Report on a
Performance Handicap System for
Windrush State Championships 2023

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1 Introduction

The 2023 Windrush (Yacht) State Championships 2023 were held on Geographe Bay, Western Australia at Dunsborough Bay Yacht Club (DBYC) in early March 2023. An Invitation Race was held on Friday 3rd of March and the 6-race Championship Series was held on Saturday 4th and Sunday 5th of March (4 races on Saturday and 2 races on Sunday). There were 30 yachts entered in the Championship series in 3 divisions: Division 1 Cat, 14 entries, Division 2 Sloop, 6 entries and Division 3 Super Sloop, 10 entries. Appendix A has a list the entrants.

The Invitation Race on Friday (not part of the Championship series) was a slalom course with all entrants on the day in a single start. Races 1 to 6 of the Championship series (Saturday/Sunday) were held on equilateral triangular courses with starts at 5-minute intervals in the Division order: Cat (1st start), Sloop (2nd start), Super Sloop (3rd start). For the Championship series, the start time of each division was recorded, and finish times recorded for each yacht completing the race and *elapsed times (ET)* determined for each finishing yacht where $ET = \text{finish time} - \text{start time}$. Appendix B has a list of elapsed times for yachts in each race.

There was one unusual 'event' in the series, and this happened in Race 2 on Saturday morning. Due to the light winds, the Race Officer displayed course flag numeral 1 (the shortest of the 3 available courses) at the warning signal for all three divisions, rather than course flag numeral 2 that had been displayed for Race 1 and that most of the sailors were expecting. Only one yacht in the entire fleet, *Catatonic* (Peter Hawley) sailed the proper course. All other yachts sailed the longer course 2. This is clearly reflected in the elapsed times for Division 1 yachts in Race 2.

All the races were sailed in slight to moderate sea conditions (no swell, small to moderate wind waves) approximately 1.5 km from the shore. The Invitation Race (Friday) was sailed in a gentle breeze (7 – 10 knots) from the South (180º). Races 1 and 2 (Saturday am) were sailed in a light to gentle breeze (6 – 8 knots) from the South and Races 3 and 4 (Saturday pm) in a gentle to moderate breeze (8 – 13 knots) from the South. Race 5 (Sunday pm) was sailed in light air (4 – 6 knots) from the North (000º) and Race 6 (Sunday pm) was sailed in moderate wind (11 – 16 knots) from WSW (245º).

The Race Committee for the Championship are interested in providing a *Performance Handicap System PHS* that can use a yacht's *allocated handicap AHC* and *ET* to produce a *corrected time CT* where $CT = ET \times AHC$. The corrected times are then arranged in ascending order (least to greatest) and race scores 1, 2, 3, etc. assigned. These are the *PHS* race scores, or as they are often described "the handicap results", and these would be in addition to the usual method of race-scores 1,2,3, etc., assigned to yachts in *ET*-order (least to greatest).

PHS results are often called *Consistency Results* and the Sailing Instructions for the championships mention Consistency Results in Section 19 **SCORING** that is shown below.

We take it that **Consistency Results** mean results from a **Performance Handicap System (PHS)** that we will describe in more detail in following section.

We note also that other yacht clubs in Western Australia have PHS results described as Consistency Results. For example, Brighton & Seacliff Yacht Club hosted the 470 Nationals in Jan-2022 and produced PHS results as well as *ET*-order results. These were published on their website under the banner "Consistency Races" (https://www.topyacht.net.au/results/bsyc/2021/regattas/470_nationals/series.htm?ty=19716). And, Royal Freshwater Bay Yacht Club show example results from a PHS (see Optimist results below) in their description of Understanding the Consistency Series on their website (https://rfbyc.asn.au/wp-content/uploads/2022/02/OTB-Results-explained.pdf)

Understanding the Consistency Series

The Consistency Series consists of a number of races over the season where a performance handicapping system (PHS) is used. In each race a boat is allocated a handicap which changes for each race based on their previous result. The handicap is calculated by a mathematical formula. The idea behind consistency is to give the less experienced skippers a chance to win based on their performance on handicap in each race as opposed to those skippers constantly crossing the finish line in first place. In some cases, a boat still may win on handicap and be the fastest boat in a race. It all depends on how much they improve on their handicap.

Consistency Results Example
Optimist PHS results Start : 11:19

	Place	Sail No	Boat Name	Skipper	ETOrd	Fin Tim	Elapsd	AHC	Cor'd T	BCH	CHC	Score	
Boats finishing before the Reference boat have their handicaps increased for next race.	1	1525	HORSE POWER	Isabelle Charly	7	12:03:21	44:21	0.871	38:38	0.923	0.897	1.0	
	2	565	LORD OF THE WIND II	Nicholas Cooper	5	12:03:12	44:12	0.887	39:12	0.926	0.906	2.0	
	3	1671	AQUA MARINE	Sarah Atkinson	4	12:03:04	44:04	0.900	39:40	0.929	0.914	3.0	
	4	1861	FIREBOLT	Isla Molyneux	2	12:02:21	43:21	0.928	40:14	0.944	0.936	4.0	
Reference Boat	5	1506	SEA SEA	Nicholas Gillham	9	12:04:01	45:01	0.909	40:55	0.909	0.909	5.0	Boat positioned 45% of the fleet
Boats finishing after the Reference boat have their handicaps reduced for next race.	6	1682	ITS ALL G	Lucas Page	8	12:03:23	44:23	0.929	41:14	0.922	0.925	6.0	
	7	1635	BEACHED AZ	Valerie Van Der Hoek	3	12:02:23	43:23	0.969	42:02	0.943	0.956	7.0	
	8	1751	NAUTI BUOY	Thomas Cooper	1	12:00:50	41:50	1.026	42:55	0.978	1.002	8.0	
	9	1500	DREAMER	Sophia Charly	11	12:07:47	48:47	0.894	43:37	0.839	0.867	9.0	
	10	1557	VIVA LA VIDA!	Lia Rafart	6	12:03:19	44:19	0.995	44:06	0.923	0.965	10.0	
	11	202	FOXTROT	Juliette Van Der Hoek	10	12:06:49	47:49	0.947	45:17	0.856	0.919	11.0	
	12	1480	GONE WITH THE WIND	Orlando Ligovich	12	12:09:07	50:07	0.945	47:22	0.816	0.917	12.0	

Abbreviations used in the results

ETOrd = Elapsed Time Order or in other words, across the line order.

AHC = Allocated handicap for the race.

Cor'd T = Corrected Time. Calculated by elapsed time x handicap.

BCH = Back Calculated Handicap. This is the handicap the boat needed for this race to end up with the same corrected time as the Reference boat. This can only be calculated after the race.

CHC = Calculated Handicap. This is the new handicap for the following race.

We will show the Race Scores and Championship Series Results based on *ET*-order and then describe in general terms how a Performance Handicap System works with explanations of some of the methods used in calculating required quantities such as the *Standard Corrected Time STC* of a race, a yacht's *Back Calculated Handicap BCH,* and *Calculated Handicap CHC.*

We then define a Performance Handicap System for the Windrush State Championships 2023 that contains the sequence of simple mathematical operations required to produce corrected times and then calculated handicaps for a yacht race with an example set of calculations in the form of a spreadsheet.

Finally, we will produce a set of PHS race and series results and a comparison between these and the *ET*-order results and a discussion of some technical aspects.

2. Nomenclature

The following notation has been used

Symbol	Meaning	Definition
α	weighting factor	$0 < \alpha \leq 1$
AHC	allocated handicap	
BCH	back calculated handicap	$BCH = SCT\big/ET$
CHC	calculated handicap	
CT	corrected time	$CT = ET \times AHC$
DNC	did not start; did not come to the starting area	
DNS	did not start (other than DNC and OCS)	
DNF	did not finish	
ET	elapsed time	$ET = \text{ finish time} - \text{ start time}$
EWMA	exponentially weighted moving average	
G	Gain	
j, k	integer counters	
OCS	did not start; on the course side of the starting line at her starting signal and failed to start	
PI	performance indicator	$PI = BCH - AHC$
PM	performance multiplier	
RET	Retired	
SCT	standard corrected time	
t	Time	
YS	yardstick	$YS = 100\big/AHC$

3 Race Scores and Championship Series Results (*ET*-order)

Appendix A shows the Yacht Entry Details for the Windrush State Championships 2023 and the elapsed times *ETs* for each yacht that finished Races 1 to 6. For each race in each division (Cat, Sloop, Super Sloop) yachts were ordered from least to greatest *ET* and given race scores 1, 2, 3, etc. Yachts recorded as DNS, DNF, DNC, RET are given a race score equal to one more than the number of entrants in the series division. The compilation of these race scores is shown in Tables 1, 2, and 3 below.

In the Windrush Cat division two boats Dirty Ore and Sea Saw were tied on 11 points after dropping their worst race score. This tie was resolved in Dirty Ore's favour according to rule A8.1[2] of the 2021-2024 Racing Rules of Sailing (RSS).

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[2] In the 2021-2024 Racing Rules of Sailing (RSS) Appendix A **SCORING,** Section A8 **Series Ties,** subsection A8.1: "If there is a series-score tie between two or more boats, each boat's race scores will be listed in order of best to worst, and at the first point(s) where there is a difference the tie shall be broken in favour of the boat(s) with the best score(s). No excluded scores shall be used."

| Windrush Cat | | Race Series Scores | | | | | | | Total after drop | |
Yacht Name	Sail No.	Race 1	Race 2	Race 3	Race 4	Race 5	Race 6	Total		Place
Dirty Ore	6468	3	4	1	1	9	2	20	11	1
Sea Saw	6463	1	2	3	2	3	3	14	11	2
Xena	6469	2	3	2	4	4	1	16	12	3
Catatonic	6466	5	1	5	3	1	15	30	15	4
Double Shot	6448	4	15	4	5	5	6	39	24	5
Sirius Lee	6402	6	5	6	8	2	9	36	27	6
Billy M	6427	7	10	7	7	7	5	43	33	7
Zephyr	6449	13	7	11	10	6	7	54	41	8
Yellow Taxi	6437	8	6	10	6	12	15	57	42	9
Eagle B	6408	12	8	15	12	8	4	59	44	10
Yeehar	6450	10	15	9	9	11	8	62	47	11
Spindrift	6459	9	15	8	15	10	15	72	57	12
Catastrophe	6429	11	9	12	11	15	15	73	58	13
Frisky	6438	15	15	15	15	13	15	88	73	14

Table 1. 2023 Windrush State Championships (Cat division)

| Windrush Sloop | | Race Series Scores | | | | | | | Total after drop | |
Yacht Name	Sail No.	Race 1	Race 2	Race 3	Race 4	Race 5	Race 6	Total		Place
Cat Fish	6361	1	1	1	1	1	1	6	5	1
Buzzbox	6411	2	2	2	7	2	2	17	10	2
Steel Cat	6458	3	4	3	3	4	7	24	17	3
Wild Thing	6343	4	3	6	5	7	3	28	21	4
Meelup	6462	7	6	5	2	3	7	30	23	5
Quindy	6416	5	5	4	4	7	7	32	25	6

Table 2. 2023 Windrush State Championships (Sloop division)

| Windrush Super Sloop | | Race Series Scores | | | | | | | Total after drop | |
Yacht Name	Sail No.	Race 1	Race 2	Race 3	Race 4	Race 5	Race 6	Total		Place
Cliff Hanger	6440	2	1	1	2	4	1	11	7	1
Feeling Lucky	6398	1	2	2	4	2	2	13	9	2
Ella	6417	4	3	3	3	7	3	23	16	3
Moment of Madness	6445	3	4	5	7	1	5	25	18	4
Wreckless	6460	5	5	4	5	6	4	29	23	5
Humm-n	6394	7	7	11	1	3	11	40	29	6
Emily Jean	6465	6	6	8	8	5	11	44	33	7
White Knuckle Tight	6423	10	9	6	6	8	11	50	39	8
Back Door Relief	6443	8	8	7	9	11	11	54	43	9
Cat Nip	6395	9	11	11	11	11	11	64	53	10

Table 3. 2023 Windrush State Championships (Super Sloop division)

4 A Performance Handicap System in Yachting

A Performance Handicap System (PHS) in yachting is a set of rules and mathematical calculations that enable yachts of varying speed potential to compete in races where the yacht with the least corrected time is the winner. A PHS works in the following general way.

1. Yachts entered in a race have handicaps or are given handicaps. These handicaps are numbers, usually somewhere between 0.750 and 1.250 and are known as *allocated handicaps AHC.*
2. At the completion of the race, each yacht's *elapsed time ET* (finish time – start time) is determined and then their *corrected time CT* from the rule $ET \times AHC = CT$.
3. The yachts are then sorted in ascending order from least to greatest corrected time and the yacht with the least corrected time is the handicap winner.
4. The *standard corrected time SCT* of the race is determined and this may be the corrected time of a selected yacht in the race, or the average corrected time of a group of yachts, or some other acceptable method. The standard corrected time is the corrected time of the *standard boat* which may be real or imaginary.
5. Each yacht's *back calculated handicap BCH* is determined from the rule $ET \times BCH = SCT$. There may be some screening of the *BCH* to detect an anomalous result.
6. Each yacht's *performance indicator PI* is determined from the rule $PI = BCH - AHC$
7. Each yacht's *calculated handicap CHC* is determined from a function of its *AHC* and *PI* and there may be some further screening of the *CHC* before it becomes the allocated handicap *AHC* for its next race.

   [Note here that steps 4 to 7 all happen after the handicap winner is determined and are all aimed at producing allocated handicaps for each yacht in their next race.]

The essence of a Performance Handicap System are the rules that enable the adjustment of handicaps after racing. Some of these rules may be arbitrary, some could be based on experience, and some could be in place to achieve desired outcomes. Indeed, a PHS used in one yacht club could be different from that used in another club; or the PHS used for a regatta could be different from the usual club PHS. And a *calculated handicap* produced by the PHS after a race is related to the number of yachts in that race; their handicaps; the method of calculating the *standard corrected time* (or selecting the imaginary or real *standard boat);* and the allowable changes in handicaps. We will now discuss some of the points above in more detail.

4.1 Determining the Standard Corrected Time SCT for a race

The standard corrected time SCT for a race is the corrected time of the standard boat, sometimes called the mark boat, that may be a yacht in the fleet or an imaginary yacht. It is obtained from the list of corrected times, sorted in ascending order from least to greatest, of the yachts in the race and there are many different methods.

We will review three methods.

4.1.1 *Trimmed Fleet Average*

World Sailing[3] in their *International Empirical Handicap Scheme for Yachts* (see Appendix B) use the average *CT* excluding the lowest 20% and highest 40% of the *CTs* (rounded down to whole numbers). That is, if there are 10 yachts in the race then $\frac{20}{100} \times 10 = 2$ and $\frac{40}{100} \times 10 = 4$, then the *CTs* of the first two, and the last four yachts are ignored and the *SCT* is the average of the *CTs* of yachts placed 3rd, 4th, 5th, and 6th. If there were 19 yachts in the race then $\frac{20}{100} \times 19 = 3.8 \rightarrow 3$ and $\frac{40}{100} \times 19 = 7.6 \rightarrow 7$, then the *CTs* of the first three, and the last seven yachts are ignored and the *SCT* is the average of the *CTs* of yachts placed from 4th to 12th.

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[3] *World Sailing* is the governing body for the sport of sailing formed in 1907 and then known as the International Yacht Racing Union (IYRU). The name was changed to the International Sailing Federation (ISAF) in 1996 before adopting the name *World Sailing* in 2015.

4.1.2 *45% Boat*

TopYacht[4] in their sailing software documentation suggest that from their experience, the *SCT* for the race be the *CT* of the "45% boat" where the 45% boat is the yacht finishing in 45th place on corrected time in a fleet of 100 yachts. If the 45% boat is not an integer (a whole number) then the nearest yacht is selected, e.g., in a fleet of 10, the 45% boat is $\dfrac{45}{100} \times 10 = 4.5 \rightarrow$ 4th and in a fleet of 19 the 45% boat is

$\dfrac{45}{100} \times 19 = 8.55 \rightarrow$ 9th

4.1.3 *Median Boat.*

The *SCT* is the *median*[5] of the *CTs* sorted in ascending order from least to greatest. The median, unlike the mean (often described as the average), is not skewed by a small proportion of extremely large or small values and is the value separating the lower-half from the higher-half of *CTs*. In a fleet of 10 yachts (an even number), the *SCT* is the average of the *CTs* of the 5th and 6th placed yachts. In a fleet of 19 (an odd number) the *SCT* is the *CT* of the yacht finishing in 10th place.

In this document we have chosen *Median Boat* as the method of calculating the Standard Corrected Time *SCT*.

4.2 Back Calculated Handicap *BCH*

After the *SCT* of the race has been determined, each yacht's *BCH* is obtained from the rule

$ET \times BCH = SCT$ that is rearranged to give $BCH = \dfrac{SCT}{ET}$.

A yacht's *BCH* is the handicap number that would produce a corrected time equal to the *SCT* of the race. This number can only be calculated after the race, hence the terminology *Back Calculated* when describing this number, and it may or may not be close to the yacht's allocated handicap *AHC*.

A *BCH* that is quite different from an *AHC* may indicate an anomalous result and to guard against this a *BCH* may be restricted to lie within certain bounds that are expressed as a percentage of a yacht's *AHC,* say for instance, within $\pm p\%$ of the yacht's *AHC*. This is expressed mathematically as the inequality

$$AHC\left(1 - \frac{p}{100}\right) \le BCH \le AHC\left(1 + \frac{p}{100}\right) \tag{i}$$

where, if $a = AHC\left(1 - \dfrac{p}{100}\right)$ and $b = AHC\left(1 + \dfrac{p}{100}\right)$ then $a \le BCH \le b$ means the *BCH* is greater than or equal a and less than or equal to b and a and b are the lower and upper bounds respectively of the *BCH*.

For example, suppose that three yachts *X, Y* and *Z* whose allocated handicaps *AHCs* are 1.042, 1.017 and 0.895 have elapsed times *ETs* of 45, 55 and 42 minutes respectively in a race where the standard corrected time *SCT* equals 47 minutes. The bounds for the back calculated handicaps *BCHs* are $\pm 15\%$ of their allocated handicaps, i.e. $p = 15$ in (i) above and their *BCHs* are determined in the following manner.

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[4] *TopYacht* (https://topyacht.com.au/web) founded by Rod McCubbin, Cheltenham VIC 3192, and now a division of Northstar Technologies Australia, Mount Lawley WA 6929, provides race management and scoring software to the Australian sailing community.

[5] The *median* of a sample of n values is obtained by first ordering the values from least to greatest and then choosing the middle value if n is odd or the average of the two middle values if n is even. In either case there will be the same number of values that are larger than or equal to the median, and smaller than or equal to the median. The median is a robust estimator of the location of a sample of values drawn from a large population.

Denote their *initial BCHs* (3 decimal places) as $BCH'_X = \dfrac{SCT}{ET_X} = \dfrac{47}{45} = 1.044$, $BCH'_Y = \dfrac{47}{55} = 0.855$, and

$BCH'_Z = \dfrac{47}{42} = 1.119$, and using these values in (i) gives

Yacht X
$$AHC_X\left(0.85\right) \le BCH'_X \le AHC_X\left(1.15\right)$$
$$0.886 \le 1.044 \le 1.198$$
(ii)

Yacht Y
$$AHC_Y\left(0.85\right) \le BCH'_Y \le AHC_Y\left(1.15\right)$$
$$0.864 \le 0.855 \le 1.170$$
(iii)

Yacht Z
$$AHC_Z\left(0.85\right) \le BCH'_Z \le AHC_Z\left(1.15\right)$$
$$0.761 \le 1.119 \le 1.029$$
(iv)

The inequality (ii) is satisfied and $BCH_X = BCH'_X = 1.044$. But the inequality (iii) is not satisfied and $BCH_Y \ne BCH'_Y$, instead the lower bound 0.864 is assigned and $BCH_Y = 0.864$. Similarly, the inequality (iv) is not satisfied and $BCH_Z \ne BCH'_Z$, instead the upper bound 1.029 is assigned and $BCH_Z = 1.029$

Back calculated handicaps determined using the inequality (i) are *constrained* to lie within the bounds $AHC\left(1 \pm \dfrac{p}{100}\right)$. In *TopYacht* terminology these constrained handicaps are known as *clamped.*

It is always advisable to flag initial back calculated handicaps that fall outside the bounds $AHC\left(1 \pm \dfrac{p}{100}\right)$ as they may indicate anomalous results due to entry of incorrect elapsed times, incorrect allocated handicaps or other causes that may require further investigation.

4.3 Calculated Handicap *CHC*

The last part of the process in the production of a new handicap (see steps 6 & 7 in Section 5) is the calculated handicap *CHC,* and if this doesn't appear to be an anomalous result then the *CHC* becomes the yacht's allocated handicap *AHC* for the next race.

There are many ways of determining the *CHC,* for example *TopYacht* (2021) describe or mention the following methods: Weighted Average, Exponential Average, Place Based Handicapping, Place Biased Exponential Handicapping, Trend Biased Average, Boat Performance Ratio. And *World Sailing* (2016) apply a system of Weighted Performance Indicators in calculating the *CHC* (see Appendix B)

We will review three methods.

4.3.1 *Weighted Performance Indicators (World Sailing)*

World Sailing (2016) describe a system of weighted performance indicators that we summarize here.

- After a race, back calculated handicaps *BCH* are determined as above.
- Performance indicators *PI* are calculated using $PI = BCH - AHC$.
- Performance multipliers *PM* are selected from Table 4

Races completed	Portion of *PI*	Multiplier *PM*
1	All	1
2	Half	0.5
3	One third	0.333333
4	One quarter	0.25
5	One fifth	0.2
Greater than 5	One fifth	0.2

Table 4. Performance Multipliers, *World Sailing* (2016)

- Calculate new handicaps using $CHC_k = AHC_k + \left(PM \times PI_k \right)$ where k is the race number, and the subscript k denotes the handicap or performance indicator for the kth race.

We can see here that the 'weighted performance indicator' is $\dfrac{1}{\text{Race No.}} \times PI_k$ up to and including Race 5 and the weighted performance indicator is $PI_k\big/5$ for all races after Race 5.

4.3.2 *Weighted Average (TopYacht)*

TopYacht (2021) describe a system they call 'weighted average' to obtain the calculated handicap from the handicaps of the race just completed and from races prior to that. We summarise their system as

- Select the number of races N that are to be used in the averaging process.
- Calculated handicaps *CHC* are given by

$$CHC_k = \begin{cases} \dfrac{1}{N}\left\{ \left(N-k\right)AHC_1 + \displaystyle\sum_{j=1}^{k} BCH_j \right\} & \text{for } k < N \\[4mm] \dfrac{1}{N} \displaystyle\sum_{j=k}^{k-N+1} BCH_j & \text{for } k \geq N \end{cases}$$

where k is the race number and j is an integer and the subscripts k and j denote the handicaps for the jth and k^{th} races. AHC_1 is the allocated handicap for the 1$^{\text{st}}$ race.

Suppose that $N = 4$ then the calculated handicaps for races 1,2,3,..., etc. are:

Race 1 $\qquad CHC_1 = \dfrac{1}{4}\left\{ \left(4-1\right)AHC_1 + \displaystyle\sum_{j=1}^{1} BCH_j \right\} = \dfrac{1}{4}\left\{ \left(3\right)AHC_1 + BCH_1 \right\}$

Race 2 $\qquad CHC_2 = \dfrac{1}{4}\left\{ \left(4-2\right)AHC_1 + \displaystyle\sum_{j=1}^{2} BCH_j \right\} = \dfrac{1}{4}\left\{ \left(2\right)AHC_1 + BCH_1 + BCH_2 \right\}$

Race 3 $\qquad CHC_3 = \dfrac{1}{4}\left\{ \left(4-3\right)AHC_1 + \displaystyle\sum_{j=1}^{3} BCH_j \right\} = \dfrac{1}{4}\left\{ AHC_1 + BCH_1 + BCH_2 + BCH_3 \right\}$

Race 4 $\qquad CHC_4 = \dfrac{1}{4}\displaystyle\sum_{j=4}^{1} BCH_j = \dfrac{1}{4}\left(BCH_4 + BCH_3 + BCH_2 + BCH_1 \right)$

Race 5 $\qquad CHC_5 = \dfrac{1}{4}\displaystyle\sum_{j=5}^{2} BCH_j = \dfrac{1}{4}\left(BCH_5 + BCH_4 + BCH_3 + BCH_2 \right)$

etc.

When the race number is equal to or greater than N, the calculated handicap is just a simple moving average and there is no 'weighting' involved in these calculations. By studying the sequence of calculated handicaps above and understanding that the allocated handicap is the previous calculated handicap we may write

$$CHC_k = AHC_k + \frac{1}{N}\left(BCH_k - BCH_{k-N+1}\right) \text{ for } k > N$$

4.3.3 Exponentially Weighted Moving Average EWMA

We follow here the work of Hunter[6] (1986) and the NIST/SEMATECH *e-Handbook.*

Suppose we have observations y up to and including time $t-1$, that is, our observations form the set $\left\{y_1, y_2, y_3, \ldots, y_{t-2}, y_{t-1}\right\}$ and we wish to forecast or predict the next observation y_t. We denote our prediction as $\hat{y}_t$ and when the actual observation y_t becomes available the prediction error is

$$e_t = y_t - \hat{y}_t$$

The *method of exponential smoothing* takes the prediction for the previous period and adds to it a proportion of the prediction error at that previous time to give the next prediction or the update as a *recurrence relation* (Deakin & Green 2023, Appendix D)

$$\hat{y}_t = \begin{cases} \mu & \text{for } t = 1 \\ \hat{y}_{t-1} + \alpha\left(y_{t-1} - \hat{y}_{t-1}\right) & \text{for } t > 1 \end{cases}$$

where $0 < \alpha \leq 1$ is a constant known as the weighting factor and μ is an apriori[7] value of the data. We can rearrange the recurrence relationship and write the update as

$$\hat{y}_t = \begin{cases} \mu & \text{for } t = 1 \\ \alpha y_{t-1} + \left(1 - \alpha\right)\hat{y}_{t-1} & \text{for } t > 1 \end{cases} \tag{*}$$

Hunter (1986) describes this recurrence relation as the *Exponentially Weighted Moving Average EWMA.*

Using (*) in a sequence gives

$$\begin{aligned} \hat{y}_2 &= \alpha y_1 + \left(1 - \alpha\right)\mu \\ \hat{y}_3 &= \alpha y_2 + \left(1 - \alpha\right)\hat{y}_2 \\ &= \alpha y_2 + \left(1 - \alpha\right)\left\{\alpha y_1 + \left(1 - \alpha\right)\mu\right\} \\ &= \alpha y_2 + \alpha\left(1 - \alpha\right)y_1 + \left(1 - \alpha\right)^2 \mu \\ \hat{y}_4 &= \alpha y_3 + \left(1 - \alpha\right)\hat{y}_3 \\ &= \alpha y_3 + \left(1 - \alpha\right)\left\{\alpha y_2 + \alpha\left(1 - \alpha\right)y_1 + \left(1 - \alpha\right)^2 \mu\right\} \\ &= \alpha y_3 + \alpha\left(1 - \alpha\right)y_2 + \alpha\left(1 - \alpha\right)^2 y_1 + \left(1 - \alpha\right)^3 \mu \end{aligned}$$

and from this sequence we can write a general form as

$$\hat{y}_t = \left[\sum_{k=1}^{t-1}\alpha\left(1 - \alpha\right)^{k-1} y_{t-k}\right] + \left(1 - \alpha\right)^{t-1}\mu \quad \text{for } t > 1$$

And for $t = 5$

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[6] J. Stuart Hunter Professor Emeritus at Princeton University.
[7] *apriori* [Latin *a priori* what is known before] often taken to mean something known beforehand or known from prior knowledge.

$$\hat{y}_5 = \left[\sum_{k=1}^{4} \alpha \left(1 - \alpha \right)^{k-1} y_{5-k} \right] + \left(1 - \alpha \right)^{5-1} \mu$$

$$= \left[\alpha \left(1 - \alpha \right)^0 y_4 + \alpha \left(1 - \alpha \right)^1 y_3 + \alpha \left(1 - \alpha \right)^2 y_2 + \alpha \left(1 - \alpha \right)^3 y_1 \right] + \left(1 - \alpha \right)^4 \mu$$

$$= \alpha y_4 + \alpha \left(1 - \alpha \right) y_3 + \alpha \left(1 - \alpha \right)^2 y_2 + \alpha \left(1 - \alpha \right)^3 y_1 + \left(1 - \alpha \right)^4 \mu$$

Suppose a *weight* is a number that reflects relative importance – larger weights reflecting more importance – then letting weights $w_4 = \alpha, w_3 = \alpha \left(1 - \alpha \right), w_2 = \alpha \left(1 - \alpha \right)^2, w_1 = \alpha \left(1 - \alpha \right)^3$ gives

$$\hat{y}_5 = w_4 y_4 + w_3 y_3 + w_2 y_2 + w_1 y_1 + \left(1 - \alpha \right)^4 \mu$$

and for $\alpha = 2/3$ and $1 - \alpha = 1/3$ the weights are

$$\begin{aligned} w_4 &= \alpha & &= 0.666667 \\ w_3 &= \alpha \left(1 - \alpha \right) & &= 0.222222 \\ w_2 &= \alpha \left(1 - \alpha \right)^2 & &= 0.074074 \\ w_1 &= \alpha \left(1 - \alpha \right)^3 & &= 0.024691 \end{aligned}$$

This demonstrates the exponential nature of the weights in the calculation of $\hat{y}_t$ where the weights are tending to zero and the difference between successive weights is also tending to zero. It should be noted here that the last term in the summation for $\hat{y}_5$ is $\left(1 - \alpha \right)^4 \mu$ and for $\alpha = 2/3$ then $\left(1 - \alpha \right)^4 = 0.012346$ and for any t this coefficient is $\left(1 - \alpha \right)^{t-1}$ and for the calculation of $\hat{y}_{10}$ then the coefficient $\left(1 - \alpha \right)^9 = 0.000051$.

If we assume that allocated handicaps *AHCs* are values predicted from past performances in yacht races then we can denote these as $\hat{y}_{t-1}, \hat{y}_{t-2}, \hat{y}_{t-3}, \ldots$ and at each of these prior races the measurements or observations related to performance were the back calculated handicaps *BCHs* denoted as $y_{t-1}, y_{t-2}, y_{t-3}, \ldots$ then we can use (*) and write

$$AHC_t = \alpha \, BCH_{t-1} + \left(1 - \alpha \right) AHC_{t-1} \quad \text{for } 0 < \alpha \leq 1 \text{ and } t > 1 \tag{**}$$

and recognising that $AHC_t = CHC_{t-1}$ and that the performance indicator $PI = BCH - AHC$ then we may write for each yacht in a race

$$CHC = \alpha \, BCH + \left(1 - \alpha \right) AHC = \alpha \, PI + AHC \tag{***}$$

For $\alpha = 1/3$ we have the common rule $CHC = \dfrac{1}{3} BCH + \dfrac{2}{3} AHC = \dfrac{1}{3} PI + AHC$

TopYacht (2021) describe a method they call 'exponential average' to obtain the calculated handicap. We summarise their system as

- Select the gain G
- If $G \geq 1$ is an integer, say $1, 2, 3, \ldots$ then the calculated handicap is

$$CHC = \frac{1}{G} BCH + \left(\frac{G-1}{G} \right) AHC \quad \text{for } G \geq 1$$

- If $G \geq 0$ is a percentage, say 10% $(G = 10)$, 20% $(G = 20)$, ... then the calculated handicap is

$$CHC = \frac{G}{100} BCH + \left(\frac{100 - G}{100} \right) AHC \quad \text{for } 0 \leq G \leq 100$$

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If the gain $G = 3$ then
$$CHC = \frac{1}{3}BCH + \frac{2}{3}AHC$$

It is very common, in Victorian yachting, to use a gain $G = 3$ (or $G = 33$ if G is a percentage)

We can see from the development above that our equation (*) that is the Exponentially Weighted Moving Average $EWMA$ can be expressed in the form (***) and if we replace α with $1/G$ we have $TopYacht's$ equation for CHC.

In this document we have chosen the method of *Exponentially Weighted Moving Average EWMA* to determine the calculated handicap CHC and we choose a weighting factor $\alpha = 1/3$

We now define a Performance Handicap System for the Windrush State Championships 2023

5 Performance Handicap System: Windrush State Championships

The rules for the Performance Handicap System to be used for the Windrush State Championships 2023 are shown below.

- Each yacht in a race will have an allocated handicap AHC and this handicap will be the calculated handicap CHC from the previous race. If there is no previous CHC then one will be allocated by the Race Committee according to the rules set out below. Then for each yacht in the race, the following sequence of calculations will apply.
- Elapsed time: $ET =$ finish time of yacht $-$ start time of race
- Corrected time: $CT = ET \times AHC$
- Standard Corrected Time: SCT will be the median of the CTs of the yachts in the race.
- Back Calculated Handicap: $BCH = \dfrac{SCT}{ET}$ and BCH is constrained such that

$$AHC\left(1 - \frac{p}{100}\right) \le BCH \le AHC\left(1 + \frac{p}{100}\right) \text{ where } p = 15$$

- Performance Indicator: $PI = BCH - AHC$
- Calculated Handicap: $CHC = \alpha\,BCH + \left(1 - \alpha\right)AHC = \alpha\,PI + AHC$ where $\alpha = 1/3$

Example Performance Handicap System spreadsheet

Sail No	Boat	Elapsed Time	Allocated Handicap	Corrected Time	Place	Back Calculated Handicap BCH		Performance Indicator	Calculated Handicap
		ET	AHC	CT		Initial	Constrained	PI	CHC
input	input	input	input	ET x AHC	input	SCT / ET	bounds = 15% of AHC	BCH - AHC	AHC + (PI / 3)
6467	Dirty Ore	0:22:11	1.150	0:25:31	1	1.374	1.323	0.173	1.208
6451	Jeez	0:29:18	0.997	0:29:12	2	1.040	1.040	0.044	1.011
6448	Breeze	0:29:44	0.989	0:29:24	3	1.025	1.025	0.036	1.001
6426	Billy Bob	0:29:08	1.026	0:29:54	4	1.046	1.046	0.020	1.033
6464	Seen It All	0:26:46	1.139	0:30:29	5	1.139	1.139	0.000	1.139
6450	Single Shot	0:27:38	1.109	0:30:38	6	1.103	1.103	-0.006	1.107
6465	Catnap	0:26:53	1.154	0:31:01	7	1.134	1.134	-0.020	1.147
6489	Zena	0:27:16	1.150	0:31:22	8	1.118	1.118	-0.032	1.139
6407	Seriously	0:33:12	1.083	0:35:58	9	0.918	0.921	-0.162	1.029

Standard Corrected Time (SCT) = 0:30:29

Note in the example spreadsheet that *Seen It All* is the median boat (5th place on corrected time) and boats finishing above (with lesser corrected times and positive performance indicators PIs) have calculated

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handicaps *CHCs* less than their allocated handicaps *AHCs*. Boats finishing below the median boat have negative *PIs* and *CHCs* greater than their *AHCs.*

Appendix C has some information on Performance Handicap Systems used at two other clubs: Fremantle Sailing Club, Western Australia and Mordialloc Sailing Club, Victoria. There is some different terminology (Fremantle use Yardstick to describe the standard corrected time of the race) but both describe a similar PHS to the one we have defined in this section, and they both propose the calculation of *CHCs* as we have but with slightly different values for α .

5.1 Handicaps, Ratings, Yardsticks

A yacht's PHS derived handicap is different from a yacht's *rating* which is a numerical measure of potential speed based upon the yacht's parameters, e.g., waterline length, beam, displacement, sail area, etc. and a sequence of mathematical formula related to the physics of hydrodynamics and aerodynamics as applied to yachting force models. There are several measurement systems that give yacht ratings, e.g., The International Offshore Rule (IOR), the Chanel Rating System (CHS), the International Measurement System (IMS) and the International Rating Certificate (IRC). Ratings are usually associated with keelboats.

A yacht's *yardstick* is a number in the range 60 – 180 and usually associated with classes of dinghies (monohulls), catamarans (multihulls) and trailerable keelboats. The aim of a yardstick is to provide a basis for different classes of yachts to compete fairly when sailed together in mixed fleets. Australian Sailing maintains a list of yardsticks for yacht classes in collaboration with UK and US yachting associations and for calculations like the PHS described above has the following definitions.

- *Elapsed time ET* is the time taken for a boat to sail a proper course,
- *Corrected time CT* is the elapsed time divided by the boat's class *yardstick YS* and multiplied by 100. That is $CT = \left(\dfrac{ET}{YS} \right) \times 100$
- *Standard Boat Time SBT* is the corrected time for the first boat on corrected times to sail a proper course. Alternatively, a consistently sailed boat finishing in the top five of the fleet on corrected time, can be taken as the standard boat.
- *Back Calculated Yardstick BCYS* is the corrected time divided by the standard boat time and multiplied by its own yardstick. That is $BCYS = \left(\dfrac{CT}{SBT} \right) \times YS$
- *Performance Factor PF* is the *BCYS* divided by the boat's class yardstick. This is used to rate the class yardstick.

5.2 Relationships between Yardsticks and Handicaps

From the Yardstick definitions and the rules for the Performance Handicap System (PHS) defined above we may obtain $AHC = \dfrac{100}{YS}$ and if $SCT = SBT$ then $\dfrac{100}{BCYS} = \dfrac{SCT}{ET} = BCH$

Boat Class	Yardstick	AHC	Boat Class	Yardstick	AHC
Windrush 4.3 cat	94	1.064	Laser 4.7	125	0.800
Windrush 4.3 Sloop	89	1.124	Pacer	127.5	0.784
Windrush 4.3 Super Sloop	87	1.149	14ft Skiff	84	1.190
Windrush 4.3 Super Sloop Spin	84	1.190	29er	96.5	1.036
Laser	114	0.877	Minnow	168.5	0.593
Laser Radial	118.5	0.844	Flying Ant	136	0.735

Table 5. Some Yardsticks and Handicaps

5.3 Allocation of handicaps by Trial Races

It is proposed that three Trial Races be used to determine a yacht's allocated handicap AHC. These Trial Races will be Races 1, 2, and 3 of the championship series. Only yachts with elapsed times in each of these three races will have an AHC by this method.

In each of the three Trial Races the PHS defined in this section will be used with a common AHC that is equal to 100 divided by the class *yardstick* (see Table 5). This will yield three calculated handicaps CHC_1, CHC_2, and CHC_3 and the allocated handicap for each yacht after the trial will be

$$AHC = \frac{CHC_1 + CHC_2 + CHC_3}{3}$$

5.4 Allocation of handicaps by the Race Committee

For yachts not included in the trail races, the average value of the $CHCs$ for that yacht's division (Cat, Sloop, or Super Sloop) will be assigned as the yacht's AHC.

6 Trial Races for Initial Handicaps

Races 1, 2, and 3 of the championship series were used as Trial Races for determining initial handicaps and the eligible yachts are shown in Appendix A, Table A2 with an asterisk. These yachts all completed Races 1, 2, and 3, noting that *Catatonic* was not selected as she was the only yacht in Race 2 that sailed the proper course, and her elapsed time could be considered an anomaly for the purposes of establishing initial handicaps.

The results of the Trial Races are shown in Appendix D noting that in each of the trial races a yachts AHC is derived from the class yardstick (see Table 5), i.e., Cat division $AHC = 1.064$, Sloop division $AHC = 1.124$, and Super Sloop division $AHC = 1.149$.

6.1 Allocated Handicaps *AHCs* for Race 1

The calculated handicaps CHC_1, CHC_2, and CHC_3 and the Average $= \dfrac{CHC_1 + CHC_2 + CHC_3}{3}$ for each yacht in the Trial Races (see Appendix D) is shown in Tables 6, 7, and 8 below, and these averages will become the allocated handicap AHC for each yacht in Race 1. For example, in the Cat division *Sirius Lee* will have an $AHC = 1.071$, *Billy M* will have an $AHC = 1.042$, etc. In the Sloop division *Wild Thing* will have an $AHC = 1.113$, *Cat Fish* will have an $AHC = 1.170$, etc., and in the Super Sloop division *Feeling Lucky* will have an $AHC = 1.156$, *Ella* will have an $AHC = 1.152$, etc.

Yachts that were not eligible for the Trial Races will have the average of the averages as their allocated handicap. For example, in the Cat division *Eagle B, Frisky, Double Shot, Yeehar, Spindrift, Catatonic,* and *Xena* will all have an $AHC = 1.059$ and in the Sloop division *Meelup* will have an $AHC = 1.131$

Sail No	Boat	Calculated Handicaps			Average
		Race 1	Race 2	Race 3	
6402	Sirius Lee	1.075	1.072	1.066	1.071
6427	Billy M	1.053	1.011	1.062	1.042
6429	Catastrophe	1.041	1.011	1.011	1.021
6437	Yellow Taxi	1.051	1.057	1.011	1.039
6449	Zephyr	1.011	1.029	1.011	1.017
6463	Sea Saw	1.091	1.098	1.086	1.092
6468	Dirty Ore	1.093	1.093	1.103	1.096
6469	Xena	1.093	1.096	1.096	1.095

Ave =   1.059

Table 6. Initial Handicaps for Windrush Cat division.

Sail No	Boat	Calculated Handicaps			Average
		Race 1	Race 2	Race 3	
6343	Wild Thing	1.115	1.124	1.101	1.113
6361	Cat Fish	1.180	1.151	1.180	1.170
6411	Buzzbox	1.180	1.148	1.180	1.169
6416	Quindy	1.084	1.071	1.123	1.093
6458	Steel Cat	1.124	1.081	1.124	1.110

Ave = 1.131

Table 7. Initial Handicaps for Windrush Sloop division.

Sail No	Boat	Calculated Handicaps			Average
		Race 1	Race 2	Race 3	
6398	Feeling Lucky	1.156	1.154	1.158	1.156
6417	Ella	1.150	1.151	1.156	1.152
6423	White Knuckle Tight	1.123	1.137	1.125	1.128
6440	Cliff Hanger	1.153	1.155	1.191	1.166
6443	Back Door Relief	1.140	1.141	1.116	1.133
6445	Moment of Madness	1.151	1.149	1.147	1.149
6460	Wreckless	1.148	1.149	1.151	1.149
6465	Emily Jean	1.147	1.143	1.115	1.135

Ave = 1.146

Table 8. Initial Handicaps for Windrush Super Sloop division.

7 Performance Handicap Race Scores and Series Results

Appendix E shows the Performance Handicap System (PHS) results for Races 1 to 6. For each race in each division (Cat, Sloop, Super Sloop) yachts were ordered from least to greatest CT and given race scores 1, 2, 3, etc. Yachts recorded as DNS, DNF, DNC, RET are given a race score equal to one more than the number of entrants in the series division. The compilation of these race scores is shown in Tables 9, 10, and 11.

Windrush Cat		Race Series Scores						Total	Total after drop	Place
Yacht Name	Sail No	Race 1	Race 2	Race 3	Race 4	Race 5	Race 6			
Dirty Ore	6468	4	4	2	2	9	3	24	15	1
Xena	6469	3	3	3	10	6	2	27	17	2
Catatonic	6466	5	1	5	5	2	15	33	18	3
Sea Saw	6463	2	2	6	4	8	5	27	19	4
Zephyr	6449	13	7	8	3	1	7	39	26	5
Billy M	6427	7	10	1	7	7	4	36	26	6
Double Shot	6448	1	15	4	9	5	8	42	27	7
Sirius Lee	6402	6	6	7	11	3	9	42	31	8
Yellow Taxi	6437	8	5	10	1	12	15	51	36	9
Eagle B	6408	12	8	15	12	4	1	52	37	10
Yeehar	6450	11	15	12	6	11	6	61	46	11
Catastrophe	6429	9	9	9	8	15	15	65	50	12
Spindrift	6459	10	15	11	15	10	15	76	61	13
Frisky	6438	15	15	15	15	13	15	88	73	14

Table 9. 2023 Windrush State Championships (Performance Handicap Cat division).

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Windrush Sloop		Race Series Scores						Total	Total after drop	Place
Yacht Name	Sail No	Race 1	Race 2	Race 3	Race 4	Race 5	Race 6			
Cat Fish	6361	1	2	2	3	2	2	12	9	1
Buzzbox	6411	2	3	1	7	3	1	17	10	2
Steel Cat	6458	3	5	4	2	4	7	25	18	3
Wild Thing	6343	4	1	6	5	7	3	26	19	4
Meelup	6462	7	6	5	1	1	7	27	20	5
Quindy	6416	5	4	3	4	7	7	30	23	6

Table 10. 2023 Windrush State Championships (Performance Handicap Sloop division).

Windrush Super Sloop		Race Series Scores						Total	Total after drop	Place
Yacht Name	Sail No	Race 1	Race 2	Race 3	Race 4	Race 5	Race 6			
Ella	6417	4	2	2	3	8	2	21	13	1
Feeling Lucky	6398	1	4	3	7	2	4	21	14	2
Cliff Hanger	6440	6	3	1	4	5	3	22	16	3
Moment of Madness	6445	2	6	5	8	1	5	27	19	4
Wreckless	6460	5	5	4	6	6	1	27	21	5
White Knuckle Tight	6423	10	1	6	2	7	11	37	26	6
Emily Jean	6465	3	8	8	5	4	11	39	28	7
Humm-n	6394	8	9	11	1	3	11	43	32	8
Back Door Relief	6443	7	7	7	9	11	11	52	41	9
Cat Nip	6395	9	11	11	11	11	11	64	53	10

Table 11. 2023 Windrush State Championships (Performance Handicap Super Sloop division).

8 Discussion

Inspection of the ET-order results (Section 3) and the PHS results (Section 7) reveal that the same yachts make up the 'top-four' in each division in both scoring systems. This is shown in Tables 12, 13, and 14.

Windrush Cat		Race Scores						Total	Total after drop	Place
Yacht Name	Scoring system	1	2	3	4	5	6			
Dirty Ore	ET	3	4	1	1	9	2	20	11	1
	PHS	4	4	2	2	9	3	24	15	1
Sea Saw	ET	1	2	3	2	3	3	14	11	2
	PHS	2	2	6	4	8	5	27	19	4
Xena	ET	2	3	2	4	4	1	16	12	3
	PHS	3	3	3	10	6	2	27	17	2
Catatonic	ET	5	1	5	3	1	15	30	15	4
	PHS	5	1	5	5	2	15	33	18	3

Table 12. Top-four yachts in Cat division.

Windrush Sloop		Race Scores						Total	Total after drop	Place
Yacht Name	Scoring system	1	2	3	4	5	6			
Cat Fish	ET	1	1	1	1	1	1	6	5	1
	PHS	1	2	2	2	2	2	12	9	1
Buzzbox	ET	2	2	2	2	2	2	17	10	2
	PHS	2	3	1	7	3	1	17	10	2
Steel Cat	ET	3	4	3	3	4	7	24	17	3
	PHS	3	5	4	2	4	7	25	18	3
Wild Thing	ET	4	3	6	5	7	3	28	21	4
	PHS	4	1	6	5	7	3	26	19	4

Table 13. Top-four yachts in Sloop division.

Windrush Super Sloop		Race Scores						Total	Total after drop	Place
Yacht Name	Scoring system	1	2	3	4	5	6			
Ella	ET	3	4	1	1	9	2	20	11	1
	PHS	4	4	2	2	9	3	24	15	1
Feeling Lucky	ET	1	2	3	2	3	3	14	11	2
	PHS	2	2	6	4	8	5	27	19	4
Cliff Hanger	ET	2	3	2	4	4	1	16	12	3
	PHS	3	3	3	10	6	2	27	17	2
Moment of Madness	ET	5	1	5	3	1	15	30	15	4
	PHS	5	1	5	5	2	15	33	18	3

Table 14. Top-four yachts in Super Sloop division.

It is often assumed that a handicap system will have a levelling effect and spread the top results more evenly amongst the fleet. This is more likely to be true in a longer series of races, say in a club championship season. For a relatively short series (six races with a drop) this overall levelling effect is less obvious, but in the Cat Division the winners of races were: Race 1 *Double Shot* (7th overall), Race 2 *Catatonic* (3rd), Race 3 *Billy M* (6th), Race 4 *Yellow Taxi* (9th), Race 5 *Zephyr* (5th), and Race 6 *Eagle B* (10th). So, five of the six race winners didn't finish in the top-four overall and that could be thought of as a plus for the handicap system.

It is also worth noting that the handicaps of the top-four yachts were generally increasing as the series progressed whilst those in the middle to lower group where generally decreasing. This would indicate that the top end of the fleet was improving (sailing above their handicaps) and the others were maintaining their performance or perhaps failing to improve – noting that in a short series, a poor performance in a single race can have an undesirable effect on the handicap, and the allowed bounds on the BCH of $\pm15\%$ of the AHC did mean some relatively large fluctuations in the $BCHs$ and the $AHCs$ for subsequent races.

As an example, consider the following four yachts in the Cat division

Yacht	Allocated Handicaps *AHCs*					
	Race 1	Race 2	Race 3	Race 4	Race 5	Race 6
Dirty Ore (1st)	1.096	1.118	1.128	1.148	1.178	1.119
Sea Saw (2nd)	1.092	1.118	1.133	1.134	1.145	1.143
Billy M (6th)	1.042	1.042	0.990	1.105	1.013	1.013
Eagle B (10th)	1.059	1.034	0.993	0.993	0.943	0.964

Table 15. Allocated handicaps *AHCs* for selected yachts in the Cat division.

A plot of these yachts' handicaps is shown in Figure 1
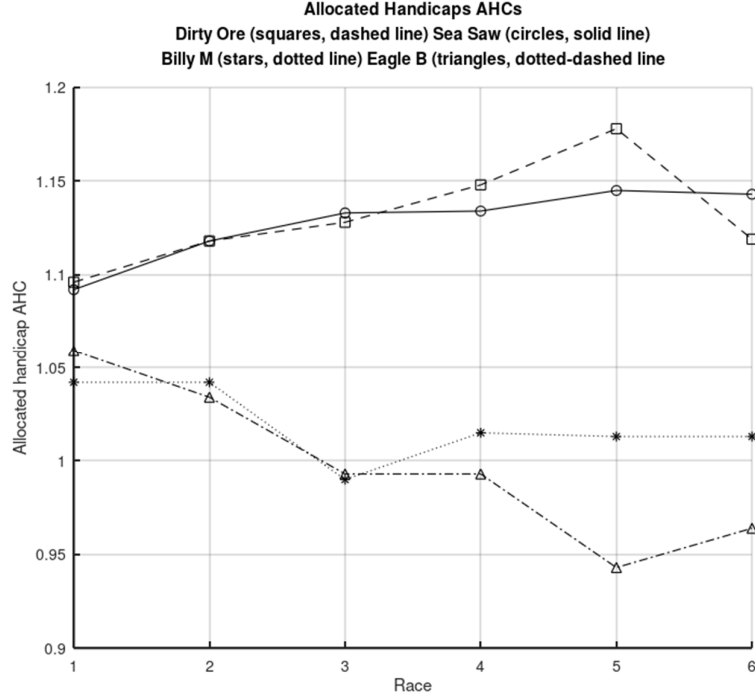
Figure 1. Plot of Allocated Handicaps over the six-race series

As mentioned above, the PHS we have used has bounds on the BCH of $AHC\left(1 \pm \dfrac{p}{100}\right)$ where $p = 15$ and

this can probably be regarded as quite large. Most other clubs using PHS would have a value of 4 or 5 for p.
Thus, our system allows relatively large fluctuations in the $BCHs$ and subsequent $AHCs$ and we have
investigated the fluctuations of the $BCHs$ for the Cat division to see if $p = 15$ is a reasonable value.

Division	Races						Entrants
	1	2	3	4	5	6	
Cat	13	9	12	12	13	9	14
Sloop	5	6	6	5	4	3	6
Super Sloop	10	9	8	9	8	5	10

Table 16. Number of finishers in each race

Table 16 shows that for the Cat division there were $13 + 9 + 12 + 12 + 13 + 9 = 68$ finishers in the 6-race

series and there were 68 calculations of a $BCH = \dfrac{SCT}{ET}$ and this handicap value could be thought of as being

equal to a function of the AHC and a parameter p that can be expressed as $BCH = \dfrac{SCT}{ET} = AHC\left(1 + \dfrac{p}{100}\right)$

where p can take positive and negative values. This can be rearranged as

$$p = \left(\frac{BCH}{AHC} - 1\right)100 = \left(\frac{SCT}{CT} - 1\right)100$$

The values of p were calculated for each of the 68 finishers in the Cat division and are tabulated in a *stem
and leaf plot* where for $p = 19.6$ the 'stem' is 19 and the 'leaf' is 6 and for the three values
$p = \left\{-2.1, -2.5, -2.5\right\}$ the (common) stem is -2 and the leaves are 1,5,5

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```
+19|6
 14|6
 13|6
 11|1
 10|48
  9|2
  7|01678
  6|1388
  5|48
  4|0
  3|4446
  2|6679
  0|00024668
 -0|44677
 -1|5
 -2|155
 -3|2
 -4|4
 -5|18
 -7|00
-10|59
-12|1
-14|9
-15|5
-17|0259
-19|17
-22|045
-23|6
-32|2
-36|7
```
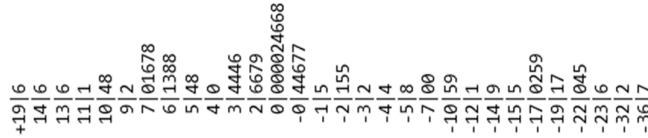
Figure 2. Stem-and-leaf plot of x

From the data in Figure 2, 54 values of p lie between ± 15, i.e., 79% of the data lie between ± 15. And 30 values (44%) lie between ± 5. In the PHS we have chosen $p = 15$

It also should be borne in mind that in the PHS, the calculated handicap $CHC = \alpha\, BCH + \left(1 - \alpha\right) AHC$

where $\alpha = 1\big/3$ or $CHC = \dfrac{1}{3} BCH + \dfrac{2}{3} AHC$ and the effect of a relatively large change in BCH is somewhat damped.

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Note that the Excel spreadsheet calculations in Example 2 can be found at URL
https://www.sailing.org/tools/documents/EHWebRaceResultandNumberAdjustmentVers2-[20432].xlsx

(This Excel workbook contains 2 spreadsheets, **Points** and **Race 6**. The workbook was created in 2013 and last modified on 15-Mar-2016. The author is Ken Kershaw)

APPENDIX A

Yacht Entry Details for Windrush State Championships 2023

Division	Yacht Name	Sail No.	Helm Name	Crew Name
Cat	Sirius Lee	6402	Leanne Jones	
Cat	Eagle B	6408	John Lethlean	
Cat	Billy M	6427	Michael Mogridge	
Cat	Catastrophe	6429	Jon Hall	
Cat	Yellow Taxi	6437	Eion Lindsay	
Cat	Frisky	6438	Herman Gerritsen	
Cat	Double Shot	6448	Ric Edwards	
Cat	Zephyr	6449	Madeleine Stephens	
Cat	Yeehar	6450	Nicole Doick	
Cat	Spindrift	6459	Julie Plummer	
Cat	Sea Saw	6463	Craig Saunders	
Cat	Catatonic	6466	Peter Hawley	
Cat	Dirty Ore	6468	Paul Waters	
Cat	Xena	6469	Iain Stephens	
Sloop	Wild Thing	6343	Ben McCarthy	Leo McDonald
Sloop	Cat Fish	6361	Jayson Watchorn	Daniel Watchorn
Sloop	Buzzbox	6411	Mal Buzza	Evan Walsh
Sloop	Quindy	6416	Rob Egerton-Warburton	Zara Egerton-Warburton
Sloop	Steel Cat	6458	Duncan Robertson	Lee Robertson
Sloop	Meelup	6462	Brian Innes	? Innes
Super Sloop	Humm-n	6394	Brett Bassett	
Super Sloop	Cat Nip	6395	Michael Shellabear	
Super Sloop	Feeling Lucky	6398	Harry Thurecht	
Super Sloop	Ella	6417	Roger Thurecht	
Super Sloop	White Knuckle Tight	6423	William Thomas	
Super Sloop	Cliff Hanger	6440	Cliff Rolfe	
Super Sloop	Back Door Relief	6443	Chris Westley	
Super Sloop	Moment of Madness	6445	Alec Duncan	
Super Sloop	Wreckless	6460	Stephen Gallagher	
Super Sloop	Emily Jean	6465	Nathan Wood	

Table A1.

Elapsed Times for Windrush State Championships 2023

Windrush Cat division		Elapsed Times					
Yacht Name	**Sail No.**	**Race 1**	**Race 2**	**Race 3**	**Race 4**	**Race 5**	**Race 6**
Sirius Lee*	6402	0:42:29	0:44:27	0:39:44	0:29:12	0:37:42	0:43:43
Eagle B	6408	0:47:52	0:52:59	DNS	0:34:48	0:43:51	0:35:43
Billy M*	6427	0:45:14	0:57:34	0:40:16	0:29:08	0:43:36	0:36:30
Catastrophe*	6429	0:46:51	0:57:07	0:54:54	0:32:17	DNS	RET
Yellow Taxi*	6437	0:45:34	0:46:21	0:52:56	0:27:38	1:04:19	DNF
Frisky	6438	DNS	DNS	DNS	DNS	1:05:50	RET
Double Shot	6448	0:40:45	DNS	0:38:16	0:27:16	0:39:04	0:39:55
Zephyr*	6449	0:52:00	0:50:24	0:53:43	0:29:44	0:39:05	0:42:14
Yeehar	6450	0:45:49	DNS	0:52:46	0:29:18	0:57:52	0:43:00
Spindrift	6459	0:45:40	DNS	0:52:36	DNS	0:53:27	DNF
Sea Saw*	6463	0:40:18	0:41:27	0:37:41	0:25:11	0:38:49	0:34:33
Catatonic	6466	0:42:05	0:29:11	0:38:43	0:26:46	0:35:37	DNF
Dirty Ore*	6468	0:40:33	0:41:57	0:36:04	0:23:46	0:44:22	0:31:57
Xena*	6469	0:40:30	0:41:41	0:36:40	0:26:53	0:38:57	0:31:28
Windrush Sloop division		Elapsed Times					
Yacht Name	**Sail No.**	**Race 1**	**Race 2**	**Race 3**	**Race 4**	**Race 5**	**Race 6**
Wild Thing*	6343	0:55:40	0:42:48	0:50:56	0:32:50	DNF	0:43:00
Cat Fish*	6361	0:40:40	0:39:55	0:38:05	0:24:11	0:43:07	0:33:44
Buzzbox*	6411	0:42:10	0:40:14	0:38:07	DNS	0:44:18	0:33:58
Quindy*	6416	1:00:54	0:49:47	0:47:56	0:30:17	DNS	RET
Steel Cat*	6458	0:54:20	0:48:24	0:47:46	0:26:40	0:52:05	RET
Meelup	6462	DNF	0:50:00	0:48:42	0:26:29	0:46:50	RET
Windrush Super Sloop division		Elapsed Times					
Yacht Name	**Sail No.**	**Race 1**	**Race 2**	**Race 3**	**Race 4**	**Race 5**	**Race 6**
Humm-n	6394	0:47:49	0:42:54	DNS	0:20:30	0:41:59	RET
Cat Nip	6395	0:49:08	DNS	DNS	DNS	DNF	RET
Feeling Lucky*	6398	0:46:00	0:41:37	0:36:36	0:21:37	0:41:33	0:31:51
Ella*	6417	0:46:49	0:41:57	0:36:42	0:21:25	0:55:50	0:31:56
White Knuckle Tight*	6423	0:50:19	0:43:31	0:39:58	0:21:50	0:58:00	RET
Cliff Hanger*	6440	0:46:25	0:41:30	0:33:45	0:20:40	0:43:19	0:30:15
Back Door Relief*	6443	0:47:58	0:43:00	0:40:56	0:32:34	DNF	RET
Moment of Madness*	6445	0:46:35	0:42:05	0:37:39	0:22:34	0:39:04	0:34:28
Wreckless*	6460	0:46:57	0:42:10	0:37:11	0:21:42	0:54:54	0:32:10
Emily Jean*	6465	0:47:10	0:42:48	0:41:05	0:22:34	0:44:58	DNF

Table A2.   Elapsed times for Windrush State Championships 2023 (Sail No. order).
Yachts marked with an asterisk are eligible for Trial Races.
(Times are in hh:mm:ss format where h,m,s are hour, minute, second respectively).

In Table A2 the following abbreviations are used. DNC = Did not start; did not come to the starting area. DNS = Did not start (other than DNC and OCS). DNF = Did not finish. OCS = Did not start; on the course side of the starting line at her starting signal and failed to start. RET = Retired

APPENDIX B

WORLD SAILING[8] – INTERNATIONAL EMPIRICAL HANDICAP SCHEME FOR YACHTS

Welcome to the World Sailing Empirical Handicap Scheme for Yachts. As the name suggests the scheme is intended to permit yachts, generally displacement boats with keels, of varying designs to race against each other and after racing determine, by calculation, the race results by excluding the performance differences of the boats themselves. The scheme is an empirical handicap scheme, that is a scheme where after racing the relative performance of each boat - their handicap, is determined from the times it took each boat to complete the race.

World Sailing provides this scheme to any race organiser who wishes to use it. It is intended to operate in isolation at local/race organiser level requiring no input to or from World Sailing or elsewhere. World Sailing does however offer users a basic method of handicap allocation to a boat for use in its first race.

Before using the scheme an organiser needs to address four factors:-

- The allocation of a boats handicap for its first race
- How to calculate race results
- How to adjust a boats handicap after racing
- Whether or not to attempt to exclude the varying skills of crews from the calculations

The allocation of a boats handicap for its first race

A boats handicap is expressed as a number based about 1. Faster boats handicaps will be higher than 1 with slow boats handicaps less than 1. Generally, the range of handicaps will be no more than 1.2 and no less than 0.8.

It would never be wrong for a race organiser to allocate a first race handicap based on their own subjective opinion of a boat. If the organiser considers the boat to be of average performance, then a handicap of 1 would suit. If, however the organiser considers the boat faster than the fleet average then a handicap above 1 in the range of say 1 to1.2 would be appropriate. If the performance is thought to be below average, then a handicap of less than 1 in the range of 0.8 to 1 should be used.

Alternatively, if the race organiser wishes the first race handicap could be allocated using the basic calculator at the following link - .

Whatever the case the handicap number used to calculate the race results for a boat in its first and subsequent races should be adjusted before use in the boats next race.

How to calculate race results

The results of a race are determined by comparing the *corrected times* for each boat with the least time being the race winner, the next least second place and so on for each boat completing in the race.

The *corrected time* (CT) for each boat is calculated by multiplying its elapsed time (ET), that is the time it took to complete the race, by its handicap (H) i.e. CT = ET x H

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[8] *World Sailing* is the governing body for the sport of sailing formed in 1907 and then known as the International Yacht Racing Union (IYRU). The name was changed to the International Sailing Federation (ISAF) in 1996 before adopting the name *World Sailing* in 2015.

An example of the calculations and how best to set this out is shown below.

Example 1 - Race Results

Sail No	Boat	Finish Time	Elapsed Time (ET)	Handicap (H)	Corrected Time (CT)	Finishing Place
1	A	14:56:37	01:26:37	1.079	01:33:28	3
2	B	15:12:36	01:42:36	0.957	01:38:11	8
3	C	15:18:24	01:48:24	0.929	01:40:42	9
4	D	15:03:59	01:33:59	1.008	01:34:44	4
5	E	15:04:21	01:34:21	1.005	01:34:49	5
6	F	15:04:44	01:34:44	1.004	01:35:07	6
7	G	15:02:29	01:32:29	1.003	01:32:46	2
8	H	15:15:44	01:45:44	0.948	01:40:14	10
9	I	15:07:14	01:37:14	0.982	01:35:29	7
10	J	14:53:17	01:23:17	1.074	01:29:27	1

Start Time =   13:30:00

How to adjust a boats handicap after racing

The life blood of empirical handicap racing is the adjustment of handicaps after racing. Without this race results and the scheme will soon become meaningless.

The World Sailing empirical handicap scheme attempts to adjust the handicap of each boat based on the *standard corrected time* (SCT) of the fleet which is the average CT excluding the lowest 20% and highest 40% of the CTs (rounded down to whole numbers).

Using the race result example above those CTs exclude are flagged in red and green as shown below. The remaining CTs are averaged to give a SCT for the race (1:34:32 in the example).

Dividing the SCT by a boats ET gives the calculated handicap which the boat would have had in the race for its CT to have equaled the SCT i.e. it gives the handicap to which the boat sailed in the race (h).

The difference between H and h gives a performed indicator (PI) i.e. PI = h - H (which may be plus or minus). A proportion of the PI should be applied to the boats race handicap (H) with the result used as the boats new handicap in its next race (H').

The portion of the PI applied to adjust the handicap depends on the number of races the boat has completed in the fleet. The table below gives the portions. The new handicap H' = H + (PI x PM).

Races completed	Portion	Multiplier
1	All	1
2	Half	0.5
3	One third	0.33
4	One quarter	0.25
5	One fifth	0.2
Greater than 5	One fifth	0.2

Example 2 – Race Results and Number Adjustment

Sail No	Boat	Finish Time f	Elapsed Time ET	Handicap H	Corrected Time CT	Finishing Place		CTs used for SCT	Performed Handicap h	Performed Indicator PI	PI Multiplier PM	New Handicap H'
input	input	input	f - ST	input	ET x H	input		input	SCT / ET	h - H	input	H + (PI x PM)
1	A	14:56:37	1:26:37	1.079	1:33:28	3		1:33:28	1.091	0.012	0.2	1.081
2	B	15:12:36	1:42:36	0.957	1:38:11	8			0.921	-0.036	0.2	0.950
3	C	15:18:24	1:48:24	0.929	1:40:42	9			0.872	-0.057	1	0.872
4	D	15:03:59	1:33:59	1.008	1:34:44	4		1:34:44	1.006	-0.002	0.2	1.008
5	E	15:04:21	1:34:21	1.005	1:34:49	5		1:34:49	1.002	-0.003	0.25	1.004
6	F	15:04:44	1:34:44	1.004	1:35:07	6		1:35:07	0.998	-0.006	0.25	1.002
7	G	15:02:29	1:32:29	1.003	1:32:46	2			1.022	0.019	0.33	1.009
8	H	15:15:44	1:45:44	0.948	1:40:14	10			0.894	-0.054	0.5	0.921
9	I	15:07:14	1:37:14	0.982	1:35:29	7			0.972	-0.010	0.5	0.977
10	J	14:53:17	1:23:17	1.074	1:29:27	1			1.135	0.061	0.2	1.086

Start Time (ST) =   1:30:00   SCT =   1:34:32

Whether or not to attempt to exclude the varying skills of crews from the calculations

Unlike a Rating System an Empirical Handicap Scheme of the type explained here allocates handicaps to the combined boat performance and the crew skill. This can sometimes work to the detriment of good crews and benefit of not so good crews as their ability is reflected in the adjusted handicaps. Whether or not to attempt to exclude crew skill from the calculations is a decision for the race organiser bearing in mind that to attempt this mathematically will involve on-going subjective judgements on the part of the organiser. For more information on the exclusion of crew skill from the calculations please contact World Sailing at – technical@sailing.org

This document at URL https://www.sailing.org/tools/documents/TurnkeytextVer2-[7780].pdf (accessed 26-Mar-2023).

Note that the Excel spreadsheet calculations in Example 2 can be found at URL https://www.sailing.org/tools/documents/EHWebRaceResultandNumberAdjustmentVers2-[20432].xlsx (This Excel workbook contains 2 spreadsheets, **Points** and **Race 6**. The workbook was created in 2013 and last modified on 15-Mar-2016. The author is Ken Kershaw)

APPENDIX C

OTHER PERFORMANCE HANDICAP SYSTEMS

Fremantle Sailing Club

Section 22 of the 2022-23 Sailing Handbook describes Fremantle Sailing Club's Performance Handicap System. (https://fsc.com.au/wp-content/uploads/2022/10/Handbook-2023.pdf)

22   HANDICAP PRINCIPLES

22.1   At the beginning of a series, the previous series handicaps are used to assign handicaps as agreed between the Inshore Captain, Handicapper and Division Reps.

22.2   For each race after the 1st, the handicaps are adjusted for the following race based on the performance of the current race

22.3   The adjustments are calculated on the following basis:

22.4   Calculate the race's Yardstick (YS)

22.4.1   YS is the average of each boats corrected time

22.4.2   If a boats performance against the YS is worse than 8% it is excluded from the YS calculation and the YS is recalculated recursively.

22.4.3   A boats performance (Perf Pct) is assessed against the YS by:

22.4.4   Per Pct = ((YS-CT)-1)x100

22.4.5   If a boat Perf Pct is 4% worse than the YS then their Perf Pct is limited to -4% for the calculation of the handicap for the next race.

22.4.6   Using the Perf Pct then a Perf handicap (Perf Corr) is calculated using the prerace handicap (PH):

22.4.7   Perf Corr = PHx(1+Perf Pct/100)

22.4.8   The new handicap (NH) for the next race is the result of 70% of the PH plus 30% of the Perf Corr handicap:

22.4.9   NH = 0.7PH + 0.3Perf Corr

22.5   Boats that don't sail 2 races in a row may have their handicaps altered based on the performance of their closest prestart peers as published (Manual Intervention).

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Mordialloc Sailing Club, Victoria

https://www.mordiallocsc.com.au/club-sailing/handicaps/

Handicaps

On a general basis we all know what a handicap is, but in sailing what is it and how is it used?

In a non-handicap (scratch) race, boats are allocated points based on their position crossing the finish line. In this type of race the time they took (elapsed time) to complete the race is irrelevant as it does not affect their finishing position.

In a handicap race the final finish position of a boat in the race is determined by its corrected time. Corrected time? Corrected time is a combination of the boats elapsed time modified by their handicap. The boat with the lowest corrected time is first and boats are allocated positions based on ascending corrected times.

For racing at Mordialloc Sailing Club we generally use two different handicap systems, Yardstick and Club Handicap.

Yardstick

The aim of the yardstick is to provide a basis for yachts of different class to compete fairly when sailed well. The yardstick is not intended to compensate for differences in skills or competence of individual sailors (that is the Club Handicap). The yardstick is calculated and maintained by Yachting Victoria on a statistical basis and within broad limits remains valid for a variety of wind strengths and courses sailed.

DEFINITIONS

Elapsed Time (ET) is the time taken (in minutes and decimal minutes, or in seconds) for a boat to sail a proper course.
Corrected Time (CT) is the elapsed time divided by the boat's class yardstick (YS) and multiplied by 100

Club Handicap

The club handicap is very similar to a golf handicap in that it allows people of different skills and abilities to compete together. To this end it is the person who sails better than normal who will place first, however just like a golf handicap it will change over time based on results.

Similar to the Yardstick, the Club Handicap, or Allocated Handicap (AHC), modifies the elapsed time of a boat to calculate the corrected time and thus determine the winner of the race and subsequent positions.

DEFINITIONS

Allocated Handicap (AHC) – Boats sail a race with an Allocated Handicap (AHC). This is the HC allocated to that boat for the particular race.

Back Calculated Handicap (BCH) – After each race a Back Calculated Handicap (BCH) is generated/calculated for each boat. This is the HC a boat needed to be placed equal on HC corrected finish

time with every other boat in that race. This is a direct measure of this boat when compared to others in the fleet.

Calculated Handicap (CHC) is the value calculated after this race for the handicap to use for the next race.

Clamped BCH – If a boat sails above/below the "norm" +/- 3%, then it is probably an unusual circumstance (non typical for that boat) and most HCers do not believe that such a BCH should be allowed to overly bias the ongoing HC calculations. Consequently "clamps" are applied. This is a user defined percentage below and above the AHC for that race.

APPLICATION

Each boat is allocated a handicap (AHC) when they enter a series. In race one the AHC is used to determine their corrected time and thus their finishing position in the race. Their performance in this race is used to calculate the BCH which is used with the AHC to work out the CHC. The CHC becomes the AHC for the next race.

If the boat greatly over or under performs their handicap then the BCH is clamped (CBCH). Clamped means we limit the difference between the AHC and BCH to avoid large swings in a boats handicap. In this case it is the BCHC and the AHC that are used to produce the CHC.

E.g. A boat has a AHC of 1.00 and sails well above their handicap and has a BCH of 1.04. If we have a clamp of +/- 3% then the CBCH would clamps would be 0.97 to 1.03. In this case we would use the CBCH of 1.03 to calculate the CHC.

How do we calculate the CHC?

There are many methods for for doing this but we use the weighted average method. This averages the AHC and the BCH or CBCH but weights the AHC 3 to 1 against the BCH or CBCH.

E.g. CHC= 0.75 x AHC + 0.25 x BCH or CHC=0.75 x AHC + 0.25 x CBCH

Sound complicated? Well thankfully our results system works all of this out for us automatically and throughout the year we will publish the current handicaps and how these relate to elapsed times on the water to make it more tangible for when you are actually sailing.

Appendix D

Trial Races to establish Handicaps

Trial Race 1: Windrush Cat division

Sail No	Boat	Elapsed Time	Allocated Handicap	Corrected Time	Place	Back Calculated Handicap BCH		Performance Indicator	Calculated Handicap
		ET	AHC	CT		Initial	Constrained	PI	CHC
input	input	input	input	ET x AHC	input	SCT / ET	bounds = 15% of AHC	BCH - AHC	AHC + (PI / 3)
6402	Sirius Lee	0:42:29	1.064	0:45:12		1.098	1.098	0.034	1.075
6427	Billy M	0:45:14	1.064	0:48:08		1.032	1.032	-0.032	1.053
6429	Catastrophe	0:46:51	1.064	0:49:51		0.996	0.996	-0.068	1.041
6437	Yellow Taxi	0:45:34	1.064	0:48:29		1.024	1.024	-0.040	1.051
6449	Zephyr	0:52:00	1.064	0:55:20		0.897	0.904	-0.160	1.011
6463	Sea Saw	0:40:45	1.064	0:43:21		1.145	1.145	0.081	1.091
6468	Dirty Ore	0:40:33	1.064	0:43:09		1.151	1.151	0.087	1.093
6469	Xena	0:40:30	1.064	0:43:06		1.152	1.152	0.088	1.093

Standard Corrected Time (SCT) =   0:46:40

Trial Race 1: Windrush Sloop division

Sail No	Boat	Elapsed Time	Allocated Handicap	Corrected Time	Place	Back Calculated Handicap BCH		Performance Indicator	Calculated Handicap
		ET	AHC	CT		Initial	Constrained	PI	CHC
input	input	input	input	ET x AHC	input	SCT / ET	bounds = 15% of AHC	BCH - AHC	AHC + (PI / 3)
6343	Wild Thing	0:55:40	1.124	1:02:34		1.097	1.097	-0.027	1.115
6361	Cat Fish	0:40:40	1.124	0:45:43		1.502	1.293	0.169	1.180
6411	Buzzbox	0:42:10	1.124	0:47:24		1.448	1.293	0.169	1.180
6416	Quindy	1:00:54	1.124	1:08:27		1.003	1.003	-0.121	1.084
6458	Steel Cat	0:54:20	1.124	1:01:04		1.124	1.124	0.000	1.124

Standard Corrected Time (SCT) =   1:01:04

Trial Race 1: Windrush Super Sloop division

Sail No	Boat	Elapsed Time	Allocated Handicap	Corrected Time	Place	Back Calculated Handicap BCH		Performance Indicator	Calculated Handicap
		ET	AHC	CT		Initial	Constrained	PI	CHC
input	input	input	input	ET x AHC	input	SCT / ET	bounds = 15% of AHC	BCH - AHC	AHC + (PI / 3)
6398	Feeling Lucky	0:46:00	1.149	0:52:51		1.171	1.171	0.022	1.156
6417	Ella	0:46:49	1.149	0:53:48		1.151	1.151	0.002	1.150
6423	White Knuckle Tight	0:50:19	1.149	0:57:49		1.071	1.071	-0.078	1.123
6440	Cliff Hanger	0:46:25	1.149	0:53:20		1.161	1.161	0.012	1.153
6443	Back Door Relief	0:47:58	1.149	0:55:07		1.123	1.123	-0.026	1.140
6445	Moment of Madness	0:46:35	1.149	0:53:31		1.156	1.156	0.007	1.151
6460	Wreckless	0:46:57	1.149	0:53:57		1.147	1.147	-0.002	1.148
6465	Emily Jean	0:47:10	1.149	0:54:12		1.142	1.142	-0.007	1.147

Standard Corrected Time (SCT) =   0:53:52

Trial Race 2: Windrush Cat division

Sail No	Boat	Elapsed Time	Allocated Handicap	Corrected Time	Place	Back Calculated Handicap BCH		Performance Indicator	Calculated Handicap
		ET	AHC	CT		Initial	Constrained	PI	CHC
input	input	input	input	ET x AHC	input	SCT / ET	bounds = 15% of AHC	BCH - AHC	AHC + (PI / 3)
6402	Sirius Lee	0:44:27	1.064	0:47:18		1.087	1.087	0.023	1.072
6427	Billy M	0:57:34	1.064	1:01:15		0.839	0.904	-0.160	1.011
6429	Catastrophe	0:57:07	1.064	1:00:46		0.846	0.904	-0.160	1.011
6437	Yellow Taxi	0:46:21	1.064	0:49:19		1.042	1.042	-0.022	1.057
6449	Zephyr	0:50:24	1.064	0:53:38		0.958	0.958	-0.106	1.029
6463	Sea Saw	0:41:27	1.064	0:44:06		1.165	1.165	0.101	1.098
6468	Dirty Ore	0:41:57	1.064	0:44:38		1.152	1.152	0.088	1.093
6469	Xena	0:41:41	1.064	0:44:21		1.159	1.159	0.095	1.096

Standard Corrected Time (SCT) =   0:48:18

Trial Race 2: Windrush Sloop division

Sail No	Boat	Elapsed Time	Allocated Handicap	Corrected Time	Place	Back Calculated Handicap BCH		Performance Indicator	Calculated Handicap
		ET	AHC	CT		Initial	Constrained	PI	CHC
input	input	input	input	ET x AHC	input	SCT / ET	bounds = 15% of AHC	BCH - AHC	AHC + (PI / 3)
6343	Wild Thing	0:42:48	1.124	0:48:06		1.124	1.124	0.000	1.124
6361	Cat Fish	0:39:55	1.124	0:44:52		1.205	1.205	0.081	1.151
6411	Buzzbox	0:40:14	1.124	0:45:13		1.196	1.196	0.072	1.148
6416	Quindy	0:49:47	1.124	0:55:57		0.966	0.966	-0.158	1.071
6458	Steel Cat	0:48:24	1.124	0:54:24		0.994	0.994	-0.130	1.081

Standard Corrected Time (SCT) =   0:48:06

Trial Race 2: Windrush Super Sloop division

Sail No	Boat	Elapsed Time	Allocated Handicap	Corrected Time	Place	Back Calculated Handicap BCH		Performance Indicator	Calculated Handicap
		ET	AHC	CT		Initial	Constrained	PI	CHC
input	input	input	input	ET x AHC	input	SCT / ET	bounds = 15% of AHC	BCH - AHC	AHC + (PI / 3)
6398	Feeling Lucky	0:41:37	1.149	0:47:49		1.163	1.163	0.014	1.154
6417	Ella	0:41:57	1.149	0:48:12		1.154	1.154	0.005	1.151
6423	White Knuckle Tight	0:43:31	1.149	0:50:00		1.112	1.112	-0.037	1.137
6440	Cliff Hanger	0:41:30	1.149	0:47:41		1.166	1.166	0.017	1.155
6443	Back Door Relief	0:43:00	1.149	0:49:24		1.126	1.126	-0.023	1.141
6445	Moment of Madness	0:42:05	1.149	0:48:21		1.150	1.150	0.001	1.149
6460	Wreckless	0:42:10	1.149	0:48:27		1.148	1.148	-0.001	1.149
6465	Emily Jean	0:42:48	1.149	0:49:11		1.131	1.131	-0.018	1.143

Standard Corrected Time (SCT) =   0:48:24

Trial Race 3: Windrush Cat division

Sail No	Boat	Elapsed Time	Allocated Handicap	Corrected Time	Place	Back Calculated Handicap BCH		Performance Indicator	Calculated Handicap
		ET	AHC	CT		Initial	Constrained	PI	CHC
input	input	input	input	ET x AHC	input	SCT / ET	bounds = 15% of AHC	BCH - AHC	AHC + (PI / 3)
6402	Sirius Lee	0:39:44	1.064	0:42:17		1.071	1.071	0.007	1.066
6427	Billy M	0:40:16	1.064	0:42:51		1.057	1.057	-0.007	1.062
6429	Catastrophe	0:54:54	1.064	0:58:25		0.775	0.904	-0.160	1.011
6437	Yellow Taxi	0:52:56	1.064	0:56:19		0.804	0.904	-0.160	1.011
6449	Zephyr	0:53:43	1.064	0:57:09		0.792	0.904	-0.160	1.011
6463	Sea Saw	0:37:41	1.064	0:40:06		1.129	1.129	0.065	1.086
6468	Dirty Ore	0:36:04	1.064	0:38:22		1.180	1.180	0.116	1.103
6469	Xena	0:36:40	1.064	0:39:01		1.161	1.161	0.097	1.096

Standard Corrected Time (SCT) = 0:42:34

Trial Race 3: Windrush Sloop division

Sail No	Boat	Elapsed Time	Allocated Handicap	Corrected Time	Place	Back Calculated Handicap BCH		Performance Indicator	Calculated Handicap
		ET	AHC	CT		Initial	Constrained	PI	CHC
input	input	input	input	ET x AHC	input	SCT / ET	bounds = 15% of AHC	BCH - AHC	AHC + (PI / 3)
6343	Wild Thing	0:50:56	1.124	0:57:15		1.054	1.054	-0.070	1.101
6361	Cat Fish	0:38:05	1.124	0:42:48		1.410	1.293	0.169	1.180
6411	Buzzbox	0:38:07	1.124	0:42:51		1.409	1.293	0.169	1.180
6416	Quindy	0:47:56	1.124	0:53:53		1.120	1.120	-0.004	1.123
6458	Steel Cat	0:47:46	1.124	0:53:41		1.124	1.124	0.000	1.124

Standard Corrected Time (SCT) = 0:53:41

Trial Race 3: Windrush Super Sloop division

Sail No	Boat	Elapsed Time	Allocated Handicap	Corrected Time	Place	Back Calculated Handicap BCH		Performance Indicator	Calculated Handicap
		ET	AHC	CT		Initial	Constrained	PI	CHC
input	input	input	input	ET x AHC	input	SCT / ET	bounds = 15% of AHC	BCH - AHC	AHC + (PI / 3)
6398	Feeling Lucky	0:36:36	1.149	0:42:03		1.175	1.175	0.026	1.158
6417	Ella	0:36:42	1.149	0:42:10		1.171	1.171	0.022	1.156
6423	White Knuckle Tight	0:39:58	1.149	0:45:55		1.076	1.076	-0.073	1.125
6440	Cliff Hanger	0:33:45	1.149	0:38:47		1.274	1.274	0.125	1.191
6443	Back Door Relief	0:40:56	1.149	0:47:02		1.050	1.050	-0.099	1.116
6445	Moment of Madness	0:37:39	1.149	0:43:16		1.142	1.142	-0.007	1.147
6460	Wreckless	0:37:11	1.149	0:42:43		1.156	1.156	0.007	1.151
6465	Emily Jean	0:41:05	1.149	0:47:12		1.046	1.046	-0.103	1.115

Standard Corrected Time (SCT) = 0:43:00

Appendix E

Performance Handicap System Race Results

RACE 1 Windrush Cat

Sail No	Boat	Elapsed Time ET	Allocated Handicap AHC	Corrected Time CT	Place	Back Calculated Handicap BCH		Performance Indicator PI	Calculated Handicap CHC
						Initial	Constrained		
input	input	input	input	ET x AHC	input	SCT / ET	bounds = 15% of AHC	BCH - AHC	AHC + (PI / 3)
6402	Sirius Lee	0:42:29	1.071	0:45:30	6	1.109	1.109	0.038	1.084
6408	Eagle B	0:47:52	1.059	0:50:41	12	0.985	0.985	-0.074	1.034
6427	Billy M	0:45:14	1.042	0:47:08	7	1.042	1.042	0.000	1.042
6429	Catastrophe	0:46:51	1.021	0:47:50	9	1.006	1.006	-0.015	1.016
6437	Yellow Taxi	0:45:34	1.039	0:47:21	8	1.034	1.034	-0.005	1.037
6438	Frisky	DNS	1.059		15				1.059
6448	Double Shot	0:40:45	1.059	0:43:09	1	1.157	1.157	0.098	1.092
6449	Zephyr	0:52:00	1.017	0:52:53	13	0.906	0.906	-0.111	0.980
6450	Yeehar	0:45:49	1.059	0:48:31	11	1.029	1.029	-0.030	1.049
6459	Spindrift	0:45:40	1.059	0:48:22	10	1.032	1.032	-0.027	1.050
6463	Sea Saw	0:40:18	1.092	0:44:00	2	1.170	1.170	0.078	1.118
6466	Catatonic	0:42:05	1.059	0:44:34	5	1.120	1.120	0.061	1.079
6468	Dirty Ore	0:40:33	1.096	0:44:27	4	1.162	1.162	0.066	1.118
6469	Xena	0:40:30	1.095	0:44:21	3	1.164	1.164	0.069	1.118

Standard Corrected Time (SCT) = 0:47:08

RACE 1 Windrush Sloop

Sail No	Boat	Elapsed Time ET	Allocated Handicap AHC	Corrected Time CT	Place	Back Calculated Handicap BCH		Performance Indicator PI	Calculated Handicap CHC
						Initial	Constrained		
input	input	input	input	ET x AHC	input	SCT / ET	bounds = 15% of AHC	BCH - AHC	AHC + (PI / 3)
6343	Wild Thing	0:55:40	1.113	1:01:57	4	1.083	1.083	-0.030	1.103
6361	Cat Fish	0:40:40	1.170	0:47:35	1	1.483	1.346	0.176	1.229
6411	Buzzbox	0:42:10	1.169	0:49:18	2	1.430	1.344	0.175	1.227
6416	Quindy	1:00:54	1.093	1:06:34	5	0.990	0.990	-0.103	1.059
6458	Steel Cat	0:54:20	1.110	1:00:19	3	1.110	1.110	0.000	1.110
6462	Meelup	DNF	1.131		7				1.131

Standard Corrected Time (SCT) = 1:00:19

RACE 1 Windrush Super Sloop

Sail No	Boat	Elapsed Time ET	Allocated Handicap AHC	Corrected Time CT	Place	Back Calculated Handicap BCH		Performance Indicator PI	Calculated Handicap CHC
						Initial	Constrained		
input	input	input	input	ET x AHC	input	SCT / ET	bounds = 15% of AHC	BCH - AHC	AHC + (PI / 3)
6394	Humm-n	0:47:49	1.146	0:54:48	8	1.130	1.130	-0.016	1.141
6395	Cat Nip	0:49:08	1.146	0:56:18	9	1.100	1.100	-0.046	1.131
6398	Feeling Lucky	0:46:00	1.156	0:53:11	1	1.175	1.175	0.019	1.162
6417	Ella	0:46:49	1.152	0:53:56	4	1.154	1.154	0.002	1.153
6423	White Knuckle Tight	0:50:19	1.128	0:56:45	10	1.074	1.074	-0.054	1.110
6440	Cliff Hanger	0:46:25	1.166	0:54:07	6	1.164	1.164	-0.002	1.165
6443	Back Door Relief	0:47:58	1.133	0:54:21	7	1.126	1.126	-0.007	1.131
6445	Moment of Madness	0:46:35	1.149	0:53:31	2	1.160	1.160	0.011	1.153
6460	Wreckless	0:46:57	1.149	0:53:57	5	1.151	1.151	0.002	1.150
6465	Emily Jean	0:47:10	1.135	0:53:32	3	1.146	1.146	0.011	1.139

Standard Corrected Time (SCT) = 0:54:02

RACE 2 Windrush Cat

Sail No	Boat	Elapsed Time	Allocated Handicap	Corrected Time	Place	Back Calculated Handicap BCH		Performance Indicator	Calculated Handicap
		ET	AHC	CT		Initial	Constrained	PI	CHC
input	input	input	input	ET x AHC	input	SCT / ET	bounds = 15% of AHC	BCH - AHC	AHC + (PI / 3)
6402	Sirius Lee	0:44:27	1.084	0:48:11	6	1.084	1.084	0.000	1.084
6408	Eagle B	0:52:59	1.034	0:54:48	8	0.909	0.909	-0.125	0.993
6427	Billy M	0:57:34	1.042	0:59:59	10	0.837	0.886	-0.156	0.990
6429	Catastrophe	0:57:07	1.016	0:58:02	9	0.843	0.864	-0.152	0.965
6437	Yellow Taxi	0:46:21	1.037	0:48:05	5	1.039	1.039	0.002	1.038
6438	Frisky	DNS	1.059		15				1.059
6448	Double Shot	DNS	1.092		15				1.092
6449	Zephyr	0:50:24	0.980	0:49:24	7	0.956	0.956	-0.024	0.972
6450	Yeehar	DNS	1.049		15				1.049
6459	Spindrift	DNS	1.050		15				1.050
6463	Sea Saw	0:41:27	1.118	0:46:20	2	1.162	1.162	0.044	1.133
6466	Catatonic	???	1.079		1				1.079
6468	Dirty Ore	0:41:57	1.118	0:46:54	4	1.148	1.148	0.030	1.128
6469	Xena	0:41:41	1.118	0:46:36	3	1.156	1.156	0.038	1.131

Standard Corrected Time (SCT) = 0:48:11

RACE 2 Windrush Sloop

Sail No	Boat	Elapsed Time	Allocated Handicap	Corrected Time	Place	Back Calculated Handicap BCH		Performance Indicator	Calculated Handicap
		ET	AHC	CT		Initial	Constrained	PI	CHC
input	input	input	input	ET x AHC	input	SCT / ET	bounds = 15% of AHC	BCH - AHC	AHC + (PI / 3)
6343	Wild Thing	0:42:48	1.103	0:47:13	1	1.193	1.193	0.090	1.133
6361	Cat Fish	0:39:55	1.229	0:49:02	2	1.279	1.279	0.050	1.245
6411	Buzzbox	0:40:14	1.227	0:49:23	3	1.269	1.269	0.041	1.241
6416	Quindy	0:49:47	1.059	0:52:43	4	1.025	1.025	-0.033	1.048
6458	Steel Cat	0:48:24	1.110	0:53:43	5	1.055	1.055	-0.055	1.092
6462	Meelup	0:50:00	1.131	0:56:33	6	1.021	1.021	-0.110	1.094

Standard Corrected Time (SCT) = 0:51:03

RACE 2 Windrush Super Sloop

Sail No	Boat	Elapsed Time	Allocated Handicap	Corrected Time	Place	Back Calculated Handicap BCH		Performance Indicator	Calculated Handicap
		ET	AHC	CT		Initial	Constrained	PI	CHC
input	input	input	input	ET x AHC	input	SCT / ET	bounds = 15% of AHC	BCH - AHC	AHC + (PI / 3)
6394	Humm-n	0:42:54	1.141	0:48:56	9	1.130	1.130	-0.011	1.137
6395	Cat Nip	DNS	1.131		11				1.131
6398	Feeling Lucky	0:41:37	1.162	0:48:22	4	1.165	1.165	0.003	1.163
6417	Ella	0:41:57	1.153	0:48:21	2	1.156	1.156	0.003	1.154
6423	White Knuckle Tight	0:43:31	1.110	0:48:18	1	1.114	1.114	0.004	1.111
6440	Cliff Hanger	0:41:30	1.165	0:48:22	3	1.168	1.168	0.003	1.166
6443	Back Door Relief	0:43:00	1.131	0:48:38	7	1.127	1.127	-0.003	1.130
6445	Moment of Madness	0:42:05	1.153	0:48:30	6	1.152	1.152	-0.001	1.152
6460	Wreckless	0:42:10	1.150	0:48:29	5	1.150	1.150	0.000	1.150
6465	Emily Jean	0:42:48	1.139	0:48:44	8	1.133	1.133	-0.006	1.137

Standard Corrected Time (SCT) = 0:48:29

RACE 3 Windrush Cat

Sail No	Boat	Elapsed Time ET	Allocated Handicap AHC	Corrected Time CT	Place	Back Calculated Handicap BCH Initial	Back Calculated Handicap BCH Constrained	Performance Indicator PI	Calculated Handicap CHC
input	input	input	input	ET x AHC	input	SCT / ET	bounds = 15% of AHC	BCH - AHC	AHC + (PI / 3)
6402	Sirius Lee	0:39:44	1.084	0:43:04	7	1.079	1.079	-0.005	1.082
6408	Eagle B	DNS	0.993		15				0.993
6427	Billy M	0:40:16	0.990	0:39:52	1	1.065	1.065	0.075	1.015
6429	Catastrophe	0:54:54	0.965	0:52:59	9	0.781	0.820	-0.145	0.917
6437	Yellow Taxi	0:52:56	1.038	0:54:57	10	0.810	0.882	-0.156	0.986
6438	Frisky	DNS	1.059		15				1.059
6448	Double Shot	0:38:16	1.092	0:41:46	4	1.120	1.120	0.029	1.101
6449	Zephyr	0:53:43	0.972	0:52:13	8	0.798	0.826	-0.146	0.923
6450	Yeehar	0:52:46	1.049	0:55:21	12	0.813	0.892	-0.157	0.996
6459	Spindrift	0:52:36	1.050	0:55:14	11	0.815	0.893	-0.158	0.998
6463	Sea Saw	0:37:41	1.133	0:42:41	6	1.138	1.138	0.005	1.134
6466	Catatonic	0:38:43	1.079	0:41:47	5	1.107	1.107	0.028	1.089
6468	Dirty Ore	0:36:04	1.128	0:40:41	2	1.189	1.189	0.061	1.148
6469	Xena	0:36:40	1.131	0:41:27	3	1.169	1.169	0.039	1.143

Standard Corrected Time (SCT) = 0:42:52

RACE 3 Windrush Sloop

Sail No	Boat	Elapsed Time ET	Allocated Handicap AHC	Corrected Time CT	Place	Back Calculated Handicap BCH Initial	Back Calculated Handicap BCH Constrained	Performance Indicator PI	Calculated Handicap CHC
input	input	input	input	ET x AHC	input	SCT / ET	bounds = 15% of AHC	BCH - AHC	AHC + (PI / 3)
6343	Wild Thing	0:50:56	1.133	0:57:42	6	1.005	1.005	-0.128	1.090
6361	Cat Fish	0:38:05	1.245	0:47:25	2	1.344	1.344	0.099	1.278
6411	Buzzbox	0:38:07	1.241	0:47:19	1	1.343	1.343	0.101	1.275
6416	Quindy	0:47:56	1.048	0:50:13	3	1.068	1.068	0.020	1.054
6458	Steel Cat	0:47:46	1.092	0:52:08	4	1.071	1.071	-0.020	1.085
6462	Meelup	0:48:42	1.094	0:53:18	5	1.051	1.051	-0.043	1.080

Standard Corrected Time (SCT) = 0:51:11

RACE 3 Windrush Super Sloop

Sail No	Boat	Elapsed Time ET	Allocated Handicap AHC	Corrected Time CT	Place	Back Calculated Handicap BCH Initial	Back Calculated Handicap BCH Constrained	Performance Indicator PI	Calculated Handicap CHC
input	input	input	input	ET x AHC	input	SCT / ET	bounds = 15% of AHC	BCH - AHC	AHC + (PI / 3)
6394	Humm-n	DNS	1.137		11				1.137
6395	Cat Nip	DNS	1.131		11				1.131
6398	Feeling Lucky	0:36:36	1.163	0:42:34	3	1.177	1.177	0.014	1.168
6417	Ella	0:36:42	1.154	0:42:20	2	1.173	1.173	0.020	1.160
6423	White Knuckle Tight	0:39:58	1.111	0:44:25	6	1.078	1.078	-0.034	1.100
6440	Cliff Hanger	0:33:45	1.166	0:39:22	1	1.276	1.276	0.110	1.203
6443	Back Door Relief	0:40:56	1.130	0:46:14	7	1.052	1.052	-0.078	1.104
6445	Moment of Madness	0:37:39	1.152	0:43:23	5	1.144	1.144	-0.009	1.150
6460	Wreckless	0:37:11	1.150	0:42:45	4	1.158	1.158	0.009	1.152
6465	Emily Jean	0:41:05	1.137	0:46:42	8	1.048	1.048	-0.088	1.107

Standard Corrected Time (SCT) = 0:43:04

RACE 4 Windrush Cat

Sail No	Boat	Elapsed Time	Allocated Handicap	Corrected Time	Place	Back Calculated Handicap BCH		Performance Indicator	Calculated Handicap
		ET	AHC	CT		Initial	Constrained	PI	CHC
input	input	input	input	ET x AHC	input	SCT / ET	bounds = 15% of AHC	BCH - AHC	AHC + (PI / 3)
6402	Sirius Lee	0:29:12	1.082	0:31:36	11	1.006	1.006	-0.076	1.057
6408	Eagle B	0:34:48	0.993	0:34:32	12	0.844	0.844	-0.148	0.943
6427	Billy M	0:29:08	1.015	0:29:34	7	1.009	1.009	-0.006	1.013
6429	Catastrophe	0:32:17	0.917	0:29:36	8	0.910	0.910	-0.007	0.915
6437	Yellow Taxi	0:27:38	0.986	0:27:15	1	1.063	1.063	0.077	1.012
6438	Frisky	DNS	1.059		15				1.059
6448	Double Shot	0:27:16	1.101	0:30:01	9	1.078	1.078	-0.024	1.093
6449	Zephyr	0:29:44	0.923	0:27:27	3	0.988	0.988	0.065	0.945
6450	Yeehar	0:29:18	0.996	0:29:12	6	1.003	1.003	0.006	0.999
6459	Spindrift	DNS	0.998		15				0.998
6463	Sea Saw	0:25:11	1.134	0:28:34	4	1.167	1.167	0.032	1.145
6466	Catatonic	0:26:46	1.089	0:29:08	5	1.098	1.098	0.009	1.092
6468	Dirty Ore	0:23:46	1.148	0:27:18	2	1.236	1.236	0.088	1.178
6469	Xena	0:26:53	1.143	0:30:44	10	1.093	1.093	-0.051	1.127

Standard Corrected Time (SCT) = 0:29:23

RACE 4 Windrush Sloop

Sail No	Boat	Elapsed Time	Allocated Handicap	Corrected Time	Place	Back Calculated Handicap BCH		Performance Indicator	Calculated Handicap
		ET	AHC	CT		Initial	Constrained	PI	CHC
input	input	input	input	ET x AHC	input	SCT / ET	bounds = 15% of AHC	BCH - AHC	AHC + (PI / 3)
6343	Wild Thing	0:32:50	1.090	0:35:48	5	0.941	0.941	-0.149	1.041
6361	Cat Fish	0:24:11	1.278	0:30:55	3	1.278	1.278	0.000	1.278
6411	Buzzbox	DNS	1.275		7				1.275
6416	Quindy	0:30:17	1.054	0:31:56	4	1.021	1.021	-0.034	1.043
6458	Steel Cat	0:26:40	1.085	0:28:56	2	1.159	1.159	0.074	1.110
6462	Meelup	0:26:29	1.080	0:28:36	1	1.167	1.167	0.087	1.109

Standard Corrected Time (SCT) = 0:30:55

RACE 4 Windrush Super Sloop

Sail No	Boat	Elapsed Time	Allocated Handicap	Corrected Time	Place	Back Calculated Handicap BCH		Performance Indicator	Calculated Handicap
		ET	AHC	CT		Initial	Constrained	PI	CHC
input	input	input	input	ET x AHC	input	SCT / ET	bounds = 15% of AHC	BCH - AHC	AHC + (PI / 3)
6394	Humm-n	0:20:30	1.137	0:23:19	1	1.219	1.219	0.082	1.164
6395	Cat Nip	DNS	1.131		11				1.131
6398	Feeling Lucky	0:21:37	1.168	0:25:14	7	1.156	1.156	-0.012	1.164
6417	Ella	0:21:25	1.160	0:24:51	3	1.167	1.167	0.006	1.162
6423	White Knuckle Tight	0:21:50	1.100	0:24:01	2	1.144	1.144	0.044	1.115
6440	Cliff Hanger	0:20:40	1.203	0:24:52	4	1.209	1.209	0.006	1.205
6443	Back Door Relief	0:32:34	1.104	0:35:57	9	0.767	0.938	-0.166	1.049
6445	Moment of Madness	0:22:34	1.150	0:25:57	8	1.107	1.107	-0.042	1.135
6460	Wreckless	0:21:42	1.152	0:25:01	6	1.151	1.151	-0.001	1.152
6465	Emily Jean	0:22:34	1.107	0:24:59	5	1.107	1.107	0.000	1.107

Standard Corrected Time (SCT) = 0:24:59

RACE 5 Windrush Cat

Sail No	Boat	Elapsed Time ET	Allocated Handicap AHC	Corrected Time CT	Place	Back Calculated Handicap BCH		Performance Indicator PI	Calculated Handicap CHC
						Initial	Constrained		
input	input	input	input	ET x AHC	input	SCT / ET	bounds = 15% of AHC	BCH - AHC	AHC + (PI / 3)
6402	Sirius Lee	0:37:42	1.057	0:39:51	3	1.171	1.171	0.114	1.095
6408	Eagle B	0:43:51	0.943	0:41:21	4	1.007	1.007	0.064	0.964
6427	Billy M	0:43:36	1.013	0:44:09	7	1.013	1.013	0.000	1.013
6429	Catastrophe	DNS	0.915		15				0.915
6437	Yellow Taxi	1:04:19	1.012	1:05:05	12	0.687	0.860	-0.152	0.961
6438	Frisky	1:05:50	1.059	1:09:43	13	0.671	0.900	-0.159	1.006
6448	Double Shot	0:39:04	1.093	0:42:43	5	1.130	1.130	0.037	1.106
6449	Zephyr	0:39:05	0.945	0:36:56	1	1.130	1.087	0.142	0.992
6450	Yeehar	0:57:52	0.999	0:57:47	11	0.763	0.849	-0.150	0.949
6459	Spindrift	0:53:27	0.998	0:53:19	10	0.826	0.848	-0.150	0.948
6463	Sea Saw	0:38:49	1.145	0:44:27	8	1.138	1.138	-0.008	1.143
6466	Catatonic	0:35:37	1.092	0:38:53	2	1.240	1.240	0.148	1.141
6468	Dirty Ore	0:44:22	1.178	0:52:15	9	0.995	1.001	-0.177	1.119
6469	Xena	0:38:57	1.127	0:43:53	6	1.134	1.134	0.007	1.129

Standard Corrected Time (SCT) =   0:44:09

RACE 5 Windrush Sloop

Sail No	Boat	Elapsed Time ET	Allocated Handicap AHC	Corrected Time CT	Place	Back Calculated Handicap BCH		Performance Indicator PI	Calculated Handicap CHC
						Initial	Constrained		
input	input	input	input	ET x AHC	input	SCT / ET	bounds = 15% of AHC	BCH - AHC	AHC + (PI / 3)
6343	Wild Thing	DNF	1.041		7				1.041
6361	Cat Fish	0:43:07	1.278	0:55:07	2	1.294	1.294	0.016	1.283
6411	Buzzbox	0:44:18	1.275	0:56:29	3	1.260	1.260	-0.016	1.270
6416	Quindy	DNS	1.043		7				1.043
6458	Steel Cat	0:52:05	1.110	0:57:48	4	1.071	1.071	-0.038	1.097
6462	Meelup	0:46:50	1.109	0:51:56	1	1.191	1.191	0.082	1.136

Standard Corrected Time (SCT) =   0:55:48

RACE 5 Windrush Super Sloop

Sail No	Boat	Elapsed Time ET	Allocated Handicap AHC	Corrected Time CT	Place	Back Calculated Handicap BCH		Performance Indicator PI	Calculated Handicap CHC
						Initial	Constrained		
input	input	input	input	ET x AHC	input	SCT / ET	bounds = 15% of AHC	BCH - AHC	AHC + (PI / 3)
6394	Humm-n	0:41:59	1.164	0:48:53	3	1.214	1.214	0.050	1.181
6395	Cat Nip	DNF	1.131		11				1.131
6398	Feeling Lucky	0:41:33	1.164	0:48:21	2	1.227	1.227	0.063	1.185
6417	Ella	0:55:50	1.162	1:04:54	8	0.913	0.988	-0.174	1.104
6423	White Knuckle Tight	0:58:00	1.115	1:04:40	7	0.879	0.948	-0.167	1.059
6440	Cliff Hanger	0:43:19	1.205	0:52:12	5	1.177	1.177	-0.028	1.196
6443	Back Door Relief	DNF	1.049		11				1.049
6445	Moment of Madness	0:39:04	1.135	0:44:21	1	1.305	1.305	0.170	1.192
6460	Wreckless	0:54:54	1.152	1:03:15	6	0.929	0.979	-0.173	1.095
6465	Emily Jean	0:44:58	1.107	0:49:47	4	1.134	1.134	0.027	1.116

Standard Corrected Time (SCT) =   0:50:59

RACE 6 Windrush Cat

Sail No	Boat	Elapsed Time ET	Allocated Handicap AHC	Corrected Time CT	Place	Back Calculated Handicap BCH		Performance Indicator PI	Calculated Handicap CHC
						Initial	Constrained		
input	input	input	input	ET x AHC	input	SCT / ET	bounds = 15% of AHC	BCH - AHC	AHC + (PI / 3)
6402	Sirius Lee	0:43:43	1.095	0:47:52	9	0.903	0.931	-0.164	1.040
6408	Eagle B	0:35:43	0.964	0:34:27	1	1.105	1.105	0.141	1.011
6427	Billy M	0:36:30	1.013	0:36:58	4	1.082	1.082	0.069	1.036
6429	Catastrophe	RET	0.915		15				0.915
6437	Yellow Taxi	DNF	0.961		15				0.961
6438	Frisky	RET	1.006		15				1.006
6448	Double Shot	0:39:55	1.106	0:44:08	8	0.989	0.989	-0.117	1.067
6449	Zephyr	0:42:14	0.992	0:41:54	7	0.935	0.935	-0.058	0.973
6450	Yeehar	0:43:00	0.949	0:40:47	6	0.918	0.918	-0.031	0.938
6459	Spindrift	DNF	0.948		15				0.948
6463	Sea Saw	0:34:33	1.143	0:39:29	5	1.143	1.143	0.000	1.143
6466	Catatonic	DNF	1.141		15				1.141
6468	Dirty Ore	0:31:57	1.119	0:35:45	3	1.236	1.236	0.117	1.158
6469	Xena	0:31:28	1.129	0:35:31	2	1.255	1.255	0.126	1.171

Standard Corrected Time (SCT) = 0:39:29

RACE 6 Windrush Sloop

Sail No	Boat	Elapsed Time ET	Allocated Handicap AHC	Corrected Time CT	Place	Back Calculated Handicap BCH		Performance Indicator PI	Calculated Handicap CHC
						Initial	Constrained		
input	input	input	input	ET x AHC	input	SCT / ET	bounds = 15% of AHC	BCH - AHC	AHC + (PI / 3)
6343	Wild Thing	0:43:00	1.041	0:44:45	3	1.007	1.007	-0.034	1.029
6361	Cat Fish	0:33:44	1.283	0:43:18	2	1.283	1.283	0.000	1.283
6411	Buzzbox	0:33:58	1.270	0:43:08	1	1.275	1.275	0.005	1.271
6416	Quindy	RET	1.043		7				1.043
6458	Steel Cat	RET	1.097		7				1.097
6462	Meelup	RET	1.136		7				1.136

Standard Corrected Time (SCT) = 0:43:18

RACE 6 Windrush Super Sloop

Sail No	Boat	Elapsed Time ET	Allocated Handicap AHC	Corrected Time CT	Place	Back Calculated Handicap BCH		Performance Indicator PI	Calculated Handicap CHC
						Initial	Constrained		
input	input	input	input	ET x AHC	input	SCT / ET	bounds = 15% of AHC	BCH - AHC	AHC + (PI / 3)
6394	Humm-n	RET	1.181		11				1.181
6395	Cat Nip	RET	1.131		11				1.131
6398	Feeling Lucky	0:31:51	1.185	0:37:44	4	1.136	1.136	-0.049	1.168
6417	Ella	0:31:56	1.104	0:35:16	2	1.133	1.133	0.028	1.114
6423	White Knuckle Tight	RET	1.059		11				1.059
6440	Cliff Hanger	0:30:15	1.196	0:36:10	3	1.196	1.196	0.000	1.196
6443	Back Door Relief	RET	1.049		11				1.049
6445	Moment of Madness	0:34:28	1.192	0:41:05	5	1.049	1.049	-0.143	1.144
6460	Wreckless	0:32:10	1.095	0:35:12	1	1.124	1.124	0.030	1.104
6465	Emily Jean	DNF	1.116		11				1.116

Standard Corrected Time (SCT) = 0:36:10