

# Brief Contents

- 1 A Short History of Marine Community Ecology 1

## PART I Processes that Generate Pattern in Marine Communities 9

- 2 The Physical Context of Marine Communities 11
- 3 Foundation Species in Marine Ecosystems 37
- 4 Marine Dispersal, Ecology, and Conservation 57
- 5 The Role of Infectious Diseases in Marine Communities 85
- 6 Biodiversity and Ecosystem Function: Does Pattern Influence Process? 109
- 7 The Biogeography of Marine Communities 131
- 8 Marine Historical Ecology: Informing the Future by Learning from the Past 165

## PART II Community Types 201

- 9 Intertidal Rocky Shores 203
- 10 Soft-Sediment Communities 227
- 11 Salt Marsh Communities 251
- 12 Ecology of Seagrass Communities 271
- 13 Coral Reef Ecosystems: A Decade of Discoveries 299
- 14 Kelp Forests: Dynamic Patterns, Processes, and Feedbacks 315
- 15 Pelagic Communities 337
- 16 Phytoplankton Communities 365
- 17 Deep-Sea Hydrothermal Vent Communities 383

## PART III Conservation 401

- 18 Services of Marine Ecosystems: A Quantitative Perspective 403
- 19 Climate Change and Marine Communities 427
- 20 Threats to Marine Ecosystems: Overfishing and Habitat Degradation 449
- 21 Ecosystem-Based Approaches to Marine Conservation and Management 477
- 22 Marine Restoration Ecology 495
- 23 The Future of Marine Conservation and Management 517

# Contents

---

## **1** A Short History of Marine Community Ecology 1

The Beginning of Marine Ecology 1

Simple but Powerful Field Experiments Shift the Focus and Rigor of Marine Ecology 3

Marine Community Ecology since 2000 5

Why Marine Ecology? 6

PART



## **Processes that Generate Pattern in Marine Communities 9**

---

## **2** The Physical Context of Marine Communities 11

The Context Sensitivity of Organismal–Environmental Interactions 12

*Scaling up* 13

Important Aspects of the Physical Environment 13

*A few basic properties of fluids* 13

*Derived quantities* 13

The Importance of Gradients 18

*Gradients as determinants of physiological performance* 18

*Mass transfer* 18

*Heat transfer* 19

*Benthic, momentum, and diffusive boundary layers* 19

Ecological Implications 20

*Ecological effects of DBL and mass flux limitation* 20

*Flow effects in the benthic boundary layer* 21

Effects of Physical Forces across Scales 23

*Fertilization, attachment, and propagule supply* 25

*Food delivery* 29

*Regulation of predator–prey information transfer* 30

*Propagule supply and large-scale connectivity* 30

## **3** Foundation Species in Marine Ecosystems 37

Foundation Species along Environmental Stress Gradients 39

Foundation Species Shape the Spatial Pattern of the Landscape 41

Interactions among Multiple Foundation Species 43

Societal Value of Foundation Species 47

Conservation Concerns 48

Future Considerations 51

---

## **4** Marine Dispersal, Ecology, and Conservation 57

Dispersal Kernels 57

The Importance of Dispersal 58

*Population dynamics* 58

*Community structure* 59

*Metapopulation dynamics* 60

*Biogeography* 60

*Spread of advantageous alleles* 60

Measuring Dispersal with Genes 61

**Standard Equilibrium Population Genetics 61**

- Genetic drift* 61
- Hardy–Weinberg equilibrium* 61
- Testing differentiation* 62
- Measuring gene flow* 62
- The Waples zone* 62

**The Geography of Dispersal and Genetics 63**

- Isolation by distance (IBD)* 63
- Seascape models of gene flow* 64
- Nonequilibrium conditions* 65
- Assignment to populations and parents* 66
- Natural selection, gene flow, and dispersal* 67

**Key Determinants of Dispersal Spread and Pattern 68**

- Pelagic duration* 68
- Larval feeding* 68
- Larval behavior* 68
- Adult spawning behavior* 69
- Temporal variation in oceanographic conditions* 69
- Habitat patchiness* 70
- Retention versus immigration* 70
- Selection for or against immigrants* 71
- Influence of population size* 71

**Regional Surveys of Genetics and Dispersal 72**

- Meta-analyses of genetics and dispersal* 73

**What We Can Infer about Dispersal 74****Dispersal and Marine Conservation 75**

- Scales of dispersal* 75
- Dispersal and local fish stocks* 75
- Population rescue* 76
- Marine protected area design* 76
- Dispersal and MPAs in California* 77
- Dispersal and local adaptation* 77

## 5 The Role of Infectious Diseases in Marine Communities 85

**An Introduction to Infectious Diseases 85**

- Trophic strategies* 85
- Life cycles* 86
- Taxonomic groups* 86

**Parasites as a Part of Marine Biodiversity 87****Basic Epidemiology 88****Effects of the Environment on Infectious Diseases 89**

- Thermal stress and climate warming* 89

*Ocean acidification* 90

*Eutrophication* 90

**Effects of Free-Living Diversity on Infectious Diseases 91****Parasite Communities 92**

- Parasite communities in fishes* 92
- Larval trematode communities in snails* 93

**Host Regulation by Infectious Diseases 95**

- Bacteriophages and bacteria* 95
- Sea urchin epidemics* 95
- Trematodes and snails* 95
- Oysters and protozoan parasites in Delaware Bay* 96
- Parasites and sea otters* 96

**Mass Mortalities 97****Effects of Infectious Diseases on Marine Communities 99**

- Indirect effects of infectious diseases* 99
- Behavior* 100
- Food webs* 101

**Applied Aspects of Infectious Diseases 101**

- Fisheries and infectious diseases* 101
- Invasive species* 103

## 6 Biodiversity and Ecosystem Function: Does Pattern Influence Process? 109

**Definitions and Key Concepts 111****Theoretical, Conceptual, and Empirical Approaches 111**

- Theoretical foundations of biodiversity–ecosystem function research* 111
- Experimental approaches for testing concepts, questions, and theory* 114

**Major Findings of Marine BEF Research 117**

- Genetic diversity affects resilience and other functions* 118
- Species diversity affects function within and across trophic levels* 118
- Functional diversity explains diversity effects* 120
- Food web structure modifies the effects of diversity* 121
- Extinction order can determine how diversity loss alters function* 121

**Scaling Up Diversity Effects from Local Experiments to Regional Processes 123****BEF and Current Challenges in Marine Ecological Research 125**

---

## **7 The Biogeography of Marine Communities 131**

### **Species' Geographic Range Limits 132**

- Niche-based modeling* 133
- Temperature effects on survival and reproduction: Mechanistic studies* 134
- Biogeographic boundaries: Temperature or transport?* 134
- Dispersal limitation and range boundaries* 136
- Interactive effects of temperature and dispersal on range boundaries* 137
- Evolutionary processes and range boundaries* 138
- Implications and future directions* 139

### **The Geography of Abundance 139**

- The abundant-center hypothesis* 139
- Role of environmental heterogeneity* 140
- Role of dispersal in uncoupling habitat favorability and local abundance* 141
- Geographic variation in individual performance and demographic processes* 142
- Role of plasticity in physiological and life history traits* 144
- Role of evolutionary processes* 145
- Implications and future directions* 146

### **Latitudinal Variation in Species Interactions 147**

- Environmental stress gradients and the strength of competition and facilitation* 147
- Influence of temperature on per capita predation and herbivory* 148
- Population density, community composition, and context dependency* 149
- The role of variation in recruitment* 150
- Geographic mosaics of selection* 151
- Tropical–temperate comparisons of species interactions* 152
- Implications and future directions* 154

### **Local versus Regional Effects on Species Richness 154**

- Tests of community saturation and regional enrichment in marine systems* 155
- Latitudinal variation in local species interactions versus regional enrichment* 157
- Implications and future directions* 158

---

## **8 Marine Historical Ecology: Informing the Future by Learning from the Past 165**

### **Origin and Development of Marine Historical Ecology 166**

#### **How We Can Learn about the Past 167**

- Paleontological data* 168
- Archaeological data* 170
- Historical data* 172
- Fisheries and hunting records* 174
- Scientific surveys* 175
- Living memory* 178
- Molecular data* 178
- Integrating different data sources and disciplines* 179

#### **What We Can Learn from the Past 182**

- Environmental changes* 182
- Changes in species occurrence and abundance* 183
- Habitat alterations* 185
- Changes in water quality* 185
- Species invasions* 186
- Changes in ecosystem structure, functioning, and services* 186
- Overarching patterns* 187

#### **How the Past Can Inform the Future 188**

- Science and ecology* 188
  - Management and conservation* 192
  - Teaching and communication* 195
-

PART



# Community Types 201

---

## 9 Intertidal Rocky Shores 203

Oceanographic Drivers of Rocky Intertidal Community Structure 205

Scale: Relating Pattern to Process 207

*The analysis of pattern at multiple scales* 208

*Effects of scale in manipulative experiments* 209

The Community Consequences of Predation Risk 211

*Nonconsumptive predator effects and trait-mediated indirect interactions* 212

*NCEs, food chains, and ecosystem function* 214

*The effects of physical factors on the importance of NCEs and TMIs* 214

Biodiversity and Ecosystem Functioning 215

Climate Change and Local Human Impacts 216

*Shifting species ranges* 217

*Climate-driven environmental fluctuations* 217

*Local human impacts* 219

## 10 Soft-Sediment Communities 227

General Patterns 227

Invasive Species in Soft Sediment 234

*Soft-sediment estuaries and associated marshes are the most invaded marine habitats* 234

*Exotic species may have greater impacts in soft-sediment habitats* 234

Habitat Complexity and Soft-Sediment Communities 236

*Abiotic and biogenic structure in soft sediments* 236

*Soft sediments as a model for understanding structural complexity effects* 237

*Losses of habitat complexity to anthropogenic impacts* 239

Anoxia and Eutrophication in Soft-Sediment Communities 240

*Eutrophication and bottom-water hypoxia* 240

*Immediate and longer-term impacts of hypoxic events on community structure and biogeochemistry* 241

The Microphytobenthos 242

## 11 Salt Marsh Communities 251

The History of Salt Marsh Ecology 252

*Salt marsh experimental community ecology* 253

What's New in Salt Marsh Community Ecology? 255

*Salt marsh biogeography* 255

*Biodiversity* 257

*Human impacts* 258

*Grazer control, trophic cascades, and salt marsh die-off* 260

*Consumer control in southern United States marshes* 262

*Grazer-driven marsh die-off in northern United States marshes* 264

How Will Marshes Survive the Onslaught of Human Impacts? 267

Where Marsh Community Ecology Is Going 267

## 12 Ecology of Seagrass Communities 271

Seagrass Community Interaction Webs: A Conceptual Framework 275

Seagrasses as Foundation Species 275

*Seagrass modification of the environment and of biotic interactions* 275

*Seagrass demographic processes: Community-level consequences* 278

Control of Seagrass Community Processes 279

*Bottom-up control in seagrass communities* 279

*Top-down control in seagrass communities* 280

*Indirect effects of predation: Trophic cascades in seagrass ecosystems* 281

*Grazer diversity and trophic processes in seagrass beds* 283

## **Seagrass Ecosystem Functioning and Services** 284

*Control of productivity and trophic transfer in seagrass ecosystems* 284

*Landscape-level interactions among seagrasses and other habitats* 285

*Importance of seagrasses to human society* 286

## **Human Impacts on Seagrass Ecosystems** 287

*Change in seagrass ecosystems* 287

*Seagrass management and restoration* 290

## **Conclusions and Looking Forward** 291

*Seagrasses in a global seascape* 291

*Biological diversity and functioning of seagrass ecosystems* 291

*Seagrasses in a changing world* 292

# **13 Coral Reef Ecosystems: A Decade of Discoveries** 299

## **Biodiversity** 299

*How many species on coral reefs?* 299

*Patterns of species diversity* 301

## **Ecological Interactions** 302

*Predation and disease* 302

*Competition* 303

*Herbivory* 303

*Positive interactions* 303

*Food webs and trophic cascades* 305

*Community (dis)assembly rules* 306

## **The State of Coral Reefs** 306

*Local causes of decline* 307

*Global causes of decline* 309

*Interactions between multiple stressors* 310

*Phase shifts, tipping points, alternative states, and extinctions* 311

## **Prospects for Conservation and Management** 311

# **14 Kelp Forests: Dynamic Patterns, Processes, and Feedbacks** 315

## **The Evolution and Global Distribution of a Major Marine Biome** 316

*Diversity, biogeography, and evolution* 316

*Global distribution of kelp forests: Setting the stage* 317

## **Assembly and Disassembly of Kelp Forests: Global and Local Ecosystem Drivers** 319

*Kelp growth and forestation* 319

*Kelp deforestation: Abiotic and biotic drivers* 320

*Predation: Indirect effects on kelp forests* 323

*Trophic cascades: General ecological theory illustrated by kelp forest dynamics* 324

## **Alternative Stable States: Ecosystem Flips, Locks, and Feedbacks** 325

*Multiplicative effects of climate change and fishing* 327

*Other phase shifts from kelp forest: Interactions of local stressors with climate change* 330

# **15 Pelagic Communities** 337

## **Boundaries on a Boundless Ocean** 340

*Physical environment* 340

*Temperature* 341

*Stratification* 341

*Fronts* 342

*Upwelling* 343

*Eddies* 344

## **Delineation of Pelagic Habitats and Production Units** 344

*Boundary schemes* 344

*Boundless species* 345

## **Patterns and Processes in Pelagic Habitats** 347

*Patchiness and scale of physical and biological variables* 347

*Benthic–pelagic coupling* 348

*Size-structured food webs* 348

*Gradients in species diversity and body size* 349

## **Top-Down versus Bottom-Up Forcing in Pelagic Communities** 352

*Forcing from below (bottom-up control)* 352

*Forcing from above (predation)* 353

*Context dependence of food chain stability* 355

## **Major Perturbations Affecting the Structure and Function of Pelagic Ecosystems** 356

*Climate change* 356

*Eutrophication* 357

*Ecosystems exploited to the limit and beyond* 357

## 16 Phytoplankton Communities 365

Major Taxonomic Groups of Marine  
Phytoplankton 366

Principles Underlying Phytoplankton Community  
Structure and the Maintenance of Diversity 368

*Cell size and community co-limitation by resources and  
predators* 368

*Gradients of light versus nutrient availability* 371

*Nutrient ratios and nitrogen fixation* 372

*Non-equilibrium dynamics* 374

*Food web complexity* 376

Global Change 378

## 17 Deep-Sea Hydrothermal Vent Communities 383

Vent Habitat and Inhabitants 385

New Insights on Species Interactions 387

*What are the roles of species interactions in a physically  
extreme habitat?* 387

Larval Dispersal and Exchange in Patchy,  
Disturbed Habitat 388

*Can larvae travel far enough to disperse between  
vents?* 389

*Are vent populations open or closed?* 390

Colonization and Succession 392

Metacommunity Dynamics 393

Conservation of Vent Communities 396

## PART



## Conservation 401

## 18 Services of Marine Ecosystems: A Quantitative Perspective 403

Marine Ecosystem Services 404

*Spatial variation in the ecological production functions of  
coastal landscapes* 406

*Valuation of coral reef benefits* 408

Why Quantify Ecosystem Services? 408

*Assessing trade-offs* 409

*Evaluating cumulative impacts* 409

*Measuring management effectiveness* 410

Quantifying and Valuing Marine  
Ecosystem Services 411

*Mangrove conservation versus shrimp aquaculture  
development in Thailand* 411

*Louisiana Master Plan for Coastal Restoration and  
Protection* 413

*Ecosystem-based planning for multiple marine ecosystem  
services in British Columbia* 414

*Local investment in building resilient coastal  
communities* 416

Challenges for the Future 417

*Quantifying the role of biodiversity in supporting marine  
ecosystem services* 417

*Assessing marine ecosystem resilience* 419

*Linking science with action* 420

## 19 Climate Change and Marine Communities 427

What Is Climate Change? 427

Physical and Chemical Effects of Climate  
Change on the Oceans 428

*Ocean warming* 430

*Ocean acidification* 431

Ecological Effects of Climate Change 431

*Individual-level effects of ocean warming:  
Ecophysiology* 431

*Population-level effects of ocean warming* 432

*Individual- and population-level effects of ocean  
acidification* 433

*Changes in geographic ranges and phenology* 435

*Population- and species-level effects: Adaptation and  
acclimatization* 439

*Population- and species-level effects: Extinction* 439

*Community-level effects of climate change* 440  
 Ocean Solutions to Climate Change 441  
 Climate Change and Ocean Ecosystem  
 Services 443

---

## **20** Threats to Marine Ecosystems: Overfishing and Habitat Degradation 449

Types of Fisheries 450

Direct Effects of Fishing on Community  
 Structure 453

*Changes in abundance and biomass* 453

*Changes in size and age structure* 454

*Changes in composition and diversity* 455

*Extinction risk* 456

*Summary of direct effects* 457

Indirect Ecosystem Effects 457

*Top-down effects and trophic cascades* 457

*Bottom-up effects* 459

*Effects on ecosystem functioning* 460

*Summary of indirect effects* 460

Habitat Loss and Alteration 461

*Fishery-related habitat disturbance* 461

*Other forms of habitat disturbance* 461

*Direct effects of fisheries on benthic habitats* 462

*Effects of other habitat-degrading activities* 464

*Indirect effects of habitat degradation* 467

*Summary: Effects of habitat degradation* 467

*Habitat restoration* 468

Synthesis: The Ecosystem Approach to Fisheries  
 Management 470

*What is overfishing?* 470

*Ecosystem overfishing* 470

*Reference points for management* 471

*Summary of ecosystem-based fisheries  
 approaches* 473

Conclusions and Future Directions 473

---

## **21** Ecosystem-Based Approaches to Marine Conservation and Management 477

Ecosystem-Based Management 478

Marine Protected Areas 478

*The science of MPAs* 479

*The application of MPAs* 480

Marine Spatial Planning 483

A Key Related Tool: Cumulative Impact  
 Mapping 485

Major Themes in Marine Conservation and  
 Management in the Last Decade 487

*Humans as part of the system (social ecological  
 systems)* 487

*Ecosystem function and dynamics* 487

*Interdisciplinary science to support management for  
 multiple objectives* 488

*Resilience* 489

---

## **22** Marine Restoration Ecology 495

What Is Restoration? 495

Population-Level Approaches 497

Habitat-Level Approaches 499

*Salt marshes* 501

*Seagrasses* 503

*Oyster reefs* 504

*Coral reefs* 507

*Mangroves* 508

Landscape-Level Approaches 508

Ecosystem-Level Restorations 510

Socioeconomic Considerations in Marine  
 Restoration 511

---

## **23** The Future of Marine Conservation and Management 517

History of Marine Conservation and  
 Management 517

A New Framing: Emerging Issues in Marine  
 Conservation and Management 518

The Promise and Challenges  
 of Marine Conservation 519

*Beyond single-species fishery management* 519

*Fishery catch shares for job security and  
 conservation* 520

*Beyond marine protected areas: Managing cumulative  
 impacts and land-sea interactions* 522

*Ecosystem indicators: Tracking progress toward multiple  
 management objectives* 523

*Restoration ecology and economy* 526



*Incorporating climate into adaptation and hazard  
mitigation planning* 526  
*Considering linked dynamics of social and ecological  
systems* 528  
*Governance of common-pool resources* 529  
*Intermediate-complexity models for multi-objective  
management* 530  
*Ecolabeling and fishery certification* 531

*Using ecosystem service information in decisions* 533  
*Improving food security through seafood* 534  
**The Science and Art of Communication** 536  
**Opportunities Facing the Next Generation of  
Marine Conservation Scientists** 538

---

**Index** 545

---