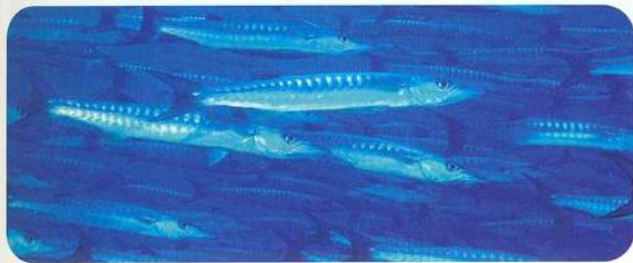


CONTENTS

Preface to the second edition xi
Preface to the first edition xii
Phylogenetic relationships among living and extinct fish groups xv



Part I Introduction 1

1 The science of ichthyology 3

What is a fish? 3
Superlative fishes 5
A brief history of ichthyology 6
Additional sources of information 7
Summary 9

2 Systematic procedures 11

Species 11
Taxonomy versus systematics 12
Approaches to classification 12
Taxonomic characters 14
Vertebrate classes 15
Units of classification 16
International Code of Zoological Nomenclature 16
PhyloCode 17
Name changes 17

Collections 18
Summary 19
Supplementary reading 19



Part II Form, function, and ontogeny 21

3 Skeleton, skin, and scales 23

Skeleton 23
Integumentary skeleton 36
Summary 40
Supplementary reading 40

4 Soft anatomy 41

Muscles 41
Cardiovascular system 45
Alimentary canal 48
Gas bladder 50
Kidneys 52
Gonads 52
Nervous system 54
Summary 56
Supplementary reading 56

5 Oxygen, metabolism, and energetics 57

Respiration and ventilation 57

Gas transport 64

Metabolic rate 66

Energetics 68

Summary 73

Supplementary reading 73

6 Sensory systems 75

Mechanoreception 75

Electroreception 80

Vision 84

Chemoreception 87

Magnetic reception 89

Summary 89

Supplementary reading 90

7 Homeostasis 91

Coordination and control of regulation 91

Temperature relationships 94

Osmoregulation, excretion, ion and pH balance 100

The immune system 105

Stress 106

Summary 108

Supplementary reading 109

8 Functional morphology of locomotion and feeding 111

Locomotion: movement and shape 111

Feeding: biting, sucking, chewing, and swallowing 119

Summary 127

Supplementary reading 128

9 Early life history 129

Complex life cycles and indeterminate growth 129

Early life history: terminology 130

Eggs and sperm 130

Embryology 137

Larvae 139

Getting from here to there: larval transport mechanisms 145

Summary 147

Supplementary reading 148

10 Juveniles, adults, age, and growth 149

Juveniles 149

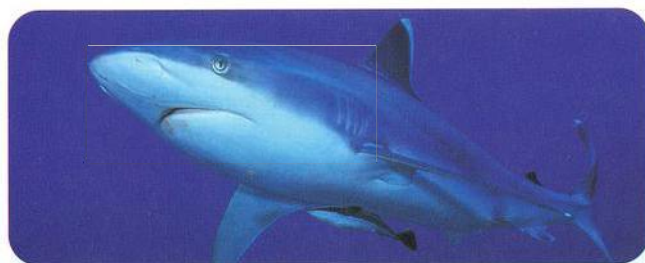
Adults 153

Age and growth 157

The ontogeny and evolution of growth 162

Summary 164

Supplementary reading 165



Part III Taxonomy, phylogeny, and evolution 167

11 "A history of fishes" 169

Jawless fishes 170

Gnathostomes: early jawed fishes 175

Advanced jawed fishes I: teleostomes (Osteichthyes) 178

Advanced jawed fishes II: Chondrichthyes 197

A history of fishes: summary and overview 200

Summary 203

Supplementary reading 204

12 Chondrichthyes: sharks, skates, rays, and chimaeras 205

Subclass Elasmobranchii 205

Subclass Holocephali 227

Summary 229

Supplementary reading 230

13 Living representatives of primitive fishes 231

Jawless fishes: lancelets, hagfishes, and lampreys 231

Primitive bony fishes 241

Conclusions 258

Summary 258

Supplementary reading 259

14 Teleosts at last I: bonytongues through anglerfishes 261

Teleostean phylogeny 261

A survey of living teleostean fishes 263

Neognathi 280

Neoteleostei 281

Acanthomorpha: the spiny teleosts 284

Summary 289

Supplementary reading 290

15 Teleosts at last II: spiny-rayed fishes 291

Superorder Acanthopterygii: introduction 291

Series Mugilomorpha 292

Series Atherinomorpha 293

Series Percomorpha: basal orders 296

Series Percomorpha, Order Perciformes: the perchlike fishes 300

Series Percomorpha: advanced percomorph orders – flatfishes and twisted jaws 322

Summary 325

Supplementary reading 326



Part IV Zoogeography, genetics, and adaptations 327

16 Zoogeography 329

Marine fishes 329

Freshwater fishes 339

Summary 354

Supplementary reading 354

17 Fish genetics 355

Fish genomics 355

Molecular ecology 360

Population genetics 365

Phylogeography 370

Molecular evolution 379

Conservation genetics 385

Summary 389

Supplementary reading 390

18 Special habitats and special adaptations 393

The deep sea 393

The open sea 401

Polar regions 405

Deserts and other seasonally arid habitats 410

Strong currents and turbulent water 415

Caves 417

Summary 420

Supplementary reading 421



Part V Behavior and ecology 423

19 Fishes as predators 425

Search and detect 425

Pursuit 426

Attack and capture 429

Handling 433

Scavengers, detritivores, and herbivores 436

Optimally foraging fishes 437

Summary 437

Supplementary reading 438

- 20 Fishes as prey** 439
- Avoiding detection** 439
 - Evading pursuit** 446
 - Preventing and deflecting attacks** 447
 - Discouraging capture and handling** 448
 - Balancing foraging against predatory threat** 452
 - Summary 453
 - Supplementary reading 454

- 21 Fishes as social animals: reproduction** 455
- Reproductive patterns among fishes** 455
 - Courtship and spawning** 461
 - Parental care** 468
 - Alternative mating systems and tactics** 473
 - Summary 475
 - Supplementary reading 476

- 22 Fishes as social animals: aggregation, aggression, and cooperation** 477
- Communication** 477
 - Agonistic interactions** 485
 - Aggregations** 488
 - Interspecific relations: symbioses** 492
 - Summary 496
 - Supplementary reading 497

- 23 Cycles of activity and behavior** 499
- Diel patterns** 499
 - Semilunar and lunar patterns** 507
 - Seasonal patterns** 509
 - Annual and supra-annual patterns: migrations** 515
 - Summary 522
 - Supplementary reading 523

- 24 Individuals, populations, and assemblages** 525
- Individuals** 525

- Populations** 529
- Assemblages** 536
- Summary 549
- Supplementary reading 550

25 Communities, ecosystems, and the functional role of fishes

 551

- Community-level interactions between fishes and other taxonomic groups** 551
- The effects of fishes on plants** 554
- The effects of fishes on invertebrate activity, distribution, and abundance** 559
- Fishes in the ecosystem** 563
- Influence of physical factors and disturbance** 577
- Summary 580
- Supplementary reading 581



Part VI The future of fishes

 583

26 Conservation

 585

- Extinction and biodiversity loss** 585
- General causes of biodiversity decline** 589
- What can be done?** 618
- Summary 621
- Supplementary reading 622

- References* 625
- Index* 693