min)	Speed (kn)		
500	--	--	30.0	2.0	???	
1000	60.0	1.0	20.0	3.0	2.0	1.0
1500	30.0	2.0	15.0	4.0	3.0	1.0
2000	20.0	3.0	12.0	5.0	4.0	1.0
2500	12.0	5.0	8.6	7.0	6.0	1.0
3000	8.6	7.0	6.7	9.0	8.0	1.0
3500	5.5	10.9	4.6	13.0	12.0	1.0
4000	4.0	15.0	3.5	17.1	16.0	1.0
4500	3.8	15.8	3.3	18.2	17.0	1.2
5000	3.7	16.2	3.2	18.8	17.5	1.2



5-10. The speed is 47 ft./7 seconds or 6.71 ft. per second. Now 1 ft./sec. works out to, 1 ft/sec * 1 NM/6076 ft *60 sec/min * 60 min/hour = .5925 kt. Your speed, therefore, is 6.71*(0.5925)=4.0 kts. As point of interest,

this is one of the simplest methods of measuring speed. The table following shows the speed in knots corresponding to various vessel lengths and time.

SPEED THROUGH THE WATER IN KNOTS FOR DUTCHMAN'S LOG									
VESSEL STERN LENGTH (FT)]	TIME (SECONDS) FOR WOOD TO PASS FROM BOW TO STERN								
	2	3	4	5	6	7	8	9	10
20	5.9	4.0	3.0	2.4	2.0	1.7	1.5	1.3	1.2
21	6.2	4.1	3.1	2.5	2.1	1.8	1.6	1.4	1.2
22	6.5	4.3	3.3	2.6	2.2	1.9	1.6	1.4	1.3
23	6.8	4.5	3.4	2.7	2.3	1.9	1.7	1.5	1.4
24	7.1	4.7	3.6	2.8	2.4	2.0	1.8	1.6	1.4
25	7.4	4.9	3.7	3.0	2.5	2.1	1.9	1.6	1.5
26	7.7	5.1	3.9	3.1	2.6	2.2	1.9	1.7	1.5
27	8.0	5.3	4.0	3.2	2.7	2.3	2.0	1.8	1.6
28	8.3	5.5	4.1	3.3	2.8	2.4	2.1	1.8	1.7
29	8.6	5.7	4.3	3.4	2.9	2.5	2.1	1.9	1.7
30	8.9	5.9	4.4	3.6	3.0	2.5	2.2	2.0	1.8
31	9.2	6.1	4.6	3.7	3.1	2.6	2.3	2.0	1.8
32	9.5	6.3	4.7	3.8	3.2	2.7	2.4	2.1	1.9
33	9.8	6.5	4.9	3.9	3.3	2.8	2.4	2.2	2.0
34	10.1	6.7	5.0	4.0	3.4	2.9	2.5	2.2	2.0
35	10.4	6.9	5.2	4.1	3.5	3.0	2.6	2.3	2.1
36	10.7	7.1	5.3	4.3	3.6	3.0	2.7	2.4	2.1
37	11.0	7.3	5.5	4.4	3.7	3.1	2.7	2.4	2.2
38	11.3	7.5	5.6	4.5	3.8	3.2	2.8	2.5	2.3
39	11.6	7.7	5.8	4.6	3.9	3.3	2.9	2.6	2.3
40	11.8	7.9	5.9	4.7	4.0	3.4	3.0	2.6	2.4
41	12.1	8.1	6.1	4.9	4.0	3.5	3.0	2.7	2.4
42	12.4	8.3	6.2	5.0	4.1	3.6	3.1	2.8	2.5
43	12.7	8.5	6.4	5.1	4.2	3.6	3.2	2.8	2.5
44	13.0	8.7	6.5	5.2	4.3	3.7	3.3	2.9	2.6
45	13.3	8.9	6.7	5.3	4.4	3.8	3.3	3.0	2.7
46	13.6	9.1	6.8	5.5	4.5	3.9	3.4	3.0	2.7
47	13.9	9.3	7.0	5.6	4.6	4.0	3.5	3.1	2.8
48	14.2	9.5	7.1	5.7	4.7	4.1	3.6	3.2	2.8
49	14.5	9.7	7.3	5.8	4.8	4.1	3.6	3.2	2.9
50	14.8	9.9	7.4	5.9	4.9	4.2	3.7	3.3	3.0

LESSON 6. PILOTING

Study Questions

S6-1. The reference to charted landmarks, ATONS, and depth soundings.

S6-2. Buoys can be sunk or off station.
It is also important to note that there is a third reason for concern in the use of buoys for determination of LOPs or fixes. That is the buoy may be on station as far as the Coast guard is concerned, but not at the location shown on the nautical chart. Depending upon the area, buoys may be moved many times over their useful life. Each time the Coast Guard moves a buoy to a new location, a notice is issued to that effect, as discussed in the ACN text in Chapter 10. Ultimately these changes are reflected in the nautical charts when the next edition is issued.

At many times in the ACN text we stress the importance of using up-to-date and corrected charts. Nonetheless, the sad truth is that many mariners persist in using out-of-date or uncorrected charts. As a practical matter, many of the chart changes have to do with the location of buoys. (To give you some idea of the number of such changes, compare the 1210-Tr chart with the “real” chart of the area, issued just a few years later.) So there is a distinct possibility that the buoy in question is on station (“watching properly” to use the technical term), but not in the location shown on your chart.

Of course, much the same can be said for fixed aids and landmarks, but generally these change location or characteristics less frequently than floating aids. (In fact, the location of many buoys are not shown on charts, because shifting channels cause these to be reset so frequently that it is impractical to chart the location.)

Many students are initially surprised to learn that fixed structures and landmarks move but, on reflection, they can understand why this is so.

Even water depths can be different from what is shown on the chart, in some cases because of shoaling, in others because a more recent survey becomes available. Thus, fixes determined using soundings can also be in error. An interesting example of chart depth revisions occurred in July 1948, when the *SS American Scout* recorded 20 fathoms of water some 600 miles east of Newfoundland on one of the major seaways; her charts indicated the depth of water as 2,400 fathoms. This anomalous depth was confirmed by other steamers, causing the chartmakers to give this area a name, the *American Scout Seamount*, and duly modified the charts of this area. This seamount was subsequently investigated by several survey ships in the late 1950s and early 1960s, and determined to be illusory. The *American Scout Seamount* was later removed from the charts. This story is recounted in an interesting article by Jack A. Somer in *Yachting*, March 1982.

Taken to its logical extreme, nothing can be relied upon for position fixing; arguably every “fix” can only be regarded as an estimated position. As a practical matter, such extreme skepticism is unwarranted. The overwhelming proportion of fixed aids and buoys are where they are supposed to be (though not always where they appear on your chart). However, the prudent navigator should regard every observation with caution, especially those taken from buoys, and seek to verify any fix using all available means-- GPS, Loran-C, radar, depth, another visual LOP, etc. This topic is discussed at some length in Chapter 12 of the text.

S6-3. On its top with the time of observation (using four digits in the 24-hour system) and maybe labeled on the bottom with the true bearing from the vessel to the object.

S6-4. Add the relative bearing to the true heading to obtain an LOP.

S6-5. Extend the range until it crosses the course line. Then record the time the alignment occurred on the top of the LOP.

- S6-6. a. RADAR;
b. Measurement of vertical angle; sextant
c. Range Finder;
- S6-7. feet; Mean High Water
- S6-8. a. Cross Bearings;
b. Range and a Bearing;
c. Two Ranges;
d. Two Distances;
e. Distance and Bearing of Object;
f. Passing close to a fixed aid to navigation.
- S6-9. Inaccurate measurement of relative bearings;
Mathematical errors;
Inaccurate compass reading;
Inaccurate plotting.
- S6-10. A point with a full circle around it and the time (in the 24-hour system) parallel to the horizontal base of the chart.
- S6-11. a. Allow for a time lapse between the first and second bearings.
b. One LOP is advanced (retired) by moving it parallel to itself forward (backward) in the direction of the course line corrected for current for the distance traveled also corrected for current. The intersection of these two LOPs is the RUNNING FIX.
c. A new dead reckoning plot is started at the position of the R FIX.
d. Avoid advancing an LOP for more than 30 minutes.

NOTE: The example given in the text did not consider current allowances as these are more fully explained in Chapter 7. However, for maximum accuracy all advanced or retired LOPs must include the best estimate of current available in their calculation. Usually, confining the time lapse to no more than 30 minutes makes the current component small and is often ignored, but on a small vessel making little speed the current is often a large portion of the actual vessel movement. Any current determination in these cases will improve the accuracy of the fix. Failure to include current is the major cause of inaccurate running fixes. If a third time lapse LOP is obtained, in addition to plotting its resultant running fix, retiring

ing the LOP to the previous running fix will alert the navigator to an unknown current. If the two fixes do not coincide, unknown current has occurred and the resultant fix must be viewed with caution.

Construction of an EP at the 1000 position of the example given in Figure 6-8 of the text and depth information at 1000 would have given the navigator of the PERDIDA a good estimate of current. These estimates are discussed in Chapter 7.

Practice Problems

- | | | | |
|-------|--|--|---|
| P6-1. | a. 1813/330
d. 2253/150
g. 0801/345
j. 0328/270 | b. 0930/000
e. 1016/140
h. 0625/320
k. 1431/030 | c. 1300/298
f. 0730/270
i. 0625/309
l. 0000/352 |
| P6-2. | a. <u>0215</u>
d. <u>0023</u>
g. <u>1123</u>
j. <u>2217</u> | b. <u>1415</u>
e. <u>0735</u>
h. <u>1828</u> | c. <u>1512</u>
f. <u>2035</u>
i. <u>0913</u> |
| P6-3. | a. <u>2215</u>
D 3.1
d. <u>0825</u>
D 6.5
g. <u>0003</u>
D 3.2
j. <u>1727</u>
D 1.9 | b. <u>0715</u>
D 2.0
e. <u>1428</u>
D 5.0
h. <u>1515</u>
D 2.6
k. <u>1300</u>
D 3.7 | c. <u>0625</u>
D 4.2
f. <u>2338</u>
D 5.2
i. <u>1818</u>
D 1.8 |

Comments on the answers to Problem 6-3.

United States Power Squadron (USPS) standard practice is to label the distance associated with a circular LOP with the prefix "D." Thus, for example, a radar range of 3.5 miles would be labeled D 3.5. The clear intent of the USPS convention is to avoid confusion of distance units with speed units.

Chapman recommends denoting the distance with the label "mi," but this invites confusion with statute miles.

Yet other texts, including *Bowditch* and *Admiralty Manual of Navigation*, do not bother to write in the distance at all! Presumably the reason for this omis-

sion is that the measured distance would be recorded in the navigator's log for future reference if desired, and need not "clutter" up the chart.

In the end, each student of navigation will evolve a convenient system of notation.

- P6-4. a. $\frac{C231}{S10.0}$ b. $\frac{2230}{321}$
- P6-5. a. $\frac{1900}{186}$
- P6-6. a. $\frac{0930}{276}$
- P6-7. a. 352C
b. DOT WITHIN CIRCLE, 0625
L: 41°22.8'N Lo: 70°55.4W
- P6-8. a. $\frac{1527}{307}$; $\frac{1527}{019}$;
b. DOT WITHIN CIRCLE, 1527
L:41°15.7'N Lo: 70°40.4'W
- P6-9. DOT WITHIN CIRCLE, 0625;
L:41°22.8'N; Lo: 70°55.4'W
- P6-10. a. DOT WITHIN CIRCLE, 0715
RADAR;
b. L:41°20.3'N Lo: 70°57.5'W
c. 083
d. 012
- P6-11. a. DOT WITHIN CIRCLE, 2215
RADAR;
b. L:41°13.2'N Lo: 70°43.2'W;
c. 2215
5.1
d. 2215
302
- P6-12. a. $\frac{C231}{S10.0}$ b. $\frac{1715}{321}$ c. $\frac{1733}{212}$
d. $\frac{1715-1733}{321}$ e. 1733 R FIX
f. L:41°24.7'N Lo: 70°47.0'W
- P6-13. a. $\frac{C231}{S10.0}$ b. $\frac{1715}{321}$ c. $\frac{1733}{212}$
d. $\frac{1715-1733}{321}$ e. 1733 R FIX
f. L:41°24.0'N Lo: 70°47.6'W

P6-14. 1039 R FIX

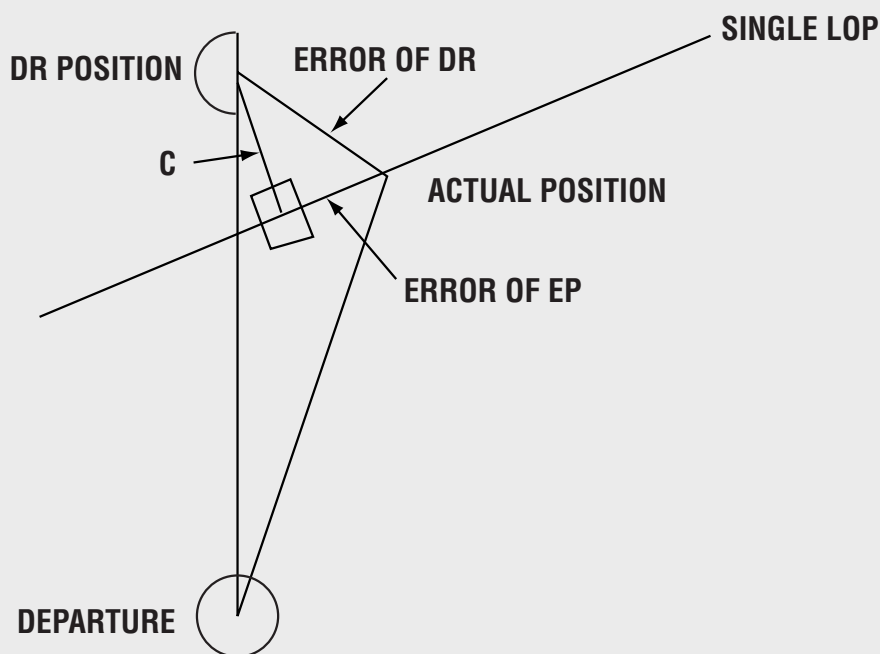
L:41°22.1'N Lo: 70°51.4'W

P6-15. NLT 282T, NLT 297M, NLT 299C

- P6-16 a. $\frac{C120}{S12.0}$
b. DOT WITHIN SEMICIRCLE and 1840 at
angle to bottom of chart
c. $\frac{1840}{356}$
d. DOT WITHIN SQUARE (Possibly time)
L:41°15.9'N Lo:70°44.2'W

P6-17.*This problem is more advanced and was inserted as an exercise to stretch your brain. To see this consider the diagram on the following page. In this diagram, a vessel takes departure from the point indicated in the DR plot. Let us suppose, however, that the vessel does not follow the DR plot but instead drifts to the east of the DR course. Its actual position at the time of the DR position is as shown in the diagram, south and east of the DR position. Suppose that a single LOP is determined as shown. The usual construction leads to the EP denoted by the square. The "correction," C, to the DR position is shown as the length of the perpendicular line from the DR position to the LOP. The error of the EP, denoted r (for residual) is the length of the line from the EP to the actual position. The error of the DR position, denoted d (for dead reckoning) is the length of the line from the DR position to the actual position. Note from the construction that c, r, and d form the sides of a right triangle. From this it follows that $d^2 = c^2 + r^2$. This equation is the familiar relation for a right triangle that the sum of the squares of the opposite and adjacent sides is equal to the length of the hypotenuse squared. Since d squared is equal to c squared plus r squared, it follows that d must always be greater than or equal to r. Put differently, the residual position error of the EP is less than or at most equal to the error of the DR position. In this sense, the EP is a clear improvement to the DR.

GEOMETRY OF ADJUSTMENTS TO DR FROM SINGLE LOP



LESSON 7. CURRENT SAILING

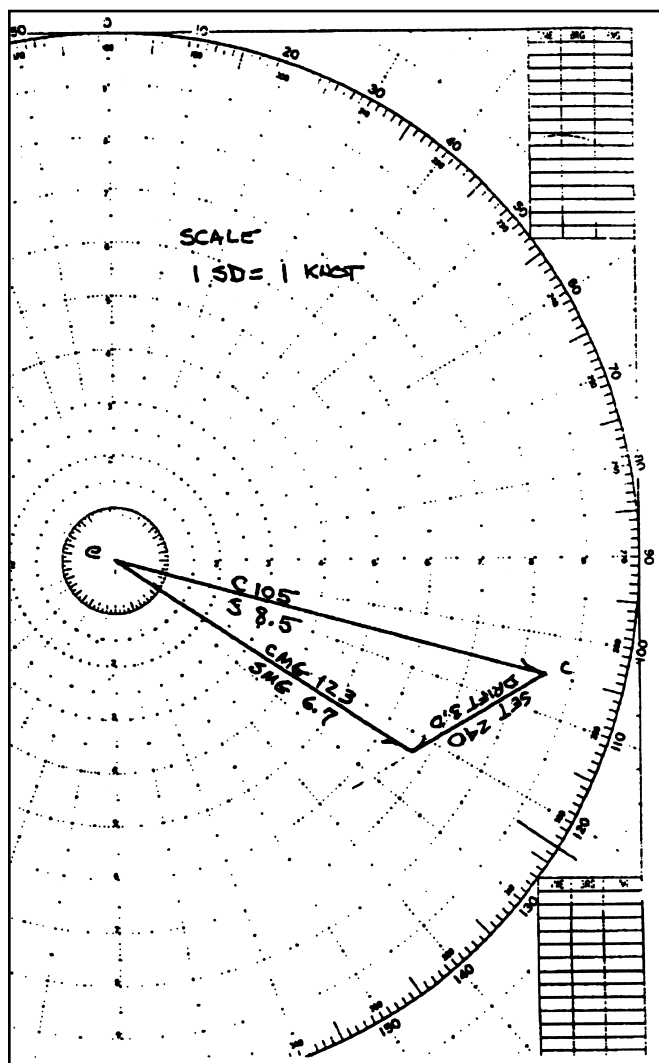
Study Questions

- S7-1. Current Sailing.
- S7-2. 1. the horizontal motion of water over the ground, including ocean current, tidal and river currents.
2. the effect of wind and seas, and
3. the effects of steering due to the helmsman, compass error, speed curve error, tachometer error or other engine error, log or speedometer error, fouled bottom, or unusual trim.
- S7-3. estimated position
- S7-4. developed from evaluation of known or predicted forces using calculations, current tables, diagrams and/or charts.
- S7-5. measured as the difference between the vessel's actual position (fix), and that predicted without taking into account the effects of current (the DR position.)
- S7-6. direction *toward* which a current flows, or the direction *toward* which the vessel has been moved as a result of the current. Set is expressed in degrees true.
- S7-7. magnitude or speed of the current. Drift is expressed in knots or statute miles per hour as appropriate.
- S7-8. difference between the course steered and the estimated track or CMG.
- S7-9. intended or expected; actual.
- S7-10. from the DR position to the fix.
- S7-11. estimated position.

- S7-12. relative bearing of the set compared to the course steered and the ratio of the drift to the vessel's speed.

Practice Problems

- P7-1. a. SET:180; b. DRIFT:3.0 kts; c. foul
P7-2. SET:257,DRIFT:0.8kts
P7-3. SET:301,DRIFT:2.7kts
P7-4. SET:223,DRIFT:2.5kts
P7-5. SET:076,DRIFT:1.0kts
P7-6. See excerpt from maneuvering board below.
Solution follows text example and is:
a. CMG 123 degrees, and
b. SMG 6.7kts.



- P7-7. CMG:099, SMG:7.4 knots.
P7-8. CMG:142, SMG:7.0 knots.
P7-9. COURSE: C259, SOA 7.9 kts, ETA:1328.
P7-10. COURSE: CO74, SOA: 8.6kts, ETE: 30 minutes.
P7-11. COURSE: CO10, SOA: 8.8 knots.
P7-12. SMG is estimated as 7.7 knots. From the vector diagram the SET is 278 degrees, and the DRIFT 3.3 knots. Remember to correct the drift based on the correct time, 70 minutes in this example.
P7-13. SET:072, DRIFT:3.1 knots.
P7-14. SET:087, DRIFT:1.8 knots.
P7-15. a. L:41°18.5'N., Lo:70°55.3'W.
b. CMG:208, SMG:9.2 knots.
c. SET:257, DRIFT:2.1 knots.
P7-16. a. BEARING:316, DISTANCE:7.3M.
b. COURSE:C329, SOA:8.9 knots,
c. ETA: 1449
P7-17. a. CMG:327, SMG:4.6 knots.
b. SET:186, DRIFT:1.7 knots.
P7-18. a. L:41°14.1'N, Lo:70°42.4'W
b. SET:080, DRIFT:2.2 knots.
c. SET:048, DRIFT:2.6 knots.

In principle, this is likely to be a better estimate. However, the crossing angle of the fix is only about 33 degrees, far from the ideal 90-degree crossing angle. As a practical matter, it would be preferable to check this fix with a third bearing. Although fixed aids would be preferable, buoys R "2" south of Nomans Land or "1" just east of the island would both give better crossing angles.

P7-19. a. 287 as measured on the chart.
b. COURSE: 279, SOA: 5.2 knots,
c. L:41°24.8'N, Lo:71°09.8'W.
d. SET:020, DRIFT:1.1 knots.

P7-20. *First*, plot the radar fix. The 2.0 nautical mile radius is drawn on the following chart. Next, the relative bearing, 235R, is converted to a true bearing. Reference to the deviation table given in the text indicates that the deviation is 005E, on a compass heading of 075C.

CDMVT calculations are highlighted below:

COMPASS 075C
DEVIATION +005E
MAGNETIC 080M
VARIATION 015W
TRUE 065

The true bearing of Pt. Judith is, therefore, $065 + 235 = 300$, and the fix is plotted as shown on the attached portion of the chart.

Second, the DR plot is constructed. The compass course 090C is equivalent (using CDMVT) to a true course of 078. Over a 45-minute period the vessel will traverse a distance of $(5)(45)/60 = 3.75$ nautical miles. This 1545 DR position is plotted and labeled as shown.

Third, the current vector is drawn by a dashed line on the chart with a set of 000 degrees a length equal to $(2)(45)/60 = 1.5$ nautical miles, the drift experienced over a 45 minute period.

Fourth, the 1545 LOP is plotted. The magnetic bearing, 331 M, is converted to true by subtracting the variation, 015 W, to give 316 degrees true. This LOP is plotted and labeled.

Finally, the EP (considering both the current and the LOP) is plotted by dropping a perpendicular from the head of the current vector to the 1545 LOP. The distance from this EP to the Brenton Reef Light is measured as approximately 2.9 nautical miles.

P7-21* a. The fix will differ from the vessel's position by the distance that the vessel drifts in the interval between fixes. Depending upon the set of the effective current, the vessel will lie somewhere on a circle of radius $(T)(Dft)/60$ from the DR position. The area of this circle (in square nautical miles), denoted A, is approximately,
 $A = 8.727 \times 10^{-4}(Dft)^2(T)^2$.

b. Substituting 2.5 knots for Dft and 60 minutes for time in the above equation leads to a value of 19.63 square nautical miles for the area of uncertainty! The following table shows how this area varies with the drift and fix interval.

c. Solving the equation in reverse leads to the following expression for the fix interval, T, necessary to ensure that the vessel's position is known at all times to within an area A,

$$T = 33.85/Dft \cdot \sqrt{A}$$

so that if Dft = 2.5 and A = 4, the maximum interval between fixes is approximately 27 Minutes.

POSSIBLE POSITION UNCERTAINTY (SQUARE NAUTICAL MILES) AS A FUNCTION OF FIX INTERVAL (MINUTES) AND CURRENT DRIFT (KNOTS).	INTERVAL BETWEEN FIXES (MINUTES)	CURRENT DRIFT (KNOTS)					
		0.5	1.0	1.5	2.0	2.5	3.0
	15	0.05	0.20	0.44	0.79	1.23	1.77
	30	0.20	0.79	1.77	3.14	4.91	7.07
	45	0.44	1.77	3.98	7.07	11.04	15.90
	60	0.79	3.14	7.07	12.57	19.63	28.27

LESSON 8.—TIDES AND CURRENTS

Study Questions

- S8-1. Vertical; horizontal.
- S8-2. The maximum height reached by each rising tide; the minimum height reached by each falling tide.
- S8-3. The difference between consecutive high and low waters.
- S8-4. Diurnal; semidiurnal; mixed.
- S8-5. Apogee; perigee.
- S8-6. Spring tides.
- S8-7. Neap tides.
- S8-8. Mean lower low water (MLLW).
- S8-9. Reference stations; subordinate stations.
- S8-10. The difference in height between mean high water and mean low water.
- S8-11. Average semidiurnal range occurring semi-monthly as a result of the moon's being new or full.
- S8-12. A plane midway between mean low water and mean high water, measured from chart datum.
- S8-13. a. Neglecting to convert from daylight to standard time, b. not being alert to date changes when calculating tides for subordinate stations, and c. applying high water time differences to low water or the converse.
- S8-14. a. observed directly from the movement of the water around stationary objects, b. calculated as you go using the methods of current sailing, c. estimated or calculated from various published aids.
- S8-15. The time of all slacks, the time and strength of ebbs and floods, and the direction of the ebb and flood.
- S8-16. A tidal current which flows alternately in approximately opposite directions with a slack water at each reversal of direction.

S8-17. A tidal current that flows continually with the direction of flow changing through all points of the compass during the tidal period.

S8-18. The most advantageous time of departure to maximize fair currents over the intended voyage route.

Practice Problems

- P8-1. Semidiurnal.
- P8-2. Mixed.
- P8-3. $4.7 (= 56/[2 + 6 + 4])$.
- P8-4. 1107; 3.0 ft.
- P8-5. 1247; -0.5 ft.
- P8-6. There is more than one instance. One example occurs on 1 January 1999 at 0642 when the tide reaches 4.8 ft.
- P8-7. 19 March 1999 at 0211, -1.0 ft.
- P8-8. 4.2 ft. $(4.0 - (-0.2)) = 4.2$.
- P8-9. New London, CT.
- P8-10. 0502.
- P8-11. 3.4 ft; 4.2 ft.
- P8-12. See attached worksheet in Table 8-1. 0519, 3.5 ft., 1223, -0.1 ft., 1743, 3.1 ft., 0028 (28 Feb), -0.2 ft.
- P8-13. 3.4 ft.
- P8-14. 7.4 ft.
- P8-15. 0954, 1.7 E.
- P8-16. 225 degrees true.
- P8-17. See attached tidal current worksheet and computer output.
- P8-18. See attached tidal current worksheet and computer output. The estimated current is 0.9 knots and ebbing at 190 degrees true.
- P8-19. Weak and variable. Reference to the appropriate table shows weak and variable for this substation at all times.
- P8-20. From computer output 1.2 knots ebbing at 237 degrees.

Substation: <u>Pt. Judith</u>	Date: <u>27 Feb 1999</u>	Look up these values from Table 2., "Tidal Differences and Other Constants." This section can be omitted if the desired location can be found in Table 1 "Daily Tide Predictions" of the <i>Tide Tables</i> . Height differences denoted with an asterisk are to be multiplied rather than added to reference station height.
Ref. Station: <u>Newport</u>	Substation #: <u>1187</u>	
HW Time Diff: <u>-0:01</u>	Diff of Hgt. At HW: <u>*0.87</u>	
LW Time Diff: <u>0:37</u>	Diff of Hgt. at LW: <u>*0.54</u>	

Calculations:			Look up heights and times for reference stations in Table 1., Daily Tide Predictions. Add or subtract time differences for substations to Table 1 times for reference Stations. Calculate the height at the substation from the height of the tide at the reference station plus or minus the height difference tabulated above, unless denoted with an asterisk — in which case the tabulated factors should be multiplied by the heights of the corresponding tides at the reference station. Keep in mind that the time differences may place the required reference tide on the day before or after the date in question for the substation. Remember, times given in tables are standard zone time, not daylight savings time. Subtract 1 hour from daylight savings time to calculate zone time.
Ref. Station: <u>Newport</u> Substation: <u>1187</u>			
Condition Time Height	Condition Time Height		
LW _____	LW _____		
HW <u>0520</u> <u>4.0</u>	HW <u>0519</u> <u>3.5</u>		
LW <u>1151</u> <u>-0.2</u>	LW <u>1223</u> <u>-0.1</u>		
HW <u>1744</u> <u>3.6</u>	HW <u>1743</u> <u>3.1</u>		
LW <u>2356</u> <u>-0.4</u>	LW <u>0028'</u> <u>-0.2</u>		
HW _____	HW _____		

¹ 28 Feb

Height of Tide at Any Time:		
Location: <u>Pt. Judith</u>	Time: <u>0600</u>	Date: <u>27 Feb 1999</u>
Duration of Rise or Fall: <u>7:04</u>	Length of time between high and low tides that bracket desired time	
Time from Nearest Tide: <u>00:41</u>	Use the lesser of the times from the last tide, or time until the next tide	
Range of Tide: <u>3.6</u>	Difference in height between tides on either side of desired time: re that subtracting a negative number is logically equivalent to addition	
Height of Nearest Tide: <u>3.5</u>	Height of tide closest to desired time	
Tabled Correction: <u>0.1</u>	From Table 3	
Height of Tide at Time: <u>3.4</u>	Add above correction if nearest tide is low water, subtract otherwise	
Charted Depth: <u>4</u>	Determined from chart	
Depth of Water at Time: <u>7.4</u>	Add tide height to charted depth to calculate depth at required time	

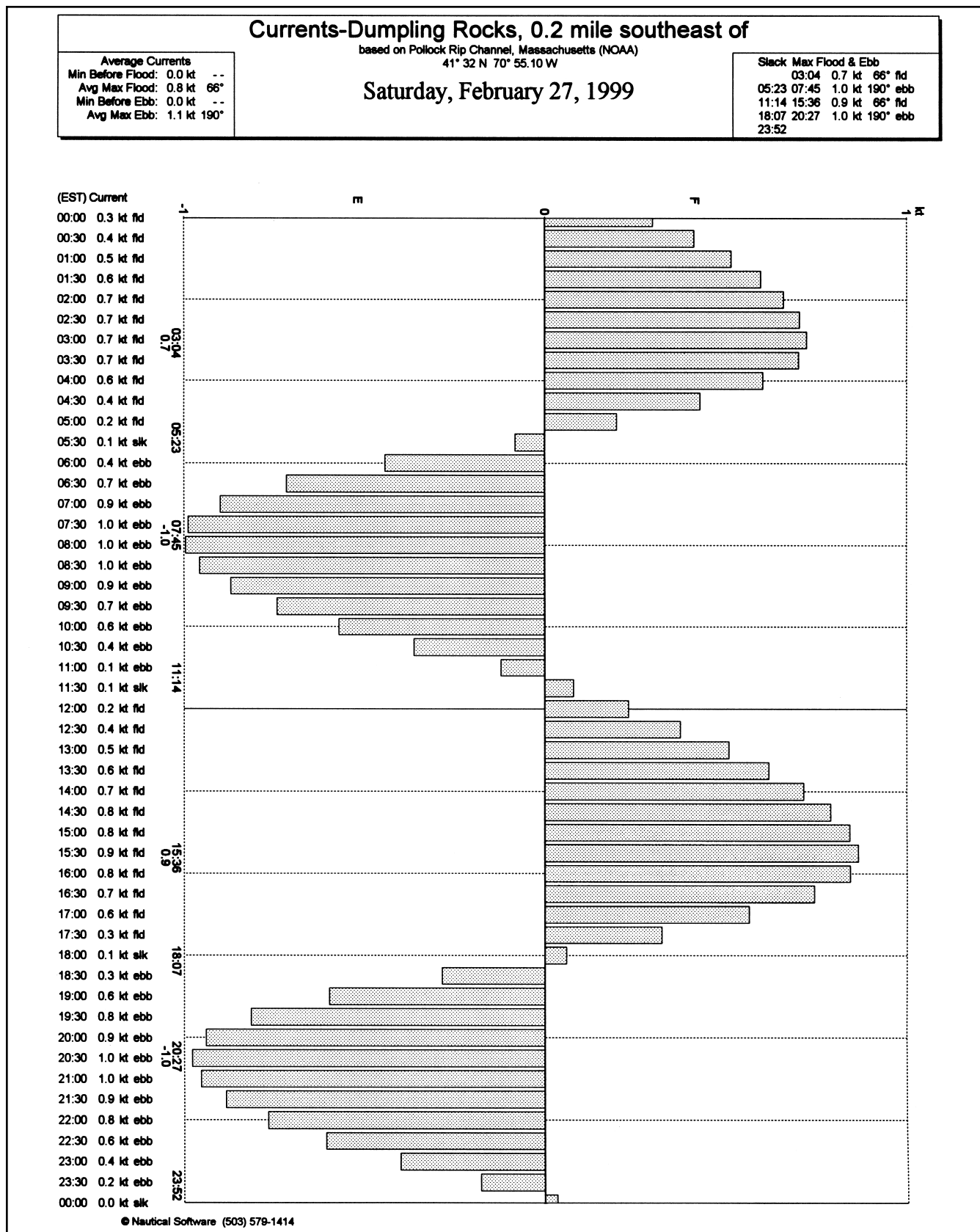
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TABLE 8-1—Complete Tide Table Worksheet.

Substation: <u>2091</u> Time Differences: Min. Bef. Flood: <u>-1:43</u> Flood: <u>-1:03</u> Min. Bef. Ebb: <u>-1:32</u> Ebb: <u>-2:09</u>	Ref. Station: <u>Pollock</u> Speed Ratios: Flood: <u>0.4</u> Ebb: <u>0.6</u>	Date: <u>27 Feb 1999</u> Directions: Flood: <u>066</u> Ebb: <u>190</u>
Look up these values from Table 2, "Current Differences and Other Constants." This section can be omitted if the desired location can be found in Table 1, "Daily Current Predictions." Pay careful attention to any footnotes applicable to the station.		

CALCULATIONS:					
Ref. Station: <u>Pollock</u>			Substation: <u>2091</u>		
Condition	Time	Speed	Condition	Time	Speed
Slack			Slack		
Ebb			Ebb		
Slack	<u>0036</u>	<u>0</u>	Slack	<u>2253¹</u>	<u>0</u>
Flood	<u>0408</u>	<u>1.8</u>	Flood	<u>0305</u>	<u>0.7</u>
Slack	<u>0656</u>	<u>0</u>	Slack	<u>0524</u>	<u>0</u>
Ebb	<u>0954</u>	<u>1.7</u>	Ebb	<u>0745</u>	<u>1.0</u>
Slack	<u>1258</u>	<u>0</u>	Slack	<u>1115</u>	<u>0</u>
Flood	<u>1639</u>	<u>2.2</u>	Flood	<u>1536</u>	<u>0.9</u>
Slack	<u>1939</u>	<u>0</u>	Slack	<u>1807</u>	<u>0</u>
Ebb	<u>2236</u>	<u>1.6</u>	Ebb	<u>2027</u>	<u>1.0</u>

VELOCITY OF CURRENT AT ANY TIME:		
Location: <u>2091</u>	Time: <u>0900</u>	Date: <u>27 Feb</u>
Interval Between Slack and Desired Time:	<u>2:15</u>	Time difference between desired time and nearest slack.
Interval Between Slack and Max Current:	<u>3:30</u>	Time difference between slack and maximum current that bracket desired time.
Max Current:	<u>1.0</u>	Drift of maximum current (ebb or flood) closest to desired time.
Tabled Correction:	<u>0.85</u>	From Table 3—be careful to use correct table if more than 1.
Calculated Velocity:	<u>0.9</u>	Multiply correction by max current.
Direction:	<u>190</u>	Take direction from top data block.


TABLE 8-2—Complete Current Table Worksheet.



LESSON 9. RADIONAVIGATION

Study Questions

- S9-1. 0.1; 0.25 nautical miles.
- S9-2. An onboard navigation receiver and a chain of three to five land-based transmitting stations..
- S9-3. Two or more lines of position based on the TDs.
- S9-4. The corrections for signal propagation are more complex and variable for near shore areas than for outlying areas. In consequence the possible errors may be larger.
- S9-5. Space segment, control segment, and user segment.
- S9-6. ranging.
- S9-7. Standard Positioning Service and Precise Positioning Service.
- S9-8. 100 meters horizontally.
- S9-9. Differential GPS; 10 meters.
- S9-10. Horizontal datum.
- S9-11. Stored.
- S9-12. The closest distance of the aircraft or vessel from its intended track.
- S9-13. The vessel or aircraft passes within a user-defined distance of a destination waypoint.
- S9-14. Plan position indicator (PPI)..
- S9-15. Navigation; collision avoidance.
- S9-16. Proper; radar plotting.
- S9-17. Ship's head up; north up.
- S9-18. Variable range markers.
- S9-19. Electronic bearing markers or electronic bearing lines.
- S9-20. Constant bearing, decreasing range.
- S9-21. Closest point of approach.
- S9-22. Direction of relative motion, closest point of approach, and the time to the closest point of approach.

S9-23. Course and speed.

S9-24. Observation and detection; plotting and analysis; selection of evasive action; and monitoring results.

S9-25. Automatic Radar Plotting Aid.

Practice Problems

- P9-1. The distance should be approximately 6.3 M. The bearing depends upon how the receiver is set up. If the directional reference is true north, it should read approximately 278 degrees. If referenced to magnetic north, it should read approximately 293 degrees. The setup routines in the receiver enable the user to specify whether true or magnetic north is the reference.
- P9-2. The distance between these waypoints (see above) is approximately 6.3 nautical miles. At 17 knots, it should take approximately 22.2 minutes to complete this leg. Therefore, the TTG should be approximately 22 minutes as waypoint 01 is passed.
- P9-3. The cross track error is approximately 1.2 miles (to the left of the intended track). If the receiver were equipped with a course deviation indicator (CDI), the vessel icon should be to the left of the intended track. The bearing is approximately 308 degrees magnetic.
- P9-4. The bearing should be approximately 306 degrees magnetic and the distance should be approximately 10.7 nautical miles.
- P9-5. Check the coordinates of the waypoint in the receiver. A mistake has been made in data entry or the receiver is not operating correctly. This should have been checked before departure. Most navigation receivers can display the bearing and distance between any waypoints.
- P9-6. Based on 10.7 miles at 17 knots the TTG should be approximately 38 minutes.

- P9-7. The GPS navigation receiver should be set to the same horizontal datum as the chart. Note: consult your owner's manual to see how to adjust the datum for your receiver.
- P9-8. It appears that the vessel is over a rocky pinnacle in this position. From the chart, any reading between 37 ft. and 60 ft. is possible.
- P9-9. If the receiver is operating properly and the vessel is making any appreciable speed, the distance to the waypoint should decrease. A failure to decrease could mean that the receiver has lost signal or is otherwise inoperative. This is a good reason for having a backup receiver. If the primary receiver is GPS or DGPS it is preferable to have Loran-C as the backup. That way, if the GPS is down for whatever reason, the vessel can continue to use electronic navigation. If the vessel is equipped with both GPS and Loran-C, check the other receiver to see if the distance to the waypoint is decreasing. Look for any indications of an alarm in the receiver (e.g., "no fix," not ready, or other indication).
- P9-10. A little common sense is helpful here. If at all possible, extra margins should be allowed. Charts also have errors and it is very difficult to measure short distances on charts.
- P9-11. No chart detail of any kind is provided in this area. The navigator should use other charts for trips in this area. The applicable chart numbers are shown in an inset in this chart. A check of the Nautical Chart Catalog indicates that none of these large-scale charts is available with Loran-C overprinting (denoted with a C in a circle next to the chart number).
- P9-12. L: 41° 19.7' N, Lo: 71° 26.7' W.
- P9-13. The position of the target corresponds to lighted buoy R "2" Fl 10 sec Whistle, but you cannot be certain, so alert the lookouts and consider plotting the target.
- P9-14. The target is most probably a vessel, because there are no fixed or floating ATONs in this vicinity. This can be verified by plotting the target or by visual observation if circumstances permit.
- P9-15. 008 R, 12.1 knots.
- P9-16. From the results given below, a vessel of some sort. The answers are 0.7 M, 332 R, XX34, 11.0 knots, and 294 degrees. The problem statement does not ask you to discuss the implications of this plot in terms of the NAVRULES, but you might give the matter some thought. From the RMP and the vector diagram it is clear that this is a crossing situation. If the vessels are in sight of one another, the other vessel is the stand-on vessel and our vessel is the give-way vessel (Rule 15). If it is assumed that visibility is restricted so that the vessels are not in sight of one another, we still have an obligation (Rule 19d) to take avoiding action in ample time.
- In the plotting example, we neither altered course or speed—even though the CPA was 0.7 miles. Whether or not this action was reasonable depends upon several factors—including the type of each vessel involved, ability to maneuver, and the visibility. In good visibility, such a miss distance might be acceptable—certainly for small vessels.
- P9-17. See attached plot. CPA = 0.5 M, TCPA = XX32, bearing 208 R, target course and speed are 276 degrees and 16.5 knots, respectively.

BASIC WORKSHEET FOR SOLVING RADAR PROBLEMS ON MANEUVERING BOARD

DATA FOR PLOTTING: EXAMPLE/CASE: _____ OWN SHIP'S COURSE AND SPEED: 305/10

TIME	DISTANCE IN MILES OR YARD NOTE UNITS	OWN SHIP'S HEADING (TRUE OR MAG)	TARGET RELATIVE BEARING	TARGET TRUE <u>MAG</u> BEARING	REMARKS
<u>XX16</u>	<u>2.5</u>	<u>310</u>	<u>125</u>	<u>075</u>	DISTANCE AND TARGET TRUE OR MAGNETIC BEARING ARE TO BE PLOTTED ON MANEUVERING BOARD. IF TRUE BEARINGS ARE DESIRED ITS NECESSARY TO CONVERT FROM COMPASS HEADING TO TRUE HEADING USING CDMVT ADD EAST LOGIC. CHOOSE AND LABEL BOTH SPEED AND DISTANCE SCALES ON THE BOARD. ENSURE POINTS ARE PLOTTED CAREFULLY USING THE CORRECT SCALE!
<u>XX22</u>	<u>1.6</u>	<u>308</u>	<u>132</u>	<u>080</u>	
<u>XX28</u>	<u>0.8</u>	<u>312</u>	<u>147</u>	<u>099</u>	

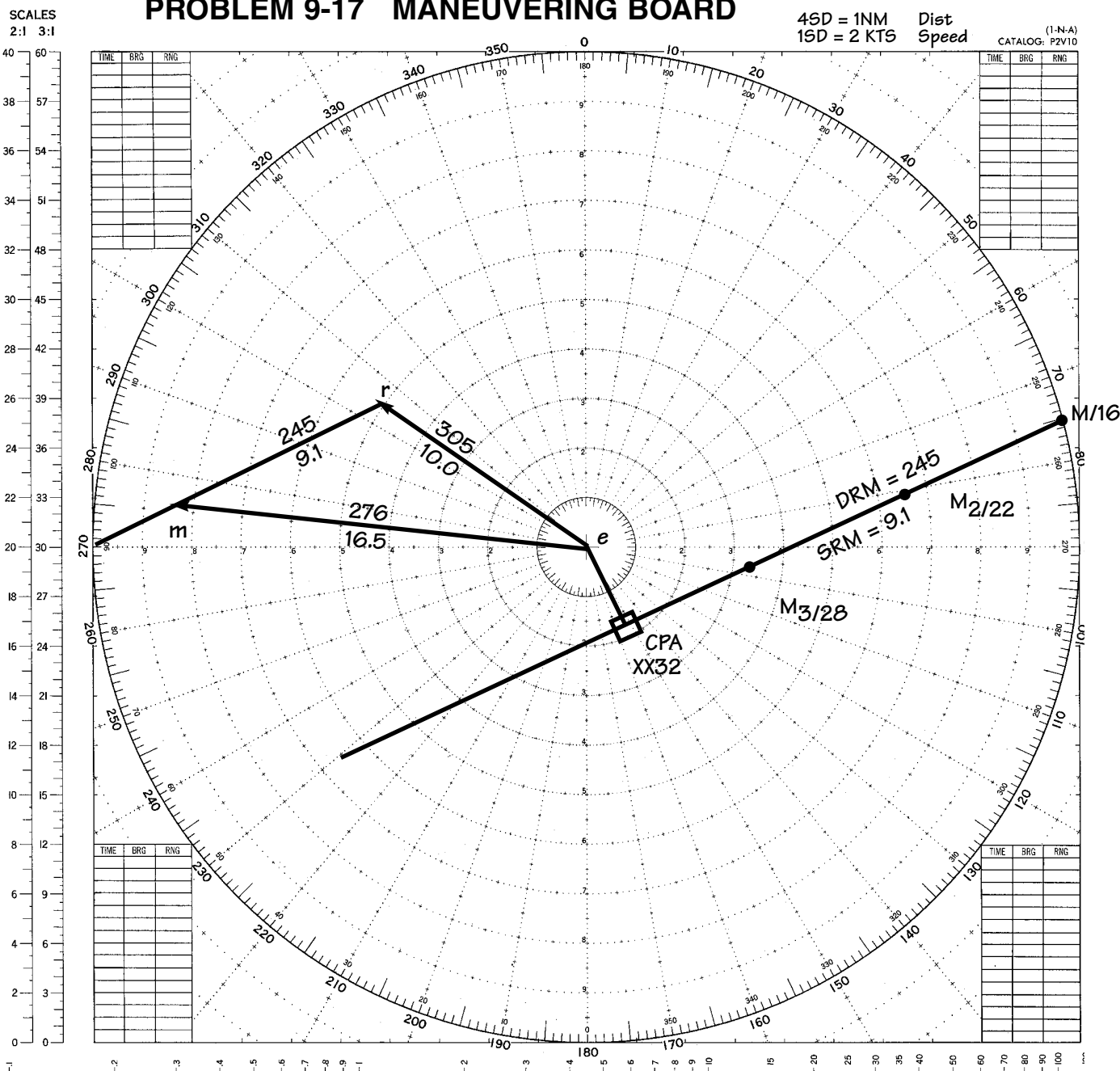
HOW EN- TRIES ARE OB- TAINED	RECORDED READ FROM		READ FROM COMPASS OR GYRO	READ FROM EBL ON RADAR SCOPE	CALCULATED FROM SH + RB (360 MAY HAVE TO BE SUBTRACTED)	SCALE	SD	VALUE
	AT TIME OF OBS.	RANGE RING OR VRM				DISTANCE	<u>4</u>	<u>1 NM</u>
						SPEED	<u>1</u>	<u>2 KNOTS</u>

INSERT REMARKS HERE ON MANEUVERING BOARD PLOTS:

COMPUTATIONS:

TOPIC	QUANTITY	VALUE	REMARKS ON CALCULATION
RELATIVE MOTION	DIRECTION OF RELATIVE MOTION:	<u>245</u>	MEASURED FROM RELATIVE MOTION PLOT-DO NOT ERR BY 180 DEGI
	DIST BETWEEN OBSERVATIONS:	<u>1.825</u>	TAKEN FROM LINEAR PORTION OF RELATIVE MOTION PLOT (RMP)
	TIME BETWEEN OBSERVATIONS:	<u>12</u>	TAKEN FROM INPUTS ON LINEAR PORTION OF RMP
	SPEED OF RELATIVE MOTION:	<u>9.1</u>	CALCULATED FROM ABOVE TWO ENTRIES $S = 60D/T$
CPA	DISTANCE TO CPA:	<u>0.45</u>	EXTRAPOLATED OR INTERPOLATED FROM RELATIVE MOTION PLOT
	TRUE OR MAGNETIC BEARING OF CPA:	<u>155</u>	FROM DRM PLUS OR MINUS 90 DEGREES
	RELATIVE BEARING OF CPA:	<u>210</u>	FROM TRUE OR MAGNETIC BEARING MINUS OWN SHIP'S HEAD
	DIST FROM LAST OBS TO CPA:	<u>0.65</u>	MEASURED FROM RELATIVE MOTION PLOT
	TIME TO TRAVERSE THIS DIST:	<u>4</u>	FROM $T = 60D/S$
	TIME OF CPA:	<u>XX32</u>	FROM ABOVE PLUS TIME OF LAST OBSERVATION
TARGET MOVEMENT	TARGET COURSE:	<u>276</u>	FROM COMPANION VECTOR PLOT ON MANEUVERING BOARD
	TARGET SPEED:	<u>16.5</u>	FROM COMPANION VECTOR PLOT ON MANEUVERING BOARD

▲
TABLE 9-17



LESSON 10. NAVIGATION REFERENCE PUBLICATIONS

Study Questions

- S10-1. National Ocean Service, Charting and Geodetic Services; nine.
- S10-2. Topics covered include coast and channel descriptions, communication frequencies, anchorages, drawbridge schedules and signals, bridge and cable clearances, currents, tide and water levels, prominent features, pilotage, towage, weather, ice conditions, wharf descriptions, dangers, etc.
- S10-3. United States Coast Guard; annually.
- S10-4. The geographic range is the greatest distance the curvature of the earth permits an object of a given height to be seen from a particular height of eye without regard to luminous intensity or visibility conditions.
- S10-5. The luminous range of the light is the greatest distance a light can be expected to be seen given its nominal range and the prevailing meteorological visibility.
- S10-6. The nominal range of the light is the maximum distance a light can be seen in clear weather.
- S10-7. The actual range is the smaller of the luminous range and the geographic range.
- S10-8. This pamphlet contains the latest information on navigational safety, changes in aids to navigation, channels, and chart information over a broad area useful to the ocean-going and coastal vessels alike.
- S10-9. Watching properly.
- S10-10 The Commander of the local U. S. Coast Guard District.

Practice Problems

- P10-1. Computations for light "A": geographic range = $1.17 \cdot \sqrt{10} + 1.17 \cdot \sqrt{57} = 12.5$ Miles
luminous range (from diagram)= approximately 14 M.

The geographic range, 12.5 M, is the smaller of the two and is the approximate range at which light "A" would be seen under these conditions.

For light "B" the geographic range is 22.1 M, and the luminous range from the diagram is slightly less than 10 nautical miles. The luminous range is the smaller of the two and is the approximate range at which light "B" would be seen under these conditions.

Comparing the two, light "A" would be seen at a slightly greater range. Of course, the mariner should seek to see and identify each light, in case these could be used to determine a fix

In this example, perhaps surprisingly, the light with the lower height had the greater nominal range. In fact, this situation occurs quite frequently. The nominal range of an installed light is a function of many factors, including the importance of the light, constraints imposed by nearby human habitation, and technological and economic limitations. As a broad statistical generalization, in the New England area lights with greater structure height also have greater nominal ranges. This trend is shown on the following graph with a random sample of 130 lights selected from Volume 1 of the *Light List*. Note, however, that there are many exceptions to this overall trend. Highlands Light (LLNO 32335) has a height of 246 ft. and a nominal range of only 14 miles, whereas Eastern Point Light (LLNO 305) has a height of 57 ft. and a nominal range of 20 miles.

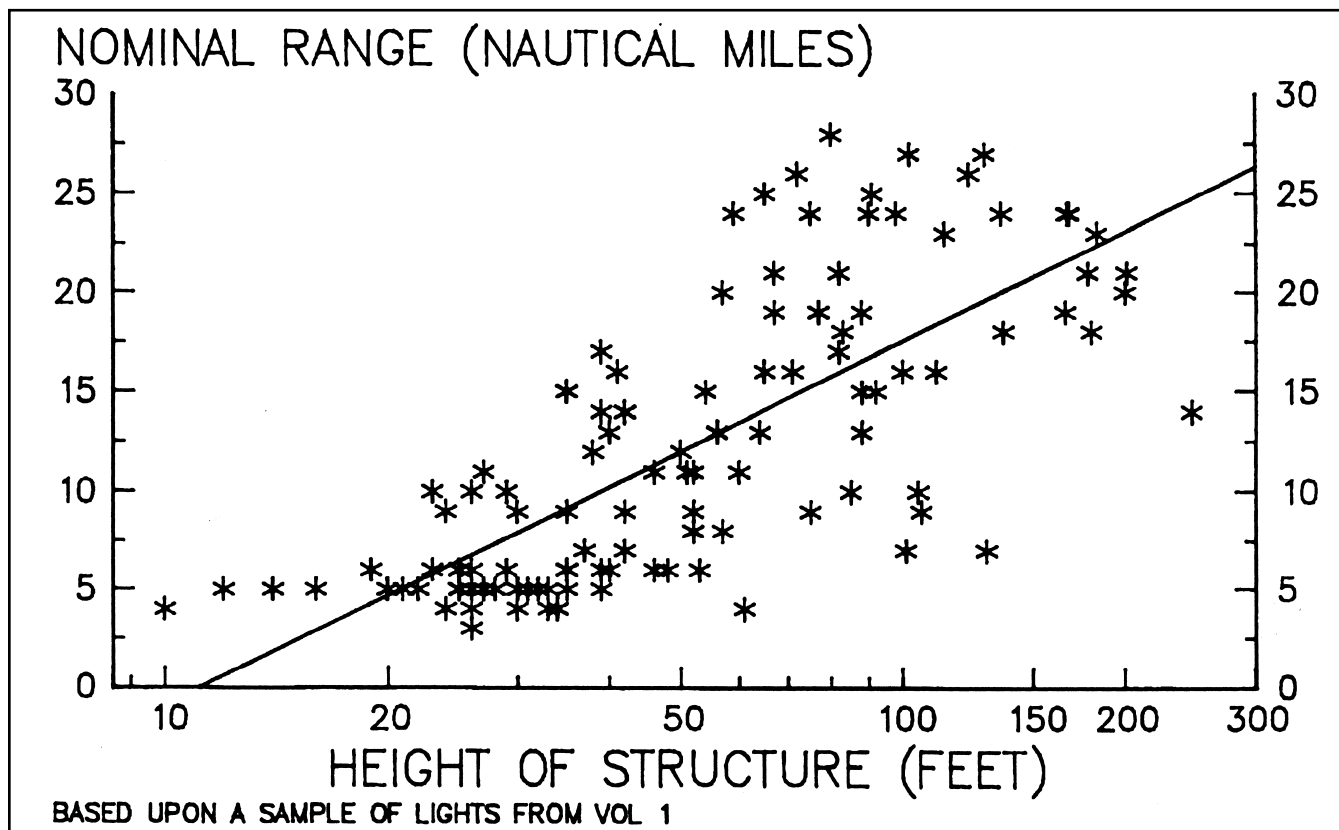
- P10-2. 11.1 miles
- P10-3. Approximately 22M to 23M based on the logarithmic scale.
- P10-4. 19.0 miles; yes.
- P10-5 0.3 miles.
- P10-6. The channel is reported to shoal rapidly after dredging and mariners are advised to seek local knowledge.

P10-7. See *Coast Pilot* excerpt - several sunken rocks and ledges are in this passage.

P10-8. Contact the harbormaster on VHF/FM channel 16.

P10-9. Although several channels exist, only Quicks Hole is recommended for strangers.

PROBLEM 10-1 RELATIONSHIP BETWEEN HEIGHT OF STRUCTURE AND NOMINAL RANGE OF LIGHT



LESSON 11: FUEL AND VOYAGE PLANNING

Study Questions

- S11-1. A fuel consumption chart or curve integrates two types of information. First, it includes the relationship between engine throttle setting in RPM and the vessel's speed through the water (STW). Second, it includes the relationship between engine RPM and the fuel consumption rate, measured in gallons per hour.
- S11-2. Fuel efficiency is the distance the vessel can travel on each gallon of fuel, measured in MPG.
- S11-3. The range is the distance in nautical miles that a vessel can travel with the fuel available.
- S11-4. The endurance is the length of time in hours that the vessel can be operated at a given throttle setting until the en route fuel is exhausted.
- S11-5. The fuel reserve is a reserve or set-aside to allow for contingencies or unforeseen circumstances that could arise in a voyage.
- S11-6. For a displacement or semi-displacement vessel, increased speed generally decreases efficiency and range.
- S11-7. The relationship is more complex. Efficiency may decrease at displacement speeds, and then increase as the vessel gets on plane. Ultimately, fuel efficiency decreases at high speeds.
- S11-8. Factors that affect fuel efficiency include vessel hull design, condition of hull, engine type, horsepower, and condition, engine throttle setting, weight and weight distribution, trim settings, fair or foul currents, wind and sea conditions, and the ability of the helmsman to maintain course.
- S11-9. Fair currents increase fuel efficiency, foul currents decrease fuel efficiency.
- S11-10. A "Howgozit" chart shows the vessel's fuel state and distance remaining. It is used for underway fuel management.

Practice Problems

- P11-1. See attached Table 11-C-1. Throttle setting 750 RPM, endurance 450 hours, range 360 M. Throttle setting 3000 RPM, endurance 7.5 hours, range 86 M.
- P11-2. The lowest setting of 750 RPM maximizes the range. The corresponding range with 10% reserve is 360 nautical miles.
- P11-3. See attached Table 11-C-2. Endurance maximizing: 750 RPM, endurance 450 hours. Range maximizing: 2000 RPM, range 135 M.
- P11-4. Reduces it from 360 M to 135 M, a 62.5% reduction.
- P11-5. See Table 11-C-3. Note that the throttle setting for maximum range is not the lowest given.
- P11-6. Throttle setting 1500 RPM, endurance 22.2 hours, range 182 M. Throttle setting 5300 RPM; endurance 2.4 hours, range 149 M.
- P11-7. Endurance maximizing; 1500 RPM, endurance 22.2 hours. Range maximizing; 3000 RPM, range 259 M.
- P11-8. See Table 11-C-4. No change in throttle setting for either objective, but maximum range is decreased to 243 M, rather than 259 M, a 6.2% reduction.
- P11-9. The planing hull vessel is less affected by current.

TABLE 11-C-1. FUEL PLANNING WORKSHEET

VESSEL: EXAMPLE 11-C-1 DATA SOURCE: STUDENT WORKBOOK
 FUEL CAPACITY: 150 GALLONS
 FOUL CURRENT: 0.00 KNOT(S)--FOUL CURRENTS ARE NEGATIVE

THROTTLE SETTING (RPM)	SPEED THRU THE WATER STW (KNOTS)	SPEED OF ADVANCE SOA (KNOTS)	FUEL CONSUMPTION RATE (GPH)	FUEL EFFICIENCY (MPG)	ESTIMATED RANGE IN NAUTICAL MILES WITH FUEL RESERVE		ESTIMATED ENDURANCE IN HOURS WITH FUEL RESERVE	
					10%	20%	10%	20%
750	0.8	0.80	0.30	2.67	360	320	450.0	400.0
1000	1.0	1.00	0.43	2.33	314	279	314.0	279.1
1250	1.9	1.90	0.90	2.11	285	253	150.0	133.3
1500	3.3	3.30	2.00	1.65	223	198	67.5	60.0
1750	5.1	5.10	3.50	1.46	197	175	38.6	34.3
2000	7.5	7.50	5.50	1.36	184	164	24.5	21.8
2250	8.5	8.50	6.90	1.23	166	148	19.6	17.4
2500	9.8	9.80	9.50	1.03	139	124	14.2	12.6
2750	11.3	11.30	13.00	0.87	117	104	10.4	9.2
3000	11.5	11.50	18.00	0.64	86	77	7.5	6.7

INFEASIBLE POWER SETTINGS ARE THOSE WITHOUT POSITIVE SOAs.

TABLE 11-C-2. FUEL PLANNING WORKSHEET

VESSEL: EXAMPLE 11-C-1 DATA SOURCE: STUDENT WORKBOOK
 FUEL CAPACITY: 150 GALLONS
 FOUL CURRENT: -2.00 KNOT(S)--FOUL CURRENTS ARE NEGATIVE

THROTTLE SETTING (RPM)	SPEED THRU THE WATER STW (KNOTS)	SPEED OF ADVANCE SOA (KNOTS)	FUEL CONSUMPTION RATE (GPH)	FUEL EFFICIENCY (MPG)	ESTIMATED RANGE IN NAUTICAL MILES WITH FUEL RESERVE		ESTIMATED ENDURANCE IN HOURS WITH FUEL RESERVE	
					10%	20%	10%	20%
750	0.8	-1.20	0.30	INFEASIBLE	INFEASIBLE	INFEASIBLE	450.0	400.0
1000	1.0	-1.00	0.43	INFEASIBLE	INFEASIBLE	INFEASIBLE	314.0	279.1
1250	1.9	-0.10	0.90	INFEASIBLE	INFEASIBLE	INFEASIBLE	150.0	133.3
1500	3.3	1.30	2.00	0.65	88	78	67.5	60.0
1750	5.1	3.10	3.50	0.89	120	106	38.6	34.3
2000	7.5	5.50	5.50	1.00	135	120	24.5	21.8
2250	8.5	6.50	6.90	0.96	127	113	19.6	17.4
2500	9.8	7.80	9.50	0.82	111	99	14.2	12.6
2750	11.3	9.30	13.00	0.72	97	86	10.4	9.2
3000	11.5	9.50	18.00	0.53	71	63	7.5	6.7

INFEASIBLE POWER SETTINGS ARE THOSE WITHOUT POSITIVE SOAs.

TABLE 11-C-3. FUEL PLANNING WORKSHEET

VESSEL:		PLANING HULL						
FUEL CAPACITY:		200 GALLONS						
FOUL CURRENT:		0.00 KNOT(S)--FOUL CURRENTS ARE NEGATIVE						
THROTTLE SETTING (RPM)	SPEED THRU THE WATER STW (KNOTS)	SPEED OF ADVANCE SOA (KNOTS)	FUEL CONSUMPTION RATE (GPH)	FUEL EFFICIENCY (MPG)	ESTIMATED RANGE IN NAUTICAL MILES WITH FUEL RESERVE		ESTIMATED ENDURANCE IN HOURS WITH FUEL RESERVE	
					10%	20%	10%	20%
1500	8.2	8.20	8.10	1.01	182	162	22.2	19.8
2000	13.8	13.80	15.30	0.90	162	144	11.8	10.5
2500	22.5	22.50	20.10	1.12	201	179	9.0	8.0
3000	31.4	31.40	21.80	1.44	259	230	8.3	7.3
3500	37.6	37.60	27.70	1.36	244	217	6.5	5.8
4000	41.5	41.50	31.80	1.31	235	209	5.7	5.0
4500	47.2	47.20	54.90	0.86	155	138	3.3	2.9
5000	55.0	55.00	71.60	0.77	138	123	2.5	2.2
5300	61.0	61.00	73.80	0.83	149	132	2.4	2.2

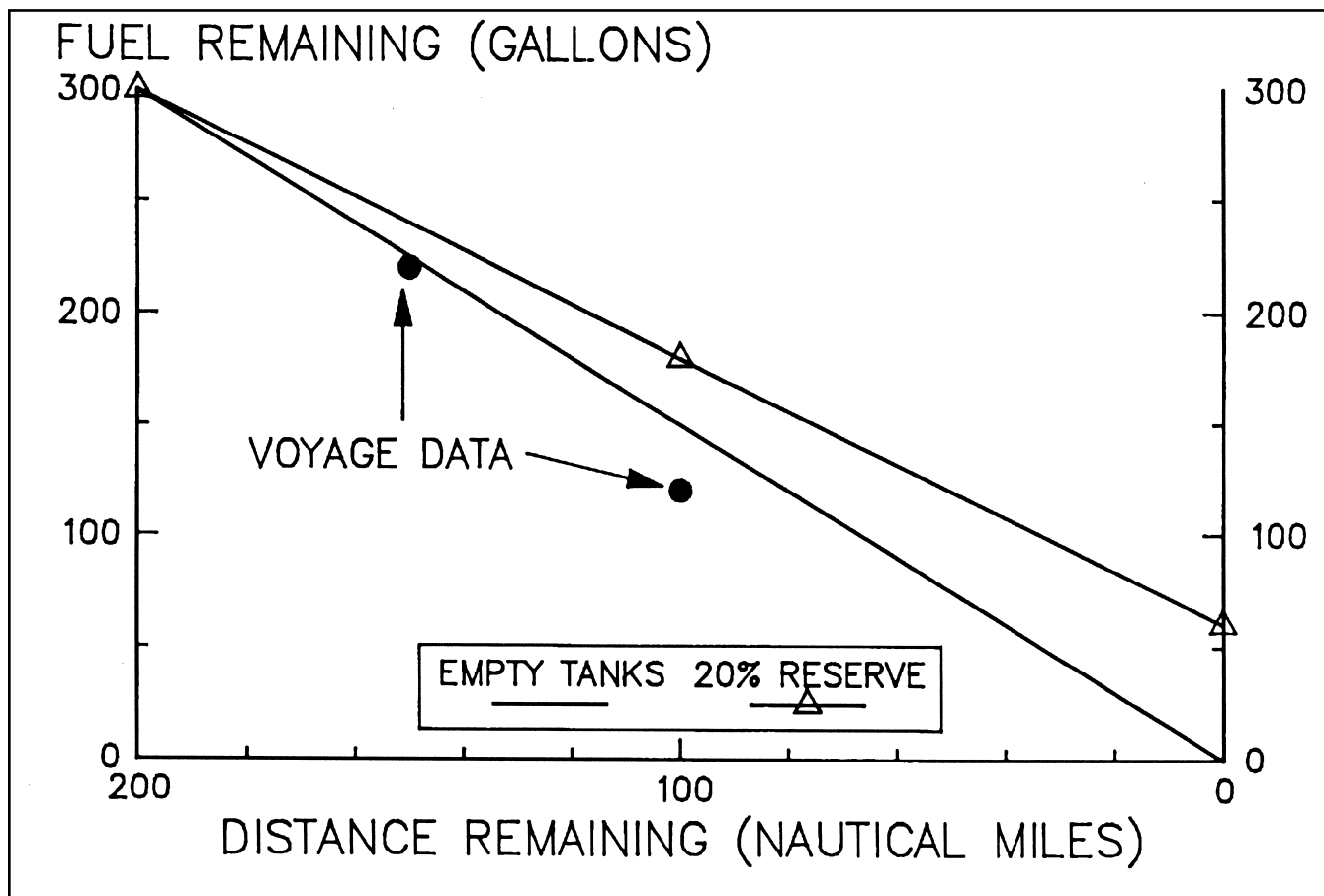
TABLE 11-C-4. FUEL PLANNING WORKSHEET

VESSEL:		PLANING HULL						
FUEL CAPACITY:		200 GALLONS						
FOUL CURRENT:		-2.00 KNOT(S)--FOUL CURRENTS ARE NEGATIVE						
THROTTLE SETTING (RPM)	SPEED THRU THE WATER STW (KNOTS)	SPEED OF ADVANCE SOA (KNOTS)	FUEL CONSUMPTION RATE (GPH)	FUEL EFFICIENCY (MPG)	ESTIMATED RANGE IN NAUTICAL MILES WITH FUEL RESERVE		ESTIMATED ENDURANCE IN HOURS WITH FUEL RESERVE	
					10%	20%	10%	20%
1500	8.2	6.20	8.10	0.77	138	122	22.2	19.8
2000	13.8	11.80	15.30	0.77	139	123	11.8	10.5
2500	22.5	20.50	20.10	1.02	184	163	9.0	8.0
3000	31.4	29.40	21.80	1.35	243	216	8.3	7.3
3500	37.6	35.60	27.70	1.29	231	206	6.5	5.8
4000	41.5	39.50	31.80	1.24	224	199	5.7	5.0
4500	47.2	45.20	54.90	0.82	148	132	3.3	2.9
5000	55.0	53.00	71.60	0.74	133	118	2.5	2.2
5300	61.0	59.00	73.80	0.80	144	128	2.4	2.2

- P11-10 a. See plot.
 b. Things do not look so good at this point!
 Actual fuel is beneath the “empty tank” line.
 c. You have 120 gallons remaining after 100 mile. To have a 20% reserve (based upon the original fuel on board), 60 gallons must remain in the tank on reaching port. This leaves 102 - 60 or 60 gallons en route fuel

to voyage the remaining 100 miles. At 1500 RPM and 10 knots this will take 10 hours. Ten hours at 8.3 GPH works out to 83 gallons -- and leaves you 37 (120-83) gallons at your destination, Think again! Either reduce the throttle setting further (700 RPM will just work), accept a lower reserve, or think about an alternate destination.

“HOWGOZIT” CHART FOR EXAMPLE 11-10



P11-11 The table below shows the required information.

Throttle Setting (RPM)	STW (knots)	Fuel Consumption (GPH)	Trip Time (Hours)	Fuel Required (Gallons)	Fuel Remaining at Destination (Gallons)
700	5.0	3.0	40.0	120.0	210.0
1000	6.5	3.4	30.8	104.7	225.3
1250	8.0	4.4	25.0	110.0	220.0
1500	10.0	8.3	20.0	166.0	164.0
1750	12.0	11.4	16.7	190.4	139.6
2000	14.0	17.5	14.3	250.3	79.7
2250	15.5	25.8	12.9	332.8	-2.8
2500	15.8	31.8	12.7	403.9	-73.9

A throttle setting of 1750 RPM looks OK. This offers a reasonable voyage time (16.7 hours) and still leaves a 42% fuel reserve. Higher throttle settings do not reduce the trip time by much and could put the vessel in a fuel-critical position.

CRUISE EXERCISE ANSWERS

- | | | | |
|-----|---|-----|---|
| 1. | C | 19. | B |
| 2. | A | 20. | A |
| 3. | B | 21. | C |
| 4. | A | 22. | B |
| 5. | A | 23. | A |
| 6. | C | 24. | B |
| 7. | B | 25. | A |
| 8. | C | 26. | D |
| 9. | D | 27. | B |
| 10. | A | 28. | D |
| 11. | B | 29. | C |
| 12. | C | 30. | A |
| 13. | A | 31. | A |
| 14. | D | 32. | B |
| 15. | D | 33. | C |
| 16. | D | 34. | D |
| 17. | C | | |
| 18. | B | | |

