Another look at the PHRF-LO handicap adjustment factor "Q" on Lake Ontario.

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BACKGROUND

Time on Time Scoring

The "Q" factor is a variable in the PHRF-LO time on distance (TOD) to time on time (TOT) conversion formula that can be used to adjust the relative handicap between faster and slower boats. The "Q" factor does not change relative positions of individual boat handicaps but rather adjusts the global handicap differences. This is more completely described in my May 9, 2008 white paper "A Study of Q in the PHRF-LO Time on Time Conversion".

The Time on Time multiplier is calculated using the following equation:

$$TOT = \frac{\sqrt{R} + \left(Q \times \sqrt{R \times Rs}\right)}{\sqrt{Rs} + \left(Q \times \sqrt{R \times Rs}\right)}$$

Where:

TOT = Time on Time Multiplier TOD = Time on Distance Number TODs = Scratch Boat Time on Distance Number

$$R = \frac{8360000}{(TOD+378.2)^2} \qquad Rs = \frac{8360000}{(TODs+378.2)^2}$$

The constants 8360000 and 378.3 and the formulas for R and Rs are used to convert the TOD (sec/mile) handicap of the boat in question (R) and the "scratch boat" (Rs) to a "rated length" which is a term sometime used in measurement handicap systems and directly relates to the potential hull speed. Rs actually has no effect on the finish position but is used to scale the final corrected time so that corrected time is a meaningful representation of real time.

Evaluating the equations using a single Q and Rs value and applying the constants results in a simple equation of the form:

$$TOT = \frac{A}{B+TOD}$$

Where A is a factor directly related to the scratch boat value and B is related to the Q value. The factor A can be adjusted without changing boat finishing positions but changing the B value will change the effective rating of the boats (Q adjustment) and could cause a change in finishing positions in any race.

History of the Q value

Initially Q was set to 0.000 on Lake Ontario but the subsequent race results were perceived as favoring slower rated boats and Q was changed to a value of 0.045. The Q variable was somewhat forgotten and remained at the 0.045 value for many years. As personal computers became available allowing easy large scale number crunching, PHRF-LO began accumulating race data and initiated the use of race data to predict boat performance and adjust handicaps. A concern later arose, that even with the individual boat rating adjustments, that there might still be an endemic bias in the race results. In 2008 Andrew Sensicle and I (PHRF-LO technical committee members) began to study race results to evaluate and, if needed, optimize the Q value. The result of the 2008 analysis showed that there was indeed a bias towards faster boats in any division and fairer race results could be obtained by lowering the Q variable closer to its initial value of zero. The technical committee spent another year looking at additional race results and finally recommended that PHRF-LO consider adjusting the value of Q to 0.008.

In 2009 PHRF-LO adjusted the Q value to 0.008 where it has remained. The Q value of 0.008 and a scratch boat rating of 165 results in a simplified conversion formula of:

$$TOT = \frac{566.431}{401.431 + TOD}$$

Here we are in 2018

Over the last nine years we have accumulated more race data, added new boats, adjusted individual handicaps, and perhaps had slightly different race conditions. A new study would consider these potential differences and challenge the existing Q value.

The analysis technique utilizes an iterative method that systematically adjusts the Q value (race by race) to find a Q that produces no bias in the resulting corrected data as determined by a linear regression of boat rating vs. corrected time. When the linear regression calculates a slope of zero any bias due to rating differences has been adjusted out. A potential problem with this method is that an optimum Q value (zero slope) cannot be calculated for all races. For example, if a boat of slower handicap finishes ahead of a faster rated boat in elapsed time, an optimum Q value cannot be obtained. Additionally races with very little rating spread and/or large difference in scratch time will not optimize with realistic Q values. Q must be between approximately -0.14 and 0.99 to be usable. It is observed that the results of about one third of the race data are discarded with this analysis method.

Classical statistical sampling theory tells us that a "population" of data can be identified by a much smaller number of datum if the population is sampled randomly. This is a basic statistical axiom that finds use in a great many industrial and scientific applications. By excluding one

third the data, possibly non-randomly and without fully understanding the implications, we risk introducing selection bias and potential error in the results.

Analysis

The original computer program used to find the optimum Q for each race was written 29 years ago using a programing language called Microsoft Quick Basic 4.5. Unfortunately this language is no longer supported by Microsoft and can only be run in a Microsoft DOS environment. This left a choice of either rewriting the program in a currently supported language or procure a machine running an old DOS based system. The latter was clearly the quickest and more reliable path so an old PC running Windows XP was resurrected and set up to run the software. Since small changes in the program were made, and a direct comparison to previous data was desired, the older data was re-analyzed along with the new race data so that a direct comparison could be made.

The race data was divided into 6 separate sets of data from years 2000-2006, 2007-2009, and 2013-2017 each separated into flying sail and non-flying sail groups. Each data set contains several thousand individual races that were individually corrected and optimized. Because of the non-linearity of Q to corrected time, the resulting distribution of optimum Q's for each data set is skewed and truncated at the low end. Because of the difference of this distribution to a normal distribution the median is probably a better estimator of the optimum Q than the mean. The graph below shows a typical distribution of optimum Q values.



The following two pages containing contain the results of the analysis for all six data sets. Perhaps more important than the absolute values, the graphs of the trends show that while there are small differences from year to year groups, there is no consistent evidence that the new race data (2013-2017) is significantly different than the older previously analyzed data.





The 2008 analysis showed that there was a correlation of rating to the calculated optimum Q. The lower rated (faster) handicaps on average required a higher numerical Q value than the

higher rated (slower) boats. This study appears to show that the difference of optimum Q due to rating is narrowing with time.

It should be remembered that numerically lowering the Q value in the conversion formula provides additional handicap to slower rated boats in any division and adjusting Q values numerically higher provides more handicap to faster rated boats.

An Alternate Analysis Approach

Considering the potential problems of the iterative analysis approach and the resulting loss of data, a more straight forward and simpler approach was considered. Every race might not have an optimum Q value but every race has a regression slope of the handicap vs. the corrected time that is either positive or negative (almost never exactly zero). A positive slope indicates the faster rated boats are advantaged and a negative slope indicates the slower rated boats are advantaged in that race. A measure of equitability is proposed that over a large number of races, there should be an equal number of positive and negative slope races, half the races favoring the slower rated and half the races favoring the faster rated boats. The value of Q that satisfies this requirement is optimum.

Using this method (called technique 2) each data set was corrected over a range of Q values to find the Q that produced an equal number of positive and negative corrected time data slopes (the center point). The following histogram shows the population of data slopes for the 2013-2017 flying sail data set at the optimum Q = 0.013. The slopes are symmetrically arranged around the slope zero point at the optimum Q value.



The following charts show the results of this analysis using the slope technique for each of the six data sets. The Q values around the optimum value (highlighted) are also shown to show the effect of slight Q differences around the optimum.

	20	13-2017	Flying Sa	ail		2013-2017 Non-Flying Sail							
	Slope	Slope	# Races	# Races	# Races		Slope	Slope	# Races	# Races	# Races		
Q	Mean	Median	< 0	= 0	> 0	Q	Mean	Median	< 0	= 0	> 0		
0	0.000880	-0.000142	2509	0	2222	0.004	-0.000090	-0.000021	2436	1	2349		
0.002	0.000910	-0.000119	2486	1	2244	0.008	-0.000052	0.00008	2407	1	2377		
0.004	0.000930	-0.000099	2464	0	2267	0.009	-0.000043	0.000016	2398	1	2386		
0.008	0.000980	-0.000054	2423	1	2307	0.01	-0.000034	0.000026	2390	0	2395		
0.01	0.001000	-0.000033	2402	2	2327	0.011	-0.000025	0.000034	2385	0	2400		
0.012	0.001020	-0.000014	2382	1	2348	0.012	-0.000016	0.000044	2380	3	2402		
0.013	0.001030	-0.000007	2371	0	2360	0.016	0.000019	0.000077	2340	1	2439		
0.014	0.001040	0.000003	2357	5	2369								
0.016	0.001070	0.000025	2336	3	2392								
0.045	0.001320	0.000261	2109	1	2621								

2007-2009 Flying Sail							2007-2009 Non-Flying Sail						
	Slope	Slope	# Races	# Races	# Races			Slope	Slope	# Races	# Races	# Races	
Q	Mean	Median	< 0	= 0	> 0		Q	Mean	Median	< 0	= 0	> 0	
-0.004	0.000371	-0.002100	2094	2	1705		-0.004	0.000125	-0.000013	1456	0	1439	
0.000	0.000427	-0.000159	2048	0	1753		-0.003	0.000136	-0.00003	1450	0	1445	
0.004	0.000480	-0.000102	2004	1	1796		-0.0025	0.000142	0.000002	1446	1	1448	
0.008	0.000531	-0.000059	1963	0	1838		-0.002	0.000147	0.000009	1441	1	1453	
0.012	0.000519	-0.000019	1920	1	1880		-0.001	0.000157	0.000019	1437	0	1458	
0.014	0.000602	0.000000	1900	1	1900		0.000	0.000168	0.000032	1432	0	1463	
0.015	0.000914	0.000011	1888	1	1912		0.006	0.000229	0.000089	1382	1	1512	
0.016	0.000625	0.000019	1878	1	1922								
0.017	0.000636	0.000031	1870	1	1930								

	20	00-2006	Flying Sa	ail	-	2000-2006 Non-Flying Sail					
	Slope	Slope	# Races	# Races	# Races		Slope	Slope	# Races	# Races	# Races
Q	Mean	Median	< 0	= 0	> 0	Q	Mean	Median	< 0	= 0	> 0
-0.002	-0.000260	-0.000191	3874	0	3280	0.010	0.000137	-0.000110	2616	0	2405
0.000	-0.000232	-0.000169	3832	0	3322	0.015	0.000183	-0.000072	2593	1	2427
0.006	-0.000152	-0.000098	3728	2	3424	0.017	0.000201	-0.000054	2572	2	2447
0.014	-0.000053	-0.000014	3595	2	3557	0.019	0.000218	-0.000039	2555	1	2465
0.015	-0.000041	-0.000002	3580	1	3573	0.02	0.000227	-0.000032	2544	2	2475
0.016	-0.000030	0.000008	3562	2	3590	0.022	0.000244	-0.000014	2525	0	2496
0.018	-0.000007	0.000028	3527	1	3626	0.023	0.000252	-0.000009	2518	1	2502
						0.024	0.000261	-0.000001	2512	1	2508
						0.025	0.000269	0.000004	2499	5	2517
						0.026	0.000277	0.000013	2496	0	2525

Comparing the old and new calculation methods

If the first set of data wasn't confusing enough we just added another set of results. Putting the optimum Q's of both systems in one place yields the following chart:

Optimum Q by 2 Methods										
	Flying Sail Data									
	2000-2006	2007-2009	2013-2017							
Technique 1	-0.018 (.030)	-0.007 (.039)	-0.02 (.037)							
Technique 2	0.015	0.014	0.013							
		Non-Flying Sail								
	2000-2006	2013-2017								
Technique 1	-0.024 (.042)	-0.031 (.019)	-0.03 (.025)							
Technique 2	0.024	-0.0025	0.01							
	Technique 1: n	nedian (mean)								

At first glance the results of the two techniques don't seem to match but in reality they are reasonably close considering the differences in analysis method. Technique #1 generally yielded Q's that are slightly below our present 0.008 Q value and technique #2 yields Q's that are generally slightly above our present Q = 0.008 value.

If we were to calculate the average median value for technique #1 (optimum Q) it would be minus (-) 0.009 and for technique #2 it would be positive (+) 0.012. Our present Q=0.008 is nestled comfortably between these two values. To better understand the consequence of that magnitude of Q change we use another spreadsheet to calculate the differences.

	ORIGINAL	NEW			TOD			ORIGINAL	NEW			TOD
	T/T	T/T			Change			T/T	T/T			Change
	Multiplier	Multiplier	%	EQUIV.	from			Multiplier	Multiplier	%	EQUIV.	from
T/D#	Q =	Q =	Change	NEW TOD	Original	T/D#		Q =	Q =	Change	NEW TOD	Original
	0.008	0.012						0.008	0.012			
-21	1.4889	1.4745	-0.97%	-17	4	141		1.0442	1.0433	-0.09%	141	0
-15	1.4658	1.4523	-0.92%	-11	4	147		1.0328	1.0321	-0.07%	147	0
-9	1.4434	1.4307	-0.88%	-6	3	153		1.0216	1.0212	-0.04%	153	0
-3	1.4217	1.4098	-0.84%	0	3	159		1.0107	1.0105	-0.02%	159	0
3	1.4006	1.3894	-0.80%	6	3	165		1.0000	1.0000	0.00%	165	0
9	1.3801	1.3697	-0.75%	12	3	171		0.9895	0.9897	0.02%	171	0
15	1.3602	1.3505	-0.72%	18	3	177		0.9793	0.9797	0.04%	177	0
21	1.3409	1.3318	-0.68%	24	3	183		0.9692	0.9698	0.06%	183	0
27	1.3221	1.3136	-0.64%	30	3	189		0.9594	0.9601	0.08%	189	0
33	1.3038	1.2960	-0.60%	36	3	195		0.9497	0.9507	0.10%	194	-1
39	1.2861	1.2788	-0.57%	42	3	201		0.9402	0.9414	0.12%	200	-1
45	1.2688	1.2620	-0.53%	47	2	207		0.9310	0.9323	0.14%	206	-1
51	1.2520	1.2457	-0.50%	53	2	213		0.9219	0.9233	0.16%	212	-1
57	1.2356	1.2298	-0.47%	59	2	219		0.9130	0.9146	0.17%	218	-1
63	1.2196	1.2143	-0.44%	65	2	225		0.9042	0.9060	0.19%	224	-1
69	1.2041	1.1992	-0.41%	71	2	231		0.8956	0.8975	0.21%	230	-1
75	1.1889	1.1844	-0.38%	77	2	237		0.8872	0.8892	0.23%	236	-1
81	1.1741	1.1700	-0.35%	83	2	243		0.8790	0.8811	0.24%	241	-2
87	1.1597	1.1560	-0.32%	89	2	249		0.8709	0.8731	0.26%	247	-2
93	1.1456	1.1423	-0.29%	94	1	255		0.8629	0.8653	0.28%	253	-2
99	1.1319	1.1289	-0.26%	100	1	261		0.8551	0.8576	0.29%	259	-2
105	1.1185	1.1158	-0.24%	106	1	267		0.8474	0.8500	0.31%	265	-2
111	1.1054	1.1031	-0.21%	112	1	273		0.8399	0.8426	0.32%	271	-2
117	1.0926	1.0906	-0.18%	118	1	279	Ц	0.8361	0.8389	0.33%	274	-2
123	1.0801	1.0784	-0.16%	124	1	285		0.8288	0.8317	0.34%	280	-2
129	1.0679	1.0664	-0.14%	130	1	291		0.8216	0.8245	0.36%	286	-2
135	1.0559	1.0547	-0.11%	136	1	297		0.8145	0.8175	0.37%	291	-3

As can be seen from the columns labeled "TOD Change from Original", for a Q change from 0.008 to 0.012 there would be only a 7 second per mile change in relative rating over the whole handicapping range. This magnitude of rating change is insignificant.

Looking next at the results from technique #1 and an average change to Q = -.009 the change over the entire range (PHRF -21 to 297) would produce a rating difference of 30 sec/mile. Within a typical division of 60 sec/mile this would account for about a 6 sec per mile change from fastest to slowest rated boats. This is a more significant change and its effect on a racing division could be noticeable.

	ORIGINAL	NEW			TOD		ORIGINAL	NEW			TOD
	T/T	T/T			Change		T/T	T/T			Change
	Multiplier	Multiplier	%	EQUIV.	from		Multiplier	Multiplier	%	EQUIV.	from
T/D#	Q =	Q =	Change	NEW TOD	Original	T/D#	Q =	Q =	Change	NEW TOD	Original
	0.008	-0.009					0.008	-0.009			
-21	1.4889	1.5615	4.87%	-39	-18	141	1.0442	1.0487	0.42%	139	-2
-15	1.4658	1.5337	4.63%	-32	-17	147	1.0328	1.0361	0.31%	145	-2
-9	1.4434	1.5069	4.40%	-26	-17	153	1.0216	1.0237	0.21%	152	-1
-3	1.4217	1.4810	4.17%	-19	-16	159	1.0107	1.0117	0.10%	158	-1
3	1.4006	1.4560	3.96%	-12	-15	165	1.0000	1.0000	0.00%	165	0
9	1.3801	1.4318	3.75%	-6	-15	171	0.9895	0.9885	-0.10%	172	1
15	1.3602	1.4084	3.54%	1	-14	177	0.9793	0.9773	-0.20%	178	1
21	1.3409	1.3858	3.35%	7	-14	183	0.9692	0.9664	-0.29%	185	2
27	1.3221	1.3638	3.16%	14	-13	189	0.9594	0.9557	-0.38%	191	2
33	1.3038	1.3426	2.97%	20	-13	195	0.9497	0.9452	-0.48%	198	3
39	1.2861	1.3220	2.79%	27	-12	201	0.9402	0.9349	-0.56%	204	3
45	1.2688	1.3021	2.62%	34	-11	207	0.9310	0.9249	-0.65%	211	4
51	1.2520	1.2827	2.45%	40	-11	213	0.9219	0.9151	-0.74%	218	5
57	1.2356	1.2639	2.29%	47	-10	219	0.9130	0.9055	-0.82%	224	5
63	1.2196	1.2456	2.13%	53	-10	225	0.9042	0.8961	-0.90%	231	6
69	1.2041	1.2279	1.98%	60	-9	231	0.8956	0.8868	-0.98%	237	6
75	1.1889	1.2106	1.83%	66	-9	237	0.8872	0.8778	-1.06%	244	7
81	1.1741	1.1939	1.68%	73	-8	243	0.8790	0.8690	-1.14%	250	7
87	1.1597	1.1776	1.54%	80	-7	249	0.8709	0.8603	-1.21%	257	8
93	1.1456	1.1617	1.40%	86	-7	255	0.8629	0.8518	-1.29%	264	9
99	1.1319	1.1463	1.27%	93	-6	261	0.8551	0.8435	-1.36%	270	9
105	1.1185	1.1312	1.14%	99	-6	267	0.8474	0.8353	-1.43%	277	10
111	1.1054	1.1166	1.01%	106	-5	273	0.8399	0.8273	-1.50%	283	10
117	1.0926	1.1023	0.89%	112	-5	279	0.8361	0.8233	-1.53%	287	11
123	1.0801	1.0884	0.77%	119	-4	285	0.8288	0.8155	-1.60%	293	11
129	1.0679	1.0748	0.65%	126	-3	291	0.8216	0.8079	-1.67%	300	12
135	1.0559	1.0616	0.53%	132	-3	297	0.8145	0.8004	-1.73%	306	12

Conclusions

1. There doesn't appear to be any significant difference in the optimum Q of the 2013-2017 race data to earlier data.

2. The difference in calculated optimum Q value for boats with ratings under 100 sec/mile to boats over 100 sec/mile has narrowed (a single Q value for all ratings is less of a compromise).

3. The new analysis method (technique #2) appears to be a viable, if not a preferred, way to calculate Q value due to its simplicity, ease of calculation, and avoidance of potential selection error.

Recommendation

Considering the slight difference in the results of the two calculation methods and consideration of the present value of Q, a change from the present Q value of 0.008 does not appear to be warranted.

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