Math Exploration – Nick Scott

Does having a set A and B factor in the TCF formula create a bias towards certain designs of keelboats?

Introduction

Since I was nine years old, I've been sailing and racing in keelboats, a certain type of sailboat. Thus far, my family has owned and raced two different keelboats. The first, *Alligator Pie*, was a 23 foot-long C&C Paceship Bluejacket. An old, fairly slow boat, constantly in need of repairs, with low quality sails. Our second boat is named *Ghost*, a 30 foot Olson 30. A relatively new and fast boat, well taken care of, with good quality racing sails. In keelboat racing, the range of the boats racing is very great, including boats like *Alligator Pie* and *Ghost* among its competitors. Since the two boats are very different both in design and speed, when they are racing, each is given an appropriate handicap which is put into a formula, known as the TCF (Time Correction Formula) formula, which includes variables like the time it took for the boat to finish the race, the wind conditions of race, the length of the course, and so forth. This handicap system is known as the PHRF ratings system. I have only recently learned of the PHRF ratings system, and upon discovering the role of mathematics in this sport that I find myself so invested in, I wished to learn more about it. In my research, I discovered that, in general, the PHRF ratings system strives to even out the playing field between keelboats and promote competition in the races. Since *Alligator Pie* is a slow boat, she was given a slow rating of 231 and 237, the first rating for races in which she raced with a spinnaker, (a large third sail used to sail more quickly) and the second for races in which she raced without a spinnaker, (so racing with two sails as opposed to three). On the other hand, *Ghost* is a fast boat, and was given a faster rating of 102 and 120, the first for spinnaker races and the second for white-sail races.

When racing in *Alligator Pie*, our crew did quite well, despite her tender conditions and her unhurried pace. And so I was very surprised by our results when we upgraded from this boat to our current one, *Ghost*. In racing *Ghost*, our placement in races has actually dropped, despite the seeming upgrade. This led me to wonder why this might be, as I initially believed that the faster a boat was, the more likely her chances of placing well, as in my experience, I have noticed that the boats at our yacht club that typically win races are the faster boats with faster ratings. Initially, it made me doubt the rating of our boat, that it might be too fast to properly represent our boat, and although I am still unsure to it's effect, I have chosen to focus the exploration on aspects of the formula used by the PHRF ratings system to calculate the race's result; the TCF formula.

The Time Correction Factor Formula

The TCF formula is used to correct the raw time a boat takes to finish a race in order to bridge the gap that exists between slower and faster designs of boats to create a more competitive racing environment. The TCF is determined using the Time on Time rule, rather than Time on Distance, which is the more commonly used rule in the PHRF ratings system. The Time on Time rule is independent of the course lengths or wind strengths, meaning that the TCF formula is not changed depending on the length of the course or the conditions of the races. The TCF formula is instead created based on an individual boat's handicap, (for example, *Ghost*'s would be 102, if it was a spinnaker race). This is then multiplied against the elapsed time a boat has taken to complete a course, and this results in the boat's corrected time.

The formula for the TCF = A / (B + C), in Atlantic Canada = this is 695 / (525 + PHRF rating)

A = A number that's supposed to make the TCF of the average boat in the fleet = 1.000

B = The wind conditions of the race. (In PEI this is set at 525)

480 = heavy air or all of the wind

550 = average conditions

600 = light air or all windward work

C = The PHRF rating of a boat.

So, if *Ghost* and *Alligator Pie* raced against each other in a spinnaker race, and *Ghost*'s raw time was 40 minutes, while *Alligator Pie* raw time was 45 minutes, the formula for each would be as follows:

Ghost	*Alligator Pie*
TCF = A / (B + C)	TCF = A / (B + C)
= 695 / (525 + 102)	= 695 / (525 + 231)
= 1.10 85	= 0.91 93
Corrected Time = TCF * Elapsed Time	Corrected Time = TCF * Elapsed Time
= 1.1085 *40	= 0.91 93 * 45
= 44.34 minutes	= 41.37 minutes

Thus, although on raw time, *Ghost* finished 5 minutes ahead of *Alligator Pie*, using the TCF formula, *Alligator Pie* would have been the victor, finishing 2.97 minutes ahead of Ghost on corrected time.

Limitations of a Set "A" Factor

There are limitations to all of the factors involved in the TCF formula. For A, although it's a number that's supposed to be affected by the *fleet*, our yacht club bases the A factor off of Atlantic Canada's A factor. This means that all of the boats listed in the PHRF database in Atlantic Canada are used to find the median boat in the whole region's fleet. This could potentially create a bias towards certain designs of boats at CYC, as the boats that are present in Atlantic Canada are not necessarily representative of those found at CYC. The A factor for Atlantic Canada is 695 (696 – but ok) (median rating of the fleet,

171, added to the B factor 525) Below is a chart of the fleet found at CYC, which will then be used to calculate a possible A factor for CYC, for both white sail races as well as spinnaker races.

If there is an asterisk (*) found before the rating, it indicates that the rating may not be accurate, as that rating could not be found on www.sailnovascotia.com's PHRF ratings database, and if there is an asterisk followed by a blank space, it is indicative that the rating could not be found, and therefore, the boat will be excluded from the calculations, for both white sail and spinnaker. These given examples will also be highlighted.

List of Boats and their PHRF Ratings at CYC

Boat Name (Class)	PHRF rating (white sail)	PHRF rating (spinnaker)
Farr to Tangley (A)	69	51
Pepper (A)	90	72
Salt (A)	90	72
Babe (A)	102	90
Ghost (A)	120	102
Dog Party (A)	102	81
Joyridin' (A)	129	117
Goodtogo (A)	129	117
J One For Two (A)	126	108
Jeorgia Girl (A)	126	108
Midnite (A)	153	135
Endeavor (A)	156	138
Surprise (A)	153	135
First Leg (A)	156	138
Intuition (A)	141	123
Jabber Wocky (A)	108	96
J2K (A)	126	108
Jaeger (A)	126	108

Jade Star (B)	219	*207
X Ta Sea (B)	183	165
Leilani (B)	195	*
Phoenix (B)	213	201
Effie (B)	210	210
Sea Spirit (B)	252	234
Affliction (B)	198	*
Spirit of Comfort (B)	219	201
Psychopath (B)	*	198
Bob (B)	225	207
Chance (B)	234	216
Heart's Content (B)	225	*
Milagros (B)	244	228
Snap Dragon (B)	249	228
Picture Perfect (B)	255	237
Soul Spray (B)	246	*
Ebony (B)	324	300
Indecision (D)	*	228
Alligator Pie (D)	237	231
Sierra M (D)	*	216

Modified “A” Factor for White Sail Races

To find the median rating of the fleet, I will arrange the PHRF white sail ratings from greatest to least.

324, 255, 252, 249, 244, 237 (*Alligator Pie*), 234, 225, 219, 219, 213, 210, 183, 156, 156, 153, 153, 141, 129, 129, 126, 126, 126, 126, 120 (*Ghost*), 108, 102, 90, 90, 69

The median is between 156 and 153.

156 – 153 = 3

3 / 2 = 1.5

153 + 1.5 = 154.5

The median PHRF rating of the fleet is 154.5

Therefore, the A factor of CYC's white sail's races should be:

A = (median of PHRF ratings + B)

A = (154.5 + 525)

A = 679.5, or 680

Thus, a considerable difference between Atlantic Canada's A factor (695) and CYC's white sail A factor (680) is displayed. To further examine the effects of the difference in the A factor, I will substitute my A factor into one of our CYC race night results and see how they change.

The new TCF formula I will be using to calculate this is:

TCF = 680 / (525 + PHRF rating)

So, for example. the new TCF formula for *Ghost* would be:

TCF = 680 / (525 + 120)

= 1.05 43

I will then multiply the TCF by the boat's elapsed time to arrive at it's Corrected Time, so for *Ghost* this would be:

Corrected Time = TCF * Elapsed Time

= 1.05 43 * 66.95

= 70.59

OR why not use the previous example of Ghost = 40 min and AP = 45

TCF = 680 / (525 + 231)

0.8994

Corrected Time = TCF * Elapsed Time Corrected Time = TCF * Elapsed Time

= 1.05 43 * 40 = 0.8994 * 45

= 42.172 = 40.473

Before continuing, I must acknowledge that there will be limitations into the investigation. In this table, I use the median of all the keelboats at my yacht club that have registered for the racing season. However, many of those who register race only once a year, or many don't race at all. These boats are often the slower rated boats, and so, it could be argued that the A factor should perhaps be calculated with each race, by figuring out what boats are racing that night, to get the most accurate results. However, I believe that those who are registered, but who don't race often, should still be considered in the calculation for the "A" factor, even when not present, as by registering they are paying for the privilege of being included in the race, and all the calculations that come from it, and to disclude them from the TCF formula in itself would be unjust. And to add, it would be very difficult for the race committee to determine a different A factor each race. Therefore, although it could possibly be more representative of the actual racing fleet to have an A factor that changed with every race, in my opinion it would neither be fair to do so, for both the keelboats as well as for the race committee.

As well, it should be acknowledged that this is only one race among many of the season. With variable such as the wind, the tide, the length of the course and the boats that racing, the results can vary vastly from race to race, and so, in using this one example, it's not truly representative of all white sail races at our yacht club.

White Sail Race

Boat Name	PHRF Rating	Original TCF	Modified TCF	Elapsed Time Dec.Min	Original Corrected	Modified Corrected	Original Overall Finish	Modified Overall

	(white sail)				Time Dec.Min	Time Dec.Min	Position	Finish Position
Pepper	90	1.13 01	1.10 57	68.45	77.36	75.69	4	4
Babe	102	1.10 85	1.08 45	81.72	90.58	88.63	10	10
Ghost	120	1.07 75	1.05 43	66.95	72.14	70.59	2	2
Joyridin'	129	1.06 27	1.03 98	73.75	78.37	76.69	6	6
Goodtogo	129	1.06 27	1.03 98	71.23	75.7	74.07	3	3
Midnite	153	1.02 51	1.00 29	86.23	88.4	86.48	9	9
Surprise	153	1.02 51	1.00 29	77.72	79.67	77.95	7	7
J2K	126	1.06 76	1.04 45	66.27	70.75	69.22	1	1
Jaeger	126	1.06 76	1.04 45	73.38	78.34	76.65	5	5
X Ta Sea	183	0.98 16	0.96 05	102.65	100.76	98.6	11	11
Chance	234	0.91 57	0.89 59	91.33	83.63	81.82	8	8
Milagros	244	0.90 38	0.88 43	115.9	104.75	102.49	12	12

Although the overall finishing positions of the fleet didn't change, the effect of the modified A factor and TCF formula were certainly felt. For the slowest rated boat in the fleet, *Milagros*, the adjusted TCF gave them 2.26 minutes, while it gave 1.67 minutes to the fastest rated boat, *Pepper.* Thus, the new A factor gives more of a handicap to slower rated boats, while giving less to faster rated boats, bridging the gap between the two. If implemented, this would create a more competitive and equal racing environment at our yacht club, as it would more aptly represent the boats that are found there. And while it may not be a vast difference, races often come down to a matter of seconds between first and second place, a position in which something such as the A factor and the TCF would have a profound effect.

Modified “A” Factor for Spinnaker Races

Since keelboats race both in white sail and spinnaker, I will also modify the A factor for one of

our yacht club's spinnaker races to note the difference. To find the median rating of the fleet, I will arrange the PHRF spinnaker ratings from greatest to least.

300, 237, 234, 231 (Alligator Pie), 228, 228, 216, 210, 207, 207, 201, 165, 138, 138, 135, 135, 123, 117, 117, 108, 108, 108, 108, 102 (Ghost), 96, 90, 81, 72, 72, 51

The median PHRF rating of the fleet is 135.

Therefore, the A factor of CYC's spinnaker races should be 660.

Thus, a considerable difference between Atlantic Canada's A factor (695) and CYC's spinnaker A factor (660) is displayed. To further examine the effects of the difference in the A factor, I will substitute my A factor into one of our CYC race night results and see how they change.

As well, upon calculating my modified version of the A factor for spinnaker ratings, I realized that another limitation to Atlantic Canada's set A factor is that it doesn't take into consideration the difference of ratings between white sail races and spinnaker races. To truly reflect the results of a race, I would think that the A factor should vary based on the changed ratings of the boats racing.

As with the table for the white sail races, I again wish to acknowledge that this race has it's limitations. In it, we can see that there are only eight boats racing, and only three of them have a rating above of 130. It is not truly representative of all spinnaker races at our yacht club, for the variables aforementioned, yet it was one of the few spinnaker races that my boat Ghost raced in this year, and so, I have a certain biased inclination to include it in the research.

TCF = 660 / (525 + PHRF rating)

Spinnaker Race

Boat Name	PHRF Rating (white sail)	Original TCF	Modified TCF	Elapsed Time Dec.Min	Original Corrected Time Dec.Min	Modified Corrected Time Dec.Min	Original Overall Finish Position	Modified Overall Finish Position
Ghost	102	1.10 85	1.05 26	50.27	55.72	52.91	2	2
Joyridin'	117	1.08 26	1.02 80	54.40	58.89	55.92	5	5
Goodtogo	117	1.08 26	1.02 80	50.67	54.85	52.09	1	1
J2K	108	1.09 79	1.04 27	50.98	55.97	53.16	3	3
Jaeger	108	1.09 79	1.04 27	60.62	66.55	63.21	6	6
X Ta Sea	165	1.00 72	0.95 65	81.67	82.25	78.12	8	8
Chance	216	0.93 79	0.89 07	61.37	57.56	54.66	4	4
Milagros	228	0.92 30	0.87 65	80.37	74.18	70.44	7	7

Although the overall finishing positions of the fleet didn't change, the effect of the modified A factor and TCF formula were certainly felt. For the slowest rated boat in the fleet, *Milagros*, the adjusted TCF gave them 3.74 minutes, while it gave 2.81 minutes to the fastest rated boat, *Ghost*. Thus, as before, the new A factor gives more of a handicap to slower rated boats rather than faster boats, bridging the gap between the two. With the original corrected time, 19.33 minutes laid between the first and last boat, but with the modified TCF formula, this was reduced by nearly a minute to 18.35 minutes. And as said with the white sail example, such a change, although seemingly small, might have a profound effect on longer races that last many hours, or those which last days.

Limitations of a Set “B” Factor

Another of the variables found in the TCF formula, the B factor is meant to represent the wind conditions of the race, and the course itself. However, on PEI, we have a set B factor of 525. This is speculated to create a certain bias towards boats designed for medium-wind conditions, as if the B factor is constantly set in medium-wind conditions, the boats designed for these conditions will benefit the most from the TCF formula. To test the validity of this claim, I will take the results from a NSTYA

(Northumberland Strait Yachting Association) spinnaker race, held at our yacht club CYC, named “The Northumberland Strait Challenge”. This particular race has been chosen because of it’s length, (4-6 hours), which an adjusted B factor would make itself apparent. In this race, I will adjust the B factor to the different wind conditions, 480 for heavy air, 550 for average conditions, and 600 for light wind, and evaluate the results, seeing how they may change as a result.

However, the limitations of this process must be acknowledged. Firstly, I was not able to find the exact pre-existing wind conditions of said race, which is notable, as they would give certain designs of boats an advantage over others. However, if my memory serves me correct, and the memory of others at the race, the wind was around 10-15 knots in the first half of the race, (medium winds conditions), and 15-20 knots in the last half (heavy winds conditions). For example, if it was a windy day, which I’m fairly certain it was, boats designed for windy conditions would be inclined to do well, and so the pre-existing results may play foul with my calculations. Secondly, very seldom do wind conditions or the conditions of the course itself remain consistent throughout the length of the race. The conditions are constantly shifting, such as the strength of the wind, and it would be difficult to calculate a B factor if the wind is strong in the beginning of the race, (15-20 knots), but dies down to light conditions by the end of the race, (8-10 knots). And for such a race as the Northumberland Strait Challenge, the length both hinders my research as well as helps it, because although the effect of changing the B factor will make itself more apparent, the length of the race makes it more unlikely that the wind was light, medium, or heavy for the entire length of the race.

Modified “B” Factor

For the following tables, I will substitute the new B factors, varying by heavy (480), medium (550), and light (600) wind conditions into the TCF formula, creating a new TCF for each boat. It will look as

follows, using the example of the boat *Babe*, adjusting the B factor for light winds conditions. (*Babe* was built for heavy winds conditions) The A factor will be set to Atlantic Canada's 695, as for now I only wish to examine the effects of changing the B factor.

TCF = A / (B + C)

= 695 / (600 + 90)

= 1.00 72

I will then multiply the new TCF by the elapsed time, as I have done in the previous examples.

Before I begin these tables, I just want to acknowledge that the results may not be all that impressive. As out of the seven boats that raced, two pairs of them are of the same design, in effect, only five designs of boats are being considered. Ideally, the perfect race for analysis and a change in the overall finish would be one in which many different designs of boats were racing in, in which the positions were all very close to each other, and filled by different designs of boats with vastly different ratings. However, I prefer only to choose races that I have participated in, as I can try and remember details of the race that might help or hinder my research, and so, I chose not to use such an example, helpful though it may have been.

Heavy Winds Race (B factor is 480)

Boat Name	PHRF Rating (spinnaker)	Original TCF	Modified TCF (Heavy)	Elapsed Time Dec.Min	Original Corrected Time Dec.Min	Modified Corrected Time Dec.Min	Original Overall Finish	Modified Overall Finish
Joyridin	117	1.08 26	1.16 42	249.55	230.32	290.53	1	1
Goodtogo	117	1.08 26	1.16 42	249.58	230.36	290.56	2	2
Babe	90	1.13 01	1.21 93	240.36	231.53	293.07	3	3
Pepper	72	1.16 42	1.25 91	236.30	235.30	297.53	4	4

Jeorgia Girl	108	1.09 79	1.18 20	274.52	301.47	324.48	6	6
Jaeger	108	1.09 79	1.18 20	291.21	319.53	344.21	7	7
Picture Perfect	237	0.91 21	0.96 93	330.48	301.42	320.33	5	5

Upon completion of this particular table, I realized that it was the sole of my examples in which the modified corrected time of each boat was actually lengthened, rather than reduced, as in my other tables. Obviously, this was because the heavy winds B factor, 480, was smaller than that of the pre-set B factor, 525, and so it resulted in larger TCFs for the faster rated boats. And so, it gave slow boats, such as *Picture Perfect*, an advantage. And finally, adjusting the B factor bridged the gap between the last boat, *Jaeger*, and the first boat, *Joyridin*, from the original time of 89.21 minutes to 53.68 minutes.

Medium Winds Race (B factor is 550)

Boat Name	PHRF Rating (spinnaker)	Original TCF	Modified TCF (Medium)	Elapsed Time Dec.Min	Original Corrected Time Dec.Min	Modified Corrected Time Dec.Min	Original Overall Finish	Modified Overall Finish
Joyridin	117	1.08 26	1.04 20	249.55	230.32	260.03	1	1
Goodtogo	117	1.08 26	1.04 20	249.58	230.36	260.06	2	2
Babe	90	1.13 01	1.08 59	240.36	231.53	261.01	3	3
Pepper	72	1.16 42	1.11 74	236.30	235.30	264.04	4	4
Jeorgia Girl	108	1.09 79	1.05 62	274.52	301.47	289.95	6	5
Jaeger	108	1.09 79	1.05 62	291.21	319.53	307.58	7	7
Picture Perfect	237	0.91 21	0.88 31	330.48	301.42	291.85	5	6

Light Winds Race (B factor is 600)

Boat Name	PHRF Rating (spinnaker)	Original TCF	Modified TCF (Heavy)	Elapsed Time Dec.Min	Original Corrected Time Dec.Min	Modified Corrected Time Dec.Min	Original Overall Finish	Modified Overall Finish
Joyridin	117	1.08 26	0.96 93	249.55	230.32	241.89	1	1
Goodtogo	117	1.08 26	0.96 93	249.58	230.36	241.92	2	2
Babe	90	1.13 01	1.00 72	240.36	231.53	242.09	3	3
Pepper	72	1.16 42	1.03 42	236.30	235.30	244.38	4	4
Jeorgia Girl	108	1.09 79	0.98 16	274.52	301.47	269.47	6	5
Jaeger	108	1.09 79	0.98 16	291.21	319.53	285.85	7	7
Picture Perfect	237	0.91 21	0.83 03	330.48	301.42	274.40	5	6

I grouped my reflection for the changed B factor for medium and lights wind conditions firstly because both were higher than the set B factor for Atlantic Canada, and secondly, because I believed that the results would be very similar to those of all my other examples. However, it came to my immense surprise and joy that the changing of the B factor directly had an effect on the results on both races. In the results of both the Medium Winds Race and the Lights Winds Race table, the two boats, *Jeorgia Girl*, (PHRF rating of 108), and *Picture Perfect*, (PHRF rating of 237) switched positions in their overall finish, which I found extremely exciting. Previously, *Picture Perfect* had held the overall finish of 5th, whereas *Jeorgia Girl* had come in 6th, but by adjusting the B factor higher, making the TCF smaller, allowing *Jeorgia Girl* to pull slightly ahead of *Picture Perfect*. What I found especially gratifying was the relatively miniscule shift from Atlantic Canada's set B factor, (525), and the suggested medium winds B factor (550) making all the difference in the overall finish. To me, this is proof of the importance of mathematics in a sport I am so personally invested in, and upon realizing it's importance, I wish to see it incorporated more actively into the sport, and will definitely pursue the idea further in the future.

Effects of a Higher or Lower TCF

Consequentially, I wondered how a higher or lower TCF might change the results of race, and how each would affect boats with a faster or slower rating. In my calculations, I state whether the TCF was lowered or raised by the changed A/B factor. I then contrast the original and modified range between the race's fastest and slowest rated boats. Finally, I contrast the time added or subtracted to the corrected times of fastest and slowest rated boats of the races.

Beginning with the White Sail Race, the TCF was lowered by the changed A factor (680). The original range was 27.39 minutes, and the modified range was 26.80 minutes. 1.67 minutes were taken from the fastest rated boat, while 2.26 minutes were taken from the slowest rated boat.

In the Spinnaker Race, the TCF was lowered by the changed A factor (660). The original range was 18.46 minutes, and the modified range was 17.53 minutes. 2.81 minutes were taken from the fastest rated boat, while 3.74 minutes were taken from the slowest rated boat.

In the Heavy Winds Race version of the Northumberland Strait Race, the TCF was raised by the changed B factor (480). The original range was 66.12 minutes, and the modified range was 22.8 minutes. 62.23 minutes were added to the fastest rated boat, while 18.91 minutes were added to the slowest rate boat.

In the Light Winds Race version of the Northumberland Strait Race, the TCF was lowered by the changed B factor (600). The original range was 66.12 minutes, and the modified range was 30.02 minutes. 9.08 minutes were added to the fasted rated boat, while 27.02 minutes were taken from the slowest rated boat.

Originally, all I drew from this was that no matter the change in TCF, it must benefit the slowest rated boats more than the fastest rated boats, as with the modifications, the range constantly grew smaller, and the slowest rated boats always had more time taken away or less time added than the fasted rated boats. However, upon contrasting the Heavy Winds Race and the Lights Winds Race, I noticed that the change in TCF had a profound effect. The modified range of the Heavy Winds race 7.22 minutes shorter than the Light Winds Race. As well, although time was added to both the fastest and slowest rated boats in the Heavy Winds Race, in the Light Winds Race, time was only added to the fastest rated boat, and taken away from the slowest rated boat, and that there was less of a distance between the added/subtracted time in the Light Winds Race than in the Heavy Winds Race, giving the slowest rated boat less of an advantage. Thus, the conclusion that I gathered from this is that lower TCF's are more beneficial for faster rated boats, as they create less of a handicap for the fleet, which would mean that the results would be closer to the elapsed time, beneficial for faster rated boats as they tend to finish well in elapsed time, while the higher TCF's are more beneficial for slower rated boats, as they covet the highest handicap possible, as the way the TCF formula is calculated, it gives slower rated boats a proportionately smaller TCF than their faster counterparts, allowing for a better corrected time.

Other Possible Flaws of the Current PHRF Handicap

Upon doing these tables, I also thought of something else. In my exploration, I explore how the results should be changed based on the fleet that is racing, as well as the wind conditions of the race, but upon completing these table, and all of the examples in the exploration, in which I noted a lack of change in the overall results, I wondered if a boat's handicap rating should be made even more specific, based on empirical data such as the length of the boat's hull, the size of it's sails, it's width, as well as more qualitative data such as the quality of the sail or of the boat, the experience of the crew and so

forth. I came to this by thinking of the boat I was racing on during the race, *Babe*. Their crew are fairly new to sailing, and so their results often vary greatly. However, they also have a quite new boat, with very good quality sails, and so they tend to do well more often than not. This led me to wonder how might their results be affected, if their rating was changed based on the excellent quality of the boat and it's sails, versus the relative inexperience of the crew. Should such qualities be taken into consideration for a boat's handicap? It might certainly even out the playing field, although certain arguments that might be presented could be that racers that put a lot of money and time into creating a well-trained crew are doing so to gain an edge over the competition, and that by giving more of a handicap to inexperienced and poor quality boats, we are levelling the two, which is unfair as each has put vastly different amounts of time and money into their boats' performance. Another difficulty would be in determining the handicap for each individual boat as well. To do so, each boat would have to be accessed on the quality of it's hull, it's sails, and it's crew, all variables which are extremely prone to change, and thus, each boat's handicap would have to be addressed time and time again.

However, if handicaps were created based on empirical data, such as the length of the hull, the mast, the width of the boat and so forth, I believe it would be relatively easy to give a certain design of boat a more representative rating, and it wouldn't create an unfair bias towards any particular type of racer, as each rating would benefit each design of boat equally.

As it stands, I believe that the PHRF race committee creates a rating for new boats introduced into the region through either a) Looking at comments from the boat's designer on the recommended handicap for the boat, or more commonly, b) Basing the newly introduced boat's rating off of other of the same, or similarly designed, boats in other regions, and then over the years, observe the results of newly introduced boat in races it performed in, and adjust the rating accordingly. The issue with both of these is that in taking the advice of the boat's designer, although none else would know the boat better,

there is most probably a bias towards a lower rating from the boat from it's designer, as a lower rating would result in better positions for the boat, which the designer would covet, as he is trying to sell his product to the market. As for basing the boat's rating off it's, or similarly designed boats', performance in other regions, it presents the limitation that no two regions' weather patterns are exactly the same, and so a boat's handicap should not be duplicated from one region to the next.

Limitations of Changing the "A" and "B" Factor

The limitations of changing the A and B factor from being set would mostly be the difficulties that would accompany it. As well as the limitations listed before, it would also be very difficult, and time-consuming to determine the results, as because of the constantly changing B factor, the A factor would also be constantly changing, as the formula for finding A is the median rating of the fleet added to the B factor, and thus, the TCF for each boat would be different from each race, which would take quite some time to calculate.

Conclusion

While changing the A and B factors could certainly create a more competitive and representative racing environment between keelboats, it would also create a lot more confusion and work, and thus, I believe that for races such as our yacht club's monday and wednesday night races, a set A and B factor should suffice. For races of a more official stature, for example, NSTYA races, like the Northumberland Strait Race, which are held more rarely, and in which changing the A and B factors would have a more noticeable and appreciable effect, perhaps having an unfixed A and B factor would be a good idea. However, I may be wrong as well, since I have found that playing with the TCF may actually create a bias towards one design of boat over another, although alternately, this could act as a balance, as different sets of conditions tend to naturally bias one design of boats already.

However, despite the conclusions I have formed from my exploration, I was initially drawn to the topic through my realization of how I could bring mathematics into a sport I dedicate so much of my life into. Needless to say, I was surprised by the largess of it's role in the sport. Before, I proclaimed myself to be an agnostic of the mathematics. I didn't care too much for it, as I couldn't see how it affected me, yet in my exploration, I've realized that I can apply mathematics very clearly to topics I care vastly about. I have become much more passionate about mathematics as a result, and wish to explore other ways to incorporate mathematics into sailing, for example, how sailboats can sail on a diagonal angle into the wind. As a result of this exploration, I have learned to appreciate mathematics on a much more basic, and relatable level.

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