



2nd edition

HIGH FRANK BETHWAITE
PERFORMANCE
SAILING Faster Racing
Techniques

Contents

Introduction	xv
Some who helped	xix
Units, bows and noses	xx

PART ONE Wind

Chapter One ■ The Racing Helmsman's Wind	1
1.1 Where to sail?	1
1.2 Kiel	2
1.3 Marstrand	2
1.4 Keppel bay	3
1.5 Lake Garda	3
1.6 Rio de Janeiro	4
1.7 The different possibilities	4
Chapter Two ■ The Gradient Wind	5
2.1 The wind's driving force	5
2.2 Circulation	6
2.3 Ups and downs	8
2.4 Fires in the sky	8
Chapter Three ■ The Two Surface Winds	10
3.1 The two surface winds	10
3.2 Light airs	10
3.3 Breezes	10
3.4 Wind recording instruments	15
3.5 Factors which shape the wind	15
Chapter Four ■ Light Airs	20
4.1 Steady light air	20
4.2 Thermal excitation	20
4.3 Thermal excitation over water	21
4.4 Thermal excitation over dry land	21
4.5 Isolated thermal	22
4.6 Isolated thermals over large areas	23
4.7 The cellular mechanism	23
4.8 Unsteady air – the cellular pattern	24
4.9 Roll mechanism	25

- 4.10 Pulsing air – the transverse roll 25
- 4.11 Oscillating air – the longitudinal roll 25
- 4.12 Ribboning air – the boosted longitudinal roll 26
- 4.13 Shore effects 26
- 4.14 Pattern size 26
- 4.15 Practicalities 26
- 4.16 What to look for 27
- 4.17 Sydney Harbour – Australian Intervarsity championships 29
- 4.18 Tallinn – Baltic pre-olympic regatta 1978 30

Chapter Five ■ The Breeze over a Cool Surface

32

- 5.1 The onset of turbulence 32
- 5.2 The change of wind force on sails 32
- 5.3 The shape of the breeze 33
- 5.4 The gust mechanism 36
- 5.5 The fan 39
- 5.6 The effect of depth of the boundary layer 40

Chapter Six ■ Friction and Wind-Wave Patterns

41

- 6.1 Order – but where from? 41
- 6.2 Waves in the air – the friction mechanism 43
- 6.3 Oscillating surface waves 44
- 6.4 Regular or random 46
- 6.5 Transverse and other rolls 48

Chapter Seven ■ Heat and Thermal Patterns

52

- 7.1 Surface heat in calm conditions 52
- 7.2 Surface heat in light airs 52
- 7.3 Surface heat in breeze 52
- 7.4 Gusts plus surface heat 52
- 7.5 Wind-waves plus surface heat 53
- 7.6 Big wind-waves plus heat – the harmonic patterns 53
- 7.7 Small wind-waves – plus surface heat 57
- 7.8 The convergent/divergent pattern 59
- 7.9 The channelling winds 61
- 7.10 The two cell sizes 62
- 7.11 ‘Look for the speckled area’ 62
- 7.12 The wandering breeze 62
- 7.13 Chilled air 63

Chapter Eight ■ Winds near Clouds

64

- 8.1 The significant clouds 64
- 8.2 Frontal clouds 64
- 8.3 Ball clouds 65
- 8.4 Cumulus clouds – non raining 66
- 8.5 Raining clouds 69

Chapter Nine ■ Winds near Shores	73
9.1 Standing points	73
9.2 The sea breeze mechanism	73
9.3 The quadrant effect	75
9.4 Refinements	78
9.5 The funnelling winds	82
9.6 Shoreline factors	83
9.7 The chilled wind situation	88
9.8 The land breezes	89
Chapter Ten ■ Wind Appraisal and the Stability Index	92
10.1 The parts of the puzzle	92
10.2 The kind of wind	93
10.3 The probable pattern	96
10.4 The stability index	99
Chapter Eleven ■ Race preparation	102
11.1 Principles and priorities	102
11.2 Preparation – overview	104
11.3 The water's waves and currents	105
11.4 Pre-regatta preparation	105
11.5 Pre-race preparation	107
11.6 Pre-start preparation	108
11.7 The winds	108
11.8 Pre-regatta preparation	108
11.9 Pre-race preparation	110
11.10 Pre-start preparation	113
11.11 In unsteady winds	113
11.12 In the steadier winds	114
11.13 In the quicker oscillations	115
11.14 In deep boundary layers	117
Chapter Twelve ■ Sailing the Wind Patterns	119
12.1 The four groups	119
12.2 Sailing the unsteady winds	119
12.3 Sailing the wind-waves	122
12.4 Sailing through fronts	137
12.5 Sailing the cloud winds	137
12.6 The effects on wind of 'open' barriers	143

PART TWO Water

Chapter Thirteen ■ Waves	147
13.1 The four wave systems	147
13.2 Wave motion	148
13.3 Regular waves	149

High Performance Sailing

- 13.4 Chaotic waves 150
- 13.5 Swell 151
- 13.6 Standing waves 152

Chapter Fourteen ■ Depth and the Warm Surface Layer 154

- 14.1 Depth 154
- 14.2 The warm surface layer 154

Chapter Fifteen ■ Currents and Tidal Stream 158

- 15.1 Drive force 158
- 15.2 Friction effects and the velocity gradient 158
- 15.3 Flows through channels 158
- 15.4 Momentum effects 158
- 15.5 Flow over bars 159
- 15.6 Curves and eddies 160
- 15.7 Wind shear effects 160
- 15.8 Current and wave size 160

Preface to Part Three 163

PART THREE ▲ The Boat

Introduction 163

Chapter Sixteen ■ The Quest for Speed 164

- 16.1 Forces on a sailboat when sailing to windward 164
- 16.2 To sail faster 166
- 16.3 Changes of wind speed 167
- 16.4 The two wind speed ranges 169
- 16.5 Change of size 171
- 16.6 The emergence of ratios and weight 172
- 16.7 Historical performance limitations 171
- 16.8 Moving the crew to windward 174
- 16.9 The reduction of weight 174
- 16.10 The Eighteens and the third step 175
- 16.11 The dominance of ratios 178
- 16.13 Downwind faster 180
- 16.14 Some unexpected observations 182
- 16.15 The dynamics of catamarans and sailboards 183
- 16.16 The application of ratios and the future 184
- 16.17 Different paths – same destination 184

Chapter Seventeen ■ Sails 188

- 17.1 The starting point 188
- 17.2 Wings 188
- 17.3 The boundary layer 191
- 17.4 Sails behind masts 191

- 17.5 The separation bubble 194
- 17.6 Sails without masts 196
- 17.7 Super-critical and sub-critical flow 197
- 17.8 Dreams and realities 199
- 17.9 Modern rig development 204
- 17.10 Wingmasts – early development 207
- 17.11 The modern wingmast 209

Chapter Eighteen ■ Rigs

220

- 18.1 The four rig groups 220
- 18.2 Group one – gaff rigs 220
- 18.3 Group two – early Bermudan rigs 221
- 18.4 Group three – the experimental years 222
- 18.5 Objects and dynamics 223
- 18.6 Modern rigs 227

Chapter Nineteen ■ Foils

232

- 19.1 The foils – the centreboard, keel and rudder 232
- 19.2 Laminar flow sections 232
- 19.3 Surface texture 232
- 19.4 Modern foil development 234
- 19.5 Control at higher speeds 237
- 19.6 The drag of surface-piercing foils in wake 241
- 19.7 Centreboard area, point of sailing, wind speed and experience 243
- 19.8 Cambered centreboards 245
- 19.9 The rudder blade 245
- 19.10 Summary 246

Chapter Twenty ■ Hulls

247

- 20.1 Experimental background 247

The motion of a dinghy hull

- 20.2 Summary 262
- 20.3 Skin friction 262
- 20.4 Form drag 263
- 20.5 Induced drag and leeway 264
- 20.6 Rudder deflection drag 264

Wave making drag

- 20.7 The three modes 265
- 20.8 Displacement sailing 266
- 20.9 The forced mode 267
- 20.10 Breakout and planing 268
- 20.11 The fourth mode 270

Drag in waves

- 20.12 Drag in regular waves – upwind and downwind 271
- 20.13 Drag in regular waves – crosswind 274
- 20.14 Drag in chaotic waves 274
- 20.15 Drag in swell 275
- 20.16 Concepts of mode sailing 275

PART FOUR  Handling

Chapter Twenty One ■ Scope 277

- 21.1 Relevant conditions 277
- 21.2 High performance and other sailboats 277
- 21.3 Physical principles and administrative restrictions 277

Chapter Twenty Two ■ Handling to Windward 279

- 22.1 Conventional and high performance handling 279
- 22.2 Sailing for speed, comfort and survival 280
- 22.3 The three handling regimes 281
- 22.4 In light airs 281
- 22.5 In moderate breezes – the vital changes 287
- 22.6 Sail trim techniques 288
- 22.7 Effects of fluctuations and gusts on techniques 290
- 22.8 Handling in moderate breezes 290
- 22.9 In stronger breezes – the new factors 295
- 22.10 The trims for most power and least drag 296
- 22.11 Sail trim in 12–16 knots 297
- 22.12 Sail trim in 17–25 knots 298
- 22.13 Handling in stronger breezes 298
- 22.14 In rough air 302
- 22.15 Survival 304
- 22.16 To windward in waves 305
- 22.17 The effects of waves on performance 306
- 22.18 In waves and light airs 306
- 22.19 In waves and breeze – sail trim in 6 to 14 knots 309
- 22.20 In waves and breeze – sail trim in 15 to 25 knots 310
- 22.21 Handling in regular waves 315
- 22.22 Handling in chaotic waves 315
- 22.23 Handling in swell 316
- 22.24 Handling in waves and rough air 318

Chapter Twenty Three ■ Kinetics 320

- 23.1 Introduction 320
- 23.2 Negative kinetics – the part power pause 320
- 23.3 Positive kinetics 322
- 23.4 Impulse 322
- 23.5 Energy recovery 323
- 23.6 Overtrimming (pumping) 325
- 23.7 Combined impulse and pumping 326
- 23.8 Surging 328
- 23.9 Other possible techniques 329
- 23.10 Summary 331

Chapter Twenty Four ■ Sailing Crosswind 333

- 24.1 Crosswind sailing 333
- 24.2 Reaching dynamics 334

- 24.3 The design wind zones 336
- 24.4 The balance position 340
- 24.5 Steering for balance 341
- 24.6 Control at high speeds 344
- 24.7 In light air and flat water 346
- 24.8 In light air and waves 348
- 24.9 In moderate breeze and flat water 349
- 24.10 In moderate air and waves 351
- 24.11 Sailtrim crosswind in stronger breezes 352
- 24.12 Arc 1 – flat water and windward planing 353
- 24.13 Arc 1 – rough water 354
- 24.14 Arc 2 355
- 24.15 Arc 3 – zone A and flat water 355
- 24.16 Arc 3 – zone A and rough water 356
- 24.17 Arc 3 – zone B 357
- 24.18 Introduction to Arc 3 – zone C 358
- 24.19 Arc 3 – zone C in steady wind and flat water 358
- 24.20 Arc 3 – zone C in gusts and channelling 358
- 24.21 Arc 3 – zone C in waves 359

Chapter Twenty Five ■ Sailing Downwind

362

- 25.1 Sailing downwind – the principles and the performance factors 362
- 25.2 The fleeting dynamics of wind and wave 363
- 25.3 Rig characteristics and the properties of the delta planform 364
- 25.4 Hull characteristics 368
- 25.5 Handling in light airs and flat water 369
- 25.6 Two mode sailing 375
- 25.7 Handling in light air and waves 377
- 25.8 Downwind in breeze 379
- 25.9 Handling in blocking waves 380
- 25.10 Handling in surfing waves 382
- 25.11 Handling in mixed waves 384
- 25.12 Handling in chaotic waves 385
- 25.13 Handling in swell 386
- 25.14 Sailing the shifts 386
- 25.15 Handling in gusts 388
- 25.16 Practical handling downwind 392

Postscript 404

Appendix ■ Faster Sailing with Foilers

409

- 1. The unfinished foiler 410
- 2. 49er T-foiler (moth configuration) 410
- 3. 49er motor foiler 411
- 4. 49er sail foiler, Mk1, Jan to July '09 413
- 5. 49er sail foiler, Mk2, *Longlegs* 415

Index 417