Contents

1 Introduction 1
- 1.1 General objectives of the book 1
- 1.2 Why modelling radioactivity dispersion in the marine environment? 2
- 1.3 Marine dispersion models: from box models to full 3D dispersion models for non conservative radionuclides 3

2 Model structure and processes 11
- 2.1 Processes governing radionuclide dispersion 11
- 2.2 Model configuration. Resolution 15
- 2.3 Mixing time scales 16

3 Introduction to the transport equation 19
- 3.1 Introduction 19
- 3.2 Advection 19
- 3.3 Diffusion 23
  - 3.3.1 Vertical diffusion in the sea 27

4 Solving hydrodynamics 29
- 4.1 Introduction 29
- 4.2 Hydrodynamic equations 30
- 4.3 Numerical solution 32
- 4.4 Computing tidal currents. Boundary conditions 35
- 4.5 Something about tides 40
- 4.6 Residual transport 46

5 Solving hydrodynamics and dispersion 49
- 5.1 Introduction 49
- 5.2 Hydrodynamics on-line and off-line 49
- 5.3 The transport equation in non constant water flows and depths 51
- 5.4 Open boundary conditions 54

6 Modelling the dispersion of non conservative radionuclides 57
6.1 Introduction ... 57
6.2 Modelling the transport of suspended sediments ... 57
6.3 Kinetic models for uptake/release ... 62
6.4 The Rhone River plume dispersion model ... 73
6.4.1 Model description ... 76
6.4.2 Results: some examples ... 78

7 Lagrangian dispersion models ... 91
7.1 Introduction ... 91
7.2 Advection, diffusion and decay ... 92
7.3 GISPART model ... 95
7.3.1 Hydrodynamic module ... 96
7.3.2 Dispersion code ... 97
7.3.3 Input data ... 97
7.3.4 Model output ... 98
7.3.5 Examples ... 100
7.4 Water-sediment interactions ... 104
7.4.1 Formulation ... 104
7.4.2 Application ... 110

8 Dispersion in estuaries: an example ... 117
8.1 Introduction ... 117
8.2 The Odiel-Tinto estuary ... 119
8.3 Model description ... 120
8.4 Examples of results ... 123

9 Sensitivity analysis ... 135
9.1 Introduction ... 135
9.2 Classical sensitivity analysis ... 136
9.3 Monte Carlo based sensitivity study ... 138

10 Review of some radionuclide dispersion models ... 147
10.1 The European Continental Shelf model by Prandle ... 147
10.2 Ifremer long-term dispersion model for the English Channel and southern North Sea ... 148
10.3 THREETOX: Three dimensional model of toxicants transport ... 149
10.4 CEFAS Irish Sea model ... 150
10.5 MEAD model ... 151
10.6 Suez Canal model ... 151
10.7 The Artic Ocean environment ... 152
10.8 PCFLOW3D model ... 154
10.9 Global scale models ... 155

A Rhone River model: 3D equations 159
A.1 Hydrodynamic model 159
A.2 Suspended sediment model 162
A.3 Radionuclide equations 163
A.4 Numerical solution 165
A.5 Normalized σ coordinates 165

B Examples of codes 169
B.1 Advection term using the upstream scheme (1D) 169
B.2 Advection term using the MSOU scheme (1D) 170
B.3 Diffusion equation (1D) 171
B.4 Upstream scheme for a 2D problem 172
B.5 MSOU scheme for a 2D problem 174
B.6 Kinetic exchanges water-sediment 176
B.7 Stochastic method for the radioactive equation 177
B.8 Hydrodynamic model of the Strait of Gibraltar 178

C Disk contents 185

References 187

Index 199