Preface to the Second Edition			Xiii
Preface to the First Edition			xiv
List	of Con	tributors	XV
1	Intro	duction	1
	John	S. Lucas	
	1.1	What is aquaculture?	1
	1.2	Origins of aquaculture and agriculture	2
	1.3	Aquaculture and capture fisheries production	4
	1.4	The 'Blue Revolution'	6
	1.5	An allegory	11
	1.6	Diversity of aquaculture	12
	1.7	Stock enhancement	12
	1.8	New developments in aquaculture	14
	1.9	Conclusions	16
		References	17
2	General Principles		18
	Peter Appleford, John S. Lucas and Paul C. Southgate		
	2.1	Introduction	18
	2.2	Structures used for aquaculture	18
	2.3	Intensity of aquaculture	26
	2.4	Static, open, semi-closed and recirculating (closed) systems	32
	2.5	Plumbing and pumps	37
	2.6	Site selection and development	42
	2.7	Hatchery systems	44
	2.8	Selecting a new species for culture	46
	2.9	Developing a new cultured species	48
		References	50
3	Water Quality		52
	Claude Boyd		
	3.1	Introduction	52
	3.2	Water quality variables	52
	3.3	Effects of water quality on culture species	62
	3.4	Water quality management	68
	3.5	Effluents	80

	3.6	Summary	81
		References	82
4	Environmental Aspects		
	Martin Kumar and Simon Cripps		
	4.1	Public image	84
	4.2	Impacts from land-based aquaculture	85
	4.3	Impacts of aquaculture within large water bodies	91
	4.4	General impacts on the environment	93
	4.5	Impact assessment	99
	4.6	Integrated wastewater treatment and aquaculture	101
	4.7	Integrated resource management	103
	4.8	Conclusions	104
		References	105
5	Deser	: Aquaculture	107
	Inland	l: Sagiv Kolkovski, Yitzhak Simon and Gideon Hulata	
	Coast	al: Sagiv Kolkovski and Nasser Ayaril	
	5.1	Introduction	107
	5.2	The Israeli experience	108
	5.3	Regional variation in Israel	108
	5.4	Aquaculture in geothermal water	108
	5.5	Water-limited aquaculture	112
	5.6	Indoor aquaculture facilities	116
	5.7	Desert coastal aquaculture technology – the Saudi Arabian experience	116
	5.8	Brine shrimp (Artemia sp.) production in Western Australia	120
	5.9	Species for water-limited aquaculture	121
	5.10	Conclusions and future directions	123
		References	124
6	Repro	duction, Life Cycles and Growth	126
	John	S. Lucas and Paul C. Southgate	
	6.1	Introduction	126
	6.2	Reproductive physiology	126
	6.3	Life cycles	129
	6.4	Growth	133
		References	137
7	Genetics		
	Rex Dunham		
	7.1	Introduction	138
	7.2	Basic genetics	138
	7.3	Domestication and strain evaluation	140
	7.4	Selection	141
	7.5	Inbreeding and maintenance of genetic quality	145
	7.6	Crossbreeding and hybridization	145
	7.7	Chromosomal techniques	149
	7.8	Molecular and genomic techniques	155
	7.9	Future developments	161
		References	162

8	Nutrition					
	Sena De Silva, Giovanni Turchini and David Francis					
	8.1	Introduction	164			
	8.2	Feed intake, digestion and nutrient absorption	165			
	8.3	Nutritional requirements	166			
	8.4	Types of feed	177			
	8.5	Selecting feed ingredients and formulation	180			
	8.6	Feed management	181			
	8.7	Major feed-related issues confronting the aquaculture sector	182			
	8.8	Conclusions	186			
		References	186			
9	Foods	Foods and Feeding				
	Paul C. Southgate					
	9.1	Introduction	188			
	9.2	Foods for hatchery culture systems	188			
	9.3	Microalgae	188			
	9.4	Zooplankton	194			
	9.5	Feeding strategy for larval culture	199			
	9.6	Compound hatchery feeds	200			
	9.7	Development of artificial diets for fish larvae	201			
	9.8	Harvesting natural plankton	202			
	9.9	Pond fertilisation as a food source for aquaculture	202			
	9.10	Compound feeds	204			
	9.11	Dispensing aquaculture feeds	210			
		References	212			
10	Diseases 2					
	Leigh (	Owens				
	10.1	Introduction	214			
	10.2	General principles of diseases in aquaculture	214			
	10.3	The philosophy of disease control	216			
	10.4	Generalised disease management techniques	217			
	10.5	Major diseases	220			
	10.6	Conclusions	228			
		References	228			
11	Post-harvest Technology and Processing					
	Allan Bremner					
	11.1	Introduction	229			
	11.2	Basic characteristics	229			
	11.3	Safety and health	230			
	11.4	Nutritional aspects	231			
	11.5	The balance between safety and nutrition	231			
	11.6	Aquaculture and fisheries products	231			
	11.7	Harvesting	232			
	11.8	Live transport	232			
	11.9	Muscle structure: rigor and texture	234			
	11.10	Stunning and post-mortem processing	236			
	11.11	Effects of feed on the product	237			

	11.12	Specialised niche market products	238
	11.13	Flavours and taints	238
	11.14	Texture	239
	11.15	Concepts: quality, freshness, shelf-life and quality index	239
	11.16	Microbiology, specific spoilage organism (SSO) and other spoilage processes	241
	11.17	Freezing and frozen storage	242
	11.18	Packaging	246
	11.19	Quality control, quality assurance, HACCP and risk assessment	248
	11.20	Traceability, identification and origin	249
	11.21	Canning	249
	11.22	Smoking	250
	11.23	Concluding remarks	250
		References	251
12		mics and Marketing	252
	Clem '		
	12.1	Introduction	252
	12.2	Profitability from a business viewpoint (farm models)	253
	12.3	Markets and marketing	256
	12.4	Economies of scale and similar factors	259
	12.5	Allowing for and coping with business risk and uncertainty	261
	12.6	Economic assessment from a social standpoint	264
		References	266
13	Seawe	ed and Microalgae	268
	Seawe	ed: Nicholas A. Paul and C. K. Tseng	
	Micro	algae: Michael Borowitzka	
	13.1	General introduction	268
	13.2	Seaweed	268
	13.3	Microalgae	284
		References	292
14	Carps		294
	Sena 1	De Silva	
	14.1	Introduction	294
	14.2	Aspects of biology	295
	14.3	Artificial propagation	296
	14.4	Nutrient requirements	299
	14.5	Culture	300
	14.6	Diseases	307
	14.7	Genetic improvement	307
	14.8	Economic viability	307
	14.9	Culture-based fisheries	308
	14.10	Recent developments in carp culture	310
	14.11	Conclusions	311
		References	311
15	Salmo	onids	313
	John I	Purser and Nigel Forteath	
	15.1	Introduction	313
	15.2	Biology	315

	15.3	Freshwater farming	317
	15.4	Marine farming	327
	15.5	Feeds	331
	15.6	Grading and stocking densities	333
	15.7	Maturation, sex reversal and triploidy	334
	15.8	Fish health	335
	15.9	Harvesting and products	336
		References	336
16	Tilapias		338
		Suresh and Ram C. Bhujel	
	16.1	Introduction	338
	16.2	Family, species and genetic variation	339
	16.3	Ecology and distribution	343
	16.4	Sex determination and reproduction	344
	16.5	Control of reproduction	345
	16.6	Seed production	348
	16.7	Nutrition, feeds and feeding	350
	16.8	Grow-out systems	354
	16.9	Disease management	359
	16.10	Harvest, processing and marketing	361
		References	362
17	Channel Catfish		365
		Tucker	2/-
	17.1	Introduction	365
	17.2	Biology	365
	17.3	Commercial culture	366
	17.4	Culture facilities	367
	17.5	Production practices	368
	17.6	Water quality management	373
	17.7	Nutrition, feeding and feed formulation	375
	17.8	Infectious diseases	376
	17.9	Harvesting and processing	380
	17.10	The future of channel catfish farming References	381 382
18	Marine	e Fish	384
10	John T		304
	18.1	Introduction	384
	18.2	Early development	384
	18.3	Environmental conditions for culture	387
	18.4	Rearing systems	394
	18.5	Fish for stocking	397
	18.6	Nutrition of larvae	401
	18.7	Larval culture types	406
	18.8	Juvenile and adult nutrition	409
	18.9	Health	413
	18.10	Family accounts	417
	20.10	References	443

19	Preven	iting Diseases in Fish by Vaccination	445
	Andrev	w Barnes	
	19.1	Definition	445
	19.2	History of fish vaccines	445
	19.3	Fish immunology in a nutshell	445
	19.4	Vaccinating fish	449
	19.5	Types of vaccine	449
	19.6	Routes of delivery	452
	19.7	Adjuvants	456
	19.8	Vaccination in practice	457
	19.9	Research and development track for commercial fish vaccines	458
	19.10	Conclusions	459
		References	459
20	Soft-sl	nelled Turtles	460
	Qingju	ın Shao	
	20.1	Introduction	460
	20.2	Biological characteristics	462
	20.3	Commercial culture	463
	20.4	Culture methods and facilities	464
	20.5	Culturing the developmental stages	466
	20.6	Water quality	469
	20.7	Nutrition, feeding and feed formulation	469
	20.8	Infectious diseases	471
	20.9	Harvesting and processing	472
	20.10	The future of soft-shelled turtle farming	474
		References	474
21	Marine	476	
	Darry	l Jory and Tomás Cabrera	
	21.1	Introduction	476
	21.2	Cultured species	478
	21.3	Grow-out systems	481
	21.4	Preparation of ponds	484
	21.5	Reproduction and maturation	488
	21.6	Hatchery design and larval culture	491
	21.7	Seedstock quality and stocking	494
	21.8	Production management and harvest	497
	21.9	Nutrition, formulated diets and feed management	503
	21.10	Emerging production technologies and issues	507
	21.11	Responsible shrimp farming and the challenge of sustainability	510
		References	512
22	Other Decapod Crustaceans		514
	Chaoshu Zeng, Yongxu Cheng, John S. Lucas and Paul C. Southgate		
	22.1	Introduction	514
	22.2	Cultured species	516
	22.3	The Chinese mitten crab	517
	22.4	Freshwater prawns	522
	22.5	Freshwater crayfish	527

	22.6	Mud crabs	533
	22.7	Spiny lobsters	538
		References	539
23	Rivaly	e Molluscs	541
23		Lucas	-
	23.1	Introduction	541
	23.2	Aspects of biology	541
	23.3	Cultured bivalves	545
	23.4	Phases of bivalve aquaculture	547
	23.5	Culture problems	554
	23.6	Introductions and other environmental issues	558
	23.7	Industry reviews	559
	23.8	The future of bivalve aquaculture	564
	23.0	References	565
24	Gastro	pod Molluscs	567
		Castell	
	24.1	Introduction	567
	24.2	Abalone	569
	24.3	Conchs	576
	24.4	Trochus	577
	24.5	Stock enhancement	579
	24.6	Conclusion	580
		References	581
25	Ornamentals		
	Daniei	Knop (marine) and Jonathan Moorhead (freshwater)	
	25.1	Introduction	583
	25.2	The aquatic ornamental industry	583
	25.3	Trade in ornamental fish	583
	25.4	Comparing the freshwater and marine ornamental fish trades	585
	25.5	Tropical marine ornamentals	585
	25.6	Aquaculture of coral reef fish	586
	25.7	Aquaculture of marine invertebrates	588
	25.8	Aquaculture of live rock	592
	25.9	Culture versus field collection of marine ornamentals	593
	25.10	Tropical freshwater ornamentals	594
	25.11	Commonly traded freshwater species	595
	25.12	Aquaculture of freshwater ornamental species	597
	25.13	Production and marketing goals	603
	25.14	The future of the ornamental industry	603
		References	603
26	The Next 20 Years		606
	Rohana Subasinghe and Nathanael Hishamunda		
	26.1	Introduction	600
	26.2	Recent trends in aquaculture development and major challenges	600
	26.3	Aquaculture development slows down, but it continues to grow	609
	26.4	Marine resources and aquafeeds	611

612

617

26.6	Diversification and expansion	613
26.7	Communication and networks	614
26.8	Aquaculture insurance	615
26.9	Unexplored opportunities	615
26.10	Conclusions	615

Environmental and social aspects

Index