Chapter 6

6 Statistics from races

The first thing to do, before you attempt any calculation of statistics from races, is to check the data to identify any data errors. One frequent error is that the type of the boat is spelled in different ways in different races. One boat type may then be treated as several different boat types.

Another error may be that some results are obtained with a spinnaker, and some results without a spinnaker. Therefore data must indicate which handicapping number the boat was actually using in each particular race. In the LYS system boats get a reduction of 0.03 when they sail without a spinnaker. If you calculate performance only, and compare with listed handicapping numbers, you may make mistakes.

Calculations should be based on differences between average actual numbers and average calculated performance numbers.

Statistics from races

- Test for data errors
- Test for minimum number of competitors in each race
- Calculate IDEAL TIME for each race
- Delete individual boats with too large spread in each race (2 iterations)
- Delete races with too large spread
- Calculate difference between average performance and average rating for each boat type
- Test if the difference is significant
- Make top list of boat types with minimum 20 significant results in minimum 10 races
- This procedure produces a list of candidates for evaluation

When you calculate statistics from races, you should be aware of the fact that weather variations during a race may cause very serious distortions of results. Therefore you should use the IDEAL TIME method explained in the chapter "Corrected time errors and IDEAL TIME calculation" above. This method should not be used for too small number of entries in a race, so you will have to discard races with small number of fulfilling boats. The limit of acceptable number of fulfilling boats in a race is

$$n \geq 0.07/dL^2 \qquad \text{Eq 6.1}$$

where dL is the difference in LYS between the largest and smallest boat in the race. For example if the largest boat has LYS = 1.35 and the smallest has LYS = 1.25 you get

$n \geq 0.07/0.1^2 = 7.$

We also use 7 as a lower number of finishing boats for any dL, so we never use races with less than 7 boats for statistical purposes.

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For all races with acceptable numbers of finishing boats, we calculate the IDEAL TIME for each boat.

The results you get then may contain errors. If the elapsed times are entered manually you may get an elapsed time of 30 minutes for one boat, while all the others have elapsed times of about 1 hour and 30 minutes. You may also have results where one boat broke the mainsail and finished very late, or one or two boats were on the right side of the course when a significant wind shift occurred, and finished far ahead of the others. In order to delete all boats with such errors we calculate the standard deviation of the IDEAL TIME for each race. Then you can delete boats that are out of range as compared to the standard deviation of IDEAL TIME and the number of boats. The criteria used are the following. If the difference between the IDEAL TIME for a boat and the average of IDEAL TIME in the race is larger than a number dependent on the number of finishing boats and the standard deviation of the IDEAL TIME, then the boat is deleted from the race:

Ideal - m(Ideal) > s(Ideal) * log(n)*sqrt(pi)/2 Eq 6.2

where

Ideal	is IDEAL TIME
m(Ideal)	is the mean of Ideal
s(Ideal)	is the standard deviation of Ideal
n	is the number of finishing boats.

IDEAL TIME is calculated according to the chapter "Corrected time errors and IDEAL TIME calculation"

If one or more boats have been deleted from the race because of this test, the IDEAL TIME calculation is repeated without the deleted boats. Then the standard deviation of IDEAL TIME will be lower, and more boats may be deleted. If more boats are deleted IDEAL TIME is calculated once more.

With this procedure boats with data errors or suspect results will be deleted.

The entire race may, however, be suspect. If the standard deviation of IDEAL TIME is larger than 10% of the average of IDEAL TIME, this indicates that there have been unacceptable wind variations during the race. So the entire race is deleted if:

s(Ideal)/m(Ideal) > 0.10. Eq 6.3

For the remaining races without the deleted individual boats we calculate the experienced LYS numbers Le for each boat in every race as

Le = L* m(Ideal/Ideal Eq 6.4

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where L is the actual LYS number used in the race.

Then we get values of Le and L for each result in all accepted races, and the next step is to calculate the averages m(Le) of Le and m(L) of L for each boat type in all races:

m(Le) is the average of Le for a boat type from all races
m(L) is the average of L for a boat type from all races.

Then we calculate the difference between the boats performance and its actual handicapping number as

diff = m(Le) - m(L). Eq 6.5

If diff is small as compared to the standard deviation s(m(Le))of m(Le) it may be due to expected statistical variations, and therefore we test if diff is large enough to be regarded as significant. diff is significant if

diff > 1.96 * s(m(Le)) Eq 6.6

where

s(m(Le)) = m(Le)/sqrt(n). Eq 6.7

(Strictly speaking the number 1.96 should also be a function of n, but we make a slight simplification here.)

The last thing we do for the annual statistics, is to make a top list of all boat types with a significant diff from at least 20 results in at least 10 different races.

An example of such a top list is shown below:

Table 6.1 Nordic LYS statistics besed on IDEAL TIME for the year 2000

Analysed regattas/results (only keel-boats): 402/ 6504
Regattas/results that comply with minimum requiremets: 307/ 5660

Top list with minimum 20 results in minimum 10 regattas: 29 boat types.

ID	Boat type	LYS	n Res.	N Reg.	m(LYS)	m(Le)	s(Le)	s(m(Le))	Sign. diff
6-06	606	1.03	71	53	1.0239	1.048	0.0519	0.0062	3.887 0.0241
7-07	707	1.09	31	27	1.0877	1.101	0.0369	0.0066	2.015 0.0133
ALAL	ALBIN ALPHA	1.10	30	23	1.0963	1.067	0.0454	0.0083	-3.530 -.0293
BLLD	BALLAD	1.08	48	30	1.0800	1.045	0.0435	0.0063	-5.555 -.0350
BE31	BEASON 31	1.09	54	53	1.0839	1.099	0.0352	0.0048	3.145 0.0151

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CHLM	CARRERA HELMSMAN	1.22	69	33	1.2193	1.209	0.0386	0.0046	-2.239
-.0103									
CN33	CONTRAST 33	1.16	72	45	1.1474	1.126	0.0454	0.0054	-3.962
-.0214									
CW31	CROWN 31	1.16	20	19	1.1590	1.220	0.0449	0.0100	6.100
0.0610									
CMLS	CUMULUS	1.08	67	48	1.0746	1.098	0.0549	0.0067	3.492
0.0234									
DV35	DIVA 35	1.25	30	29	1.2500	1.204	0.0348	0.0064	-7.187
-.0460									
EXPR	EXPRESS	1.11	380	137	1.1087	1.137	0.0504	0.0026	10.884
0.0283									
FENX	FENIX	1.07	125	68	1.0598	1.075	0.0568	0.0051	2.980
0.0152									
FRTS	FORTISSIMO	1.09	20	20	1.0900	1.034	0.0659	0.0147	-3.809
-.0560									
HBT	H-BÅT	1.07	105	69	1.0694	1.086	0.0621	0.0061	2.721
0.0166									
J/24	J/24	1.11	25	25	1.1088	1.090	0.0328	0.0066	-2.848
-.0188									
LYHL	LADY HELMSMAN	1.16	25	22	1.1584	1.128	0.0610	0.0122	-2.491
-.0304									
MX77	MAXI 77	1.03	100	56	1.0213	0.995	0.0590	0.0059	-4.457
-.0263									
MX99	MAXI 999	1.15	49	29	1.1420	1.113	0.0656	0.0094	-3.085
-.0290									
FLKB	NORDISK FOLKBÅT	0.97	77	44	0.9712	0.993	0.0528	0.0060	3.633
0.0218									
OM28	OMEGA 28	1.07	36	31	1.0703	1.051	0.0585	0.0097	-1.989
-.0193									
PSSD	PASSAD	1.16	27	26	1.1600	1.128	0.0718	0.0138	-2.318
-.0320									
RI22	RIVAL 22	1.12	118	50	1.1192	1.110	0.0505	0.0046	-2.000
-.0092									
RJ85	RJ 85	1.03	31	25	1.0258	1.055	0.0746	0.0134	2.179
0.0292									
S-30	S 30 CLASSIC	1.17	27	15	1.1700	1.153	0.0432	0.0083	-2.048
-.0170									
SCMP	SCAMPI	1.09	143	49	1.0898	1.109	0.0646	0.0054	3.555
0.0192									
SMGD	SMARAGD	1.19	137	64	1.1861	1.206	0.0407	0.0035	5.685
0.0199									
WA3L	WASA 30 LR	1.19	26	20	1.1888	1.142	0.0426	0.0083	-5.638
-.0468									
WA36	WASA 360	1.22	22	16	1.2205	1.251	0.0727	0.0155	1.967
0.0305									
X-99	X-99	1.24	90	50	1.2397	1.269	0.0367	0.0039	7.512
0.0293									

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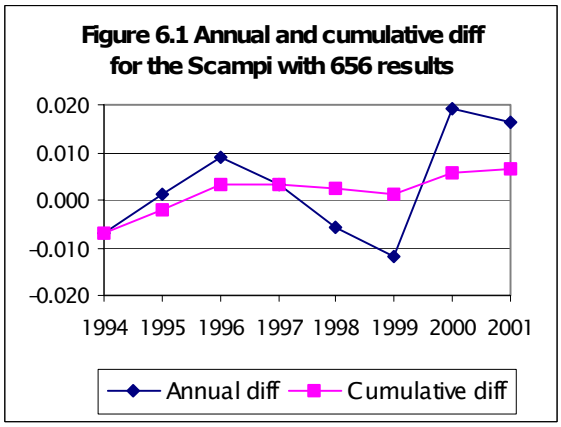
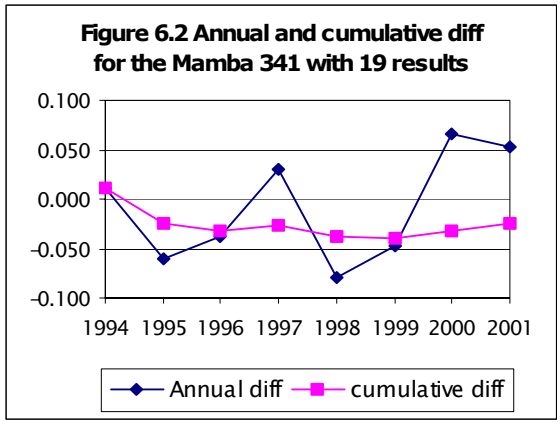
We also make statistics for all years, from the results of each year. Table 6.2 gives an example of statistics for a Scampi.

Figure 6.2 Statistics for the Scampi for the years 1994-2001

Year	Number of boats	Number of races	m(L)	m(Le)	s(Le)	diff	n*diff
1994	70	46	1.089	1.082	0.056	-0.007	-0.490
1995	95	47	1.090	1.091	0.036	0.001	0.095
1996	151	63	1.089	1.098	0.057	0.009	1.359
1997	57	24	1.090	1.093	0.041	0.003	0.171
1998	37	26	1.088	1.082	0.063	-0.006	-0.222
1999	38	28	1.083	1.071	0.055	-0.012	-0.456
2000	143	49	1.090	1.109	0.065	0.019	2.717
2001	65	26	1.090	1.106	0.051	0.016	1.040
Sum	656	309					4.214
Average						**0.006**	





A positive or negative diff, in particular a significant value for a large number of results, indicates that the boat type has performed better or worse than its actual listed number, and we should evaluate whether this should lead to modifications of LYS for that boat type. Then we must take all the factors mentioned in chapter 2 into account. A positive diff for a boat type that is usually sailed by very experienced sailors, or a negative diff for a typical cruiser, will not necessarily lead to any modifications of their LYS. Your professional experience as a rating officer will have to be used. This table also illustrates the important fact, that even when there is a large number of results for each year, you need several years to get a stable average. Figures 6.1 and 6.2 illustrate the development of diff over 7 years for a Scampi with a total number of 591 results and for a Mamba 341 with only 17 results. Cumulative diff here means that the value for a given year includes results from all previous years.

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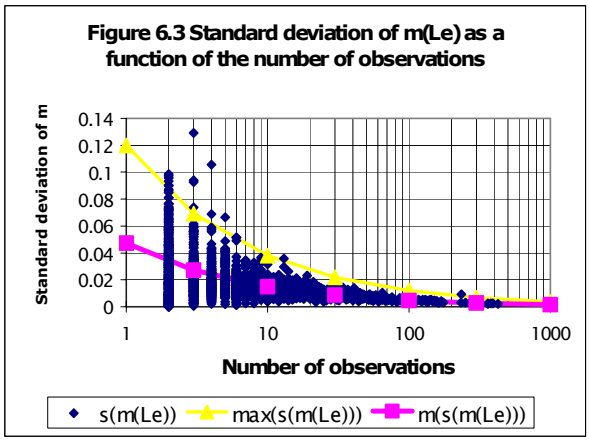
This shows that you need a considerable number of results over many years to get stable results, and that results from only one year may vary quite a lot.



The coefficient of variation of the observed LYS, Le, is on average 0.047 from all our data, which means that the coefficient of variation for the average of Le is

s(m(Le)) = 0.047/sqrt(n) Eq 6.8

where n is the number of observations.
This function is shown in Table 6.3 and in Figure 6.3, together with the observed values. Figure 6.3 shows that the maximum value of s(m(Le)) is approximately

max(s(m(Le))) = 0.12/sqrt(n) Eq 6.9

This gives a measure of how many observations you need in order to get the statistical errors below certain limits. We know that Le is normally distributed (see Figures 3.2 and 3.3), so with 10 observations, according to Table 6.3, you will expect that one third of the values of m(Le) will deviate more than +- 1.5% from the value you would expect with a large number of observations. The maximum value of s(m(Le)) from Table 6.3 is 0.0379, so occasionally you would expect deviations of more than 3.79% with 10 observations. To be reasonably confident that two thirds of the statistical deviations are less than 1% you need about 100 observations for one type of boat.

Individual results from one race should not be relied upon at all. On average one third of such results are expected to deviate more than +- 4.7% from the expected long term values, and occasionally one third of such results deviate more than +- 12% from the expected long term values.

Table 6.3 Standard deviation of the mean of the experienced rating as a function of number of race results

n	Average s(m(Le))	Maximum s(m(Le))
1	0.047	0.1200
3	0.0273	0.0693
10	0.0150	0.0379
30	0.0086	0.0219
100	0.0047	0.0120
300	0.0027	0.0069
1000	0.0015	0.0038

It should be remembered that these results have been obtained by means of IDEAL TIME calculations, and that suspect results and regattas have been deleted. The statistical errors given here are about the smallest that can be obtained.
Therefore if you don't use IDEAL TIME, and don't sort out suspect results, the statistical errors will be much larger, more than twice as large as shown here. This means that for individual results from one race you would expect that a boat with LYS = 1.0 occasionally will get results of 0.80 or 1.20.

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So individual results should not be trusted at all as a measure of handicapping number. Even 100 results for one year may be considerably biased. You need many results for several years to be reasonably confident that the statistics really tells you how well the boat has performed.

The number of LYS regattas and individual boat results analysed between 1994 and 2001 are shown in Table 6.4. This shows that generally speaking we have a fairly extensive statistical background for the LYS numbers, but for new boats it takes a few years to get reliable and stable statistics. Table 6.5 shows the top 20 list of boats with large numbers of results.

Table 6.4 Amount of data used in the Nordic LYS statistics

	Analysed		Used		Discarded		Discarded in %	
Year	Regattas	Boats	Regattas	Boats	Regattas	Boats	Regattas	Boats
1994	364	6089	292	5097	72	992	19.8	16.3
1995	378	6503	322	5852	56	651	14.8	10.0
1996	373	7063	302	5896	71	1167	19.0	16.5
1997	179	3202	139	2279	40	923	22.3	28.8
1998	275	4864	224	3865	51	999	18.5	20.5
1999	327	4379	275	3791	52	588	15.9	13.4
2000	402	6504	307	5660	95	844	23.6	13.0
2001	339	5342	231	3815	108	1527	31.9	28.6
Sum	**2637**	**43935**	**2092**	**36245**	**545**	**7690**	**20.7**	**17.5**

Table 6.5 Top 20 list of boats with large numbers of observed results

Boat type	1994	1995	1996	1997	1998	1999	2000	2001	Total
Express	394	363	427	163	276	276	380	289	2568
IF	233	234	252	109	134	362	271	175	1770
H-boat	113	170	154	76	152	115	104	139	1023
Folkboat	98	157	117	65	135	168	77	97	914
Smaragd	62	100	133	61	88	83	137	76	740
Fenix	145	161	94	29	49	78	125	40	721
606	92	130	103	52	77	147	71	31	703
Scampi	70	95	151	57	37	38	143	65	656
Maxi 77	96	56	97	32	66	55	100	41	543
Rival 22	67	82	57	41	26	53	119	86	531
Cumulus	92	52	77	45	68	52	66	59	511
X-99	21	55	58	26	56	56	90	65	427
Contrast 33	123	52	33	16	19	29	72	73	417
X-79	58	66	65	20	41	56	57	47	410
Albin 78 Cirrus	44	42	62	27	27	58	87	44	391
Maxi Racer	36	14	72	24	39	109	46	42	382
Comfortina 32	97	89	61	19	32	20	27	32	377
NF	32	56	65	18	17	55	55	58	356
Ballad	59	42	40	26	33	36	48	53	337
Omega 34	41	43	46	24	45	17	26	53	295

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I would like to thank Jørgen Bugge for his excellent co-operation. He has programmed the statistical analysis program and run the results all these years.

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