



# Performance Handicap Racing Fleet

## TIME-ON-TIME SCORING

An alternative for PHRF

Time-on-time scoring is not new. It has been widely used nationally and internationally as a valid method to score handicap yacht racing. The most well known recent use of time-on-time was the PORTSMOUTH Handicap numbers, a predecessor to our own PHRF system, which for many years provided an easily implemented handicap system for local racing.

### The Basics

Before getting more into the technical aspects of scoring systems, it's important to understand the difference between a handicap system and a scoring system and how both are implemented in PHRF. A handicap system is the method by which numbers are generated that represent the speed potential of individual boats or boat classes. In general, there are measurement rules and performance rules. Measurement rules try to predict boat performance by complicated physical measurements of boat dimensions. On the other hand, performance rules observe the difference in speed potential of boats and use this difference to obtain a handicap number. PHRF is, by definition, a performance rule.

A scoring system is the mathematical method used to correct races using the numbers generated by a handicapping system. There are basically two types of scoring systems: Time-on-Time, and Time-on-Distance, both of which will be further clarified.

A PHRF rating is published as a handicap number, given in seconds or minutes per nautical mile of rhumb line racecourse distance. A rating of 180 sec/mile means that for every rhumb line mile of racecourse, the contestant is given 180 seconds of credit to his finish time. If a boat with a rating of 180 sec/mile is racing against a boat with a rating of 174 sec/mile, the net advantage is 180 minus 174 or 6 sec/mile. In a race of one-mile rhumb line distance, the presumably slower boat at 180 sec/mile is given 6 seconds of time credit over the boat at 174 sec/mile. This correction method is known as time-on-distance scoring.

Time-on-time scoring is somewhat different in concept. A handicap number is given which is the ratio of the potential average speed of the yacht to an arbitrary standard yacht, and is generally expressed as a multiplier. As an example, if the reference boat has a handicap of 1.00, a boat with a handicap of 0.90 will have a corrected time equal to .90 times its elapsed time. A boat with a handicap of 1.10 would have a corrected time equal to 1.10 times its elapsed time.

As an additional example, we can set up a couple of hypothetical test races with only two contestants. Two boats will compete in this race, boat A with a handicap of 1.00, and boat B with a handicap of 0.90. For purposes of this example we will assume that the handicaps are correct and the boats are equally well sailed.

### The Test Race

The boats race on a one-mile course and boat A averages 5 knots. Boat A completes the course in 1/5 hour or 12 minutes. Boat B, by definition, is 10% slower and therefore sails at 4.5 knots completing the course in 1/4.5 hours or 13 minutes and 20 seconds (13.3333 minutes). Since we already know that the boats were correctly rated and equally well sailed, the corrected race should end in a tie.

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FINISH TIME x RATING =CORRECTED TIME

Boat A 12.0000 min x 1.00 =12.00 minutes

Boat B 13.3333 min x .90 =12.00 minutes

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As predicted, the boats have equal corrected times and the race is a tie.

We can now correct the same race with time-on-distance scoring. However, we must first determine the time-on-distance rating for boat A and Boat B. Since both boats were equally well sailed (and lucky), we will assume the difference in their finish time was due only to the difference in speed potential of the boats. In time-on-distance scoring this difference is the handicap and must be subtracted from the results by the rating system. Boat B finished 1 minute and 20 seconds (80 seconds) behind boat A. Therefore, if boat A has a rating of 0 seconds/mile, boat B must have a rating of 80 seconds/mile greater to compete on an equal basis. Correcting the race using time-on-distance scoring produces the following results:

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FINISH TIME - (RATING x DISTANCE) =CORRECTED TIME

Boat A 12.00 min -( 0 sec/mile x 1 mile) =12.00 minutes

Boat B 13.33 min -(80 sec/mile x 1 mile) =12.00 minutes

(80 sec/mile = 1.33 min/mile)

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The race corrected by time-on-distance scoring also produces a tie. Each scoring method produced equal corrected times and therefore provided equitable racing under the initial conditions tested.

### **What If The Initial Conditions Change?**

Let us assume that for this next hypothetical race, the same boats race, this time in lighter conditions. Boat A travels at 3 knots and completes the course in 20 minutes. Boat B is still 10% slower and sails at 2.7 knots, completing the course in 22.2222 minutes. Correcting the race using time-on-time scoring yields the following:

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FINISH TIME x RATING = CORRECTED TIME

Boat A 20.0000 min x 1.00 = 20.00 minutes

Boat B 22.2222 min x .90 = 20.00 minutes

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Again, the race ends in a tie.

If we use time-on-distance scoring however, the results are quite different. (Remember the rating number always remains the same.)

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FINISH TIME x (RATING x DISTANCE) =CORRECTED TIME

Boat A 20.00 min -( 0 sec/mile x 1 mile) =20.00 minutes

Boat B 22.22 min -(80 sec/mile x 1 mile) =20.89 minutes

(80 sec/mile=1.33 sec/min)

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Boat A has the lowest corrected time and therefore is the race winner even though both boats were equally well sailed and should have tied.

Although these are very simplistic examples and admittedly make some assumptions about boat performance, they point out a basic shortcoming of time-on-distance scoring-the actual handicap given to a boat remains constant regardless of the average speed of the race.

### **Physical Parameters That Affect A Race**

There are many physical parameters that influence the speed relationship between smaller and larger boats. They include wind velocity and gradient, sea conditions, racecourse layout and a host of other uncontrollable occurrences, all of which can have a dramatic impact on a boat's finish time on the course.

### **How Does Time-On-Time Scoring Help?**

It's no secret that larger boats have an advantage upwind, especially in heavy seas (going a mile to weather usually takes longer than sailing a mile off the wind). Time-on-time scoring gives more time to the slower boats in such conditions. Offwind races however, usually provide an advantage to small boats. These races are generally faster and time-on-time scoring correctly allows the slower rated boats less handicap.

In light wind conditions, tall-masted boats seem to catch more of the "higher air" due to vertical wind gradient and are less affected by leftover sea conditions. Again, because the average boat velocities are slower, the races take longer to complete and the smaller boats get proportionally more handicap time.

In summary, time-on-time scoring provides a first order correction for the speed of the race. The correction provided by time-on-time scoring tends to compensate for major racecourse phenomena that make individual races unequal. This is of particular importance for port-to-port/long distance races where a balanced mix of upwind and offwind work cannot be guaranteed.

The only instance when time-on-time scoring theoretically fails is when the boats completely stop moving. In this case, handicap builds up without a change in relative distance between boats. In practice however, this rarely results in significant errors since boats seldom completely stop during a race, and when they do, the race is frequently (and mercifully) abandoned due to time limitations.

A counter argument can be made that time-on-distance scoring, on the average (over a number of races), can be just as equitable. This is probably correct, but most would rather sail a season of races where each race was as equitable as possible instead of trading the advantage from boat to boat. Time-on-time scoring is a positive step in that direction.

## Easier To Score

Time-on-distance scoring requires an accurate measurement of the course distance. While this may not seem like a major problem, unless highly accurate electronic navigation gear is available or the course is set on geographically known marks, there can be considerable error in estimating the actual rhumb line distance. The handicap error is directly proportional to the error associated with the distance. The accuracy of time-on-time scoring is dependent only on the accuracy of the measurement of time. With quartz timepieces, the error is negligible from a handicapping standpoint. Also, shortening the course requires no additional attention from a handicap standpoint. The same multiplier is always used regardless of the course length.

## A Conversion Method

At the inception of PHRF-LAKE ONTARIO, time-on-time scoring was proposed and included in the PHRF-LO charter. Although the time-on-time scoring concept is not new, Lake Ontario was, to the best of our knowledge, the first to implement it with PHRF handicap. Subsequent to the initial inclusion, Charles Kramer of Sodus Bay Yacht Club, a PHRF-LO handicapper, completed an analysis and derived the following formula based in part on his interpretation of the published results of the original H. Irving Pratt Ocean Race Handicapping project at M.I.T. This formula was adopted by PHRF-LO in 1985 and represents an improvement over the conversion method that was initially used.

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$$\text{MULTIPLIER} = ((\text{SQR})R + (Q \times (\text{SQR})(R \times R_s))) / ((\text{SQR})R_s + (Q \times (\text{SQR})(R \times R_s))) *$$

$$Q = .045 \text{ (correlation constant) **}$$

$$R = 8360000 / ((T/D\# + 384.3)^2)$$

$$R_s = 8360000 / ((\text{SCRATCH } T/D\# + 384.3)^2)$$

T/D# is the standard time-on-distance handicap number.

SQR= "Square Root"

\* This formula normalizes the results to the scratch boat rating (Rs). A mid-fleet rating is best

(approx. 171).

\*\* The Q correlation constant controls the relative spread between the low and high ratings and was determined empirically from race data.

10 Q=.045 'Q factor

20 TD=171 'scratch boat rating

30 C1=8360000 'constant #1

40 C2=384.3 'constant #2

50 FOR X = 0 TO 300 STEP 3

60 R=C1/(X+C2)<sup>2</sup>

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70 RS=C1/(TD+C2)2
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80 M=(SQR(R)+(Q*SQR(R*RS)))/(SQR(RS)+(Q*SQR(R*RS)))
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90 PRINT X,M
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100 NEXT X
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110 END
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The above is a simple computer program written in Basic to calculate the multipliers from 0 to 300 seconds per mile

### **What To Expect In Typical Races**

When compared to the same results scored by time-on-distance methods, time-on-time scoring has minimal effect on the results or finish places of races within division splits of 10 to 20 sec/mile. If a change in position takes place at all, it is generally only one corrected finishing position. However, if results are compared over large ranges in boat handicaps such as overall winners in large invitational races, the results can be more dramatic and boats may change several positions.

### **Acceptance On Lake Ontario**

PHRF of Lake Ontario has left the selection of scoring methods up to the individual clubs and has provided both a time-on-distance number and a time-on-time multiplier on each certificate. Reaction to time-on-time scoring on the lake has been mixed; there is a certain amount of reluctance by some clubs to accept a time-on-time scoring method partly because some participants have difficulty in accepting a non-constant handicap. These individuals apparently feel more comfortable entering a race knowing exactly how much time is given to each yacht in the race. This problem has been partially solved by publishing a seconds/hour number along with the multiplier, but again it requires some mental calculation and is still not totally acceptable to some individuals.

Owners of larger boats also tend to object to the time-on-time scoring method primarily because they find themselves correcting behind smaller boats more often than with the time-on-distance method. (It's harder to accept correcting behind a smaller boat than a larger one.) Also, time-on-time represents a change in custom and changes in yacht handicapping are generally regarded with skepticism.

Despite this resistance to change, many clubs on Lake Ontario have accepted time-on-time scoring as the preferred method and are using it at club and invitational events with great success.

### **Conclusions**

It is evident that the present PHRF handicaps, although adequate over narrow handicap ranges, do not seem to work over large ranges of boat sizes. This is of particular significance to small clubs where large and small boats must compete head to head.

One potential solution is to re-rate all boats. This apparently is the action being taken at PHRF of the Northwest, according to Frank Cole in the May/June 1985 issue of The PHRF Journal. A second method is to provide a correlation factor adjusting the handicap spread between large and small boats. This correlation factor is implemented in the time-on-time conversion formula with the "Q" constant, which can be adjusted from area to area or race to race if necessary.

### **A Note To Other Handicappers**

An advantage with handicap yacht racing is that a new handicap system can be tested on existing data without jeopardizing a season of racing. If the new system is tried on old data and the results are positive, the system can be safely implemented with the knowledge that it has worked successfully in the past. You are invited to test this system on existing data in your own region and judge for yourself if an overall improvement is obtained.

Steve Corona

Thanks to Charles Kramer, Fred Hubble, Debra Butler, Earl Cliffl, and Rick Hibbs, all of whom have contributed to the analysis, support, and success of time-on-time scoring on Lake Ontario.