

Contents

Preface — V

List of contributing authors — XV

Josefino C. Comiso

1	Variability and trends of global sea ice cover and sea level: effects on physicochemical parameters — 1
1.1	Introduction — 1
1.2	Variability and trends of global sea ice — 2
1.2.1	Arctic Region — 5
1.2.2	Antarctic Region — 8
1.3	Variability and trends in sea level — 12
1.3.1	Contributions from warming oceans — 13
1.3.2	Contributions from glaciers, ice sheets and others — 15
1.4	Effects on physicochemical parameters — 19
1.4.1	Large-scale changes in surface temperature — 19
1.4.2	Large-scale changes in plankton concentration and primary productivity — 20
1.4.3	Changes in other physicochemical parameters — 26
1.5	Discussion and conclusions — 29

Begoña Espiña, Marta Prado, Stephanie Vial, Verónica C. Martins, José Rivas, and Paulo P. Freitas

2	New techniques in environment monitoring — 35
2.1	Introduction — 35
2.2	<i>In situ</i> harmful algal bloom monitoring — 36
2.2.1	Optical remote sensing — 36
2.2.2	Automated monitoring — 38
2.2.3	HABs sampling based on absorption — 42
2.3	Liquid chromatography and mass spectrometry — 44
2.4	Biosensors for HABs monitoring — 46
2.4.1	Optical biosensors — 49
2.4.2	Electrochemical biosensors — 51
2.4.3	Mass biosensors — 51
2.4.4	Magnetic-based biosensors — 52
2.5	Advances in nanotechnology for HAB detection — 53
2.5.1	Nanoparticles — 54
2.5.2	Analytical nano-applications — 55
2.6	Molecular biology-based techniques for HABs detection — 64

2.6.1	Overview —	64
2.6.2	DNA/RNA targets —	65
2.6.3	Hybridization-based techniques —	70
2.6.4	Amplification-based techniques —	72
2.6.5	Aptamers for toxin detection —	75
2.7	Future perspectives —	76

Mikko Nikinmaa and Katja Anttila

3	Responses of marine animals to ocean acidification —	99
3.1	Introduction —	99
3.2	What causes ocean acidification —	99
3.2.1	Effect of atmospheric carbon dioxide loading —	100
3.2.2	Influence of primary production —	101
3.2.3	Carbon balance in coastal areas —	101
3.2.4	Interactions between temperature changes and ocean acidification —	102
3.3	Processes of animals that are expected to be affected —	102
3.3.1	pH regulation —	102
3.3.2	Calcification —	107
3.3.3	Development —	108
3.3.4	Oxygen transport and metabolism —	110
3.3.5	Behavior —	114
3.4	Conclusions —	115

Shauna Murray, Uwe John, and Anke Kremp

4	<i>Alexandrium</i> spp.: genetic and ecological factors influencing saxitoxin production and proliferation —	125
4.1	Introduction —	125
4.2	<i>Alexandrium</i> taxonomy, phylogenetics and species evolution —	126
4.3	What are saxitoxins? —	129
4.3.1	Which species produce saxitoxins? —	130
4.3.2	The <i>sxt</i> genes in dinoflagellates —	131
4.4	Ecological factors influencing <i>Alexandrium</i> spp. proliferation and toxicity —	133
4.4.1	The role of ecophysiological adaptations in ecology and bloom formation of <i>Alexandrium</i> life cycles —	133
4.4.2	Mixotrophic nutrition —	133
4.4.3	Allelopathy —	134
4.5	Effects of environmental factors on <i>Alexandrium</i> proliferation and toxicity —	135
4.5.1	Nutrients —	135
4.5.2	Temperature —	135

- 4.5.3 CO₂ — 138
- 4.5.4 Salinity — 139
- 4.6 Adaptation to changing climate conditions — 141

Susanna A. Wood, Jonathan Puddick, Hugo Borges, Daniel R. Dietrich, and David P. Hamilton

- 5 Potential effects of climate change on cyanobacterial toxin production — 155**
 - 5.1 Introduction — 155
 - 5.1.1 Microcystins and nodularins — 156
 - 5.1.2 Cylindrospermopsins — 157
 - 5.1.3 Saxitoxins — 157
 - 5.1.4 Anatoxin-a and homo-anatoxin-a — 157
 - 5.1.5 Anatoxin-a(S) — 158
 - 5.1.6 Lipopolysaccharides (LPS) — 158
 - 5.2 Effects of climate change on common toxin producing species — 159
 - 5.2.1 Microcystis — 160
 - 5.2.2 Cylindrospermopsis — 161
 - 5.2.3 Dolichospermum — 161
 - 5.2.4 Planktothrix — 162
 - 5.2.5 Phormidium — 163
 - 5.3 Effects of climate change on toxin regulation — 164
 - 5.3.1 Microcystins — 164
 - 5.3.2 Nodularins — 166
 - 5.3.3 Cylindrospermopsins — 166
 - 5.3.4 Saxitoxins — 167
 - 5.3.5 Anatoxins — 167
 - 5.4 Climate change and its effect on cyanobacteria and toxin production in Polar environments — 168
 - 5.5 Conclusions — 170

Gustaaf M. Hallegraeff

- 6 Harmful marine algal blooms and climate change: progress on a formidable predictive challenge — 181**
 - 6.1 Introduction — 181
 - 6.2 Algal bloom range extensions and climate change — 182
 - 6.3 Range extensions further aided by ship ballast water transport — 184
 - 6.4 The formidable challenge of predicting phytoplankton community responses — 187
 - 6.5 We can learn from the fossil record, long-term plankton records and decadal scale climate events — 188
 - 6.6 Mitigation of the likely impact on seafood safety — 188

Elke S. Reichwaldt, Som Cit Sinang, and Anas Ghadouani

7	Global warming, climate patterns and toxic cyanobacteria — 195
7.1	Introduction — 195
7.2	The effect of global warming on inland water bodies — 196
7.2.1	Direct effects of global warming on inland water bodies — 196
7.2.2	Indirect effects of global warming on inland water bodies — 197
7.3	The ecology of cyanobacteria and toxin production — 203
7.3.1	Environmental factors affecting cyanobacterial biomass — 203
7.3.2	Environmental factors affecting microcystin production — 204
7.3.3	Ecological factors affecting cyanobacterial blooms: competition — 206
7.4	Direct and indirect effects of global warming on cyanobacterial growth — 208
7.4.1	Temperature, stratification, and mixing — 215
7.4.2	Nutrients — 216
7.4.3	Salinity — 217
7.4.4	Turbidity and pH — 217
7.5	Direct and indirect effects of global warming on microcystin concentration — 217
7.6	Why should we care? — 219

Aristidis Vlamis and Panagiota Katikou

8	Human impact in Mediterranean coastal ecosystems and climate change: emerging toxins — 239
8.1	Introduction — 239
8.2	Mediterranean coastal ecosystems — 240
8.2.1	Human impact — 242
8.2.2	Socio-economical implications of Climate Change — 244
8.2.3	Effect to ecosystem from extreme events of climate change — 245
8.2.4	Ecological response to Climate Change — 246
8.3	Emerging toxins in the Mediterranean Sea — 248
8.3.1	Identified emerging toxins and climate change effects — 249
8.4	Conclusion — 259

Gurjeet S. Kohli, Hazel Farrell, and Shauna A. Murray

9	<i>Gambierdiscus</i>, the cause of ciguatera fish poisoning: an increased human health threat influenced by climate change — 273
9.1	The genus <i>Gambierdiscus</i> — 273
9.2	Morphology and phylogenetics — 274
9.3	Geographic distribution and abundance — 279
9.3.1	The Pacific and Indian Ocean Regions — 282
9.3.2	The Atlantic Ocean Region — 282
9.4	CTXs and MTXs — 283

- 9.5 Toxicity of different species of *Gambierdiscus* — 288
- 9.6 Detection of CTXs and MTXs in seafood — 289
- 9.7 Conclusion — 303

Dani J. Barrington, Xi Xiao, Liah X. Coggins, and Anas Ghadouani

- 10 Control and management of Harmful Algal Blooms — 313**
 - 10.1 Introduction — 313
 - 10.2 Global water crisis — 313
 - 10.3 Cyanobacteria and cyanotoxins — 314
 - 10.4 Cyanobacterial prevention and mitigation — 315
 - 10.5 Cyanobacterial management — 320
 - 10.6 Case study: The management of cyanobacteria in waste stabilization ponds — 323
 - 10.7 Treatment of cyanobacteria and cyanotoxins with hydrogen peroxide — 326
 - 10.8 New techniques for the control and characterization of cyanobacterial blooms — 335
 - 10.8.1 Allelopathic control of cyanobacteria — 335
 - 10.8.2 Optimization of the FDA-PI method using flow cytometry to measure metabolic activity of cyanobacteria — 336
 - 10.9 New perspectives and future directions — 338

Joaquín Espinosa, Sara Silva-Salvado, and Óscar García-Martín

- 11 Global climate change profile and its possible effects on the reproductive cycle, sex expression and sex change of shellfish as marine toxins vectors — 359**
 - 11.1 Introduction — 359
 - 11.2 Shellfish as marine toxins vectors — 360
 - 11.2.1 General considerations — 360
 - 11.2.2 Global increase in HABs — 362
 - 11.2.3 Global climate change — 365
 - 11.3 Reproductive cycle, sex expression and sex change in shellfish — 378
 - 11.3.1 Reproductive cycle, reproductive period and sex expression in bivalve mollusks — 378
 - 11.3.2 What is sex? — 379
 - 11.3.3 Sex determination: everything happens in the embryo — 380
 - 11.3.4 Sex determination of the gonad and sex differentiation of primordial germ cells (PGCs): molecular basis and regulation — 381
 - 11.3.5 Gonad somatic sex and germline sex in bivalve mollusks — 382
 - 11.3.6 Sex, sex reversal, types of sexuality and sex change in bivalve mollusks — 384

- 11.3.7 What does sex change mean and how could this process be performed by bivalve mollusks? — **391**
- 11.3.8 Temperature, photoperiod, reproductive cycle and sex change in bivalve mollusks — **393**
- 11.3.9 Climate change, reproductive cycle, sex expression and sex change in bivalve mollusks — **398**
- 11.4 Concluding remarks — **402**

M. Carmen Louzao, Natalia Vilariño, and Luis M. Botana

- 12 Effects on world food production and security — 417**
- 12.1 Introduction — **417**
- 12.2 Foodborne and waterborne diseases — **417**
- 12.3 Zoonosis and other animal diseases — **418**
- 12.4 Product safety in fisheries — **419**
- 12.5 Aquaculture food production — **423**
- 12.6 Harmful algal blooms — **423**
- 12.6.1 Impact of temperature change on harmful algal blooms — **424**
- 12.6.2 Acidification of waters and effect on harmful algal blooms — **426**
- 12.6.3 Impact of sea-level rise and increased precipitation on harmful algal communities — **426**
- 12.6.4 Microalgal toxicity — **427**
- 12.7 Harmful algal blooms and aquatic food safety — **428**
- 12.7.1 Predictive modeling — **433**
- 12.8 Future perspectives — **434**

Natalia Vilariño, M. Carmen Louzao, María Fraga, and Luis M. Botana

- 13 From science to policy: dynamic adaptation of legal regulations on aquatic biotoxins — 441**
- 13.1 Introduction — **441**
- 13.2 Current worldwide regulations on marine phycotoxins — **441**
- 13.2.1 Maximum permitted levels — **441**
- 13.2.2 Official detection methods — **446**
- 13.3 Current worldwide regulations on cyanotoxins — **447**
- 13.4 New occurrences of toxic episodes challenge protection of consumer's safety — **455**
- 13.5 Limitations for the development and implementation of new regulations: from science to policy or from policy to science? — **457**
- 13.5.1 Technical limitations for recent/future toxin regulations — **457**
- 13.5.2 Toxicological limitations for new toxin regulations — **461**
- 13.5.3 Economic limitations — **465**
- 13.6 Modification of monitoring and surveillance programs — **466**

13.7	Integrative example: tetrodotoxin as a biomarker of climate change —	467
13.8	Concluding remarks —	470
Index —		483