

CONTENTS

Introduction 1

Interrelationships of the Ocean	1
Population Impacts on Coastal Ecology and the Open Ocean	2
Rational Use of Technology	3

1

History of Oceanography 5

The Concept of Geography Develops	5
Early History The Middle Ages Age of Discovery	
The Search to Increase Scientific Knowledge of the Oceans	8
Captain James Cook Matthew Fontaine Maury Charles Darwin The Rosses—Sounders of the Deep Edward Forbes The <i>Challenger</i> Expedition Fridtjof Nansen	
20th Century Oceanography	13
Voyage of the <i>Meteor</i> Oceanography in the United States	
Law of the Sea	18
Summary	22

2

The Origin of the Earth, Its Oceans, and Life in the Oceans 25

The Universe We See	25
Origin of the Earth	26
Origin of the Atmosphere and Oceans	28
The Atmosphere Forms The Oceans Evolve	
The Chemical Balance Sheet	30
Excess Volatiles	
Development of the Oceans and Their Basins	31

Life Forms in the Ocean	31
Carbon—The Organizer of Life Plants and Animals Evolve	
Summary	34

3 Marine Provinces 39

Isostasy	39
Techniques of Determining Bathymetry	41
Continental Margin	41
Continental Shelf Continental Slope Submarine Canyons Turbidity Currents Continental Rise	
Deep-Ocean Basin	50
Abyssal Plains Trenches Oceanic Ridges and Rises Volcanic Features Fracture Zones	
Summary	52

4 The Origin of Ocean Basins: Global Plate Tectonics 57

Development of the Theory	58
Continental Jigsaw	
Continental Geology	58
The Fossil Record Radioactive Dating Ancient Life and Climates Laurasia and Gondwanaland Continental Magnetism Apparent Polar Wandering Magnetic Polarity Reversals	
Marine Geology	64
Paleomagnetism Sea-Floor Spreading	
Plate Boundaries	67
Constructive Boundaries Destructive Boundaries Shear Boundaries	
Intraplate Features	72
Metallic Ores and Plate Tectonics	
Summary	79

5 Marine Sediments 83

Sediment Texture Sediment Transport	
Composition of Marine Sediment	85
Lithogenous Sediment Biogenous Sediment Hydrogenous Sediment Cosmogenous Sediment Types of Marine Sedimentary Deposits	
Sediments of the Continental Margin (Neritic Sediments)	90
Turbidites Glacial Deposits Carbonate Deposits	
Sediments of the Deep-Ocean Basins (Oceanic Sediments)	92
Abyssal Clay Oozes	
Distribution of Oceanic Sediment	94
Fecal Pellets	
Summary	96

6 The Nature of Water 101

Solvent Properties of Water	102
Thermal Properties of Water	102
Heat Capacity Freezing and Boiling Points of Water Latent Heats of Melting and Vaporization	
Surface Tension	106
Water Density	108
Salinity of Ocean Water	109
Salinity and Density	
Residence Time	111
GEOSECS	113
Summary	114

7 Air-Sea Interaction 117

Physical Properties of Ocean Water	117
Light Density Sound	
Solar Energy	121
Distribution of Solar Energy Heat Balance of the Earth Coriolis Effect	
Heat Budget of the World Ocean	126

The Oceans, Weather, and Climate	126
Climate Patterns in the Oceans Sea Ice Icebergs	
Renewable Sources of Energy	131
Summary	133

8 Ocean Circulation 139

Horizontal Circulation	139
Ekman Spiral Geostrophic Currents Westward Intensification	
Antarctic Circulation	143
Atlantic Ocean Circulation	144
Surface Circulation	
Pacific Ocean Circulation	146
Indian Ocean Circulation	146
Vertical Circulation	147
Wind-Induced Circulation Thermohaline Circulation Research in Ocean Circulation Power from Winds and Currents	
Summary	156

9 Waves 161

Wave Characteristics	162
Deep-Water Waves Shallow-Water Waves Transitional Waves	
Wind-Generated Waves	164
Sea Swell Surf Wave Refraction Wave Reflection Storm Surge	
Tsunami	173
Internal Waves	176
Power from the Waves	
Summary	178

10 Tides 183

Tide-Generating Forces	183
Law of Gravitation	
Equilibrium Theory of Tides	186
The Rotating Earth Combined Effects of Sun and Moon Effects of Declination Effects of Distance Equilibrium Tide Prediction	

Dynamical Theory of Tides	191
Types of Tides Tides in Narrow Bays Tides in Rivers	
Tides as a Source of Power	195
Summary	198

11 The Shore 203

General Description of the Coastal Region	203
Erosional Shore Features Depositional Shore Features	
Changing Levels of the Shoreline	209
Tectonic and Isostatic Movements Eustatic Movements	
The United States Coasts	211
The Gulf Coast The Atlantic Coast The Pacific Coast	
Effect of Artificial Structures	215
Summary	219

12 The Coastal Ocean 223

General Conditions	223
Salinity Temperature Coast Currents	
Estuaries	225
Origin of Estuaries Water Mixing in Estuaries	
Wetlands	227
Lagoons	230
Laguna Madre	
Mediterranean Sea	231
Summary	232

13 The Marine Habitat 235

General Conditions	235
Support Effects of Salinity Availability of Nutrients Availability of Solar Radiation Margins of the Continents Water Color and Life in the Oceans Size Viscosity Temperature	
Divisions of the Marine Environment	244
Pelagic Environment Benthic Environment	

Distribution of Life in the Oceans	248
Plankton Nekton Benthos	
Summary	252

14

Biological Productivity—Energy Transfer

257

Taxonomic Classification	257
Macroscopic Plants	259
Phaeophyta (Brown Algae) Chlorophyta (Green Algae) Rhodophyta (Red Algae) Spermatophyta (Seed-Bearing Plants)	
Microscopic Plants	259
Chrysoophyta (Golden Algae) Pyrrophyta (Dinoflagellate Algae)	
Primary Productivity	262
Photosynthetic Productivity Distribution of Productivity Temperature Stratification and Nutrient Supply Chemosynthetic Productivity	
Energy Transfer	269
Marine Ecosystem Energy Flow Composition of Organic Matter Biogeochemical Cycling	
Trophic Levels and Biomass Pyramids	274
Trophic Levels Transfer Efficiency Biomass Pyramid	
Summary	277

15

Animals of the Pelagic Environment 281

Staying Above the Ocean Floor	281
Gas Containers Floating Forms Swimming Forms Modifications Associated with Swimming Behavior	
Marine Mammals	289
Cetaceans	
Group Behavior	293
Schooling Migration	
Summary	298

16

Animals of the Benthic Environment

303

Rocky Shores	303
Supralittoral (Spray) Zone	
Sediment-Covered Shore	310
The Sediment Life in the Sediment The Sandy Beach The Mud Flat	
The Shallow Offshore Ocean Floor	316
The Rocky Bottom (Sublittoral) Coral Reefs Sediment-Covered Bottom	
Deep-Ocean Floor	321
The Physical Environment The Deep Fauna	
Summary	326

17

Food from the Sea 331

Fisheries	331
Early History of Fisheries Assessment and Management in the United States Fisheries and Marine Biology The Ecosystem Approach to Fishery Assessment Upwelling and Fisheries A Global Approach to the Study of Upwelling Ecology The Peruvian Anomaly New Technologies Useful in Studying Fisheries Ecology Fishermen and Marine Science The Future of Fisheries Management Regulation	
The Peruvian Anchoveta Fishery	340
Physical Conditions Biological Conditions A Natural Hazard An Artificial Hazard	
Mariculture	342
Algae Bivalves Crustaceans Fish	
What Lies Ahead?	344
Summary	345

18

Marine Pollution 349

Capacity of the Oceans for Accepting Society's Wastes	349
Predicting the Effects of Pollution on Marine Organisms	350

Marine Pollution Control in the United States	350
Areas of Concern	352
Plastics Petroleum Sewage	
Radioactive Waste Halogenated	
Hydrocarbons (DDT and PCBs) Mercury	
International Efforts to Protect the Marine	
Environment	361
Summary	361

Appendixes

I Scientific Notation	365
II The Metric System and Conversion Factors	366
III Periodic Table of the Elements	367
IV The Geologic Time Table	368
V The Phylogenetic Tree	369

VI Taxonomic Classification of Common	
Marine Organisms	

Glossary 373

Index 389

Color Plates

Introductory Overview (plates 1–8)	
Following page xvi	
Marine Geology (plates 9–14)	
Following page 64	
Physical Oceanography (plates 15–22)	
Following page 128	
Marine Biology (plates 23–29)	
Following page 320	