Contents

List of tables (v)
List of figures (vii)

Chapter 1 Introduction **1-23**

1.1 Isotopic Fractionation of Nitrogen..... 3
1.2 Natural distribution of $^{15}N/^{14}N$..... 5
1.3 Biogeochemical transformation of nitrogen in the marine environment..... 5
1.3.1 Nitrogen Fixation 6
1.3.2 Assimilation..... 7
1.3.3 Nitrification..... 8
1.3.4 Denitrification..... 8
1.3.5 Mineralisation..... 9
1.4 Global distribution of Nitrogen..... 9
1.5 Role of nitrogen and its isotopes in understanding the ocean biogeochemistry..... 9
1.5.1 Primary production and biological pump: Role in carbon cycle.... 11
1.5.2 Concept of New and Regenerated production..... 13
1.5.3 Estimation of New, Regenerated and Export production..... 15
1.5.4 Basis for using nitrogen for new and regenerated production..... 16
1.5.5 $\delta^{15}N$ in suspended particulate matter..... 16
1.6 Earlier productivity related works in the world ocean and the study Area..... 17
1.7 Scope of the present work..... 19
1.8 Outline of the thesis..... 20
1.9 Scientific questions addressed..... 21

Chapter 2 Materials and methods **24-53**

2.1 Introduction..... 25
2.2 New and Regenerated production estimation..... 26
2.3 Sampling..... 27
2.3.1 Bay of Bengal..... 27
2.3.2 Northeastern Arabian Sea..... 31
2.4 Nutrients..... 35
2.5 Tracer addition..... 36
2.6 Incubation..... 36
2.7 Filtration..... 37
2.8 Isotopic Analysis and Instrumentation..... 38
2.8.1 Principle of Analysis..... 38
2.8.2 Instrumentation..... 39

2.9	Standards Used and precision	43
2.10	^{15}N atom% Measurement	43
2.10.1	^{15}N atom% for blank samples	43
2.10.2	Error in ^{15}N atom% estimation	44
2.10.3	Linearity for ^{15}N atom%	44
2.11	Estimation of Particulate Nitrogen Content	45
2.11.1	Error in the Particulate Nitrogen Content estimates	47
2.12	Estimation of uptake rate	49
2.12.1	Concept of the general equation for uptake	49
2.12.2	Equation used for the calculation of uptake rate during the present study and involved uncertainties	50
2.13	Quality Control	52
2.14	Physical and chemical parameters	52

Chapter 3 The Northeastern Arabian Sea **54-107**

3.1	Introduction	55
3.2	^{14}C based Productivity in the Arabian Sea	58
3.3	^{15}N based productivity in the Northwestern and the Central Arabian Sea	62
3.4	Chlorophyll a, nutrients and physical parameters during January 2003 in the Northeastern Arabian Sea	63
3.4.1	Chlorophyll a	63
3.4.2	Nutrients	64
3.4.3	Hydrographic and meteorological conditions	66
3.5	^{15}N based productivity study during January 2003	69
3.5.1	Total Production	69
3.5.2	New Production	71
3.5.3	Regenerated production	73
3.5.4	Rationale for preference of ammonium over nitrate	74
3.5.5	Vertical profile of Nitrate and Ammonium Uptake	76
3.5.6	f-ratio during January 2003	78
3.5.7	Effect of winter cooling on the f-ratio	80
3.5.8	Low f-ratio despite presence of nutrients in the water column	81
3.6	Chlorophyll a, nitrate and physical parameters during late February- early March 2003 in the Northeastern Arabian Sea	82
3.6.1	Chlorophyll a	82
3.6.2	Nitrate	84
3.6.3	Hydrographic and meteorological conditions	85
3.7	^{15}N based productivity study during late February-early March 2003	88
3.7.1	Total Production	88
3.7.2	Regenerated Production	89
3.7.3	New production	90
3.7.4	Vertical profiles of nitrate uptake	92
3.7.5	f-ratio	93
3.7.6	Source of nutrients for the sustenance of the bloom	94

3.8	Natural Isotopic Composition of Surface Suspended Matter.....	96
3.8.1	January.....	98
3.8.2	Late February- Early March.....	98
3.8.3	Possible reasons for increased $\delta^{15}N$.....	100
3.9	Conclusions.....	107

Chapter 4 The Bay of Bengal **108-172**

4.1	Introduction.....	109
4.2	Effect of tracer concentration and incubation time on the uptake rate of nutrients.....	110
4.2.1	Material and Methods.....	112
4.2.2	Physical conditions and nutrients at the experimental stations.....	113
4.2.3	Results and Discussion.....	115
4.3	Earlier measurements of ^{14}C based Productivity and Chl *a* in the Bay of Bengal.....	123
4.4	Chlorophyll *a*, nitrate and physical parameters during the postmonsoon (September-October) 2002.....	124
4.4.1	Chlorophyll *a*.....	124
4.4.2	Nitrate.....	125
4.4.3	Hydrographic and meteorological conditions.....	126
4.5	^{15}N based productivity study during postmonsoon 2002.....	128
4.5.1	Total Production.....	128
4.5.2	New Production.....	129
4.5.3	Regenerated Production.....	131
4.5.4	f-ratio.....	132
4.6	Chlorophyll *a*, nitrate and physical parameters during premonsoon (April-May 2003)	133
4.6.1	Chlorophyll *a*.....	133
4.6.2	Nitrate.....	134
4.6.3	Hydrographic and meteorological Conditions.....	135
4.7	^{15}N based productivity study during premonsoon 2003.....	137
4.7.1	Total Production.....	137
4.7.2	New Production.....	138
4.7.3	Regenerated Production.....	140
4.7.4	f-ratio.....	142
4.8	Implications of the new production measurements in the Bay of Bengal	143
4.9	Relationship between new and total production: possible implication.....	147
4.10	Possible nutrient sources to the Bay of Bengal.....	150
4.11	Natural Nitrogen Isotopic Composition of Suspended Matter.....	154
4.11.1	Surface suspended matter.....	154
4.11.2	Depth profiles of $\delta^{15}N$ of suspended matter.....	160
4.12	Primary productivity estimation using IRS P4 OCM.....	163
4.12.1	OCM data processing for Oceanic constituents.....	164
4.12.2	Estimation of Primary production.....	166
4.12.3	Discussion.....	168
4.13	Conclusion.....	172

Chapter 5 Summary and scope for future work **173-181**

5.1 Important findings of this study..... 174
5.5.1 New productivity study in the Bay of Bengal..... 174
5.5.2 Results from uptake experiment..... 176
5.5.3 Natural isotopic composition of nitrogen in suspended matter of the Bay of Bengal..... 176
5.5.4 Total productivity comparison with IRSP4 data..... 177
5.5.5 New and regenerated production in the Northeastern Arabian Sea..... 177
5.5.6 Natural isotopic composition of nitrogen in the suspended matter of the Arabian Sea..... 178
5.2 Scope for future work..... 179

References **182-202**