

A COAST TO EXPLORE

Coastal Geology and Ecology of Central California

Miles O. Hayes and Jacqueline Michel

TABLE OF CONTENTS

	Page
PREFACE	xi
ACKNOWLEDGEMENTS	xiii
1. INTRODUCTION	1
SECTION I: COASTAL PROCESSES AND GEOMORPHOLOGY	
2. GENERAL STRUCTURE AND ORIGIN	5
Introduction	5
Characteristics of Depositional Coasts	7
Characteristics of Leading-Edge Coasts	10
Origin of the Central California Coast	12
Introduction	12
How Old Is It?	18
Evolution of the Coast	20
The Coast Ranges	32
Earthquakes	35
Gold, Oil, and Water	38
Relative Abundance of Shoreline Types	41
3. COASTAL PROCESSES	44
Tides	44
Waves	48
General Introduction	49

Waves on the Central California Coast	56
Major Coastal Storms	58
Tsunamis	60
4. MAJOR LANDFORMS OF THE COAST	63
Rocky Coasts	63
Introduction	63
Rock Cliffs	63
Rock Platforms	66
Raised Marine Terraces	68
Sand Beaches	70
A River of Sand	70
The Beach Profile	71
The Beach Cycle or “Normal Seasonal Changes”	72
Two Studies of California Beach Profiles	73
Smaller-scale Physical Sedimentary Features	78
Gravel Beaches	84
Introduction	84
Occurrence of Gravel Beaches	85
Highly Exposed Coarse-grained Gravel Beaches	85
Littoral Cells	90
Easily Recognizable, Repetitive Shoreline Features	92
Crenulate Bays	92
Tidal Inlets	93
Rocky Headlands	102
Natural Groin/Sand Beach Systems	102
Coastal Dune Fields	102
River Deltas	104
5. HABITATS OF THE COASTAL WATER BODIES	107
Introduction	107
Definition of an Estuary	107
Estuarine Characteristics	108
Marshes	110
Tidal Flats	110
Definition	110
Exposed Sandy Tidal Flats	110
Sheltered Mud Flats	110
Dominant Biogenic Features	111
Tidal Channels	111
6. CONTINENTAL SHELF AND SUBMARINE CANYONS	112
7. SHORELINE EROSION AND LANDSLIDES	116
Introduction	116
Major Causes of Shoreline Erosion	117
Introduction	117
Deficits in Sand Supply	117
Sea-level Rise	119
Methods Commonly Used to Prevent Shoreline Erosion	121

Landslides	123
California’s Shoreline Erosion Problem – An Assessment	123
Concluding Remarks	126

SECTION II: COASTAL ECOLOGY OVERVIEW

8. INTRODUCTION	129
9. WHY THE CENTRAL CALIFORNIA COASTAL WATERS ARE SO RICH	131
10. KEY BIOLOGICAL RESOURCES OF CENTRAL CALIFORNIA	132
Features on the Ecological Maps Presented in Section III	132
Marine Mammals	132
Introduction	132
Whales Along the Central California Coast	133
Dolphins and Porpoises	134
Pinniped Haulouts and Rookeries	135
Sea Otters	137
Marine and Coastal Birds	137
Introduction	137
Threatened and Endangered Bird Species	137
Reptiles and Amphibians	138
Fish and Invertebrates	138
Marine and Estuarine Fishes	138
Anadromous Fishes	138
Invertebrates and Tide Pool Communities	139
Intertidal Habitats: Biological Communities	139
Rocky Shores	139
Sand Beaches	140
Tidal Flats	141
Salt Marshes	141
Subtidal Habitats: Kelp Forests and Eelgrass Beds	141
11. NATIONAL MARINE SANCTUARIES	143

SECTION III: MAJOR COMPARTMENTS

12. INTRODUCTION	145
13. COMPARTMENT 1 – THE SAN ANDREAS FAULT VALLEY	146
Introduction	146
Bodega Harbor and Vicinity	146
Central Uplands	153
Dillon Beach and Dunes	154
Tomales Bay	155
14. COMPARTMENT 2 – POINT REYES	162
Introduction	162
Tomales Peninsula	165
Point Reyes Beach	168
Point Reyes	172
Drakes Bay Shoreline	174
15. COMPARTMENT 3 – SAN FRANCISCO’S OUTER SHORE	179

Introduction	179
Double Point Uplands (Point Resistance to Bolinas Point)	179
Bolinas Lagoon and Vicinity	182
Muir Beach Uplands (Gull Rock to Point Bonita)	185
Golden Gate Entrance	190
South Beaches (Lands End to San Pedro Rock)	192
16. COMPARTMENT 4 – CENTRAL HEADLAND	200
Introduction	200
Montara Uplands (San Pedro Rock to Pillar Point)	202
Half Moon Bay	206
Scalloped Terrace (Miramontes Point to Tunitas Creek)	207
The Sandy Strand (Tunitas Creek to Pescadero Creek)	209
Pigeon Point Uplands (Pescadero Creek to Año Nuevo Creek)	211
Santa Cruz Uplands (Año Nuevo Creek to Capitola)	218
17. COMPARTMENT 5 – MONTEREY BAY AND VICINITY	223
Introduction	223
The North Beaches (Capitola to Moss Landing Inlet)	223
Moss Landing and Elkhorn Slough	227
The South Beaches (Moss Landing to Monterey Harbor)	231
Monterey Headland (Monterey Harbor to Pescadero Point)	236
Carmel Bay (Pescadero Point to San Jose Creek)	239
18. COMPARTMENT 6 – BIG SUR	243
Introduction	243
Climate of the Big Sur Country	243
Geology of the Big Sur Country	245
Carmel Uplands (San Jose Creek to Point Sur)	247
Santa Lucia Uplands (Point Sur to Lopez Point)	253
Ragged Point Uplands (Lopez Point to Point Piedras Blancas)	259
San Simeon Strand (Point Piedras Blancas to Cayucos Creek)	269
19. COMPARTMENT 7 – THE SOUTH BAYS	274
Introduction	274
Estero Bay (Cayucos Creek to Islay Creek)	276
Montaña De Oro Headland (Islay Creek to Point San Luis)	283
San Luis Obispo Bay (Point San Luis to Point Sal)	285
San Antonio Valley (Point Sal to Purisima Point)	289
Santa Ynez Valley (Purisima Point to Point Pedernales)	292
Santa Ynez Headlands (Point Pedernales to Point Conception)	295
20. A LOOK TO THE FUTURE	301
RECOMMENDED ADDITIONAL READING	302
GLOSSARY	304
REFERENCES CITED	320
INDEX	332
ABOUT THE AUTHORS	344