



# PIANC

The World Association for Waterborne  
Transport Infrastructure

## ENVIRONMENTAL ASPECTS OF DREDGING, PORT AND WATERWAY CONSTRUCTION AROUND COASTAL PLANT HABITATS



EnviCom Working Group Report N° 157 – 2023

**PIANC REPORT N° 157**  
ENVIRONMENTAL COMMISSION

**ENVIRONMENTAL ASPECTS OF DREDGING,  
PORT AND WATERWAY CONSTRUCTION  
AROUND COASTAL PLANT HABITATS**

October 2023

PIANC has Technical Commissions concerned with inland waterways and ports (InCom), coastal and ocean waterways (including ports and harbours) (MarCom), environmental aspects (EnviCom) and sport and pleasure navigation (RecCom).

This report has been produced by an international Working Group convened by the Environmental Commission (EnviCom). Members of the Working Group represent several countries and are acknowledged experts in their profession.

The objective of this report is to provide information and recommendations on good practice. Conformity is not obligatory and engineering judgement should be used in its application, especially in special circumstances. This report should be seen as an expert guidance and state-of-the-art on this particular subject. PIANC disclaims all responsibility in the event that this report should be presented as an official standard.

**PIANC HQ**  
**Boulevard du Roi Albert II 20 B. 3**  
**1000 Brussels | Belgium**

<http://www.pianc.org>

VAT BE 408-287-945

ISBN 978-2-87223-032-7

© All rights reserved

# CONTENTS

CONTENTS .....	4
PREFACE.....	7
TERMS OF REFERENCE .....	7
MEMBERS OF PIANC WORKING GROUP 157.....	7
ACKNOWLEDGEMENTS.....	8
GLOSSARY.....	8
1 INTRODUCTION .....	1
1.1 Why Dredging, Port and Waterway Construction near Coastal Plant Habitats?.....	1
1.2 Consequences of Dredging, Port and Waterway Construction near Coastal Plant Habitats... 1	
1.3 Recommended Reading.....	4
2 COASTAL PLANT HABITATS & THEIR VALUE.....	6
2.1 What are Coastal Plant Habitats.....	6
2.2 Seagrass Habitats .....	6
2.2.1 What is Seagrass? .....	6
2.2.2 Where are Seagrasses Found? .....	7
2.2.3 The Biology of Seagrasses .....	7
2.2.4 The Importance of Seagrasses .....	8
2.3 Macroalgae Habitats .....	10
2.3.1 What are Macroalgae? .....	10
2.3.2 Where are Macroalgae Found? .....	10
2.3.3 The Biology of Macroalgae .....	11
2.3.4 The Importance of Macroalgae .....	12
2.4 Mangrove Habitats.....	12
2.4.1 What are Mangroves? .....	12
2.4.2 Where are Mangroves Found?.....	12
2.4.3 The Biology of Mangroves.....	13
2.4.4 The Importance of Mangroves.....	14
2.5 Tidal Marsh Habitats.....	15
2.5.1 What are Tidal Marshes? .....	15
2.5.2 Where are Tidal Marshes Found? .....	15
2.5.3 The Biology of Tidal Marshes .....	16
2.5.4 The Importance of Tidal Marshes .....	17
2.6 Recommended Reading.....	17
3 DREDGING, PORT AND WATERWAY CONSTRUCTION TECHNIQUES .....	19
3.1 Geotechnical Characteristics and Coastal Plant Habitats .....	19
3.2 Types of Dredging Equipment .....	21
3.2.1 Cutter Suction Dredgers.....	22
3.2.2 Trailing Suction Hopper Dredgers.....	23
3.2.3 Mechanical Dredgers .....	24
3.2.4 Plough Jet Plough and Water Injection Dredgers .....	25
3.2.5 Other Dredging Techniques.....	26
3.3 Reclamation/ Placement Techniques.....	27
3.3.1 Direct Placement.....	27
3.3.2 Rainbowing .....	27
3.3.3 Pumping Ashore.....	28
3.4 Recommended Reading.....	29
3.5 Case Study 3: Beneficial Application of Dredged Material at Horsey Island, UK .....	30
4 TYPES OF IMPACTS .....	31
4.1 Project Impacts.....	32
4.1.1 Construction Phase.....	32
4.1.2 Post-Construction and Operation Phase.....	32
4.2 Process Impacts.....	34
4.2.1 Construction Phase.....	34
4.3 Recommended Reading.....	36
5 RESPONSE OF COASTAL PLANT HABITATS TO IMPACTS .....	38
5.1 Mangroves .....	39
5.1.1 Sedimentation Impacts.....	39

5.1.2	Water Quality Acidification Impacts .....	40
5.1.3	Impacts from Hydrological Changes (Tidal Inundation) .....	40
5.1.4	Impacts from Hydrodynamic Changes (Currents, Waves) .....	41
5.2	Tidal Marshes.....	41
5.2.1	Impacts from Dredging and Filling .....	41
5.2.2	Impacts due to Canal Construction.....	42
5.2.3	Impacts of Altered Sediment Supply and 'Thin-layer Placement' .....	42
5.2.4	Impacts of Altered Salinity Regime .....	43
5.2.5	Impacts Associated with Heavy Metals.....	43
5.3	Seagrasses.....	44
5.3.1	Dredging Near Seagrasses .....	44
5.3.2	Impacts from Turbidity and Sedimentation .....	44
5.4	Macroalgae.....	45
5.4.1	Dredging and Macroalgae .....	45
5.4.2	Impacts of Sediment Deposition and Resuspension .....	46
5.4.3	Changes in Species Abundance and Composition .....	46
5.4.4	Inhibition of Settlement and Recruitment.....	47
5.5	Recommended Reading.....	47
5.6	Case Study 5: Understanding Seagrass Responses to Dredging.....	49
6	MINIMISING IMPACTS THROUGH PLANNING AND DESIGN .....	50
6.1	Introduction.....	50
6.2	Working with Nature .....	50
6.3	Mitigation through Planning .....	51
6.3.1	Site Selection .....	54
6.4	Mitigation through Design.....	55
6.4.1	Understanding Coastal Processes.....	55
6.4.2	Layout Optimisation .....	56
6.5	Recommended Reading.....	57
7	IMPACT ASSESSMENT .....	59
7.1	Introduction.....	59
7.2	Baseline .....	61
7.3	Predictive Modelling.....	66
7.3.1	Hydrodynamic Modelling .....	67
7.3.2	Sediment Plume Modelling .....	67
7.3.3	Water Quality Modelling .....	68
7.3.4	Morphological Modelling.....	69
7.3.5	Expert Input .....	69
7.4	Establishing Threshold Levels .....	69
7.4.1	Suspended Sediments .....	70
7.4.2	Sedimentation.....	71
7.4.3	Erosion .....	71
7.4.4	Flushing .....	72
7.4.5	Inundation/Salinity .....	72
7.5	Impact Assessment Criteria .....	73
7.6	Permitting and Approvals .....	73
7.7	Terms of Reference for Construction.....	74
7.8	Recommended Reading.....	74
8	PREVENTION, MITIGATION AND COMPENSATION MEASURES.....	75
8.1	Overview of Prevention, Mitigation and Compensation .....	75
8.2	Best Practice Examples of Technical Mitigation Measures .....	77
8.2.1	Choice of Equipment .....	77
8.2.2	Prevention of Leakage from Equipment .....	78
8.2.3	Dredging Volume Requirement and Excavation Accuracies .....	78
8.2.4	Control of Sediment Spill .....	79
8.2.5	Minimisation of Propeller Wash .....	79
8.2.6	TSHD Overflowing techniques.....	80
8.2.7	Restricted Overflow .....	80
8.2.8	Temporarily Relocating the Dredger .....	80
8.2.9	Silt Curtains .....	80
8.2.10	Environmental Windows .....	81
8.2.11	Controlling Discharge from the Reclamation Area .....	81
8.2.12	Profiling Channel Slopes.....	82
8.2.13	Choice of Placement Sites.....	82

8.2.14	Adaptation/Optimisation of Port/Waterway Design to Minimise Hydrodynamic/ Hydrologic Effects .....	83
8.3	Mitigation and Compensation Measures for Coastal Plant Habitats .....	83
8.3.1	Seagrass.....	83
8.3.2	Mangroves.....	84
8.3.3	Macroalgae (Kelp) .....	84
8.3.4	Tidal Marshes .....	85
8.3.5	Restoration.....	85
8.3.6	Transplantation and Translocation .....	88
8.3.7	Facilitated Natural Recovery .....	88
8.3.8	Beneficial Use of Dredged Material.....	89
8.3.9	Alternative Compensation & Offsets.....	90
8.3.10	Managed Realignment .....	92
8.3.11	Sustainability .....	92
8.4	Recommended Reading.....	92
9	MONITORING AND MANAGEMENT.....	95
9.1	<i>Establishing the</i> Environmental Management Plan Baseline .....	98
9.1.1	Indicators .....	98
9.1.2	Common Baseline Environmental Survey Components with Respect to Seagrass and Macroalgal Beds .....	98
9.1.3	Common Baseline Environmental Survey Components with Respect to Mangroves and Tidal Marshes.....	102
9.1.4	Common Baseline Habitat Monitoring Components .....	104
9.1.5	Layout of Monitoring Stations .....	106
9.2	Adaptive Management Strategies .....	107
9.3	Tiered Response.....	109
9.4	Components of Feedback Monitoring and Management Plan.....	110
9.4.1	Control Monitoring.....	110
9.4.2	Habitat Monitoring and the Feedback Loop .....	113
9.4.3	Spill Budget.....	114
9.4.4	Spill Hindcast Modelling .....	115
9.4.5	Current, Water Level and Sedimentation/ Erosion Forecast or Hindcast Modelling..	115
9.4.6	Compliance Monitoring and Reporting.....	116
9.5	Post-Project Monitoring .....	116
9.6	Management Responsibilities .....	117
9.7	Data, Information and Publication.....	118
9.8	Recommended Reading .....	118
10	KEY REFERENCES .....	121



## **PREFACE**

PIANC Working Group 157 has developed the following guidelines for the implementation of best practice methodology in environmental assessment and environmental management for dredging, port and waterway construction around coastal plant habitats. While these best practices are likely to be further improved in the years to come, experience shows that by adopting the sound planning, impact assessment, monitoring and management practices described in these guidelines, large benefits can be achieved in terms of avoiding or minimising adverse environmental effects on coastal plant habitats from dredging, port and waterway construction activities.

## **TERMS OF REFERENCE**

The document will discuss coastal plant habitats, such as mangroves, tidal marshes, seagrass meadows and macroalgal beds, potential impacts on these habitats from dredging, port and waterway construction, mitigation options and how environmental monitoring and management during these works can help avoid or minimise unwanted, detrimental effects to coastal plant habitats. The guidelines are based on available scientific and grey literature and practical experience, including case studies on dredging, port and waterway construction activities around coastal plant habitats.

The document identifies knowledge gaps, critical environmental issues and practical constraints associated with dredging, port and waterway construction around coastal plant habitats. State-of-the-art methodologies for assessment of impacts are described along with their practical application. Finally, techniques used to prevent, minimise, mitigate and/or compensate impacts, are assessed with respect to their practicality, effectiveness and relevance around coastal plant habitats.

## **MEMBERS OF PIANC WORKING GROUP 157**

### **Dr Paul Erfemeijer (Chair)**

University of Western Australia

### **Mr Matt Jury (Co-Chair)**

DHI Water & Environment, Singapore

### **Dr Jasper Dijkstra (Secretary)**

Deltares, the Netherlands

### **Dr Deborah Shafer**

USACE, USA (retired)

### **Mr Björn Gäbe**

River and Waterways Authority Wilhelmshaven, Germany

### **Mr Daniël Leggett**

DEME, Belgium

### **Dr Jose A.J. de la Peña**

University of Cantabria, Spain

**Mr René Kolman (PIANC EnviCom)** International Association of Dredging Companies (IADC), the Netherlands

## ACKNOWLEDGEMENTS

The Working Group members are grateful for EnviCom providing an opportunity to prepare this guide. We are especially grateful for the input provided by the following independent external reviewers, which have helped with the focus and balance of the document: Mrs Maike Huener & Dr Elmar Fuchs (German Federal Institute of Hydrology, BfG), Mr Fokko van der Goot (Ecoshape/Boskalis), Dr Chris Vivian (GESAMP), Dr Gabriel Grimsditch (UNEP, Marine and Coastal Ecosystems Unit), and Dr Burton Suedel (USACE).

## GLOSSARY

Acronym	Meaning
ADCP	Acoustic Doppler Current Provider
AUV	Autonomous underwater Vehicle
BMPs	Best Management Practices
BPAR	Benthic Photosynthetically Active Radiation
BuDSS	Buoy-Deployed Seedling System
BwN	Building with Nature
CDOM	Coloured Dissolved Organic Matter
CEDA	Central Dredging Association
CIRIA	Construction Industry Research and Information Association
CSD	Cutter Suction Dredger
CSIRO	Commonwealth Scientific and Industrial Research Organisation
dBH	Diameter at Breast Height
DGPS	Differential Global Positioning System
DHI	Danish Hydraulics Institute
DO	Dissolved Oxygen
DOP	Dredging Operation Plan
ECI	Early Contractor Involvement
EIA (ESIA)	Environmental (and Social) Impact Assessment
EMC	Environmental Management Committee
EM(M)P	Environmental Management (and Monitoring) Plan
FDM	Finite-Difference Method
FEM	Finite-Element Method
GD	Grab Dredger
HABs	Harmful Algal Blooms
HAT	Highest Astronomical Tide
IADC	International Association of Dredging Companies
ICZM	Integrated Coastal Zone Management
IUCN	International Union for Conservation of Nature
LNG	Liquified Natural Gas
MHW	Mean High Water MHWS/N Mean High Water Spring/Neap
MLW	Mean Low Water
MLR	Minimum Light Requirement
NDVI	Normalised Difference Vegetation Index
NGO	Non-governmental organisation
PAM	Pulse-Amplitude Modulated Fluorometer
PER	Public Environmental Review
PIANC	The World Association for Waterborne Transport Infrastructure



ROV	Remotely Operated Vehicle/Vessel
LIT	Line Intercept Transect
LISST	Laser In-Situ Scattering and Transmissometry
MPs	Management Practices
PAR	Photosynthetically Active Radiation
pH	Acidity
PLCs	Permits, Licenses or Consents
ppm	Parts per million
PVC	Polyvinyl Chloride
REDD+	Reducing Emissions from Deforestation and forest degradation in Developing countries, and the role of conservation, sustainable management of forests and enhancement of forest carbon stocks in developing countries
SCUBA	Self-Contained Underwater Breathing Apparatus
SET	Surface Elevation Table
SI	Surface Irradiance
SS, TSS	(Total) Suspended Solids
TSHD	Trailing Suction Hopper Dredger
USACE	United States Army Corps of Engineers
USGS	United States Geological Survey
WA	Western Australia
WAMSI	Western Australian Marine Science Institution
WID	Water Injection Dredger
WwN	Working with Nature