

Contents

1	Why R, and Why Now?	1
2	R Tutorial for Oceanographers	5
2.1	Introduction	5
2.2	First Steps with R	8
2.2.1	License	8
2.2.2	Installation	8
2.2.3	R Packages	8
2.2.4	Running R	10
2.2.5	Getting Help	11
2.3	Syntax	12
2.3.1	Expressions	12
2.3.2	Variables	14
2.3.3	Basic Storage Types	16
2.3.4	Vectors	24
2.3.5	Arrays and Matrices	25
2.3.6	Lists	28
2.3.7	Factors	29
2.3.8	Data Frames	31
2.3.9	Contingency Tables	32
2.3.10	Conditional Evaluation	32
2.3.11	Functions	33
2.3.12	Loops	39
2.3.13	Alternative to Loops	40
2.4	Graphics	41
2.4.1	Scatter and Line Plots	41
2.4.2	Contour Plots	43
2.4.3	Image Plots	44
2.4.4	Hexagon Binning	45
2.4.5	Three-Dimensional Plots	46
2.4.6	Time-Series Plots	46

2.4.7	Box Plots	47
2.4.8	Lagged Autocorrelation Plots	47
2.4.9	Histogram Plots	48
2.4.10	Spectrum Plots	49
2.4.11	Pairs Plots	50
2.4.12	Conditioning Plots	51
2.4.13	Function Plots	52
2.4.14	Aesthetic Control of R Graphics	52
2.4.15	Limitations of R Graphics	53
2.5	Probability and Statistics	54
2.5.1	Probability	54
2.5.2	Statistics	55
2.5.3	Summaries and Overview Functions	57
2.5.4	Hypothesis Testing	58
2.5.5	Regression	61
2.5.6	Analysis of Variance	70
2.5.7	Partitioning Decision Trees	71
2.6	Numerical Methods	73
2.6.1	Sorting	73
2.6.2	Root Finding	73
2.6.3	Integration	73
2.6.4	Piecewise Linear Interpolation	74
2.6.5	Two-Dimensional Interpolation	75
2.6.6	Locally Weighted Polynomial Fitting	76
2.6.7	Interpolating and Smoothing Splines	76
2.6.8	Cluster Analysis	77
2.6.9	Fast Fourier Transforms	79
2.7	Input and Output	80
2.7.1	Reading from Text Files	80
2.7.2	Reading Binary Data	83
2.7.3	Reading Databases	84
2.7.4	Reading NetCDF Files	85
2.7.5	Writing Files	86
2.8	Creating R GUI Systems	87
2.9	Debugging	89
3	The <code>oce</code> Package	91
3.1	Package Options	91
3.2	File Formats	91
3.3	Object Orientation	93
3.4	Datasets	95
3.5	Functions	96
3.6	A Practical Example	98
3.7	Evolution of <code>oce</code>	100

4	Historical Examples	103
4.1	Seawater Chemistry (Redfield 1934)	103
4.2	Ecosystem Modelling (Riley 1946)	108
4.3	Plate Tectonics (Wilson 1963)	111
4.4	Ocean Mixing (Munk 1966)	113
4.5	Concluding Remarks	116
5	Practical Operating Procedures	119
5.1	Introduction	119
5.2	Hydrography	120
5.2.1	Seawater Calculation	120
5.2.2	Profile and Section Analysis	122
5.2.3	Water-Mass Analysis	129
5.3	Acoustical Data	137
5.4	Sea-Level and Tidal Analysis	139
5.5	Coastlines	142
5.6	Topography	142
5.7	Argo Floats	142
5.8	Satellites	143
5.9	General Analysis	146
5.9.1	Processing QC Flags	146
5.9.2	Handling Faulty Data	147
5.9.3	Dealing with Log-Normally Distributed Data	150
5.9.4	Time-Series Analysis	151
5.9.5	Gridding and Spatial Mapping	166
5.9.6	Differential Equations	171
5.9.7	Optimization	176
5.9.8	Eigenanalysis Methods	177
5.9.9	Neural Networks and Machine Learning	183
6	Solutions	187
6.1	Exercises in Chap. 2	187
6.2	Exercises in Chap. 3	209
6.3	Exercises in Chap. 4	211
6.4	Exercises in Chap. 5	217
Appendix A	Switching from Matlab to R	241
Appendix B	GUI Systems for R	245
Appendix C	Map Projections in <code>oce</code>	247
Appendix D	Seawater Formulations in <code>oce</code>	255
Appendix E	High-Performance Calculations	259

Appendix F The Future of R 267

References 269

Index 279