North American Cruiser Association

International Organization for Predicted Log/Cruiser Navigation Contests

Predicted Logging Essentials

by Ed Lloyd

Prepared for the North American Cruiser Association and available to members of the NACA and affiliated organizations.

The Author:

Ed Lloyd is the author of the book well-known to many loggers, PREDICTED LOGGING NOTES. His affiliations include NACA, SCCA, USPS, USCGA, the Chesapeake Yacht Club of Shadyside, MD, and the Southwestern Yacht Club of San Diego. As an experienced yachtsman on both the U.S. east and west coasts, he has participated in log and similar contests for many years. Among many awards, in the Chesapeake Bay area he received the 1969 Potomac River Power Squadron award for best score for the year; he won the Craig Trophy against 80 contestants in 1974. He is a retired engineer and physicist, with an extensive background in instrumentation and measurement.

FOREWORD

From time to time a yachtsman is reminded of the attractions of predicted logging in magazine articles, by comments of fellow yachtsmen, or perhaps by the sudden need on some cruise for some of the skills that are a part of logging. The rewards of logging are at least three-fold, though perhaps not in the same order for every participant: (1) it is a source of improved knowledge and skill in boat operation and in judging weather effects on boat performance, (2) it is a challenging participating competition (In which chance plays a sufficient part that every contestant will receive recognition sooner or later!), and (3) it is an important meeting ground for all those having a common interest in boats and cruising.

Whatever the source of the interest that has led the reader to this publication, he now presumably desires to gain a better understanding of logging, and review (or perhaps see for the first time) a step-by-step description of how to prepare for and run a contest in his own boat. This pamphlet is intended to outline the basic points that he should take into account. It is assumed that he is familiar with the NACA Rules, and has at least been aboard a contesting boat sufficiently to know the general procedures.

The material is based, in part, on the author's book "Predicted Logging Notes," published in 1973. Loggers who may wish to delve into the subject in greater detail are referred to that book.

Ed Lloyd
February 1983

Section 1 -- GENERAL APPROACH

The Contest

A predicted log contest has the great virtue, in common with a few other types of contests of skill, of being simple in basic concept. It is a competition in piloting a vessel over a prescribed course in a time predicted by each contestant, without access to any means for determining elapsed time. This is equivalent to a competition using timepieces, in which performance is measured by the error in position reached at the end of a run from a marked starting point to a specified but unmarked finish point. Because of the practical difficulty in measuring accurately a contestant's position error with respect to an unmarked finish point, the equivalent quantity, the time error in reaching a marked finish point, has been adopted as the means for determining piloting skill.

Thus, a predicted log contest closely simulates the conditions encountered in actual piloting, where safe arrival at a destination may require the navigator to strive accurately to assess and compensate for wind, current, uncontrolled speed variations, and other disturbing elements that may introduce errors into his estimated position.

Strictly speaking, each leg of a predicted log contest is a separate contest, because the error in running one leg cannot be cancelled by the error made on another leg.* This is an important point, since it immediately provides some guidance for minimizing overall score. The consequences are that in running a contest, each new leg must be run without any attempt to "make up" for time that the contestant feels, perhaps on the basis of new current information gleaned along the course, was gained or lost on a previous leg. In particular, changes in speed just to finish the final leg close to other boats will, in general, result in a poorer score. A further consequence is that, since percentage errors on the shortest legs contribute least to the final score, most effort and attention should be given to minimizing percentage errors on the longer legs by, for example, acquiring better current estimates on the longer legs.

Factors Affecting Scores

When the prospective contestant receives the official description of the contest course, his immediate task is to prepare a log based on his estimate of the running time for each leg. This involves a decision as to the boat speed to be used and the determination of the corresponding engine rpm required, the measurement of the leg

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* The predicted log contest score is computed as the sum of the time errors for each leg, expressed as a percentage of the total predicted time for the entire course.

lengths,* estimates of turning times, and estimates of current and wind effects. All of these quantities involve uncertainties which, together with other uncertainties encountered in the actual running of the course, combine to determine the final score. Thus achieving a favorable contest score really comes down to dealing with these sources of error.

Some general points can be made concerning errors, that may be helpful in a contestant's planning and running of a contest.

First, it is to be kept in mind that scores are on a percentage basis rather than calculated directly as errors in time. Thus, in efforts to achieve best scores, the relative sizes of errors must be considered as a percentage of leg time rather than compared on the basis of absolute size. For example, if a starting error of a 6 knot boat is 6 seconds, and of a 12 knot boat is 4 seconds, the 6 second error will be smaller on a percentage basis since the leg time will be twice as log for the lower speed.

Secondly, in improving contest scores, the contestant's efforts will be most effective if the largest errors are given primary attention. Thus, there is little to be gained from improving current estimates until speed errors are reduced to generally the same size. This type of conclusion is applicable generally to the various sources of error that compete for a contestant's time and attention.

Contest Strategy

The contest strategy considered here consists in preparing the best practicable predicted log by use of information from charts, Current Tables, wind forecasts, examination of critical points of the course, and accurate speed curves, and then during the contest applying "mid-course corrections" in the form of small engine rpm changes to compensate for unexpected or unallowed-for effects such as errors in current estimates.

The extent to which mid-course corrections are used is, of course, a matter of choice, and depends upon the benefits expected. If the circumstances of a particular contest make it apparent that distance uncertainties will be predominant, or that speed-through-the-water errors are likely to be large, no significant benefit will accrue from mid-course corrections dealing with much smaller current or timing errors. Again, the fact that expected errors are not directly additive, but combine to make the largest errors predominant, may justify a decision to give little attention to mid-course corrections. On the other hand, under favorable contest conditions, where distance errors are known to be small and weather and other factors permit speed-through-the-water errors to be held to minimum values, the finish order of competing boats

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*Here, distances are in nautical miles and speeds in knots.

will very frequently depend on the skill of the contestants in dealing with current, wind, and timing errors, by application of mid-course corrections.

While skill and judgment are required in preparing the log, the fact that time for this is not specifically limited tends to make this a more routine part of the overall task. During the contest, decisions relative to speed corrections must be made within definite times, with limited information, and this part of the task provides considerable scope for exercise of ingenuity and skill.

Because of the demanding nature of these decisions, the task of piloting the boat is probably best separated from other activities. This makes desirable a crew of at least two persons, in which one gives full time and attention to helmsmanship while the other devotes his efforts to estimating and compensating for disturbing influences and to overall direction.

Usually, the contestant aims to run the entire contest course at the same nominal speed through the water, making only such speed adjustments as are required to compensate for unallowed-for effects.

Pre-contest calculations then, are based on a constant speed-through-the-water, with mid-course corrections being made as necessary to obtain an average speed-over-the-bottom for each leg corresponding to the leg times used in making the official predicted log entries. This scheme permits the contestant's maximum time and attention during the contest to be concentrated on departures from expected conditions and on making necessary corrections for them. Thus, if no need for speed corrections were to occur, the entire course would be run at the same engine rpm.

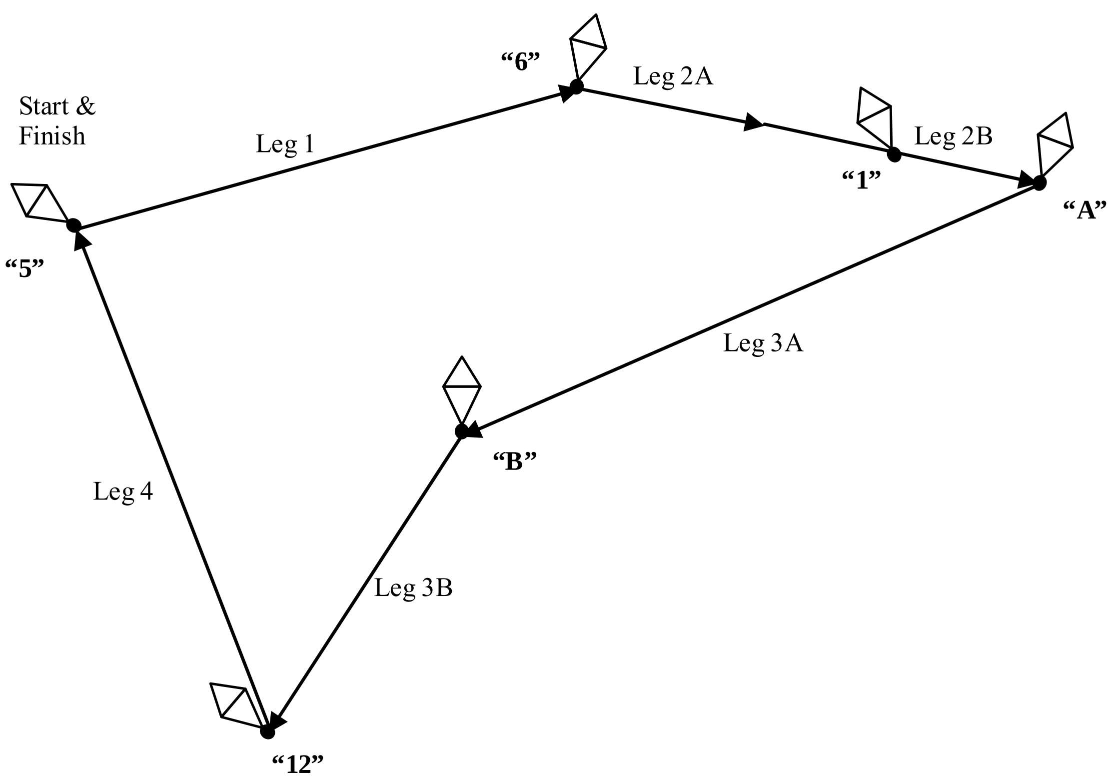
The boat heading for each leg is maintained until the control point is abeam, at which moment the mark is called and the turn to the next leg is commenced. The turning time is then always part of the time for the leg following the turn.

Steering is by compass, assisted by visual sighting of control points and other recognizable objects to the maximum extent permitted by conditions on the contest course. Under conditions of most contests, errors attributable to compass inaccuracy are not of great importance if compass accuracy is within limits attainable by normal compass compensation, perhaps within two degrees with deviation correction.

Finally, the boat speed is set and controlled by setting engine rpm, using tachometers and previously prepared speed curves.

An important part of contest strategy is the accumulation, over a number of contests, of information that will contribute to improved performance in subsequent contests. Thus, useful local knowledge concerning currents may be acquired; accuracy of charted positions of buoys and other objects may be improved, sometimes substantially; ranges on landmarks may become familiar as indicators of lines of position; a tabulation of accurately known distances between pairs of frequently used turning points may be developed, as well as a tabulation of coordinates of such turning points, which may then be used for rapid and accurate calculation of distances; speed curves and other data on boat performance may be improved; and alternate techniques tried out. This aspect of contest strategy can hardly be emphasized too strongly for the contestant who is seriously interested in improved boat operation as well as in improved scores in predicted logging.

In running the legs of the course, and to be prepared for dealing with mid-course corrections, it is helpful to have at hand during the contest a tabulation giving pertinent information for each leg. Such a tabulation is shown on the next page for a hypothetical course of four legs. The sketch below shows the course itself.



The first and last legs are marked only by buoys at the ends, designated as control points, but the second and third legs each consist of two shorter legs. Leg 2 happened say, to pass close to buoy "1" and so could be considered as two shorter legs, 2A and 2B, while Leg 3 contained an intermediate turning point, buoy "B", in the contest instructions and so was broken into 3A and 3B. As will be seen below, an advantage in considering each "sub-leg" separately is that the necessary mid-course corrections are more easily and accurately made. Also, inclusion of the intermediate point on Leg 2 provides an additional steering point.

The tabulation of course information is conveniently posted for ready reference by navigator and helmsman during the contest.

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	
Leg	Magnetic Course	Starting From	Leave To	Distance – Naut. Miles/YDS	Current – Knots	Turning time – Seconds	Leg Time w/Turn – Min:Sec/Seconds	Remarks
1	060°	"5"	-	6.21/12580	+0.3	-	36:10/2170	
2A	088°	"6"	Stbd	3.54/7170	+0.8	1	19:41/1181	
2B	088°	"1"	Port	1.20/2430	+0.6	-	6:48/408	
3A	234°	"A"	Stbd	7.20/14580	-0.5	23	45:51/2751	
3B	206°	"B"	Stbd	4.00/8100	-1.0	-1	26:39/1599	
4	330°	"12"	Stbd	5.19/10510	-1.3	16	36:04/2164	Finish at "5"

Pass all marks 15 yds off. Starting Time: 11:08:47
Turning radius 60 yds, Turning rate 5.4°/sec. Finish Time: 14:00:00
Nominal speed 10 knots @ 2150 rpm, 5.6 yds/sec.
Engine speed change per tenth knot (speed rate), 25 rpm

Columns (1) through (4) are self-explanatory.
Column (5) is the distance from point to point, with no allowance for turns or boat heading variations. The dual listing of leg lengths by nautical miles and by yards is an aid in making mental estimates during the contest.
Column (6) lists expected values of current projected along the leg, derived from Current Tables and other sources. In this column, a plus sign indicates that the current will increase boat speed by the amount given, and minus sign indicates that speed will be reduced.
Turning time, Column (7), is calculated using one of the methods later described. These times are the time lost or gained due to the turn – not necessarily the same as the actual time in the turn, since the turn may carry the boat into or away from the next leg. The time for leg 3B is minus one second – that is, one second saved – because an inside turn is made at the start of the leg at buoy "B". If a standing start (rather than a running start) is made at the start of Leg 1, the time lost is listed in Column (7) and treated the same as a turning time.
Leg times, Column (8), are computed by the familiar 60D=ST formula for the leg distances, Column (5), using speeds for each leg obtained by combining the nominal speed, 10 knots, with the current values of Column (6).* Thus the speed for calculating time for Leg 1 is 10.3 knots, and for Leg 4 the speed is 8.7 knots.

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*In this example, it is assumed that heading corrections due to cross-course currents are small. When heading corrections exceed four or five degrees it may be desirable to make a further small speed allowance for the effect of current, as described in Section 2 (page 12).

As listed in Column (8), these leg times are also increased or decreased to include the turning times, Column (7), at the start of each leg.

The Column (8) times are the leg times used in making up the official predicted log, the times for Legs 2A and 2B, and for 3A and 3B, being combined. Dual listing of leg times by minutes and seconds, and all-seconds, is needed for estimating corrections during the contest.

In the space below the columns, the figures given for nominal speed in knots and yards per second, engine rpm, and speed rate, are used in estimation mid-course corrections.

In this example, it was assumed that expected wind and wave effects were uncertain, but could be compensated for as they occurred during the contest.

Mid-course Corrections

As noted earlier, mid-course corrections are often necessary if best scores are to be made. In some cases however, poor visibility or other conditions of the contest may make mid-course corrections of little value. Or, a skipper just entering predicted logging, perhaps with a new boat, may feel that various uncertainties are not yet well enough in hand to justify using mid-course corrections. Then the course may as well be run directly from the course-distance-time tabulation above, without change. But eventually the contestant will wish to take advantage of mid-course corrections, and these are outlined below.

Out at the start of Leg 1, shortly before the starting time, the actual current is estimated (by observing floating objects relative to fixed objects, "ripple reading", etc.) and any correction to the +0.3 knot figure of Column (6) is noted. This correction, in tenths of a knot, is multiplied by the speed rate (25 rpm per tenth knot in the example) to obtain an engine speed correction for the first leg. If necessary, a speed correction for the estimated effect of wind and waves is similarly handled. As the starting point is passed (assuming a running start), the time in seconds fast or slow with respect to the planned starting time is noted and translated into an additional speed correction, using one of the methods outlined below. The resulting rpm change is then combined with the rpm correction just determined for current, wind, and waves. The same procedure is followed on succeeding legs, with the total of estimated timing errors taking the place of starting error.

Any other unplanned-for occurrence that affects leg time or distance is also handled in this way. For example, it may be necessary to pass a control point at a greater distance than planned, due to traffic conditions or for other reasons. If the error is estimated as time lost, as can easily be done for turns where the mark is passed at nearly constant distance off, the time error is handled in the same way as a starting error to obtain an rpm change for the leg. Otherwise, the error may be estimated as distance lost. For turning angles near 90 degrees this is easy, since the distance error is nearly equal to the error in distance off. Correction of a distance error by an rpm change is described below.

Time error correction

There are several ways that a time error, such as a starting error, may be translated into an rpm change for the leg. Here are two:

(1) The time error in seconds is divided by the leg time in seconds (usually a rough mental calculation will suffice), the leg time being taken from Column (8), and the resulting percentage applied as a percentage change in rpm for the leg.

(2) More accurate results are obtained if the percentage time change is used as a percentage speed change, converted to tenths of a knot, and this figure applied to the previously determined speed rate to give the rpm change for the leg.

As an example to illustrate corrections applied at the start of Leg 1, suppose that the actual current is estimated to be 0.4 knot instead of the 0.3 knot expected, and that wind and waves are negligible. Then speed would be reduced by 0.1 knot or 25 rpm for the first leg. Then if the starting line were passed 7 seconds early, the additional speed reduction needed (using method 2) would be 7/2170 or 0.3 percent. Since the nominal speed is 10 knots, this means that speed must be reduced 0.03 knot or, at a speed rate of 25 rpm per tenth knot, 8 rpm. Thus, the total engine speed change for the first leg is a reduction of 33 rpm.

Distance error correction

The distance error in yards may be divided by the leg distance in yards from Column (5), and the resulting percentage change applied as a percentage change in rpm, as in method (1) for time errors.

Alternatively, for greater accuracy, the percentage distance error may be considered as a needed percentage change in boat speed and applied to the speed rate to obtain the corresponding rpm change, as in (2) above for time errors.

In the example, if a distance of 50 yards was lost at the control point at buoy "6", this would be 50/7170 or 0.7 percent of Leg 2A, calling for a speed increase of 0.07 knot for Leg 2A. This translates into an rpm increase of 25 x 0.7, or 17 rpm. The 17 rpm would, of course, be combined with any other rpm change necessary due to current or other factors on Leg 2A.

Time or distance loss in mid-leg

When either time or distance is lost in mid-leg, the loss can be compensated for roughly, but often well enough, by estimating the time or distance lost, converting this into an rpm increase needed for the entire leg, and then increasing this rpm change further in inverse proportion to the estimated fraction of the leg distance remaining.

Thus, if approximately half way along Leg 4 a delay estimated at 60 seconds occurred, the increased speed required for the leg would be 10 x (60/2164), equal to 0.28 knot, or 0.56 knot for the half leg remaining.

Any rpm correction that is to be applied for an entire leg, which was not actually applied until some distance into the leg, should be increased in inverse proportion to the fraction of the leg distance remaining. An important advantage in having a leg divided is that the entire speed correction can be so applied to just the final portion of the leg (Leg 2B or 3B in the example), giving further time and distance for studying and calculating corrections.

Section 2 -- PREPARING THE LOG

Before filling out the official predicted log form, a course-distance-time chart should be prepared, similar to that shown on page 8. This will usually require that the tabulation first be completed with the leg times listed only approximately, for use in estimating time-of-day for arrival at the mid-point of each leg. With this information available, current estimates are made for each leg, and the leg times are then re-calculated in final form. The steps involved in this, and suggested procedures, are outlined below.

1. The official course is laid out on the chart, incorporating such "dog legs" as may be necessary to avoid obstructions or other hazards. Whenever a dog leg is used, the turning point in the dog leg should be readily identifiable on the chart <u>and</u> out on the course, in order that the leg length be accurately known. Course lines may be drawn between Marks form point to point, so long as the Mark can be passed within, say, 100 yards – rather than drawn to a position alongside the Mark. Then, the time for the additional distance required to round the Mark is taken care of later as the "turning time". If the Mark cannot be passed within 100 yards or so, (for example, it might be a light house ashore) then the course may be plotted through a turning point located at a nearby buoy, if one exists, or located by ranges or bearings on the Mark or other nearby objects. Use of ranges is preferable to use of bearings, since much better accuracy is usually obtained. On the chart, such unmarked turning points may be designated TP1, TP2, etc.

2. The length of each leg or leg segment, in nautical miles and yards, is measured. This may be done by carefully scaling distances from the chart, using dividers for short distances and a draftsman's scale or equivalent for distances longer than one moderate divider span.

The wide availability of electronic calculators has made the <u>calculation</u> of chart distances easy and more accurate. Thus, the scaled distances may be checked, and accuracy often improved, by measuring the latitude and longitude of each point, and then calculating the distance by a traverse calculation as described in the Appendix. Once obtained, these positions and distances are often useable for subsequent contests.

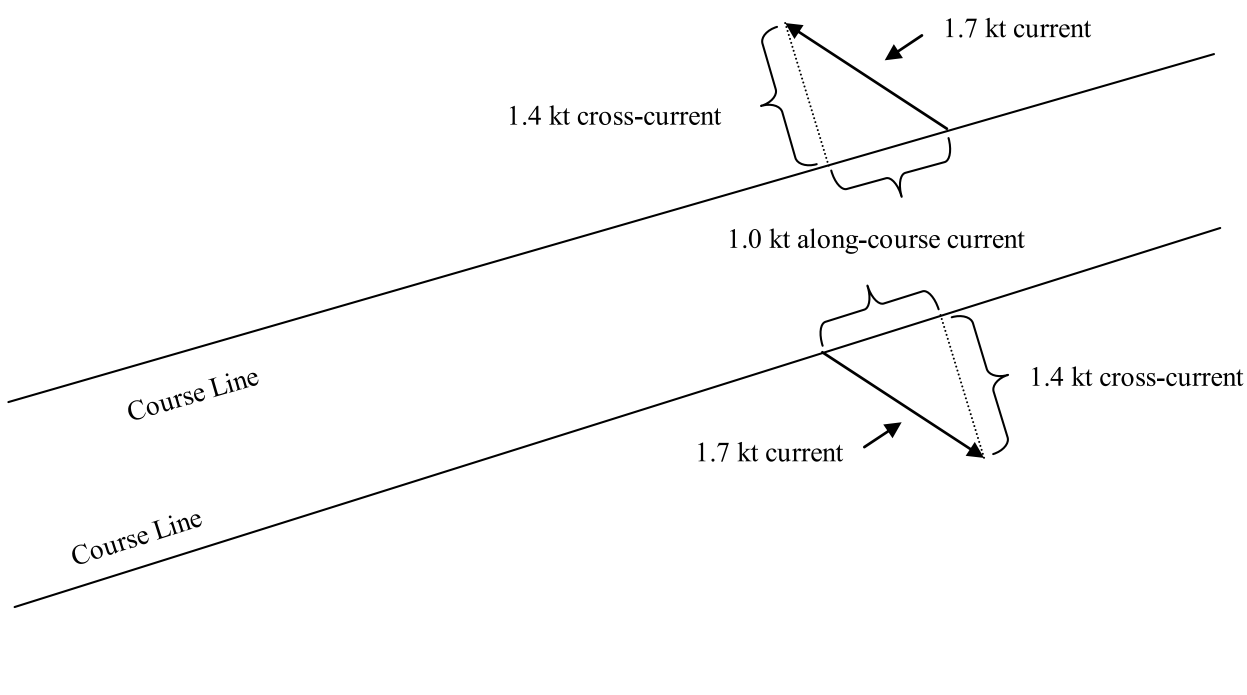
An alternative, and perhaps better method, is to use calculation as the primary way of determining leg lengths, and then to check these results by scaling the chart only for gross errors.

3. The side on which to pass each Mark is chosen, as well as the distance off the Mark when it first comes abeam. When a choice exists, a Mark is usually passed

inside – that is the path followed cuts inside rather than around the Mark. This makes the turning time small, and reduces the turning error. Where conditions permit, the distance off should be as small as one or two boat lengths, since smaller distances are more accurately estimated by eye. A distance off equal to the boat turning radius may simplify calculation of turning times.

4. A preliminary listing of leg times is made, assuming no current. From these figures and the official finish time, the approximate time-of-day for reaching the mid-point of each leg or leg segment is calculated. Using these times-of-day, the expected current magnitude and direction for each mid-point is obtained from publications, including Tidal Current Tables, Current Charts, notations on nautical charts (Canadian), etc. The current so-found for the mid-point is usually assumed to hold for the entire leg or leg segment, but occasionally the variation expected in current along the leg may require special treatment.

On the chart, it is convenient to draw an arrow on the course line near the start of each leg showing the expected direction of the current. Draw the length of the arrow to represent the strength of the current (say, ½ inch per knot). Then the along-course current and the cross-course current are easily found by completing the right triangle for which the current arrow is the hypotenuse, and then measuring the lengths of the sides to the same scale. Two examples are shown below, one with the current assisting boat speed (assumed to be right to left) and the other opposing.

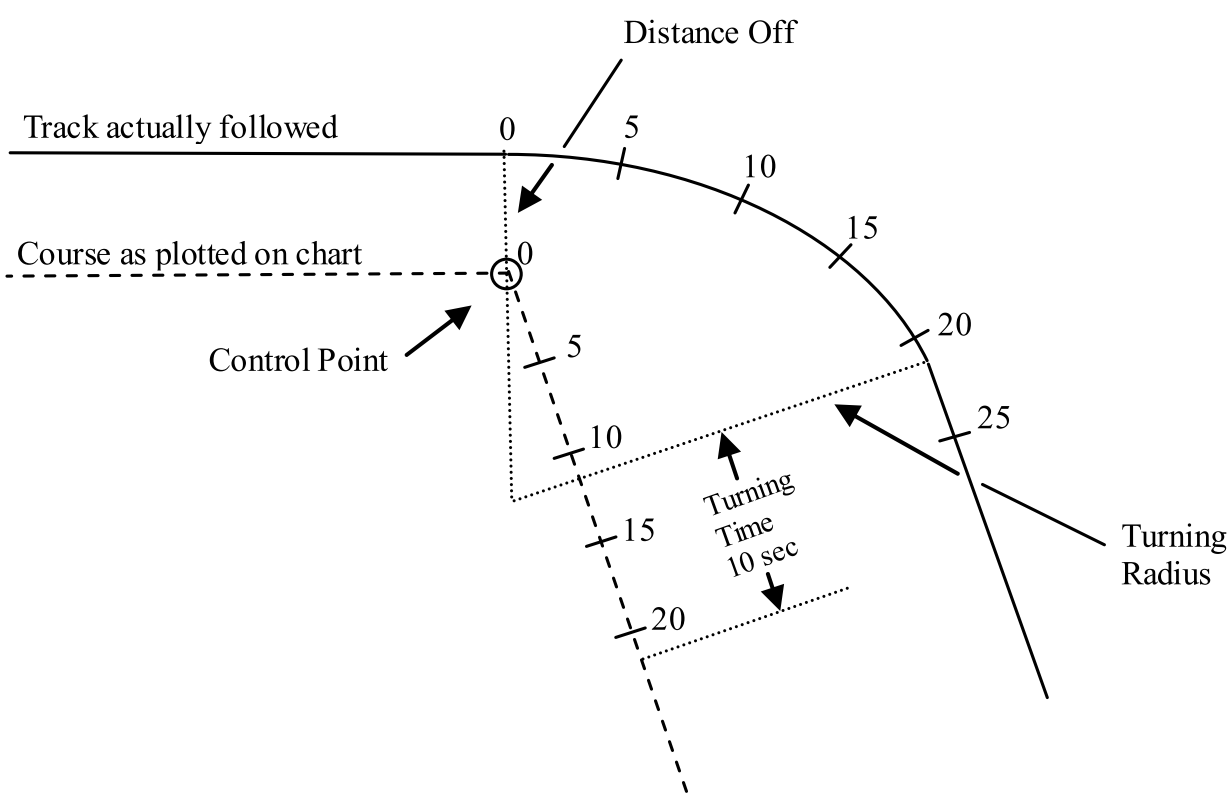


5. With knowledge of expected currents, the speed to be run may be chosen. For best score, there is an optimum speed for each boat under the conditions of any given

contest, and experience over many contests shows that this speed very often lies between 8 knots and 14 knots. In general, the faster the currents, and the longer the official legs of the course, the higher the optimum speed. When a speed handicap system is in effect, as is often the case, the optimum speed is likely to be one or two knots lower.

Thus for a course of short legs (legs of, say, less than 3 miles) run on a lake with no appreciable currents, the speed chosen might be 7 to 9 knots. But for course of long legs (over 10 miles) run in strong tidal current areas, the optimum speed could well be 13 to 15 knots or higher. The speed actually adopted, of course, is subject to still other factors that may have an over-riding effect: (1) maximum boat cruising speed, and the need to run at less than maximum to permit mid-course corrections, (2) need to avoid an unstable region between displacement and planing speeds, or speeds associated with undue mechanical vibration, and (3) speed limitations due to weather conditions or water traffic.

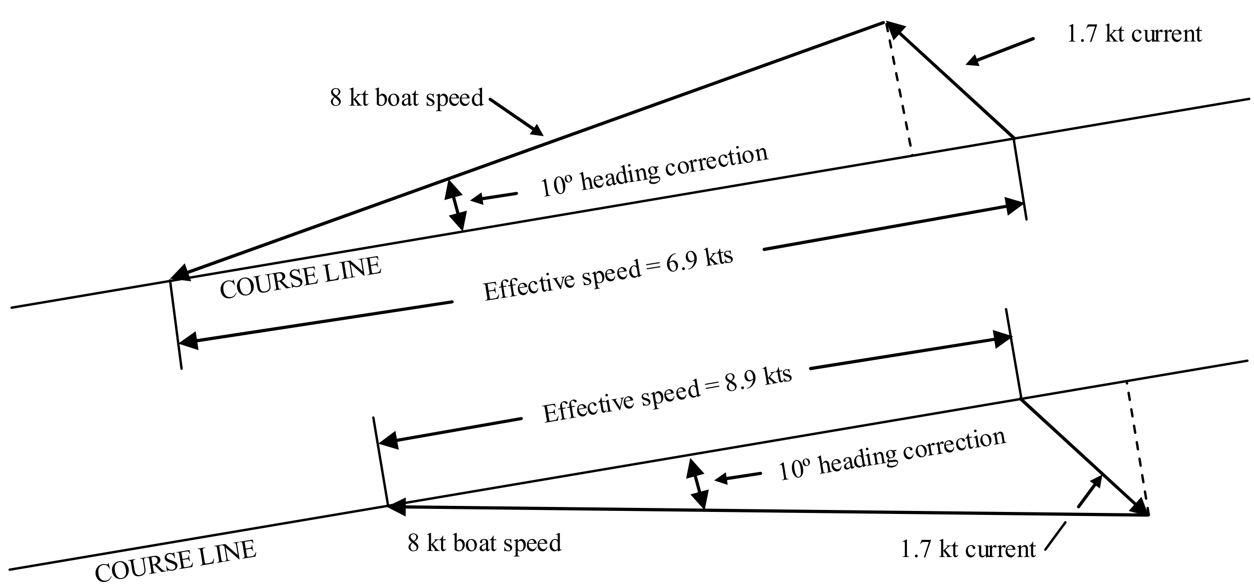
6. Turning times are determined. For outside turns, if distance off has been chosen equal to the boat turning radius, the turning time is simply the time required to run an arc of a circle corresponding to the turning angle. For <u>inside</u> turns of 90 degrees or less, the turning time is small and may often be ignored. But, for any case, the turning time may be found from a diagram like the one shown in the example below. (See the Appendix for an alternate method.)



The turn is laid out to scale. The dashed lines represent the course directly between control points, and the actual course followed is shown by solid lines. Starting at the point where the control point is first abeam, the distance that would be traveled in 5-second intervals is laid out with dividers on both the direct course and on the actual course. If the turning speed is slower than the straight-course speed, the 5-second distance intervals are made correspondingly smaller on the actual course line. The time in seconds so found to run the turning arc is marked also on the direct course, and the time lost, equal to the turning time, is then taken directly from the diagram. The method is applicable to both inside and outside turns.

In many cases, particularly with larger boats, the turn may start up to several seconds late due to helm response time and inertia of the boat. To allow for this turning lag, an additional turn time of one second per 30° of turn angle (for turn angles up to 180°) may be added to the value taken from the diagram. In the example shown the turning time would then be increased from 10 seconds to 12 seconds. This "rule of thumb" may be checked by trial 90° turns as outlined in Section 3.

7. The magnetic course to steer is measured from the chart for each leg or segment. Allowance for distance off may be made, but this usually is not necessary. But allowance for cross-course current may be necessary for strong current areas. This heading correction is readily found by adding a line to the triangular current diagram shown on page 10. Draw another arrow from the head end of the current arrow back to the course line, with the length equal to the boat speed to the same scale used for the current arrow. The angle between the course line and the boat speed arrow is then the heading correction required. The sketch below shows the two examples on page 13 redrawn in this way to give the heading correction.



8. With current estimates in hand, leg times are recalculated with the speed for each leg corrected for current. When the heading correction found in item 7 above is less than 4º or 5º, as is the cases except for legs run at low speed in strong current, the effect of cross-current on boat speed can usually be ignored, and corrected boat speeds calculated by adding or subtracting along-course currents. However, when larger heading corrections are involved, the effective boat speed should either be scaled from the diagram as shown, or the through-the-water speed should be reduced by a factor depending on the heading correction, as follows:

Heading correction:	4º	6º	8º	10º	12º
Speed reduction:	.25%	.5%	1%	1.5%	2%

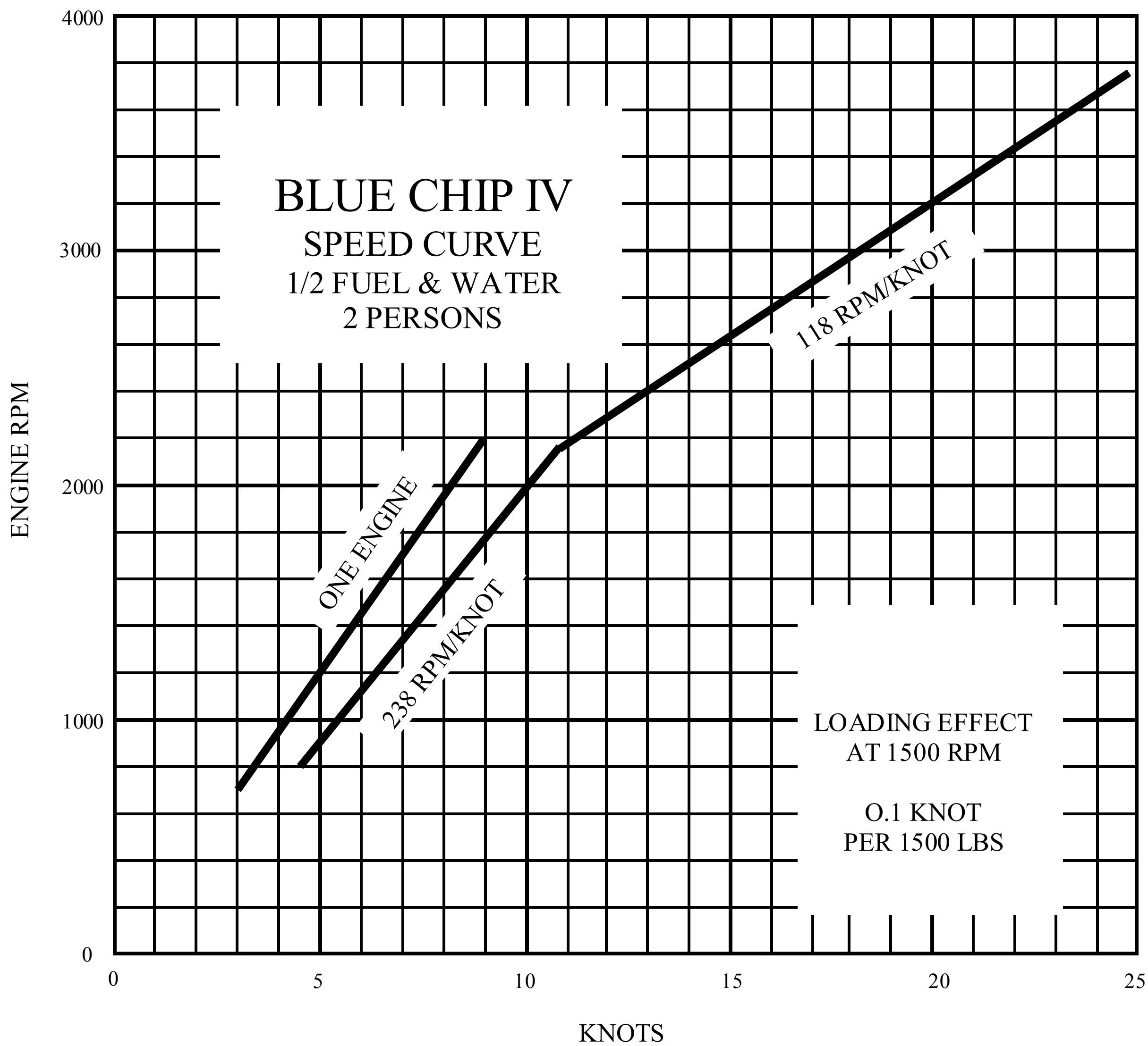
In the examples shown, with an 8 knot boat running in a strong current, the effect of the cross-current alone is to reduce the boat speed by about 0.1 knot below the speeds that would be calculated by combining boat speed with along-course current. This same 0.1 knot correction applies either with current aiding or opposing.

Section 3 -- BOAT CHARACTERISTICS

Here are mentioned the several items that the skipper should have at hand to run a log contest. Most important of these is a speed curve. But also, as experience is gained, information is needed on turning characteristics, time lost in a standing start, effect of loading on boat speed, and wind and wave effects. A compass deviation card should, of course, be available.

<u>Speed Curve.</u>

A sample speed curve is shown below.



Round trip runs on the measured mile are made at each of several constant engine speeds, and the run each way timed by stop watch to the nearest second or better. At each constant engine rpm the speed measured in one direction is averaged with the speed in the other direction to cancel out the effect of current. The speeds, not the times, are averaged. The fuel, water, and crew load are noted. The results are plotted in the form shown.

To determine the loading effect, runs are made at a substantially different loading at least one speed near the expected contest speed range. The load change required to change the speed 0.1 knot at this speed can then be calculated.

In making the timed runs for the speed curve, the following points should be kept in mind:

1. To provide the accuracy needed, the measured mile should be a surveyed distance marked by a fixed range at each end. A full mile course should be used.

2. Range markers should be sighted from the same position in the boat at the start and finish of the run in each direction.

3. The boat should be on course and up to speed when the starting range is passed. During the run, heading errors should be kept within 5 degrees.

4. In smaller boats, crew members should not move about the boat during runs, or occupy different positions during different runs, in order to avoid changes in trim that may affect speed. If doubt exists on the point, runs may be made with crew members in different locations and resulting speeds compared.

5. Each pair of one-way runs should be made at the same distance from shore, to eliminate possibility of error due to variations in current across the width of the course.

6. Runs should be made only at times of little wind (wind under 5 knots), and on days of least current. However, in tidal areas runs may best be made at times away from slack water, since the most rapid change in current occurs at the slack.

7. The underwater hull must be in clean condition. Then just prior to a contest, a measured mile run at a single speed will permit a correction to be made for any fouling.

Tachometers.

The speed curve obtained can be no better than the repeatability and readability of the engine tachometers. Original equipment tachometers may not provide performance that justifies more than moderate effort on the measured mile, and predicted log scores will suffer accordingly. Ultimately, the log skipper will require instruments having a combined repeatability and readability of 10 rpm or better. Both new and used aircraft tachometers are available providing this performance, and equally accurate digital tachometers have made an appearance in recent years. A digital tachometer may provide equal or better performance if the instrument is of a type that gives true 4-figure indication (units figure active), is not unduly sensitive to temperature or vibration, and is stabilized to eliminate rapid fluctuations in indication.

Turning and starting characteristics.

In quiet water, with the helm held over for a turn, the diameter of the circle described can be estimated fairly well by timing a run across a diameter of the circle marked by the wake. This can be checked roughly by figuring the circumference of the circle from the time around, although for a fast turning-rate the boat speed may be appreciable less in the turn than on a straight run. Then the running radius is one-half of this diameter. The turning rate in degrees per second is 360 divided by the number of seconds to complete a circle.

With the turning rate established, the lag at the start of a turn can be found by timing a 90º turn, starting from a signal given while running a straight course. The lag is then the difference between the 90º turn so measured and the time for a 90º turn calculated from the turning rate at the same rudder position. This lag, which may be up to a few seconds, increases the turning times found from the diagram on page 17, in proportion to the turning angle. Thus, if the lag found for the 90º turn is 3 seconds, the turning times taken from the diagram should be increased by 1 second per 30º of turning angle.

The extra time to be allowed for a standing start can be found at various speeds by trial runs between a closely-spaced pair of buoys. The additional time is the difference between the running time with a running start and a standing start, care being taken to establish a repeatable way of advancing the throttles in the standing start.

Effect of weather.

With the basic speed curve completed, timed runs under various weather conditions, when compared with runs under calm water conditions, can give information of speed allowance to make for wind and waves. If the calm-water run can be made over the same course, the runs need not be on a measured mile, since only differences in speed are required.

Turning time curves.

Turning time curves, if needed (see Appendix), may be prepared for a particular boat by making a series of timed runs over a short course, in which each run is started by entering the course at an angle and immediately executing a turn to bring the boat parallel to the course. Entering angles of 30º, 60º, 90º, 120º, 150º, and 180º, with turns executed at each of several rudder angles, should give sufficient data for plotting the curves. Turning time allowances are the differences between these times and the time for a straight run on the course. The course length need not be accurately known, but must be marked by accurately parallel ranges.

APPENDIX

Alternate method for turning times.*

Section 2 outlines a method for determining turning times by making a scale drawing of the turn. An alternate method is described below that does not require use of a scale drawing. This scheme may use the calculated curves of turn angle vs. turning time allowance, shown on the next page and giving approximated results for any boat, or may use a similar set of curves made up for a particular boat, determined by timing a series of trial turns as described on page 20.

For either the calculated curves or curves made from test runs, the turning time allowances are for the case where the distance off the turning point is zero – that is, the track runs through the turning point. If the turning point is a buoy or other obstacle that must be passed a distance off, an allowance for this is made as follows:

(1) An approximate correction is taken from the tabulation given in the box on the plot on page 22, or

(2) The leg distances are measured not from Mark to Mark, but between the positions that the boat will occupy (off the Marks) at the ends of the legs, so that the distance off is, in fact, zero. On charts of scale 1:25000 or less, the difference in leg lengths may be difficult to determine accurately, but in these cases leg times are usually long, and the percentage error will often be small enough to be disregarded.

In using the turning time curves, select the curve corresponding to the turning rate previously determined by running timed circles (or an interpolated curve sketched in with the aid of the tick marks along the right side marking 1°/second intervals). The turning time allowance to the nearest second is read for each turn. Then a correction for distance off is applied to this result. An example is shown by the dashed line for a turning rate of 7°/second and a turning angle of 123°, giving a time allowance of 15 seconds. Then if the Mark is to be passed in an outside turn 30 yards off, a distance off correction of +4 seconds is added, giving a total turning time allowance of 19 seconds.

The curves shown have been calculated from a formula given on page 35 of Predicted Logging Notes, with turning times increased an amount depending on the turn angle to allow 3 seconds for the boat to reach full turning rate. The turns are also for the case where there is no significant reduction in speed in the turns.

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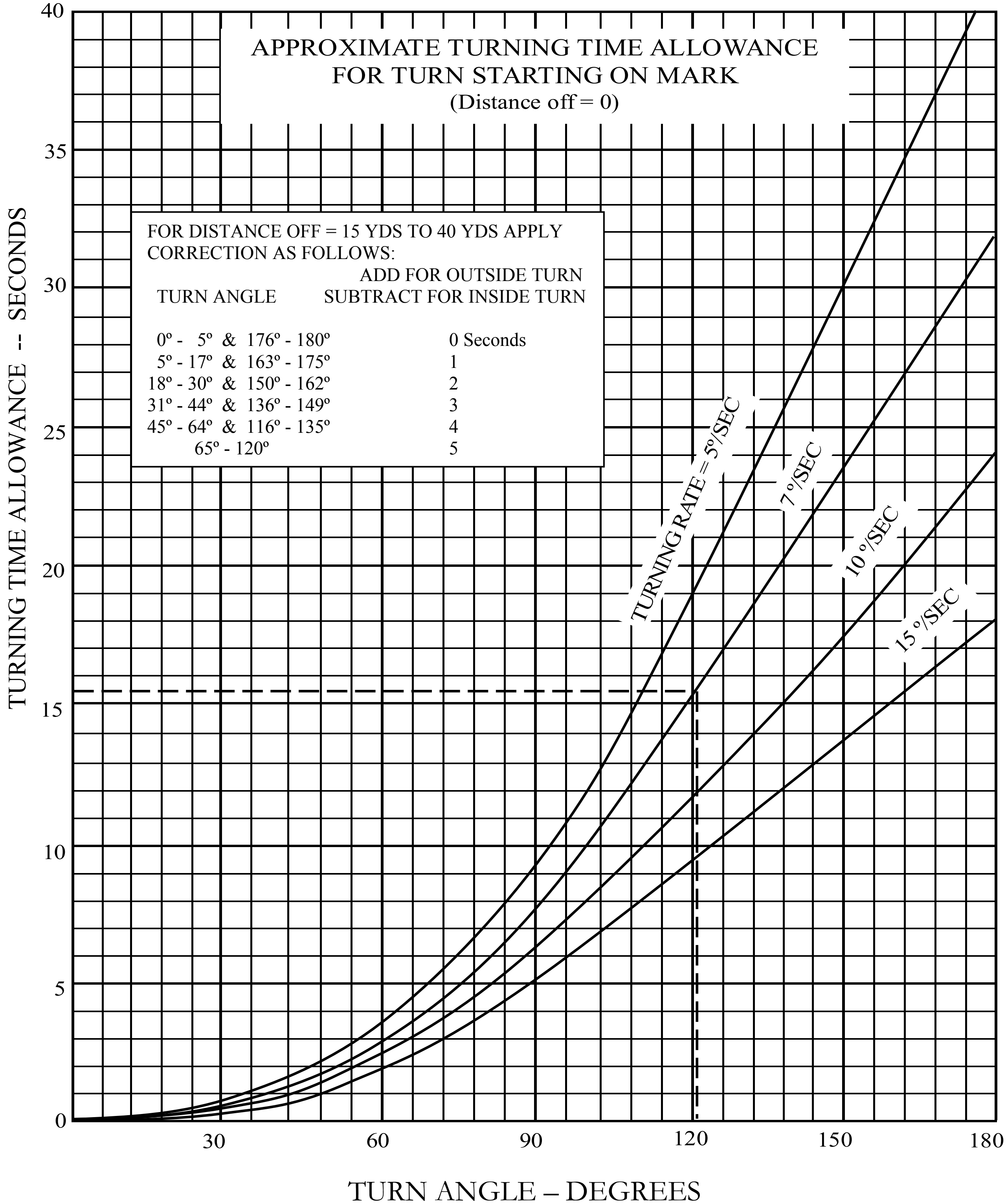
* For a contest with short average leg times (say, 15 minutes) and weak currents, turning time errors may be predominant, and this will affect choice of methods.

Turning time allowances from these curves may be in error by 2 or 3 seconds, or occasionally more, depending on the boat characteristics, speed of response of the helm, etc., but these values will often be of small significance because of other uncertainties.



Distance between two points, and course angle, by calculation.

(1) From the chart, measure latitude and longitude of the two points in degrees and decimal minutes to 2 decimal places – 3 decimal places if the scale of the chart permits. Then, by subtraction, determine the difference in latitude and the difference in longitude between the two points in decimal minutes.

(2) Convert the two latitudes to decimal degrees and average them to obtain the mid-latitude, to one decimal place. Then from the tables on the next page find the length of one minute of latitude and of one minute of longitude for this mid-latitude.

(3) Multiply the value obtained for the length of one minute of latitude by the difference in latitude found in (1) above to obtain the N-S separation of the two points in nautical miles. Multiply the value for the length of one minute of longitude by the difference in longitude to obtain the E-W separation in nautical miles.

(4) Square each of the two separation distances, add the two results together, and take the square root of the sum to obtain the distance between the two points in nautical miles. Multiply this final result by 2025.4 to obtain the distance in yards. Note: Accuracy is within 0.1% for distances up to 100 miles, assuming no error in coordinates.

(5) Find the direction angle from a true N-S line to the course line between the two points by dividing the E-W distance by the N-S distance, and determining the angle for the tangent value so obtained (Bowditch 1966 Ed. Table 31, or by use of a calculator having trigonometric functions). The true course is either this angle or 360º minus the angle, or the reciprocal of one of these courses, depending on which of the four quadrants the course angle lies in.

Example: Find the distance and true course from Dana Point S. Jetty Light to Oceanside Harbor W. Jetty Light.

(1)		Latitude		Longitude
	Dana Point	33 deg 27.259 min		117 deg 41.429 min
	Oceanside Hbr	33 12.372		117 deg 24.122
	Diff. In Lat.	14.877 min	Diff. In Long.	17.307 min

(2)		Latitude	
	Dana Point	33.45 deg	
	Oceanside Hbr.	33.21	
	Mid-Lat.	33.33 deg	Use 33.3 deg.

(3) N-S separation = 14.887 x .9981 = 14.859 nautical miles
E-W separation = 17.307 x .8382 = 14.507 nautical miles

(4) Distance = $\sqrt{(14.859)^2 + (14.507)^2}$ = 20.766 nautical miles. Use 20.77
Distance = 20.766 x 2025.4 = 42060 yards

(5) Tangent of direction angle = 14.507/14.859 = .976
Direction angle = 44.3º. Use 44º
Course angle is in S-E quadrant, so is reciprocal of 360-44 or 136º True.

LENGTH OF ONE MINUTE OF LATITUDE – NAUTICAL MILES

LATITUDE -DEGREES-	ONE MINUTE -NAUT. MILES-						
25.0 – 25.1	.9968		33.8 – 34.3	.9982		42.0 – 42.4	.9996
25.2 – 25.8	.9969		34.4 – 34.9	.9983		42.5 – 43.0	.9997
25.9 – 26.5	.9970		35.0 – 35.5	.9984		43.1 – 43.6	.9998
26.6 – 27.2	.9971		35.6 – 36.1	.9985		43.7 – 44.1	.9999
27.3 – 27.9	.9972		36.2 – 36.7	.9986		44.2 – 44.7	1.0000
28.0 – 28.6	.9973		36.8 – 37.3	.9987		44.8 – 45.2	1.0001
28.7 – 29.3	.9974		37.4 – 37.9	.9988		45.3 – 45.8	1.0002
29.4 – 29.9	.9975		38.0 – 38.4	.9989		45.9 – 46.4	1.0003
30.0 – 30.6	.9976		38.5 – 39.0	.9990		46.5 – 46.9	1.0004
30.7 – 31.2	.9977		39.1 – 39.6	.9991		47.0 – 47.5	1.0005
31.3 – 31.8	.9978		39.7 – 40.2	.9992		47.6 – 48.1	1.0006
31.9 – 32.5	.9979		40.3 – 40.7	.9993		48.2 – 48.6	1.0007
32.6 – 33.1	.9980		40.8 – 41.3	.9994		48.7 – 49.2	1.0008
33.2 – 33.7	.9981		41.4 – 41.9	.9995		49.3 – 49.8	1.0009
						49.9 – 50.0	1.0010

LENGTH OF ONE MINUTE OF LONGITUDE – NAUTICAL MILES

LATITUDE - DEGREES	LATITUDE – TENTH DEGREES .0	.1	.2	.3	.4	.5	.6	.7	.8	.9
25	.9085	.9078	.9070	.9063	.9055	.9048	.9040	.9033	.9025	.9018
26	.9010	.9002	.8995	.8987	.8979	.8972	.8964	.8956	.8948	.8940
27	.8932	.8924	.8917	.8909	.8901	.8893	.8884	.8876	.8868	.8860
28	.8852	.8844	.8836	.8827	.8819	.8811	.8803	.8794	.8786	.8777
29	.8769	.8761	.8752	.8744	.8735	.8726	.8718	.8709	.8701	.8692
30	.8683	.8675	.8666	.8657	.8648	.8639	.8631	.8622	.8613	.8604
31	.8595	.8586	.8577	.8568	.8559	.8550	.8541	.8531	.8522	.8513
32	.8504	.8495	.8485	.8476	.8467	.8457	.8448	.8439	.8429	.8420
33	.8410	.8401	.8391	.8382	.8372	.8363	.8353	.8343	.8334	.8324
34	.8314	.8404	.8295	.8285	.8275	.8265	.8255	.8245	.8235	.8225
35	.8215	.8205	.8195	.8185	.8175	.8165	.8155	.8145	.8135	.8125
36	.8114	.8104	.8094	.8083	.8073	.8063	.8052	.8042	.8032	.8021
37	.8011	.8000	.7990	.7979	.7968	.7958	.7947	.7937	.7926	.7915
38	.7904	.7894	.7883	.7872	.7861	.7851	.7840	.7829	.7818	.7807
39	.7796	.7785	.7774	.7763	.7752	.7741	.7730	.7719	.7707	.7696
40	.7685	.7674	.7663	.7651	.7640	.7629	.7617	.7606	.7595	.7583
41	.7572	.7560	.7549	.7537	.7526	.7514	.7503	.7491	.7479	.7468
42	.7456	.7444	.7433	.7421	.7409	.7398	.7386	.7374	.7362	.7350
43	.7338	.7326	.7314	.7303	.7291	.7279	.7267	.7254	.7242	.7230
44	.7218	.7206	.7194	.7182	.7170	.7157	.7145	.7133	.7120	.7108
45	.7096	.7084	.7071	.7059	.7046	.7034	.7021	.7009	.6996	.6984
46	.6971	.6959	.6946	.6934	.6921	.6908	.6896	.6883	.6870	.6857
47	.6845	.6832	.6819	.5806	.6793	.6781	.6768	.6755	.6742	.6729
48	.6713	.6703	.6690	.6677	.6664	.6651	.6638	.6625	.6611	.6598
49	.6585	.6572	.6559	.6546	.6532	.6519	.6506	.6492	.6479	.6466