How the Next Handicap is Calculated.

Necessary Definitions

➢ **AHC**: – the "Allocated Handicap" i.e. the handicap Allocated to a boat for a particular race.

➢ **Elapsed Time**: - Finish Time - Start Time[1].

➢ **Corrected Time**: - Elapsed Time * AHC.

➢ **BCH**: – the "Back Calculated Handicap" for each boat. This is the handicap the boat needed for this race to end up with the same handicap corrected time as that of the reference boat. This can only be calculated after the race – hence the terminology "Back" calculated. If each boat had started the race with their BCH as their AHC then all boats would have a virtually identical handicap- corrected times.

➢ **CBCH**: – the "Clamped" Back Calculated Handicap. The BCH is passed through a clamping algorithm that applies some 'sanity checks' to the BCH. These checks endeavour to cull out BCHs which are not truly representative of that boat's performance. The set points used in the sanity checks as supplied in TopYacht Standard handicapping maths are empirically derived, but have withstood the test of time. See Appendix 1. This indicates how the clamps manipulate the BCH before the being used to compute the CHC.

➢ **CHC:** – the "Computed Handicap" for each boat. This is the projected handicap to be allocated to each boat for the next race.

➢ **TCF:** - or "Time Correction Factor", being a number that the elapsed time is multiplied by to compute the corrected time. Also known as an **AHC**

➢ **Mark (or Reference) Boat** – is the boat chosen that is about mid-fleet within the finishing Group.

Handicap Types

There are 4 main handicap types, selected as follows:

➢ **Time on Time:** - where the handicap value is expressed as a Time Correction Factor, usually whose value is around 1.0 +/- 0.5

➢ **Time on Distance: -** Usually expressed in minutes (or seconds) per mile

➢ **Time (Pursuit): -** a per-boat time offset which is added to the reference start time of a pursuit race to compute the start time of each boat.

➢ **Time: -** Expressed in minutes, it is a per race time penalty, regardless of the elapsed time of the race, or the winning margin.

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[1] TopYacht **strongly recommends** the use of Time of Day in 24-hour format for the Start and Finish time. "I finished at about 3:25 (15:25)" is much more meaningful to a competitor instead of "105 minutes after the start (assuming a 13:30 start time)

So How to Derive the Next-Race Handicap for Each Boat

This is essentially a five step process. The following discussion assumes that the previous race has been completed, and the race results have been computed. The **CHC** is calculated as part of the computing process.

Step 1

Determine the **Mark Boat**.

> ➢ The boats in the handicap group are ranked in corrected time order.

> ➢ Parameter 1 in the handicap recipe is user selectable. Typically it is 45%[2]. The boat selected is this percentage from the top of the list. The **Corrected Time** is ear-marked. See Appendix 4.

> Those towards the top of the fleet are considered to have sailed above their handicap and those towards the bottom of the fleet are considered to have sailed below their handicap.

Step 2

Calculate the **BCH**.

> ➢ For each boat, the BCH is calculated by dividing the **Corrected Time** of the **Mark Boat** by the **Elapsed Time** of each boat in the Group. Note that the **BCH** and the **AHC** for the **Mark Boat** are equal in value

Step 3

Clamp the **BCH**.

> ➢ For each boat, some sanity checks are applied to the BCH to calculate the **CBCH**. See Appendix 1.

> The set-points used in the algorithm have heed derived empirically, and withstood the test of time. They are designed to moderate (or reject) **BCH** values that are extreme (The competitor was in the right place at the right time when the breeze changed, or in the wrong place at the wrong time!)

Step 4

Calculate the **CHC**.

While various parameters all significantly impact on the generation of the next race handicap, probably the key element is the amount of CBCH used in calculating the next race handicap.

There are three primary ways the **CHC** is calculated:

> ➢ **Weighted Average** of the last N CBCH's.

> In essence this averages the last (say) 4 race's CBCHs.

> So after Race No. 4, Race No. 5's **CHC** is (CBCH1 + CBCH2 + CBCH3 +CBCH4)/4.

> After Race 5, Race 6's **CHC** is (CBCH2 + CBCH3 + CBCH4 +CBCH5)/4

> At each new race the oldest **CBCH** is dropped and the last race CBCH added into the averaging process. This can have some apparently weird outcomes where a boat can win a race (or be in the top place getters) and have the next race handicap go down. Likewise a boat towards the bottom of the fleet can actually have their handicap go up after the race.

> When there are less than N races, the start-up works like:

> R1 CHC = 3/N AHC1 + 1/N CBCH1;

> R2 CHC = 2/N AHC1 + 1/N CBCH1 + 1/N CBCH2

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[2] The 45% boat has been shown through time to provide most stable handicap adjustments over a season.]

etc until there are N CBCHs.

- ➤ **Exponential Average** with a 'Gain' of X.

    This form of handicapping has been shown to provide a very similar outcome to weighted-average handicapping over the duration of a Series. To achieve this similarity the various parameters need to be appropriately set.

    For Gain Numbers less than 10

    As an example, let's use a 'gain[3]' of 3, (the default value used in TopYacht as downloaded) the next race **CHC** = $^1/_3$ of the CBCH plus $^2/_3$ of the **AHC**.

    For Gain Numbers greater than 10

    The mathematics changes. TopYacht treats the value as a percentage.

    Instead of the case where increasing numbers make the system more sluggish, for values increasing in value increases the percentage of the **BCH** used in computation of the **AHC**

    CHC = (gain / 100) x **BCH 10** + ((100-gain) / 100 * **AHC**)

    This system does not suffer from the issue of winner's handicaps having the potential to actually drop or loser's handicaps actually going up!

    It is also very easy to understand; and if a boat performs well, their handicap goes up and conversely.

    It also enables the club handicapper to quickly address boats that were given an inappropriate initial handicap as altering the **AHC** for a race has a significant impact on the next race handicap whereas under weighted average, the handicap is only affected by the running sum of the **BCH**s and can take quite a number of races to attain a sensible handicap for a boat. See Appendix 2.

- ➤ **Place Based Handicapping.**

    This technique is a recipe-driven system where the handicap adjustments are made based on some rules the user enters into the handicap recipe. The size of each adjustment is based on the boat's place in each race. For details, see Appendix 5 and Appendix 6

- ➤ **Place Biased Exponential Handicapping.**

    Unlike Exponential Averaging this technique applies a progressive scale factor to boats with the biggest impact on the winner, next biggest on the second place getter and continues right down the mid place getter. The same progressive scale factor applies to the loser, second last etc. In all cases the scale factor varies the percentage of **BCH** that is used in calculating the new **AHC**. The winner might have a new **AHC** = 80% of **BCH** plus 20% of **AHC**; second might get 75% of **BCH** plus 25% **AHC** etc. This approach alters the new handicap by a sliding scale factor AND (importantly) by the **BCH** (which is a direct measure of how much the boat performed above or below their **AHC**). In using this maths you would actually use the 'clamped' **BCH** not the raw **BCH** so any extreme **BCH**s are limited in their impact on the next race **AHC**.

- ➤ **Trend Biased Average**

    This uses a formula to try to calculate where the AHC will be for the next race. For a normal boat whose BCHs are simply oscillating up and down it provides a very similar outcome to the Running Average. For a boat that is improving or not it attempts to predict a sensible CHC for the next race.

- ➤ **Boat Performance Ratio**

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[3] 'Exponential' is an abbreviation of Exponentially Weighted Moving Average (EWMA)' The term 'Gain" while widely used, is incorrect and counter intuitive. It is actually a 'time constant', and determines the response of the mathematics. Increasing the value makes it **less responsive** (more sluggish)

Unlike all other system that determines a boat's handicap results by comparing them to all the other boats, this system compares the boat to its average previous performances. If you wish to experiment with this system you will need to chat to Rod about how to implement this method. It is not just a 'turn on and it goes' system as it needs preparation and must follow some rules.

Step 5

Veto. (Optional)

The handicapping process is purely mathematical. While the clamping algorithm automatically suppresses some outlandish outcomes, it cannot cater for some real-life events.

For example, if the wind drops out after the first few boats have finished but before the **mark boat** finishes, those early finishers will get a **BCH** that could push through the upper clamp and create a major disturbance in the **CHC.** The Club's handicapper has the right to specifically exclude that race's BCH calculations in the prediction.

Appendix 1

Clamping Algorithm

Clamps.

Scenarios

⇨ What if a boat ran aground and took 10 minutes to get free. Should you use this BCH?

⇨ What is a boat was lucky enough to be in just the right spot when an unexpected wind change occurred? Should you use this BCH?

Let's us consider the case of the boat running aground and, and recording a very poor performance [low BCH]. There are several options available.

The choice is yours.

⇨ Use this BCH.

⇨ Ignore it.

⇨ Use a modified value for this BCH.

If the competitor's allocated handicap was 0.800 and the BCH was 0.720. This BCH is 10% below the allocated handicap. You may choose to "clamp" the lowest acceptable BCH to say 5% of the allocated handicap **below** the allocated handicap. Instead of using .720 as a BCH, 0.760 would be substituted. Since historical observations strongly suggest that competitors perform within +/- 4% of their allocated handicap for the vast majority of their races, clamps of +/- 4% makes sense, and have stood the test of time

Limits

Further, for the competitor who ran aground you may decide to totally ignore the BCH from that race. This can be achieved by setting a "Lower Limit" of (say) 6%. Then BCH that falling below this figure will be ignored when calculating the new handicap. The current allocated handicap value is substituted.
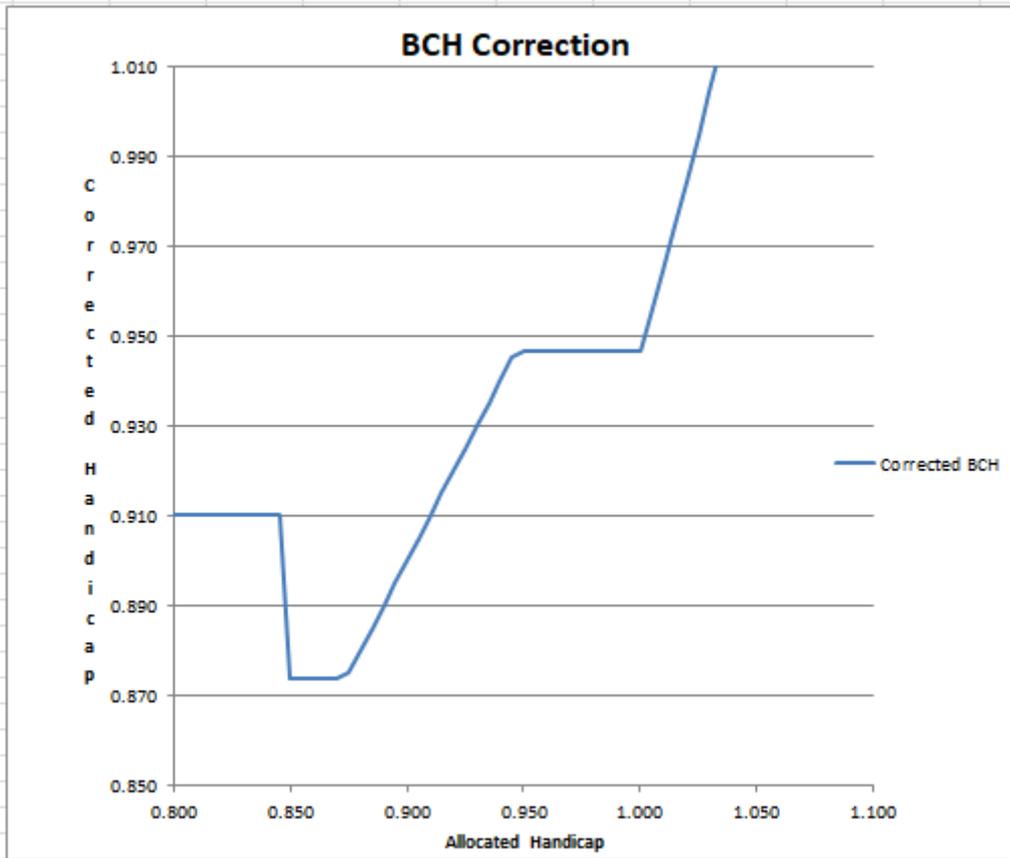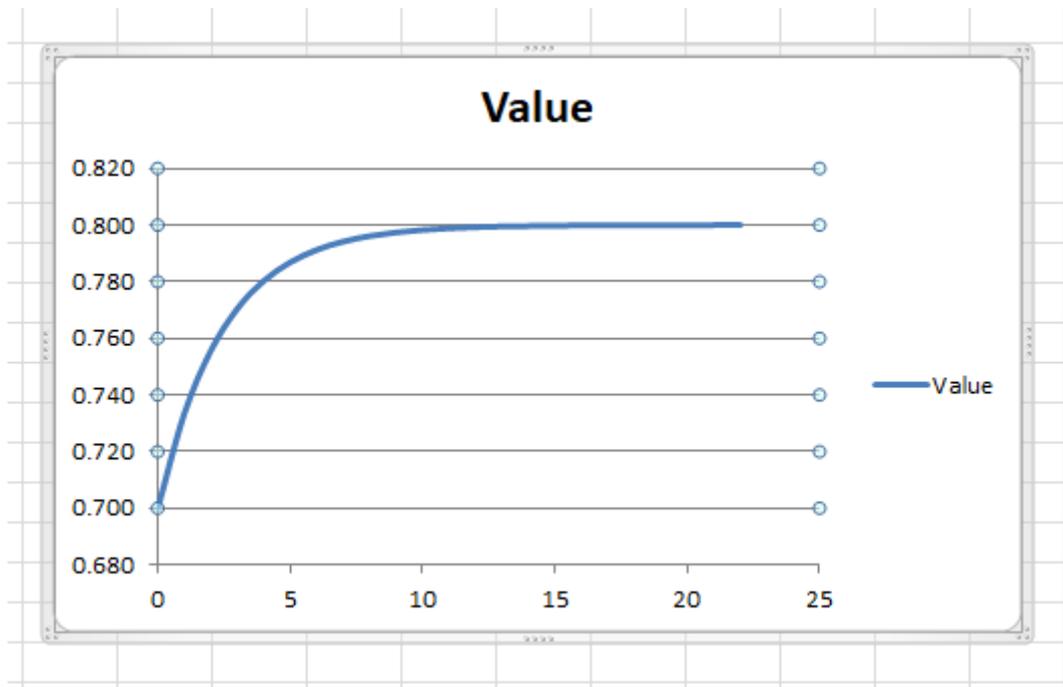
This diagram describes the clamping / limiting of the BCH.

It is from a Microsoft Excel Spreadsheet, where the Clamp / Limit algorithm has been built from the actual TopYacht code.

Users can be downloaded from here and manipulate the parameters to observe the impact the manipulation will have.

Appendix 2

EWMA

This demonstrates the Exponential filtering.

The Time Constant ('gain') value determines the sluggishness of the response.

The initial value is 0.700

The terminal value is 0.800

The 'gain' is 3.

By definition:

- After one time constant (3 races) the boat would be about 67% of its target value
- The terminal value is 'reached' after about 5 time constants. So for a gain (time constant) of 3, it takes 3 x 5 = 15 races to reach its terminal value.

This spread-sheet can be downloaded from here and manipulated by interested parties.

Appendix 3

TopYacht's Handicap Recipe

Appendix 4

TopYacht's Typical handicap Results output.

Place	Sail No	Boat Name	Elapsd	AHC	Cor'd T	BCH	CHC	Skipper	Score	Fin Tim	CREW
1	5672	ANTARES	28:39	0.974	27:54	1.026	0.974	Nathan Field	1.0	11:10:39	Josh Garner
2	9698	WILDCARD	29:53	0.941	28:07	0.983	0.941	Lulu Di Sciascio	2.0	11:11:53	Charley Stephens
3	8931	MIDNIGHT MAGIC	35:51	0.791	28:21	0.820	0.791	Sebastian Durran	3.0	11:17:51	Holly Durran
4	9545	SMOOTH CRIMINAL	29:07	1.000	29:07	1.009	1.000	Jarrah Harris Moore	4.0	11:11:07	Evie Mcdonald
5	9559	RESISTANCE	30:57	0.943	29:11	0.949	0.943	Benjamin Garner	5.0	11:12:57	Sam Williamson
6	9919	SPARKLE	29:21	1.001	29:23	1.001	1.001	Emma Kelly	6.0	11:11:21	Oliver Grieves
7	5679	TICKLED PINK	35:06	0.851	29:52	0.837	0.851	Georgia Delaney	7.0	11:17:06	Ashley Delaney
8	9527	MUSTANG SALLY	31:06	0.965	30:01	0.945	0.965	Tim McCoy	8.0	11:13:06	
9	9930	AQUILO	33:22	0.960	32:02	0.881	0.960	Cooper Field	9.0	11:15:22	Forbes Phyland
10	9616	IMP	34:47	0.925	32:10	0.845	0.925	Molly Grimes	10.0	11:16:47	Caitlin Murgatroyd
11	9560	ASSASSIN	33:09	0.971	32:11	0.886	0.971	Imogen Farnell	11.0	11:15:09	Will Farnell
12	9523	BROTHERS IN ARMS	34:50	0.942	32:49	0.844	0.942	Xavier Smith	12.0	11:16:50	Bobby Mcdonald
13	5760	ANACONDA	33:14	0.990	32:54	0.884	0.990	Elliot Hughes	13.0	11:15:14	
14	9913	OCEAN WARRIOR	34:58	0.982	34:20	0.840	0.982	Milli Mcdonald	14.0	11:16:58	Cate McCoy
DNC	9624	NEED FOR SPEED		0.864				Lil Henderson	18.0		Mia Eastman
DNC	9822	SPITFIRE		1.038				Peter Allen	18.0		Ashton Rawstron
DNC	4677X	RESISTANCE		0.982				Ella Purnell	18.0		Declan Audrins

The **mark boat** can be identified in the list. The **AHC** is the same as the **BCH**, and highlighted by the green ribbon.

In this list it is "SPARKLE'. The location of the boat in the finishing list is 45% the way down. Note that mathematical rounding occurs, and the boat closest to 45% is selected.

Appendix 5

Place Based Handicap where **Time Correction Factors(TCF)** e. g. 0.851, are adjusted based on a place.

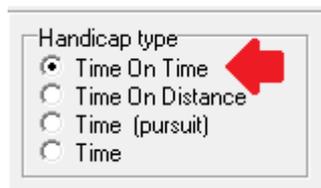Users can set-up their own recipe by following these steps.

Step 1:

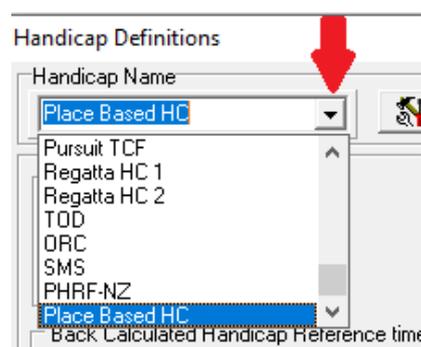Open the handicap screen. ***Admin | Maintain | For Master List | Define / Edit Handicaps***
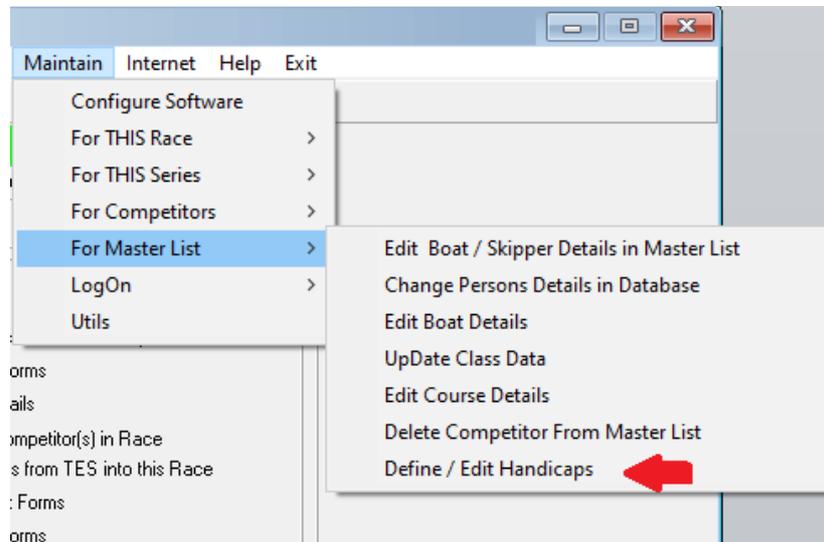
Step 2:

Select 'Time on Time' option.

Step 3:

Click on the Drop-Down box arrow.

Select **Place Based HC.**

The recipe will appear in Item 8 as below.

	Rule No	Place	DidNot	Adjust	
▶	1	1		0.01	
	2	2		0.005	
	3	3		0.0	
	4	100%		-0.002	
	5		DNF	-0.002	
	6		RET	-0.002	

8] Place Based Rules — [Add Rule] [Delete Rule]

In this example:

➢ First Place has 0.01 added to the **ACH** to calculate the **CHC** for the next race

➢ Second Place has 0.005 added to the **ACH** to calculate the **CHC** for the next race

➢ Third Place **AHC** remains unaltered.

➢ The remainder of the fleet have 0.002 deducted from their individual **AHC** to calculate the **CHC** for the next race.

➢ Boats that Retired or did not complete the course have 0.002 deducted from their individual **AHC** to calculate the **CHC** for the next race.

Adjustments may also be entered as a percent… (Make sure the % symbol is used or interesting outcomes will occur!!!)

The user is free to add, alter or delete rules as required by the Club's sailing instructions.
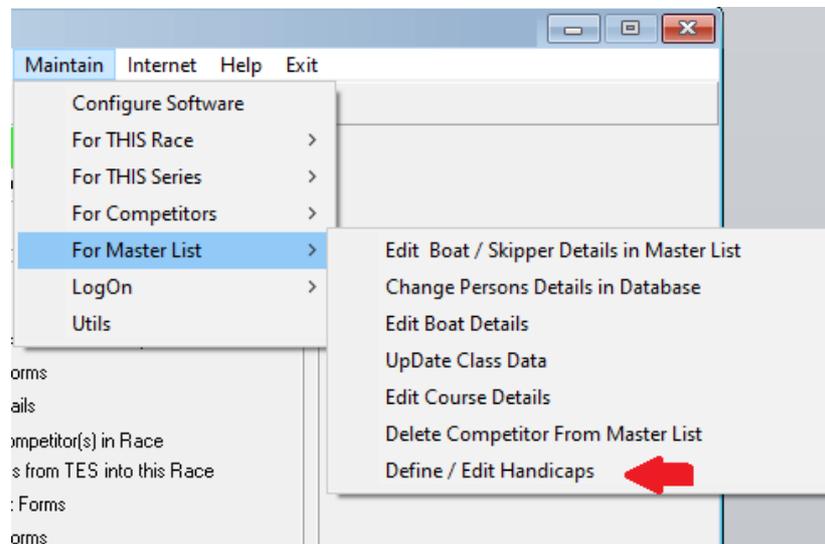
Appendix 6

Place Based Handicap handicaps for a pure time-based handicap system (e.g. a handicap of 5 minutes for achieving a first place) are in the form of a **time penalty** adjustments based on a place.

Users can set-up their own recipe by following these steps.

Step 1:

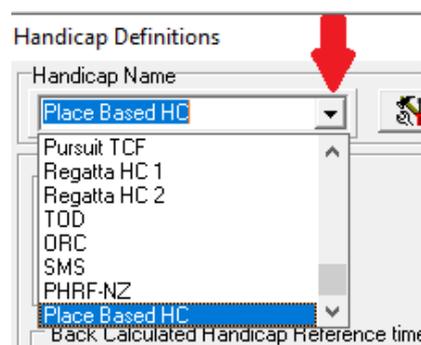Open the handicap screen. *Admin | Maintain | For Master List | Define / Edit Handicaps*

Step 2:

Select 'Time' option.

Step 3:

Click on the Drop-Down box arrow.

Select **Place Based HC.**

The recipe will appear in Item 8 as below.

Rule No	Place	DidNot	Adjust
1	1		-3
2	2		-2
3	3		-1
4	100%		0
5		DNC	0

8] Place Based Rules — Add Rule / Delete Rule

In this example:

➢ First Place has a time adjustment of 3 minutes added to the **ACH** to calculate the **CHC** for the next race.

➢ Second Place has a time adjustment of 2 minutes added to the **ACH** to calculate the **CHC** for the next race.

➢ Third Place has a time adjustment of 1 minute added to the **ACH** to calculate the **CHC** for the next race.

➢ The remainder of the fleet remain unaltered.

➢ For the next race, the **CHC** list is searched for the lowest time offset. This number is then added to every boat such that the boat with the lowest number starts with a zero time offset (being the **'scratch'** boat).

Notes:

➢ The time offset must be entered as a negative number to increase the minutes handicap.

➢ The time offset must be entered as a positive number to reduce the minutes handicap.

➢ The smallest unit of adjustment is whole minutes. Entering a value less that one minute will cause unpredictable rounding errors.

8] Place Based Rules

Rule No	Place	DidNot	Adjust
1	1		3.5
2	2		2
3	3		1
4	4		0.5
5	5		0
6	6		-0.5

➢ The "Place Penalty" adds an additional penalty over and above those described in the 'Rules' above.

Document Revision

01-04-2021, 13-10-2020, 28-10-2019, 06-08-2019, 03-08-2019, 24-07-2019, 09-01-2019