CONTE	NTS		
PREFACE Chapter	1	Ocean Science	iii 2
		OCEANOGRAPHY AS A SCIENCE MARINE RESOURCES AND TECHNOLOGY	4 5
CHAPTER	2	OCEAN CAREERS	5
	-	Exploration and the Development of Oceanography	6
		EARLY EXPLORATION	9
		MAPS AND CHARTS – SIZE AND SHAPE OF THE OCEANS LATITUDE AND LONGITUDE MAP PROJECTIONS	10 11 12
		NAVIGATION – FINDING ONE'S POSITION AT SEA ELECTRONIC NAVIGATION AIDS	14 15
		DEVELOPMENT OF MODERN OCEANOGRAPHY	18 22
		OCEANOGRAPHIC DEVELOPMENT IN THE UNITED STATES THE ERA OF INTERNATIONAL PROGRAMS	26 29
		SUMMARY	32

CHAPTER	3	Earth: The Planet With an Ocean	34
		PLACE OF THE EARTH IN THE SOLAR SYSTEM STRUCTURE OF THE SOLAR SYSTEM	36 36
		ORIGIN OF THE OCEANS	38
		MAJOR FEATURES OF THE EARTH	40
		OCEAN DEPTHS	43
		ECHO SOUNDING BATHYMETRIC MAPS	43 43
		DISTRIBUTION OF ELEVATION AND DEPTH ON LAND AND SEA	44
			45
		SUMMARY	48 51
CHAPTER	4	Physical Properties	
		or seawater	52
		TEMPERATURE	53
		SALINITY	57
		DENSITY	59
		SEA ICE	60
		SEA ICE LIGHT IN THE OCEANS	60 61
		SEA ICE LIGHT IN THE OCEANS SOUND IN THE SEA	60 61 63
		SEA ICE LIGHT IN THE OCEANS SOUND IN THE SEA USE OF UNDERWATER SOUND	60 61 63 66
	-	SEA ICE LIGHT IN THE OCEANS SOUND IN THE SEA USE OF UNDERWATER SOUND SUMMARY	60 61 63 66 67

		RADIATION ENERGY BALANCE	69
		HEAT TRANSFER PROCESSES	71
		NET LONG-WAVE RADIATION	72
		EVAPORATION	72
		SENSIBLE HEAT LOSS	72
		LOCAL HEAT BALANCE	73
		GEOGRAPHIC DISTRIBUTION OF HEAT AND COLD	77
		GLOBAL WATER BALANCE	79
		LONG-RANGE WEATHER FORECASTING AND	
		CLIMAIIC CHANGE	80
		SUMMARY	84
CHAPTER	6	Principles of Ocean	0.4
		Circulation	80
		WHAT DRIVES THE OCEAN— THE WINDS	88
		WHAT DRIVES THE OCEAN — THE SUN	90
		STEADY-STATE CIRCULATION — THE CORIOLIS FORCE	94
		GEOSTROPHIC CURRENTS	97
		MORE CORIOLIS EFFECTS	97
		SUMMARY	103
CHAPTER	7	Major Ocean Currents	104
		THE DEEP OCEAN	105
		THE MAJOR WIND-DRIVEN CURRENTS	108

		WESTERN BOUNDARY CURRENTS	111
		CURRENTS ALONG THE EASTERN SIDES OF OCEANS — UPWELLING	116
		EQUATORIAL CURRENTS	117
		POLAR CIRCULATION	119
		SUMMARY	121
CHAPTER	8	Waves and Tides	122
		PHASE VELOCITY	126
		WAVE DISPERSION AND GROUP VELOCITY	129
		WAVE SPECTRUM AND FULLY DEVELOPED SEA	130
		WAVE PROPAGATION, REFRACTION AND BREAKING	132
		REFRACTION AND BREAKERS	133
		WAVE FORECASTING	134
		TSUNAMI WAVES	134
		SEICHES AND OTHER TRAPPED WAVES	135
		TIDES	137
		TIDAL-PRODUCING FORCES	138
		TIDAL WAVES	139
		SUMMARY	143
CHAPTER	9	Chemical Cycles Within	
			144
		CONVENTIONS ABOUT CONCENTRATIONS	146

		 BIOLOGICALLY CONTROLLED LEMENTS NUTRIENT ELEMENTS: PHOSPHORUS AND NITROGEN OXYGEN SHELL-FORMING COMPONENTS: SILICON DIOXIDE, CALCIUM CARBONATE AND STRONTIUM SULFATE TRACE METALS MUTRIENT ELEMENTS AND OXYGEN AS OCEANIC TRACERS NATRIENT ELEMENTS AND OXYGEN AS OCEANIC TRACERS NATURAL RADIOCARBON AS A TRACER SUMMARY 	146 146 148 150 152 152 153 153 153
CHAPTER	10	Life in the Sea Diversity of marine life Biological activities Biochemical synthesis Acquisition of energy And materials Patterns of energy capture Energy sources Modes of life	160 162 164 164 165 166 166 167 175
CHAPTER	11	The Marine Ecosystem SIMPLE ECOSYSTEM MODELS	176 177

		MAIN PATHS OF ENERGY AND	177
		COMPONENTS OF THE ECOSYSTEM	179
		ECOSYSTEM PROCESSES	179
		TROPHIC LEVELS	183
		ECOSYSTEM GEOMETRY	185
		ECOSYSTEM DYNAMICS	188
		ABUNDANCE OF ORGANISMS	188
		ORGANIC PRODUCTION	188
		FACTORS REGULATING ORGANIC PRODUCTION	190
		GEOGRAPHIC VARIATIONS IN PRODUCTION	193
		SEASONAL VARIATIONS	194
		MARINE COMMUNITIES	196
		CORAL REEFS	196
		ROCK-PAVEMENT COMMUNITIES	199
		MUD-BOTTOM COMMUNITIES	200
		SUMMARY	201
CHAPTER	12	Food From the Sea	202
		MAJOR GLOBAL FOOD-	
		PRODUCTION SYSTEMS	203
		HARVESTING THE SEA	205
		VARIETIES OF SEAFOOD	205
		FISHING TECHNIQUES	208
		GEOGRAPHY OF MARINE FISHERIES	210
			212
			217
			218
		LIIVII I S	218

		SUMMARY	219
CHAPTER	13	Sediments: Where They Come From and What They Are	220
		SOURCES	224
8 9 9 9		THE CONTINENTS AS A SOURCE	221
		OF SEDIMENTS	222
		VOLCANOES WITHIN THE OCEAN BASINS	226
		MINERALOGY OF SEDIMENTS	228
		SILICATE MINERALS	228
		MINERALOGY OF BIOGENIC	
		DEPOSITS	230
		SUMMARY	231
CHAPTER	14	Deep-Sea Deposits	232
		ASSESSING SEDIMENT REPOSITORIES	233
		OCEANIC PROCESSES AFEECTING	200
		DISTRIBUTION OF SEDIMENTS	235
		SUBMARINE CANYONS AND	236
		SEDIMENT TRANSPORT BY	200
		DEEP CURRENTS	241
		DISTRIBUTION OF SEDIMENTS	243
		CALCIUM CARBONATE	245
		SILICEOUS DEPOSITS	247
		SILICATE MINERALS EEDDOMANGANESE NODHLES	24/
			247
			ZUU

CHAPTER	15	Stratigraphy of Marine Deposits	252
		SAMPLING THE SEDIMENT COLUMN	
		IN THE OCEANS	254
		SEDIMENT CORING	254
		DEEP-SEA DRILLING	255
		THE FUNDAMENTAL STRATIGRAPHIC PROBLEM	256
		STRATIGRAPHIC CORRELATION	259
		BIOSTRATIGRAPHY	259
		MAGNETIC STRATIGRAPHY	260
		OXYGEN ISOTOPE STRATIGRAPHY	261
		RADIOACTIVE	
		GEOCHRONOMETRY	265
		SUMMARY	270
CHAPTER	16	Exploring the Structure	274
		of ocean basins	2/4
		TECHNIQUES OF DETERMINING PHYSICAL PROPERTIES OF THE OCEAN FLOOR	274
		TECHNIQUES OF DETERMINING PHYSICAL PROPERTIES OF THE OCEAN FLOOR ACOUSTIC METHODS	274 274
		TECHNIQUES OF DETERMINING PHYSICAL PROPERTIES OF THE OCEAN FLOOR ACOUSTIC METHODS SEISMIC REFRACTION METHODS	274 274 274
		TECHNIQUES OF DETERMINING PHYSICAL PROPERTIES OF THE OCEAN FLOOR ACOUSTIC METHODS SEISMIC REFRACTION METHODS EARTHQUAKE SEISMOLOGY	274 274 274 276
		TECHNIQUES OF DETERMINING PHYSICAL PROPERTIES OF THE OCEAN FLOOR ACOUSTIC METHODS SEISMIC REFRACTION METHODS EARTHQUAKE SEISMOLOGY GRAVITY METHODS	274 274 274 276 279
		TECHNIQUES OF DETERMINING PHYSICAL PROPERTIES OF THE OCEAN FLOOR ACOUSTIC METHODS SEISMIC REFRACTION METHODS EARTHQUAKE SEISMOLOGY GRAVITY METHODS MAGNETIC METHODS	274 274 274 276 279 282
		TECHNIQUES OF DETERMINING PHYSICAL PROPERTIES OF THE OCEAN FLOOR ACOUSTIC METHODS SEISMIC REFRACTION METHODS EARTHQUAKE SEISMOLOGY GRAVITY METHODS MAGNETIC METHODS THERMAL METHODS	274 274 274 276 279 282 283
		TECHNIQUES OF DETERMINING PHYSICAL PROPERTIES OF THE OCEAN FLOOR ACOUSTIC METHODS SEISMIC REFRACTION METHODS EARTHQUAKE SEISMOLOGY GRAVITY METHODS MAGNETIC METHODS THERMAL METHODS OCEAN BASIN STRUCTURE	274 274 274 276 279 282 283 285
		TECHNIQUES OF DETERMINING PHYSICAL PROPERTIES OF THE OCEAN FLOOR ACOUSTIC METHODS SEISMIC REFRACTION METHODS EARTHQUAKE SEISMOLOGY GRAVITY METHODS MAGNETIC METHODS THERMAL METHODS OCEAN BASIN STRUCTURE THE OCEAN BASIN PROPER	274 274 274 276 279 282 283 285 285
		TECHNIQUES OF DETERMINING PHYSICAL PROPERTIES OF THE OCEAN FLOOR ACOUSTIC METHODS SEISMIC REFRACTION METHODS EARTHQUAKE SEISMOLOGY GRAVITY METHODS MAGNETIC METHODS THERMAL METHODS OCEAN BASIN STRUCTURE THE OCEAN BASIN PROPER OCEAN RIDGES	274 274 274 276 279 282 283 285 285 290

		CONTINENTAL MARGINS AND ISLAND ARCS	291
		SUMMARY	297
CHAPTER	17	Plate Tectonics and History of the Ocean Basins	208
			270
		EARLY FRAMEWORK	300
		CONTRACTING EARTH	300
		EXPANDING EARTH	301
			301
			302
			304
			308
		ASTHENOSPHERE	308
		SEPARATION OF PLATES	310
		CONVERGING PLATES	315
		THE MODEL	317
		DEEP-SEA DRILLING: A TEST FOR PLATE TECTONICS BED-ROCK GEOLOGY OF	318
		THE OCEANS	320
		SUMMARY	320
CHAPTER	18	Cycles Between Land	300
			522
		IS THE OCEAN GETTING SALTIER? STREAMS AND THE MEAN RESIDENCE TIME OF ELEMENTS	323
		IN THE OCEAN	325

		WHAT CONTROLS THE	
		COMPOSITION OF THE SEA?	326
		POTASSIUM	327
		MAGNESIUM	328
		CALCIUM	328
		SILICON	330
		WHAT ABOUT THE TRACE METALS?	330
		ROLE OF PLATE TECTONICS IN	
		COMPLETING THE CYCLE	332
		SUMMARY	333
CHAPTER	19	Ocean Records of	
		Past Climate	334
		THE CLIMATE SYSTEM	336
		ELEMENTS OF THE SYSTEM	336
		INTERACTIONS	337
		ROLE OF THE OCEAN	337
		ROLE OF THE CRYOSPHERE	338
		CHANGES IN OCEANIC CLIMATE:	
		THE TWENTIETH CENTURY	339
		EL NINO	339
		THE NORTH PACIFIC	340
		THE NORTH ATLANTIC	344
		GEOGRAPHIC PATTERNS OF ANCIENT CLIMATE	345
		LITTLE ICE AGE	345
		LAST GREAT ICE AGE	347
		CLIMATES OF OLDER GEOLOGICAL PERIODS	351
		ICE-AGE CYCLE	354
		SUMMARY	357
			007

CHAPTER	20	Where the Land Meets the Sea	358
		ESTUARINE CIRCULATION	359
		SHAPING OF THE COASTLINE	363
		SUBMERGED COASTLINES	366
		EMERGENT COASTLINES	367
		COASTAL FEATURES DUE TO THE ACTION OF WAVES	367
		DEPOSITION FEATURES	369
		DELTAS	369
		SALT MARSHES	373
		SUMMARY	374
CHAPTER	21	Mineral Resources of the Sea	376
		CONCEPT OF A RESOURCE	377
		RESOURCES IN SEAWATER	378
		FRESH WATER	378
		COMMON SALT (NaCI)	380
		MAGNESIUM-MAGNESIUM SALTS	380
		HYDROTHERMAL BRINES	382
		RESOURCES ON THE SEA FLOOR	383
		METAL-RICH SEDIMENTS	383
			384
		PHOSPHORIE NODULES	385
			380
			300
		SEA FLOOR	387
		SULFUR	387

		hydrocarbons SUMMARY	387 396
CHAPTER	22	Man Meets the Sea	398
		TRANSPORTATION	399
		MILITARY POWER AND THE OCEANS	401
		SHORE-LINE DEVELOPMENT	402
		FISHERIES RESOURCES	404
		MANAGEMENT OF MINERAL RESOURCES	406
		POLLUTION	407
		ARE SWORDFISH SAFE TO EAT (OR WHERE DID THE MERCURY COME FROM?)	409
		A PROBLEM?	411
		INTERNATIONAL LAW – WHO OWNS THE OCEANS?	413
		SUMMARY	417
		Appendix I Conversion Factors and Constants	419
		Appendix II The Periodic Chart of the Elements	420
		Appendix III The Geologic Time Chart	422
		References Cited	423
		Glossary	431
		Index	439