

Coastal Processes in Tideless Seas

R.D. Kos'yan N.V. Pykhov B.L. Edge



1801 Alexander Bell Drive Reston, Virginia 20191-4400

Abstract: Originally published in 1991 by the Russian Academy of Sciences, Shirshov Institute of Oceanology, the authors have updated and translated this text into English. The book describes the modern state of the problem of sediment transport under wave influence in the coastal zone of tideless seas. Divided into three parts, this text addresses: hydrodynamic and elementary processes of sediment transport, characterization of research sites, measuring procedures, nearshore sediment mass transport, and some aspects of modeling.

Library of Congress Cataloging-in-Publication Data

Kos'ian, R. D. (Ruben Derenikovich)

[Gidrogennye peremeshseniia osadkov v beregovoi zone moria. English] Coastal processes in tideless seas / R.D. Kos'ian, N.V. Pykhov, B.L. Edge.

p. cm.

Includes bibliographical references and index.

ISBN 0-7844-0018-0

1. Coast changes. 2. Water waves. 3. Sediment transport. I. Pykhov, N. V. (Nikolai Valentinovich) II. Edge, Billy L.

GB451.2 .K6813 2000 551.45'7---dc21

00-023204

Any statements expressed in this material are those of the author and do not necessarily represent the views of ASCE, which takes no responsibility for any statement made herein. No reference made in this publication to any specific method, product, process, or service constitutes or implies an endorsement, recommendation, or warranty thereof by ASCE. This material is for general information only and does not represent a standard of ASCE, nor is it intended as a reference in purchase specifications, contracts, regulations, statutes, or any other legal document. ASCE makes no representation or warranty of any kind, whether express or implied, concerning the accuracy, completeness, suitability, or utility of any information, apparatus, product, or process discussed in this publication, and assumes no liability therefore. This information should not be used without first securing competent advice with respect to its suitability for any general or specific application. Anyone utilizing this information assumes all liability arising from such use, including but not limited to infringement of any patent or patents.

Photocopies. Authorization to photocopy material for internal or personal use under circumstances not falling within the fair use provisions of the Copyright Act is granted by ASCE to libraries and other users registered with the Copyright Clearance Center (CCC) Transactional Reporting Service, provided that the base fee of \$8.00 per chapter plus \$.50 per page is paid directly to CCC, 222 Rosewood Drive, Danvers, MA 01923. The identification for ASCE Books is 0-7844-0018-0 / 00 / \$8.00 + \$.50 per page. Requests for special permission or bulk copying should be addressed to Permissions & Copyright Department, ASCE.

Copyright © 2000 by the American Society of Civil Engineers. All Rights Reserved. Library of Congress Catalog Card No.: 00-023204 ISBN 0-7844-0018-0 Manufactured in the United States of America



Acknowledgments	vii
Preface	ix
PART I Modern Concepts of Nearshore Hydrodynamics and Elementary Coastal Processes	1
CHAPTER 1Nearshore Hydrodynamics1.1 Bottom boundary layer of wave flow1.2 Horizontal water circulation1.3 Longshore currents1.4 Vertical circulation1.5 Infragravity waves	3 5 34 39 43 48
CHAPTER 2 Elementary Hydrodynamic Transport Processes 2.1 Initiation of particle movement	55 56 67 76

PART II Field Research

CHAPTER 3
Measuring Methods 107
3.1 Measurement of surface wave parameters 107
3.2 Velocity measurement 110
3.3 Measurement of sediment erosion and accumulation
at a nearshore site
3.4 Measurement of parameters, direction, and rate of bedform
migration 115
3.5 Methods of measuring suspended sediment concentration 116
3.6 Grain-size analysis of bottom and suspended sediment
3.7 Sedimentation method 129
CHAPTER 4
Characterization of Testing Sites. Description of
Experiments, and Observation Data 131
4.1 The Black Sea testing sites 13.
4.2 The Baltic Sea "Lubiatowo" testing site
4.3 The Mediterranean testing sites
4.4 Issyk-Kul

CHAPTER 5

Study of Bed Microforms in the Nearshore Zone	143
5.1 Characteristics of observed data	144
5.2 Types of bedforms in the nearshore zone	144
5.3 Composition of bed microform sediment	148
5.4 Conditions for active ripple existence	151
5.5 Active ripple parameters	158
5.6 The possibility of wave hindcasting on the basis of paleofacial	
observations	161

CHAPTER 6 Suspended Se

uspended Sediment in the Nearshore Zone	167
6.1 Distribution of mean concentration values and mean diameter	
of suspended sediment particles during a storm	168
6.2 Variability of the concentration and mean size of suspended	
particles during a storm	173

207

6.3 Low frequency variations of suspended sand concentration
and composition
6.4 Distribution features in the breaking zone
6.5 Calculation of suspended sediment concentration and mean
diameter
6.6 Prediction of suspended sediment distribution over the entire
nearshore zone

PART III Sediment Transport

CHAPTER 7209Longshore Sediment Transport2107.1 In situ measurements.2107.2 Semi-empirical models.2197.3 An example of calculation of suspended sediment longshore
discharge.223

CHAPTER 8

Cross-Shore Sediment Transport and Variabil	ity of the
Underwater Slope Profile	235
8.1 Sediment discharge	
8.2 Equilibrium profile modeling	
8.3 Field studies of the variability of bed sediment c	omposition and
underwater relief during a storm	
CHAPTER 9 Conclusions	263
References	267
Appendix	295
Index	301

This page intentionally left blank

Acknowledgments

The authors are grateful to S.M. Antsyferov, T. Basinski, V. Dachev, S.A. Efremov, S. Keremetchiev, B. Kirilova, A.D. Kochergin, O.L. Kuznetsov, I.O. Leont'ev, G.G. Mineev, H. Nikolov, E.L. Onischenko, V.I. Pakho-

mov, A.P. Phylippov, and N.S. Speransky for considerable assistance in the marine studies. The authors thank E.I. Birina, L.P. Fursova, T.M. Podymova, O. Ju. Potapenko, and O.V. Zaguskina for assistance in book design; Joyce Hyden for her editorial assistance and untiring support; students Sean Kelley and Ty Wamsley for their reviews, and Thorndike Saville, Jr., for his helpful review.

The authors owe special thanks to Professor V.V. Longinov for his constant support, kindly discussions, and helpful advice at all stages of research. His image will remain in our perpetual memory. It is a pleasure to acknowledge the ongoing support and encouragement of Mr. Orville Magoon for his assistance in the publishing of this book to whom we proudly dedicate this work. This page intentionally left blank

Preface

The nearshore zone, though constituting only a small part of seas and oceans, plays an important role in human existence. Situated adjacent to the shore, it has been actively developed by people living in the narrow

coastal zone. The first studies of nearshore dynamics were undertaken because of the concern of sailors over sea waves, which are especially dangerous in the vicinity of the coast.

Coasts without natural harbors of refuge had to be modified by hydraulic works (jetties, breakwaters, etc.) to protect vessels from storms. Works of this type were constructed in the Mediterranean by the Phoenicians, Greeks, and Romans as early as 500 B.C. (Edge, Magoon, and Baird, 1993). As ship drafts increased, the problem of silting arose, both for natural harbors in river mouths and for newly constructed ones. This problem could not be solved without the knowledge of sediment transport by waves and currents in the nearshore zone. In the second half of the twentieth century, rapid tonnage growth required the construction of navigation channels; prediction of silting in these channels became one of the important practical tasks of sediment transport studies. The solution to many present-day practical tasks depends on knowledge of the rate of sediment deposition and transport processes in the nearshore zone. Intake of sea water with minimal impurities for cooling systems of nuclear and thermal power stations is of vital importance, as the majority of these stations are being constructed on the coasts. There are some areas where quarrying of building materials (sand, shell) presents a serious problem since their removal from the seabed and beach in scientifically unreasonable quantities can result in severe ecological damage. Prediction of sediment discharge, deformation of the bottom relief, and change in the beach profile is vital for the security of various communications (cables, pipelines) and coastal structures (piers, unloading terminals, bridges), for support of recreational beaches, and for artificial beach creation.