

# Contents

<b>1</b>	<b>Sampling and Storage</b> . . . . .	1
1.1	Sampling . . . . .	1
1.2	Sampling Devices . . . . .	3
1.2.1	Intercomparison of Seawater Sampling for Trace Metals . . .	7
1.2.2	Intercomparison of Sampling Devices and Analytical Techniques Using Seawater from a CEPEX (Controlled, Ecosystem Pollution Experiment) Enclosure . .	12
1.3	Sample Preservation and Storage . . . . .	17
1.3.1	Losses of Silver, Arsenic, Cadmium, Selenium, and Zinc from Seawater by Sorption on Various Container Surfaces [54] . . . . .	19
1.3.2	Losses of Phthalic Acid Esters and Polychlorinated Biphenyls from Seawater Samples During Storage . . . . .	26
1.4	Sample Contamination During Analysis . . . . .	27
	References . . . . .	34
<b>2</b>	<b>Determination of Anions</b> . . . . .	39
2.1	Acetate . . . . .	39
2.1.1	Ion Chromatography . . . . .	39
2.2	Acrylate . . . . .	39
2.2.1	Ion Chromatography . . . . .	39
2.3	Alkalinity . . . . .	39
2.3.1	Titration Method . . . . .	39
2.3.2	Spectrophotometric Methods . . . . .	40
2.4	Arsenate/Arsenite . . . . .	41
2.4.1	Spectrophotometric Method . . . . .	41
2.5	Benzoate . . . . .	41
2.5.1	Ion Chromatography . . . . .	41
2.6	Butyrate . . . . .	41
2.6.1	Ion Chromatography . . . . .	41
2.7	Borate . . . . .	42
2.7.1	Spectrophotometric Method . . . . .	42
2.8	Bromate . . . . .	42
2.8.1	Spectrophotometric Titration and Differential Pulse Polarography . . . . .	42

---

2.9	Bromide . . . . .	45
2.9.1	Titration Method . . . . .	45
2.9.2	X-ray Emission Spectrometry . . . . .	45
2.9.3	Segmented Flow Analysis . . . . .	46
2.9.4	Solid State Membrane Electrodes . . . . .	46
2.9.5	X-ray Fluorescence Spectroscopy . . . . .	46
2.9.6	Isotachoelectrophoresis . . . . .	46
2.10	Chloride . . . . .	47
2.10.1	Titration Method . . . . .	47
2.10.2	Ion Selective Electrodes . . . . .	47
2.10.3	Chronopotentiometry . . . . .	48
2.10.4	Miscellaneous . . . . .	48
2.11	Chromate and Dichromate . . . . .	48
2.11.1	Atomic Absorption Spectrometry . . . . .	48
2.11.2	Organic Forms of Chromium . . . . .	49
2.12	Fluoride . . . . .	53
2.12.1	Spectrophotometric Method . . . . .	53
2.12.2	Ion Selective Electrodes . . . . .	53
2.12.3	Photoactivation Analysis . . . . .	56
2.12.4	Atomic Absorption Spectrometry . . . . .	56
2.13	Formate . . . . .	57
2.13.1	High Performance Liquid Chromatography (HPLC) . . . . .	57
2.14	Hypochlorite . . . . .	58
2.14.1	Spectrophotometric Method . . . . .	58
2.15	Iodate . . . . .	58
2.15.1	Spectrophotometric Method . . . . .	58
2.16	Iodide . . . . .	62
2.16.1	Titration Method . . . . .	62
2.16.2	Spectrophotometric Method . . . . .	63
2.16.3	Cathodic Stripping Voltammetry . . . . .	63
2.16.4	Ion Chromatography . . . . .	64
2.16.5	Miscellaneous . . . . .	64
2.17	Molybdate . . . . .	65
2.17.1	Atomic Absorption Spectrometry . . . . .	65
2.18	Nitrate . . . . .	65
2.18.1	Spectrophotometric Methods . . . . .	65
2.18.2	Ultraviolet Spectroscopy . . . . .	66
2.18.3	Chemiluminescence Method . . . . .	68
2.18.4	Flow Injection Analysis . . . . .	68
2.18.5	Continuous Flow Analysis . . . . .	69
2.18.6	Cathodic Stripping Voltammetry . . . . .	69
2.18.7	Ion Chromatography . . . . .	69
2.18.8	Bacteriological Method . . . . .	69
2.18.9	Miscellaneous . . . . .	71

2.19	Nitrite . . . . .	71
2.19.1	Spectrophotometric Methods . . . . .	71
2.19.2	Flow Injection Analysis . . . . .	72
2.19.3	Isotope Dilution Gas Chromatography . . . . .	72
2.19.4	Cathodic Stripping Voltammetry . . . . .	72
2.20	Nitrate and Nitrite . . . . .	73
2.20.1	Spectrophotometric Method . . . . .	73
2.20.2	Flow Injection Analysis . . . . .	73
2.20.3	Continuous Flow Analysis . . . . .	75
2.20.4	Reverse Phase Ion Interaction Liquid Chromatography . . . . .	75
2.20.5	Miscellaneous . . . . .	75
2.21	Perrhenate . . . . .	76
2.22	Phosphate . . . . .	76
2.22.1	Reverse Flow Injection Analysis . . . . .	76
2.22.2	Spectrophotometric Method . . . . .	77
2.22.3	Ion Chromatography . . . . .	82
2.23	Propionate . . . . .	82
2.23.1	Ion Chromatography . . . . .	82
2.24	Pyruvate . . . . .	82
2.24.1	Ion Chromatography . . . . .	82
2.25	Selenate/Selenite . . . . .	82
2.25.1	Fluorometric Method . . . . .	82
2.26	Silicate . . . . .	83
2.26.1	Spectrophotometric Methods . . . . .	83
2.26.2	Flow Injection Analysis . . . . .	84
2.26.3	Ion Exclusion Chromatography . . . . .	84
2.27	Sulfide . . . . .	85
2.27.1	Gas Chromatography . . . . .	85
2.27.2	Capillary Isotachoelectrophoresis . . . . .	85
2.28	Sulfate . . . . .	86
2.28.1	Titration Method . . . . .	86
2.28.2	Inductively Coupled Plasma Atomic Emission Spectrometry . . . . .	86
2.28.3	Polarography . . . . .	87
2.28.4	Ion Chromatography . . . . .	88
2.29	Valerate . . . . .	88
2.29.1	Ion Chromatography . . . . .	88
2.30	Multianion Analysis . . . . .	88
2.30.1	Spectrophotometric Methods, Phosphate, Arsenate, Arsenite, and Sulfide . . . . .	88
2.30.2	Electrostatic Ion Chromatography, Bromide, Nitrate, and Iodide . . . . .	89
2.30.3	Miscellaneous . . . . .	90
2.31	pH . . . . .	90
2.32	Suspended Solids . . . . .	91

---

2.33	Anion Preconcentration . . . . .	92
	References . . . . .	92
<b>3</b>	<b>Anions in Estuary and Coastal Waters . . . . .</b>	<b>99</b>
3.1	Nitrate . . . . .	99
3.1.1	Ultraviolet Spectroscopy . . . . .	99
3.2	Nitrate and Nitrite . . . . .	99
3.2.1	Autoanalyser Method . . . . .	99
3.3	Phosphate . . . . .	100
3.3.1	Spectrophotometric Method . . . . .	100
3.4	Selenate and Selenite . . . . .	100
3.4.1	Spectrofluorometric Method . . . . .	100
3.4.2	Atomic Absorption Spectrometry . . . . .	101
3.5	Sulfate . . . . .	101
3.5.1	Spectrophotometric Method . . . . .	101
3.6	Multianion Analysis . . . . .	102
3.6.1	Spectrophotometric Method, Sulfate, Phosphate, Nitrate, and Sulfide . . . . .	102
	References . . . . .	102
<b>4</b>	<b>Dissolved Gases . . . . .</b>	<b>103</b>
4.1	Free Chlorine . . . . .	103
4.1.1	Amperometric Titration Procedures . . . . .	103
4.2	Ozone . . . . .	108
4.3	Nitric Oxide . . . . .	108
4.4	Hydrogen Sulfide . . . . .	108
4.5	Carbon Dioxide . . . . .	108
	References . . . . .	109
<b>5</b>	<b>Cations in Seawater . . . . .</b>	<b>111</b>
5.1	Introduction . . . . .	111
5.2	Actinium . . . . .	112
5.3	Aluminium . . . . .	112
5.3.1	Spectrophotometric Methods . . . . .	112
5.3.2	Spectrofluorometric Methods . . . . .	113
5.3.3	Atomic Absorption Spectrometry . . . . .	114
5.3.4	Anodic Stripping Voltammetry . . . . .	114
5.3.5	Gas Chromatography . . . . .	114
5.4	Ammonium . . . . .	115
5.4.1	Spectrophotometric Methods . . . . .	115
5.4.2	Flow Injection Analysis . . . . .	118
5.4.3	Ion-Selective Electrodes . . . . .	118
5.4.4	High-Performance Liquid Chromatography . . . . .	118
5.5	Antimony . . . . .	119

5.5.1	Atomic Absorption Spectrometry . . . . .	119
5.5.2	Hydride Generation Atomic Absorption Spectrometry . . . . .	119
5.6	Arsenic . . . . .	120
5.6.1	Spectrophotometric Methods . . . . .	120
5.6.2	Atomic Absorption Spectrometry . . . . .	121
5.6.3	Neutron Activation Analysis . . . . .	122
5.6.4	Inductively Coupled Plasma Mass Spectrometry . . . . .	123
5.6.5	Anodic Stripping Voltammetry . . . . .	123
5.6.6	X-ray Fluorescence Spectroscopy . . . . .	124
5.7	Barium . . . . .	124
5.7.1	Atomic Absorption Spectrometry . . . . .	124
5.8	Beryllium . . . . .	125
5.8.1	Graphite Furnace Atomic Absorption Spectrometry . . . . .	125
5.8.2	Miscellaneous . . . . .	125
5.9	Bismuth . . . . .	126
5.9.1	Atomic Absorption Spectrometry . . . . .	126
5.10	Boron . . . . .	127
5.10.1	Spectrophotometric Methods . . . . .	127
5.10.2	Atomic Absorption Spectrometry . . . . .	128
5.10.3	Coulometry . . . . .	128
5.11	Cadmium . . . . .	129
5.11.1	Atomic Absorption Spectrometry . . . . .	129
5.11.2	Anodic Stripping Voltammetry . . . . .	134
5.12	Caesium . . . . .	135
5.12.1	Atomic Absorption Spectrometry . . . . .	135
5.13	Cerium . . . . .	136
5.14	Calcium . . . . .	136
5.14.1	Titration Methods . . . . .	136
5.14.2	Atomic Absorption Spectrometry . . . . .	138
5.14.3	Flame Photometry . . . . .	138
5.14.4	Calcium-Selective Electrodes . . . . .	138
5.14.5	Inductively Coupled Plasma Atomic Emission Spectrometry . . . . .	139
5.15	Chromium . . . . .	139
5.15.1	Total Chromium . . . . .	139
5.15.2	Chromium (III) . . . . .	142
5.15.3	Chromium (III) and (VI) . . . . .	143
5.15.4	Chromium (III) and Total Chromium. Gas Chromatography . . . . .	145
5.15.5	Organic Forms of Chromium . . . . .	145
5.16	Cobalt . . . . .	148
5.16.1	Spectrophotometric Methods . . . . .	148
5.16.2	Atomic Absorption Spectrometry . . . . .	149
5.16.3	Flow Injection Analysis . . . . .	150
5.16.4	Atomic Fluorescence Spectrometry . . . . .	150
5.16.5	Spectrofluorometry . . . . .	150

5.16.6	Chemical Luminescence Analysis . . . . .	150
5.16.7	Cathodic Stripping Voltammetry . . . . .	151
5.16.8	Polarography . . . . .	151
5.17	Copper . . . . .	152
5.17.1	Titration Procedures . . . . .	153
5.17.2	Atomic Absorption Spectrometry . . . . .	154
5.17.3	Spectrophotometric Method and Spectrofluorometric Method	155
5.17.4	Ion-Selective Electrodes . . . . .	155
5.17.5	Electroanalytical Methods . . . . .	155
5.17.6	Isotope Dilution Methods . . . . .	157
5.17.7	Electron Spin Resonance Spectrometry . . . . .	157
5.17.8	Miscellaneous Methods . . . . .	157
5.17.9	Copper Speciation . . . . .	157
5.18	Dysprosium . . . . .	163
5.19	Erbium . . . . .	163
5.20	Europium . . . . .	163
5.21	Gadolinium . . . . .	163
5.22	Gallium . . . . .	163
5.23	Germanium . . . . .	163
5.23.1	Hydride Generation Furnace Atomic Absorption Spectrometry . . . . .	163
5.24	Gold . . . . .	164
5.24.1	Inductively Coupled Plasma Mass Spectrometry . . . . .	164
5.24.2	Photometry . . . . .	164
5.25	Holmium . . . . .	164
5.26	Indium . . . . .	164
5.26.1	Neutron Activation Analysis . . . . .	164
5.27	Iridium . . . . .	165
5.28	Iron . . . . .	165
5.28.1	Spectrophotometric Methods . . . . .	165
5.28.2	Atomic Absorption Spectrometry . . . . .	166
5.28.3	Chemiluminescence . . . . .	166
5.28.4	Voltammetry . . . . .	167
5.28.5	Radioisotope Dilution . . . . .	167
5.29	Lanthanum . . . . .	167
5.30	Lead . . . . .	168
5.30.1	Atomic Fluorescence Spectroscopy . . . . .	168
5.30.2	Flow Injection Analysis . . . . .	168
5.30.3	Atomic Absorption Spectrometry . . . . .	168
5.30.4	Anodic Stripping Voltammetry . . . . .	172
5.30.5	Mass Spectrometry . . . . .	174
5.30.6	Miscellaneous . . . . .	174
5.31	Lithium . . . . .	174
5.31.1	Atomic Absorption Spectrometry . . . . .	174

---

5.31.2	Gel Permeation Chromatography . . . . .	174
5.31.3	Neutron Activation Analysis . . . . .	174
5.32	Lutetium . . . . .	175
5.33	Magnesium . . . . .	175
5.33.1	Gravimetric Method . . . . .	175
5.33.2	Atomic Absorption Spectrometry . . . . .	175
5.34	Manganese . . . . .	175
5.34.1	Spectrophotometric Methods . . . . .	176
5.34.2	Spectrofluorometric Method . . . . .	177
5.34.3	Atomic Absorption Spectrometry . . . . .	177
5.34.4	Polarography . . . . .	180
5.34.5	Neutron Activation Analysis . . . . .	180
5.35	Mercury . . . . .	180
5.35.1	Atomic Absorption Spectrometry . . . . .	180
5.35.2	Inductively Coupled Plasma Mass Spectrometry . . . . .	184
5.35.3	Inductively Coupled Plasma Atomic Emission Spectrometry . . . . .	184
5.35.4	Atomic Emission Spectrometry . . . . .	184
5.35.5	Colloid Flotation . . . . .	184
5.35.6	Miscellaneous . . . . .	186
5.36	Molybdenum . . . . .	186
5.36.1	Spectrophotometric Methods . . . . .	186
5.36.2	Atomic Absorption Spectrometry . . . . .	187
5.36.3	Inductively Coupled Plasma Mass Spectrometry . . . . .	188
5.36.4	Electrochemical Methods . . . . .	188
5.36.5	X-ray Fluorescence Spectrometry . . . . .	189
5.36.6	Miscellaneous . . . . .	189
5.37	Neodymium . . . . .	189
5.38	Neptunium . . . . .	190
5.39	Nickel . . . . .	190
5.39.1	Spectrophotometric Method . . . . .	190
5.39.2	Atomic Absorption Spectrometry . . . . .	190
5.39.3	Cathodic Stripping Voltammetry . . . . .	191
5.39.4	Liquid Scintillation Counting . . . . .	192
5.40	Osmium . . . . .	192
5.40.1	Resonance Ionisation Mass Spectrometry . . . . .	192
5.41	Palladium . . . . .	192
5.42	Platinum . . . . .	192
5.42.1	Cathodic Stripping Voltammetry . . . . .	192
5.43	Plutonium . . . . .	192
5.44	Polonium . . . . .	193
5.45	Potassium . . . . .	193
5.45.1	Titration . . . . .	193
5.45.2	Polarography . . . . .	193
5.45.3	Ion-Selective Electrodes . . . . .	194

---

5.46	Praseodymium . . . . .	194
5.47	Promethium . . . . .	194
5.48	Radium . . . . .	194
5.49	Rare Earths . . . . .	194
5.49.1	Cerium . . . . .	194
5.49.2	Praseodymium . . . . .	195
5.49.3	Neodymium . . . . .	195
5.49.4	Promethium . . . . .	195
5.49.5	Samarium . . . . .	195
5.49.6	Europium . . . . .	196
5.49.7	Gadolinium . . . . .	196
5.49.8	Terbium . . . . .	196
5.49.9	Dysprosium . . . . .	196
5.49.10	Holmium . . . . .	196
5.49.11	Erbium . . . . .	196
5.49.12	Thulium . . . . .	196
5.49.13	Ytterbium . . . . .	196
5.49.14	Lutetium . . . . .	196
5.49.15	Analysis of Rare Earth Mixtures . . . . .	197
5.50	Rhenium . . . . .	199
5.50.1	Graphite Furnace Atomic Absorption Spectrometry . . . . .	199
5.50.2	Neutron Activation Analysis . . . . .	200
5.51	Rubidium . . . . .	200
5.51.1	Atomic Absorption Spectrometry . . . . .	200
5.51.2	Spectrometry . . . . .	201
5.51.3	Mass Spectrometry . . . . .	201
5.51.4	X-ray Fluorescence Spectroscopy . . . . .	201
5.52	Ruthenium . . . . .	201
5.53	Samarium . . . . .	201
5.54	Scandium . . . . .	201
5.55	Selenium . . . . .	201
5.55.1	Spectrophotometry . . . . .	202
5.55.2	Atomic Absorption Spectrometry . . . . .	202
5.55.3	Hydride Generation Atomic Absorption Spectrometry . . . . .	202
5.55.4	Cathodic Stripping Voltammetry . . . . .	202
5.55.5	Gas Chromatography . . . . .	203
5.55.6	Neutron Activation Analysis . . . . .	203
5.56	Silver . . . . .	203
5.56.1	Atomic Absorption Spectrometry . . . . .	203
5.56.2	Neutron Activation Analysis . . . . .	204
5.57	Sodium . . . . .	204
5.57.1	Amperometry . . . . .	204
5.57.2	Polarimetry . . . . .	204
5.58	Strontium . . . . .	205



---

5.58.1	Atomic Absorption Spectrometry . . . . .	205
5.59	Technetium . . . . .	205
5.60	Tellurium . . . . .	205
5.60.1	Atomic Absorption Spectrometry . . . . .	205
5.61	Terbium . . . . .	206
5.62	Thallium . . . . .	206
5.63	Thorium . . . . .	206
5.63.1	Thermal Ion Mass Spectrometry . . . . .	206
5.63.2	Neutron Activation Analysis . . . . .	206
5.64	Thulium . . . . .	207
5.65	Tin . . . . .	207
5.65.1	Spectrophotometric Method . . . . .	207
5.65.2	Atomic Absorption Spectrometry . . . . .	207
5.65.3	Gas Chromatography . . . . .	207
5.65.4	High-Performance Liquid Chromatography . . . . .	209
5.65.5	Anodic Stripping Voltammetry . . . . .	210
5.65.6	Miscellaneous . . . . .	211
5.66	Titanium . . . . .	211
5.66.1	Spectrophotometric Method . . . . .	211
5.67	Tungsten . . . . .	211
5.68	Uranium . . . . .	211
5.68.1	Spectrophotometric Method . . . . .	211
5.68.2	Cathodic Stripping Voltammetry . . . . .	211
5.68.3	Polarography . . . . .	212
5.68.4	Miscellaneous . . . . .	212
5.69	Vanadium . . . . .	213
5.69.1	Spectrophotometric Method . . . . .	213
5.69.2	Atomic Absorption Spectrometry . . . . .	213
5.69.3	Inductively Coupled Plasma Mass Spectrometry . . . . .	214
5.69.4	Cathodic Stripping Voltammetry . . . . .	214
5.69.5	Neutron Activation Analysis . . . . .	214
5.70	Ytterbium . . . . .	215
5.71	Yttrium . . . . .	215
5.72	Zinc . . . . .	215
5.72.1	Spectrofluorometric Method . . . . .	216
5.72.2	Atomic Absorption Spectrometry . . . . .	216
5.72.3	Flow Injection Analysis . . . . .	217
5.72.4	Stripping Voltammetry . . . . .	217
5.72.5	Miscellaneous . . . . .	218
5.73	Zirconium . . . . .	218
5.74	Multication Analysis . . . . .	218
5.74.1	Titration Procedures . . . . .	218
5.74.2	Spectrophotometric Procedure . . . . .	219
5.74.3	Molecular Photoluminescence Spectrometry . . . . .	219

5.74.4	Flame Atomic Absorption Spectrometry . . . . .	220
5.74.5	Graphite Furnace Atomic Absorption Spectrometry . . . . .	223
5.74.6	Zeeman Graphite Furnace Atomic Absorption Spectrometry . . . . .	231
5.74.7	Hydride Generation Atomic Absorption Spectrometry . . . . .	233
5.74.8	Inductively Coupled Plasma Atomic Emission Spectrometry . . . . .	240
5.74.9	Inductively Coupled Plasma Mass Spectrometry . . . . .	244
5.74.10	Plasma Emission Spectrometry . . . . .	248
5.74.11	Anodic Stripping Voltammetry . . . . .	248
5.74.12	Cathodic Stripping Voltammetry . . . . .	259
5.74.13	Chronopotentiometry . . . . .	260
5.74.14	X-ray Fluorescence Spectrometry . . . . .	261
5.74.15	Neutron Activation Analysis . . . . .	262
5.74.16	Isotope Dilution Mass Spectrometry . . . . .	268
5.74.17	High-Performance Liquid Chromatography . . . . .	271
5.74.18	Metal Speciation . . . . .	271
5.74.19	Metal Preconcentration . . . . .	285
5.74.20	Miscellaneous . . . . .	288
	References . . . . .	288
<b>6</b>	<b>Cations in Estuary, Bay, and Coastal Waters . . . . .</b>	<b>313</b>
6.1	Ammonium . . . . .	313
6.2	Arsenic . . . . .	314
6.2.1	Hydride Generation Atomic Spectrometry . . . . .	314
6.3	Barium . . . . .	314
6.3.1	Atomic Absorption Spectrometry . . . . .	314
6.4	Cadmium . . . . .	315
6.4.1	Atomic Absorption Spectrometry . . . . .	315
6.5	Calcium and Magnesium . . . . .	316
6.6	Copper . . . . .	316
6.6.1	Titration Procedure . . . . .	316
6.6.2	Anodic Stripping Voltammetry . . . . .	316
6.7	Mercury . . . . .	317
6.7.1	Miscellaneous . . . . .	317
6.8	Manganese . . . . .	318
6.8.1	Polarography . . . . .	318
6.9	Selenium . . . . .	318
6.9.1	Hydride Generation Graphite Furnace Atomic Absorption Spectrometry . . . . .	318
6.10	Tin . . . . .	318
6.10.1	High-Performance Liquid Chromatography . . . . .	318
6.11	Multication Analysis . . . . .	319
6.11.1	Heavy Metals, Isotope Dilution, Spark Source Mass Spectrometry, and Inductively Coupled Plasma Atomic Emission Spectrometry . . . . .	319

6.11.2	Anodic Stripping Voltammetry . . . . .	322
6.11.3	Cathodic Stripping Voltammetry . . . . .	322
6.11.4	Emission Spectrometry . . . . .	323
6.11.5	Hydride Generation Atomic Spectrometry . . . . .	323
6.11.6	Inductively Coupled Plasma Mass Spectrometry . . . . .	323
6.11.7	Preconcentration Techniques . . . . .	324
6.11.8	Speciation . . . . .	325
	References . . . . .	325
<b>7</b>	<b>Radioactive Elements . . . . .</b>	<b>329</b>
7.1	Naturally Occurring Cations . . . . .	329
7.1.1	Actinium . . . . .	329
7.1.2	Polonium and Lead . . . . .	329
7.1.3	Radium . . . . .	331
7.1.3.1	Radium, Barium, and Radon . . . . .	331
7.1.3.2	Radium, Thorium, and Lead . . . . .	332
7.1.4	<sup>99</sup> Techneium . . . . .	333
7.1.5	Thorium . . . . .	333
7.1.6	Bromide . . . . .	335
7.1.7	Phosphate . . . . .	335
7.2	Fallout Products and Nuclear Plant Emissions . . . . .	336
7.2.1	Americium and Plutonium . . . . .	336
7.2.2	<sup>137</sup> Caesium . . . . .	336
7.2.3	<sup>60</sup> Cobalt . . . . .	338
7.2.4	<sup>55</sup> Iron . . . . .	338
7.2.5	<sup>54</sup> Manganese . . . . .	338
7.2.6	<sup>237</sup> Neptunium . . . . .	339
7.2.7	Plutonium . . . . .	339
7.2.8	<sup>106</sup> Ruthenium and Osmium . . . . .	341
7.2.9	<sup>90</sup> Strontium . . . . .	341
7.2.10	Uranium . . . . .	342
7.2.11	Miscellaneous . . . . .	344
	References . . . . .	344
<b>8</b>	<b>Sample Preparation Prior to Analysis for Organics . . . . .</b>	<b>349</b>
8.1	Soluble Components of Seawater . . . . .	350
8.1.1	Reverse Osmosis . . . . .	350
8.1.2	Freeze Drying . . . . .	350
8.1.3	Freezing-Out Methods . . . . .	351
8.1.4	Froth Flotation . . . . .	351
8.1.5	Solvent Extraction . . . . .	351
8.1.6	Coprecipitation Techniques . . . . .	353
8.1.7	Adsorption Techniques . . . . .	354
8.2	Volatile Compounds of Seawater . . . . .	355

8.2.1	Gas Stripping . . . . .	355
8.2.2	Headspace Analysis . . . . .	357
8.2.3	Fractionation . . . . .	358
8.3	Chemical Pretreatment of Organics . . . . .	361
	References . . . . .	362
<b>9</b>	<b>Organic Compounds . . . . .</b>	<b>365</b>
9.1	Aliphatic Hydrocarbons . . . . .	366
9.1.1	Spectrofluorometry . . . . .	366
9.1.2	Dynamic Headspace Analysis . . . . .	366
9.1.3	Raman Spectroscopy . . . . .	368
9.1.4	Flow Calorimetry . . . . .	368
9.2	Aromatic Hydrocarbons . . . . .	368
9.2.1	Spectrofluorometry . . . . .	368
9.2.2	High-Performance Liquid Chromatography (HPLC) . . . . .	369
9.3	Polyaromatic Hydrocarbons . . . . .	369
9.4	Oil Spills . . . . .	370
9.4.1	Spectrofluorometry . . . . .	370
9.4.2	Infrared Spectroscopy . . . . .	371
9.4.3	Gas Chromatography . . . . .	373
9.4.4	Gas Chromatography–Mass Spectrometry (GC–MS) . . . . .	375
9.4.5	Miscellaneous . . . . .	377
9.5	Carboxylic Acids and Hydroxy Acids . . . . .	377
9.5.1	Spectrophotometric Method . . . . .	377
9.5.2	Gas Chromatography . . . . .	377
9.5.3	Liquid Chromatography . . . . .	378
9.5.4	Atomic Absorption Spectrometry (AAS) . . . . .	379
9.5.5	Diffusion Method . . . . .	379
9.6	Ketones and Aldehydes . . . . .	380
9.6.1	Spectrophotometric Method, Fluorometric and Chemiluminescence Methods . . . . .	380
9.6.2	Potential Sweep Voltammetry . . . . .	380
9.6.3	Gas Chromatography . . . . .	381
9.7	Phenols . . . . .	381
9.7.1	Spectrophotometric Methods . . . . .	381
9.7.2	Gas Chromatography–Mass Spectrometry (GC–MS) . . . . .	382
9.8	Phthalate Esters . . . . .	382
9.9	Carbohydrates . . . . .	382
9.9.1	Spectrophotometry . . . . .	382
9.9.2	Enzymic Methods . . . . .	384
9.9.3	Liquid Chromatography . . . . .	384
9.9.4	Gas Chromatography . . . . .	385
9.9.5	Miscellaneous . . . . .	385
9.10	Cationic Surfactants . . . . .	386

9.10.1	Titration Method . . . . .	386
9.10.2	Atomic Absorption Spectrometry (AAS) . . . . .	386
9.10.3	Gas Chromatography–Mass Spectrometry (GC–MS) . . . . .	386
9.11	Anionic Surfactants . . . . .	386
9.11.1	Titration . . . . .	386
9.11.2	Spectrophotometry . . . . .	387
9.11.3	Atomic Absorption Spectrometry (AAS) . . . . .	387
9.11.4	High-Performance Liquid Chromatography (HPLC) . . . . .	388
9.12	Non-Ionic Surfactants . . . . .	388
9.12.1	Spectrophotometry . . . . .	388
9.12.2	Atomic Absorption Spectrometry (AAS) . . . . .	389
9.12.3	Liquid Chromatography–Mass Spectrometry (LC–MS) . . . . .	389
9.13	Aliphatic Chloro Compounds . . . . .	390
9.13.1	Gas Chromatography . . . . .	390
9.13.2	Purge and Trap Analysis . . . . .	390
9.13.3	Head Space Analysis . . . . .	391
9.13.4	Miscellaneous . . . . .	392
9.14	Volatile Organic Compounds . . . . .	392
9.14.1	Head Space Analysis . . . . .	392
9.14.2	Stripping Methods . . . . .	393
9.14.3	Mass Spectrometry . . . . .	393
9.15	Chlorinated Dioxins . . . . .	393
9.16	Nitrogen Compounds . . . . .	393
9.16.1	Spectrofluorometry . . . . .	394
9.16.2	Proteins and Peptides . . . . .	397
9.16.3	Nucleic Acids . . . . .	397
9.16.4	Enzyme Activity . . . . .	398
9.16.5	Aliphatic and Aromatic Amines . . . . .	398
9.16.6	Nitro-Compounds . . . . .	399
9.16.7	Azarenes . . . . .	400
9.16.8	Urea . . . . .	400
9.16.9	Hydroxylamine . . . . .	400
9.16.10	Acrylamide . . . . .	400
9.16.11	Ethylene Diamine Tetracetic Acid and Nitriloacetic Acid . . . . .	401
9.17	Sulfur Compounds . . . . .	401
9.17.1	Alkyl Sulfides and Disulfides . . . . .	401
9.17.2	Thiols . . . . .	402
9.17.3	Dimethyl Sulfoxide . . . . .	402
9.17.4	Thiabendazole . . . . .	402
9.17.5	Cysteine and Cystine . . . . .	403
9.17.6	Miscellaneous . . . . .	403
9.18	Chlorinated Insecticides . . . . .	403
9.18.1	Gas Chromatography . . . . .	403
9.18.2	High-Performance Liquid Chromatography . . . . .	404

9.19	Polychlorobiphenyls . . . . .	404
9.19.1	Gas Spectrofluorometry . . . . .	405
9.19.2	Gas Chromatography . . . . .	405
9.19.3	Column Chromatography . . . . .	408
9.19.4	Miscellaneous . . . . .	409
9.20	Organophosphorus Compounds . . . . .	409
9.20.1	Spectrophotometric Method . . . . .	409
9.20.2	Gas Chromatography . . . . .	410
9.20.3	Enzymatic Methods . . . . .	410
9.20.4	X-ray Fluorescence Spectrometry . . . . .	411
9.21	Azine Herbicides . . . . .	411
9.21.1	Gas Chromatography . . . . .	411
9.21.2	Gas Chromatography–Mass Spectrometry (GC–MS) . . . . .	411
9.21.3	High-Performance Liquid Chromatography (HPLC) . . . . .	411
9.22	Diuron, Irgalol, Chlorothalonil . . . . .	412
9.23	Lipids . . . . .	412
9.24	Sterols . . . . .	413
9.25	Chelators . . . . .	415
9.26	Humic Materials and Plant Pigments . . . . .	416
9.27	Vitamins . . . . .	423
9.28	Cobalamin . . . . .	423
9.29	Pectenotoxins . . . . .	423
9.30	Flavins . . . . .	426
9.31	Microcystine . . . . .	426
9.32	Preconcentration of Organics . . . . .	426
	References . . . . .	426
<b>10</b>	<b>Organometallic Compounds . . . . .</b>	<b>443</b>
10.1	Organoarsenic Compounds . . . . .	443
10.1.1	Atomic Absorption Spectrometry . . . . .	444
10.1.2	Spectrophotometric Method . . . . .	445
10.1.3	Miscellaneous Methods . . . . .	446
10.2	Organocadmium Compounds . . . . .	446
10.2.1	Anodic Scanning Voltammetry . . . . .	446
10.3	Organocopper Compounds . . . . .	446
10.4	Organolead Compounds . . . . .	447
10.5	Organomercury Compounds . . . . .	447
10.5.1	Atomic Absorption Spectrometry . . . . .	450
10.5.2	Gas Chromatography . . . . .	452
10.5.3	Miscellaneous . . . . .	454
10.6	Organothallium Compounds . . . . .	454
10.7	Organotin Compounds . . . . .	455
10.7.1	Atomic Absorption Spectrometry . . . . .	455
10.7.2	Gas Chromatography . . . . .	456

10.7.3	Hydride Generation Gas Chromatography–Microwave Induced Atomic Emission Spectrometry (HGGC–MIAES) . . . . .	459
10.7.4	Thermal Desorption-Gas Chromatography–Inductively Coupled Plasma Mass Spectrometry (TDGC–ICPMS) . . . . .	460
10.7.5	High-Performance Liquid Chromatography . . . . .	461
10.7.6	Miscellaneous . . . . .	461
	References . . . . .	462
<b>11</b>	<b>Elemental Analysis</b> . . . . .	<b>467</b>
11.1	Boron . . . . .	467
11.2	Total Iodine . . . . .	467
11.3	Organic Nitrogen . . . . .	468
11.4	Organic Phosphorus . . . . .	470
11.5	Silicon . . . . .	471
11.6	Total Sulfur . . . . .	471
11.7	Carbon Functions . . . . .	472
11.7.1	Dissolved Organic Carbon . . . . .	472
11.7.2	Dissolved Inorganic Carbon . . . . .	487
11.7.3	Particulate Organic Carbon . . . . .	489
11.7.4	Dissolved Organic Carbon . . . . .	490
11.7.5	Chemical Oxygen Demand . . . . .	493
11.7.6	Biochemical Demand . . . . .	496
11.8	Oxygen Isotopic Ratios . . . . .	498
	References . . . . .	498
<b>Subject Index</b>	. . . . .	<b>505</b>