

Contents

Part I Habitat, Substrata and Communities

Coordinated by Andrew R. Davis

Introduction	3
Andrew R. Davis	
1 Habitat Characteristics and Typical Functional Groups	7
Martin Wahl	
1.1 Particularities of the Aquatic Medium	7
1.2 Life Forms in Hard Bottom Communities	10
References	16
2 The Role of Mineral, Living and Artificial Substrata in the Development of Subtidal Assemblages	19
Andrew R. Davis	
2.1 Patterns on Temperate Hard Substrata	19
2.2 The Colonisation Process	22
2.3 The Role of Substrata in the Colonisation and Development of Assemblages	22
2.3.1 Artificial Substrata	23
2.3.2 Mineral Substrata	25
2.3.3 Biogenic Living Surfaces	28
2.4 Future Focus	30
References	31
3 Communities on Deep-Sea Hard Bottoms	39
Craig M. Young	
3.1 Islands in a Sea of Mud	39
3.2 Types of Hard Substrata in the Deep Sea	40
3.2.1 Substrata Formed by Volcanism	40
3.2.2 Polymetallic Nodules and Manganese Crusts	41
3.2.3 Carbonates	41

3.2.4	Methane Hydrate.....	42
3.2.5	Biogenic Surfaces	42
3.2.6	Organic Remains from the Upper Ocean.....	42
3.3	Major Groups of Deep-Sea Organisms.....	43
3.4	Population and Community Ecology of Hard-Bottom	
Deep-Sea Epifauna.....		45
3.4.1	Chemosynthetic Communities.....	45
3.4.2	Seamounts, Continental Slopes, and Islands	49
3.4.3	Deep Coral Reefs.....	51
3.4.4	Ferromanganese Nodules.....	52
3.4.5	Organic Materials from the Upper Ocean.....	52
3.4.6	Epizooism	53
3.5	Conclusions.....	54
References.....		55
4	Epibiosis: Ecology, Effects and Defences	61
	Martin Wahl	
4.1	Sessile Mode of Life	61
4.2	Establishment of an Epibiotic Community	61
4.3	Consequences of Epibioses.....	63
4.4	Distributional Patterns of Epibioses.....	65
4.5	Responses of the Host.....	67
References.....		69
 Part II Diversity Patterns and Their Causes		
Coordinated by Sean D. Connell		
Introduction.....		75
Sean D. Connell		
5	Latitudinal Patterns of Species Richness	
	in Hard-Bottom Communities	81
	João Canning-Clode	
5.1	Introduction.....	81
5.2	Case Studies.....	82
5.3	Discussion.....	84
References.....		85
6	Regional-Scale Patterns.....	89
	Jonne Kotta and Jon D. Witman	
6.1	Introduction.....	89
6.2	Regional Diversity—Biotic Interchange and Speciation	90
6.3	Influence of Regional Species Pools on Local Diversity.....	92
6.4	Local Diversity.....	94

6.5 Conclusions..... 96

References..... 97

7 Patterns Along Environmental Gradients 101
Antonio Terlizzi and David R. Schiel

7.1 Introduction..... 101

7.1.1 Definitions of Diversity..... 102

7.2 Zonation..... 103

7.2.1 Intertidal Zone..... 103

7.2.2 Subtidal Zone..... 105

7.3 Gaps in Knowledge..... 106

7.4 Concluding Remarks..... 107

References..... 109

8 Evolutionary Patterns of Diversity and Their Causes 113
Sharyn J. Goldstien and David R. Schiel

8.1 Introduction..... 113

8.2 Evolutionary Process..... 113

8.3 Regional Biogeographic Patterns..... 116

8.3.1 North America 117

8.3.2 Australasia 118

8.3.3 Europe..... 119

8.4 Discussion..... 121

References..... 122

9 Environmental Variability: Analysis and Ecological Implications 127
Lisandro Benedetti-Cecchi

9.1 Introduction..... 127

9.2 A Framework for Investigating Ecological Variability 128

9.3 Observational Approaches: Variability
in Ecological Responses 130

9.4 Experimental Approaches: Manipulation of Intensity
and Variance of Ecological Drivers 132

9.5 Future Directions 136

9.6 Conclusions..... 138

References..... 139

Part III Community Dynamics
Coordinated by Christopher D. McQuaid

Introduction..... 145
Christopher D. McQuaid

10 Fertilization Strategies	149
Ester A. Serrão and Jon Havenhand	
10.1 Introduction.....	149
10.2 Scope and Definition of Terms	150
10.2.1. Definitions.....	150
10.3 Main Topics in Fertilization Ecology of Rocky Shore Species	150
10.4 Gamete Traits that Influence Fertilization Success.....	153
10.4.1 In Broadcast Spawners.....	153
10.4.2 In Spermcasters	154
10.4.3 In Copulatory Fertilizers	155
10.5 Gamete Mixing	156
10.5.1 Role of Hydrodynamics	156
10.5.2 Role of Density/Aggregation Spawning	157
10.5.3 Role of Spawning Synchrony	157
10.6 Risk of Polyspermy and the Role of Polyspermy Blocks.....	158
10.7 Fertilization Compatibility.....	159
10.8 Conclusions.....	160
References.....	160
11 Larval Supply and Dispersal	165
Dustin J. Marshall, Craig Styan, and Christopher D. McQuaid	
11.1 Introduction.....	165
11.2 Variability in the Production of Larvae.....	165
11.2.1 Variation in Fecundity.....	165
11.2.2 Variation in Fertilisation	166
11.3 Mortality in the Plankton	167
11.3.1 Estimates of Mortality in the Field	167
11.3.2 Sources of Planktonic Mortality	168
11.3.3 Phenotypic Degradation of Larvae in the Field	168
11.4 Scales of Dispersal and Larval Supply	169
11.5 Genetic Consequences of Variation in Larval Production and Dispersal.....	172
11.6 Conclusions.....	173
References.....	173
12 Settlement and Recruitment	177
Stuart R. Jenkins, Dustin Marshall, and Simonetta Fraschetti	
12.1 Introduction.....	177
12.2 Definitions of Settlement and Recruitment.....	177
12.3 Patterns of Settlement and Recruitment on Hard Substrata.....	178
12.4 Behaviour at Settlement	180

12.5 Biological and Physical Interactions at Settlement..... 181

12.6 Early Post-Settlement Survival 183

12.7 Consequences of Variation in Settlement and Recruitment..... 184

12.8 Summary 186

References..... 186

13 Seasonal Dynamics..... 191
 Josep-Maria Gili and Peter S. Petraitis

13.1 Introduction..... 191

13.2 Causes, Cues and Clocks 192

13.3 Identifying Drivers and Responses 193

13.4 From Intertidal Habitats to Deep-Sea Communities..... 195

13.5 Future Directions 198

References..... 198

14 Disruption, Succession and Stochasticity..... 201
 J. Timothy Wootton, Mathieu Cusson, Sergio Navarrete,
 and Peter S. Petraitis

14.1 Definitions..... 201

14.1.1 Anthropogenic Versus Natural Disturbance..... 202

14.1.2 Physical Disturbance Versus Consumers 202

14.1.3 Other Ecological Disruptions..... 203

14.1.4 Stochasticity 204

14.2 Disruptions as Unique Events 205

14.3 Disruption as a Chronically Recurring Process 207

References..... 211

**15 Changes in Diversity and Ecosystem Functioning
 During Succession 213**
 Laure M.-L.J. Noël, John N. Griffin, Paula S. Moschella,
 Stuart R. Jenkins, Richard C. Thompson,
 and Stephen J. Hawkins

15.1 Introduction..... 213

15.2 Concepts and Terminology 213

15.3 Creation of New Space 215

15.4 Early Colonisation by Microorganisms 215

15.5 Macrobiotic Succession on Rocky Shores 216

15.6 Succession, Species Diversity and Ecosystem Processes 218

15.6.1 Diversity 218

15.6.2 Functional Consequences..... 219

15.7 Overview and Concluding Remarks 220

References..... 221

16 Simple and Complex Interactions 225
 Markus Molis and Bernardo A.P. da Gama

16.1 Introduction..... 225

16.2 Intraspecific Interactions..... 225

16.3 Interspecific Interactions..... 227

16.4 Community Interactions..... 231

 16.4.1 Multiple Predator and Prey Effects 232

References..... 234

Part IV Changing Biodiversity

Coordinated by Angus C. Jackson and M. Gee Chapman

Introduction 241
 Angus C. Jackson and M. Gee Chapman

17 Anthropogenic Changes in Patterns of Diversity on Hard Substrata: an Overview..... 247
 Brianna G. Clynick, David Blockley, and M. Gee Chapman

17.1 Introduction..... 247

17.2 Scales of Disturbances Affecting Distributions and Abundances 248

 17.2.1 Effects of Disposal of Waste Material and Spills..... 250

 17.2.2 Changes to Habitat Provided by Hard Substrata..... 251

 17.2.3 Direct Effects on Species 252

17.3 Conclusions..... 254

References..... 255

18 Shifts in Abiotic Variables and Consequences for Diversity 257
 Christopher D.G. Harley and Sean D. Connell

18.1 Introduction..... 257

18.2 Global-Scale Change 257

 18.2.1 Changes in Water Temperature 258

 18.2.2 Changes in Sea Level..... 259

 18.2.3 Increasing Frequency and Intensity of Storms..... 259

 18.2.4 Changes in Upwelling and Circulation 260

 18.2.5 Ocean Acidification 260

 18.2.6 Increasing UV Radiation..... 261

18.3 Regional-Scale Change 261

 18.3.1 El Niño–Southern Oscillation (ENSO)..... 262

 18.3.2 Other Interannual Oscillations 262

18.4 Local-Scale Change 263

 18.4.1 Permanent Abiotic Shifts: a Catchment Perspective..... 263

18.4.2 Regional and Middle-Scale Contingencies
of the Catchment Perspective..... 264

18.4.3 Departures: Abiotic Shifts Can Be Subtle
and Disconnected from Their Source..... 265

18.5 Conclusions..... 266

References..... 266

**19 The Loss of Natural Habitats and the Addition
of Artificial Substrata 269**
 Laura Airoidi, Sean D. Connell, and Michael W. Beck

19.1 Human Changes to Coastal Habitats..... 269

19.2 Causes of Habitat Loss..... 270

19.3 Trends of Habitat Loss..... 271

19.3.1 A Case History: the Decline of Native Oyster
Reefs in Europe..... 271

19.3.2 Habitat Conversion: Switches from Canopy
Habitats to Barrens/Turfs 272

19.4 The Addition of Artificial Hard Substrata 274

19.5 The Importance of Regional and Historical Contexts..... 276

19.5.1 Regional Contexts of Habitat Change..... 276

19.5.2 Historical Habitat Loss and the Shifting-Baseline
Syndrome 277

19.6 The Case for Mitigating Habitat Loss..... 277

References..... 278

**20 Multiple Stressors and Disturbances:
When Change Is Not in the Nature of Things 281**
 David R. Schiel

20.1 Introduction..... 281

20.2 A Framework of Disturbance by Multiple Stressors 282

20.3 Types of Stressors and Responses..... 282

20.4 Temporal Stressors..... 283

20.5 Spatial Patterns of Stressors..... 284

20.6 Empirical Evidence of Stressor Effects 284

20.6.1 Sedimentation 285

20.6.2 Species Reductions 286

20.6.3 Extractions, Harvesting, Removals 287

20.6.4 Non-indigenous Species (NIS) 288

20.6.5 Climate Change..... 289

20.6.6 Other Stressors 290

20.7 Conclusions..... 291

References..... 291

21 Mass Mortalities and Extinctions 295
 Carlo Cerrano and Giorgio Bavestrello

21.1 Introduction..... 295

21.2 Porifera..... 295

21.3 Cnidaria..... 296

 21.3.1 Hexacorals—Hard Corals 296

 21.3.2 Other Hexacorals..... 298

 21.3.3 Octocorals 299

21.4 Molluscs 300

21.5 Echinoderms 300

21.6 Ascidians..... 301

21.7 Extinctions and Massive Mortalities:
 Effects on Benthic Communities 301

References..... 303

**22 Biological Invasions: Insights from Marine Benthic
 Communities**..... 309
 Christopher D. McQuaid and Francisco Arenas

22.1 Introduction..... 309

22.2 The Arrival of Introduced Species:
 Vectors and Propagule Pressure 309

22.3 What Makes a Good Invader?..... 311

22.4 Which Communities Are More Susceptible to Invasion?..... 312

 22.4.1 Biotic Resistance, Competition, Predation
 and Facilitation: Interactions Between
 Native and Invasive Species 312

 22.4.2 The Role of Diversity in the Susceptibility
 of Communities to Invasion 313

 22.4.3 Disturbance and the Susceptibility to Invasion..... 314

22.5 The Effects of Invasions..... 315

22.6 Overview 317

References..... 317

**23 Habitat Distribution and Heterogeneity in Marine
 Invasion Dynamics: the Importance of Hard
 Substrate and Artificial Structure**..... 321
 Gregory M. Ruiz, Amy L. Freestone, Paul W. Fofonoff,
 and Christina Simkanin

23.1 Introduction..... 321

23.2 Habitat Distribution of Non-native Species
 in North America 321

 23.2.1 Importance of Hard Substrata for Marine
 Invasions..... 322

- 23.2.2 Temporal Pattern of Marine Invasions
on Hard Substrata..... 323
- 23.2.3 Distribution of Non-native Species Among Bays,
Estuaries and Outer Coasts 324
- 23.2.4 Role of Artificial Hard Substrata in Marine
Invasions..... 327
- 23.3 Integrating Substratum Heterogeneity
and Spatial Scale 329
- References..... 331

- 24 Rehabilitation of Habitat and the Value of Artificial Reefs..... 333**
Paris J. Goodsell and M. Gee Chapman
- 24.1 Introduction..... 333
- 24.2 Rehabilitation of Marine Habitats..... 334
 - 24.2.1 Removal of Obstructions to Natural Recovery 334
 - 24.2.2 Adding Biota or Structure to Existing Habitat..... 335
 - 24.2.3 Providing Novel Habitat 336
 - 24.2.4 Constructing Biotic Habitat 337
- 24.3 Evaluating Success of Rehabilitation..... 338
- 24.4 Conclusions..... 341
- References..... 341

- 25 Protection of Biota and the Value of Marine
Protected Areas 345**
Paris J. Goodsell and A.J. Underwood
- 25.1 Introduction..... 345
- 25.2 Protection Outside Reserves 345
 - 25.2.1 Contaminants 346
 - 25.2.2 Harvesting 347
- 25.3 Reserves as Protection—Principles 348
- 25.4 Reserves as Protection—Practice 349
- 25.5 What Happens Outside Reserves? 350
- 25.6 Assessing Effectiveness of Marine Reserves 352
- 25.7 Conclusions..... 353
- References..... 353

- Part V Role of Diversity**
Coordinated by Tasman P. Crowe, Heather E. Sugden,
and Stephen J. Hawkins

- Introduction..... 359**
Tasman P. Crowe, Heather E. Sugden, and Stephen J. Hawkins

26 The Role of Biodiversity for the Functioning of Rocky Reef Communities..... 361
 Lars Gamfeldt and Matthew E.S. Bracken

26.1 Introduction..... 361

26.2 How and Why Biodiversity Can Be Linked to Ecosystem Performance..... 362

26.3 Roles of Species in Mediating Ecosystem Performance..... 363

26.4 Biodiversity and Primary Production..... 364

26.5 The Role of Consumer Diversity 366

26.6 The Role of Within-Species Diversity 367

26.7 Conclusions and Outlook 368

References..... 369

27 Functional and Taxonomic Perspectives of Marine Biodiversity: Functional Diversity and Ecosystem Processes 375
 Tasman P. Crowe and Roly Russell

27.1 Introduction..... 375

27.2 Defining Diversity..... 375

27.3 Operational Characterisation of Functional Diversity 377

27.3.1 Trophic Position 378

27.3.2 Ad-hoc Groupings Based on Individual Characteristics..... 378

27.3.3 Classifications Based on Multiple Traits 379

27.3.4 Generalisable Quantifications of Functional/Trait Diversity..... 380

27.4 How to Test the Validity and Value of Particular Methods/Groupings..... 381

27.4.1 Correlational Approaches 382

27.4.2 Experimental Approaches..... 383

27.4.3 Modelling Approaches..... 384

27.5 Evidence from Hard Substrata Regarding Sensitivity of Systems to Changes in Functional Diversity 384

27.6 The Relative Importance of Functional and Taxonomic Diversity: Summary of Current Knowledge and Suggestions for the Future 386

References..... 387

28 Mechanisms Underpinning Diversity–Stability Relationships in Hard Bottom Assemblages..... 391
 Lisandro Benedetti-Cecchi

28.1 Introduction..... 391

28.2 Measures of Stability 393

- 28.3 Three Mechanisms Relating Stability to Diversity 394
 - 28.3.1 The Statistical Averaging (Portfolio) Effect 394
 - 28.3.2 The Covariance Effect..... 396
 - 28.3.3 Overyielding..... 398
- 28.4 Diversity–Stability Relationships in Assemblages
of Rocky Shores 398
- 28.5 Discussion 403
- References..... 405

**29 The Aesthetic Value of Littoral Hard Substrata
and Consideration of Ethical Frameworks
for Their Investigation and Conservation..... 409**

Heather E. Sugden, A.J. Underwood,
and Stephen J. Hawkins

- 29.1 Introduction..... 409
- 29.2 Aesthetics 410
 - 29.2.1 Rocky Shores 410
 - 29.2.2 Diving..... 410
 - 29.2.3 Impacts on Aesthetic Value..... 411
- 29.3 Ethics..... 412
 - 29.3.1 A Brief Background 412
 - 29.3.2 Experimental Ecology..... 414
 - 29.3.3 Recoverability 414
 - 29.3.4 Slow Recovery or Non-reversible Manipulations 415
 - 29.3.5 Biogeographic Studies and Non-native Species 415
 - 29.3.6 Genetic Considerations 416
- 29.4 Conclusions..... 418
- References..... 419

Part VI Appropriate Research Methods

30 Field and Research Methods in Marine Ecology 425
A.J. Underwood and Angus C. Jackson

- 30.1 Field Methods in Marine Ecology 425
 - 30.1.1 Sampling Organisms and Habitats 425
 - 30.1.2 Plankton 426
 - 30.1.3 Settlement of Organisms..... 426
 - 30.1.4 Measuring Behaviour..... 427
 - 30.1.5 Measuring Physical and Chemical Variables 427
 - 30.1.6 Data Handling 428
- 30.2 Experimental and Sampling Designs 428
 - 30.2.1 Why Do We Need Experiments? 428
 - 30.2.2 What Are Experiments? 429

30.2.3	Why Are Statistical Procedures Necessary?	431
30.2.4	Experimental and Sampling Designs	431
30.2.5	Some Major Issues with Experimental Designs	432
	References.....	434
Index	437



<http://www.springer.com/978-3-540-92703-7>

Marine Hard Bottom Communities
Patterns, Dynamics, Diversity, and Change
Wahl, M. (Ed.)

2009, XXIV, 446 p. 36 illus., 1 illus. in color., Hardcover
ISBN: 978-3-540-92703-7