

SOUTH WESTERN RIVER BASIN DISTRICT

MARINE MORPHOLOGY NATIONAL METHODOLOGY REPORT






**South Western River Basin District Project Office
5 Eastgate Avenue
Little Island
Cork**

Job Nr: B1537400

June 2008

Revision Control Table

User is Responsible for Checking the Revision Status of this Document

		For & On Behalf of SWRBD Project Office			
Rev	Description of Changes	Prepared By	Checked by	Approved by	Date
A	N/A – First Issue	K Garry J Massey J Barlow	C Farrell	J McKenna	April 2008
B	Updated following Marine Morphology Steering Group Review and Approval	K Garry	C Farrell	J McKenna	June 2008
	Signed:				

No part of this document may be re-produced or transmitted in any form or stored in any retrieval system of any nature, without the written permission of SWRBD Project Office, as Copyright Holder, except as agreed for use on this specific project.

TABLE OF CONTENTS

	Page
GLOSSARY OF TERMS	i
EXECUTIVE SUMMARY	vii
1 INTRODUCTION AND BACKGROUND	
1.1 The Water Framework Directive & Morphology	3
1.2 Initial Risk Assessment	6
1.3 Overall Approach – Marine Morphology PoMs Study	10
1.4 Report Structure	14
2 LITERATURE REVIEW	
2.1 Introduction	1
2.2 Conclusions	10
3 DATA REVIEW	
3.1 Introduction	1
3.1.1 Metadata	2
3.1.2 Interim Data Review	2
3.1.3 Tool Development	5
3.2 Final Data Review Findings	6
3.2.1 Baseline Data	7
3.2.1.1 TraC Water Body Boundaries	7
3.2.1.2 Irish Coastline / High Water Mark	8
3.2.1.3 Intertidal Area	9
3.2.1.4 CORINE	10
3.2.1.5 Foreshore Licence/Lease Register	10
3.2.1.6 Environmental Impact Statement Register	11
3.2.1.7 Coastal Images	12
3.2.1.8 Historic Maps	17
3.2.1.9 Bathymetric Data	17
3.2.2 Pressures	18
3.2.2.1 Dredging, Other Disturbances & Disposal at Sea	21
3.2.2.2 Piled, Flow and Sediment Manipulation Structures	29
3.2.2.3 Shoreline Reinforcement	33
3.2.2.4 Flood Embankments	37
3.2.2.5 Impounding Structures & Causeways	41
3.2.2.6 Land Claim	46
3.2.2.7 Intensive Land Use	48
3.2.2.8 Abstractions	50
3.3 Morphology	52
3.3.1 Data Resources	52
3.4 Ecology	53
3.4.1 Data Resources	53
3.4.2 Methodology for Assessing Ecology	57
3.5 Pressure Footprints	57
3.6 Delivery and dissemination	58
3.7 Recommendations for Further Data Requirements	59
3.7.1 Baseline Data	60
3.7.2 Morphological Data	60
3.7.3 Pressures	61
3.8 Conclusions	63

4	REVIEW OF EXISTING MONITORING SYSTEMS	
4.1	Introduction	2
4.2	Review of Organisations Involved	3
4.3	Review Summary of Existing Marine Monitoring	7
4.3.1	Introduction	7
4.3.2	Pre-WFD Monitoring Programmes	8
4.3.3	Variable Measured for Marine Water Samples	13
4.3.4	Environmental Impact Assessments / Investigations	16
4.3.5	Conservation Monitoring	16
4.3.6	Post-WFD Monitoring Programmes	17
4.4	Water Framework Directive Monitoring Programme for TraC Waters	19
4.5	Conclusions	25
5	MORPHOLOGICAL IMPACT METHODOLOGY AND ASSESSMENT TOOL	
5.1	Introduction to Morphology/Ecology Relationships in the Context of the WFD	2
5.2	Transitional and Coastal Morphological Impact Assessment System	11
5.2.1	Module 1: Eco-geomorphic Attributes	13
5.2.2	Module 2: Typology	16
5.2.3	Module 3: Sensitivity Assessment	17
5.2.4	Module 4: Impact Assessment (Pressures)	18
5.2.5	Module 5: Capacity Based Scoring System	19
5.3	Pressures	23
5.3.1	Land Claim & Tidal Realignment	24
5.3.2	Dredging, Other Disturbances to Seabed, & Disposal at Sea	25
5.3.3	Piled Structures	29
5.3.4	Flow and Sediment Manipulation Structures	30
5.3.5	Impounding Structures & Causeways	31
5.3.6	Shoreline Reinforcement	34
5.3.7	Flood Embankment	36
5.3.8	Intensive Land-Use	37
5.3.8.1	<i>Salt Marsh Grazing</i>	40
5.3.8.2	<i>Peat Bogs</i>	41
5.3.8.3	<i>Intensive Sea Use</i>	42
5.4	Development & Use of TraC-MImAS for the Purpose of Risk Assessments	44
5.4.1	Clonakilty Harbour (SW_100_0100)	44
5.4.2	Development and approval stages of TraC-MImAS for use as a morphological assessment tool in Ireland	53
6	FURTHER CHARACTERISATION METHODOLOGY & OUTCOMES	
6.1	Introduction	1
6.2	Methodology - Further Characterisation	4
6.2.1	Assumptions	4
6.2.2	Water Body Typology	4
6.2.3	TraC-MImAS Application (Steps 1 - 3)	6
6.3	Results - Further Characterisation	11
6.3.1	Results of Step 1	16
6.3.2	Results of Step 2	16
6.3.3	Results of Step 3	17
6.3.4	Water bodies further characterised as at risk of failing to achieve Good Ecological Status	31
6.3.5	Results Summary	31

7	GOOD PRACTICE REVIEW FOR MORPHOLOGICAL MITIGATION MEASURES	
7.1	Introduction	1
7.2	Key Definitions and Concepts	2
7.2.1	WFD Morphological Conditions in Transitional and Coastal Waters	2
7.2.2	Conceptual frameworks for restoration and recovery in TraC environments	2
7.3	Review Process	4
7.3.1	Information Reviewed	4
7.4	Potential Types of Measures	8
7.5	Contents and use of the accompanying spreadsheet (Appendix 7-1)	9
7.6	Identifying Potential Measures	10
7.6.1	Applying the good practice guidance	10
7.6.2	Information on costs/cost effectiveness	10
7.6.3	A decision-making framework to select measures	13
8	FUTURE TRENDS	
8.1	Introduction	1
8.2	Drivers Sectors	2
8.2.1	Coastal Defence and Flood Management	3
8.2.2	Sea-level rise	4
8.2.3	Infrastructure	6
8.2.4	Navigation	10
8.2.5	Recreation	12
8.2.6	Agriculture	12
8.2.7	Mining, Quarrying and Mineral Extraction	13
8.2.8	Water Abstraction	14
8.3	Conclusions	15
9	RECOMMENDATIONS FOR THE DESIGN OF THE MONITORING PROGRAM	
9.1	Introduction	1
9.2	Recommendations for baseline conditions and change	1
9.2.1	Baseline Conditions (existing status)	1
9.2.2	Monitoring of morphological changes	8
9.2.3	Intertidal	8
9.2.4	Subtidal, Coastal and Transitional	9
9.3	Recommendations for Information Requirements	11
9.4	Conclusions	16
10	RECOMMENDATIONS FOR THE DESIGN OF THE PROGRAMMES OF MEASURES	
10.1	Introduction to the Requirements for a Programme of Measures	3
10.1.1	Basic Measures	6
10.1.2	Supplementary Measures	8
10.2	Existing Legal Framework Relevant to Morphology in TraC Waters	9
10.2.1	Responsible Bodies Governing Irish TraC Waters	9
10.2.2	Legislative Structure Governing Irish TraC Waters	10
10.2.2.1	<i>Governing Legislation - International</i>	10
10.2.2.2	<i>Governing Legislation - European</i>	11
10.2.2.3	<i>Governing Legislation - National, Regional and Local Levels</i>	20
10.2.2.4	<i>Guidance</i>	27

	10.2.3	Conclusions from Legislative Appraisal (Basic Measures)	29
10.3		Recommendations for Basic Measures and Supplementary Measures	31
10.4		Prioritisation of TraC Water Bodies for the Application of Appropriate Measures	33
	10.4.1	Introduction	33
	10.4.2	Prioritisation of TraC Water Bodies	40
	10.4.3	Identification of Appropriate Measures	50
10.5		Overall Conclusions	63
11		RECOMMENDED REGULATORY DECISION SUPPORT METHODOLOGY FOR FUTURE USE	
11.1		Introduction	1
	11.1.1	Planning and Environmental Impact Assessment	2
	11.1.2	The WFD and Physical Modifications	5
11.2		Decision Support for the Regulation of Physical Modifications	9
	11.2.1	Regulatory Process for the Authorisation of Developments consisting of Physical Modifications	11
	11.2.2	Screening	13
	11.2.3	Pre-application Discussions	14
	11.2.4	Scoping	16
	11.2.5	Receipt of Application	16
11.3		Worked Example: Inner Bantry ay Proposed Harbour Development	18
	11.3.1	Pre-application Discussions	20
	11.3.2	Scoping	21
	11.3.3	Receipt of Application	30
11.4		Further Development	30
	11.4.1	Base Data and TraC-MImAS	30
	11.4.2	Water Body Scaling and Single Activity Limits - Thresholds for screening	34

12 REFERENCES

APPENDICES

2-1	Literature Review
3-1	Data Review
3-2	Environmental Impact Statements
6-1	RoI MImAS Trial Results Version M2d
6-2	pHMWB MImAS Trial Results Version M2d & pHMWB MImAS Trial Results Version M2f
6-3	Overall Results
6-4	WB Summary Sheets
7-1	Interactive Good Practice Spreadsheet
10-1	Recommendations for the Design of the Programmes of Measures
11-1	Proposed Measures

GLOSSARY OF TERMS

ABP	Associated British Ports
ACE	Advisory Committee on Ecosystems
ACFM	Advisory Committee on Fishery Management
ACME	Advisory Committee on the Marine Environment
AFF	An Foras Forbartha
ALAC	Aquaculture Licence Advisory Committee
ALSM	Airborne Laser Swath Mapping
AMAP	Arctic Monitoring and Assessment
AMBI	ATZI Marine Biotic Index
ArcGIS	Geologic Information System software (ESRI)
Art 5	Article 5
ATBI	All Taxa Biodiversity Index
AWB	Artificial Water Bodies
BDC	Biodiversity Committee (OSPAR)
BGS	British Geological Survey
BIM	Bord Iascaigh Mhara
BioMAR	Identification, description and mapping of biotopes project.
BP	Best Practice
BPP	Biological Primary Production
CCW	Countryside Council for Wales
CDT	Conductivity, Depth and Temperature
CEDA	The Central Dredging Association
CEFAS	Centre for Environment Fisheries and Aquaculture
CFB	Central Fisheries Board
CFRAMS	Catchment Flood Risk Assessment and Mapping Studies
CIA	Central Intelligence Agency (US)
CICRA	Communication Information Resource Centre Administrator
CIRIA	Construction Industry Research and Information Association
CIS	Common Implementation Strategy
CIWEM	Chartered Institute of Water and Environmental Management
CMRC	Coastal and Marine Resource Centre
CMS	Coastal Management for Sustainability
COAST	WFD Working Group for Typology, Reference Conditions and Classification of Transitional and Coastal Waters.
CoCo	County Council
CORINE	Coordination of Information on the Environment
COZAS	Coastal Zone Administration System
CREH	Centre for Research into Environment and Health
CRP	Collaborative Research Programme
cSAC	Candidate Special Areas of Conservation

CSO	Central Statistics Office
DAFF	Department of Agriculture, Fisheries and Food
DARD	Department for Agriculture and Rural Development
DCENR	Department of Communications, Energy and Natural Resources
DCMNR	Department of Communications, Marine and Natural Resources
DEFRA	Department for Environment, Food and Rural Affairs
DEHLG	Department of Environment, Heritage and Local Government
DoM	Department of Marine
DoT	Department of Transport
DPSIR	Driver, Pressure, State, Impact, Response
EA	Environment Agency
EC	European Commission
EcoServe	Ecological Consultancy Services Ltd
EEA	European Environment Agency
EEZ	European Economic Zone
EHS	Environment Heritage Service (NI)
EIA	Environmental Impact Assessment
EIHA	Working Group (OSPAR) on the Environmental Impact of Human Activities
EIS	Environmental Impact Statement
ENFO	Information on the Environment
EMS	Environmental Management System
EPA	Environmental Protection Agency
EQS	Environmental Quality Standards
ERBD	Eastern River Basin District
ERDF	European Regional Development Fund
ERI	Environmental Research Institute
ERU	Environmental Research Unit
ESB	Electricity Supply Board
ESPO	European Sea Ports Organisation
ESRI	Environmental Systems Research Institute, Inc
EU	European Union
EU INTERREG	EU funded programme that helps Europe's regions form partnerships to work together on common projects.
EUNIS	European Nature Information Centre
EUROSION	European study into coastal erosion at a European scale
FAO	Food and Agriculture Organisation (United Nations)
FCS	Favourable Conservation Status
FRC	Fisheries Research Centre
FTT	Fish Task Team
FW	Fresh water
GD	Guidance Document
GEBCO	General Bathymetric Chart of the Oceans

GEP	Good Ecological Potential
GES	Good Ecological Status
GIS	Geographic Information System
GNP	Gross National Productivity
GSI	Geological Survey of Ireland
HabMap	HABitat MAPping for conservation and management of the Southern Irish Sea
HELCOM	Helsinki Commission
HES	High Ecological Status
HGES	High or Good Ecological Status
HMWB	Heavily Modified Water Bodies
HWM	High Water Mark
IADC	International Association of Dredging Companies
IC	WFD Impacts and Pressure Working Group
ICES	International Committee for the Exploration of the Seas
ICZM	Integrated Coastal Zone Management
IEC	International Electrotechnical Commission
IFIS	Integrated Fisheries Information System
IHO	International Hydrographic Office
ILU	Intensive Land Use
IM	Investigative Monitoring
IMAGIN	Irish Sea Marine Aggregates Initiative
IMDO	Irish Maritime Development Office
IMPRESS	WFD Impacts and Pressure Working Group
INFOMAR	INtegrated mapping FOr the sustainable development of Ireland's MARine Resource
INSPIRE	Infrastructure for Spatial Information in the European Community, EU Directive 2007/2/EC
INSS	Irish National Seafloor Survey
IOSEA	Irish Offshore Strategic Environmental Assessment
IPCC	Intergovernmental Panel on Climate Change
IPPC	Integrated Pollution Prevention and Control
ISO	International Standards Organisation
JMG	Joint Monitoring Group (OSPAR)
JNCC	Joint Nature Conservation Committee (UK)
LA	Local Authority
LGCSB	Local Government Computer Service Board
LiDAR	Light Detection And Ranging
LNG	Liquid Natural Gas
LWM	Low Water Mark
MarLIN	UK Marine Biological Association's Marine Life Information Network
MASH	Working Group (OSPAR) on Marine Protected Areas, Species and Habitats
MBA	Marine Biological Association
MBITT	Marine Benthic Invertebrate Task Team

MCLs	Morphological Condition Limits
MEP	Maximum Ecological Potential
MESH	Marine Environmental Seabed Habitats
MI	Marine Institute
MIDA	Marine Irish Digital Atlas
MImAS	Morphological Impact Assessment System
MLCs	Morphological Condition Limits
MLVC	Marine Licence Vetting Committee
MMDST	Marine Morphology Decision Support Tool
MNCR	Marine Nature Conservation Review
MTT	Marine Task Team
NBIRBRD	Neagh Bann International River Basin District
NBN	National Biodiversity Network (UK)
NDP	National Development Plan
NEMP	National Environmental Monitoring Programme
NHA	Natural Heritage Area
NI	Northern Ireland
NIMA	US National Imagery and Mapping Agency
NOAA	National Oceanic and Atmospheric Administration
NPWS	National Parks and Wildlife Service
NRA	National Roads Authority
NSS	National Spatial Strategy
NS-Share	North-South Share
NWIRBD	North Western International River Basin District
OECD	The Organisation for Economic Co-operation and Development
OM	Operational Monitoring
OPW	Office of Public Works
OSi	Ordnance Survey Ireland
OSPAR	Oslo and Paris Convention
OSPARCOM	Oslo and Paris Commissions
PAD	Petroleum Affairs Division
PDF	Portable Document Format
PIANC	Permanent International Association of Navigation Congress
PIP	Petroleum Information Programme
pNHA	Proposed Natural Heritage Area
PoMS	Programme of Measures and Standards
PoMs	Programme of Measures
PPP	Proposed Plans and Programmes
PRB	Pilot River Basin
PROCLAN	WFD Working Group for Best Practices in river basin planning
PTT	Plant Task Team
RA	Risk Assessment

R & D	Research and Development
RBD	River Basin District
RBMP	River Basin Management Plan
RBMS	River Basin Management Strategy
REFCOND	WFD Reference Conditions in inland waters working group
REPS	Rural Environmental Protection Scheme
ROI	Republic of Ireland
RPII	Radiological Protection Institute of Ireland
PSPB	Royal Society for the Protection of Birds
SAC	Special Area of Conservation
SAHFOS	Sir Alister Hardy Foundation for Oceanic Sciences
SBS	Sea Bed Sediment
SDT	Secchi disc transparency
SEA	Strategic Environmental Assessment
SEABED	Working Group (OSPAR) on the impact on the seabed
SensMap	Sensitivity and mapping of inshore marine biotopes in the southern Irish Sea
SEPA	Scottish Environmental Protection Agency
SERBD	South Eastern River Basin District
SFPA	Sea-Fisheries Protection Authority
SGSOBS	Study Group on Ecological Quality Objectives for Sensitive and for Opportunities Benthos Species
ShIRBD	Shannon International River Basin District
SIAM	Synergies in Assessment and Monitoring
SM	Surveillance Monitoring
SNH	Scottish Natural Heritage
SnapMap	Oblique coastal helicopter survey image viewer (DCENR)
SNIFFER	Scotland and Northern Ireland Forum For Environmental Research
SPA	Special Protection Area
SSSI	Special Site of Scientific Interest
SWMI	Significant Water Management Issues
SWRBD	South Western River Basin District
TCD	Trinity College Dublin
ToR	Terms of Reference
TraC	Transitional and Coastal
TraC-MImAS	Transitional and Coastal Morphological Impact Assessment System
UCC	University College Cork
UCD	University College Dublin
UK	United Kingdom
UKTAG	United Kingdom Technical Advisory Group
UNCLOS	United Nations Convention on Law Of the Sea
UNCSD	United Nations Commission on Sustainable Development
UNESCO	United Nations Educational, Scientific and Cultural Organisation

US	United States of America
USGS	United States Geological Survey
WASA	Wave and Storm in the Northern Atlantic group
WATECO	WFD Economic Analysis Working Group
WB	Water Body
WFD	Water Framework Directive
WG	Working Group
WGICZM	Working Group (ICES) on Integrated Coastal Zone Management
WGMDM	Working Group (ICES) on Marine Data Management
WRBD	Western River Basin District
XML	Extensible Markup Language

EXECUTIVE SUMMARY

The Marine Morphology Programme of Measures and Standards (PoMS) Study aims to provide a protocol to apply in the further characterisation and risk appraisal for morphology in transitional and coastal (TraC) waters, the outcomes of which will contribute to the development of a tool aimed at supporting the assessment and management of morphology in these water bodies.

The objectives of the study are as follows:

- Establish the relationship between morphology characteristics and biological status;
- Identify what level of morphological pressure is sustainable within a water body;
- Establish which morphological indicators should be included in TraC monitoring programmes;
- Identify water bodies where morphology restoration measures are required (linked to HMWB designation process);
- Identify the available buffer (or capacity) of water bodies in order to prioritise action levels;
- Prioritise morphology pressures; and
- Develop a decision support tool for regulators to assess the potential impact of future developments on individual water bodies (i.e. to prioritise activities and establish a tiered assessment system).

This study involves all 309 TraC water bodies within the Republic of Ireland (RoI), but was undertaken in parallel to the North-South Share (NS-Share) project to ensure compatibility of methodologies between Northern Ireland (NI) and the RoI.

The hydromorphological quality elements defined by Annex V of the WFD must be taken into account when assigning surface water bodies to high ecological status. For other status classes, the hydromorphological elements are required to have '*conditions consistent with the achievement of the values specified for the biological quality elements*' (WFD, Annex V).

Member States are only required to report on hydromorphology for those water bodies designated as 'High Status'. For these water bodies it is assumed the European Commission will require information on the normative definitions, for example the structure of the water body's intertidal zone indicates little or no human impacts. It is important to note that the impact assessment tool used in this study can only indicate the likely risk to the WFD quality elements; monitoring results are required to quantify these risks.

The initial risk assessments completed across Europe have shown that hydromorphology is one of the most significant pressures operating in surface waters and therefore contributing to the failure to achieve WFD objectives.

The Irish initial risk assessments completed in 2005 concluded that 35% of transitional (estuarine) water bodies, and 18% of coastal water bodies within the RoI were '*at risk*' or '*probably at risk*' of failing to meet the WFD objective of 'Good' Status due to physical alteration. The Marine Morphology Study further characterises these risks by researching the relationship between morphology and ecology and further defining the pressures on morphology.

Literature Review

An initial step in achieving the objectives of the Marine Morphology study was to undertake a Literature Review. This review concluded that the most common, and in most cases necessary, approach to assessing and reporting the impact of morphological pressures on ecology involves a mixture of qualitative and quantitative assessments, and although it is clear that many anthropogenic activities which result in pressures to morphology have some impact on ecology there are limited quantitative data throughout Europe describing the relationships between morphological conditions and ecological health.

The lack of sufficient criteria and thresholds available to assess the risk of a water body failing to meet Good Status is being investigated by the UK-Ireland Marine Task Team. However, the progression of this work in relation to morphology, at the time of writing has yet to result in formal classification tools (criteria or thresholds).

The conclusions drawn by the Literature Review led to consideration of the Scottish Environment Protection Agency's (SEPA) Transitional and Coastal Morphological Impact Assessment System (TraC-MImAS) for the purpose of further characterisation of TraC morphological pressures and as a decision support tool for the future regulation of TraC water bodies in the RoI.

Data Review

In preparation for the use of the TraC-MImAS tool, where possible, a series of national marine morphology pressure datasets were created as shapefiles in a Geographic Information System (GIS). Various restrictions associated with data licence agreements were experienced throughout this process. This included the limited availability of orthophotos, coverage of which was essential to the creation of new pressure footprints.

However, the data was developed to the best scale and detail possible given the limitations experienced, to provide a comprehensive and consistent dataset for Ireland.

The confirmation of an 'end user' of such a tool was fundamental to the licence agreements and data requests required for this study. However, notwithstanding support from the Marine Morphology Steering Group an appropriate end user for this tool has not as yet been identified. As a temporary alternative, to ensure the progress of this study, the SWRBD, and Cork County Council, were identified as substitute end users. The SWRBD, and Cork County Council, have no function to hold or use such a tool for the purpose of regulation and are intended only as a temporary 'end user' until an appropriate assessment or regulatory body is identified.

Existing Monitoring

A review of existing European and national monitoring programmes was undertaken with the aim to determine if these programmes are of benefit to the assessment of morphological conditions within TraC waters.

There are two main requirements for marine morphology data under the WFD

- to determine the ecological status of a water body, and
- to detect change that may affect this status.

In order to assess these requirements, a morphological baseline is needed and investigative monitoring relating pressures to morphology must be collected. It is important to note that changes in morphology can be triggered by natural changes in TraC waters and this should be considered in the collection and interpretation of monitoring results.

Monitoring for both baseline and change of morphology is a difficult process. Natural morphological change occurs over long periods and must therefore be monitored and reported as time series data. The morphological quality elements prescribed by the WFD have yet to be formally adopted within a classification system. The difficulty in classifying these elements has been demonstrated by the 'Metrics' project initiated by UK and Ireland Marine Task Team.

There are few national monitoring programmes specifically associated with morphological conditions. Monitoring has predominately been aimed at water quality and associated with the compliance of bathing and shellfish water legislation. In addition to this, protected areas require monitoring of their biological and environmental quality; but this assessment is generally infrequent and, with the exception of saltmarsh and benthic monitoring, is not of particular relevance.

Morphological Impact Assessment

The link between morphology and ecology is relatively well established in fluvial environments. However, there is less documented information and scientific research linking morphology to ecology in marine environments. In the context of the WFD, there is a need to understand how changes in the morphological quality elements (resulting from pressures) result in alteration to biological elements, causing them to be disturbed from the reference condition and leading to deterioration in quality status. It is acknowledged that there are currently gaps in understanding many of these linkages, particularly at the water body scale. Future monitoring has the potential to increase understanding of these relationships (together with physico-chemical elements).

Although a review of recent seabed mapping projects (*MarLIN* and *SensMap*), and development of links between habitat and species in marine environments, show that there are sound theoretical bases for assuming that changes to morphology brought about by pressures will have resulting impacts on ecological and biological features, the absence of suitably detailed baseline data to use these methods now for the WFD means that the first round of river basin planning will need to rely on tools which focus on general links between morphology and ecology.

In order to be able to estimate and report on the risk posed by morphological alterations to the ecological status of TraC water bodies, morphological impact assessment tools were investigated. Firstly the Marine Morphology study investigated the use of marine 'Metrics' which were being developed by the UK Environment Agency in association with the Scotland and Northern Ireland Forum for Environmental Research (SNIFFER) as part of a project to develop hydromorphological reference conditions and a draft classification scheme for TraC waters. This project was focused on defining only high status and the boundary between high/good, and emphasised that the biological classification scheme should incorporate metrics that are sensitive to hydromorphological changes. The threshold limits proposed by this study were largely based on expert judgement due to considerable limitations in current understanding and availability of data.

In determining a suitable framework which could facilitate the development of environmental standards for TraC waters within the time scales required of the first river basin planning cycle, the UK Technical Advisory Group (UKTAG) reviewed both these Metrics and the River Morphological Impact Assessment (MImAS) tool being applied in Scotland. UKTAG concluded that the framework currently being developed for the Metrics would require further development within a more structured framework to allow environmental standards to be developed and approved. Following a request from UKTAG

to determine if the MImAS framework could be successfully adopted for TraC waters, it was confirmed that the scientific principles underpinning MImAS were transferable to TraC waters. Therefore work on a draft TraC-MImAS tool commenced.

Participation in the UKTAG TraC Morphology Steering Group and the TraC-MImAS Technical Panel Ireland (RoI and Northern Ireland Marine Morphology PoMS teams) supported the development of TraC-MImAS.

The TraC-MImAS tool was developed with the intention to help regulators determine whether changes to the morphology of TraC waters could pose a risk to ecology, and thereby identify those proposals that could:

- Threaten the aim of achieving 'good ecological status'; or
- Result in a deterioration in ecological status

The TraC-MImAS tool is not intended to provide a detailed assessment of ecological status, but rather provide a means of identifying where ecological conditions are likely to be impaired through impacts to morphology, i.e. it is based on the assumption that an assessment of impacts on ecologically relevant features and processes can be used to protect morphology and ecology.

The tool uses a concept of 'system capacity' (allowable morphological change) to measure impacts to morphological conditions, assuming that pristine TraC waters have a measure of assimilative 'capacity', which can be degraded by anthropogenic activities. SEPA have defined 'system capacity' as:

A measure of the ability of the water environment to absorb morphological alterations. The likelihood (or risk) that morphological and ecological conditions are degraded will increase as system capacity is consumed. This concept does not infer that degradation of the environment is acceptable; rather it assumes that there is a degree to which minor changes can be tolerated by the system.

TraC-MImAS is underpinned by a series of assumptions:

- 1 A TraC water body has some capacity to accommodate morphological change without changes to its ecological status.
- 2 There is a relationship between the extent of morphological alteration and the impact on ecological status.
- 3 The response of a water body's morphology to an engineering activity or other pressure is predictable for that type of water body.

- 4 The response of the ecology to morphological change is predictable and depends on the sensitivity of the ecology of the water body.

TraC-MImAS comprises 5 modules which combine to estimate the existing system capacity of a water body as a percentage.

Module 1: Eco-geomorphic attributes

Module 2: Typology

Module 3: Sensitivity assessment

Module 4: Impact assessment

Module 5: Capacity based scoring system

Each module can be updated independently thereby facilitating future development of this tool.

The eco-geomorphic attributes of Module 1 were chosen for their role in the direct or indirect support of ecological communities and the supporting processes needed to create and maintain the physical environment on which ecological communities depend and relevance to the morphological quality elements specified by Annex V of the WFD.

The function of TraC-MImAS is heavily reliant on the typology of water bodies, a point which was highlighted by the UK and Ireland Marine Task Team. It was agreed that the function of this tool would benefit greatly from the further improvement of this module (through further field assessments).

The sensitivity considered by Module 3 combines both the estimated morphological and ecological sensitivity of each TraC water body type. It is based on the likelihood that an eco-geomorphic attribute and its supported ecology will change in response to an applied pressure.

Module 4 forms a distinction between the intensity and extent of the likely impact of a pressure but indicating the likelihood that a pressure will impact an eco-geomorphic attribute, and whether these impacts are likely to be contained within the vicinity of a pressure footprint or be pervasive.

In the absence of Environmental Standards for morphology, TraC-MImAS uses Morphological Condition Limits (MCLs) to help quantify the potential risk that a new morphological alteration could impair achievement of the ecological objectives of the WFD. SEPA define the MCLs as “*thresholds of alteration to morphological conditions beyond*

which there is a risk that the ecological status objectives of the WFD could be threatened'. MCLs are expressed in terms of % capacity of a water body, and are defined for 3 TraC zones: Hydrodynamic; Intertidal; and Subtidal.

As with the thresholds investigated as part of the marine 'Metrics' study, the MCLs were largely based on expert judgement due to considerable limitations in current understanding and availability of data.

The UK and Ireland Marine Task Team agreed the following points in relation to the use of TraC-MImAS:

- The group was comfortable that the principles and approach underpinning TraC-MImAS are logical and reasonable.
- TraC-MImAS is suitable to support the three purposes defined by SEPA:
 - Regulatory risk assessments.
 - Identification of high status conditions for morphology.
 - Contribute to surrogate classification assessments for the other ecological status boundaries (but not to be used in isolation).
- The condition limits proposed are set at an acceptable level for incorporation into the UKTAG Environmental Standards report; however, these values should be reviewed and refined where possible.

The further development of the typology module of this tool was a key recommendation. With regard to the further development of the MCLs, further field assessments including investigative monitoring are required to refine the association between these values and morphological and ecological status class.

Working with SEPA, TraC-MImAS trials were undertaken in Ireland to assist in its development process. The purpose of the trials was to test the appropriateness of the MCLs and the also the framework within which MImAS may be applied to support regulation.

TraC-MImAS was updated on completion of both these trials and an external technical review undertaken by Anton Edwards of Metoc Environmental Consultants.

TraC-MImAS expresses the risk of a water body failing WFD objectives by indicating the potential ecological status class that may be achieved based on the water body type and pressure extents identified. For example, a result of 'Good' indicates that this water body is potentially at risk of failing to achieve high morphological status and in turn high ecological

status. It is important to note that the results of this study are wholly based on the detailed risk assessment undertaken for the purpose of further characterising TraC waters, and any reference to status class boundaries is wholly based on this risk assessment and has not been verified by field assessments or reference to biological classification. The formal classification of morphological status for TraC water bodies in Ireland is outside the scope of the Marine Morphology Study.

Following endorsement by the both the Marine Morphology Steering Group and Marine Task Team, TraC-MImAS (version M2f (final)) was applied to Irish TraC water bodies for the purpose of further characterising the risk associated with anthropogenic physical alterations.

Further Characterisation

Of the 309 TraC water bodies, 122 were prioritised for further characterisation using TraC-MImAS. This prioritisation was based on a number of assumptions agreed with the Marine Morphology Steering Group. In addition, TraC-MImAS was also applied to a further fourteen water bodies following a request from the EPA.

Further characterisation of pressures on TraC water bodies concluded that the NWRBD and WRBD contain the least percentage coverage of morphological pressure footprints identified. Also, with the exception of 'low impact dredging' (maintenance) and 'other disturbances to seabed', morphological pressures are generally most extensive within transitional water bodies. This was an expected result as many of Ireland's urban/industrial areas as well as sensitive coastlines are concentrated within the transitional water bodies.

Low impact dredging and other disturbances to seabed are significant pressures within all River Basin Districts (RBDs). Low impact dredging is of most significance within the Shannon and South Western RBDs, where this pressure was identified as associated with the maintenance of both shipping navigation channels and drainage channels. The pressure 'other disturbances to seabed' combining the footprints of shellfish dredging, ferry channels, marine cables and pipelines, and areas zoned for wind farm development is dominated by areas designated for shellfish dredging. Licensed shellfish areas noted by this assessment occupy approximately 17 % of the TraC water body area. It should be noted that the detailed assessment of the impact of aquaculture practices is outside the scope of this study and the areas identified as shellfish dredging areas are not necessarily the "worked" area.

Shannon International River Basin District (ShIRBD)

The ShIRBD exhibits the most extensive shoreline and areal pressure footprints. However, the areal pressures are primarily associated with low impact dredging and other disturbances to seabed; the latter of which requires further assessment of aquaculture areas to confirm pressure extents. Nearly 14% of this river basin district's shoreline is embanked, which is 11% greater than any other RBD. This extensive network of embankments within the ShIRBD is heavily concentrated on the following water bodies:

- Cashen
- Fergus Estuary
- Mague Estuary
- Upper Shannon Estuary

Eastern River Basin District (ERBD)

The ERBD is also subject to extensive shoreline pressure footprints, with nearly 13% of its entire shoreline reinforced. Also, approximately 38% of the ERBD TraC water body area is subject to pressures such as low impact dredging (maintenance dredging), land claim and other disturbances to seabed. The latter pressure consists of footprints for shellfish dredging, vessel movements, and marine cables and pipelines; shellfish dredging was identified as the most significant of the three. Over 1% of this RBD's coast has been reclaimed, a significant proportion of which is in the Dublin area.

Neagh-Bann River Basin District (NBRBD)

The most significant pressure footprints identified for the NBRBD TraC water bodies are those associated with other disturbances to seabed, low impact dredging and embankments. Of those embankments identified all features were concentrated within the Glyde and Ballymascanlan Estuaries.

South Western River Basin District (SWRBD)

A significant proportion of the SWRBD's TraC water body area has been identified as impacted by shellfish dredging, which is a component of the pressure 'other disturbances to seabed'. Second only to the ShIRBD, over 6% of this RBD's total water body area is subject low impact dredging. The majority of the high impact shoreline reinforcement identified is concentrated on the transitional water bodies.

South Eastern River Basin District (SERBD)

Second only to the ERBD, a significant portion of the SERBD's shoreline is subject to high impact shoreline reinforcement. The other significant pressures identified for this RBD are low impact dredging and other disturbances to seabed.

Western River Basin District (WRBD)

The most significant pressure on the WRBD TraC water bodies is that associated with shellfish dredging, with over 25% of its area designated as the pressure 'other disturbances to seabed'. Low impact dredging also contributes to the morphological pressures within this district, whereas footprints for all other pressures are minimal.

North Western River Basin District (NWRBD)

Limited pressure footprints were identified for this RBD as a whole, with the most extensive pressures of low impact dredging and 'other disturbances to seabed' present in approximately 5% and 10% of the TraC water body area respectively. Although the results indicate that pressure footprints are limited for the RBD overall, the concentration of embankments within the following water bodies has significant impact on their potential to achieve GES:

- Blanket Nook Lough
- Foyle and Faughan Estuaries
- Inch Lough
- Swilly Estuary

Further characterisation of the pressures on the morphology of Irish TraC water bodies has concluded that 12% of transitional water bodies, and 2% of coastal water bodies within the Republic of Ireland are likely to be at risk of failing to meet the WFD objective of good ecological status. At this stage of assessment, prior to confirmation via monitoring and formal classification, 12% of transitional and 10% of coastal water bodies indicate the ability to achieve high ecological status.

Good Practice Review

Existing information relating to good practice measures for activities involving hydromorphological alterations to TraC waters has been collated within an interactive database to aid decisions which aim to identify appropriate measures.

Measures relating to morphology in TraC waters will be those that seek to prevent deterioration, maintain status/quality, or 'restore' conditions, related to:

- Depth variation
- Structure and substrate of the subtidal bed
- Structure of the intertidal zone

The hydrological elements are strongly connected with these and include the direction of dominant currents, the degree of wave exposure, and the amount of freshwater flow in estuaries.

There is potential for the recommended good practice measures themselves to result in direct or indirect changes to morphological conditions; for example the use of training walls to reduce the frequency of dredging operations in estuaries (to promote self-scouring) may impact on all three of the morphological elements listed above.

The measures reviewed can be classified as:

- General good environmental practice and management plans
- Mitigation measures
- Restoration measures
- Natural recovery (which should not be discounted as an option)

Detailed information on these measures, including theory and case studies, is included in the database appended and the reference links within.

In reviewing generic 'Good Practice', it is important to emphasise that mitigation measures that have proven successful in one location may not be directly applicable in other environments. Most good practice guidance emphasises the need for site-specific investigations and design in the context of a wider strategy (in this case the strategic scale is led by the RBMP).

Various economic-based research reports of relevance to morphology were identified, summaries and reference links to which are provided in the database. These include the development of a methodology to assess disproportionate costs, a database for benchmark costs and guidance on applying cost-effectiveness methodology, and a scoping report with specific focus on economic impacts in TraC waters. The latter concludes that the financial and economic implications for sectors operating in TraC waters could be significant.

Costing of individual measures is difficult for a number of reasons. Specific examples include: the lack of available and up to date data (often information is confidential and related to contracts); the geographical scale of implementation required; site specific details and the necessary costs of feasibility and design; and the associated costs of legislative or other mechanisms to implement the measures.

Measures which might be achievable at minimum cost typically include: the development or application of codes of good practice; better enforcement of (often existing) local regulation; some zoning initiatives; and various research initiatives. Potential measures involving anticipated moderate costs include: some research initiatives; required modifications

(whether to plant, gear or working methods); and/or certain types of constraints imposed on activities by regulatory bodies. Depending on specific details, measures prohibiting certain activities or working methods (e.g. certain dredging techniques) may be shown to be disproportionately costly, particularly if the full range of consequential costs is considered in the analysis.

Future Trends

The WFD presents a need to analyse not only existing pressures on water bodies, but also those that may influence the achievement of the WFD objectives by 2015.

The main overarching trends likely to affect marine morphology are climate change and associated sea level rise, and the effect these have on coastal areas, causing increased flood risk and the need for coastal protection.

The uncertainties of climate change make it difficult to predict with any accuracy, the coastal protection or other measures that might be associated with sea level rise / increase in storm surges or possible impact of freshwater shortages that could affect Ireland in the future.

Additional pressures, linked to climate change, include the possibility of water demands exceeding supply in some areas, resulting in the need for water abstraction and potentially desalination, to meet requirements. The possibility of these water shortages could change agricultural patterns and could place more pressure on coastal areas by increasing the need for expansion of fisheries and aquaculture industries to meet growing demands.

Pressures from ports and coastal population centres are also likely to develop in coastal areas and estuaries. Ireland is reliant on sea transport for much of its trade; therefore it is considered that all major Irish ports are likely to expand in the near future together with the addition of new facilities to distribute and augment national capacity. Ports often expand by land claim or require additional shoreline reinforcement and flow modification structures to operate. Ports are responsible for safe navigation, which will involve continued or more intensive (for larger vessels) dredging of channels and berths, and the dumping of this material at sea whenever re-use is not appropriate.

Marine energy generation is also likely to increase in the near future. Oil and Gas exploration licencing is currently being rolled out in Ireland with the National Energy Policy highlighting the need for safeguarding Ireland's energy supplies. Also within the energy policy are drivers to increase the amount of renewable energy production, and marine

technologies (wind, wave and current) are likely to increase in the near future. The expansion of these industries will also result in increased requirements for subsea pipelines and cables.

Coastal and marine recreation are also important sectors which are likely to increase, resulting in an increase of coastal structures and facilities, such as marinas.

Finally, there have been programmes undertaken to assess the offshore aggregates available to Ireland. As terrestrial sources become scarcer or more expensive, there is a possibility that marine aggregate industries may develop further in Ireland.

Ireland is likely to see an increase in the demand for coastal resources in the future, which will in turn increase the potential for coastal pressures. The recognition of these issues within each RBMP area will help contribute to the appropriate management of these pressures.

Recommendations for the design of the monitoring programme

For the purpose of the WFD, the EPA proposed to combine existing marine monitoring programmes into a strategic sampling programme. This monitoring programme has been scoped, proposed and costed by the Marine Institute and EPA; however, this did not include specific monitoring for marine morphology.

Following a review of existing and planned monitoring programmes, it is proposed to adapt and record morphological monitoring surrogates to existing programmes to assist in the monitoring of baseline conditions and the detection of changes.

Using the eco-geomorphic attributes considered in TraC-MImAS, details of the following are provided:

- Relevant parameter/s currently monitored (or potentially available via surrogate methods).
- Frequency and spatial extent of this data.
- The associated ecological observations from such monitoring.
- Recommendations for additional monitoring measures.

In summary, recommendations made for the design of a monitoring programme include:

- An increased, focused network of tidal gauges and current metering.
- A central repository for data collected by various studies such as those undertaken for EIAs and foreshore licence applications. These can provide useful sources of

information relating to the investigative monitoring of change associated with physical alterations. Also, this repository should include co-ordination with the INFOMAR programme and Special Areas of Conservation (SAC) baseline surveys to help build seabed sediment maps and bathymetry data for Ireland.

- Expansion of existing and proposed hydrometric monitoring downstream to TraC waters.
- Addition of salinity measurements at WFD monitoring sites.
- Co-ordination with flood monitoring to be undertaken for the purposes of meeting Floods Directive requirements.
- Co-ordination of the frequency of Ordnance Survey Ireland orthophotography and LiDAR data, and ground-truthing of data.
- Supplement current sediment monitoring with particle size analysis to ensure consistency.

It is essential for the monitoring of marine morphology, that a reliable baseline against which to make assessments and assess future development proposals is collected. There are a number of programmes already underway, (the most notable being INFOMAR), that can provide this information. However, they will not be complete until towards the end of this first river basin planning cycle.

As a result, it is proposed that records from a number of national survey and monitoring programmes be used to assess potential marine morphological changes until such time as this baseline is available.

Once this baseline is available it will be possible to investigate morphological changes that have caused ecological deterioration.

The execution of a detailed morphological monitoring programme and / or the adequate consideration of the morphology quality elements within existing programmes will assist in the achievement of the following requirements identified throughout the study:

Further definition of the relationship between morphology and ecology

In addition to seagrass and benthic monitoring to be carried out as part of the WFD monitoring programme, investigative monitoring of the impact of the identified pressures on morphological conditions is required. In the absence of a formal classification system the eco-geomorphic attributes recorded by this study should be considered.

The improvement of the typology module of TraC-MImAS is fundamental to the overall refinement of this tool. Monitoring of baseline conditions would contribute to the refinement of water body ‘types’. The assessment of this can facilitate the division of water bodies into various sub-types to reflect the appropriate baseline conditions. Potential for further development may involve the possibility increasing the sensitivity of a water type if, for example, a large portion of its area is associated with saltmarsh i.e. the capacity of the water body is likely to be absorbed quicker due to the sensitivity [and conservation status] of saltmarsh habitats

Further development of TraC-MImAS as a regulatory support tool

To assist in the implementation of the recommendations proposed for Ireland's regulatory framework, additional monitoring and appraisal of the pressures should be undertaken to develop adequate baseline information on the morphology of TraC water bodies as well as evidence-based thresholds for the consideration of risk (refinement of Morphological Condition Limits).

Recommendations for the design of the programme of measures

The WFD requires the setting of objectives for all water bodies; compliance with standards and objectives set for protected areas; and the implementation of cost effective programme of measures to meet those objectives.

The term ‘measure’ can refer to both the physical actions required to achieve objectives e.g. good practice, as well as the mechanisms required to recommend and / or enforce these actions, i.e. existing and future decision and evaluation processes in place to assess physical modifications with the aim of protecting morphology and ecology. The ‘physical actions’ should consist primarily of *supplementary measures* whereas mechanisms can be addressed by either *supplementary* or new *basic measures*.

With regard to the existing mechanisms (legal framework) governing Irish TraC waters it is important to note that following the general elections held in May 2007 various responsibilities relating to coastal waters were transferred between government departments. Responsibilities are currently split between the Department of Environmental, Heritage and Local government (DEHLG), the Department of Agriculture Fisheries and Food (DAFF), and the Department of Communications, Energy and Natural Resources (DCENR) [and Local Authorities in relation to planning].

Following on from an appraisal of good practice (supplementary) measures, the requirement for new basic measures for the control of physical modifications, and other

supplementary measures, such as the improvement of guidance to enhance the ability of these mechanisms to protect, restore and improve status, was reviewed.

Within the existing legislative framework concerning TraC waters, it is considered that morphology can be adequately assessed at a project or strategic level. However, it is concluded that at present there is not adequate scope for morphology to be highlighted as a potentially significant environmental aspect or interaction i.e. for morphology to act as a 'trigger' for further environmental assessment.

Where good and high status exists, there is a priority to maintain these through the control of existing operations and future development. The Marine Morphology Study and TraC-MImAS tool can help determine the available capacity of the water bodies to further morphological change, and support the control of proposals within the existing legislative structure to prevent deterioration of status. Morphology can be affected on a wider spatial scale than Local Authority and RMBP or even national boundaries, and will therefore benefit from Integrated Coastal Zone Management and effective assessment of strategic and cumulative effects to ensure preservation of status.

Where there are existing pressures causing a water body to be at risk of reaching its required morphological status, restoration may be required. Restoration measures should be compared with current good practice and against technical feasibility and excessive costs. Once selected, the measures should be assessed through the current legislative mechanisms, which should now include morphological assessment.

Recommendations outlined include measures which are generic to TraC waters and primarily involve increasing morphology related assessment within the existing basic measures (mechanisms). On confirmation of the roles and responsibilities of governing bodies, the detailed aspects of these recommendations can be appropriately prioritised by further reviewing the current gaps identified with regard to feasibility and cost effectiveness parameters. Prior to this it is considered that the **specific inclusion of morphology and / or ecological status as a significant environmental factor / interaction in national guidance documents for existing mechanisms** is a cost effective method of increasing the appropriate awareness of these aspects relating to the achievement of WFD objectives.

The appropriate **consideration of the recommendations relating to existing and new basic and supplementary measures is fundamental to the effective application of the methods recommended by this study** for water body prioritisation and identification of appropriate measures.

Recommended regulatory decision support methodology for future use

The deliverables of the Marine Morphology PoMs Study and the current version of TraC-MImAS can help support Ireland's existing regulatory process for the assessment of WFD compliance relating to physical modifications.

The regulatory process for the authorisation of developments concerning physical modifications is summarised by the steps below:

Screening

This phase involves a review of the mandatory and discretionary provisions set out in legislation to determine if an Environmental Impact Statement (EIS) is required. Gaps in the current framework for such a process have been identified, and the following recommendations are made:

- Specific reference should be made within National EIS Guidance for the consideration of RBMPs, and associated objectives and programmes of measures.
- An addition should be made to the EIA Regulations for the Protected Areas provided in Annex IV of the WFD as a trigger for the assessment of significant environmental effects for sub-threshold developments.
- An addition should be made to the EIA Regulations for High Status water bodies as a trigger for the assessment of significant environmental effects for sub-threshold developments.

Pre-application discussions

The aim of these discussions should be to minimise the number of applications received by consent authorities that are either rejected for being incomplete, require amendment, or are refused for not meeting the relevant assessment criteria; whilst also creating an opportunity to promote Good Practice. The outputs from pre-application discussions should help regulators determine if more detailed regulatory assessments will be required, and if deteriorations in status will require management by considering an exemption on the basis of benefits to human health, human safety or sustainable development (Article 4 (7)).

Within this study recommendations are made for formal, consistent requests from the consent authority for information associated with RBMPs and morphology to be discussed at pre-application discussions. For example this formal request/agenda should require the applicant to come prepared with information relating to the proximity of Registered Protected Areas, High Status water bodies and existing pressures on morphological condition.

Scoping

Scoping is the process through which the key issues specific to the proposed project or receiving environment that are likely to be of significance during the Environmental Impact Assessment (EIA), are identified. It is recommended that this process be extended to sub-threshold developments.

Receipt and review of application

Following on from the pre-application discussions, the scope of the environmental report should adequately consider morphology where relevant. For the purpose of assessing compliance with the WFD in relation to morphology the following can be considered when reviewing submitted applications:

- a) Potential risk to a Protected Area.
- b) Likely threat to WFD objectives (TraC-MImAS).
- c) Sufficient consideration of mitigation measures (Good Practice).

As demonstrated here, the deliverables of this study and the TraC-MImAS tool can help support Ireland's existing regulatory process for the assessment of WFD compliance relating to physical modifications. However, there are opportunities to refine this process through improvement to both the base data and the assessment tool.

Further development

The overall framework of TraC-MImAS is considered a valid basis on which to undertake further research and development work to provide validation of the professional judgement values and/or assumptions applied in the tool. This is the long term intention of SEPA for TraC-MImAS, and work has already commenced for the Rivers-MImAS tool.

River-MImAS, developed within the database software, Oracle, is supported in SEPA by an internal Regulation Method which defines the steps necessary to authorise an engineering activity, as well as an Operational Guide which provides SEPA staff with detailed information on the use of the rivers tool. This structured methodology aims to reduce the time required for expert judgement, by guiding staff towards screening out low risk proposals that are unlikely to threaten WFD objectives. Before such a formal regulatory procedure can be documented for use in Ireland, further technical development of TraC-MImAS, in addition to confirmation of regulatory roles and responsibilities are required. Research and development of TraC-MImAS for this purpose is continuing within SEPA, therefore it is strongly recommended that Ireland continue liaisons with this agency during this process.

The following is a summary of information provided within the Marine Morphology Study which can facilitate both the use and refinement of TraC-MImAS:

- Recommendations are made on how Irish monitoring programmes can help increase confidence in the underlying assumption of TraC-MImAS, i.e. an assessment of impacts on ecologically relevant features and processes can be used to protect morphology and ecology.
- The methods and information type and quality required for the assessment of both existing and proposed developments using TraC-MImAS are outlined.
- Recommendations for potential improvements to each of the five TraC-MImAS modules, the most prominent being that of the Typology Module are documented. To ensure a good level of confidence in the use of TraC-MImAS for regulation, a high level of confidence is firstly required in water body extents and typology.

Further field trials, monitoring results, and professional judgement across Ireland and also the UK will all benefit the refinement of the TraC-MImAS tool as well as the quality of information required for its use (e.g. refined water body typology and delineation). However, due to the nature of estuarine and coastal water bodies, TraC-MImAS, or any similar tool developed, has limited capabilities for the assessment of site specific conditions. Therefore, further development should be focused at refining this tool for its continued use in ***supporting*** regulation with the aim of **formalising a national, non-sectoral, regulatory framework which TraC-MImAS can support.**

1 INTRODUCTION AND BACKGROUND

On behalf of the Department of Environment, Heritage and Local Government (DEHLG), Cork County Council was appointed the lead authority for the South Western River Basin District (SWRBD).

Jacobs, working in association with Mott MacDonald-Pettit and RPS Consulting Engineers, have been appointed by Cork County Council to prepare a River Basin Management Plan (RBMP), including a Programme of Measures (PoMs) for the SWRBD.

The SWRBD was assigned specific Programme of Measures and Standards (PoMS) studies for completion on a national basis, one of which is 'Marine Morphology'. The aim of the Marine Morphology task is to provide a protocol to apply in the further characterisation and risk appraisal for all transitional and coastal water bodies in Ireland.

Steering Group

A Steering Group was set up to facilitate the Marine Morphology study within the Republic of Ireland. This Steering Group was chaired by the Department of Agriculture, Fisheries, and Food (DAFF) (and formerly of the Department of the Communication, Marine and Natural Resources (DCMNR)), and comprised representatives from the Environmental Protection Agency (EPA), Marine Institute (MI), National Parks and Wildlife Services (NPWS), Cork County Council, and the North-South Share Marine Morphology task team. To ensure a harmonised approach to marine morphology throughout Ireland, work undertaken has been consistent with that being carried out within Northern Ireland.

The project Steering Group consisted of the following individuals:

- Department of Agricultural, Fisheries and Food – Mr. Dick McKeever (Chairperson, 2006 – 2008)
- Cork County Council – Mr. Sean O'Breasail (Chairperson, 2008)
- National Parks and Wildlife Service – Dr. Elizabeth Sides
- Environmental Protection Agency – Dr. Shane O'Boyle
- Marine Institute – Dr. Francis O'Beirn
- RPS Consulting Engineers (NS-Share) – Helen Nutt

Both the EPA and Marine Institute were members of the UK and Ireland WFD Marine Task Team; which provided useful guidance throughout this study.

Acknowledgements

Jacobs wish to acknowledge the valuable contribution from the individuals list above and those organisations represented (including Robert Wilkes of the EPA). Jacobs would also thank the South West River Basin District project office for providing, and facilitating, access to various data resources.

The Scottish Environment Protection Agency have provide valued guidance to Ireland's morphology studies for which Jacobs would like to express their gratitude.

1.1 The Water Framework Directive & Morphology

The fundamental aim of EC Directive 2000/60/EC, the Water Framework Directive (WFD), is to maintain high ecological status (HES) of waters where it exists, prevent any deterioration in the existing ecological status of waters and achieve at least 'good' status for all waters by 2015.

Annex V of the Directive describes the quality elements that must be used for the classification of ecological status/potential for all surface water categories, and sub-divides these quality elements into the following three groups:

1. Biological elements.
2. Hydro-morphological elements supporting the biological elements.
3. Chemical and physio-chemical elements supporting the biological elements.

Table 1.1 below further defines the hydro-morphological quality elements for transitional and coastal (TraC) waters as per Annex V of the Directive.

Table 1.1: WFD Hydro-morphological quality elements

Annex V 1.1.3 Transitional Waters	Annex V 1.1.4 Coastal Waters
<p>Tidal Regime</p> <ul style="list-style-type: none"> - Freshwater Flow - Wave Exposure <p>Morphological Conditions</p> <ul style="list-style-type: none"> - Depth Variation - Quantity, structure and substrate of seabed - Structure of intertidal zone 	<p>Tidal Regime</p> <ul style="list-style-type: none"> - Direction of dominant currents - Wave exposure <p>Morphological Conditions</p> <ul style="list-style-type: none"> - Depth variation - Structure and substrate of the coastal bed - Structure of the intertidal zone

The initial risk assessments completed in 2005 have shown that hydromorphology is one of the most significant pressures operating in European surface waters and therefore contributing to the failure to achieve WFD objectives. The main drivers in terms of hydromorphological risk identified by these risk assessments were hydropower, navigation, flood defence and agricultural activities (Common Implementation Strategy (CIS), 2006 (a) & (b)).

Figure 1.1 below outlines the roles of the WFD quality elements in the ecological status classification of surface water bodies. This illustration shows that the values of the hydromorphological quality elements must be taken into account when assigning water bodies to the HES class. For other status classes, the hydromorphological elements are required to have ‘conditions consistent with the achievement of the values specified for the biological quality elements’ (WFD, Annex V), i.e. if the biological quality element values relevant to good, moderate, poor or bad status/potential are achieved, then, by definition, the condition status of the hydromorphological quality elements are consistent with that achievement. This should be determined via monitoring of biological quality elements and the physico-chemical quality elements.

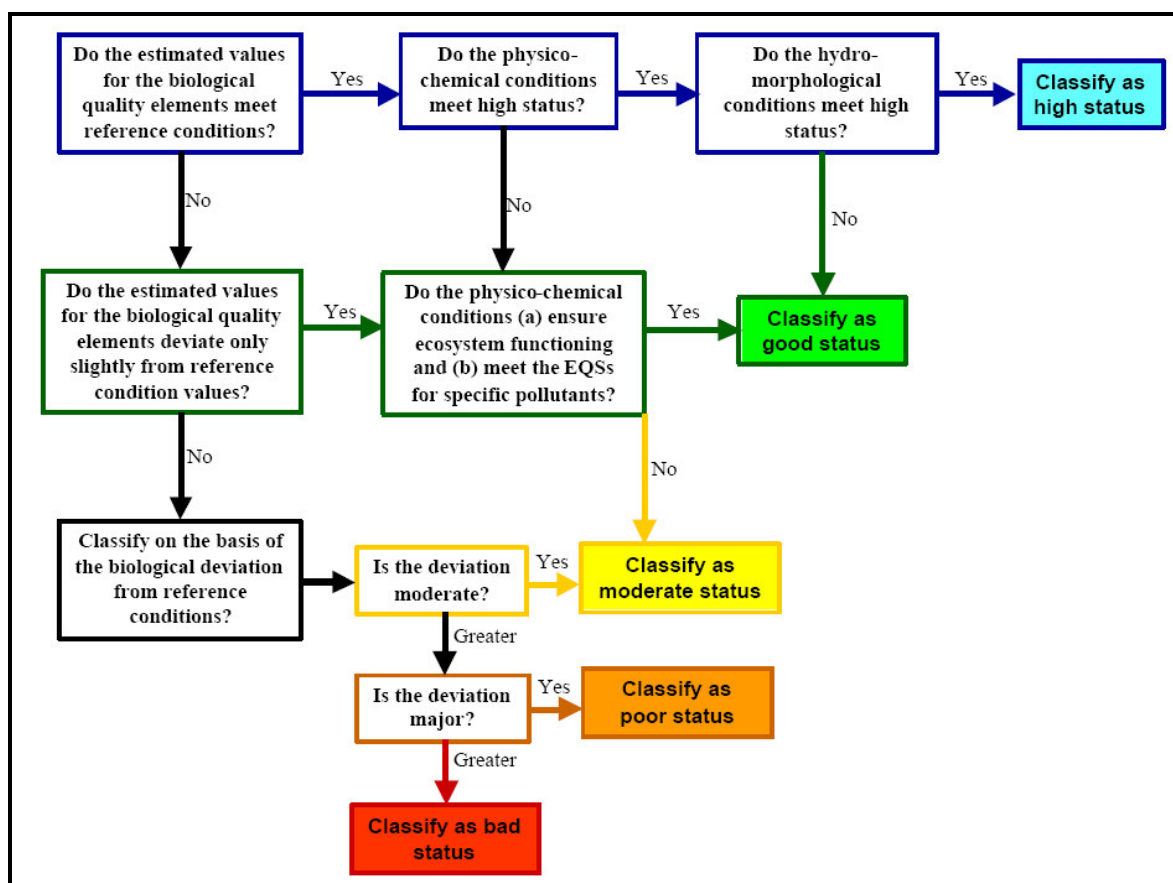


Figure 1.1: Indication of the relative roles of biological, hydromorphological and physico-chemical quality elements in ecological status classification (reproduced from (CIS), 2004)

Under certain circumstances the WFD permits Member States to designate water bodies that have been physically altered by anthropogenic (man-made or derived) activities as artificial water bodies (AWB) and heavily modified water bodies (HMWB). The objectives for these water bodies are Maximum Ecological Potential (MEP) and Good Ecological Potential (GEP).

A HMWB is defined as

“a body of surface water which as a result of physical alterations by human activity is substantially changed in character, as designated by the Member Stated in accordance with the provisions of Annex II” (Article 2(9))

An AWB is defined as

“a body of surface water created by human activity” (Article 2(8))

Article 4(3) of the WFD provides for the designation of a water body as HMWB when:

- *the changes to the hydromorphological characteristics of that body which would be necessary for achieving good ecological status (GES) would have significant adverse effects on specified uses [such as navigation or flood protection] (Art (4)(a)).*
- *the beneficial objectives served by the artificial or modified characteristics of the water body cannot, for reasons of technical feasibility or disproportionate costs, reasonably be achieved by other means, which are a significantly better environmental option (Art (4)(b)).*

The Directive then requires that such designation and the reasons for this be specifically mentioned in the River Basin Management Plans (RBMP) and reviewed every 6 years.

The concept of a HMWB was created to allow for the continuation of specified uses such as navigation which provide valuable social and economic benefits (but at the same time to allow for mitigation measures to improve water quality) (CIS 2003). Ireland's AWBs and HMWBs are assessed within a separate PoMS study. However, those identified as TraC HMWBs are included in this document. The WFD objectives in dealing with hydromorphology pressures are focused on prevention, restoration, and mitigation. The approach for dealing with hydromorphology pressures on the water environment (past and new developments) can be summarised as follows (CIS, 2006 (a):

Prevention:

For new developments there is a need to first prevent deterioration of water body 'status', and where this is not possible, mitigation measures should be applied (Article 4(7)).

Restoration:

Where a physical modification has already taken place, actions should first be considered to restore the water body with the aim to achieve GES.

Mitigation:

Where restoration is not possible, mitigation measures should be investigated with the aim to meet GEP.

1.2 Initial Risk Assessment

In accordance with Article 5 and Annex II of the WFD, an initial risk assessment was undertaken across Ireland and reported to the European Commission (EC) in March 2005. The purpose of this risk assessment was to assess the susceptibility of surface water status to the pressures identified and also to determine the likelihood of water bodies failing to meet the Article 4 environmental quality objectives. This risk assessment included the identification and assessment of a number of anthropogenic pressures that have the potential to impact on the morphological quality elements:

- Dredging
- Disposal of dredge spoil
- Coastal defence
- Flood protection
- Embankments
- Built structures
 - Ports/Harbours
 - Urbanisation
 - Industrial/Power station intakes
- Intensive land use (ILU) (transitional water bodies only)

Each TraC water body was assigned a risk category based on the proportion of the water body altered by human activities. The initial risk assessments were based on screening or semi-quantitative assessments; therefore, to help reflect confidence in the assessments a four-category risk scheme was adopted. Where information was either lacking or of low confidence, the water body was assigned to either the 'probably at risk' or 'probably not a risk' category.

1a – at risk

1b – probably at risk

2a – probably not at risk

2b – not at risk

Results

The initial risk assessments concluded that 35% of transitional water bodies, and 18% of coastal water bodies within the Republic of Ireland (RoI) were '*at risk*' or '*probably at risk*' of failing to meet the WFD objective of Good Status due to physical alteration.

Figures 1.2 and 1.3 below highlight the proportion of TraC water bodies identified by the initial risk assessments as being significantly at risk (1a and 1b) of failing the WFD objective of Good Status due to pressures on morphology for each River Basin District (RBD).

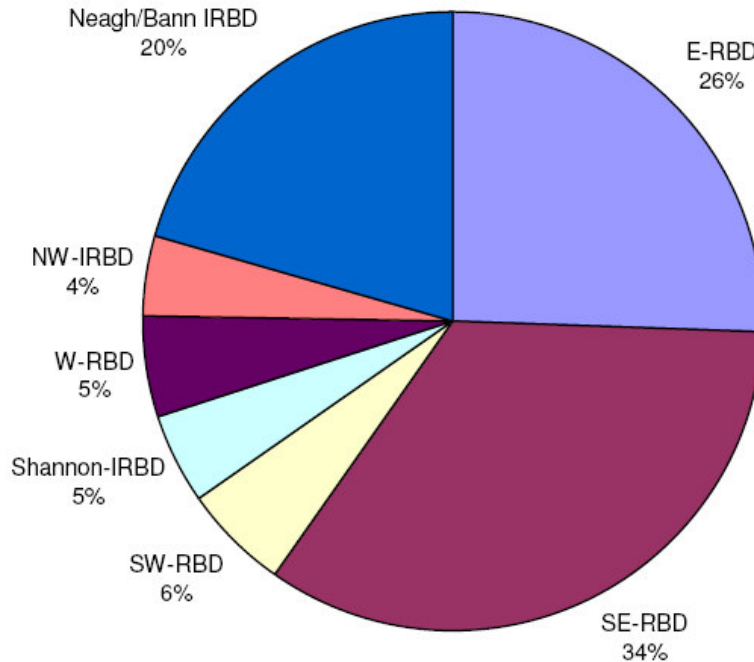


Figure 1.2: % of Coastal Water Bodies 'at risk' or 'probably at risk' from Morphology

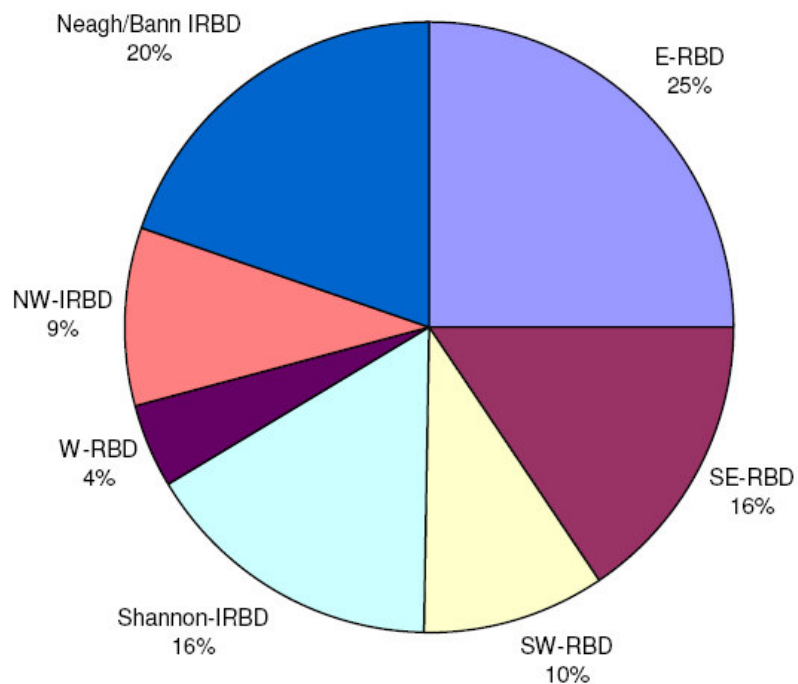


Figure 1.3: % of Transitional Water Bodies 'at risk' or 'probably at risk' from Morphology

Figures 1.4 and 1.5 below show the percentage distribution of morphological pressure types identified by the initial risk assessments as likely to result in failure of the WFD objectives in TraC waters.

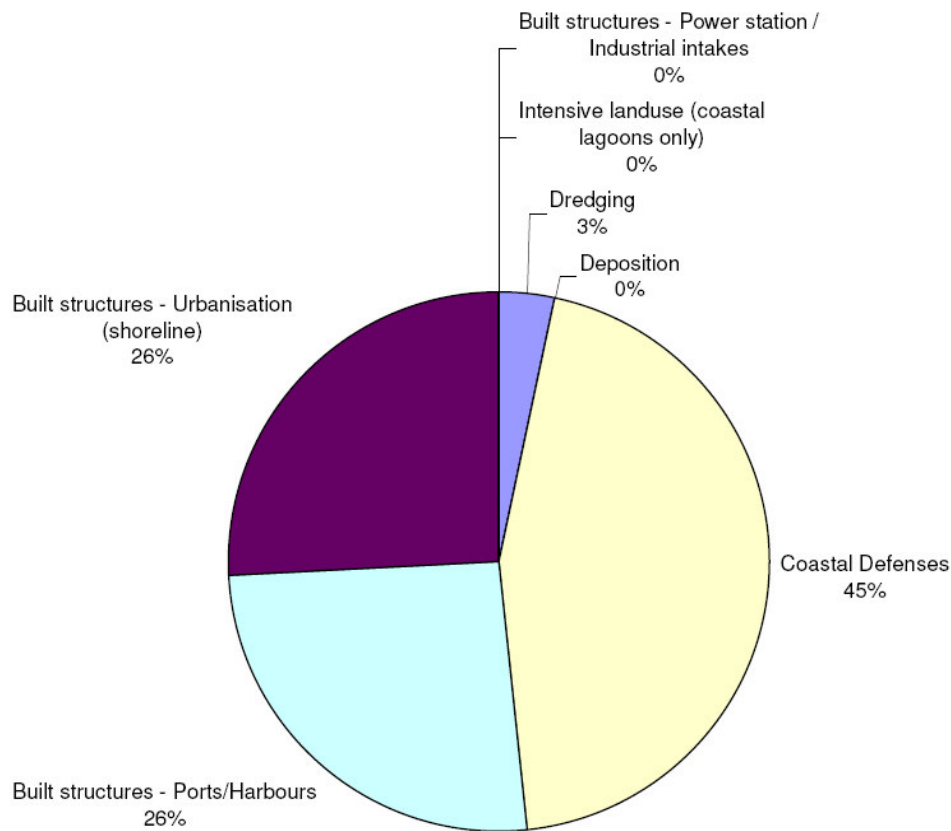


Figure 1.4: % Distribution of Morphology Pressures – Coastal Waters

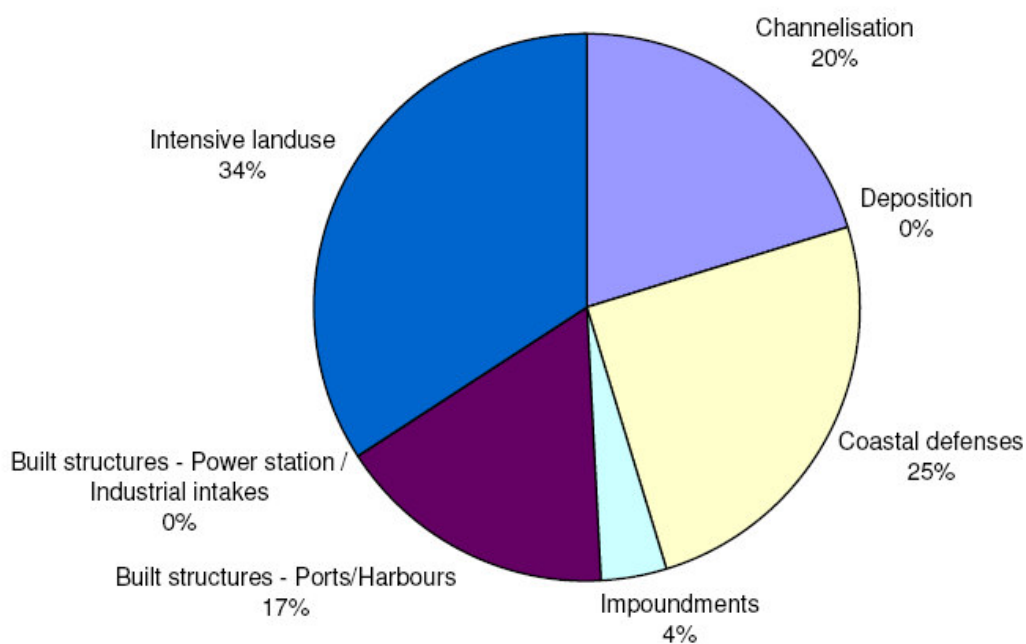


Figure 1.5: % Distribution of Morphology Pressures – Transitional Waters

Transitional waters were identified as being most at risk from ILU, channelisation; and coastal defences, whereas the risk to coastal waters was found to be attributed to the physical pressures including coastal defence, ports/harbours and urbanisation.

Conclusions of Initial Risk Assessment

Annex II of the WFD requires that further characterisation shall, where relevant, be carried out for those bodies identified as being at risk of failing the environmental quality objectives in order to optimise the design of both the monitoring programmes and the PoMs.

As the initial characterisation was based on screening or semi-quantitative assessments, it was concluded that surface waters would require more detailed assessments in order to re-characterise risk so as to report a two-category risk scheme, and then facilitate the development of tools for the management of these water bodies.

1.3 Overall Approach – Marine Morphology PoMs Study

The Marine Morphology PoMs Study aims to provide a protocol to apply in the further characterisation and risk appraisal for morphology in TraC waters, the outcomes of which will contribute to the development of a tool aimed at supporting the assessment and management of morphology in these water bodies.

The objectives of the study are as follows:

- Establish the relationship between morphology characteristics and biological status;
- Identify what level of morphological pressure is “sustainable” within a water body;
- Establish which morphological indicators should be included in TraC monitoring programmes;
- Identify water bodies where morphology restoration measures are required (linked to HMWB designation process);
- Identify the available buffer (or capacity) of water bodies in order to prioritise action levels;
- Prioritise morphology pressures; and
- Develop a decision support tool for regulators to assess the potential impact of future developments on individual water bodies (i.e. to prioritise activities and establish a tiered assessment system).

This study involves all TraC water bodies within the RoI, but was undertaken in parallel to the North-South Share (NS-Share) project to ensure compatibility of methodologies between Northern Ireland (NI) and the RoI.

The Marine Morphology study involves a total of 309 water bodies; 113 coastal water bodies (4 of which border with NI - Portstewart Bay, Mourne Coast, Lough Foyle and Carlingford Lough) and 196 transitional water bodies (4 of which border with NI - Foyle and Faughan Estuaries, Newry Estuary, Carlingford Lagoons and Shillities Loughs) within the RoI.

Figures 1.6 below illustrates the water bodies ‘typed’ as transitional or coastal for the purpose of the WFD. The risk categories assigned to each of these water bodies are shown in Figure 1.7.

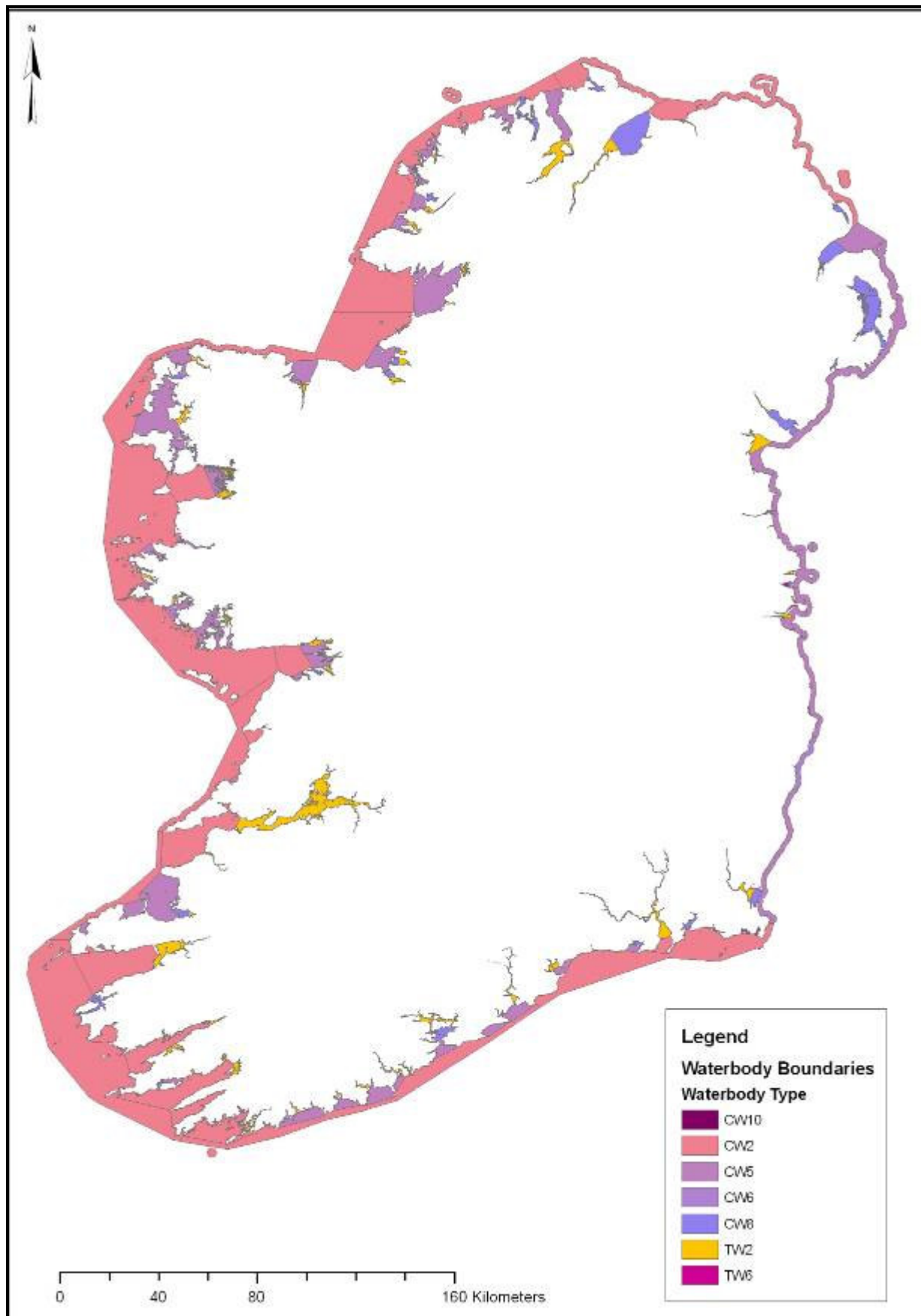


Figure 1.6: TraC water body types

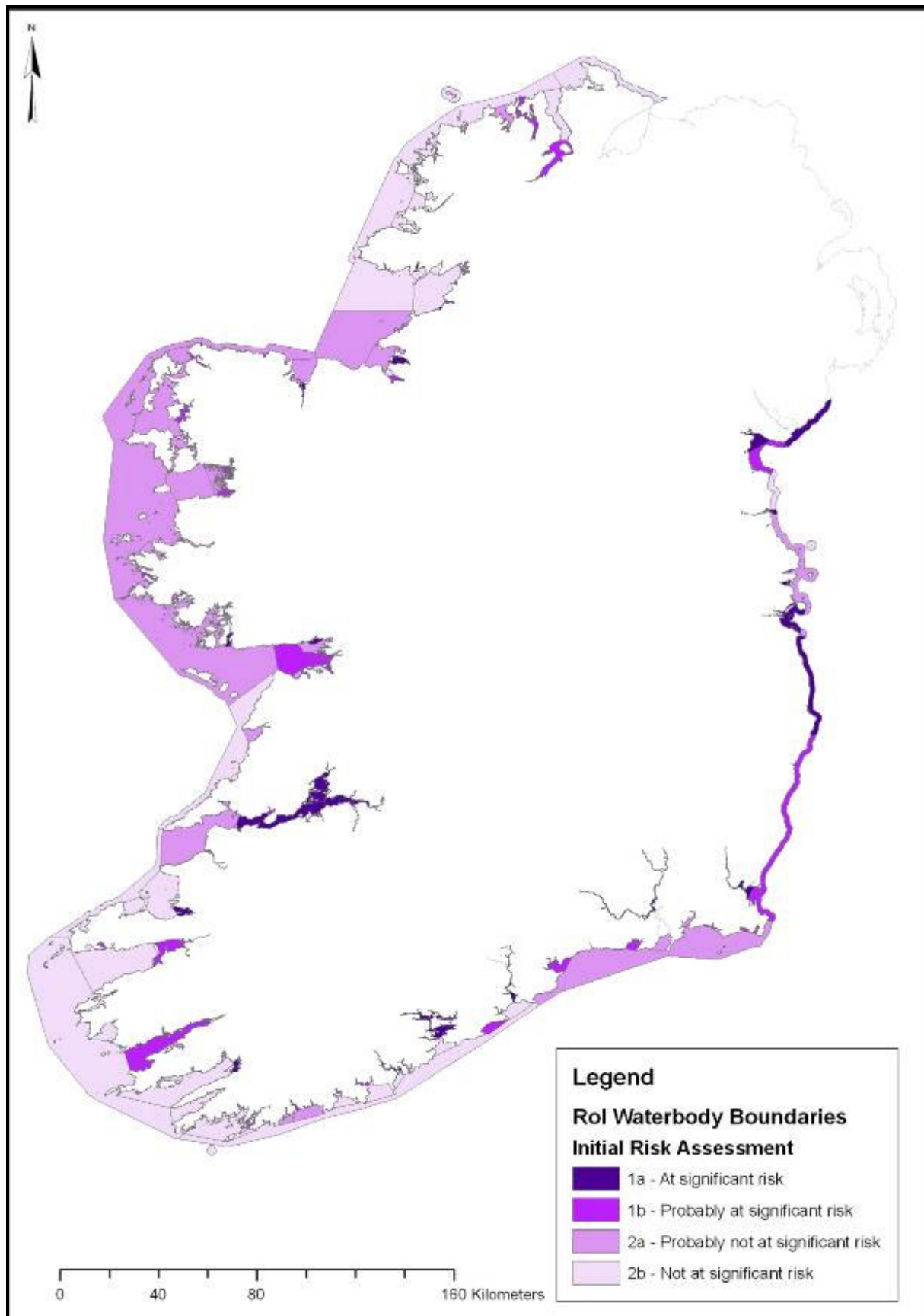


Figure 1.7: Initial risk categories assigned to TraC water bodies

Following on from the initial risk assessments; the further characterisation and risk appraisal of morphology in TraC waters are proposed to investigate the uncertainty concerning the designation of water bodies at risk of failing to meet good status. The designation of risk categories should be based on the relationship between a pressure and the impact on the morphological attributes of a water body; therefore, it was proposed to investigate this relationship using scientific methods, historical data and also the results of the monitoring programme.

The Marine Morphology Study was progressed under the following tasks:

- Literature Review
- Data Review / Data gaps
- Review of Monitoring Systems
- Improve Definition of Pressures on Receptors
- Assess Ecological Impacts of Pressures
- Develop Assessment Tool
- Prepare Final Report on National Methodology

1.4 Report Structure

The following is a summary of the work undertaken to meet the objectives set out in section 1.3 above. A key aim of this study was to further characterise the risk to the morphology of TraC waters. The classification of TraC water bodies, however, was outside the scope of this study.

Chapter 2 provides a brief summary of the Literature Review undertaken on commencement of this study. This review is documented in full in Appendix 2-1.

Chapter 3 summarises the initial Data Review undertaken on commencement of this study (Appendix 3-1). The data findings on completion of a final data review are then detailed by outlining the pressures identified for assessment and the methods used to further characterise these pressures. Recommendations for further data requirements and improvements are then made.

Chapter 4 summarises the existing monitoring systems for Irish TraC waters and their relevance to the monitoring of morphological attributes.

Chapter 5 outlines the approach taken by this study to assess the potential impact of identified pressures on morphological attributes. The current understanding of the relationship between morphology and ecology in the context of the WFD is outlined and the Morphological Impact Assessment System (MImAS), developed by the SEPA, is introduced by including reference to Irish trials undertaken during the development of this system. To outline how MImAS and the deliverables of this study can be used for the purpose of further characterising risk an example using the transitional water body Clonakilty Harbour (SW_100_0100) is provided.

Chapter 6 sets out the method applied to further characterise the risk of TraC water bodies failing to meet the WFD objectives and summarises results for each water body assessed. MImAS assessment was focused on 122 TraC water bodies identified by this study as those which required further characterisation in relation to morphology, for example those water bodies characterised as 'probably at risk' or 'probably not at risk' in the initial risk assessments. For those water bodies further characterised as at risk, Water Body Summary Sheets detailing the physical characteristics, ecology and pressures identified were produced and are provided in Appendix 6-4.

Chapter 7 brings together existing information on ‘good practice measures’ for activities which involve hydromorphological alterations to TraC waters. The accompanying interactive spreadsheet (Appendix 7-1) guides the user to sources of information which can aid decisions for identifying measures that aim to prevent deterioration in ecological status for new developments, or to identify measures to address existing modifications that will enable a water body to achieve its environmental objective under the WFD.

Chapter 8 documents a review of potential future pressures on the morphology of Irish TraC waters. This projection of future risks to the achievement of the WFD objectives is not site specific, but provides a qualitative assessment of the main drivers potentially affecting Irish TraC waters.

Chapter 9 follows on from Chapter 4 by outlining recommendations for future monitoring of morphology in Irish TraC waters.

Chapter 10 collates the information set out in the previous chapters to develop appropriate recommendations for the design of programmes of measures relating to morphology with the aim of achieving the WFD objectives by 2015. To identify the existing basic measures governing Irish transitional and coastal water bodies a summary of a review of relevant legislation is outlined. Methods for the prioritisation of TraC water bodies suitable for the assessment of appropriate measures are then recommended. Recommendations made in this chapter are generic and are not outlined specifically for each prioritised water body. Appendix 11-1 tabulates a summary of proposed measures identified as relevant for marine morphology. This appendix should be read in conjunction with both Chapters 10 and 11.

Chapter 11 outlines how the deliverables of the Marine Morphology PoMs Study can assist the regulation of future physical modifications of Ireland’s TraC waters with the aim of achieving WFD objectives. An example, in the form of a proposed harbour development, is provided to demonstrate how MImAS, in conjunction with the deliverables of this study, can be used as a regulatory decision support tool.

2 LITERATURE REVIEW

2.1 Introduction

An initial step in achieving the objectives of the Marine Morphology study was to complete a Literature Review. This review aimed to investigate and report on relevant approaches under development for the assessment of anthropogenic activities and morphology, identify current research underway into the relationship between morphology and ecology, and identify the availability and applicability of any literature and guidance for the development of an appropriate assessment methodology for the purpose of the WFD. This Literature Review is outlined in full in Appendix 2-1 and details all references reviewed for the purpose of this report. This chapter aims to summarise the findings of this Literature Review, and where relevant references to chapters within this review are provided.

The Literature Review has concluded that the most common, and in most cases necessary, approach to assessing and reporting the impact of morphological pressures on ecology involves a mixture of qualitative and quantitative assessments (Chapter 7 of Appendix 2-1). Although it is clear that many anthropogenic activities which result in pressures to morphology have some impact on ecology, it was concluded that there is limited quantitative data throughout Europe describing the relationships between morphological conditions and ecological health (Chapter 8 of Appendix 2-1). This is reflected by the recognition of the CIS Hydromorphology Group recognise that “in many cases knowledge is insufficient to assess or model precisely the impacts of hydromorphological alterations on the biological quality elements” and “mitigating measure involving physical modifications” (CIS, 2006 (b)).

The three projects identified as potentially providing the most useful information for developing a protocol for further characterisation and risk appraisal were the Joint Nature Conservation Committee’s (JNCC) ‘Irish Sea Pilot’, the United Kingdom (UK) Marine Biological Association’s Marine Life Information Network (*MarLIN*) project, and an European Union (EU) Interreg project titled ‘Sensitivity and Mapping of Inshore Marine Biotopes in the Southern Irish Sea’ (SensMap); all of which are introduced in chapter 4 of the Literature Review. All three projects required the input of very detailed information on the type and extent of habitats (including species), which is currently unavailable for Ireland. However, the overall approach used by these projects matched that being progressed by this study, i.e. the Source, Pathway, Receptor model, or as defined by the CIS working group IMPRESS; the DPSIR framework (Driver, Pressure, State, Impact, Response). This overall approach was carried forward to the development and application of MImAS which is discussed further below and in Chapter 5 of this report.

At present there are no quantitative environmental standards available to assess the ecological impacts of alterations to the morphology of TraC waters, and where regulation exists, decisions are principally made on a case by case basis, using a combination of field data and expert judgement. However, from a review of the projects noted above, the Literature Review identified environmental factors that can potentially be used to assess the sensitivity of marine species. Those factors of most relevance to morphology (and hydromorphology) include:

- Substratum loss
- Smothering
- Suspended sediment
- Desiccation
- Changes in emergence regime
- Changes in water flow rate
- Changes in wave exposure
- Physical disturbance/abrasion
- Displacement

In assessing sensitivity both *MarLIN* and SensMap concluded that the effects of an activity and resultant changes in morphological [and other] factors are site specific and cannot be generalised. Therefore, to enable some form of generic assessment of the sensitivity of coastal ecology to various pressures both projects used 'benchmarks' in order to report sensitivity to a 'specified change in an environmental factor'.

Following direction from the DEHLG, the Marine Morphology Study is being applied nationally. On completion of the Literature Review, it was concluded that the extent of information required for the assessment methods outlined by the studies researched is not available nationally for Irish TraC waters at present. Therefore, the assessment of risk to water bodies in Ireland requires a generic method that can be applied nationally but can also be used to focus assessment where site specific assessments are required.

The conclusions drawn by the Literature Review led to the consideration of the Transitional and Coastal Morphological Impact Assessment System (TraC-MImAS) for use in the Marine Morphology study. This tool was being developed by the Scottish Environmental Protection Agency (SEPA) and the United Kingdom Technical Advisory Group (UKTAG) in response to the absence of suitable data to empirically derive standards for morphological conditions. As reported in Annex I of the Literature Review (Appendix 2-1), TraC-MImAS was developed with the intention to assist regulators in determining if changes to morphology could pose a risk to ecology, and thereby identify those proposals that could

threaten the WFD aim of achieving GES (through further characterisation of risk), or result in a deterioration in ecological status (relevant to the PoMs). Further development of this tool continued following the Literature Review.

The TraC-MImAS tool is not intended to provide a detailed assessment of ecological status, but rather provide a means of identifying where ecological conditions are likely to be impaired through impacts to morphology, i.e. it is based on the assumption that an assessment of impacts on ecologically relevant features and processes can be used to protect morphology and ecology.

The tool uses a concept of 'system capacity' to measure impacts to morphological conditions, assuming that completely pristine TraC waters have a measure of assimilative 'capacity', which can be degraded by anthropogenic activities. TraC-MImAS comprises of 5 modules which combine to estimate the existing system capacity (%) of a water body (see Figure 2.1 below).

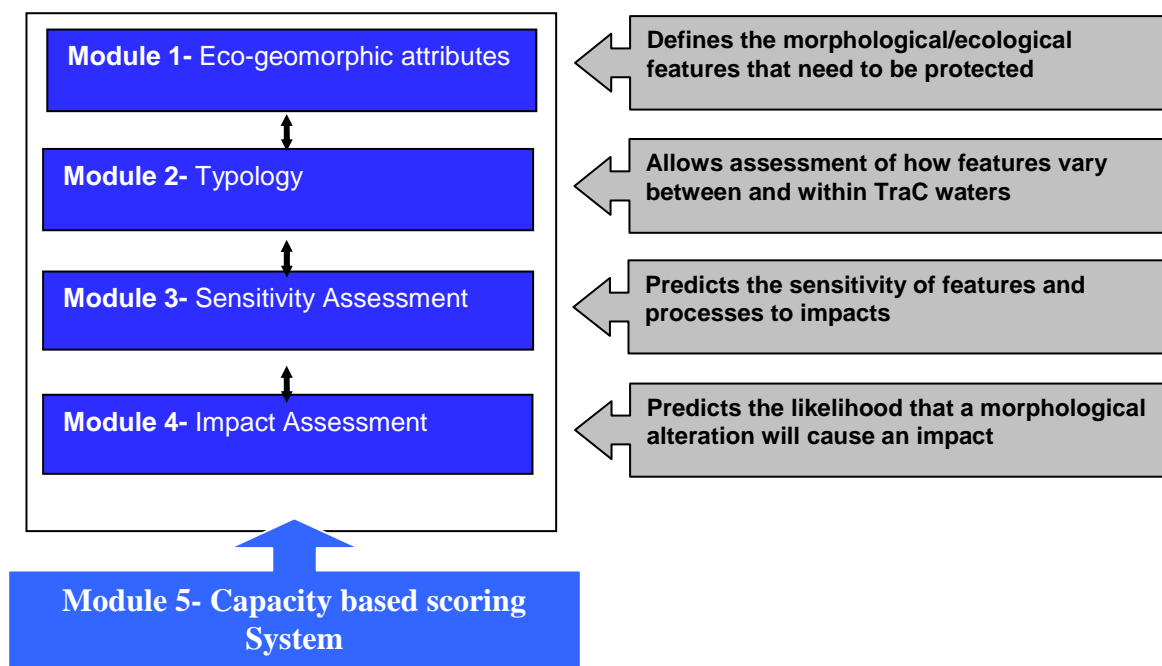


Figure 2.1: Overview of MImAS Modular Components (extract from SEPA, 2007a)

TraC-MImAS is considered suitable as both a generic and focused assessment tool which can be applied nationally to assist further characterisation and risk appraisal. The use of TraC-MImAS for specific assessments however would benefit greatly from the incorporation of monitoring results.

The pressures considered by TraC-MImAS were reviewed throughout the development of this tool. An addition to the original scope of these pressures was requested by Ireland (SWRBD and NS-Share Marine Morphology teams) via the UKTAG Technical Panel to represent aquaculture activities. This resulted in the pressure type 'Other Disturbances to Seabed'. Table 2.1 below outlines the full suite of pressures that can be assessed within TraC-MImAS and that have received approval from the Marine Morphology Steering Group.

Table 2.1: Morphological alterations considered within TraC-MImAS (extract from SEPA, 2007a)

Morphological Alteration	Description
Land and channel alteration	
Land claim- High impact	Recent or proposed enclosure of intertidal or subtidal areas within impermeable banks followed by infilling for use by agriculture, housing, port or industry. Also used for land claim that has taken place in the past and is still deemed to be having a significant impact.
Land claim- Low impact	Historic (e.g. >50yrs ago) enclosure of intertidal or subtidal areas within impermeable banks followed by infilling for use by agriculture, housing, port or industry. Can also be used for more recent land claim where the impacts are minimal or where the surrounding environment has partly recovered natural habitats and features.
Tidal channel realignment- High impact	Recent or proposed realignment of a tidal channel. Also used for realignments that have taken place in the past and is still deemed to be having a significant impact.
Tidal channel realignment- Low impact	Low impact alterations to course or planform of upper estuaries where the channel remains river-like. Includes straightening and removal of meanders to increase channel gradient and flow velocity. Typically used to cover historic work (e.g. >50yrs ago) and where the channel has partly recovered natural habitats and features.
Sediment manipulation	
Dredging- High Impact	The excavation of sediments where there is likely to be considerable damage caused to seabed environment, both within and out with the area dredged. Typically reserved for situations where dredging has not taken place in the past or where dredging has taken place within the last 10 years and impacts are still likely to be present. Typically reserved for situations where sediments are removed to a depth of greater than 1m.
Dredging- Low impact	The excavation of sediments where the damage is likely to be restricted to the area being dredged. May be used for capital dredging where the impacts are likely to short lived or are being minimised through the use of best practice. Could also be used to capture areas that have been dredged in the past and where there is evidence that some impacts still exist. Some forms of trawling could be captured under this category.
Other alterations to bed substrate	Any other temporary disturbances to bed morphology or substrate character where the impacts are likely to be remain restricted to the area of bed directly disturbed and where the bed is likely to recover significantly over time. Could include some forms of trawling.
Disposal of dredged materials	The deposit of dredged material onto intertidal and subtidal areas for the purposes of disposal.
Flow/sediment altering structures	
Piled Structures	A range of structures raised on one or more foundation structures extending out into the adjacent water body e.g. bridge and pier supports. This category also includes wind turbine monopiles.
Flow/sediment manipulation structures	Hard engineering structures built to stabilise waterways for navigation or counter the effects of longshore drift. These include breakwaters, piers, groynes, flow deflectors, training walls etc.
Impounding structures	A temporary (e.g. barrage) or permanent structure that extends across a channel that is used to impound measure or alter flow (e.g. weirs, sluices).
Causeway	A physical barrier projecting from the shore whose foundations extend to the bed and where gaps in the foundations represent < 20% of the total length. Typically used to support transport routes.
Shoreline alterations	
Shoreline reinforcement – High Impact	The use of consolidated materials, e.g. rock armour, revetments, retaining walls, gabion baskets, seawalls, wharves, sheet piling etc. to protect vulnerable coastlines or harbours from erosion. Refers to situations where the reinforcement is having a persistent influence over the intertidal or subtidal zone.
Shoreline reinforcement – Low impact	Stabilisation of the shoreline using beach material to maintain beach levels and dimensions. May include use of synthetic materials. Also includes other forms of low impact shoreline protection, for instance protection that is set back and does not have a persistent influence over the intertidal or subtidal zones.
Flood defence embankment	An artificial bank of earth or stone created to prevent inundation of estuarine and coastal floodplains.

As noted throughout the Literature Review and reflected by this study, the study Steering Group, and the UKTAG; the results of the WFD monitoring programmes are fundamental to the further development of such assessment tools. The WFD required monitoring programmes for all surface (and ground) waters to be in place by December 2006, the results of which would assist the further characterisation of water bodies as well as focus the classification of these waters.

The UK & Ireland Marine Task Team have progressed the work outlined in Section 4.11 of the appended Literature Review (Appendix 2-1) to develop classification tools for TraC waters. However, this work is still outstanding for those tools relevant to hydromorphology classification. In Ireland, both the Environmental Protection Agency (EPA) and the Marine Institute (MI) were identified as the responsible bodies for the WFD monitoring programmes in TraC waters. However, the regulatory system for coastal development and activities in Ireland has changed slightly from that documented in the Literature Review. Following the general elections held in May 2007 various responsibilities relating to coastal waters were transferred between government departments. This resulted in the formation of the new DAFF (formerly the Department of Agriculture and Food, transferred under S.I No. 705/2007) to which certain functions of the former DCMNR under the Foreshore Acts (1933 – 1998) have been transferred. The DCMNR is now altered to the Department of Communications, Energy and Natural Resources (DCENR) (S.I No 706/2007). Ireland's regulatory system for coastal development and activities is discussed further in Chapter 11 of this report.

The Literature Review further investigated the pressures assessed in the initial risk assessments (as set out in Section 1.2 of this report), and noted that the assessment of aquaculture as a pressure was outside the scope of the Marine Morphology Study (following direction from the DEHLG a specific PoMS study was not progressed).

A review of existing coastal mathematical models (primarily hydrodynamic and water quality) and existing transitional water models (hydrodynamic/ water quality/ nutrients/ ecological) was undertaken as part of the Literature Review to help identify any relevance and potential use / benefit relevant to the assessment of marine morphology. Questionnaires were issued to organisations known or thought to have been involved in the development and application of relevant models covering TraC waters. The full database of models collected is shown in Appendix IV of the Literature Review (Appendix 2-1). Using the information provided by the

questionnaires, water body codes were assigned to each model. Table 2.2 below is an extract of the marine model database showing the coverage of models across RBDs in Ireland. The details of these models should prove useful to the classification of TraC water bodies.

Table 2.2: Summary of existing coastal and transitional water models mathematical models identified

A Model Identification and General Details				B Model Categories (tick as appropriate)				C Geographical Extent (give details for each component model)	
Model name	Date of model development	Available	Is model coastal or estuarine or both	Purpose of the study	Coastal processes (hydrodynamic, wave, sediment movement)	Coastal defence (hydrodynamic, wave)	Effluent dispersal (hydrodynamic, Effluent dispersion, advection dispersal, particle tracking)	Water Quality	Water Body
Drogheda, Co Louth	1997	Limited	Both	EIS for proposed capital dredging scheme	x	x			River Boyne, Drogheda, Co Louth
Laytown, Co Meath	2004 - 2005	Limited	Both	Feasibility study for proposed beach renourishment	x	x			Coastline between laytown and Bettystown, Co Meath
Bray, Co Wicklow - Coastal Defence		Limited	Both	Environmental impact modelling	x	x			Bray Harbour
Co Meath coastline	1998	Limited	Both	Coastal zone study	x				Co Meath coastline - 21 km
Boyne Estuary and Environs		Limited	Both	Coastal hydraulic study	x				Boyne Estuary and River Boyne navigable channel
Drogheda, Co Louth	2000	Limited	Both	EIS for the turning vee on the River Boyne, Drogheda, Co Louth	x				River Boyne, Drogheda, Co Louth
The Burrow Portrane, Co Dublin	1997	Limited	Both	Coastal zone study	x				The Burrow, Portrane
Dublin Bay	2002	Commercial	Both	Assessment of the hydrodynamic regime in Dublin Bay	x		x	x	Dublin Bay - associated jpeg
Greystones Harbour	2000	Limited	Both	Hydraulic modelling study	x				Greystones Harbour
ARKLOW-EC	2004 - 2005	With certain conditions	Coastal	Study on the sediment movement and water quality in the region	x			x	52.697 - 52.90 N, 6.00 - 6.20 W
Portrane	2006	Y	Both	Environmental impact assessment of discharge from an outfall	x		x	x	Portrane
Malahide Inlet/Broadmeadow Estuary		Limited	Both	Investigate the hydrodynamic regime					Malahide Inlet/Broadmeadow Estuary
Bray Harbour	2002 - 2004	Limited	Both	Bray Harbour Feasibility Study					Bray Harbour
Irish Sea	2003	Commercial	Coastal	Investigation of scallop larvae populations off southeast coast of Ireland	x		x		Irish Sea
Irish Sea Model	2005	Commercial	Coastal	Morphodynamic modelling of the Irish Sea	x		x		Irish Sea
Irish Sea Model 3d	2005	Y	Coastal	To examine the distribution of seed mussel larvae along the eastern Irish coast	x		x	x	The entire Irish Sea
Irish Sea Model	2001	License based	Coastal	To derive boundary conditions for coastal and estuarine hydrodynamic models in UK	x		x	x	The entire Irish Sea
Courtown, Co Wexford Coastal Protection Scheme	2005	Limited	Both	Coastal erosion study	x	x			Courtown Beach
Courtown/Ardamine Study	1997	Limited	Both	Coastal regime study of active beach	x				Courtown Beach/Ardamine Beach
Wexford Harbour	2002	Commercial	Both	Measuring and modelling of nutrient fluxes in brackish waters	x		x	x	Wexford Harbour - associated jpeg
Rosslare/Wexford Harbour Coastal Erosion Study	2001	Limited	Both	Coastal erosion study	x				Wexford Harbour and Rosslare Point
South East ROMS		Restricted	Coastal	Physical climate, HAB prediction, single bay management	x		x	x	St Georges Channel, Eastern Celtic Sea, Southern Irish Sea
ROMS (Regional Modelling System)	Subject to permanent advancement	Y	Both	To develop a simulation and forecasting system for marine ecosystem dynamics in strategic areas of Irish waters	x				Celtic Seas, NE Atlantic
Bannow Bay	2004	Commercial	Estuarine	INTERREG IIIA project "Sustainable Management of Aquaculture, Recreation and Tourism: SMART"	x		x	x	Bannow Bay - associated jpeg
Dunmore East, Co Waterford	2005	Limited	Both	EIS for proposed harbour development	x			x	Dunmore East Harbour, Waterford Estuary
Waterford Harbour	In development	Commercial	Both		x		x	x	Currently under development
River Barrow Numerical Model Ref	1993		Estuarine		x				River Barrow from New Ross to the Junction with the River Suir
Rosslare Harbour	2006	Y	Both	To examine sediment transport from a dump site off the Wexford coast	x		x	x	Rosslare and Wexford Harbours
Doonbeg, Co Clare	2000	Limited	Both	Coastal processes study	x	x			Doughmore Bay
Liscannor Bay, Co Clare	1995	Limited	Both	Assessment of coastal processes	x	x			Liscannor Bay, Co Clare
Shannon Estuary Oil Spill Model	1997 - 2001	N	Estuarine	Tracking oil movement on water and transferring details on to a GIS model	x				Shannon Estuary from Limerick to Loop Head/Kerry Head
Shannon Dredge Disposal	2002	Y	Estuarine	To examine dredge disposal sites at various points in the Shannon Estuary	x				Various locations within Shannon Estuary
Cork Harbour	2002	Commercial	Both	Measuring and modelling of nutrient fluxes in brackish waters	x		x	x	Cork Harbour - associated jpeg
Cork Harbour	2004	Commercial	Both	Environmental impact assessment for Carrigrennan treatment works	x		x	x	Cork Harbour - associated jpeg
Cork Harbour	2005	Commercial	Both	Modelling caustic soda spillage in Cork Harbour	x		x	x	Cork Harbour - associated jpeg
Cobh Harbour	2004 - 2005	Limited	Both	Modelling of the fate of dredged material	x				Cobh Harbour
Ringaskiddy	2005 - ongoing	Limited	Both	Impact of port development on coastal processes	x				Ringaskiddy
Kinsale Harbour	2004	Commercial	Both	Modelling industrial discharges from Eli Lily	x		x	?	Kinsale harbour - associated jpeg
North Harbour, Clear Island	2002	Limited	Both	Hydrodynamic study	x				North Harbour, Clear Island
Bantry Bay and Dunmanus Bay	2005	Commercial	Both	Assessment of dredge spoil disposal in Castletownbere	x		?	?	Bantry Bay - associated jpeg
Kenmare Bay	1999	Commercial	Both	Environmental impact assessment of aquaculture operations	x		x	?	Kenmare Bay - associated jpeg
Knights Town Harbour, Valentia Island, Co Kerry	2004 - 2005	Limited	Both	Hydrodynamic study for proposed harbour upgrade	x				Knights Town Harbour, Valentia Island, Co Kerry, Portmagee Channel,
Cromane, Co Kerry	2003	Limited	Both	Hydrodynamic study	x				Cromane, Co Kerry
Dingle Bay	2002	Commercial	Both	Modelling scallop larvae transport pathways in Dingle Bay	x		?	?	Dingle Bay - associated jpeg
Youghal Harbour	2005	Y	Both	To examine the effects of discharging various chemicals into Youghal Harbour	x		x	x	Youghal Harbour
Kenmare Bay	1999	Y	Both	To assess the impact of aquaculture activities in Kenmare Bay	x		x	x	Kenmare Bay and River to the east of the given coordinates
Greencastle Harbour, Co. Donegal		Limited	Both	Hydrodynamic study for proposed harbour development	x				Greencastle Harbour, Co. Donegal
Port Oriel, Clogherhead, Co Louth	2003	Limited	Coastal	Coastal processes study for pier upgrade/extension	x				Clogher Head, Co Louth
Annagassan, Co Louth	2000	Limited	Both	Coastal processes study	x				Annagassan on the southern shores of Dundalk Bay, Co. Louth
Carlingford Lough	2006	Limited	Both						Carlingford Lough
RoMS (Regional Modelling System)	2004	Y	Both	To examine the environmental impact of discharge from an outfall	x		x	x	Dundalk Bay with a tidal boundary extending from Cooley Point on the north side to Dimany Point on the south side

Table 2.2 (continued): Summary of existing coastal and transitional water models mathematical models identified

Model name	Date of model development	Available	Is model coastal or estuarine or both	Purpose of the study	Coastal processes (hydrodynamic, wave, sediment movement)	Coastal defence (hydrodynamic, wave)	Effluent dispersal (hydrodynamic, Effluent dispersion, advection dispersal, particle tracking)	Water Quality	Extent of modelled area	Water Body
Magheraroarty, Co Donegal	1997	Limited	Both	Coastal erosion study	x	x			Magheraroarty Beach, Ballyness Bay	NW_170_0000
Lough Swilly		Limited	Both	Hydrodynamic study of Lough Swilly	x			x	Lough Swilly	NW_220_0000
Northern Ireland Coast		Limited	Both	Tidal flow study	x				Northern Ireland coastline	NWRBD, NBRBD
Inver Bay, Donegal Bay	2003	Y	Both	Impact assessment of sediment transport in Inver Bay	x		x	x	Inver Bay and Donegal Bay to the east of the given coordinates	NW_010_0000, NW_060_0000
Killybegs	1996, 2001	Y	Both	To examine the environmental impact of discharge from an outfall, particularly levels of ammonia	x		x	x	Killybegs Harbour out to Drumbanan Island	
Killybegs Harbour, Co Donegal	2001 - 2003	Limited	Both	Hydraulic modelling study	x			x	Killybegs Harbour, Co Donegal	NW_085_0000
Tory Island Harbour	1994 - 2000	Limited	Both	Modelling of wave disturbance and overtopping regimes	x				Tory Island Harbour	NW_180_0000
Buncrana Harbour	2000	Limited	Both	EIS for boat harbour	x			x	Buncrana, Co Donegal	NW_220_0400
Foyle Estuary	1998	Limited	Both	Development of water quality management strategy					Foyle Estuary	NW_250_0100
Flood Mapping for Northern Ireland	2003	Limited	Both	Flood Mapping for Northern Ireland					Northern Ireland including coastal areas	NBRBD, NERBD, NWRBD
Dogs Bay and Gurteen Beach Coastal Protection	2004-5	Limited	Both	Coastal Protection Scheme	x	x			Northern Shore of Outer Galway Bay	WE_100_0000
Strandhill, Co Sligo	1999 - 2001	Limited	Both	Coastal regime study of active beach	x	x			Strandhill, Co Sligo	WE_450_0000
Caladh Mór/Cora Caladh, Inis Meáin	2003 - 2005	Limited	Both	EIS of proposed pier extension	x				Caladh Mór/Cora Caladh, Inis Meáin	WE_010_0000
POM (Princeton Ocean Model)	Subject to permanent advancement	Y	Both	Hydrodynamics of Galway Bay	x				Galway Bay	
Galway Bay ROMS		Restricted	Coastal	Physical climate, HAB prediction, single bay management	x		x	x	Galway Bay	WE_100_0000, WE_170_0000, WE_160_0000
Roundstone Marine	2004	Limited	Both	Hydrodynamic studies	x				Roundstone Marina	WE_230_0100
Inishbofin, Co Galway	2001	Limited	Both	EIS for proposed dredging scheme	x				Inishbofin, Co Galway	WE_250_0000
Killary Harbour ROMS		Restricted	Coastal	Physical climate, HAB prediction, single bay management	x		x	x	Killary Harbour	WE_310_0000
Clew Bay ROMS		Restricted	Coastal	Physical climate, HAB prediction, single bay management	x		x	x	Clew Bay	WE_340_0000
Blacksod Bay, Co Mayo	2002	Limited	Both	EIS for pier extension and marina	x			x	Blacksod Bay	WE_360_0000
West of Ireland ROMS		Restricted	Coastal	Physical climate, HAB prediction, single bay management	x		x	x	West coast of Ireland to edge of continental shelf	WRBD, SHRBD, NWRBD
Atlantic Ireland SWAN		Restricted	Coastal	Wave climate for wave energy projects, sediment transport and tourism uses (surfing, yachting etc)	x		x		Shelf seas west of Ireland	WRBD, SHRBD, NWRBD
Skerd Rocks	2002	Y	Both	To predict the maximum wave height in the vicinity of Skerd Rocks	x				Skerd Rocks	WE_010_0000
Outer Galway Bay	2005	Y	Both	To examine flow from an outfall pipe in Spiddal	x		x	x	The entire bay to the east of the boundary defined by Fanore on south coast to Inveran on north coast	WE_100_0000
Inner Galway Bay	2005	Y	Both	To examine sediment transport in north Inner Galway Bay	x		x	x	Western boundary from Kilcolgan Port to White Strand	WE_170_0000
Rossaveel Harbour	2004 - 2005	Limited	Both	Dispersion studies	x				Rossaveel Harbour	WE_190_0000
Kilkieran Bay 2d	2004	Y	Both	Outfall study at Rosduggan Point	x		x	x	The entire bay to the east of the given coordinates	
Kilkieran and Greatmans Bay	2005	Y	Both	To examine water exchanges between Kilkieran and Greatmans Bays for possible bacteria transfer between fish farms	x		x	x	Both bays and their connections	WE_200_0000
Bertraghbui Bay (Bertraghboy Bay)	2005	Y	Both	To develop a 2d hydrodynamic model of Roundstone and Bertraghbui Bays	x		x	x	Roundstone and Bertraghbui Bays to the north and east of Mace Head to Gorteen Point	WE_230_0000
MIKE 21	2006		Coastal	Development of harbour and offshore facilities at Cleggan Co. Galway	x	x				
MIKE 22	2007		Coastal	Development of harbour and offshore facilities at Cleggan Co. Galway	x	x				WE_250_0000
Clifden	2003	Y	Both	To examine an outfall pipe near Clifden town	x		x	x	Clifden Bay	WE_270_0100
Killary Harbour		Y	Both	To produce an environmental impact assessment of the area with respect to increased aquacultural activities	x		x	x	Killary Harbour	WE_310_0000
Clew Bay and Approaches	2003	Y	Both	To develop a 3d hydrodynamic model of Clew Bay for various applications	x		x	x	The entire bay to the east of the given coordinates	
Clew Bay and Approaches	2006	Y	Both	To develop a 2d model of Clew Bay for comparison with 2003 3d version	x		x	x	The entire bay to the east of the given coordinates	
Clew Bay - Wave Climate Study	2005	Y	Both	To establish the wave heights at Bartraw Beach	x				The entire bay to the east of the boundary defined by the given coordinates	
Newport Bay	2004	Y	Both	To examine the environmental impact of discharge from an outfall	x		x	x	North Inner Clew Bay	
Inner Clew Bay 3d	2006	Y	Both	To examine the carrying capacity of Inner Clew Bay with regard to shellfish	x		x	x	The entire bay to the east of the given coordinates	WE_340_0000
Lough Furnace (1)	2004	Y	Both	Environmental assessment of discharge from an outfall on Lough Furnace and Newport	x		x	x	Lough Furnace and Newport Bay	WE_350_0300, WE_350_0200
Blacksod Bay	2004	Y	Both	To determine the assimilative and dispersion ability of the environment in relation to discharge from treatment works	x		x	x	The entire bay to the north of the given coordinates	WE_360_0000
Achill Sound	2003	Y	Both	Environmental impact assessments to determine the effects of a proposed turbot farm in Bunacurry	x		x	x		WE_370_0000
Broadhaven Bay	2004	Y	Both	To examine possible locations for a sewage outfall and its environmental effects	x		x	x	The entire bay to the south of the given coordinates	WE_400_0000
Crockets Town, Ballina, Co Mayo	2001 - 2004	Limited	Both	EIS for proposed sheltered moorings	x			x	Crockets Town, Ballina, Co Mayo	WE_420_0300
POM (Princeton Ocean Model)	Subject to permanent advancement	Y	Both	Tide surge model, hydrodynamics of Irish waters	x				Irish coastal waters	
Irish Coastal Protection Strategy Study	2003 - 2005	Limited	Both	Review of Irish coastal protection requirements	x				Irish coastline	
Atlantic Ireland ROMS		Restricted	Coastal	Physical climate, sea bed classification, tidal prediction including direct astronomical forcing	x		x	x	All Ireland's territorial waters out to the Hatton Bank, south to Bay of Biscay, north to Iceland	Ireland

2.2 Conclusions

As noted above, a key conclusion of the Literature Review was that the most common approach to assessing and reporting the impact of morphological pressures involves a mixture of qualitative and quantitative assessments. This approach allows for the flexibility required to assess the site specific nature of TraC water bodies.

The lack of sufficient criteria and thresholds available to assess the risk of a water body failing to meet Good Status was evident. At the time of writing of the Literature Review it was concluded that this issue was being addressed by the UK-Ireland Marine Task Team. However, the progression of this work in relation to morphology, at the time of writing this final report, has yet to result in formal classification tools (criteria or thresholds).

3 DATA REVIEW

This section summarises the initial Data Review undertaken on commencement of this study (Appendix 3-1), outlines the final data findings and information collated. This section also details the method of data assessment and interpretation to assess morphological pressures and finally, makes recommendations for further data requirements

3.1 Introduction

An assessment tool was to be developed to allow systematic assessment of future marine morphological impacts on ecological status (/ potential). The tool should allow site specific assessment of proposals taking account of the existing quality status and pressures on the water body. The tool brings together all the work undertaken under the initial reviews within a structured decision-making framework based on analysis of risks and established pressure – impact relationships.

Due to issues of data ownership and the ownership of the developed tool (as detailed in this section), a finalised data store tool could not be developed and sourcing data for the assessments was hindered. However, despite these issues, a national coverage of marine pressures on the TraC morphology was created as shapefiles in a Geographic Information System (GIS) and provided together with an impact assessment tool, as identified in Chapter 2 and 5. These pressure shapefiles, with associated metadata, will be passed under data licence agreements to Cork County Council, the co-ordinating authority for the SWRBD at project completion. Many of these datasets were under constraints and restrictions in relation to assessment and dissemination. Therefore, all GIS outputs of this study will be passed to Cork County Council as the ‘data holder’. A data catalogue of the incoming information was created to log data providers (who would be contacted in the event of any changes in the data or its status) and any licensing agreements or constraints. This information was also included in the metadata of each of the finalised layers, outlining the organisations from which permission should be obtained to change or use the data as required and from where updates may be generated. Data identified in Chapter 2 that was inaccessible was also recorded.

This information was collated and analysed using GIS in order to create pressure datasets. These areas and types of pressures were then used to carry out the impact assessment as outlined in Chapters 5 and 6. The following sections outline how these layers were created using the best available data to create a national coverage.

3.1.1 Metadata

Metadata is the structured recording of information about databases and GIS datasets. During the project, a detailed metadata catalogue was maintained of the incoming data including its sources, restrictions of use, owners, coverage, etc. This will be provided along with all the data to Cork County Council at the project close. Throughout the process care was taken to ensure that the data was licensed for use to the project, and able to be interpreted, processed as necessary and passed to Cork County Council.

Data was collected, collated and developed with reference to 'Guidance on Information Management and Data Interchange between River Basin Management Systems and National Organisations' reports (EPA, 2002).

In order to ensure the quality of the project and that results can be duplicated and any shortfalls recorded, detailed metadata of the final pressures was recorded within the shapefiles. The EPA issued a metadata style sheet of information required for each shape file. This pro forma includes information on the sources, restrictions, processes, organisations and individuals responsible for generating the data, as well as information on the extents and projection which is automatically calculated by ArcGIS. In addition, information fields required under the International Standards Organisation (ISO) 19115:2003 (and ISO/IEC 11179: 2004) were completed, in order to ensure all metadata that may be required for reporting to Europe or future reporting under the Infrastructure for Spatial Information in the European Community, EU Directive 2007/2/EC (INSPIRE) programme are included (INSPIRE, 2007). For each of the final pressure layers delivered with this project, full metadata has been recorded and stored as an xml file as outlined in the standards. In addition, the methods for the development of the pressure layers and source data are summarised below. Detailed methodologies will be passed to the SWRBD with the final morphological pressure layers.

3.1.2 Interim Data Review

The initial risk assessment undertaken as part of the Article 5 Characterisation identified gaps in the availability of quantitative information relating to the morphology of TraC waters. To address these gaps an interim Data Review was undertaken in 2005/2006 to:

- research both national and local datasets;
- include an assessment of the reliability of the data currently available;
- include studies currently underway or due to be commissioned during the life of this project, and
- summarise the data to be requested for inclusion in this Marine Morphology study

The interim Data Review is outlined in full in Appendix 3-1.

This interim Data Review outlined a proposal for the development of a Decision Support Tool, the data elements of which would act as a spatially referenced 'data store' tool. This 'tool' was intended to assist the end user in the regulation of coastal proposals with regard to the requirements of the WFD and morphology, i.e. determine whether morphological alterations could threaten the aim of achieving WFD objectives, or result in a deterioration of ecological status (for example from high to good status).

It was envisaged that compilation of this tool would involve the development of a database to hold all attribute data and information collected. This information would then be geo-referenced and displayed spatially using GIS software (ESRI ArcGIS).

It was initially proposed, and agreed with the Marine Morphology Steering Group, that the end users for such a tool should be the Marine Institute, EPA, the former DCMNR, or a combination of all three bodies, and as highlighted by the interim Data Review; confirmation of this 'end user' was fundamental to the licence agreements and data requests required for this study. However, notwithstanding support from the Marine Morphology Steering Group an appropriate end user for this tool was not identified. As a temporary alternative, to ensure the progress of this study, the SWRBD, and Cork County Council, were identified as substitute end users. The SWRBD, and Cork County Council, have no function to hold or use such a tool for the purpose of regulation and are intended only to temporarily act as the 'end user' until an appropriate assessment or regulatory body is identified. However, confirmation of an alternative end user has not transpired during the term of this study.

In the absence of an appropriate end user all formal data requests were issued via the SWRBD. Therefore, prior to the dissemination and/or editing of data resulting from this study permission must be sought from the data originators. To facilitate the future movement of data required for the assessment of morphology within TraC water bodies, it was proposed that only those datasets required for the further characterisation of pressures will be held by Cork County Council for dissemination to the ultimately identified end user. Therefore, a data store tool containing details of morphology and biology as well as that for pressures was not generated for temporary hosting by the SWRBD as it is considered that the future end user of this tool will inevitably hold more detailed data to that available to this study. Also, compliance with licence agreements for many datasets will require this data to be requested [and edited where necessary] again under the new terms for the ultimate end user. This report, therefore, recommends the structure of an appropriate Decision Support

Tool and summarises the data identified as useful to both the assessment and regulation of coastal development/activities using such a tool.

The data regenerated by this project for the pressures identified will be passed to Cork County Council together with methods of generation and metadata. This data can be uploaded into the EPA National WFD 'schema' by Cork County Council, as appropriate. The EPA National WFD schema is a national database of WFD data to which data can be uploaded by relevant authorities to ensure all regulatory parties involved in national and local government have access to the same data, and that this is as up to date as possible. The pressures data has been created in a format compatible with this database.

This uncertainty caused significant delays in data acquisition, and prevented access to several key datasets identified in the interim data review. Data such as the ongoing work on coastal flood management zones (GIS, mapping and LiDAR (Light Detection and Ranging)), Ordnance Survey (OS) maps, the Skipper series hydrographic charts and a number of other national resources were unable to be accessed by this study, despite numerous attempts. The purchasing of additional licences was not possible.

As much of the work in updating the existing information structures within the former DCMNR was underway at the time of dissolution, many of the sources of information that were to eventually be made available electronically are only available in paper form. Despite a concerted research effort on behalf of this project, not all of this information could be accessed or summarised. For example, the Coastal Engineering Division of the former DCMNR has a drawing archive of coastal structures, bridges etc. Whilst the project was eventually granted permission to access this extensive, restricted in-situ archive, the nature of the resource meant it was not practical for assessment for a national study. Where possible, these data sources have been identified in the interim data review and in following sections so that specific studies or future development appraisals can identify these resources.

The sources used to assess the morphological pressures on water bodies in Ireland are outlined in this chapter. Information on source datasets has been provided for each of the pressure types together with background information. The data collated, full data catalogue and derived information will be provided to Cork County Council at the project end where it will remain until such time as a suitable data owner can be identified.

3.1.3 Tool Development

The tool structure developed is divided into two components as noted previously:

1. **Data Store GIS:** this holds and displays the collated data to assist regulators in decision-making. The functionality of this tool can be summarised as follows:
 - The user will assess the information provided by an applicant for a proposed development/activity e.g. foreshore licence or dumping at sea application. It is envisaged that future applications will be accompanied by digital information that can be used to update the data store.
 - The user can then view and query the data relating to existing pressures within GIS. Future development of this tool will benefit greatly from WFD monitoring results.
2. **Morphological Impact Assessment:** The data store GIS provides baseline data which a regulator can interpret using expert judgement to make a decision. This second function however, uses generic assessments of potential changes to the morphological features attributed to each water body type to estimate the risks to ecology. The future development of this function will also benefit from WFD monitoring results as well as the outputs of research projects such as INFOMAR (the Integrated Mapping For the Sustainable Development of Ireland's MARine Resource); a joint venture between the Geological Survey of Ireland (GSI) and the Marine Institute.

The combination of the above elements will inform the further characterisation of TraC waters and provide a suitable approach to assist coastal managers and regulators in assessing the potential impact of future developments on individual water bodies.

Following the identification of relevant datasets and key organisations within the interim Data Review, data requests were issued to all RBD, relevant public institutions, academia and various consultancies. The main categories of information requested for this study were **Pressures** (anthropogenic activities), **State** (morphological conditions), and **Receptors** (WFD biological quality elements: phytoplankton, macroalgae, benthic invertebrates and fish (transitional only)).

Sections 3.2 and 3.3 below outline the data reviewed, requested, collated and edited as part of the Marine Morphology study. In summarising this data, Section 3.4 confirms the identified data gaps associated with the assessment and regulation of morphological alterations and outlines the key recommendations for further data requirements to fully develop an appropriate Decision Support Tool.

3.2 Final Data Review Findings

One conclusion from the interim Data Review can be carried forward to the findings of this final Data Review – that is that the existence and availability of information in suitable formats relating to the pressures on, and the attributes of, morphology in Irish TraC waters is very limited. For example, many resources relating to coastal structures exist in non-spatial or paper format, such as foreshore licence records and plans of infrastructure extents. On meeting with the former DCMNR to discuss such issues, the Marine Morphology study was informed of a national project which planned to digitise such information held by the department creating a GIS based data store. However, on the transfer of the former DCMNRs' functions following the General Elections in 2007 it is unclear how this is being progressed. Through continued communications with the bodies involved it appears that the situation is still to be resolved at the time of writing.

A significant restriction to data acquisition for this study centred on the uncertainty expressed by data originators relating to the final use of the data requested. The identification of the SWRBD (Cork County Council) as end user assisted this process; however, difficulties were experienced throughout the study. This data acquisition process was further hampered and delayed by the dissolution of the DCMNR, which lead to uncertainty of data ownership of government marine data, and an inability of former marine departments to release the information until the issue was resolved. A number of marine data and GIS programmes, were stalled or ceased altogether. Several of these data consolidation projects were initiated to assist the implementation of the WFD, its daughter directives and 'Sea Change' programmes. The urgent need for a responsible body, preferably a governmental department, agency or agent to take ownership of this process was reiterated by the Steering Group.

In order to ensure consistency, all data was assessed in Irish National Grid (TM65) projection as defined by the water body boundaries and this information was included in the metadata. For some datasets small spatial shifts in the conversions were noted and in general could be corrected by the ArcGIS projection tools. However, some data with WGS84 projections noted a marked and consistent shift. This was eventually tracked to a small error in the automatic re-projection calculation. The error was reported to ESRI who were able to correct the problem. All datasets created were subject to spatial and attribute quality assessments and the information included in the metadata.

3.2.1 Baseline Data

Data resources for baseline data are listed in Table 3.1, the following section outlines the data resources and sources and problems encountered. The baseline data provides much of the background information for the assessment, in addition, it provides the information used for visual interpretation of water bodies and pressures.

3.2.1.1 TraC Water Body Boundaries

The TraC water body boundaries used throughout the Marine Morphology Study were sourced from the EPA via the SWRBD. Water body boundaries were created using OSi 1:50,000 vector data (High Water Mark (HWM) and Low Water Mark (LWM)) and national territory from the 1959 Maritime Jurisdiction Act. The full metadata for these datasets is available from the EPA (www.epa.ie/metadata). Some digitising errors were identified by this study; these consisted of very small overlaps and also the splitting of Erne Estuary into two areas along the North West coast (see Figure 3.1 below).

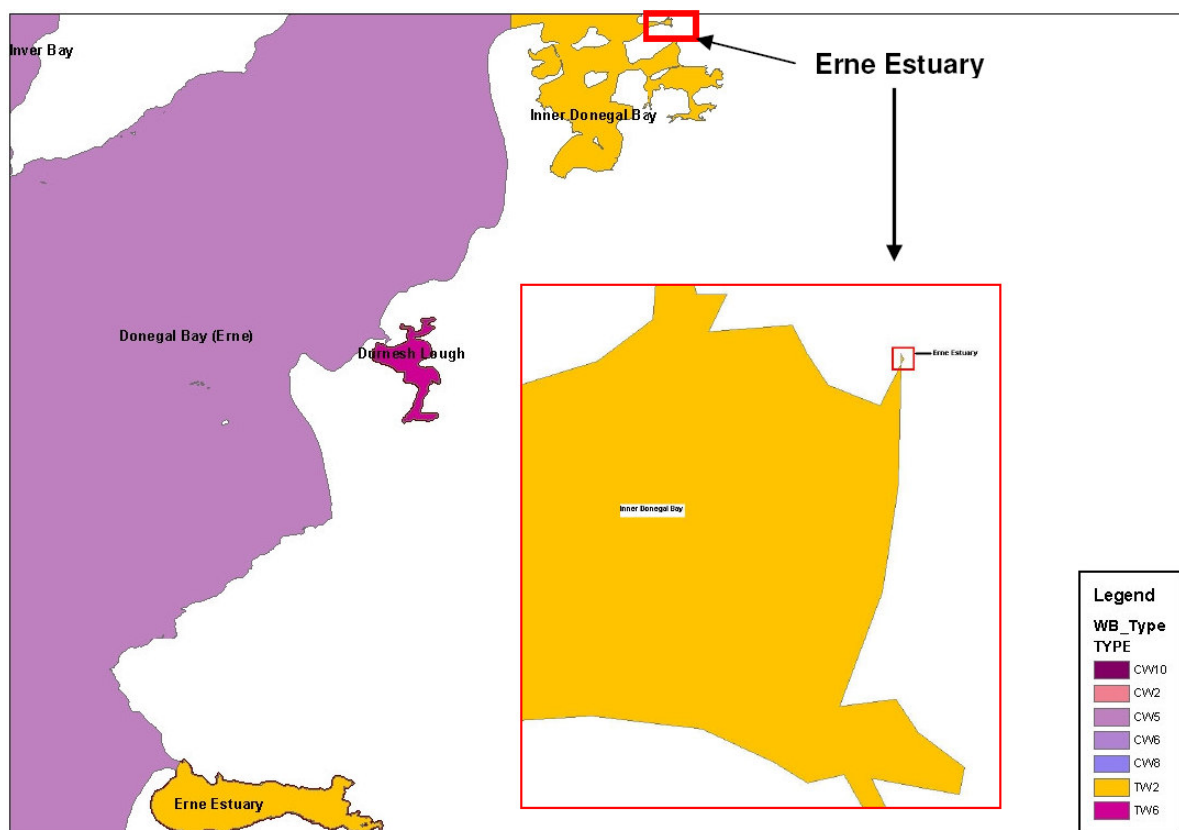


Figure 3.1: Digitising error associated with Erne Estuary

3.2.1.2 Irish Coastline / High Water Mark

The dataset referred to as Ireland's coastline for this study is that provided by the SWRBD which was sourced from the EPA. The coastline polygon was defined by the HWM from the 1:50,000 OSi mapping which was also provided by the SWRBD (See Table 3.1). The full metadata for the HWM is available from the EPA. On review of these datasets, slight discrepancies were identified between the coastline polygon and the HWM it was created from, an example of which is illustrated in Figure 3.2 below.

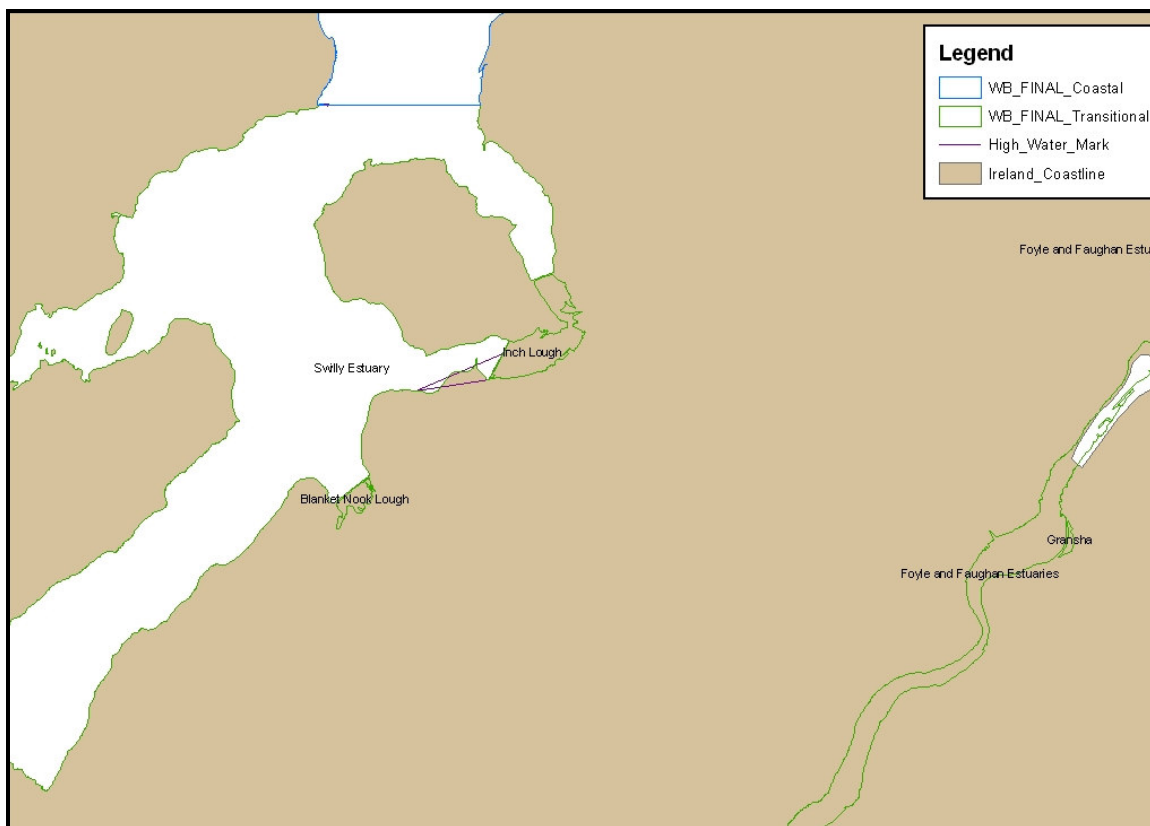


Figure 3.2: Example of discrepancies found between the Irish coastline polygon and HWM in the Swilly and Foyle Estuaries.

Figure 3.2 indicates areas where the coastline polygon (brown) excludes whole water bodies (Inch Lough and Blanket Nook Lough). Also a digitising error in the HWM polyline layer is visible between Swilly Estuary and Inch Lough. To help overcome these discrepancies prior to further data analysis a substitute coastline polygon file was created using the landward boundaries of the TraC water bodies (as sourced from the EPA). This aimed to minimise errors and ensure the total area of TraC water bodies recorded by the EPA was carried forward throughout the study.

3.2.1.3 Intertidal Area

To facilitate an assessment of pressures within Ireland's TraC water bodies, the proportion of these pressures occurring within the intertidal zone was required to be calculated. The intertidal area (or foreshore), can be defined as the area exposed to the air at low tide and submerged at high tide. In the absence of a national delineated intertidal zone, this zone was estimated as part of this study using datasets representing Ireland's high and low water marks.

The EPA provided the Marine Morphology Study with a national LWM layer sourced from the OSi at a scale of 1:250,000. This is not a very accurate scale to represent LWMs. However, the national OSi LWM at a scale of 1:10,000 (1:50,000 for islands) was unavailable to this study due to licensing restrictions. To supplement the 1:250,000 LWM the SWRBD provided 1:50,000 vector maps for Cork and Kerry. Further into the Marine Morphology study, vector maps were provided for counties Donegal and Louth. However, these were not incorporated into the Intertidal zone which had already been generated.

To estimate the intertidal zone of the TraC waters the area of water body between the HWM and LWM was calculated using the 1:50,000 LWM for Cork and Kerry and the 1:250,000 data for all other coastal areas. As noted above, the coastline (HWM) layer contained some discrepancies and for the purpose of this calculation the substitute coastline polygon created from the inner boundaries of the TraC water bodies was used as the HWM. Figure 3.3 below illustrates the intertidal and subtidal zones estimated for Castlemaine Harbour and Cromane transitional water bodies in the SWRBD.

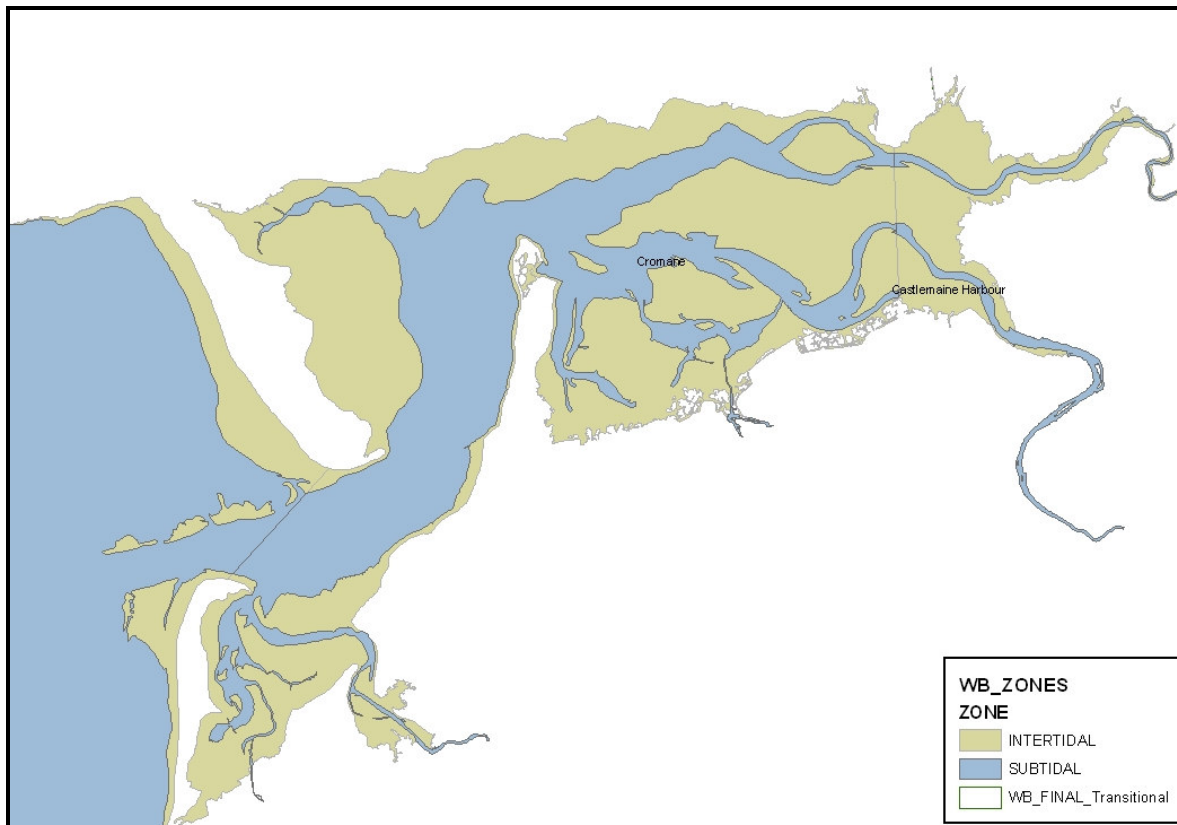


Figure 3.3: Intertidal and subtidal zones estimated for Castlemaine Harbour and Cromane

3.2.1.4 CORINE

The Coordination of Information on the Environment (CORINE) Land Cover 2000 database was made available to this study by the EPA via the SWRBD. This dataset proved useful both in the identification of areas of potential ILU and as a tool to focus the identification of pressure types. For example, the urban, transport and industrial land cover areas identified by CORINE were used to help focus the identification of areas of reclamation, flow and sediment manipulation structures (structures lying perpendicular to the coastline) and causeways.

3.2.1.5 Foreshore Licence/Lease Register

Following the initial risk assessments, licensing information such as that associated with foreshore licences and leases was identified as a useful source of data to help further characterise the pressures on the morphology of Ireland's TraC waters. It was envisaged that a review of the former DCMNR's register of foreshore licences and leases would highlight those records of potential relevance, after which the associated licence

documents, which are held in paper format in the former DCMNR's Coastal Division offices, would then be reviewed in detail. However, following a successful meeting with the former DCMNR and the Marine Institute, the former DCMNR Coastal Zone Management Division relocated from Dublin to Clonakilty, Cork at which time all files were unavailable to external bodies. Following this relocation, the transfer of responsibilities of the former DCMNR under the Foreshore Acts had yet to be confirmed, further restricting access to these documents.

To progress with the information available to the Marine Morphology study; a spreadsheet listing deeds relating to foreshore licences and leases issued under the Foreshore Acts (1933 – 1998) for the years 1933 – 2005 and prior legislation was downloaded from the former DCMNR website. This information was then converted to an ESRI compatible shapefile which was then used to help focus the review of existing data and orthophotos for additional pressures.

Each record within the register was assigned a pressure 'type' based on the descriptive information supplied in the register, and following a map search those records associated with pressures types relevant to this study were assigned a water body code. This register did not provide very detailed location information for the activities/developments, and water body codes were only assigned to 1236 of the 1984 records.

No coordinates were provided with the register therefore to display these records in ArcMap they were attributed to centroids of the water bodies and a new shapefile displaying these licence records as points was created. It should be noted that details of the extent of pressures e.g. area dredged are not provided with the foreshore register.

3.2.1.6 Environmental Impact Statement Register

As part of the Literature Review, Environmental Impact Statements (EIS) identified as relevant to the pressure types assessed by this study were obtained from ENFO, Ireland's public information service on environmental matters (see Appendix 3-2). As with the foreshore licence/lease records pressure 'types' and water body codes were assigned to each EIS record. These records were then attributed to centroids of the water bodies to create a shapefile displaying the EISs as points in ArcMap. A dataset of relevant marine EIS areas was provided by the Marine Institute as ArcGIS polygons.

3.2.1.7 Coastal Images

Georeferenced images of Ireland's coast were required to facilitate the assessment and, where necessary, digitising of pressure extents (footprints).

National infra-red coastal images sourced from the National Coastline Survey of Ireland (Marine Institute / Compass Informatics / Enterprise Ireland, 1998 - 2002) were received from the Marine Institute. However, these images, with the exception of Dunmanus and Bantry Bays, are not georeferenced and require the use of the project's map viewer to interrogate the images. The Marine Institute plan to georeference all images, which on completion will provide an invaluable resource to the outputs of this study.

Orthophotos were requested from each RBD via the SWRBD, and over 30,000 orthophotos were received (inland and coastal coverage). Using numeric grids provided by the OSi via the SWRBD, those images required for assessment were identified and retrieved from this large database of images.

Not all images received were georeferenced, and overall coverage varied across the coast with counties Kerry, Cork, Waterford and Dublin having substantial coverage (see Table 3.1). No orthophotos were received from the South Eastern RBD (SERBD), and although some coastal locations were covered by images provided by the Eastern and South Western RBDs, the majority of the coastline remained uncovered.

Figures 3.4 - 3.9(b) below illustrate the coverage of orthophotos made available to this study for each RBD.

North West RBD

Orthophotos received for the NWRBD were in a MapInfo format. There is extensive orthophoto coverage of the NWRBD coastline with only a few gaps as shown in Figure 3.4

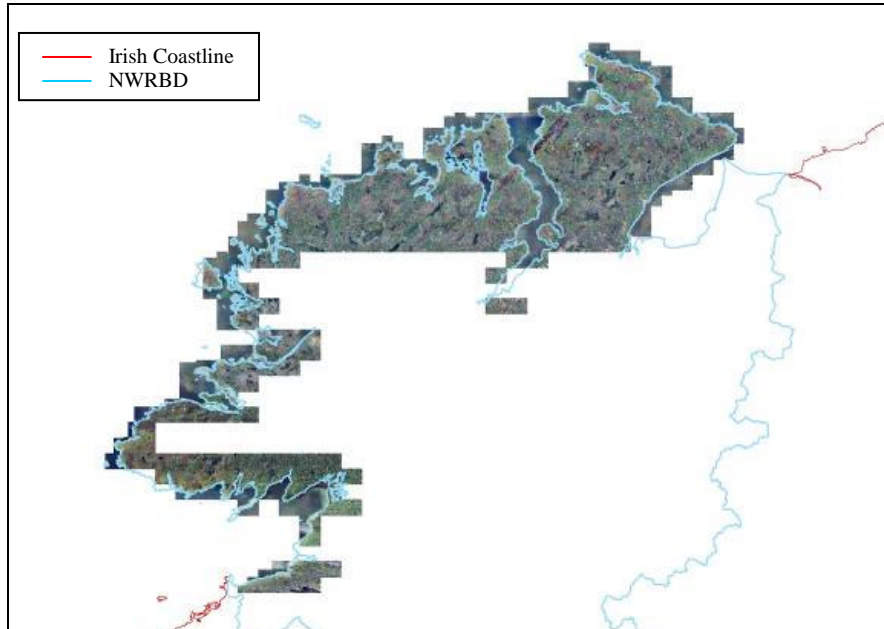


Figure 3.4 - MapInfo orthophoto coverage of the NWRBD coastline.

Western RBD

Aerial images were received for the majority of the WRBD coastline (Figure 3.5), however only approximately 40% are geo-referenced.

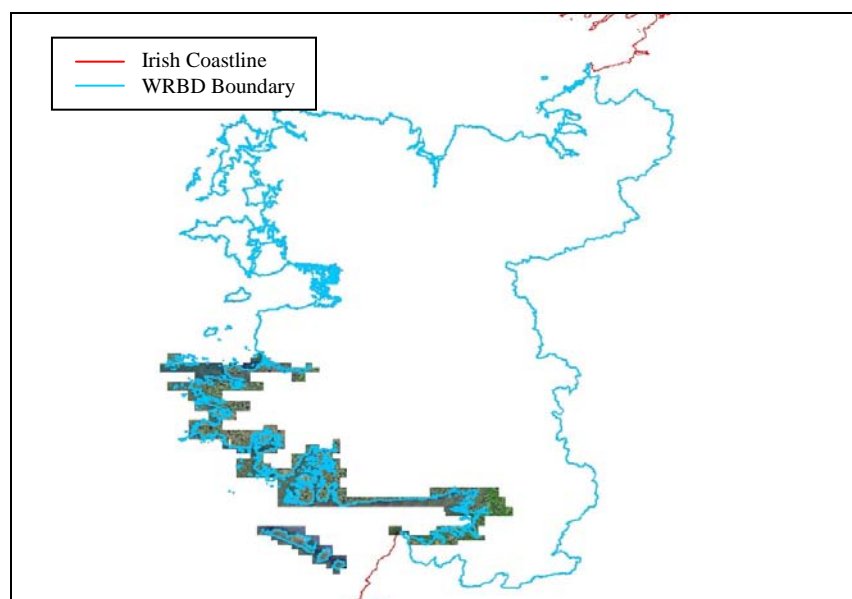


Figure 3.5 - ArcMap orthophoto coverage of WRBD coastline.

Shannon RBD

Figure 3.6 shows the coverage of orthophotos received for the Shannon RBD coastline. Orthophotos were received for approximately 50% of the coastline. Additional aerial images were received in the Limerick City region but lacked spatial references.

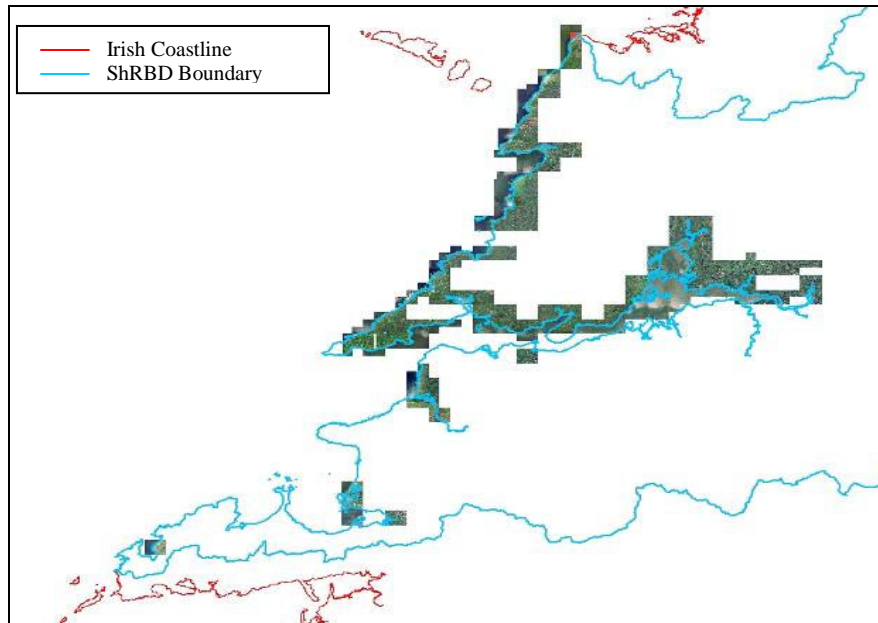


Figure 3.6 - ArcMap orthophoto coverage of the Shannon RBD's coastline.

South West RBD

Figure 3.7 shows the orthophotos made available to this project for the SWRBD coastline. County Cork is covered by a single mosaic file. County Kerry orthophotos were individual, but georeferenced. County Waterford images were contained within SERBD mosaic (see Figure 3.8).

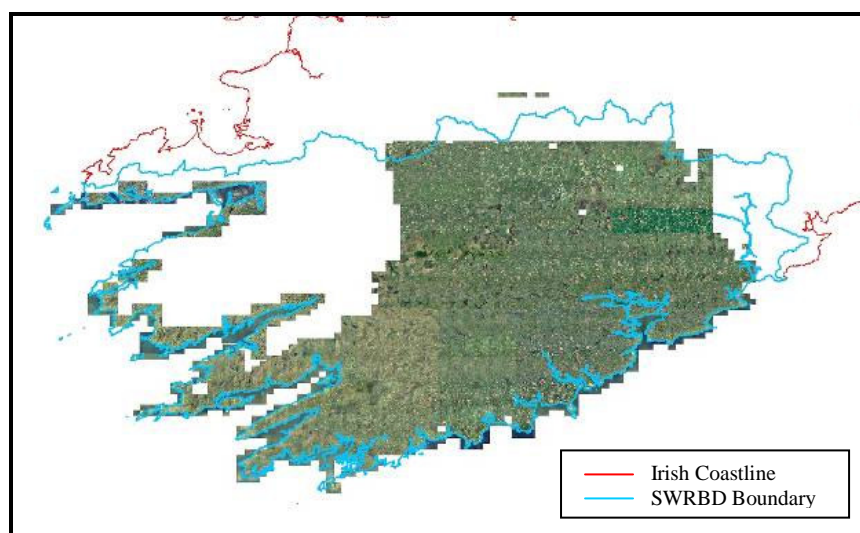


Figure 3.7 - ArcMap orthophoto coverage of the SWRBD coastline.

South East RBD

There was minimal orthophoto coverage of the SERBD coastline as shown in Figure 3.8

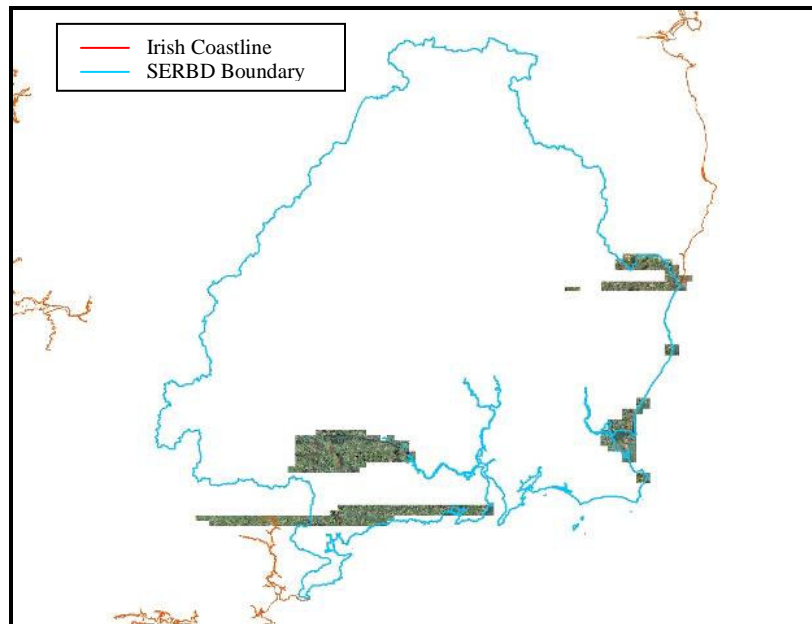


Figure 3.8 - ArcMap orthophoto coverage of the SERBD coastline.

Eastern RBD

Figure 3.9(a) and 3.9(b) convey of the orthophotos made available for the ERBD, Note that there are two figures to show the overlapping mosaic files

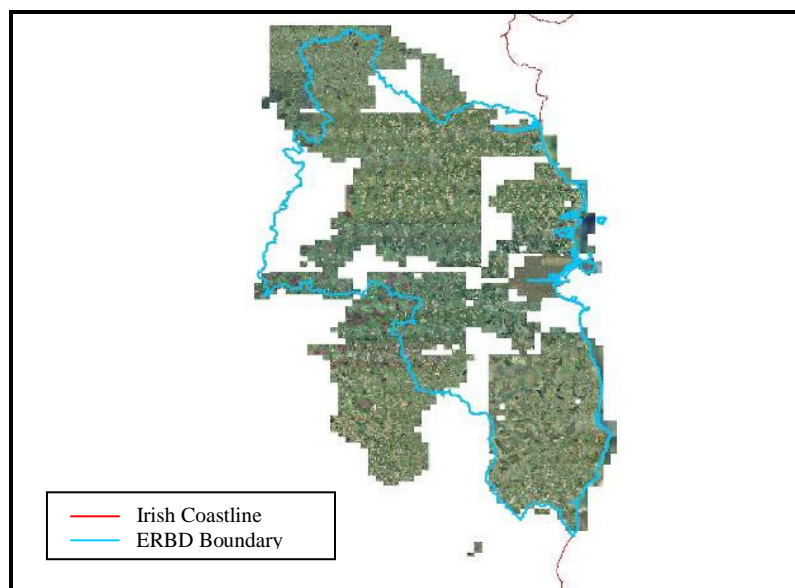


Figure 3.9(a) - ArcMap orthophoto coverage of the ERBD coastline.

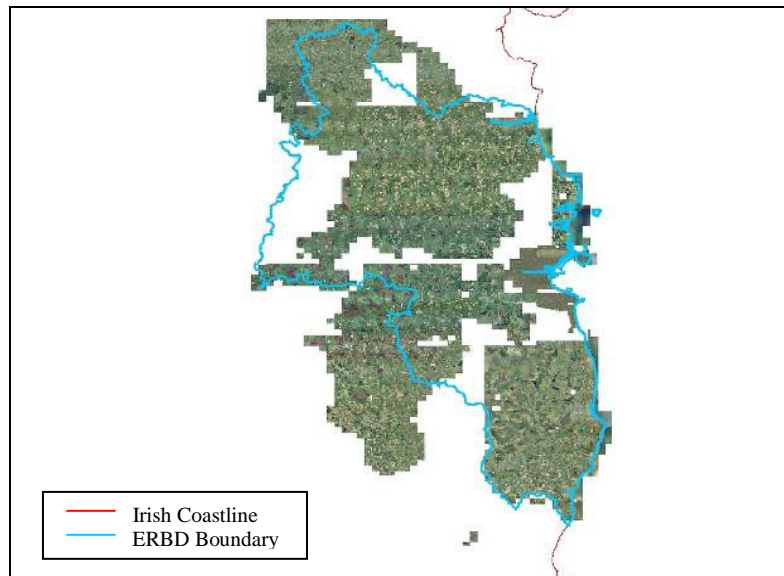


Figure 3.9(b) - ArcMap orthophoto coverage of the ERBD coastline.

In addition to the poor coverage of orthophotos for some areas, the resolution of these images varied greatly, an example of which is shown in Figures 3.10 and 3.11 below.



Figure 3.10: Low resolution image of Dublin



Figure 3.11: High resolution image of Dublin

Coastal images were used to help clarify the type of coastal structures as well as digitising structure extents. Therefore, for areas of poor resolution it was difficult to visualise the exact extents of structures being digitised due to its coarseness.

The EPA's online Envision mapper proved a useful tool to help clarify some pressures identified in areas where only low resolution orthophotos were available.

Oblique images produced by the former DCMNR Coastal Helicopter Survey (SnapMap Project) were made available for review for this study. On receipt, all photographic images were copyright 2004 DCMNR. These images proved very useful to the identification and assessment of all the pressures types.

3.2.1.8 Historic Maps

Historical maps of Ireland were requested for use by the Marine Morphology study to assist with the identification and assessment of coastal reclamation. Focusing on urban and industrial areas and where foreshore licences/leases and EISs indicate reclamation, available orthophotos were overlaid with historic maps to search for coastal land alterations.

Cork County Council provided a mosaic of georeferenced historic maps for Cork and part of Kerry generated from 6" maps (early 1900's) for use by this study. All local authorities hold historical maps for their particular area. However, for the most part these maps were not available georeferenced for use by this study.

National georeferenced historic maps are available for Ireland from the OSi, and can be viewed at OSi's online Historical Mapping Archive (<http://www.irishhistoricmaps.ie/historic/>) for a daily, weekly, monthly or yearly fee. These maps however, are only available for download in PDF (Portable Document Format).

An alternative source of historic maps was identified as georeferenced bedrock maps available from the GSI. These are 6" to one mile maps dated between 1860 and 1910. More than 2500 historic maps were obtained for assessment of Ireland's coast. These maps were georeferenced to 1:750,000 scale and were used by permission of the GSI. As with the orthophotos, numeric grids were used to identify and retrieve the images from the large database received. This dataset was comprehensive, though there were some localised areas with incomplete coverage, where specific tiles were not available. Unlike the orthophotos the coverage was nearly national. However, in order to carry out the assessments, both ortho-photographs and historic maps were required, as detailed below.

3.2.1.9 Bathymetric Data

Limited bathymetric information was available to this project. After extensive review and identification of possible resources, it was established that this is due to the limited availability of bathymetric data for Ireland. Hydrographic Charts have been electronically digitised on a world wide basis in recent years. Raster charts (georeferenced pictures) for Ireland are available, and are were licensed to the former DCMNR. However, with the re-affiliation of governmental department responsibilities, the ownership of this licence

remained in question for much of the project and was ultimately unavailable. The vectorised charts were being prepared by organisations such as SeaZone (a commercial subsidiary of the UK Hydrographic Office) which had prepared draft GIS data for areas of Ireland's waters in 2006 and were used under licence by the former DCMNR for projects such as the Irish Offshore Strategic Environmental Assessment (SEA) (Petroleum Affairs Division (PAD), 2006). Neither of these organisations was able to provide even draft copies of this information due to ongoing licence negotiation with Ireland.

The bathymetry used for the initial typology was of insufficient coverage and resolution for further analysis. Based on the 1997 GEBCO (General Bathymetric Chart of the Oceans) bathymetry, this dataset does not cover the inshore areas. Localised information was available from a number of studies such as the NPWS surveys of Special Areas of Conservation (SACs) and some of the marine models but this was inconsistent on a national basis. Chapter 4 identifies the future survey programmes designed to provide this information. The results of these programmes may influence the future characterisation

Table 3.1: Data Resources – Baseline information used in the assessments.

The following table lists the baseline resources used in the assessment and digitising of the TraC-MImAS pressures. The information includes the data source (received from) and the data owner or developer.

File Name/Type	Data Description	Geographic location	Sourced from	Data Owner / Originator
15374 2219_WFDGDB (CD 1 of 2)	Water bodies and national Article 5 Risk Assessment Datasets (excludes morphology datasets)	RoI	SWRBD	EPA
Orthophoto mosaic	Mosaic of Cork and some of Kerry aerial photos	Cork & part of Kerry	SWRBD	Cork County Council/Osi
15374 2231_Cork-Kerry-Waterford photos and vector	Orthophotos for Cork, Kerry and Waterford	Cork, Kerry and Waterford	SWRBD	OSi
15374 2258_Orthophotos and vector maps for Cavan, Longford, Monaghan and Donegal	Orthophotos and vector maps for Cavan, Longford, Monaghan and Donegal	Cavan, Longford, Monaghan and Donegal	EPA	OSi
15374 2261_Orthophotos for Shannon	Orthophotos for Shannon (12 Disks)	ShRBD	SWRBD	OSi
15374 2262_WRBD and ShRBD GIS Data and Photos	Orthophotos for WRBD	WRBD	SWRBD	WRBD/ShRBD/OSi
15374 2263_ERBD GIS Data	Orthophotos for ERBD	ERBD	SWRBD	OSi
15374_2238_CoastView	Georeferenced infra-red images of Bantry Bay and Dunmanus Bay	Bantry Bay and Dunmanus Bay	MI	MI
15374 2260_GSI - Historic Map Index	Historical 6 inch map Index of Ireland	RoI	GSI	GSI
15734 2264_GSI_Irish_Coastal_6inch_Historical maps	Historical 6 Inch maps for the Irish Coastline	RoI	GSI	GSI
15374_2236_IrishCoastalSurvey22-12-04_V3	SnapMap, oblique images of the coast of Ireland - Second collection from DCMNR (corrected image references).	RoI	DCMNR	DCENR
Environmental Impact Statements	Copies of EIS documents and catalogue summarising relevant details within the EISs, such as ecology, mitigation measures used.	RoI	ENFO	N/A
EISDevelopmentMapping.shp	EIS Development Mapping	RoI	MI	MI

Table 3.1(continued): Data Resources – Baseline information used in the assessments.

File Name/Type	Data Description	Geographic location	Sourced from	Data Owner / Originator
15374 2268_Foreshore Lic Download	Foreshore register downloaded from the former DCMNR website 09/10/2007	RoI	DCMNR	DCENR
High_Water_Mark	HWM defined by 1:50,000 OSi mapping	Ireland	SWRBD	EPA/OSi
Ireland_Coastline	Ireland polygon; coastline defined by 1:50,000 OSi mapping (HWM)	Ireland	SWRBD	EPA/OSi
15374 2256_National LWM_EPA	LWM and HWM OSi 1:250000	Ireland	EPA	Osi
Vector	Cork & Kerry vector maps (towns scaled to 1000, 2500 and 5000; coastline scaled to 50000)	Ireland	SWRBD	Cork County Council/Osi
clc00_ie	RoI land cover types defined to level 3 detail	RoI	SWRBD	EPA
clc00_lev6	RoI land cover types defined to level 6 detail	RoI	SWRBD	EPA

3.2.2 Pressures

The pressures assessed within this study are discussed in detail in Chapter 5 in relation to their potential impact on the morphology of TraC waters. The purpose of this section is to outline the information considered for the further characterisation of each pressure type and how this was prepared for assessment using TraC-MImAS. The TraC-MImAS tool was developed to help regulators determine whether changes to the morphology of TraC waters could pose a risk to ecology, and thereby identify those that could threaten the aim of achieving GES or result in a deterioration of ecological status (see Chapter 2 and 5). The tool uses a concept of 'system capacity' (allowable morphological change) to measure impacts to morphological conditions. The tool assuming that a pristine water body has a measure of assimilative 'capacity', which is degraded by anthropogenic activities or pressures.

TraC-MImAS requires each pressure to be defined by its 'footprint' (area/length) per water body as well as its proportion per tidal zone, i.e. intertidal and subtidal zone to assess the pressure areas against the 'system capacity'.

As part of the initial risk assessments undertaken in Ireland, preliminary information on the those pressures outlined in Section 2 above was obtained and translated into files compatible with the ESRI GIS 'ArcGIS'. Shapefiles were created for each of the pressures identified e.g. polygons of areas dredged. On completion of the initial risk assessments, each RBD submitted the shapefiles collated for their District to the EPA who then merged these to create national shapefiles for the purpose of reporting to the EC.

The baseline datasets outlined in Section 3.2.1 above are common to the assessment of most if not all the pressures. The coverage of orthophotos and historical maps, for the purpose of land claim pressures, was fundamental to the identification of pressure extents. In the absence of orthophotos, the EPA Envision online mapper could be used to clarify some pressure extents. However, pressures were only digitised in those areas where orthophotos were available (as shown in Figures 3.4-3.9(b) (orthophotographic coverage noted under Baseline section)).

3.2.2.1 Dredging, Other Disturbances & Disposal at Sea

'Dredging' and 'Disposal at Sea' are two pressures identified by the initial risk assessments as potentially impacting on the morphology of TraC water bodies. For the purpose of further characterisation Dredging is defined as either 'Dredging - High Impact', which corresponds

for the most part to capital dredging (first time, deep dredge), or 'Dredging - Low Impact', which corresponds for the most part to maintenance dredging (navigational channels etc).

The pressure 'Other Disturbances to Seabed' is defined as "any other temporary disturbances to bed morphology or substrate character where the impacts are likely to be restricted to the area of bed directly disturbed and where the bed is likely to recover significantly over time" (see Table 3.2). Shellfish dredging, vessel movements, wind farms, cables and pipelines were considered to represent this pressure type.

Wind farm zones were included in this pressure as, although the sea bed is unlikely to recover "significantly over time" following development of these farms; these areas are currently only 'zoned' and therefore likely to be subject to investigative surveys. For the most part, these zones are offshore and outside the boundaries of the WFD water bodies.

As noted in Section 2.1 of this report, aquaculture is outside the scope of this study. However, as this is such a prominent activity in Irish TraC waters, and is not being considered elsewhere, it was agreed with the Marine Morphology Steering Group that the pressure 'Other Disturbances to Seabed' should represent the aquaculture activities of shellfish dredging and trawling only. This is a similar approach to that of the NS-Share Marine Morphology study for which aquaculture was assessed and therefore assists in harmonisation throughout Ireland. No detailed assessment was undertaken for aquaculture other than the mapping of worked and licensed areas.

Data Resources

The following section outlines the data resources identified by the source organisations.

Office of Public Works

The information used to further characterise maintenance dredging included that associated with arterial drainage schemes and drainage districts as recorded by the Office of Public Works (OPW). The OPW is the Irish Government's principal engineering agency whose work includes the maintenance of arterial drainage schemes and the development, design and implementation of urban flood alleviation works. For the purpose of the initial risk assessments, the OPW released this information to the RBDs in 2004 for use in WFD assessments. However, in January 2005 the OPW released updated datasets for arterial drainage schemes and drainage districts to replace that previously issued. This first revision includes corrections made to the channels, benefiting lands and embankment records only. Corrected GIS layers for Drainage Districts, Bridges, Sluices and Weirs have yet to be released.

Marine Institute

The Marine Institute provided shipping navigation channel data, which in the absence of accurate maintenance dredging information, was used to provide the area impact of the navigation channels. These areas must be maintained for safe navigation and therefore are subject to maintenance dredging as required. Records from the former DCMNR foreshore and dumping at sea databases and the series of excel spreadsheets that were compiled by the Marine Institute were used to ensure the areas were subject to maintenance dredging. (Table 3.2) These sources also provided information and locations of dumping at sea areas. Attribute information on the nature of the dredge / dump material, Site IDs and Licence numbers were added to the dumping at sea areas.

The Marine Institute also provided information on subsea cables from the Kingfisher cable safety charts as part of information used to assess areas designated for future offshore wind farm development. These areas were also assessed as other disturbances to seabed, as some are already being developed.

Fisheries information was provided by the Marine Institute, providing information on inshore fisheries and fishing gear usage.

Former Department of Communications, Marine and Natural Resources

The former DCMNR provided a number of datasets on foreshore and licensing information via their website, the Marine Licence Vetting Committee and the Marine Institute. The former department had begun programmes to collate this information under the Coastal Zone Administration System (COZAS) programme, but due to departmental reorganisation these programmes had been stalled indefinitely. As a result the positional accuracy of the received data was insufficient to estimate the extents in most cases.

As an interim measure, the former DCMNR allowed access to their licence for oil and gas infrastructure from Oilfields Publications Ltd.

Similarly the Integrated Fisheries Information System (IFIS), which was intended to provide information on aquaculture and inshore fisheries, is currently unavailable. As a result, information from existing databases was combined and compared; most notably the 2005 Aquaculture database the forerunner to the IFIS, which was provided by the former DCMNR and DAFF.

Bord Iascaigh Mhara (BIM)

BIM provided shellfisheries area data for some of the RBD areas. Much of the data BIM had available was incorporated into the aquaculture database provided by the former DCMNR. However, information on bivalves fisheries could be assessed, though there was incomplete national coverage for this dataset.

Reference Information

Ferry route information was used from the ArcGIS European information. This is a series of sets of information provided by the US National Imagery and Mapping Agency (NIMA) and is based on USGS (United States Geological Survey) and the CIA (Central Intelligence Agency) world gazetteer data. The dataset includes coastline data (1:1,000,000), towns, cities, major rail and road links. The ferry routes are given for major European and UK routes.

Table 3.2: Data Resources: Summary of the information assessed for the purpose of further characterising Dredging, Disposal at Sea and Other Disturbances of Seabed

This table outlines the data used to assess seabed disturbances, including dredging and dumping at sea. In addition, where available, reports, licences and other information were consulted to provide verification or further information on activities.

File Name/Type	Data Description	Geographic location	Pressure	Sourced from	Data Owner / Originator
morphology_polygons_national.shp	National shapefile for both dredging and dumping at sea. Combination of records submitted by RBDs. Attribute data limited to Marine Dredge Area' or Marine Dumping'	Rol	Dredging / Disposal at Sea	EPA	DCENR
RBD identified Dredge locations (shapefile)	Collated from DCMNR dredging locations specified by dumping at sea applications	SWRBD, SERBD, ShRBD	Dredging	RBDs	DCENR
RBD identified Dredge locations (MS Excel spreadsheet)	Collated from DCMNR dredging locations specified by dumping at sea applications	SWRBD	Dredging	SWRBD	DCENR
Drainage Schemes & Drainage Districts	National Drainage Schemes (maintained by OPW) & Drainage Districts (maintained by Local Authorities)	Rol	Dredging	SWRBD	OPW
ShippingNavigationChannels.shp	Shipping Navigation Channels. Navigation channels must be maintained for safe navigation, therefore the channel areas represented by this dataset was used as the basis for the maintenance dredge area. This dataset does not contain detailed attribute data.	Rol	Dredging	MI	MI
RBD identified Aquaculture areas (shapefile)	Aquaculture areas	WRBD	Other Disturbances	SWRBD, SERBD, WRBD	Former DCMNR & BIM
Aqua2005.mdb	Database of aquaculture site location and extents, licence status, species. Areas represent licensed area and not necessarily the area 'worked'	Rol	Other Disturbances	former DCMNR	DAFF
FishingGears_08-08-06_region.shp	Location, extents, gear/methods and species targeted of fishing/aquaculture sites. Site extents were defined by the MI following consultation with fishing and aquaculture community/organisations across Ireland. Areas do not necessarily represent the area 'worked'.	Rol	Other Disturbances	MI (& RPS)	MI
ScallopDredgedAreas.shp	Scallop dredge and acoustic data for the SE. Outside TraC water bodies	South East	Other Disturbances	BIM	BIM

Table 3.2(continued): Data Resources: Summary of the information assessed for the purpose of further characterising Dredging, Disposal at Sea and Other Disturbances of Seabed.

File Name/Type	Data Description	Geographic location	Pressure	Sourced from	Data Owner / Originator
15374 2267_BIM Bivalve Fisheries	Bivalve Fisheries (NW, W, E & SE coasts)	NWRBD, WRBD, ERBD, SERBD	Other Disturbances	BIM	BIM
WindFarmZones.shp	Designated Wind Farm Zones	ROI	Other Disturbances	MI	MI
cables_07.shp	Marine cables. Outside TraC water bodies	Ireland (& UK)	Other Disturbances	Oil Field Publications Ltd	DCENR
pipes-06.shp	Marine pipes	Ireland (& UK)	Other Disturbances	Oil Field Publications Ltd	DCENR
wells-07.shp	Marine wells. Outside TraC water bodies	Ireland (& UK)	Other Disturbances	Oil Field Publications Ltd	DCENR
kingfisherCableWgsLine.shp	Location of submarine telecom cables around the Irish coastline	Ireland (& UK)	Other Disturbances	Marine Institute	Kingfisher Information Service / CMRC
Ferries.shp	Ferry Routes	Ireland (& UK)	Other Disturbances	US NIMA	ESRI
15374 2272_Irish dumpsites.xls	OSPAR reported dump sites (2005) - updated dump sites only, no associated dredge information	ROI	Disposal at Sea	MI	MI
15374 1885_Dumping at Sea 1993-2004 (Updated).xls	OSPAR reported dump sites 1993 - 2004 with some updated to 2005	ROI	Disposal at Sea	MI	MI
RBD identified Disposal at Sea locations (shapefile)	Dumping at Sea locations (Collated by RBDs from Marine Institute OSPAR reported dump sites)	ShRBD, ERBD, SERBD, SWRBD, WRBD	Disposal at Sea	RBDs	MI
RBD identified Disposal at Sea locations (MS Excel spreadsheet)	Collated from DCMNR dumping at sea applications	SWRBD	Disposal at Sea	SWRBD	DCMNR/ DCENR
Various pdf	Dumping at Sea Applications, 2006 and 2007	ROI	Disposal at Sea	former DCMNR	DCENR
15374 2268_Foreshore Lic Download.xls	Register of Deeds relating to Foreshore Licences. Accurate location details unavailable. Most recent record October 2005	ROI	All	former DCMNR	DCENR
15374 2288 Fshore 2005-2008.xls	Download of limited foreshore licence details from the DCMNR online database	ROI	All	former DCMNR	DCENR

Methodology for Assessing Dredging, Disposal at Sea and Other Disturbances of Seabed

The following methodology was adopted for assessing Dredging, Disposal at Sea and Other Disturbances of Seabed:

- a. Collate all dredging and disposal data received from the RBDs and the EPA to ensure all related attribute information is contained within a national shapefile. This resulted in two shapefiles representing the national findings of the initial risk assessments for both dredging and disposal at sea.
- b. Identify which records from the national dredging file are most likely to represent maintenance/capital dredging by removing those associated with aquaculture.
 - i. Firstly those records from the national dredge file that were not identical to, but intersected with sites referenced in the former DCMNR 2005 Aquaculture Database were selected.
 - ii. From this selection, those records most likely to represent maintenance/capital dredging were identified following a review of the Marine Institute fishing atlas and attribute data supplied by the RBDs.
 - iii. A review of foreshore licence records helped identify which sites were most likely maintenance and capital dredge areas, and two shapefiles representing high and low impact dredge areas were generated.
- c. Identify additional maintenance/capital dredge areas within TraC water bodies
 - i. Shipping Navigation channels: The area of maintained channel for shipping and navigation was used as the basis for maintenance dredge areas. Navigation channels must be maintained for safe navigation, although the frequency of maintenance for these areas is not recorded within this dataset.
 - ii. Dumping at Sea applications were reviewed and where possible the area dredged was compared with the shipping navigation channels; none of which lay outside these navigation areas.
 - iii. Another potential source of maintenance dredge data is that available through OPW. Those records associated with 'channels' were selected for assessment. Information relating to the extent of maintenance of these channels was limited. Therefore, to estimate the area of channel/drain maintained the following buffer extents were applied:
 - Channel drains – 4.5m buffer: as the average drain size is 7-9m wide (King, 1996)).
 - Channels – 150m: Based on the maintained channel width average for navigation.
 - Drainage Districts - data from drains and channels from the Drainage District channels dataset (data from the OPW, drainage maintained by Local

Authorities) were selected and buffered as above. The Fane estuary main channel was identified from 2007 Central Fisheries Board (CFB) surveys and ecological data as a maintained buoyed channel. The channel was therefore buffered at 150m though not identified as such from the provided attribute data.

The buffer sizes were determined by assessment of channel and drain information from OPW papers (such as scheme summaries on the OPW website and King, 1996) and in agreement with the Steering group.

- iv. The foreshore licence/lease register was consulted and any additional dredge areas and/or information of relevance to the identified dredged areas was added to the national dredge file. A channel was added in the New Ross water body consisting eight capital dredge polygons forming a channel. This had been identified as a capital dredge operation, but is now maintained for navigation and was therefore transferred to the shipping channels dataset with the agreement of the Steering Group.
- v. No additional capital (high impact) dredge areas were identified
- d. Those associated with shipping and drainage channel maintenance were merged with those identified in the initial risk assessments to generate a national file of maintenance (low impact) dredge areas.
- e. Identify pressure footprints for 'Other Disturbances to Seabed' - Shellfish dredging & trawling.
 - i. To identify sites dredged or trawled for shellfish those records identified from the Marine Institute fishing atlas as dredged and trawled with a shellfish targeted species were firstly selected. No trawling sites were targeted at shellfish species.
 - ii. The former DCMNR 2005 aquaculture database does not specify the aquaculture method used for each site. Therefore, it was assumed that aquaculture sites which intersected with the shellfish dredge areas identified from the Marine Institute fishing atlas represented licensed dredged shellfish areas. Sixty three sites were identified.
 - iii. National bivalve fishery areas were obtained from BIM. Using attribute data supplied, those areas annotated by 'dredging' were selected for assessment.
 - iv. The sites identified by the steps above overlap in many areas. Also, the site boundaries do not necessary mark the 'worked area' but where these activities are licensed to take place. It was therefore considered most appropriate to 'union' all sites within ArcGIS. This step ensures that sites that overlap do not result in a double-up in footprint area. For example, if sites from BIM and Marine Institute overlapped for 2km²; this 2km² is only counted once as a footprint but records the attribute information from both sources.
- f. Identify pressure footprints for 'Other Disturbances to Seabed' – pipelines, cables and vessel movements.

- i. Data for marine cables and pipelines was received in polyline format, but excluded information relating to the width of these structures. Therefore, to estimate the area potentially affected buffers were created for each structure as follows:
 - Kingfisher cables: 25m (based on the potential zone of impact for laying and scour action for surface cables (ABpMer, 2002))
 - Pipelines: 50m (based on the potential zone of impact for laying and scour action or rock armour impact for pipelines)
- ii. Ferry routes were buffered to 150m (based on the average maintained channel width for navigation channels)
- g. Finalise 'Other Disturbances to Seabed'
 - i. Footprints for the following pressure types were merged to create the final Other Disturbances to Seabed file:
 - Shellfish dredge areas
 - Buffered cable and pipelines
 - Designated wind farm areas
 - Buffer ferry routes
 - ii. Cables, pipes, ferry routes, and wind farms all represent additional pressures to shellfish dredge areas. Therefore, where these sites overlap the pressure footprints will double for that area.

3.2.2.2 Piled, Flow and Sediment Manipulation Structures

For the purpose of this study piled structures are defined as 'structures raised on one or more foundation structures extending out into the adjacent water body e.g. bridge and pier supports' (SEPA et al (in press)). Flow and sediment manipulation structures are defined as 'hard engineering structures built to stabilise waterways for navigation and counter the effects of longshore drift' SEPA et al (in press)) such as piers, groynes and training walls.

Data Resources

The information assessed for the purpose of further characterising piled and flow and sediment manipulation structure is summarised in Table 3.3. The following section outlines the data assessed by the source organisation

River Basin District Initial Risk Assessment

Ports and harbours were assessed as part of the pressure 'Built Structures'. The location, port name and tonnage were presented in point shapefiles. Further characterisation of 'Built Structures' required the identification of the type and extents of structures associated with these ports and harbours.

Marine Institute

The Marine Institute, in partnership with Donegal, Mayo and Galway County Councils have made available via an online National Coastal Infrastructure Service details of piers, quays, harbours and slipways. A database of these structures including additional unreleased data for County Cork was acquired from the Marine Institute for assessment of flow and sediment manipulation structures. Due to the nature of the National Coastal Infrastructure Service only specific information can be queried for external release; the following information was obtained:

- Structure name
- Structure type
- Width (m)
- Length (m)
- Location

As with the information collated for the initial risk assessments, this dataset displayed as point locations. However, measurements for structure width and length were provided for approximately 75% of the records. In addition to anthropogenic structures this dataset also included natural landing sites which were excluded from the assessment.

Coastal and Marine Resource Centre

Datasets relating to the location of ports, harbours, marinas, and sailing clubs were obtained from the Coastal and Marine Resource Centre (CMRC). Additional information provided for these locations included traffic volume, route and service information. Further characterisation of pressures associated with these navigational sectors required the extents of specific structures such as piers or jetties to be digitised.

Table 3.3: Data Resources - Summary of the information assessed for the purpose of further characterising piled and flow and sediment manipulation structure

This table outlines the information used to assess the pile, flow and sediment manipulation structures. This data was verified and expanded supported by the baseline information in Table 3.1

File Name/Type	Data Description	Geographic location	Pressure	Sourced from	Data Owner / Originator
port_tonnage.shp	ERBD Port name and tonnage, no structure details	ERBD	Flow/Sediment manipulation structures	ERBD	ERBD
Ports_Harbours.shp	SERBD port name and tonnage, no structure details	SERBD	Flow/Sediment manipulation structures	SERBD	SERBD
Ports_Structures_point.shp	Structure type and tonnage defined for some records	ShRBD	Flow/Sediment manipulation structures	ShRBD	ShRBD
Ports&Harbours.shp	Created layer based on the information contained in the CSO document "Statistics of Port Traffic" for the risk assessment. Port name and tonnage, no structure details	SWRBD	Flow/Sediment manipulation structures	SWRBD	SWRBD
WRBD_Ports_point.shp	Port location only, no structure details	WRBD	Flow/Sediment manipulation structures	WRBD	WRBD
NS_Harbours_etc.2.shp	NS Coastal features such as jetties and piers. Attribute data includes structure type and title of oblique images used to identify structure	NSS	Flow/Sediment manipulation structures	NS-Share	NS-Share
NS_Ports.shp	NS Point location of ports, no structure details	NSS	Flow/Sediment manipulation structures	NS-Share	NS-Share
15374 2271_Coastal Structures Rev3.xls	Location of piers, quays, harbours and slipways collated for the National Coastal Infrastructure Service. Details of areal extents are provided for many structures. Information for counties Donegal, Mayo and Galway is available at coastal i.e as part of a data release from the first stage of the project. Further releases will include information for other counties. Data received included unreleased data for county Cork	Galway, Mayo, Donegal and Cork	Flow/Sediment manipulation structures	MI	MI; Donegal; Mayo; Galway; & Cork CoCo
intFerryPorts.shp	Location of ports and route information	Ireland	Flow/Sediment manipulation structures	CMRC	CMRC
localFerryPorts.shp	Location of ports and route information	Ireland	Flow/Sediment manipulation structures	CMRC	CMRC

Table 3.3(continued): Data Resources - Summary of the information assessed for the purpose of further characterising piled and flow and sediment manipulation structure

File Name/Type	Data Description	Geographic location	Pressure	Sourced from	Data Owner / Originator
marinas.shp	Marinas, pontoons, mooring, sailing, berths	Ireland	Flow/Sediment manipulation structures	CMRC	CMRC
rnliStations.shp	Location of lifeboat stations and information on services available	Ireland	Flow/Sediment manipulation structures	CMRC	Royal National Lifeboat Institution
commercialPortsIE.shp	Generalised locations of ports, traffic volume (2005)	ROI	Flow/Sediment manipulation structures	CMRC	CMRC
fishingPortsIE.shp	Location of ports	ROI	Flow/Sediment manipulation structures	CMRC	CMRC
sailingClubIsa.shp	Location and other relevant information about Irish Sailing Association (ISA) member sailing clubs	ROI	Flow/Sediment manipulation structures	CMRC	CMRC
Merge_embed_26_1_04.shp	CMRC Cork Harbour Study: Merged information on shoreline features such as jetties and piers, human access points (steps & ladders)	Cork Harbour	Flow/Sediment manipulation structures	SWRBD	CMRC
Merge_ship_26_1_04.shp	CMRC Cork Harbour Study: Information on the shipping related features of shoreline, such as dock or shipyard	Cork Harbour	Flow/Sediment manipulation structures	SWRBD	CMRC
Bridge DD V1	Location of OPW Drainage District bridges. Point shapefile indicating location	ROI	Piled structures	SWRBD	OPW

Methodology for Assessing Piled, Flow and Sediment Manipulation Structures

The following methodology was adopted for assessing Piled, Flow and Sediment Manipulation Structures:

- a Firstly, those coastal structures identified by the Marine Institute database lacking areal measurements were reviewed using orthophotos and oblique images. Where identified, these structures were digitised and the relevant attribute information extracted.
- b The orthophotos and oblique images were then used to review the remaining data sources listed in Table 3.1 above. Where orthophotos were available; the extents of identified structures were digitised.
- c On completion of this step, urban and industrial areas as identified by the EPA CORINE were reviewed for any additional structures. The OPW records for bridges were also reviewed and additional piled structures were digitised.

Oblique images were not available to confirm the presence of all piled structures particularly those in upstream tidal channels.

3.2.2.3 Shoreline Reinforcement

Shoreline reinforcement structures are defined as two different structure types for the purpose of further characterisation and assessment within TraC-MImAS:

- Shoreline reinforcement – High Impact: “The use of consolidated materials, e.g. rock armour, revetments, retaining walls, gabion baskets, seawalls, wharves, sheet piling etc. to protect vulnerable coastlines or harbours from erosion”. (SEPA et al (in press)) Refers to situations where the reinforcement is having a persistent influence over the intertidal or subtidal zone.
- Shoreline reinforcement – Low Impact: “Stabilisation of the shoreline using beach material to maintain beach levels and dimensions. May include use of synthetic materials. Also includes other forms of low impact shoreline protection, for instance protection that is set back and does not have a persistent influence over the intertidal or subtidal zones.” (SEPA et al (in press))

Data Resources

A registered national database of coastal defence and protection structures is not available for Ireland. However, the former DCMNR Engineering Division hold paper records of structures licensed for construction but it was not practical to consult this data on a national scale appraisal.

The following resources (Table 3.4) were used to focus the review of Ireland's coast for shoreline reinforcement structures. Additional features were also digitised where identified during the assessment of other pressures.

- Existing records of shoreline reinforcement type structures as provided by the RBDs
- Urban and industrial areas (as identified by the EPA CORINE 2000 land use dataset)
- Ortho and oblique photos, where available; and
- Foreshore licence records (shoreline reinforcement – low impact; beach nourishment)

River Basin District Initial Risk Assessment

Coastal defence features were identified in the initial risk assessments following the review of coastal images produced by the former DCMNR Coastal Helicopter Survey (SnapMap Project) and collated by the EPA into a national coastal defence shapefile for the purpose of reporting. Records identified in the initial risk assessments for the WRBD and NWRBD were not received for this Study and were absent from the national shapefile.

The RBD datasets contain a mixture of coastal defence structures, all of which do not represent shoreline reinforcement as defined for this study but pressures of a different sort e.g. embankments.

Coastal and Marine Resource Centre

The CMRC completed a Coastal Inventory project for Cork Harbour. As part of this project the shoreline features of the following areas of Cork Harbour were identified and mapped; Upper West and Mid Harbour, East Ferry, West Passage, Spike/Cobh, Whitegate, and Owenabue. These areas of shoreline fall into the following WFD water bodies:

- Lee (Cork) Estuary Upper and Lower (SW_060_0950 and SW_060_0900);
- Lough Mahon (SW_060_0750);
- Lough Mahon (Harper's Island) (SW_060_0700);
- North Channel Great Island (SW_060_0300);
- Cork Harbour (SW_060_0000); and
- Owenboy Estuary (SW_060_1200)

The information provided by CMRC to Cork County Council (and SWRBD) is bound by the following copyright:

"The data contained on this CD can not be copied, utilised or disseminated in any way without prior written consent from the CMRC. Many of the datasets contained on the CD are used under licence from other agencies, information on the licences can be got by contacting the CMRC".

Data produced by this project and provided by the SWRBD was incorporated into the Marine Morphology study for the assessment of shoreline reinforcement in those water bodies outlined above. However, permission must be sought from the CMRC prior to the use of this data by other bodies outside Cork County Council (and SWRBD).

The former Department of Communications, Marine and Natural Resources

RPS Consulting Engineers are currently undertaking a flood risk study on behalf of the former DCMNR. Discussions with RPS concluded that 'at risk' areas have been identified for Ireland's coast and it is the intention of this study to identify existing coastal defence/protection in these areas. At the time of writing, those structures for 'at risk' areas along the eastern Irish coastline were identified, however, release of this data was not permitted until completion of the project.

Table 3.4: Data Resources - Summary of the information assessed for the purpose of further characterising Shoreline Reinforcement Structures

File Name/Type	Data Description	Geographic location	Sourced from	Data Owner / Originator
Merge_hard_26_1_04	CMRC Cork Harbour Study: Merged information on shoreline engineering such as sea walls and revetments	Cork Harbour	SWRBD	CMRC
erbd_coastal_structures	Coastal defence features identified by the initial risk assessments. The former DCMNR SnapMap service was referred to in identification of these structures. Contains linear features: mixture of defence, flow/sediment and embankment structures	ERBD	ERBD	ERBD
NS_Coastal_Defence	Coastal defence features identified by the initial risk assessments. The former DCMNR SnapMap service was referred to in identification of these structures. All features recorded as 'coastal defence' but no further detail provided	NSS	NS-Share	Former DCMNR/RPS
coastal_defence_national	National dataset of coastal defence structures identified by the RBDs in the initial risk assessments. Collated by the EPA. Structure type is defined for approximately half the records.	ROI	EPA	EPA/ Former DCMNR/RPS
COASTAL DEFENCE	Coastal defence features identified by the initial risk assessments. The former DCMNR SnapMap service was referred to in identification of these structures. Contains linear features: mixture of defence, flow/sediment and embankment structures	SERBD	SERBD	Former DCMNR/RPS
Coastal_Defence_polyline	Coastal defence features identified by the initial risk assessments. The former DCMNR SnapMap service was referred to in identification of these structures. Contains linear features: mixture of defence, flow/sediment and embankment structures	ShRBD	ShRBD	Former DCMNR/RPS
Coastal_Defences	Coastal defence features identified by the initial risk assessments. The former DCMNR SnapMap service was referred to in identification of these structures.	SWRBD	SWRBD	Former DCMNR/RPS
CoastalDefenceEndPt.	End points used to determine length of coastal structure	SWRBD	SWRBD	Former DCMNR/RPS
CoastalDefenceStartPt.	Start points used to determine length of coastal structure	SWRBD	SWRBD	Former DCMNR/RPS
Harbours,Slips,Etc	Point locations of shoreline reinforcement information; no harbours, piers listed - identified by the initial risk assessments. The former DCMNR SnapMap service was referred to in identification of these structures. Structure types specified	SWRBD	SWRBD	Former DCMNR
15374 2268_Foreshore Lic Download.xls	Register of Deeds relating to Foreshore Licences. Accurate location details unavailable. Most recent record October 2005	ROI	former DCMNR	DCENR

Methodology for Assessing Shoreline Reinforcement

The following methodology was adopted for assessing Shoreline Reinforcement:

- a All existing records of shoreline reinforcement type structures were firstly collated. These records were then reviewed, verified and/or edited using the coastal imagery resources.
- b Where structures were not identified by the resources listed in Table 3.4 above a search for additional structures was focused within areas identified as urban or industrial using the EPA CORINE 2000 land use dataset.
- c The foreshore licence/lease register was reviewed within ArcMap for areas of potential beach nourishment (shoreline reinforcement – low impact), two of which were identified:
 - MS51/8/2 Vol 7: Removal of sand for the purpose of nourishing the Beach at Bantry (1985)
 - MS51/8/984: Bere Island beach nourishment (1996)This register does not provide detail relating to the extent of these activities therefore, the footprints for these pressures could not be digitised.
- d Following reference to the coastal imagery resources and the pressure footprint description detailed in the introduction above, the structure ‘type’ and an impact rating of ‘High’ or ‘Low’ was then assigned to each feature
- e Where the likely impact of a seawall structure could not be confirmed by coastal imagery, an impact rating of ‘High’ was assigned as a conservative default.

3.2.2.4 Flood Embankments

Flood Embankments are defined for the purpose of further characterisation and assessment within TraC-MImAS as “An artificial bank of earth or stone created to prevent inundation of estuarine and coastal floodplains”. (SEPA et al (in press))

Data Resources

The data resources for flood embankment assessments are summarised in Table 3.5 below.

River Basin District Initial Risk Assessment

The information used to report on flood embankments for the initial risk assessments was obtained using data provided by the OPW and also a review of the former DCMNR coastal oblique images. As noted in Section 3.2.2.1 (Dredging – Data Resources) above the OPW released an updated revision of the GIS layer Drainage Scheme Embankments in 2005.

Embankment datasets received from the RBDs were for the most part generated from the superseded 2004 OPW dataset which incorporated additional records to those contained within the 2005 revision, including line features representing the location of lands benefiting from embankments. With respect to the request from OPW not to use the 2004 data those records provided by the RBDs were clarified with the OPW 2005 dataset and/or coastal imagery prior to inclusion as pressure footprints.

OPW requested that the following colour format be utilised for 2005 revision of Drainage Embankments:

- Line 3 pixels thick; Colour green (red: 0, green: 125; blue: 0)

Following discussions with OPW relating to additional embankments identified, OPW asked to be notified of any errors or new embankments identified on completion of this project.

Table 3.5: Data Resources - Summary of the information assessed for the purpose of further characterising embankments

This table summarises the data assessed for the creation of the embankment data. The data is predominantly collated by local authorities and the OPW.

File Name/Type	Data Description	Geographic location	Pressure	Sourced from	Data Owner / Originator
Impoundment	Impoundment locations labelled RWB or TWB - one record relevant to TWB (Broadmeadow Water Estuary / Malahide Bay)	ERBD	Impounding Structures	ERBD	ERBD
Impoundments	One feature identified: Tacumshin Lake	SERBD	Impounding Structures	SERBD	SERBD
Tidal_Barrages	One feature identified: River Fergus tidal barrage	ShRBD	Impounding Structures	ShRBD	ShRBD
Tidal_Barrages	Six features identified, includes detail of fish passage.	SWRBD	Impounding Structures & Causeways	SWRBD	SWRBD
ESB_Hydro_Scheme	Location and name only, of dams, reservoirs and hydroelectric stations. Outside TraC waters	WRBD	Impounding Structures	WRBD	WRBD
WRBD_Impoundments_point	Location only of impoundments. Outside TraC waters	WRBD	Impounding Structures	WRBD	WRBD
15374 2255_CFB Impassable Barriers	Central Fisheries Board Impassable Barriers	ROI	Impounding Structures	ShRBD	CFB
Sluice_Scheme	OPW 2004 data	ROI	Impounding Structures & Causeways	SWRBD	OPW
Weirs_Scheme	OPW 2004 data	ROI	Impoundment	SWRBD	OPW

Methodology for Assessing Flood Embankments

The following methodology was adopted for assessing Flood Embankments:

- a Features identified as embankments in the RBD coastal defence datasets (SERBD and NSS) were collated with those embankment datasets received from the SWRBD and WRBD (OPW 2004 data).
- b Embankment records from the OPW 2005 dataset were compared with those records provided by the RBDs to identify those features additional to the OPW 2005 data.
- c Additional records identified were then assessed in conjunction with coastal images and foreshore licence records to focus review for additional embankment features.
- d New embankment features were only digitised in areas for which orthophotos were available.
- e Ten foreshores licence records were identified as relating to embankments:
 - North Bull Island (MS51/4/108): embankment digitised
 - Boyne Estuary (no reference number provided): Embankments are digitized within this water body; however, their association with this particular licence cannot be confirmed.
 - New Ross Port & Barrow Suir Nore Estuary (four records; MS51/6/150, MS51/1/64): The OPW 2004 dataset includes embankments at two locations in these water bodies. Also, on review of the EPA Envision online mapper, embankments are evident in area. However, due to the lack of orthophoto coverage and oblique images for these areas embankments were not digitized.
 - Cork Harbour (Aghada): specific embankments were not identified for this area, however land claim pressures were identified for this area (near Electricity Supply Board (ESB)), a component of which may be embankments (near ESB).
 - Lough Mahon (Marino Point – MS51/8/541; and Little Island – MS51/8/429): Area at Marino Point is reclaimed therefore embankments were not required to be digitised; however embankments at Little Island were added to the pressure file.
 - Lower Shannon Estuary (Tarbert - MS51/9/213): these features are included in the OPW 2005 dataset (Unique ID: 7792).
- f As additional embankments to those recorded by the OPW (2005) were digitised where identified using orthophotos, the colour format recommended for use by OPW was not adopted for this pressure as a whole. However, the source of each feature contained within the resulting pressure dataset was annotated as follows so that those features representing records sourced from the OPW (2005) can be identified:

Records added / retained:

- “Article 5 –Coastal defence”: sourced from RBD coastal defence shapefiles
- “Article 5 & Orthophotos”: features additional to OPW datasets identified in Art 5 initial risk assessments and clarified using orthophotos.

- “Article 5, Ortho & Obliques photos”: features additional to OPW datasets identified in Art 5 initial risk assessments and clarified using ortho and oblique photos.
- “OPW 2005 & Orthophotos”
- “OPW 2005, Ortho & Oblique photos”
- “OPW_Oct_2005”: Sourced from OPW 2005 dataset, but extents not be clarified by ortho or oblique images due to lack of coverage
- “Ortho & Oblique Photos”: new features identified by orthophotos and oblique images
- “Orthophotos”: new features identified by orthophotos only

Records excluded:

- “Diff to OPW 2005 – breached – Delete”: embankment is contained within the OPW 2004 dataset but is currently breached and therefore not functioning as a flow manipulating feature
- “Diff to OPW 2005 & no Orthos – Delete”: no orthophotos were available to confirm the presence or extents of embankments
- “Diff to OPW 2005 & unclear in Orthos – Delete” resolution of orthophotos prevented confirmation of the presence or extents of embankments

3.2.2.5 Impounding Structures & Causeways

Impounding Structures and Causeways are defined as follows for the purpose of further characterisation and assessment within TraC-MImAS:

- **Impounding Structures:** A temporary (e.g. barrage) or permanent structure that extends across a channel that is used to impound, measure or alter flow (e.g. weirs, sluices).
- **Causeways:** A physical barrier projecting from the shore whose foundations extend to the bed and where gaps in the foundings represent < 20% of the total length. Typically used to support transport routes.

The pressure ‘footprint’ required for assessment of causeways within TraC-MImAS is the total area (km) of each structure identified. Also, the proportion of this footprint within the intertidal and subtidal zones must be estimated.

The footprint required for the assessment of impounding structures within TraC-MImAS was not confirmed as part of the UKTAG hydromorphology work and it was concluded that each agency applying TraC-MImAS should review potential footprint rules. Work undertaken to date to help determine a suitable impact rating for impoundments on TraC waters is discussed further in Chapter 5. Discussions with the Irish Marine Morphology Steering

Group concluded the following in relation to the assessment of impounding structures within TraC-MImAS:

- The Marine Morphology Steering Group advised that where historic impoundments are the likely cause of WFD water bodies delineated as 'lagoons' (TW6 and CW10), these impoundments should not be assigned as pressures on the lagoon, e.g. Durnesh Lough and Inch Lough.
- The pressure footprint agreed with the Steering Group for assessment with TraC-MImAS is the area of water body impounded by a structure. Adoption of this method however, prevents those structures identified at the landward boundary of TraC waters, such as embankment sluices, being assessed within MImAS, as the area of water impounded is outside the TraC boundaries. Such pressures will be identified by the either the Freshwater Morphology or Hydrometric PoMS studies. However, to ensure the consideration of all relevant pressures on TraC water bodies identified structures of this character will be reported on, where relevant, separately to MImAS.

Data Resources

The information used in the assessment in the assessment of impoundment structures and causeways is summarised in Table 3.6. The data was received from the organisations listed below.

River Basin District Initial Risk Assessment

The following resources were used to collate information relating to impounding structures for the initial risk assessments:

- Local Authority information and local knowledge (tidal barrages)
- Central Fisheries Board (CFB) dataset of impassable barriers: This dataset was prepared as part of the study completed by the Central Fisheries Board and Compass Informatics and compiled in the report "Quantification of the Freshwater Salmon Habitat in Ireland" (Mc Ginnity *et al*, 2003). This dataset has very limited attribute information but represents two types of barriers impassable to salmon:
 - Non-self sustaining salmon systems. Digitised points identify the location of the four main hydroelectric dams (Liffey, Lee, Shannon, and Erne catchments).
 - 'Complete' - These are other locations considered to limit salmon migration and represent a mixture of manmade and natural features. Although the feature types are not identified by the attribute table, it is considered that most records represent natural barriers such as waterfalls.

As part of the Freshwater Morphology PoMS, a barrier impact assessment case study was initiated in 2007 throughout the Nore catchment using data collected by the Southern Regional Fisheries Board. The purpose of the Nore study is to assess the risk

of in-river structures to the timing and success of salmon migration. The Freshwater Morphology Group is seeking to build on the existing CFB database of impassable barriers in order to progress the WFD barriers study.

Office of Public Works Sluice & Weir Data

In addition to OPW data relating to drainage channels and embankments, the 2004 OPW dataset obtained via the SWRBD contained national records of sluice and weir locations (which were not updated in 2005). These datasets were not considered for the initial risk assessments.

The OPW have requested that these datasets are not interpreted to represent accurate structure locations as they have yet to be fully quality audited (Nathy Gilligan, personal communication, Feb 2008). OPW are currently reviewing their national data - a final dataset for sluice and weir structures will not be available within the next year.

For the purpose of further characterisation, the pressure of these structures on TraC water bodies for the most part is outside TraC-MImAS i.e. the footprint agreed for such impounding structures, being the area of water body upstream of the structure, is mostly represented by freshwater channels or drains.

Table 3.6: Data Resources - Summary of the information assessed for the purpose of further characterising Impoundments.

The following table outlines the data assessed to create a national impoundment pressure layer. The information was checked and verified from the baseline data (Table 3.1) where there was sufficient coverage.

File Name/Type	Data Description	Geographic location	Pressure	Sourced from	Data Owner / Originator
Impoundment	Impoundment locations labelled RWB or TWB - one record relevant to TWB (Broadmeadow Water Estuary / Malahide Bay)	ERBD	Impounding Structures	ERBD	ERBD
Impoundments	One feature identified: Tacumshin Lake	SERBD	Impounding Structures	SERBD	SERBD
Tidal_Barrages	One feature identified: River Fergus tidal barrage	ShRBD	Impounding Structures	ShRBD	ShRBD
Tidal_Barrages	Six features identified, includes detail of fish passage.	SWRBD	Impounding Structures & Causeways	SWRBD	SWRBD
ESB_Hydro_Scheme	Location and name only, of dams, reservoirs and hydroelectric stations. Outside TraC waters	WRBD	Impounding Structures	WRBD	WRBD
WRBD_Impoundments_point	Location only of impoundments. Outside TraC waters	WRBD	Impounding Structures	WRBD	WRBD
15374 2255_CFB Impassable Barriers	CFB Impassable Barriers	Rol	Impounding Structures	ShRBD	CFB
Sluice_Scheme	OPW 2004 data	Rol	Impounding Structures & Causeways	SWRBD	OPW
Weirs_Scheme	OPW 2004 data	Rol	Impoundment	SWRBD	OPW

Methodology for Assessing Impounding Structures & Causeways

The following methodology was adopted for assessing Impounding Structures & Causeways:

- a Using the resources outlined above the locations of the impounding structures/tidal barrages identified in the initial risk assessments were reviewed.

ERBD

- One structure of those identified in the initial risk assessment is relevant to TraC waters (Broadmeadow Water Estuary / Malahide Bay). The Marine Morphology Steering Group advised that impoundments should not be assigned to lagoons created by historic impoundment (Broadmeadow Water). However, as this impounding structure has not 'land-locked' the Broadmeadow Water it was considered appropriate to represent this feature as a flow and sediment manipulation structure joined to a piled structure; both of which were assigned to the downstream water body Malahide Bay (EA_060_0000).

SERBD

- Tacumshin Lake impoundment was identified by the SERBD. A review of the historic maps and oblique images indicated that the impoundment of this water body is attributed to natural deposition of material which has created a barrier of dunes. Taking account of this information and the Marine Morphology Steering Group advice an impoundment structure was not digitised.

WRBD

- All features identified by the WRBD lay outside TraC water body boundaries.

ShRBD

- One structure was identified by the ShRBD; Fergus Tidal Barrage. This structure falls outside TraC boundaries and therefore is not digitised. This structure, however, is assessed by the HMWB PoMs study as the freshwater bodies upstream of this structure are designated as provisionally heavily modified.

SWRBD

- A 'tidal barrage' (with fish passage) was identified in Roaring Water Bay, however, on review of coastal imagery, this structure was digitised as piled structure not an impoundment.
- A 'tidal barrage' identified in Outer Cork Harbour (Roberts Cove) was digitised as a Causeway following a review of coastal imagery.
- A 'causeway' identified in Cork Harbour (cuskinny river) was confirmed and digitised.
- A record identified as 'sluice on lake' in Rostellan Lake was digitised as a causeway in Cork Harbour

- A record identified as a 'sluice/tidal barrage' in Lough Mahon (Slatty Bridge) was digitised as a combination of flow/sediment manipulation and pile structures following review of coastal imagery.
 - The presence of a 'tidal sluice' identified in Lower Black Water M Estuary was confirmed. However, this structure was not digitised as the body of water potentially impounded by this structure is not within the transitional water body boundary.
- b Using coastal imagery and the additional data resources outlined in Table 3.6 above, a search for impounding structures and causeways was undertaken. No additional impounding structures were identified and many of those recorded by the initial risk assessments were located outside TraC waters or where present were characterised as flow and sediment manipulation structures, causeways or piled structures.

3.2.2.6 Land Claim

Land Claim and Tidal Channel Realignment pressures are defined as follows for the purpose of further characterisation and assessment within TraC-MImAS:

- **Land claim - High impact:** Recent or proposed enclosure of intertidal or subtidal areas within impermeable banks followed by infilling for use by agriculture, housing, port or industry. Also used for land claim that has taken place in the past and is still deemed to be having a significant impact.
- **Land claim - Low impact:** Historic (e.g. >50yrs ago) enclosure of intertidal or subtidal areas within impermeable banks followed by infilling for use by agriculture, housing, port or industry. Can also be used for more recent land claim where the impacts are minimal or where the surrounding environment has partly recovered natural habitats and features.
- **Tidal channel realignment - High impact:** Recent or proposed realignment of a tidal channel. Also used for realignment that has taken place in the past and is still deemed to be having a significant impact.
- **Tidal channel realignment - Low impact:** Low impact alterations to course or planform of upper estuaries where the channel remains river-like. Includes straightening and removal of meanders to increase channel gradient and flow velocity. Typically used to cover historic work (e.g. >50yrs ago) and where the channel has partly recovered natural habitats and features.

The pressure 'footprint' required for assessment of Land Claim and Tidal Channel Realignment within TraC-MImAS is the total area (km²) reclaimed. Also, the proportion of this footprint within the intertidal and subtidal zones must be estimated.

Data Resources

The following resources were used to investigate the location and extent of land claim and tidal channel realignment, details of which are outlined in Section 3.2.2.6 and 3.2.2.3 above:

- Coastal imagery: orthophotos and oblique images
- Historic maps: georeferenced bedrock maps provided by the GSI
- EPA CORINE Land Cover 2000 database
- Foreshore licence records
- Environmental Impact Statements

Methodology used to assess Land Claim

The following methodology was used to assess Land Claim:

- a The review of Ireland's coast for land reclamation and tidal realignment for the most part focused on urban and industrial areas (as identified by the CORINE dataset) as well as the locations of foreshore licence and EIS records. However, additional areas were digitised where these had been identified during the review of other pressures types.
- b Using numeric grids provided by RBDs (via OSi) and the GSI, the images for both orthophotos and historic maps required for assessment were identified, and by overlaying these images changes in coastal lands could be identified. The estimated extents of reclaimed areas were digitised only where orthophotos and historic images were available. No areas of tidal realignment were identified.
- c For each area digitised an impact rating of High or Low was assigned based on the footprint definitions outlined above. Due to the lack of background information associated with reclaimed areas the age of land alteration is unknown in most cases. Therefore, when assigning 'High' or 'Low' impact the likely ability of surrounding environments to recover was considered as a prominent indicator.
- d Following agreement with the Marine Morphology Steering Group, the whole area of 'Clogheen Strand' coastal lagoon water body (SW_100_0400) was assigned to land claim.
- e On assessment of the pressure land claim within TraC-MImAS the estimated area of a water body prior to reclamation should be considered as the total water body area impacted by the land claim identified. However, it must be noted that reclaimed areas identified by this study date both before and after the delineation of the WFD water body boundaries. Where land claim has occurred prior to the delineation of water body boundaries this area is added to that of the water body to estimated the total 'original' water body area that this pressure has impacted on. Land claim which has occurred post water body delineation is considered a new pressure on the water body area.
- f The water body area entered into TraC-MImAS should be the sum of the existing water body area (as defined by the EPA) and the estimated area of land claim.

3.2.2.7 Intensive Land Use

For the purpose of the initial risk assessments, the EPA CORINE Land Cover 2000 data was used to estimate the risk associated with ILU bordering transitional water bodies. Risk categories were assigned based on the proportion of a water body shoreline flanked with the following land cover types:

- Exploited bogs;
- Urban fabric;
- Industrial, commercial, transportation;
- Coniferous forestry; and
- Arable lands.

An identified land cover type inherently contains many of the more specific and distinct pressures that have been identified and reviewed in more detail throughout the Marine Morphology study. For example, the pressures of 'Land Claim' and 'Flow and Sediment Manipulation Structures' can be related to urban and industrial land cover types, such as the development of port infrastructure, and these specific pressures have been digitised where identified in areas of orthophotos coverage.

The development of TraC-MImAS originally focused on its use in the assessment and regulation of engineering type pressures and did not consider those pressures associated with coastal land use. Therefore, pressure footprints of other land cover types such as arable land and peat exploitation have not been quantified for assessment within TraC-MImAS. However, it was agreed with the Steering Group that the proportion of TraC shoreline bordering each of the land cover types noted above should be reported on separately in MImAS so as to ensure that the potential risk of activities associated with these land covers is considered for the PoMS. The extent of each land cover type bordering Irish TraC waters is defined in Chapter 5.

Following agreement with the Marine Morphology Steering Group, the assessment of salt marsh grazing as an intensive land use pressure was also excluded from TraC-MImAS assessment within this Marine Morphology study. This pressure is discussed further in Chapter 5 and 6.

Data Resources

Table 3.7 below lists the two layers of Corrine data assessed to determine intensive land use adjacent to the TraC water bodies.

Table 3.7 Summary of the information assessed for the purpose of further characterising Intensive Land Use

File Name / Type	Data Description	Geographic location	Data Owner / Originator
clc00_ie.shp	RoI land cover types defined to level 3 detail – all land use types as identified by the CORINE project detailed to 'level 3'	RoI	EPA
clc00_lev6.shp	RoI land cover types defined to level 6 detail – land use types were further characterised for Pasture and Peatbog land used, detailing these to 'level 6'	RoI	EPA

Methodology used to Assess Intensive Land Use

The following methodology was used to assess Intensive land Use:

- Similarly to the initial risk assessment method; a buffer of 50m was created around the Irish coastline (created from the inverse of TraC water bodies) in order to estimate the length of shoreline bordering intensive land use types.
- The CORINE land cover codes queried are detailed in the Table 3.8 below. Those Corrine codes that are shaded represent the areas assessed as intensive land use

Table 3.8: Selected Corine Land Cover codes by level of detail

Level 1	Level 2	Level 3	Level 4	Level 5	Level 6
1. Artificial surfaces	1.1 Urban fabric 1.2 Industrial, commercial and transport units	1.1.1 Continuous urban fabric 1.1.2 Discontinuous urban fabric 1.2.1 Industrial and commercial units 1.2.2 Road and rail networks and associated land 1.2.3 Sea Ports			
2. Agricultural areas	2.1 Arable land	2.1.1 Non-irrigated arable land 2.1.2 Permanently irrigated land 2.1.3 Rice fields			
3. Forest and semi-natural areas	3.1 Forests	3.1.2 Coniferous forests			
4. Wetlands	4.1 Inland wetlands	4.1.2 Peat bogs	4.1.2.1 Raised 4.1.2.2 Blanket	4.1.2.1.1 Exploited 4.1.2.2.1 Upland 4.1.2.2.2 Lowland	4.1.2.2.1.1 Exploited 4.1.2.2.2.1 Exploited

- The following attributes were identified for each water body:

- Total water body shoreline length
- Shoreline length bordering each land use

- proportion of water body length bordering each land use per tidal zone
- % water body shoreline bordered by each land use

3.2.2.8 Abstractions

Data resources

Table 3.8 lists the main records assessed to establish the presence of marine surface water abstraction. In addition, searches of available information and consultation were carried out to assess whether there were any additional marine abstractions in Ireland.

River Basin District Initial Risk Assessment

The initial dataset received as part of the Article 5 characterisation has no marine abstractions listed; however, updated information from ongoing work by the River Basin Districts was requested. A data set received from the WRBD had four marine abstraction records in the Shannon. On closer examination of the attribute information it appeared that these records corresponded to only two licences, both listed under the same facility. The abstractions were listed for an aluminium plant in the Shannon (Figure 3.12) and corresponded to the updated WFD Schema data. The licences are in the order of 30,000m³ according to the IPPC data from the EPA WFD Schema data information. As a result abstractions were not produced as a separate pressures layer, as all the points were within a single water body. However, where relevant, information would be provided in the water body summary sheets. Chapter 8 gives more information on future abstraction pressures. SWRBD also provided a dataset for abstractions. On examination, none were marine.

Environmental Protection Agency

Abstractions data was received from the EPA as part of the WFD Schema geodatabase. After careful examination of the dataset, only one marine abstraction site was recorded in the database and corresponded with WRBD data. The IPPC (Integrated Pollution Prevention and Control) information within the WFD schema was interrogated for more information and the records corresponded to a single facility in the Shannon (Figure 3.12).

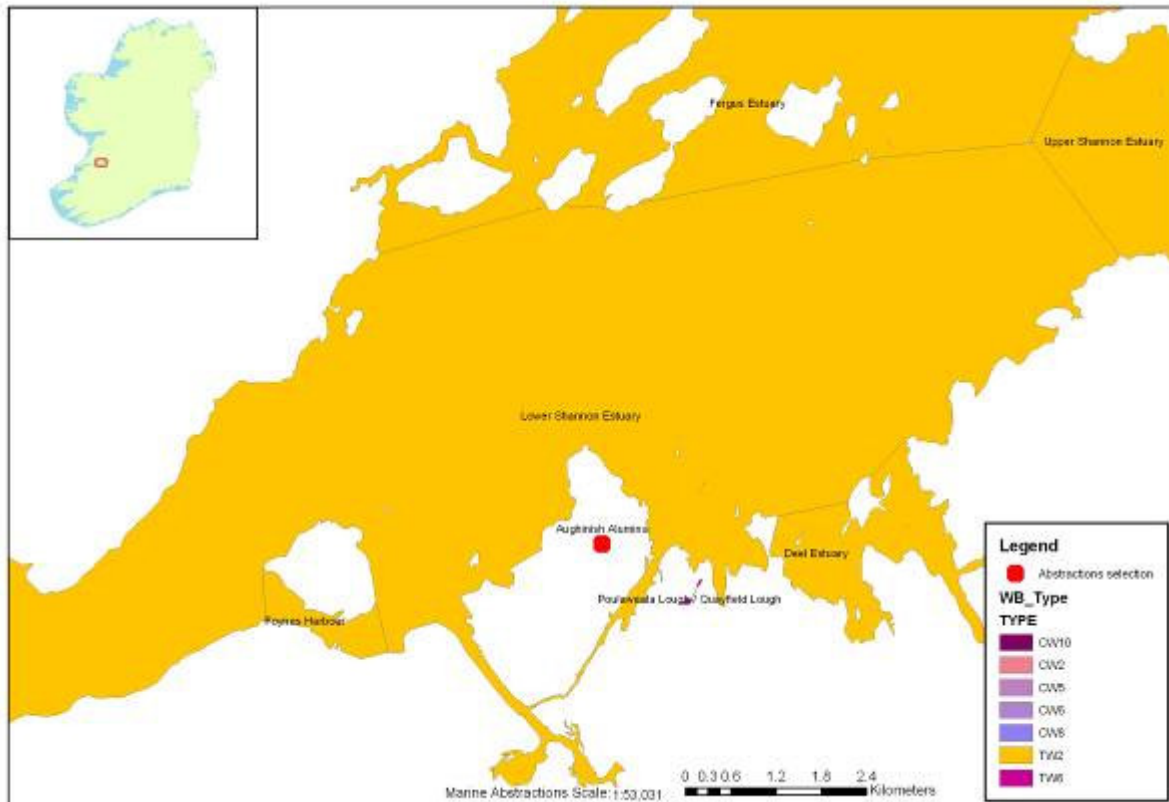


Figure 3.12 Marine Abstractions records

Table 3.9: Data Resources - Summary of the information assessed for Abstractions

File Name/Type	Data Description	Geographic location of dataset	Sourced from	Data Owner / Originator
SWRBD Surface abstractions.shp	Point data of surface water abstractions in the SWRBD area. No marine or estuarine abstractions recorded.	SWRBD	SWRBD	SWRBD
WFD schema.dbf	Abstractions table from geodatabase	RoI	EPA	EPA
WFD schema.dbf	IPPC data for coastal facilities	RoI	EPA	EPA
Abstraction surface point.shp	WRBD marine pressure layers, morphology. Four points recorded for the same facility in the Shannon	WRBD	WRBD	WRBD

3.3 Morphology

3.3.1 Data Resources

In order to provide a concise general description of the water body morphology, a number of sources were identified and assessed. These included internet searches for the area and academic texts and the information was recorded on the water body summary sheets to provide and enhance the description of the whole water body. The information was not detailed or consistent enough to allow retyping of the water bodies. This may need to be re-assessed when further information is available for the next RBMP (See Chapter 4 and 9).

River Basin District Initial Risk Assessment

Water bodies were assigned types for the initial risk assessment and this information assisted with the interpretation of the morphological conditions. The initial typology assessment (Sniffer, 2006, WFD-07) and the baseline datasets were also consulted. The information from the report classified the water bodies according to their morphology type. The GIS information also has some generic coverage of sediment types and exposure; however the coverage and resolution of the data was coarse and incomplete.

Other sources

Generic water body descriptions were compiled from a number of sources, such as SAC site synopsis, GSI descriptions and academic and other information from EIS, survey data (including BioMAR), local government information and internet searches. This was used to provide a generic description of the water body and compared to the morphological attributes used in the Morphological Description (See Chapter 4). Insufficient information was collated to reliably question the Article 5 characterisation. However no significant conflicting information was found. This information and the references were recorded in the water body summary sheets.

3.4 Ecology

In order to provide a concise general description of the water body a number of sources were identified, including internet searches for the area and academic texts. These were recorded on the water body summary sheets and are summarised in Table 3.10.

3.4.1 Data Resources

Table 3.10 lists the data sources, which, supported by academic and public literature research, were used to provide a generalised ecological overview of each water body summary sheet.

River Basin District Initial Risk Assessment

Water bodies were assigned types for the initial risk assessment and this information assisted with the interpretation of the ecology information. The initial typology assessment (Sniffer WFD-07) was also consulted. Protected areas were coded and mapped as part of the initial risk assessment.

National Parks and Wildlife Services

Protected area updates were downloaded from the website and used to ensure complete coverage of SACs, Special Protected Areas, (SPAs) and Natural Heritage Areas (NHAs). As of the 2008 protected areas update from the NPWS, the NHAs are statutory NHAs and are reported as such in the summary sheets (personal communication NPWS 07/04/08)

The NPWS website (www.npws.ie) was consulted to review the site synopses for protected areas identified within water bodies.

In 2007 some of the marine SAC sites were biotope mapped under contract from the NPWS. It is planned to continue this work for other coastal and marine SACs in the coming years (See Chapter 4). The initial results of the 2007 surveys for four sites were provided in ArcGIS by Marine Institute and permission given from the NPWS to use the data which included detailed habitat maps of the protected areas surveyed (Figure 3.13). Where these sites occurred in water bodies already assessed, the biotope information was used to inform the ecological description. The information in these surveys is significantly more detailed than that available in most areas and would allow in depth evaluation of future developments.

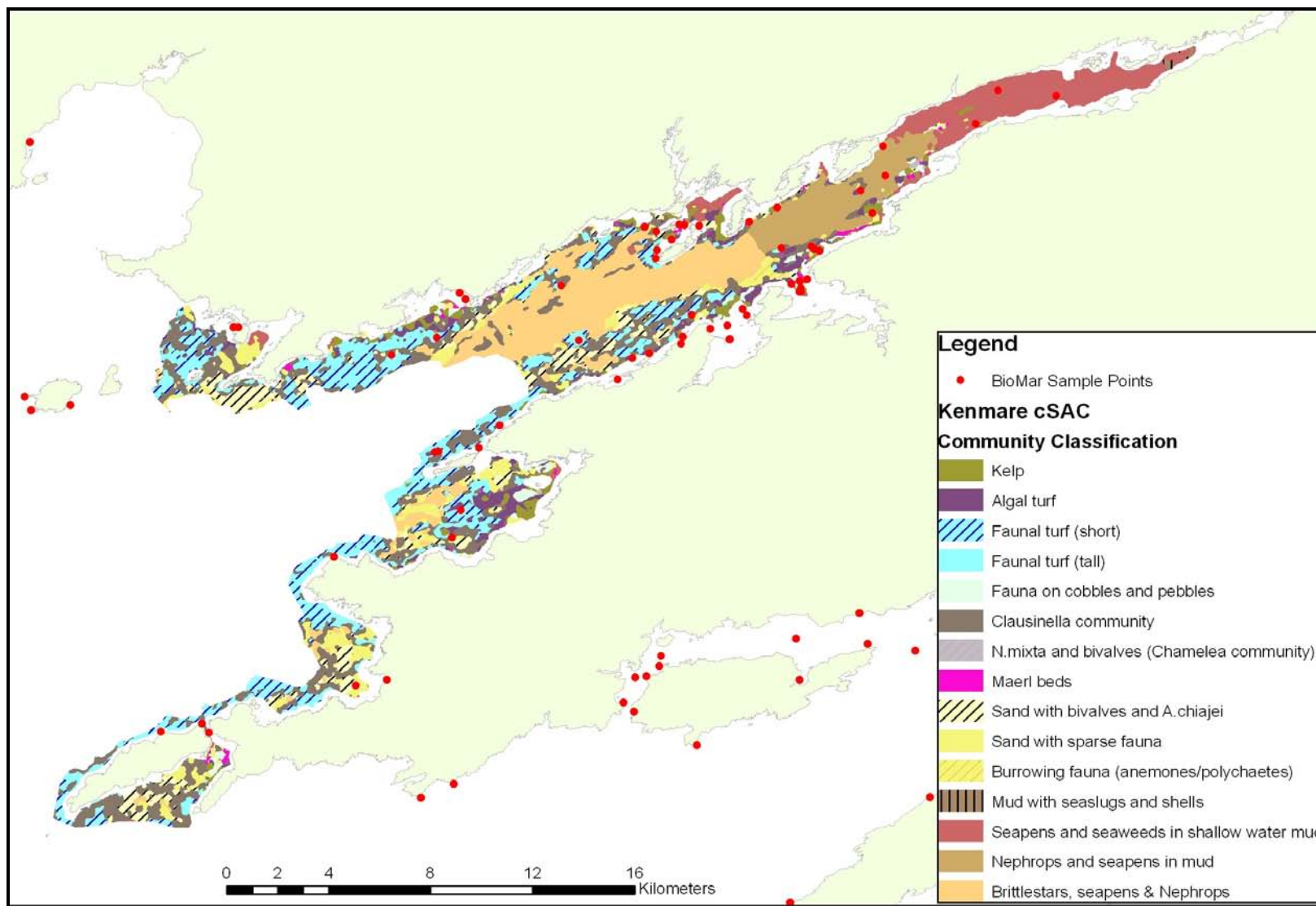


Figure 3.13: BioMAR records and NPWS habitat mapping for Kenmare Candidate Special Area of Conservation (cSAC)

BioMAR

A copy of the BioMAR database was provided by the NPWS and an x,y event layer of surveys was created. BioMAR was a part European funded survey of littoral and sublittoral coastal habitats, which ran from 1992 to 1996. The results of the recorded biotopes and descriptions were included in the water body summary sheet ecology descriptions. In addition, the database was compared with the JNCC Marine recorder data (2007) to ensure complete survey record coverage, and to capture any survey data points from 1996 to 2000. Within the water body summary sheets the information from each survey station or transect is listed. Where there are multiple points across a bay, a summary of the survey points is provided. Where recorded, a biotope code is provided as referenced in the original survey, and a description of the sample site is provided.

UK Joint Nature Conservation Committee (JNCC) Marine Recorder

Permission was given from the JNCC to compare the BioMAR results to the Marine Recorder database to ensure complete coverage (biotope_merge.shp).

Table 3.10: Summary of the information assessed for Ecology

File Name / Type	Data Description	Geographic location	Sourced from	Data Owner / Originator
Biomarsites.shp	BioMAR survey sites from database	RoI	NPWS	NPWS
Biotope_merge.shp	Point file of survey sites extracted from Marine recorder 2000 database, this was a limited copy with some sources not included due to data ownership and permissions	RoI and UK	JNCC	JNCC
Sac_merge	Merged national coverage of county datasets from www.environ.ie , downloaded and updated as of 15/02/08	RoI	NPWS	NPWS
Spa_merge	Merged national coverage of county datasets from www.environ.ie , downloaded and updated as of 15/02/08	RoI	NPWS	NPWS
Nha_merge	Merged national coverage of county datasets from www.environ.ie , downloaded and updated as of 15/02/08	RoI	NPWS	NPWS
Ramsar	RAMSAR site file with links to site synopsis from RAMSAR website	RoI	Ramsar.ie	NPWS
Protected Areas	PA coded polygons of protected areas	RoI	WFD schema	EPA
Roaringwater bay	cSAC survey data and provisional habitat map from 2007 surveys	cSAC	NPWS	NPWS
Kilkiernan	cSAC survey data and provisional habitat map from 2007 surveys	cSAC	NPWS	NPWS
Kenmare	cSAC survey data and provisional habitat map from 2007 surveys	cSAC	NPWS	NPWS
Clew Bay	cSAC survey data and provisional habitat map from 2007 surveys	cSAC	NPWS	NPWS

In addition to these resources, the EIS from the ENFO were reviewed for any coastal developments. Those with relevant marine or coastal developments were reviewed for biological information, both general descriptions and species data from baseline surveys. Where relevant this information was also summarised in the general ecological description.

3.4.2 Methodology for Assessing Ecology

The following method was used to assess Ecology:

- a. From the information available a short summary of the ecology and biotopes recorded within a water body was included in the water body summary sheets, accompanied by a map of the water body, the protected areas and any biotope records that were mapped.
- b. A link is provided in the Water Body Summary Sheets to the *MarLIN* website which provides information of the biotopes and the sensitivity to physical and chemical modifications. Unfortunately, there was insufficient biological information to carry out a full appraisal of the water body's ecological sensitivity to physical changes as outlined in Chapter. However, the links to the *MarLIN* sensitivity information is included with the summary sheets.

3.5 Pressure Footprints

Once all pressures footprints were defined where required, each feature was assigned to its corresponding water body using a combination of automatic and manual methods. The assessment of pressures within TraC-MImAS also requires that the footprint of each pressure is estimated for the intertidal and subtidal zones of each water body. The proportion of each footprint was assigned to a tidal zone using the intertidal zone shapefile created via combination of automatic and manual methods.

A shapefile containing records for all 309 water bodies was compiled with the results of the initial risk assessments and pressure footprints calculated by the above methods. Each footprint is expressed in metres and kilometres. This information is then used within the TraC-MImAS to assist in the further characterisation of risk to TraC water bodies (refer to Chapter 5).

3.6 Delivery and dissemination

Due to the end user issues, there are difficulties with the dissemination of the data gathered for this project. The pressure layers created for the project through the methods outlined above will be delivered to Cork County Council with this report, under the terms of agreement with the various data providers. These layers will include metadata outlining all source data used in the development of the layers, and acknowledges the data providers and their rights over the information. The SWRBD project team will add these layers to the EPA WFD Schema, assuming no objection from the data providers, to make this information available for national appraisal. The source data will be provided to the Cork County Council only, and archived pending future data agreements with the source organisations.

The data agreements between the various organisations and Cork County Council were defined by either the data provider, or under the data agreement prepared by the SWRBD project team. This agreement and the terms of use from others were to allow the pressures layers to be disseminated to the organisations and councils who are involved in implementing the WFD. However, in all cases the rights are reserved by the data provider. The future handover of the data from Cork County Council to a final responsible body will require permission from the data providers. It is hoped that this end user will be a governmental department or a government agent/agency. This would mean intergovernmental data agreements would be able to be used to access more comprehensive baseline data.

The relevant licence restrictions on the incoming information have been logged with the file reference and a copy is inserted into each folder.

All data generated has been provided with the following disclaimer in the metadata:

No data may be re-produced or transmitted in any form or stored in any retrieval system of any nature, without the written permission of SWRBD Project Office, as Copyright Holder, except as agreed for use on this specific project. All rights reserved by original data provider.

3.7 Recommendations for Further Data Requirements

The data that was able to be collected for the Marine Morphology task was severely limited by the departmental re-organisation of marine services within the government. This resulted in confusion in data ownership that prevented data access for this project as well as difficulties in defining the end user for the data tool.

Several sub projects designed to provide government data for applications such as this one also have had difficulties due to these changes; most notably the COZAS programme, which was to provide marine licensing GIS data from the former DCMNR. As a result the records, and particular areas of activities such as recent dredging, had to be researched in detail, and in some cases estimated from the limited available information. Hopefully this programme will be reinstated in the near future, along with the associated programmes such as the Integrated Fisheries Information System (IFIS) that was to provide centralised GIS fisheries and aquaculture information.

Though a centralised series of government databases for the marine environment is unlikely, especially with the dissolution of a designated government department, better data sharing and interoperability between departments is needed.

This project has collated a significant amount of data, much of which is relevant to future assessment of the water bodies, which will be provided to Cork County Council on project completion. In addition, work has been carried out to generate and digitise data from a number of sources, most notably the orthophotography. A responsible body or end user will need to take ownership of this work in order to allow dissemination to the various RBDs or councils to enable them to assess proposals against morphology and GES, and to ensure the data is updated.

Unfortunately, a full national coastal set of geographically referenced orthophotography was not available for this study. Ideally, each County Council should ensure that they have secured permission and the data from the OSi, and this should be a priority for future coastal appraisal and planning. This information, when used with the former DCMNR oblique coastal images allows the verification and interpretation of coastal features and data. At a local level, site visits or local knowledge verification may be possible through the relevant councils, though for this national study, such site visits are impractical.

The water bodies represent a national reference dataset of rivers, lakes, transitional and marine waters around Ireland. A national coastline is therefore the inverse of these areas, and an ERSI shape file was created of the internal area of the coastal and transitional water bodies that represented this area. However, during the course of this project, a national and low water mark were unable to be obtained – as highlighted above. As this represents a boundary of governmental and local authority department responsibilities, it is essential that this dataset be developed and provided to the various bodies involved in implementing the WFD.

3.7.1 Baseline Data

There are a number of baseline elements that are essential to the evaluation of water bodies. These elements were not available for the majority of the RoI, but are available for other European marine areas. However there are a series of programmes currently underway that will hopefully fill this knowledge gap (see Chapter 4).

The resolution of many of the baseline datasets, such as the intertidal and water body shapefiles, were generally insufficient for the study. Small spatial errors had to be corrected wherever possible to ensure accuracy of the overall appraisal. However, in the cases of the water bodies, these were set nationally and had small boundary errors with orthophotos and the Irish Coastline.

From the Interim Data Review much more data was thought to be available than could be accessed and collated for this study. As a result, much of the pressure information had to be created. The lack of vectorised Ordnance Survey, and coverage of historic maps and orthophotographs on a national basis, impacted the ability to generate information on these pressures.

For future decision making, it is essential that this baseline information is made available to national and local government. Without this baseline information, the assessment WFD issues in the marine environment will be extremely difficult.

3.7.2 Morphological Data

The morphological or eco-morphological parameters to assess the type and conditions of the water body are predominantly sediment type, depth, exposure and salinity which are all associated with the physical characteristics, flow and tidal regimes of the estuary or water body. This physical environment is the main factor affecting the ecology, and is often used as the initial definition of a biotope. For example the EUNIS classifications system initially uses

the physical hierarchy, then biological, to classify marine communities. Comparison between ecologically surveyed parameters and eco-geomorphological attributes is outlined in Chapters 4 and 9.

In inshore waters, the data for these elements is sparse. There is no vectorised bathymetric data available from the IHO (International Hydrographic Office) or Admiralty Charts, though the former DCMNR did have a raster version of the Skipper Series from which this information could be digitised. However the status and licence for this data is currently unavailable due to departmental changes and would also be an immense undertaking. Even the 1997 GEBCO charts which give point depth data for much of world, and versions that have been merged with existing data are now largely unavailable as they are no longer being distributed as the data is dated and the INFOMAR project will eventually replace this information.

Many of these near-shore parameters are being surveyed and evaluated for coastal erosion programmes. The European EUROSION data was used to evaluate areas for this project, but much of the data was not sufficiently detailed in Ireland.

Sediment maps are not available for much of the west coast. Sediment type was evaluated from various point sources. The GSI does have Sea Bed Sediment maps (SBS) but only for offshore areas or not in sufficient scale for inshore or water body evaluation. The future programmes such as INFOMAR and the protected area mapping from the NPWS will eventually provide this information for the next series of RBMPs.

Flow and salinity data for water body characterisation relied on the cross referencing of the coastal typology with the available data on ecology and tidal information from the Marine Institute and the Marine Models database. The typology for MImAS is consistent with the methods used to type the water bodies in the SNIFFER (WFD07) report, and these descriptions were checked and used to inform the impact evaluation. This information is not sufficiently detailed to reassess. However, there is monitoring planned to assess these factors in the future, and changes to water body type, either redefined by the monitoring results or as a result of impact, can be updated (see Chapter 4).

3.7.3 Pressures

Much of the data for pressures was developed or digitised for orthophotography and oblique photographic images. This is a laborious and time consuming exercise.

Much of the data on coastal structure and historical changes is available in hard copy in the DCENR Coastal Engineering division, and much of it is, or will be, digital data to support the flood risk projects currently underway. It is assumed that these drawings and records are catalogued and a valuable interim measure would be to link this catalogue to a spatial or even water body reference to allow querying of this information for the assessment of future developments. Again the release and ownership of this data was hampered by the lack of a government representative to receive the data stored and generated by this project. This is an important issue that must be resolved prior to the RBMPs being enacted.

Databases on foreshore licensing, marine dredging, dumping at sea and aquaculture / fisheries are still in their relative infancy in Ireland. The information is available, but generally in insufficient detail for mapping at water body scale. There were a series of initiatives through the former DCMNR to integrate and centralise this data, with GIS as a significant element. However, these programmes have not yet provided the mapping data required for this study, and as a result, the data was generated or surrogate information used for this study.

A number of decisions were made during the course of this study that may require further appraisal by a suitable regulator. For example, no 'time limit' was given to land claim - it was identified from changes between historic maps and the most up-to-date orthophotography available. However, in many cases, some land claim had already occurred prior to the historic maps. Dublin Bay, for example, has been altered for over 700 years as a site for ports and harbours, and there is no limit within MImAS as to the point from which an initial water body condition should be assessed.

The WFD schema, and ongoing work integrating the results of all the PoMS studies, provides an active national and local government template for potential data sharing. The nature of the WFD has allowed intergovernmental sharing of data, identification of metadata on existing information, and future planning for web-enabled mapping information to be available to decision makers and unrestricted information to be passed into the public domain.

3.8 Conclusions

This study has examined the possible sources of data for marine morphology. Though hampered by the lack of an appropriate end user, and unable to benefit from government interdepartmental data sharing that would have allowed greater access to some key datasets, the relevant pressures for marine morphology have been developed by analysing available information and digitising extents from aerial and oblique photography. The extent and demands of this data generation have been much greater than perceived at the project outset compounded by the fact that a series of supporting programmes to collate this information nationally for government did not occur for the marine environment.

Despite this, a series of national marine morphology pressures have been created and assessed as part of this study to enable impact assessment of these and future pressures on Ireland's TraC water bodies. The data was developed to the best scale and detail possible given the limitations described above, to provide a comprehensive and consistent dataset for Ireland to use in the impact assessment.

From the best information available for this study the pressures have been compiled and assessed and provided with full metadata. It is hoped that these derived layers can be made available through Cork County Council and EPA WFD Schema to the relevant national and local authorities. However, a suitable end user to take ownership for the collected information and generated data and its continued updating was not able to be identified during the course of this study.

4 REVIEW OF EXISTING MONITORING SYSTEMS

4.1	Introduction.....	2
4.2	Review of Organisations Involved.....	3
4.3	Review Summary of Existing Marine Monitoring.....	7
4.3.1	Introduction	7
4.3.2	Pre-WFD Monitoring Programmes	8
4.3.3	Variable Measured for Marine Water Samples	13
4.3.4	Environmental Impact Assessments / Investigations	16
4.3.5	Conservation Monitoring.....	16
4.3.6	Post-WFD Monitoring Programmes	17
4.4	Water Framework Directive Monitoring Programme for TraC Waters ...	19
4.5	Conclusions.....	25

This chapter summarises the findings of a review of existing European and national monitoring systems with the aim to determine if the programmes in place are of benefit to the assessment of morphological conditions within TraC waters.

There are two main requirements for marine morphology data under the WFD; to determine the ecological status of a water body, and to detect changes that may affect this status. Any relationship between existing monitoring programmes and these requirements is outlined.

Recommendations for the design of the monitoring programme in relation to morphology are outlined in Chapter 9.

4.1 Introduction

The Water Framework Directive (WFD) requires the monitoring and assessment of the ecological status of all waters within its geographic boundaries. Article 8 (1) of the directive states '*Member States shall ensure the establishment of programmes for the monitoring of water status in order to establish a coherent and comprehensive overview of water status within each river basin district*'. In accordance with Ireland's regulations implementing the WFD (S.I. No.722 of 2003); the Environmental Protection Agency (EPA) have prepared a programme of monitoring of water status to achieve the requirements of Article 8 (and Article 7 which specifically relates to the abstraction of drinking water) of the WFD, to be operational by December 2006. Also, the EPA has specified the authority by which the monitoring is to be carried out. Those authorities assigned monitoring tasks in the TraC component of the WFD monitoring programme are the EPA, the Office of Public Works and the Marine Institute.

For high ecological status to be achieved, the WFD requires that there are no more than very minor human alterations to the hydromorphological quality element. To determine this, existing baseline conditions and / or absence of pressures should be demonstrated. For all other status classes, conditions should be '*consistent with the achievement of the values specified for the biological quality elements*' (WFD, Annex V).

Formal hydromorphology classification tools have yet to be developed for use in Ireland. As noted in Section 5.4.2 of Chapter 5, work aimed at developing hydromorphological reference conditions and a draft classification scheme for TraC waters has commenced in the UK (EA and SNIFFER). However, this has not resulted in formal classification tools, but has emphasised the importance of the biological classification scheme incorporating metrics that were sensitive to hydromorphological changes. Few of the biological classification tools developed for use in Ireland are relevant to morphology; these are discussed further in Section 4.3.6.

Marine Monitoring and Marine Morphology

Monitoring of morphology is a difficult process for which extensive baseline information is required. This may include detailed bathymetry and flow information, or hydrodynamic models. A baseline of morphological condition is an essential element in providing a point of temporal reference from which change can be assessed.

However, in many cases adequate baseline information is not available. This chapter outlines the ongoing programmes that may provide this information in the future and reviews those programmes that may be enhanced to include morphological monitoring.

Though responses to man-made developments or extreme events can be rapid, in general, natural morphological changes occur over long periods of time; therefore time series data is essential to detect changes. A variety of existing marine monitoring occurs in Europe, though there are few national programmes looking specifically at morphology. As a result, indicators or surrogates for morphological change monitoring may need to be identified from the existing programmes, until such time as the WFD monitoring can provide further information.

Chapter 9 follows on from this review of existing systems to recommend surrogate information from existing sources which can be used in the meantime to assess change.

The following sections give an overview of the existing Irish and European marine monitoring systems. They also identify the existing time series data that may be available to represent baseline conditions and assist in monitoring future changes to morphology.

4.2 Review of Organisations Involved

The Department of Environment, Heritage and Local Government (DEHLG)

The Minister for the Environment has the overall responsibility for the development and implementation of environmental policy in Ireland. The Department of the Environment, Heritage and Local Government (DEHLG) formulates the relevant legislative framework to maintain satisfactory regulatory and monitoring systems for environmental protection and to secure the provision of infrastructural services necessary for both environmental and developmental purposes. The responsibilities of the Department regarding environmental information are the result of policy needs, statutory requirements and international obligations.

Environmental Protection Agency

The EPA operates under the aegis of the DEHLG. It is an independent agency that was set up according to the Environmental Protection Agency Act of 1992. Its wide

range of functions includes an overall co-ordination and supervisory role relating to environmental monitoring, including the monitoring of surface waters. In particular, the Agency is required to prepare a national monitoring programme and to identify the organisations to undertake its implementation. The EPA is one of the competent authorities under the Water Framework Directive.

The existing estuarine and coastal monitoring programme, which is discussed further in Section 4.3 below, should be replaced by the WFD Monitoring Programme (Section 4.4) which became operational on the 22 December 2006. The new WFD programme for transitional and coastal waters is to be undertaken by the Environmental Protection Agency in collaboration with the Marine Institute, Central Fisheries Board and National Parks and Wildlife Service (NPWS), with those tasks of relevance to hydromorphology assigned to the EPA, Marine Institute and the OPW. In the new programme a total of 117 water bodies consisting of 82 transitional and 35 coastal will be monitored. The existing coastal and marine surface water monitoring sites for Ireland are mapped by the EPA as shown in Figure 4.1 below.

As a result of funding issues, elements of the monitoring programme to be undertaken by the Marine Institute have not yet commenced.

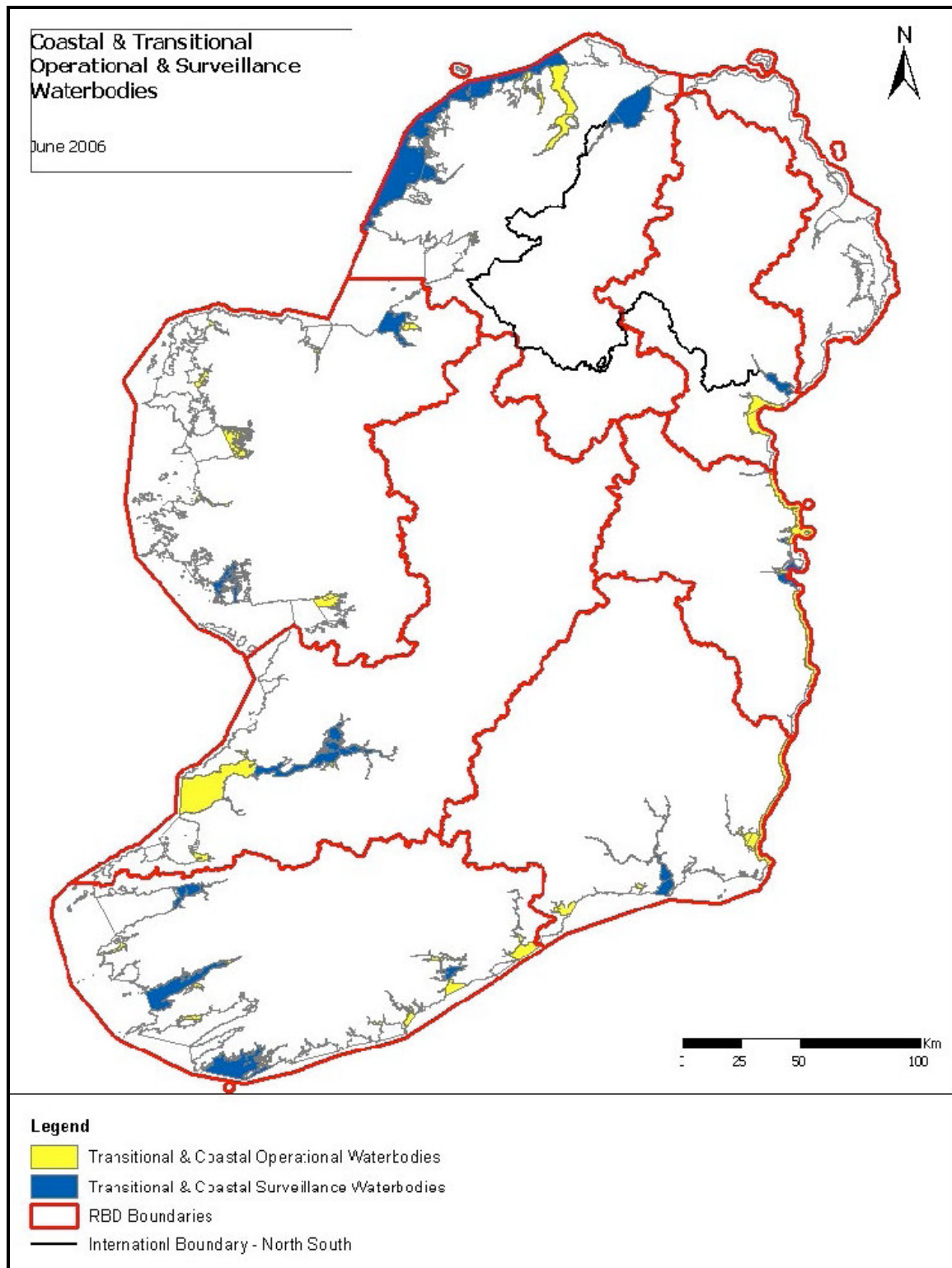


Figure 4.1: Coastal and Transitional Marine Operational and Surveillance Monitoring (Source: EPA, 2006 WFD Monitoring Programme)

National Parks and Wildlife Service

The NPWS, part of the DEHLG, manages the Irish State's nature conservation responsibilities under National and European law.

A particular responsibility of NPWS is the designation, monitoring and protection of Special Areas of Conservation (SACs), Special Protection Areas (SPAs) and Natural Heritage Areas (NHAs). Consultation with interested parties is an integral element of the designation process.

For the purpose of the WFD monitoring programme and of relevance to TraC morphology, the NPWS are responsible for the monitoring of coastal angiosperms.

The former Department of Communications, Marine and Natural Resources (DCMNR) and the Marine Institute

Prior to Ireland's reallocation of Departmental responsibilities after the 2007 general elections, the DCMNR (formally the Department of Marine) implemented marine monitoring programmes mainly through the work of its Fisheries Research Centre and this role was devolved to the Marine Institute, established under the 1991 Marine Institute Act.

The monitoring programmes have been carried out with the following objectives:

- ensuring the quality of fish for human consumption;
- identifying sources of pollution;
- determining temporal trends and spatial distribution of contaminants in offshore, coastal and estuarine environments.
- meet European and International (OSPAR, ICES etc) reporting objectives

An important aim of the programmes is to comply with various international agreements. Quality assurance activities include participation in the EU-funded QUASIMEME quality control programme. The Marine Institute also compiles a number of national data programmes for Oceanographic data, such as the National Tidal Gauge Network.

The Marine Institute, currently under the aegis of DAFF, proposed a comprehensive monitoring programme for the marine elements of the WFD in 2006/2007 (MI, in press). The programme identified the need for, but did not include the specification for monitoring of morphological elements of the WFD. However, the information collected can be interpreted for morphological monitoring as outlined in Section 4.3.3

below. Most importantly a morphological baseline is identified as being collected under the GSI (Geological Survey Ireland) and Marine Institutes' Integrated mapping for the sustainable development of Ireland's marine resource (INFOMAR) programme, which is also detailed below (Section 4.3.6).

Department of Agriculture, Fisheries and Food (DAFF)

As of 2007, the DAFF has been assigned a number of the responsibilities of the former DCMNR, with other responsibilities being managed by the DEHLG, the Department of Communications, Energy and Natural Resources (DCENR) and the Department of Transport (DoT).

4.3 Review Summary of Existing Marine Monitoring

4.3.1 Introduction

A review of existing monitoring programmes has concluded that morphological quality elements are currently poorly represented by Irish systems. However, information relating to these elements may be included in the data associated with the samples taken for other means. For example, ecological/conservation monitoring may record the location, depth and granulometry / substrate of a site, and general descriptions of the physiotope (physical habitat). This information can be used to help determine a baseline and detect changes in morphology, as it can provide time series data.

The data review undertaken by this study and reported in Chapter 3 found that Ireland has little morphological baseline information from which to monitor change, and although hydrographic charts and information is available, electronically there is poor inshore information and no vectorised Hydrographic Office data. At present the data collected by previous coastal monitoring programmes is not held within a central repository, however, as monitoring is the responsibility of few select authorities, the collation of this information is feasible.

As part of the National Monitoring Programme the NS-Share project team developed a Marine Monitoring Database collating information for existing monitoring programmes within the one nautical mile limit of TraC water bodies. Where possible,

data, which was compiled on a water body basis, consisted of the following information:

- Water body designation
- Risk assessment results
- Existing monitoring programmes
- Whether a point is a once-off dataset or repeat
- Relationship of monitoring points to other water bodies
- Pressures which exist on the water bodies

This database provides a very useful framework for the collation of TraC monitoring information, and would be of benefit if updated and maintained following the completion of national PoMS studies and WFD monitoring programme.

4.3.2 Pre-WFD Monitoring Programmes

In the EEA area the Oslo and Paris Commissions (OSPARCOM) and North Sea Task Force are responsible for the overall coordination of monitoring in the North-east Atlantic and the North Sea, while the Helsinki Commission (HELCOM) is in charge of the overall coordination of monitoring of the Baltic Sea, the monitoring of the Mediterranean being coordinated by the UNEP/MEDPOL programme.

The countries bordering these marine areas participate in the international monitoring programmes and the monitoring activities are incorporated into the national marine monitoring programmes. The national marine monitoring programmes are, however, generally more comprehensive including more sampling sites, especially in coastal areas, and measurement of more variables. The general purpose of national marine monitoring programmes is to assess the environmental state of the nationally important marine areas, and the national programmes are thus aimed at giving a nation-wide overview of marine environmental quality status.

The EEA 1996, 'Surface Water Quality Monitoring' assessed national marine monitoring programmes and made a comparison of similarities and differences between the different existing marine monitoring activities. In total, information on approximately 38 national marine monitoring programmes from ten countries has been assessed by the EEA. Table 4.1 outlines those programmes reported for Ireland and the UK. The OPSAR and INTERREG SIAM (Synergies in Assessment and Monitoring) programme is currently reviewing existing programmes, looking at synergies between programmes and European Directive objectives.

Table 4.1: National marine monitoring programmes in Ireland & the UK (derived using Surface Water Quality Monitoring, EEA (1996))

Country	Name	Variables W: Water; B: Biota; S: Sediment	Start year and sampling frequency (SF)	Geographical coverage
Ireland	General Quality of Estuarine and Coastal Receiving Waters	W: C&P WQ variables	Since 1992 SF: 1-2/yr	Significant estuarine and coastal areas
	Toxic contaminant levels in the estuarine and coastal environment	W: C&P WQ variables S: metals, OMP B: metals, OMP	Since 1993 SF: 1/5-6 yr	Nation-wide. Significant estuarine and coastal areas
	Radioactivity monitoring of the Irish marine environment	Radioactivity in water, sediment and biota	Since the early 1970s SF: 2-4/yr	Nation-wide particularly areas affected by Sellafield
	Bathing waters	W: C&P WQ variables and microbiological indicators	Since 1979 SF: 1/1-2 week in summer	Nation-wide. 92 important marine bathing areas
	Bacteriological quality of shellfish waters	COLIFAEAC in water and shellfish		
	Monitoring of human food sources	W: C&P WQ variables B: metals, OMP	Since 1992 SF: 1/yr	18 shellfish growing areas Fish landings from 5 important fishing ports
UK	UK National Marine Monitoring Plan	W: C&P WQ variables S: metals, OMP	Data from at least 1988 SF: water 1-4/yr biota 1-2/yr sediment 1/yr	Approx. 100 sites in the upper, middle and lower reaches of estuaries, inshore and offshore coastal sites around the UK
	Marine Algae Monitoring Programme	Marine algae	Since 1991 Weekly from May to September	640 identified and non-identified bathing waters
	Monitoring of Bathing Waters	Bacteria and a few physical and organic pollution determinands.	SF: 20 samples a year during the bathing season.	460 bathing waters in Scotland, Northern Ireland and England & Wales.
	Water Quality of Shellfish Waters	Heavy metals, organic micropollutants.	SF: 2-12/year depending on variable type.	29 shellfish waters.
KEY: Biology: PHYTPL - Phytoplankton; ZOOPL – Zooplankton; ZOOBEN – Zoobenthos; MAPHYT - macrophytes WQ - Water quality; C&P - Chemical and Physical				

Prior to the WFD monitoring programme, those reported as operational in Ireland's marine waters are summarised in Table 4.2 below. Subject to the confirmation of the WFD marine monitoring these programme are considered active.

This national marine monitoring programme is a combination of the EPA and Marine Institute programmes. The EPA programme aimed at providing a general assessment of the quality of Irish estuarine and coastal waters, while the Marine Institute programmes concentrated on the Irish Sea. The programme for coastal and marine areas was split into 5 individual programmes:

- M1 focuses on the impact of organic waste and nutrients.
- M2 focuses on toxic contaminants (heavy metals and organic micropollutants) in the Irish estuarine and coastal environments (this programme will sample a mix of water column concentrations and sediments).
- M3 concerns monitoring of radioactivity in the Irish marine environment from water sampling and sediments (material for dumping at sea and dredging is also monitored under the existing legislation).
- M4 focuses on bathing water quality, predominantly for faecal coliform presence,
- M5 and M6 assess the quality of seafood used for human consumption.

In addition to the programmes noted above marine biological monitoring is undertaken by the Marine Institute in a number of separate programmes of varying intensity and duration.

Some of these programmes have, and will be replaced by the WFD monitoring programme. Some associated with the Marine Institute (and DAFF) are proposed within the Marine Institute's monitoring proposal issued to the DEHLG.

The results of these programmes are reported to Europe in a standard cross country format and will form an updated version of the 'Status of the Seas' reports produced by the EEA under the EU. The common WFD format should allow cross comparison and the identification of any larger scale trends that may require strategic attention.

Table 4.2: Irish national surface water monitoring programmes (extract from EPA, 1996)

No.	Name	Responsible institution	Variables	Period of operation & Frequency (SF)	Geographical coverage	Data & national reporting
M1	General Quality of Estuarine and Coastal Receiving Waters Including Nutrients.	MI, EPA, DAFF/DEHLG & Local authorities	<u>Water</u> : Physical and chemical variables	Since 1992. 1 winter survey and a number of surveys in summer	Nation-wide. Significant estuaries & coastal areas and the Western Irish Sea	Reporting: 1/4 yr by EPA, DAFF/DEHLG & local Authorities
M2	Metals and organic micropollutants in the Estuarine and Coastal Environment.	MI, EPA, DAFF/DEHLG & Local authorities,	<u>Water</u> : organic micropollutants <u>Sediment & biota</u> : heavy metals & organic micropollutants	Since 1993 One major estuary per year in a 5-6 year cycle. Trend monitoring of metals in mussels	Nation-wide	Reporting by MI to the OSPAR Joint Monitoring Group (JMG)
M3	Radioactivity Monitoring of the Irish Marine Environment.	Radiological Protection Institute of Ireland (RPIL)	Radionuclides in water, sediment, & biota	Since the early 1970s. SF: 2-4/yr.	Nation-wide. Greatest density of sites where the impact of the Sellafield facility is greatest.	Reporting: 1/2yr by RPIL
M4	Environmental Quality of Amenity and Recreation Areas, in particular, Bathing Waters	DEHLG Local Authorities	<u>Water</u> : Physical, chemical, & microbiological variables	Since 1979 SF: 1/1-2 week from mid-May to ultimo August	Nation-wide. A total of 92 important marine bathing areas	National reporting annually by DEHLFG
M5	Bacteriological Quality of Shellfish Waters.	DAFF/DEHLG (EPA)	Faecal coli in water and shellfish.	Since 1981 SF: 2 weeks intervals throughout the year	Mainly W and SW coast. 200 locations in 50 coastal inlets	DAFF/DEHLG
M6	Monitoring of Human Food Sources.	DAFF/DEHLG/MI, (EPA)	<u>Water</u> : Physical variables <u>Shellfish</u> : metals & organic micropollutants <u>Fish</u> : HG	Since 1992 SF: Annually	Nation-wide. 18 shellfish growing waters and 5 important fishing ports	MI, JMG

Estuarine and Coastal Water Quality

2001 - 2005

- 1 Castletown Estuary
- 2 Inner Dundalk Bay
- 3 Outer Dundalk Bay
- 4 Boyne Estuary
- 5 Boyne Estuary Plume Zone
- 6 Rogerstown Estuary (Inner)
- 7 Rogerstown Estuary (Outer)
- 8 Rogerstown Estuary Adjacent Coastal
- 9 Broadmeadow Estuary (Inner)
- 10 Broadmeadow Estuary (Outer)
- 11 Broadmeadow Estuary Adjacent Coastal
- 12 Liffey Estuary
- 13 Dublin Bay
- 14 Dublin Bay Adjacent Coastal
- 15 Avoca Estuary
- 16 Avoca Estuary Adjacent Coastal
- 17 Upper Slaney Estuary
- 18 Lower Slaney Estuary
- 19 South Wexford Harbour
- 20 Wexford Harbour
- 21 Wexford Harbour Adjacent Coastal
- 22 Nore Estuary
- 23 Barrow Estuary
- 24 Barrow Nore Estuary
- 25 Upper Suir Estuary
- 26 Lower Suir Estuary
- 27 Barrow Nore Suir Estuary (Outer)
- 28 Outer Waterford Harbour
- 29 Waterford Harbour Adjacent Coastal
- 30 Colligan Estuary
- 31 Dungarvan Harbour
- 32 Upper Blackwater Estuary
- 33 Lower Blackwater Estuary
- 34 Youghal Harbour
- 35 Lee Estuary
- 36 Lough Mahon
- 37 Owenacurra Estuary
- 38 North Channel Great Island
- 39 Cork Harbour
- 40 Upper Bandon Estuary
- 41 Lower Bandon Estuary
- 42 Kinsale Harbour
- 43 Argideen Estuary
- 44 Upper Lee (Tralee) Estuary
- 45 Lower Lee (Tralee) Estuary
- 46 Tralee Bay
- 47 Upper Feale Estuary
- 48 Cashen Feale Estuary
- 49 Deel Estuary
- 50 Fergus Estuary
- 51 Maigue Estuary
- 52 Tidal Shannon River
- 53 Upper Shannon Estuary
- 54 Lower Shannon Estuary
- 55 Cornib Estuary
- 56 Inner Galway Bay North
- 57 Moy Estuary
- 58 Killala Bay
- 59 Garavoge Estuary
- 60 Sligo Harbour
- 61 Sligo Bay
- 62 Ballysadare Bay
- 63 Killybegs Harbour
- 64 McSwyne's Bay
- 65 Upper Swilly Estuary
- 66 Lower Swilly Estuary
- 67 Lower Lough Swilly

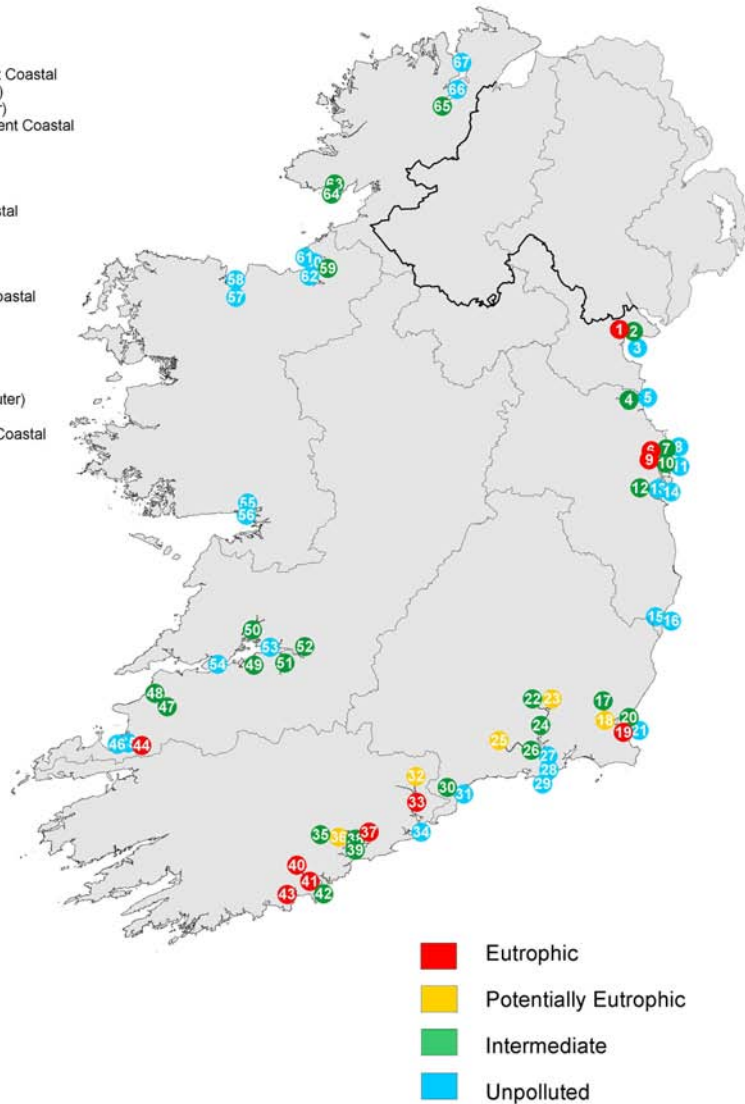


Figure 4.2: Location and results of existing water quality programmes pre-WFD (Source: EPA, 2006; Water Quality Indicators report)

4.3.3 Variables Measured for Marine Water Samples

The Irish (and other EU countries) surface water monitoring programmes assess up to 100 different chemical and physical parameters on water and sediment samples in the various marine monitoring programmes, more than half of the variables being different organic micropollutants.

The water quality variables of some relevance to morphology can be grouped into the following broad categories:

- Basic variables (e.g. salinity, water temperature, pH, conductivity, dissolved oxygen) used for a general characterisation of water quality.
- Suspended particulate matter (e.g. suspended solids, turbidity and organic matter).
- Indicators of eutrophication: nutrients, dissolved oxygen and various biological effect variables (e.g. chlorophyll a, Secchi disc transparency, phytoplankton, zoobenthos).
- Biological indicators of the environmental state of the ecosystem (e.g. phytoplankton, zooplankton, zoobenthos, fish, macrophytes).

Few of these 'pre-WFD' variables are directly relevant to morphology. However some can be used as surrogates for baseline morphological information. Depth, sediment type, flow and salinity can provide a reference for morphological conditions at a specific point in space and time that can be compared. Turbidity or suspended solids can also give an indication for the type of water body being assessed.

Basic Variables

Most of the marine monitoring programmes in Europe include measurements of basic variables such as water temperature, salinity, dissolved oxygen and pH. In many monitoring programmes basic variables are measured very frequently, typically bimonthly sampling, though in Ireland the frequency has varied dependant on the programme. Salinity results may be used to provide baseline data as well as indications of where there may have been changes to morphology (e.g. extensive tidal channel realignment / land claim). This information should be assessed on a water body basis. The use of this surrogate time series data can only assist in identification of possible recent changes until long term monitoring data for morphology is available.

Suspended Particulate Matter

Suspended solids and turbidity can give an indication of the type of water body environment. The level of turbidity is a significant environmental stress that defines the ecology. Changes in turbidity can be an indicator of changes in morphology or erosion. However, it is important to note that these changes may be attributed to changes in morphology upstream or in adjacent water bodies. Investigative monitoring can help identify the exact source.

The suspended sediments can give an indication of morphological changes, but only when supported by other information such as flow, depth or marine topographical changes, but could give an early indication of changes. Review of this data should include examination of the water body type and regime. Changes in suspended particulate matter can also indicate morphological changes from upstream of the TraC water bodies and information from adjacent water body development or morphological change should also be examined.

Eutrophication - Nutrients

Eutrophication is a product of increased nutrients. This is usually due to runoff from agricultural land, point source discharges or due to change of land use from cleared forestry or other cover. Intensive land use, maintained drainage ditches and runoff can also contribute to eutrophication, all of which are pressures identified as potentially impacting on morphology. In the absence of other monitoring systems in a water body, eutrophication may act as an indicator of physical alterations. Eutrophication associated algal blooms can reduce flow in certain waters bodies and potentially affect sediment settlement and the morphology of a water body.

All the ten countries reported by EEA (1996) have at least one national marine monitoring programme with the purpose of assessing the concentration of nutrients in the water column. As a rule the monitoring programmes include measurement of nitrogen, phosphorus, and silica. Additionally, the impact of eutrophication is measured using general indicator variables such as Secchi disc transparency (SDT), chlorophyll a and primary production.

SDT can be used as an indicator for suspended sediments which can be related to morphology, however, existing programmes have used this variable to assess algal bloom reducing under water visibility and therefore should only be used if there associated observation records referring specifically to the likely presence of

suspended sediments. Future use of such a variable will require nutrient or chlorophyll values to put this variable in context.

Metals

Ireland measures heavy metals in a number of programmes, often linked to others such as shellfisheries or areas where there have previously been levels of concern. The sampling frequency varies from once every third year to 4-5 annual samples. In most cases sample records include observations of depth and sediment type which are crude indicators of morphology, and may provide long term records. Those samples associated with measurement of metals in sediments will have more detailed granulometric information that may assist in the identification of long term morphological trends in the absence of other information. Proposed WFD programmes measuring marine contaminants can also provide future sources of this information.

Measurement of Metals in Sediments

Several of the marine monitoring programmes include measurement of metals associated with the bottom sediment.

This existing sampling programme under the previous National Monitoring Programmes, and noted in the NS-Share Monitoring Database, may be used to give some baseline temporal information to inform marine morphology. Each sample site was assessed for granulometry as well as metals. Granulometry (which can be attributed to sediment type and depth) can be used as a baseline and indicator of change in marine morphology. However, granulometry can also be attributed to natural change, a factor which should be considered when interpreting results. In the absence of a baseline for morphology, these repeat sample points, may provide a time series of depth and sediment type that can be assessed for significant changes. Any change in the overall depth of an estuary or sediment type are indicators of morphological impact (planform, sediment size range and lateral transport process are eco-geomorphologic attributes as defined in Table 5.6 of Chapter 5). By using these surrogates where they occur a time series dataset can be used to assess long term gradual changes, or marked changes can be assessed

Ireland requires the monitoring of dredge material in accordance with the requirements under OSPAR. These sampling results are reported to the regulator and contain detailed information of sediment types, granulometry as well as chemical composition, which may be of use in providing information in the case of future morphological changes, especially as they are associated with a morphological

modifying activity. In addition, this monitoring is often associated with a detailed bathymetric survey by the operator of the area dredged for navigation. This associated information provides detailed morphological information of an impacted area.

4.3.4 Environmental Impact Assessments / Investigations

Environmental Impact Assessments and other environmental reports accompanying planning applications, foreshore lease/licence and dumping at sea applications can provide good sources of baseline morphological [and ecological] data. Registers of marine models and Environmental Impact Statements (see Appendices 2-1 and 3-2 respectively) completed in Ireland were generated as part of the Literature Review.

4.3.5 Conservation Monitoring

In addition to the various water quality monitoring programmes, Ireland also reports to Europe on conservation status of protected areas and species under the Habitats and Birds Directives (92/43/EEC and 79/409/EEC respectively). In compliance with the Habitats Directive, the NPWS evaluate and report on the conservation status of Special Areas of Conservation and Annex II species at 7 year intervals. This differs from the WFD 6-year River Basin Management cycle. However, a programme of Site Inspection Reporting (SIR) is carried out by the NPWS on a 3-year cycle. SIR is the process by which activities and their impacts on designated sites are recorded by NPWS Conservation Ranges. The data collected details the overall condition of the site and lists the activities that have influenced its integrity. Protected areas currently include a range of coastal dune and saltmarsh habitats.

The WFD will help ensure that where morphology and morphological pressures are a contributing factor; this programme can provide information to assist assessment in the future.

There are several techniques for the monitoring of these transitional and coastal habitats, dependant on their location and type. In Ireland the monitoring is currently carried out by transect or point samples for which a variety of information is recorded, including the physiotope. The physiotope is an assessment of the physical habitat in which the ecology is associated. In most of the biotope (physical and biological) recording schemes this information is used to classify the ecology of a specific area. In TraC habitats this would include recording of substrate, possibly including detailed

granulometry, likely exposure etc. These are all essential elements to indicate changes in marine morphology by indicating changes in sediment regimes or erosion/deposition processes and important information on potential ecological indicators of changes.

4.3.6 Post-WFD Monitoring Programmes

Floods Directive

Under the new Floods Directive (2007/60/EC) there are expected to be a number of parallel national studies looking at coastal topology and flood risk. The surveys are currently planned or underway and employ LiDAR surveys with orthophotography. The work is being carried out in conjunction with the OPW and Coastal Engineering Division of DAFF (the former DCMNR). The results of the first area studies are due at the end of 2008. However these could provide significant nearshore information of existing baseline conditions to inform morphological assessment.

INFOMAR (and the Irish National Seabed Survey (INSS))

The programme is a joint survey run by the GSI and Marine Institute and built on the physical mapping programme of Irelands offshore waters (beyond 50m depth) the Irish National Seabed Survey (INSS 2000-2006). The INFOMAR programme, an extensive of the INSS, will provide full coverage in a large number of selected inshore areas by 2013 (Marine Institute and GSI, 2006). INFOMAR will initially focus on 26 priority bays and three priority areas around the coast (Figure 4.3) The INFOMAR programme began in the summer of 2006 with surveys of valuable fishing and fish farming areas in Bantry Bay, Dunmanus Bays and fish spawning areas off the South West Coast (GSI, 2007). In early 2007, the survey began to extend coverage of the biologically sensitive area off the Dingle Peninsula and continued mapping Galway Bay and Waterford Bay. The survey plan continues in 2008 to include surveys of Dublin Bay, Carlingford Lough, Donegal Bay and Sligo Bay (Figure 4.3)



Figure 4.3: Priority INFOMAR areas (Source: Marine Institute 2007)

For each of the bays surveyed this project will deliver hydrographic maps illustrating all types of features from sandbars to underwater canyons and cliffs; seabed classification maps showing the type of sediment on the seabed, for example sand and gravel deposits which could provide potentially valuable marine aggregates for the construction industry; and habitat maps.

These maps will be integrated with the outputs from the INSS (Irish National Seabed Survey) which covered the offshore area of Ireland. These integrated maps will allow planning for sustainable development of Ireland's 220 million acres of seabed and protect biologically sensitive areas and resources.

INFOMAR provides key baseline data to support coastal and inshore development. The data collected can also be used to input into tidal models and carrying capacity models which can be used as the marine morphological baseline from which changes can be monitored

4.4 Water Framework Directive Monitoring Programme for TraC Waters

As noted previously, the EPA prepared a report titled “Ireland – Water Framework Directive Monitoring Programme” (2006) to meet the requirements of the WFD, the National Regulations Implementing the Water Framework Directive (SI no 722 of 2003) and the National Regulations implementing the Nitrates Directive (SI no 788 of 2005). This document sets out the roles and responsibilities and tasks required to implement the monitoring programmes which are assigned to various bodies within the state as required under the National Regulations.

The EPA (2006) outlined the quality elements to be monitored by the WFD programme. With regard to hydromorphology, the EPA summarise the following for which the EPA, Marine Institute and OPW have responsibilities for:

Tidal Regime: *‘can be monitored on a national basis by a series of tide gauges located around the coast and overseen by the Marine Institute. The criteria for evaluating status have not yet been determined’.*

Freshwater Flow: *‘High precision, high frequency monitoring will be required for the long-term trend and flux sites (OSPAR and lakes). Automatic gauges will be used for these subnets. Lower precision measurements may be sufficient for other subnets – e.g. well-calibrated staff gauges with good ratings to enable flows to be determined on the day of sampling if the gauge is read accurately’.*

Morphological Conditions: *‘are described in the directive as the depth variation, structure and substrate of the seabed and condition of the intertidal zones. In view of these assessment criteria, a research project, under the auspices of the Programmes of Measures Working Group, is underway to establish which morphological indicators might best describe the conditions in coastal and transitional monitoring programmes and respond to the pressures that might act specifically on the morphology of a water body e.g. dredging (fishing, channelisation) or coastal defences. In addition the project will define the relationship between morphology characteristics and biological*

status and develop a decision support tool for regulators to assess the potential impact of future developments on individual water bodies, (i.e. to prioritise activities and establish a tiered assessment system).

Details outlined for morphological conditions can be informed by the Marine Morphology PoMS study. Chapter 5 introduces the relationship between morphological features and processes and the pressures identified. Recommendations relating to morphological indicators are then made in Chapter 9, and Chapter 11 outlines how the findings of this study can be used to support Ireland's regulatory decision framework.

The biological elements and associated classification tools identified as sensitive to hydromorphology are identified by the EPA (2006) as follows:

Macro-algae – Reduced Species List (Responsible body: EPA - in progress)

Species richness can respond to changes in hydromorphology. This tool will include measures of the number of species present on a shore and the ecological status of these species. Changes in the numbers will indicate changes in the ecological status of the area. Three to five sites in each identified water body will be monitored once every 3 years.

Seagrass – Intertidal Spatial Extent, Density and Diversity (Responsible body: EPA/NPWS - in progress)

Seagrass communities respond to physical disturbances. Likely responses include reduction in species diversity and habitat extent. Initial surveys will be on an annual basis, and once background data has been accumulated, this will be reduced to a 3 year cycle

Saltmarsh – Spatial Extent (Responsible body: EPA/NPWS; in progress)

Common in transitional waters and coastal lagoons, saltmarsh is particularly susceptible to habitat loss through erosion. Monitoring for the purpose of the WFD is based on simplified version of habitat mapping techniques (habitat extent and bed diversity). Depending on the size of the saltmarsh, habitat monitoring will take place at 1 to 3 locations in each identified water body on a 3 year cycle.

The EPA considered all 309 transitional and coastal water bodies for inclusion in the national WFD coastal and transitional waters monitoring programme. The number of

water bodies within each River Basin District and each typology is shown in Table 4.3 and the locations shown in Figure 4.1. In accordance with the Water Framework Directive and guidance provided by the Common Implementation Strategy, a representative number of water bodies were selected that were considered to provide an assessment of the overall status of Ireland's transitional and coastal waters and to meet the other specific requirements of the WFD.

Table 4.3 Number of Transitional and Coastal water bodies by type in Ireland (EPA, 2006)

River Basin District	Typology						
	TW 2	TW 6	CW 2	CW 5	CW 6	CW 8	CW 10
Eastern RBD	10	3	0	6	1	1	0
South Eastern RBD	16	5	2	4	0	3	0
South Western RBD	29	14	9	9	0	3	6
Shannon IRBD	14	6	4	4	0	1	2
Western RBD	21	47	5	15	0	5	5
North Western IRBD	14	8	4	12	0	6	1
Neagh Bann IRBD	6	3	1	3	0	1	0
Total by Type	110	86	25	53	1	20	14

The structure of the WFD monitoring for TraC water bodies is outlined. However, as noted above, elements of the monitoring programme to be undertaken by the Marine Institute have not yet commenced as a result of funding issues.

The programme describes three types of monitoring; Surveillance Monitoring (SM), Operational Monitoring (OM) and Investigative Monitoring (IM). The monitoring frequencies proposed are designed to provide meaningful data for the assessment of surface water status.

Coastal and Transitional Surveillance Monitoring Network

A selection or 'subnet' of Surveillance Monitoring water bodies was chosen to represent the range of significant pressures and typology scenarios present in Ireland's coastal and transitional waters. The subnets were also chosen with the objective of assessing natural and long-term trends.

A frequency of 6 years is proposed for hydromorphology monitoring.

Other Overlapping Subnets

Within the structure of the WFD subnets (EPA, 2006) the Surveillance Monitoring programme will also include the following overlapping subnets – overlapping in the sense that they will also be contained in one or more of the four principal subnets above.

- Eurowaternet (EIONET) sites,
- Surface water / groundwater interaction site,
- Selected reference condition sites
- WFD Intercalibration register sites
- EUROSION / IFRAMS networks (Erosion and Flooding mapping)
- Selected NPWS Protected Area sites – see also OM programme

Individual monitoring points may be included in one or more of the main subnets.

Coastal and Transitional Waters Operational Monitoring Network

The Operational Monitoring programme is a selection or subnet of representative water bodies from those identified as being 'at risk' or 'probably at risk' of failing to meet their environmental objectives. This selection was further divided into 3 additional subnets for the purposes of assessing the effectiveness of measures to address impacts arising from point, diffuse and hydromorphological pressures, as well as measures to maintain good and high status sites.

The operational programme for transitional and coastal waters has 6 subnets consisting of 80 water bodies (Figure 4.1) (EPA, 2006). A frequency of 6 years is proposed for hydromorphology monitoring.

The Marine Morphology study has further characterised the risk posed to water body status. This could be used to refine the OM programme and focus on those water

bodies estimated to at risk of failing to achieve good and / or high ecological status (see Appendix 6-3 for further characterisation results).

Coastal and Transitional Waters Investigative Monitoring Network

No TraC water bodies have been proposed for investigative monitoring. Investigative monitoring is required in situations where the reason for exceedances is unknown, where surveillance or operational monitoring have indicated a failure of objectives and not ascertained the causes. The results of such a monitoring programme will inform the establishment of a PoMs to achieve the required objectives.

In addition to the marine programme, as the proposed revised programme includes the continuation and adaptation of the existing monitoring, information and sample sites for TraC water bodies may overlap with the rivers and lakes monitoring programmes, which have commenced.

Rivers

The Freshwater Morphology PoMS study will make recommendations for the monitoring of morphology in rivers. Consideration and / or adoption of these recommendations should facilitate monitoring of TraC water bodies downstream of any monitoring sites.

A riverine monitoring programme is being undertaken by EPA Regional Inspectorates on behalf of the local authorities. The national monitoring programme includes mainly large rivers and their main tributaries with approximately 1,500 sampling sites in 300 rivers. The aim is to obtain a sampling frequency of 12 times annually, the water samples being analysed for indicators of organic pollution, nutrients and, metals. The biological quality of rivers is monitored according to a national programme operated by the EPA. The biological quality of rivers has been assessed every three to five years since 1971 and existing sample points are likely to be repeated. The third river monitoring activity is an annual recording of fish kills aimed at assessing their causes, which includes salmonid waters and therefore some transitional and coastal water body sites.

A few of the downstream river sampling points are in the transitional waters. Any long term dataset monitoring substrate and depth could potentially be analysed for changes as an indication of changes in morphology which may affect the ecology.

However, due to the nature of morphological conditions the likelihood of natural changes should also be considered.

Lakes and Reservoirs (including Saline Lagoons)

The EPA is continuing the development of a monitoring programme for lakes using aircraft-borne remote sensing. In-situ monitoring of selected lakes and reservoirs is undertaken by local authorities, by the EPA on their behalf, and by the Central Fisheries Board. Though this survey programme only applies to a few TraC sites, of particular importance to marine morphology monitoring is the technology used, which is also being applied to flood mapping and would provide a potentially important dataset for marine morphology assessment. The technology used for shallow water, LiDAR (Light Detection and Ranging, also known as Airborne Laser Swath Mapping or ALSM), can, be applied to coastal waters as well as saline lagoons. Surveys can be repeated to provide rapid assessment of morphological changes, but would only be applicable to intertidal or shallow water areas.

4.5 Conclusions

There are a series of requirements under the WFD which require Member States to monitor and assess the required hydromorphological quality elements. The following outlines how Ireland is currently positioned to meet these requirements, and how the Marine Morphology PoMs study can assist:

- The assessment of pressures and impacts on the morphology of surface waters:
 - Monitoring of the hydromorphological quality elements in TraC water bodies, with the exception of those biological elements listed above, has yet to commence.
 - The relationship between morphology and ecology has been investigated by this study and significant pressures on TraC water bodies identified. The location and extent of these pressures has been mapped where possible which can help inform both surveillance and operational monitoring.
- The restoration and monitoring of those waters significantly impacted by morphological alterations and requirements for the regulation of future engineering activities:
 - In the absence of formally adopted classification tools, the risk to TraC water bodies has been further characterised through the use of TraC-MImAS. Using the results of this assessment TraC water bodies have been prioritised by identifying the potential objectives required of the PoMs, e.g. if a water body requires restoration to at least good ecological status. This information can help refine the selection of monitoring sites.
- The identification and designation of Heavily Modified Water bodies and Artificial Water bodies:
 - The HWMB & AWB PoMS studies have identified water bodies for designation in the absence of monitoring data.
 - The Marine Morphology study can help identify water bodies unable to meet the WFD objectives due to physical alterations, and focus surveillance or even investigative monitoring.
 - If, in the absence of monitoring results, the pressures identified for a water body indicate a significant risk to the achievement of good ecological status the derogations of Article 4 of the WFD may be considered. Failure to comply with the requirements of this Article may justify the need for investigative monitoring.

- River basin management planning - setting of realistic environmental objectives but in balance with important socio-economic activities and industry (flood defence and management, navigation, hydro-electricity etc.):
 - Monitoring of hydromorphological quality elements will not be complete to provide evidence-based classification results for the first RBMP.
 - As noted above, the results of further characterisation have allowed the estimation of objectives for TraC water bodies which may be referred to for the first RBMP. However, monitoring will be required to confirm the base information used and reported by the Marine Morphology PoMS study

Ireland does not have a complete detailed bathymetric and sedimentary baseline in sufficient detail to monitoring changes in estuarine or coastal morphology.

Most of the marine monitoring programmes in Ireland, and the other European countries include monitoring of chemical and physical variables in the water column, and several also include studies of the biota (phytoplankton, zooplankton, zoobenthos, etc.). These sampling networks generally consist of a number of intensive sampling sites, typically less than 20 sites, at which frequent sampling (> 1-12 times/yr) of the water column is made and may be supplemented with an extensive sampling network including several sampling sites and low frequency sampling (1-4 times/yr) of the water column. Zoobenthos and sediment samples are generally taken at numerous sampling sites.

In Ireland the monitoring has predominantly been aimed at monitoring water quality, and quality of water and shellfish. The programmes have been designed to report for European legislation such as the Bathing Water Directive and the Shellfish Waters legislation, details of which are now addressed by the WFD monitoring programme.

The assessment of protected areas often requires a once-off or infrequent assessment of their environmental and biological quality. Whilst these may be part of a larger or national programme, they are not frequently or repetitively sampled. These surveys are separate from the WFD surface water monitoring. In Ireland, the Special Areas of Conservation status monitoring is currently under review, but has been discussed with the National Parks and Wildlife Service (telecom Dr E Kelly, 04/02/2008).

In order to assess changes and variations in morphology a baseline of sediment type and the bathymetric profile and flow must be known. Therefore, from review of the

planned monitoring programmes, it is proposed to adapt the existing and proposed programmes and record morphological monitoring surrogates to assist in the compilation of baseline data and monitoring of changes, until such time as a national inshore morphological baseline is available (refer to Chapter 9). This surrogate information (bathymetry, sediment type, exposure and associated ecology where available) can also be used to confirm the morphological classification of the water bodies.

The INFOMAR programme (2007-2013) will complete the Irish National Seabed Surveys work in the inshore areas. Once completed this will provide a detailed baseline for specific bays where changes in morphology can be assessed by targeted re-surveying.

In the meantime it is suggested that morphological data be collected as part of other existing monitoring programmes. The SAC monitoring transects carried out by the NPWS may be levelled to assist not only the detection of changes in morphology, but also identify potential changes in ecology as a result (this is discussed further in Chapter 9).

Point source information can be collected as part of the benthic grab sampling in the Marine Institute's programme. It is also possible that other parts of the programme such as plankton sampling transects, could be coupled with bathymetric or multibeam surveys to detect changes.

There are a number of other programmes proposed such as shallow water LiDAR surveys off the coast which are proposed as flood and coastal defence investigations, from which the data could be used to look at coastal morphology in this context.

5 MORPHOLOGICAL IMPACT METHODOLOGY AND ASSESSMENT TOOL

5.1	Introduction to Morphology / Ecology Relationships in the Context of the WFD...	2
5.2	Transitional and Coastal Morphological Impact Assessment System	11
5.2.1	Module 1: Eco-geomorphic Attributes	13
5.2.2	Module 2: Typology	16
5.2.3	Module 3: Sensitivity Assessment.....	17
5.2.4	Module 4: Impact Assessment (Pressures)	18
5.2.5	Module 5: Capacity Based Scoring System	19
5.3	Pressures	23
5.3.1	Land Claim & Tidal Realignment	24
5.3.2	Dredging, Other Disturbances to Seabed, & Disposal at Sea.....	25
5.3.3	Piled Structures	29
5.3.4	Flow and Sediment Manipulation Structures.....	30
5.3.5	Impounding Structures & Causeways.....	31
5.3.6	Shoreline Reinforcement.....	34
5.3.7	Flood Embankment.....	36
5.3.8	Intensive Land Use	37
5.3.8.1	Salt Marsh Grazing	40
5.3.8.2	Peat Bogs	41
5.3.8.3	Intensive Sea Use	42
5.4	Development & Use of TraC-MImAS for the Purpose of Risk Assessments	44
5.4.1	Clonakilty Harbour (SW_100_0100)	44
5.4.2	Development and approval stages of TraC-MImAS for use as a morphological assessment tool in Ireland.....	53

This chapter aims to describe the various elements considered by the Marine Morphology Study in relation to the impact assessment of morphology. The current understanding of the relationship between morphology and ecology in the context of the WFD is outlined below, with reference to the Literature Review (Appendix 2-1) and Chapter 2 of this report. The concept and functions of the Scottish EPA's (SEPA) TraC-MImAS tool introduced in section 2.1 are then detailed for each of its five modules. One of these modules is specifically associated with the pressures defined in Chapter 3, and predicts the likelihood that these pressures will impact on the morphological attributes of a water body. Section 5.3 of this chapter summarises how this module of TraC-MImAS considers each identified pressure.

Following this description of TraC-MImAS, an example of how this tool can be used for the purpose of risk assessments is provided using the transitional water body Clonakilty Harbour (SW_100_0100). The various assumptions and calculations made by the five module components are detailed using the pressure footprints identified for this water body.

5.1 Introduction to Morphology / Ecology Relationships in the Context of the WFD

Within the WFD, standards are being derived with respect to ecological quality rather than solely physico-chemical elements. The morphological pressures identified throughout this project (such as land claim, dredging, flow or sediment manipulation structures) are assumed to have some form of impact on the ecology of the marine environment. Therefore, there is a need to identify biological (as well as physical and chemical) data that will inform the development of measures of quality.

The link between morphology and ecology is relatively well established in fluvial environments; however, there is less documented information and scientific research linking morphology to ecology in marine environments. There is a need to review the basics to link the Pressure-Impact (morphological pressure-ecological impact) components of the DPSIR (Driver, Pressures, State, Impact, Receptor) approach, which is discussed in Chapters 6, 7 and 8 of the Literature Review (Appendix 2-1), and subsequently to inform the development of an impact assessment tool. In the context of the WFD, there is a need to understand how changes in the morphological quality elements (resulting from pressures) result in alteration to biological elements, causing them to be disturbed from the reference condition and leading to a deterioration in quality status (see Table 5.1). It is acknowledged that there are currently gaps in understanding many of these linkages, particularly at the water body scale. Future monitoring has the potential to increase understanding of these relationships (as with that of physico-chemical elements).

Table 5.1: Overview of biological quality elements relating to the normative definitions in the WFD (adapted from Implementation of the WFD in TraC waters presentation (D. Jowett) at Coastal Waters Network Workshop December 2003)

Ecological Status	Phytoplankton	Macroalgae/Angiosperms	Benthic Invertebrates	Fish (transitional water bodies)
High	Undisturbed	Undisturbed	Undisturbed (all sensitive taxa present)	Undisturbed
Good	Slight change from type-specific. No accelerated growth or imbalance	Slight change from type-specific. No accelerated growth or imbalance	Diversity and abundance slightly outside range. Most sensitive taxa present	Slight change in abundance of sensitive species
Moderate	Composition, abundance, biomass bloom (frequency/abundance) moderately different from type-specific	Composition and abundance moderately different from type-specific	Diversity and abundance moderately outside range. Taxa indicative of pollution present and many sensitive taxa absent	Moderate proportion of sensitive species absent due to anthropogenic impacts
Poor	Biological communities deviate substantially from undisturbed conditions			
Bad	Large portions of biological communities are absent			

The basic underlying assumption is that the presence of species at a location is encouraged or discouraged by the environmental factors occurring at that location. Those factors may be natural; resulting in the presence of a particular community and a certain species richness, or unnatural (brought about by human activities); resulting in a modification of the expected natural communities. Separating natural variability, particularly in dynamic estuarine and coastal environments, from change brought about by human activities is often difficult. A commonly used approach is to develop 'indicator species' which increase or decrease in response to pressures/environmental factors, or are considered to favour or be intolerant of different pressures/environmental factors. The following are relevant 'indicator species' studies identified and noted in section 4.8 of the appended Literature Review 2-1:

- *Review of current and historical seabed biological time-series studies in the UK and Europe* (Hiscock & Kimmance, 2003): Ninety-two seabed biological surveys that include time-series data were identified, and a description of each study entered into a time-series database, which is available as front page web browsers on the MarLIN website (http://www.marlin.ac.uk/time_series_metadata/).
- *Identification of seabed indicator species from time-series and other studies to support the implementation of the EU Habitats and WF Directives* (Hiscock *et al*, 2004). This seabed indicator research was undertaken as a follow-up to the review of the time series studies. The time-series study identified the potential for the data from some studies to describe the change in abundance of a particular marine species in response to anthropogenic activities. The Joint Nature Conservation Committee (JNCC) then commissioned a review (by the UK Marine Biological Association) of existing data to identify indicator species whose change in abundance may help assess the relative impact of anthropogenic activities on marine habitats.
- *Identification of seabed indicator species to support the implementation of the EU Habitats and WFD Directives 2nd Edition* (Hiscock *et al*, 2005a). Information from further review of literature was collated into 'A Seabed Indicators Species' database which is available on the web to search information on species habitat, impact and literature gathered in the report, http://www.marlin.ac.uk/indicatorsp/Indicator_search.php. This study is relevant to the north-east Atlantic, and is associated with predominately estuarine and near shore habitats.

- *Development of a hard substratum benthic invertebrate Water Framework Directive compliant classification tool* (Hiscock *et al*, 2005b): Findings of this report can also be searched using the Seabed Indicators Species database.

Although Hiscock (2005a) reported that there is a significant amount of information available for identifying indicators for physical disturbance, it was recommended that "a greater range of faunal and floral groups should be assessed to broaden the scope for determining indicator species such as macroalgae and angiosperms (such as sea grasses)" (Literature Review Appendix 2-1, 13.4).

Work undertaken through *MarLIN*, and other projects such as SensMap and BioMar have also focused on the 'biotope' scale of habitat and species communities, all of which were identified as useful reference points in the Literature Review (Literature Review Appendix 2-1, Chapter 2).

The basic ecological concepts evaluated within *MarLIN* and SensMap can be summarised as frequency/intensity of impact, sensitivity and tolerance of species.

Before discussing the ecological links between biology and morphology, it is useful to define some of the basic concepts that recur in recent studies, such as *MarLIN* and SensMap:

Recoverability is the ability of a habitat, community or species to return to a viable state which is at least close to that which existed before the development, activity or event. Recovery may occur through re-growth, re-colonisation by migration, or juveniles settling from undamaged populations. Recovery can be partial or complete.

Sensitivity is the intolerance of a habitat, community or individual of a species to damage, or death, from an external factor. Sensitivity refers to specific environmental perturbations.

Vulnerability expresses the likelihood that a habitat, community or individual of a species will be exposed to an external factor to which it is sensitive, and indicates the likely severity of damage should the factor occur at a defined intensity and/or frequency.

These factors (in terms of biology) are strongly linked to the frequency and intensity of physical disturbances, which may result from morphological pressures, such as:

Substrate Loss – Substrate occupied by the species or biotope under consideration is removed. Species or community recovery assumes that the substrate within the habitat preferences of the original species or community is present or recovers.

Smothering – Where an area of a biotope is smothered by sediments or impermeable materials, such as concrete, oil, or tar.

Physical Disturbance and Abrasion – This factor includes mechanical interference, crushing, physical blows against, or rubbing and erosion of the organism or habitat of interest.

Other impacts resulting from pressures, identified by *MarLIN* (Tyler Walters and Hiscock, 2005), may include; changes in suspended sediment, desiccation (linked to changes in emergence regime), changes in water flow rates, changes in turbidity (strongly linked to changes in suspended sediment), changes in wave exposure, and displacement. The effect of any given activity on an environmental factor is dependant on the site or location of that activity. Similarly, the magnitude, duration, frequency and extent of the change in an environmental factor will be dependant on:

- the type of activity;
- its scale;
- its extent and magnitude;
- its duration and frequency, as well as;
- the nature of the receiving environment, and hence;
- the location of the activity.

Both *MarLIN* and the SensMap project have produced matrices linking coastal activities with the environmental factors likely to change as a result of these activities. These matrices are outlined in Tables 5.2 and 5.3 below.

Table 5.2: *MarLIN* – Maritime and coastal activities to environmental factors matrix (Tyler-Walter et al, 2002)

		ENVIRONMENTAL FACTORS																							
		Physical													Chemical							Biological			
Coastal & Maritime Activities / Events	Sub-activities /events	Substratum loss	Smothering	Suspended sediment	Desiccation	Changes in emergence regime	Changes in water flow rate	Changes in temperature	Changes in turbidity	Changes in wave exposure	Noise disturbance	Visual presence	Abrasion / Physical disturbance	Displacement	Synthetic compound contamination	Heavy metal contamination	Hydrocarbon contamination	Radionuclide contamination	Changes in nutrient levels	Changes in salinity	Changes in oxygenation	Introduction of microbial pathogens / parasites	Introduction of non-native species	Selective extraction of target species	Selective extraction of non-target species
Aquaculture	Fin-fish		R	R			R		R		P	P	R		R				R		R	R	R		
	Macro-algae		P	P			P		P		P	P							P		P	R	R	R	R
	Predator control										R	R			P										
	Shellfisheries		R	R			R		R		R	R	R		R				R		R	R	R	R	R
Climate change	Current change						R	R	R										R	P		R	R		
	Sea level change				R	R	R			R										R					
	Temperature change				R			R	R										R		R	R	R		
	Weather pattern change				R			R														R	R		
Coastal defence	Barrage	R	R	R	R	R	R		R	R	R	R	R	R	P	P	P		R	R	R				
	Beach replenishment	P	R	R	R	R	R		R	R	R	R	R	R	P	P	P		R		R				
	Groynes	P	P	R	R				R	R		R		P							P				
	Sea walls / breakwaters	P	P	R	R	R	R		R	R		R		P							P				
Collecting	Bait digging	R	R	R	R				R		R	R	R	R											R
	Bird eggs										R	R	R												R
	Curios										P	P	R	R											R
	Higher plants	R		R			R				R	R	R	R					R						R
	Kelp & wrack harvesting	R		R	R		R		R	R	R	R	R						R		R				R
	Macro-algae	R			R		R				R	R	R	R	P										R
	Peelers (boulder turning)		R		R	R	R				R	R	R	R											R
	Shellfish	R	R	R	R				R		R	R	R	R											R
Development	Construction phase	R	R	R	R	R	R	P	R	R	R	R	R	R	P	P	P	P	R	R	R				
	Artificial reefs		P	R			R		R	R					P	P	P		R		R				
	Communication cables		P				R		R			R													
	Culverting lagoons			R	R	R	R	R	R	P									R	R	R				
	Dock/port facilities		R	R			R	P	R	R	R	R	R	R	R	P	R	P	R	P	R	R	R		
	Land claim	R	R	R	R	R	R		R	R									R	R	R				
	Marinas		R	R	R	P	R	P	R	R	R	R	R	R	R	P	R		R		R	R	R		
	Oil & gas platforms		R				R		R		R	R	R		R	R	R		R		R				
Dredging	Urban			R				R		R	R	R	R		R	R	R		R	R	R	R			
	Capital dredging	R	R	R	R	R	R		R	R	R	R	R	R	P	P	P	P	R	P	R				
	Maintenance dredging	R	R	R					R		R	R	R	R	R	P	P	P	P	R	R				
Energy generation	Nuclear power generation		P	R				R	R		R	R			R	P		P	R	P	R				
	Power stations		P	R				R	R		R	R			R	R	P		R	P	R				
	Renewable (tide/wave)		P	P	P	P	R		P	R	P	P			R		P			P					
	Wind farms	R					R			R	R	R	R	R	P	P	P								
Extraction	Maerl	R	R	R			R		R		R	R	R	R					R		R				R
	Rock/minerals (coastal quarrying)	R	R	R					R		R	R	R	R		R	R	R		R					
	Oil & gas		R								R	R			R	R	R		R		R				
	Sand / gravel (aggregates)	R	R	R			R		R	P	R	R	R	R	P	P	P	P	R		R				
	Water resources (abstraction)				P	P	R												R	R	R				
Fisheries/ Shellfisheries	Benthic trawls (e.g. scallop dredging)	R	R	R					R		R	R	R	R	P	P	P		R		R				R
	Netting (e.g. fixed nets)										R	R	R	R											R
	Pelagic trawls										P	P													R
	Potting / creeling		R								R	R	R	R											R
	Suction (hydraulic) dredging	R	R	R					R		R	R	R	R	P	P	P		R		R				R
Recreation	Angling										R	R	R	P											R
	Boating / yachting								P		R	R	R		R	P	R		R		R	R	R		
	Diving / dive site										R	R	R	R											R
	Public beach										R	R	R						P						
	Tourist resort			R					R		R	R	R		R	R	R		R		R				
	Water sports										R	R	R		R	P	R								
Uses	Animal sanctuaries										P	P	P					P				P	P		
	Archaeology	R	R	R					R		R	R	R	R	P	P	P		R		R				R
	Coastal farming		R	R					R		R	R	R		R	P	R		R		R	P			
	Coastal forestry		R	R					R		R	R	R		R	P	R		R		R				
	Education/interpretation										R	R	R	R											R
	Military										R	R	R		P	P	P	P							
	Mooring / beaching / launching		R	R			R		R		R	R	R	R	R	P	R					P	P		
	Research	P									R	R	R	P	P	P	P		P			P	P	R	P
Wastes	Shipping		P	R					R		R	R	R	R	R	R	R	P	R		R	R	R		
	Fishery & agricultural wastes		R	R					R						R				R		R	R			
	Industrial effluent discharge		R	R					R						R	R	R		R		R				
	Industrial / urban emissions (air)			P					P						R	R	R								
	Inorganic mine and particulate wastes		R	R					R				R		P	R	P	P	R		R				
	Land / waterfront runoff		R	R					R						P	P	P		R	R	R				
	Litter and debris		R										R		P	P	P								
	Nuclear effluent discharge			R					R							R		R							
	Sewage discharge		R	R					R						R	R	R	P	R		R	R			
	Shipping wastes		P	R					R						R	R	R		R		R	R	R		
Other	Spoil dumping		R	R					R				P		P	P	P	P	R		R				
	Thermal discharges (cooling water)			R				R	R						R	R	P			P	R	P	P		
	Removal of substratum	R	R	R	P	P	P		R	P	R	R	R	R	P	P	P		R		R				

Page last updated 18 March 2003

PROBABLE EFFECT - R POSSIBLE EFFECT - P

Table 5.3: SensMap - Activities and associated default environmental factors (extract from Cooke & McMath, 2001)

	CHANGES TO GEOMORPHOLOGICAL FACTORS	Substrate	Tidal Flow	Wave Exposure	Emergence Regime	PHYSICAL DISTURBANCE	Displacement	Amputation	Crushing	Abrasion	Entanglement	Collision
EXPLOITATION OF LIVING RESOURCES												
Dredging:												
Hydraulic Dredging												
Intertidal mechanical dredge												
Mussel & oyster dredge												
Scallop dredge												
Higher Plants:												
Picking for human consumption												
Saltmarsh grazing												
EXPLOITATION OF NON_LIVING RESOURCES												
Aggregate Dredging:												
Biogenic gravel (maerl)												
Sand & Gravel												
Metalliferous sediments												
Alternative Energy Production:												
Coastal wave & tidal current												
Tidal barrage												
Wind												
Water Resources & Storage												
Desalination												
Estuarine reservoirs												
Freshwater abstraction												
USE OF COASTAL LAND/WATER SPACE												
Coastal Forestry												
Coast Protection/Defence:												
Beach replenishment												
Breakwater												
Drainage												
Groynes												
Infill												
Managed retreat												
Seawall												
Docks, Marinas & Shipping:												
Anchoring												
Capital Dredging												
Maintenance dredging												
Mooring												
Navigation												
Estuarine Barrages:												
Amenity barrage												
Storm/ tidal surge barrage												
Tidal barrage												
WASTE DISPOSAL												
Agricultural run-off												
Dredge spoil dumping												
CLIMATIC CHANGE												
Current Change												
Sea Level change												
Temperature change												
Weather patterns												

Research into links between morphological conditions, ecological functions and biology have typically been carried out with links to practical applications, and often supported by European funding. There are a number of large-scale projects for mapping biotopes and sensitivity that are ongoing, or are recently completed within the EU (see Table 5.4). Many were driven by the EU Habitats Directive, but provide information which may be useful to the WFD once any problems of scale are identified and accounted for.

Table 5.4: Summary of recent large-scale projects related to Marine habitat mapping in Ireland (as detailed in Appendix 2-1, Chapter 2).

Project	Area	Timescale	Summary
MarLIN (The Marine Life Information Network) - Species and Habitats	UK and Ireland	Ongoing, started 1998 by Marine Biological Association	Key information reviews and sensitivity assessments of species and habitat biotopes. Impact of human activities on benthic biotopes and species.
BioMar - Benthic marine species survey	Ireland	1992-1996	Largest marine ecological seabed survey of the Republic of Ireland. Data provided the basis for classification of marine biotopes in the North East Atlantic, and the selection of marine Special Areas of Conservation.
SensMap	Ireland and Wales	1996-1999	SensMap produced and brought together new data on marine seabed habitats, communities and species, including biotope mapping. Developed a protocol to assess sensitivity of individual marine species and areas of benthic marine life to a broad range of maritime activities. UK data provided the basis for biotope classification (limited input from Irish data)
MESH - Mapping European Seabed Habitats	UK, Ireland, France, Netherlands, Belgium	2004-2007	Produced an array of products related to seabed habitat mapping, including WebGIS seabed habitat maps with physical and biological data.
Irish Sea Pilot and UKSeaMap	UK and Ireland	2002	Identified and mapped main marine landscapes. Summarised characteristic biological communities, where possible. Evaluation of marine landscapes in relation to their susceptibility to human activities. Links to MESH.
Marine Habitat Classification	Britain and Ireland	2004	National classification of benthic marine habitats (seashore and seabed habitats and their associated communities of species) for Britain and Ireland - building from BioMar.
UK Marine SACs project	UK	completed 2001	Support for management of Marine SACs. Information on their ecology, sensitivity and management.
INFOMAR and Irish National Seabed Survey (INSS) (initially focused on 26 priority bays)	Ireland	INSS completed 2007; INFOMAR commenced 2006	INSS & INFORMAR: Mapping of Irish seabeds: - bathymetric maps - seabed geology/ classification maps INFOMAR - habitat maps
HabMap - Habitat mapping for conservation and management of the Southern Irish Sea	Ireland	2005-2008	The HABMAP project has produced working habitat maps of the seabed of the southern Irish Sea, and has developed a model that uses physical characteristics to predict the biological community/biotopes

Of these projects, *MarLIN* has produced the most comprehensive information linking the impacts of physical pressures on marine biology, through producing 932 species and habitats reviews. As noted above, *MarLIN* published a report identifying seabed indicator species to support implementation of the Habitats Directive and WFD (Hiscock *et al* 2005a). An example of a sensitivity review for a key species to physical factors is illustrated in Table 5.5 below. Each underlined heading within Table 5.5 hyperlinks to further detail documented by *MarLIN*.

Table 5.5: Physical Factors - Species review for Common eelgrass, *Zostera marina*. Excerpt from *MarLIN* species review for Seagrasses

	<u>Intolerance</u>	<u>Recoverability</u>	<u>Sensitivity</u>	<u>Evidence/Confidence</u>
<u>Substratum Loss</u>	High	Very low	Very High	Moderate
<u>Smothering</u>	High	Very low	Very High	Moderate
<u>Change in suspended sediment</u>	Intermediate	Moderate	Moderate	Moderate
<u>Desiccation</u>	Intermediate	High	Low	Moderate
<u>Change in emergence regime</u>	Intermediate	High	Low	Low
<u>Change in water flow rate</u>	Intermediate	Moderate	Moderate	Low
<u>Change in temperature</u>	Tolerant	Not Relevant	Not sensitive	Moderate
<u>Change in turbidity</u>	High	Very low	Very High	Very low
<u>Change in wave exposure</u>	High	Very low	Very High	Low
<u>Noise</u>	Tolerant	Not Relevant	Not sensitive	Very low
<u>Visual Presence</u>	Tolerant	Not Relevant	Not sensitive	Very low
<u>Abrasion & physical disturbance</u>	Intermediate	Moderate	Moderate	Moderate
<u>Displacement</u>	High	Low	High	Low

Another approach that uses species sensitivity in response to pressures is the AMBI (Marine Biotic Index), which uses benthic macroinvertebrate community status as a biological indicator of disturbance (impacts and quality status of soft-bottom marine communities). Macrobenthos are considered a good indicator of disturbance as species respond rapidly to stressors, they are relatively sedentary, long living, and show differing tolerances to disturbance. The index has been developed to respond to water quality and pollution disturbance, but may be able to indicate areas where levels of sediment deposition are increased, resulting in benthic infaunal community shifts where communities shift from suspension feeders to dominance by deposit feeders. This is often seen as a lessening of environmental quality as communities become dominated by taxa perceived as pollution tolerant. Research using AMBI (Borja et al 2003) has shown that recovery of indicator species after disturbance usually follows a pattern of; increase in abundance; then increase in diversity, and finally a change in species composition from tolerant to sensitive taxa. This bears a resemblance to the quality statements given in Table 5.1.

The review of recent seabed mapping projects and development of links between habitat and species in marine environments shows that there are sound theoretical bases for assuming that changes to morphology brought about by pressures will have resulting impacts on ecological and biological features, and for the first round of river basin planning, we may need to use tools that focus on these general links. There is a lack of suitably detailed baseline data to currently utilise the methods developed in programmes such as *MarLIN* for the WFD, and there are still issues to be resolved between the impact on specific biotopes and at the water body scale as a whole. As part of the WFD monitoring programme however, seagrass and benthic monitoring will be carried out; both of which will significantly contribute to the understanding of the relationship between ecology and morphology. Monitoring programmes that link morphological and biological surveys at the water body scale can improve the knowledge and assessment of these issues. In summary: “Better understanding of the links between hydromorphology and ecology (via monitoring) is needed” (WFD and Hydromorphology, European workshop, October 2005, Prague).

5.2 Transitional and Coastal Morphological Impact Assessment System

As noted in section 2.1 of this report, an impact assessment tool for the purpose of estimating the risk posed by morphological alterations to the ecological status of TraC water bodies, TraC-MImAS, was developed by SEPA in response to the absence of suitable data to empirically derive standards for morphological conditions. The Marine Morphology PoMs team have been involved in the development of TraC-MImAS through participation in the UK-TAG TraC Morphology Steering Group and TraC MImAS Technical Panel. The TraC-MImAS tool development team consisted of representatives of SEPA, Environment Agency, RPS Consulting and Jacobs, with SEPA staff leading the development. Further to this work the Scotland and Northern Ireland Forum for Environmental Research (SNIFFER) commissioned an external interim technical review of the technical reports produced during the development of TraC-MImAS. This detailed review was undertaken by Mr. Anton Edwards of Metoc plc (environmental consultancy) at the end of 2007.

The TraC-MImAS tool was developed with the intention to help regulators determine whether changes to the morphology of TraC waters could pose a risk to ecology, and thereby identify those proposals that could;

- Threaten the aim of achieving 'good ecological status'; or
- Result in a deterioration in ecological status

There are, at present, no environmental standards available to assess the ecological impacts of alterations to the morphology of TraC waters, and regulatory decisions relating to morphology are largely based on expert judgement. The TraC-MImAS tool was developed in response to the current lack of ecological data required to support development of 'evidence-based' environmental standards for morphology. Of relevance to this, it was noted by A. Edwards (2007) that although it is clear that many morphological pressures have the potential to affect aquatic ecology; "there is also considerable weakness in the conceptualising and quantitative modelling of links between ecology and hydromorphology".

The TraC-MImAS tool is not intended to provide a detailed assessment of ecological status, but rather provide a means of identifying where ecological conditions are likely to be impaired through impacts to morphology, i.e. it is based on the assumption that an assessment of impacts on ecologically relevant features and processes can be used to protect morphology and ecology (SEPA, 2007).

The tool uses a concept of 'system capacity' (allowable morphological change) to measure impacts to morphological conditions, assuming that completely pristine TraC waters have a measure of assimilative 'capacity', which can be degraded by anthropogenic activities. SEPA have defined 'system capacity' as:

A measure of the ability of the water environment to absorb morphological alterations. The likelihood (or risk) that morphological and ecological conditions are degraded will increase as system capacity is consumed. This concept does not infer that degradation of the environment is acceptable; rather it assumes that there is a degree to which minor changes can be tolerated by the system.

TraC MImAS comprises of 5 modules which combine to estimate the existing system capacity (%) of a water body, refer to Figure 5.1 below.

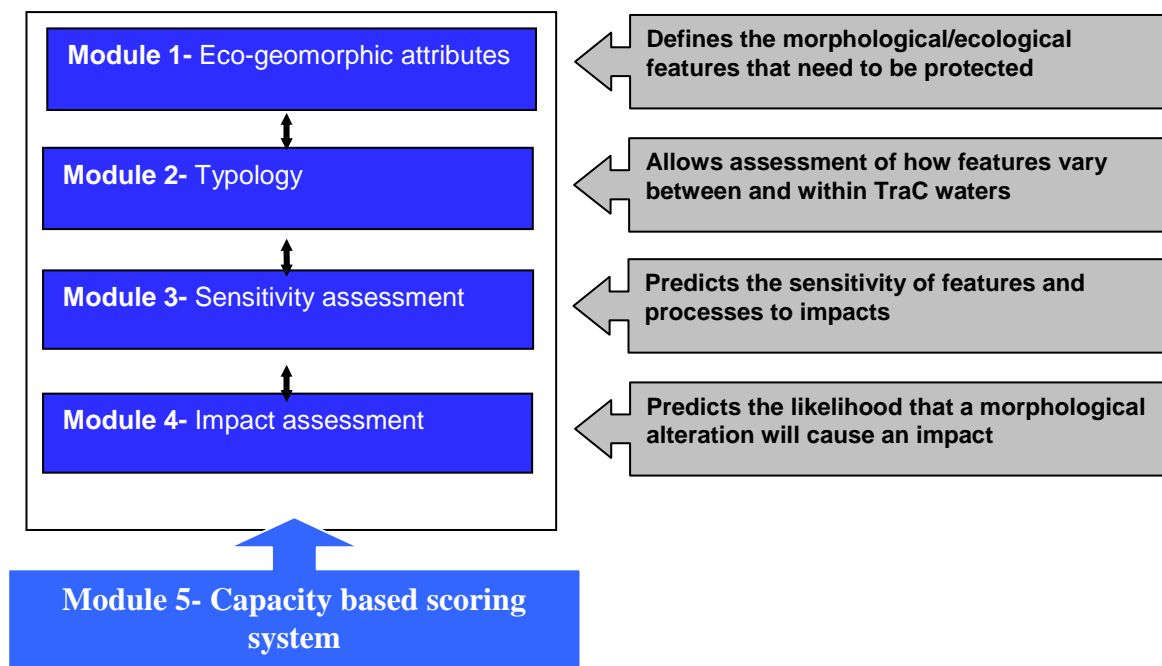


Figure 5.1: Overview of MImAS Modular Components

The capacity used by a water body is estimated for three zones; hydrodynamics, and the intertidal and subtidal zones.

SEPA's TraC-MImAS technical report and appendices titled 'Development of a Decision Support Tool for Regulating TraC Waters under the WFD version a4' outlines in detail the various components of MImAS. At the time of writing, this report had yet to be formally signed-off by UKTAG, and therefore 'does not necessarily represent the final or policy positions of UKTAG or any of its partner's agencies'.

TraC-MImAS is underpinned by a series of assumptions which should continue to be assessed throughout the future application of this tool:

- 1 A TraC water body has some capacity to accommodate morphological change without changes to its ecological status.
- 2 There is a relationship between the extent of morphological alteration and the impact on ecological status
- 3 The response of a water body's morphology to an engineering activity or other pressure is predictable for that type of water body
- 4 The response of the ecology to morphological change is predictable and depends on the sensitivity of the ecology of the water body.

In development of TraC-MImAS, *MarLIN* was a key resource reviewed by SEPA for consideration of the eco-geomorphic attributes and sensitivity assessment. Similarly to matrices produced by *MarLIN* and the SensMap project, TraC-MImAS links the identified pressures with those eco-geomorphic attributes considered likely to change as a result of the pressure (taking account of the above assumptions).

The modules of TraC-MImAS are detailed in the following sections (5.2.1 – 5.2.5). To demonstrate further how these modules are applied in practical terms, an example using Clonakilty Harbour in West Cork is provided in the subsequent section 5.4.

5.2.1 Module 1: Eco-geomorphic Attributes

A list of eco-geomorphic attributes representative of the intertidal, subtidal and hydrodynamic zones of TraC waters were selected by SEPA in consultation with the technical panel and project steering group for assessment by MImAS (Table 5.6). Each attribute was chosen “for its role in the direct or indirect support of ecological communities and the supporting processes needed to create and maintain the physical environment on which ecological communities depend” (SEPA, 2007 version a4) and relevance to the morphological quality elements specified by Annex V of the WFD (Table 5.7).

Table 5.6: Eco-geomorphic attributes defined for use by TraC-MImAS (Extract from draft SEPA (2007) TraC-MImAS Technical Report (Rev a4))

Eco-geomorphic Attributes	Definition
Hydrodynamics	Describes the influence of the tides, waves and freshwater inflow
Tidal range	<i>The height that the sea rises and falls over a tidal cycle</i>
Currents	<i>Currents associated with the rise and fall of the tide</i>
Freshwater flow	<i>Riverine input into TraC Waters, maybe modified by human interference of catchment hydrology/landuse changes</i>
Flushing/exchange	<i>The length of time it takes for a transitional water or sea loch to exchange its water</i>
Salinity/mixing/stratification	<i>Occurs in transitional waters and sea lochs where freshwater input is important</i>
Waves	<i>Waves are important in driving sediment transport processes</i>
Intertidal Zone	Describes the size and structure of the intertidal zone
Geometry	Describes the spatial extent and form of the intertidal zone
Planform	<i>Aerial view showing planar area of the intertidal zone (2D perspective). Describes the outline and spatial extent, or area of the intertidal zone which can change in response to prevailing coastal processes and/or realignment of the high water mark due to engineering activities.</i>
Profile	<i>Cross sectional form of an estuarine channel or gradient of the shoreline.</i>
Morphological features and substrate	Describes the shape and character of geomorphological features, and the size, structure and sorting of the intertidal sediments
Nature and extent of coastal features	<i>Topography and geomorphological and vegetation features of the coastal zone e.g. saltmarsh, seagrass, sand dunes, mudflats, sand bars, spits.</i>
Natural sediment size range	<i>Is the sediment size distribution natural</i>
Continuity and sediment supply	Assesses interruptions to coastal processes and sediment supply
Longitudinal sediment transport processes	<i>Describes sediment mobilization pathways i.e. transport of material by littoral drift from adjacent water bodies.</i>
Lateral sediment transport processes	<i>Includes land to sea connectivity and describes inputs and outputs of sediment from erosion of cliffs, catchment derived input from fluvial sources and material transported from offshore.</i>
Sub tidal Zone	Describes the size and structure of the subtidal zone
Geometry	Describes the spatial pattern and form of the subtidal zone
Planform	<i>Aerial view showing planar area of the subtidal zone (2D perspective). Describes the outline and spatial extent, or area of the subtidal zone which can change in response to prevailing coastal processes and/or engineering activities.</i>
Profile	<i>Cross sectional form of a channel or of the coastal zone perpendicular to the coastline</i>
Morphological features and substrate	Describes the shape and character of geomorphological features, and the size, structure and sorting of the intertidal sediments
Nature and extent of bed features	<i>Topography or specific features of the seabed e.g. sand banks, ripples.</i>
Natural sediment size range	<i>Is the sediment size distribution natural</i>
Continuity and sediment supply	Assesses interruptions to coastal processes and sediment supply
Longitudinal sediment transport processes	<i>Describes sediment mobilization pathways i.e. transport of material by littoral drift from adjacent water bodies.</i>
Lateral sediment transport processes	<i>Includes land to sea connectivity and describes inputs and outputs of sediment from erosion of cliffs, catchment derived input from fluvial sources and material transported from offshore.</i>

Table 5.7: Hydromorphological quality elements for TraC waters as specified in Annex V of the WFD

Transitional Waters Annex V 1.1.3	Coastal Waters Annex V 1.1.4
Morphological Conditions	
Depth variation	Depth variation
Quantity, structure and substrate of bed	Structure and substrate of the coastal bed
Structure of the intertidal zone	Structure of the intertidal zone
Tidal regime	
Freshwater flow	Direction of dominant currents
Wave exposure	Wave exposure

TraC-MImAS does not require data for the eco-geomorphic attributes defined in Table 5.6, but uses numerical values to define the likelihood and sensitivity of each of these attributes to change. These numeric values are specific to each TraC-MImAS water body type and zone (Typology Module).

The relevance of each attribute to each of the six water body types identified in Module 2 is defined. Those attributes recorded as not relevant in certain water body types are as follows:

- *Freshwater flushing / exchange* is not considered as a relevant attribute in sheltered to exposed sedimentary or sheltered to exposed bedrock coastal water bodies. However, it should be noted that Table 1.2.4 of the WFD Annex V specifies 'freshwater flow' as a component of the hydro-morphological quality element 'Tidal Regime' for coastal waters.
- *Natural sediment size range* in the intertidal and subtidal is not considered an important attribute of sheltered to exposed bedrock as high currents or waves are the dominant features in these 'types' of water body, removing mobile sediment.
- *Longitudinal and lateral sediment transport processes* are not considered important attributes of the intertidal and subtidal zones of sheltered to exposed coastal bedrock water bodies.
- *Longitudinal sediment transport processes* are also not assessed as a relevant attribute of transitional lagoons within TraC-MImAS.

Although the above attributes were considered to have little relevance to specific water body types for assessment within TraC-MImAS; the potential morphological and ecological sensitivity (Module 3) and likely impact of pressures (Module 4) on these attributes is still documented within TraC-MImAS. Therefore, following further research and liaisons with SEPA, the relevance of an attribute such as freshwater flow may be

changed from 0 to 1 to reflect the relevance of that attribute to the characteristics of a water body. This ability to update specific modules of TraC-MImAS can facilitate site specific assessments where evidence suggests that an attribute may be relevant and therefore included within the assessment.

The association of the defined eco-geomorphic attributes with water body types can be further developed as the monitoring of TraC waters progresses. This is discussed further in Chapter 9.

5.2.2 Module 2: Typology

The eighteen TraC water body types defined within Ireland and the UK for the WFD, using System B, were grouped into six overall water body types for development and application of TraC-MImAS (Table 5.8). These groupings were based on an assessment of similarities in physical characteristics and likely responses to morphological alterations. It is intended that these MImAS water body types reflect the presence and character of the attributes identified in the Attribute Module, therefore, those attributes not considered relevant to a water body type are excluded from assessments of that type.

Table 5.8: Grouping of System B-typed water bodies to six MImAS water body types

TraC Type	General morphological characteristics	MImAS Code
CW1 to CW9	Sheltered to exposed, micro to macrotidal	Coastal bedrock
CW1 to CW6	Moderately exposed to exposed, macro-tidal. Sedimentary	Moderately exposed to exposed coast - sedimentary
CW7 to CW9	Sheltered, micro-macrotidal. Sedimentary.	Sheltered coast - sedimentary
TW1 to TW4	Partially to fully mixed, mesotidal to macrotidal, intertidal or shallow subtidal, sand and mud.	Transitional meso to macrotidal
TW5, CW11, CW12	TraC Sea Lochs	TraC Sea Lochs
TW6, CW10	TraC Lagoons	TraC Lagoons

TraC-MImAS relies heavily on the typology of water bodies, a point which was highlighted at the November 2007 MTT meeting, at which the group agreed that the function of this tool would benefit greatly from the further improvement of this module.

For the purpose of the Marine Morphology Study, each TraC water body was assigned a typology from Table 5.8 above, and these are outlined in Section 6.2.2 of Chapter 6. With the agreement of the Marine Morphology Steering Group it is recommended that on completion of the monitoring programme, Irish TraC water bodies are reviewed and re-typed where required. This will help increase confidence in an assessment tool which is based on a water body's physical characteristics and likely responses to morphological alterations. Details of how monitoring results can increase confidence of water body typology are outlined in Chapter 9.

On further development of TraC-MImAS it may be possible to divide a water body into various sub-types to reflect the appropriate baseline conditions. Potential for further development may involve the possibility to increase the sensitivity of a water type if for example a large portion of its area is associated with saltmarsh i.e. the capacity of the water body is likely to be absorbed quicker due to the sensitivity [and conservation status] of saltmarsh habitats.

The typology module does not at present allow for the assessment of specific Protected Areas.

5.2.3 Module 3: Sensitivity Assessment

This module combines the morphological and ecological sensitivity of each of the six water body types to change.

Morphological Sensitivity

The likelihood that an attribute (as defined in Table 5.6) of a particular water body type will change in response to an applied pressure is quantified by estimating the resilience (ability to recover from change) and resistance (ability to absorb change) of that particular attribute to change.

- Resilience:
 - 1 (low) = system/feature is unlikely to recover to a pre-disturbance state or dynamic
 - 0.5 (moderate) = system/feature will potentially recover to a pre-disturbance state or dynamic
 - 0 (high) = system/feature is likely to recover to a pre-disturbance state or dynamic
- Resistance
 - 1 (low) = System/feature likely to respond to disturbance
 - 0.5 (moderate) = System/feature will potentially respond to disturbance
 - 0 (high) = system/feature unlikely to respond to disturbance

The minimum value estimated for resilience and resistance is then used to estimate the morphological sensitivity of each relevant eco-geomorphic attribute as follows:

- 0 = insensitive
- 0.5 = sensitive
- 1 = highly sensitive

Ecological Sensitivity

To estimate ecological sensitivity relating to all WFD biological elements the likelihood that a disturbance to individual attributes (via pressures) will result in a degradation of community of species integrity is quantified. The sensitivity values used are 0 = insensitive; 0.5 = sensitive; and 1 = highly sensitive.

It is important to note here that on removal of a pressure from a water body the ecological system may not be characteristic of a reversible system and in some cases may even return to a different ecological state (A. Edwards, 2007). It is considered that this sensitivity module will benefit greatly if updated using information obtained from monitoring programmes.

5.2.4 Module 4: Impact Assessment (Pressures)

This module forms a distinction between intensity and extent of impact and comprises two components:

- Likelihood that a morphological alteration will have an impact on an eco-geomorphic attribute

- Zone of impact: whether impacts are likely to be contained within the vicinity of the pressure, or likely to extend beyond the local vicinity of the pressure. Three categories are defined for use in TraC-MImAS; hydrodynamic, intertidal zone and subtidal zone.

The morphological alterations (pressures) considered by TraC-MImAS are listed in Table 2.1 of Chapter 2. For each of these pressures the likelihood that they will result in an impact on an attribute is estimated and quantified. For example, disposal at sea is scored as unlikely to result in an impact on tidal range and therefore assigned a value of '0', whereas land claim is considered highly likely to impact on the tidal range of a water body.

The Marine Morphology Steering Group identified some issues relating to the numeric values defined for the 'zone of impact'; details of which were passed on to SEPA and considered by the Technical Panel and Steering Group during the development of TraC-MImAS. SEPA (pers comm. S. Greig) responded by noting that it is correct to conclude that in some cases a whole water body will not be affected if the activity is small in nature. However, in assessing the impact to a water body, the zone of impact is combined with the footprint of the pressure, hence, pressures with a high zone of impact but small footprint will have a smaller impact on the water body than similar pressures over a greater area. SEPA also emphasised that some small scale works can affect a whole water body, e.g. works occurring in narrow parts of estuaries. The current TraC-MImAS tool cannot adequately address these situations.

The assessments within this module are independent of water body type; it is in combination with the Sensitivity Module that impact assessment becomes water body type specific.

5.2.5 Module 5: Capacity Based Scoring System

This module combines the outputs from all the above modules to quantify an estimated impact rating for a particular water body.

For each pressure type, an impact score is firstly calculated for each attribute relevant to that pressure using the equation summarised below.

Relevance	X	Ecological Sensitivity	X	Morphological Sensitivity	X	Likelihood of Impact
<i>Output from typology module</i>		<i>Output from sensitivity module</i>		<i>Output from sensitivity module</i>		<i>Output from pressure module</i>

These impact scores are averaged for the attributes within each water body zone (hydrodynamic, intertidal and subtidal) and then multiplied by the zone of impact to estimate the overall impact rating for each pressure within each water body type. The equation used to calculate this impact is summarised below.

Impact rating	=	Relevance	X	Ecological Sensitivity	X	Morphological Sensitivity	X	Likelihood of Impact	X	Zone of Impact
		<i>Output from typology module</i>		<i>Output from sensitivity module</i>		<i>Output from sensitivity module</i>		<i>Output from pressure module</i>		<i>Output from pressure module</i>

The percentage capacity used within a water body can then be estimated by combining the impact ratings of the existing pressures with the 'footprints' calculated for each i.e. the length or area over which a pressure extends.

The equation used within TraC-MImAS to calculate the percentage capacity used is summarised as:

$$\text{Capacity Used (\%)} = \sum n \left(\frac{\text{Impact rating} \times \text{Footprint of morphological alteration}}{\text{Length/area of assessment unit}} \right) \times 100$$

Where 'n' is the number of morphological alterations within the assessed area.

The percentage capacity for each zone is calculated as follows:

Hydrodynamics:

- the sum of all pressure footprints (e.g. land claim and causeways) within both the intertidal and subtidal zones are multiplied by the impact rating estimated for hydrodynamics then divided by the *water body area*

Intertidal Zone:

- linear pressure footprints (e.g. embankments) within the intertidal zone are multiplied by the impact rating for the intertidal, then divided by the *shoreline length*
- areal pressure footprints (e.g. land claim) within the intertidal zone are multiplied by the impact rating for the intertidal, then divided by the *intertidal area*

Subtidal Zone:

- linear pressure footprints within the subtidal zone are multiplied by the impact rating for the subtidal, then divided by the *shoreline length*
- areal pressure footprints within the subtidal zone are multiplied by the impact rating for the subtidal, then divided by the *subtidal area*

In the absence of Environmental Standards for morphology, TraC-MImAS uses Morphological Condition Limits (MCLs) to help quantify the potential risk that a new morphological alteration could impair achievement of the ecological objectives of the WFD. SEPA define the MCLs as “*thresholds of alteration to morphological conditions beyond which there is a risk that the ecological status objectives of the WFD could be threatened*”. MCLs are expressed in terms of % capacity of a water body, and are defined for 3 TraC zones: hydrodynamic; intertidal; and subtidal.

The MCLs tabulated below were trialled by Scotland and Ireland during the development of TraC-MImAS and were found to be consistent with professional opinion in approximately 85% of cases (SEPA will be publishing a final report detailing all trial results). Following these trials and the subsequent technical review (A. Edwards, 2007), the sensitivities of some pressures were reviewed and refined where required. All MCLs should be subject to review as new evidence (monitoring and research) becomes available.

Table 5.9: TraC Morphological Condition Limits (as proposed by SEPA to UKTAG 2007)

Zone	HIGH/GOOD	GOOD/MOD	MOD/POOR	POOR/BAD
	System Capacity Used (%)			
Hydrodynamics	5%	15%	30%	45%
Inter-tidal Zone	5%	15%	30%	45%
Sub-tidal Zone	5%	15%	30%	45%

These capacity limits are not water body type specific. The differences in response between water body types to pressures are accounted for in the scoring system outlined above.

Table 5.9 shows common MCLs for all three water body zones. It is important to emphasize that the MCLs represent percentage capacity used and not the percentage areal coverage of a pressure (development or activity), i.e. the impact ratings of pressures for each of the three zones are weighted differently to reflect the sensitivity of a zone (intertidal being the most sensitive and subtidal the least sensitive).

Within TraC-MImAS the risk of a water body failing the WFD objective of Good and High Ecological Status is conveyed by using the status class boundary titles; High, Good, Moderate, Poor, and Bad. TraC-MImAS uses the MCLs to help quantify the potential risk that a new morphological alteration could impair achievement of the ecological objectives of the WFD (for use in regulation).

As noted above, the impact ratings within TraC-MImAS have been generated using professional judgement and should be subject to further development. However, the framework underpinning TraC-MImAS is considered sound and should be used as the basis for developing further research and development work to provide empirical validation/calibration of the professional judgement values and/or assumptions applied in the tool. This is the long term intention of SEPA for TraC-MImAS, and work has already commenced for the Rivers-MImAS.

At a recent UK and Ireland MTT meeting (November 2007), attendees agreed the following points in relation to the use of TraC-MImAS:

- The group was comfortable that the principles and approach underpinning TraC-MImAS are logical and reasonable;
- TraC-MImAS is suitable to support the three purposes defined by SEPA:
 - Regulatory risk assessments
 - Identification of high status conditions for morphology
 - Contribute to surrogate classification assessments for the other ecological status boundaries (but not to be used in isolation)
- The condition limits proposed are set at an acceptable level for incorporation into the UKTAG Environmental Standards report; however, these values should be reviewed and refined where possible.

5.3 Pressures

The initial risk assessments and resulting risk characterisations were primarily based on the location of pressures and information relating to the ‘intensity’ of pressures was not reviewed in detail.

Following an initial review of the pressures potentially impacting on the morphology of TraC waters, it was concluded by Chapter 6 of the Literature Review (Appendix 2-1) that the most appropriate method of identifying the intensity of a pressure involved the subdivision of the primary pressure types into more defined activities to allow the resultant changes in environmental factors (morphological attributes) to be investigated. This is reflected within the structure of TraC-MImAS, i.e. to enable some form of generic assessment of the sensitivity of coastal morphology and ecology, primary and secondary pressures have been defined, for example, the subdivision of dredging into ‘low’ and ‘high’ impact categories to help represent pressure frequency and extent, and similar definition of shoreline reinforcement representing differences in pressure intensity.

Those pressures agreed for assessment of Irish TraC water bodies for the purpose of further characterisation using TraC-MImAS are outlined in Table 2.1 of Chapter 2. The physical characteristics of the identified pressures and how these were assessed for the purpose of characterisation are detailed in Chapter 3. It is important to note that these pressure definitions still remain in draft form. They were proposed on development of TraC-MImAS then further refined on completion of trials undertaken across Scotland and Ireland. Therefore, future application of TraC-MImAS will undoubtedly identify further refinements that will benefit the future development of this tool. The matrices development by *MarLIN* and SensMap when linking similar pressures to environmental factors were outlined above in Tables 5.2 - 5.3, and although these matrices do not detail the probable scale of impact, the links identified are considered consistent with those made within TraC-MImAS.

The sections below briefly outline the relationship between the pressures and potential resultant impacts on ecology and morphology. The likelihood of impacts on the eco-geomorphic attributes is tabulated for each pressure (Tables 5.10 – 5.17.)

5.3.1 Land Claim & Tidal Realignment

Land Claim is defined as follows:

- **Land claim - High impact:** Recent or proposed enclosure of intertidal or subtidal areas within impermeable banks followed by infilling for use by agriculture, housing, port development or industry. Also used for land claim that has taken place in the past and is still deemed to be having a significant impact.
- **Land claim - Low impact:** Historic (e.g. >50yrs ago) enclosure of intertidal or subtidal areas within impermeable banks followed by infilling for use by agriculture, housing, port development or industry. Can also be used for more recent land claim where the impacts are minimal or where the surrounding environment has partly recovered natural habitats and features.

The reclamation of any area of seabed has a direct impact on the biological integrity of the existing habitats. Particularly, a reduction in intertidal area can reduce the carrying capacity of existing habitats such as those associated with feeding grounds for invertebrates, fish, and / or birds. Reclamation can be associated with additional pressures related to the use of this new land such as intensive vessel movements. Further to the definition of high and low impact land claim, the impact of reclamation on TraC tidal zones is weighted differently by TraC-MImAS to reflect the increased pressure likely on intertidal zones relative to that likely within the subtidal zones.

In addition to the direct removal of habitat, this new area of land also has the potential to disrupt/alter coastal processes and natural sediment dynamics, as well as altering bathymetry.

Table 5.10: Likelihood of the pressure ‘Land Claim’ resulting in an impact on the defined eco-geomorphic attributes (extract from SEPA version a4 (2007))

Eco-geomorphic Attributes	Land Claim - Low Impact	Land Claim - High Impact
Hydrodynamics		
Tidal Range	Moderate	High
Currents	Moderate	High
Waves	Moderate	High
Flushing/exchange	Moderate	High
Salinity/mixing/stratification	Moderate	High
Freshwater Flow	Low	Low
Intertidal Zone		
Planform	High	High
Profile (lateral)	High	High
Nature and extent of coastal features	Moderate	High
Natural sediment size range	Moderate	Moderate
Longitudinal sediment transport processes	Moderate	High
Lateral sediment transport processes	Moderate	High
Subtidal Zone		
Planform	High	High
Profile	High	High
Nature and extent of coastal features	Moderate	High
Natural sediment size range	Moderate	Moderate
Longitudinal sediment transport processes	Moderate	High
Lateral sediment transport processes	Moderate	Moderate

5.3.2 Dredging, Other Disturbances to Seabed, & Disposal at Sea

Dredging is considered to be one of the most significant pressures on morphology, particularly in HMWBs containing important infrastructure such as ports. Dredging and disposal activities primarily increase turbidity/suspended sediment and deposition, which can potentially influence primary productivity by phytoplankton and the growth and survival of benthic species. Depending on the type of dredging activity, the bathymetry of a water body can be significantly altered, with aggregate dredging posing the most risk.

A significant impact of disposal at sea is considered to be that associated with the likely change in natural sediment size range. Disposal also has the direct impact of smothering existing floral and faunal habitats, and can alter bathymetry of the disposal site.

On assessing the ecological effect of dumping dredged sediments, Essink (1999) recognised impaired growth of filter feeding organisms, deriving thresholds for

smothering by deposits of one to two centimetres for these organisms. Other, more mobile macrozoobenthos were found to survive burial of 20-30cm, as they were able to migrate back to the surface (a process that took 1-2 weeks). Phytoplankton are sensitive to light penetration, which is strongly impeded by suspended sediments. Impacts of restricted light were found to be local and restricted in time, and are unlikely to always be significant at the water body scale (depending on the scale and frequency of dredging). Increased turbidity was also found to impair the growth of angiosperms such as eelgrass. Some fish avoid turbid water, and enhanced suspended matter is unfavourable to young herring and smelt, but this is difficult to generalise.

TraC-MImAS does not specifically consider suspended solids and turbidity as impacts on ecology; however, these can be related to the eco-geomorphic attribute 'natural sediment size range'.

Sedimentation brought about by the dredging and deposition of material was found to have varied impacts by Essink (1999). On intertidal flats, microphytobenthos species were found to be well adapted to natural re-working of sediment by waves and currents, however little information was sourced relating to the impacts on plants, although it is concluded that the stability of intertidal sediments plays an important role in the establishment and maintenance of sea grasses. Sessile (non-moving) species generally had a low tolerance to increased sedimentation, while motile species had more varied tolerance, often dependent on the substrate type. A change from predominantly soft sediments to hard substrates as a result of decreased sedimentation would introduce different communities, for example the development of rocky shore communities. Frequent, short disturbances (perhaps one or two per year), were found to have a similar impact to less frequent dredging in larger quantities, as less time was available for sediments to redistribute and species to recover.

Aggregate dredging within Ireland is currently not an active pressure. However, recent research undertaken in Irish waters, such as that associated with the Irish Sea Marine Aggregates Initiative (IMAGIN) will provide information to inform policy generation in this field. This pressure is likely to impact on off-shore waters, outside the WFD delineated water bodies. If most aggregate extraction is concentrated in offshore areas, adverse impacts on coastal process are likely to be limited, but impacts can include losses of species diversity, population density and biomass of benthic invertebrates in dredged areas.

The assessment of the potential impacts that dredging activities may impose on the morphology of TraC waters was considered using the following pressure types:

- **Low impact dredging:** within the Marine Morphology Study this pressure is associated with maintenance dredging for purposes of navigation as identified using the extents of shipping navigation channels, and also that associated with OPW/Local Authority channel drainage schemes of TraC water bodies and connected upstream waters
- **High impact dredging:** this was associated with identified capital dredging and is also a suitable pressure definition for aggregate dredging. However, as aggregate dredging can permanently change seabed bathymetry and significantly alter bed ecology, the impact rating defined in TraC-MImAS may need to be increased.
- **Other Disturbances to Seabed:** In addition to the presence of marine cables and pipes; this pressure type was used to define commercial dredging for shellfish

As noted above, Module 4 (impact assessment) of TraC-MImAS estimates both the intensity (likelihood) and extent of impact (zone of impact). However, during a peer review of TraC-MImAS. A. Edwards (2007) noted that the extent of impact can vary between attributes “e.g. *dredging will affect fine sediments over an area that is large relative to the dredged-out cavity*”. In the cavity benthos can be destroyed, whereas outside of this the rate of fine deposition is only increased.

To assist in compliance of Arterial Drainage Maintenance operations with the European Communities (Natural Habitat) Regulations 1997, the OPW have completed a series of ecological impact assessments of the effects of statutory arterial drainage maintenance activities on Natura 2000 sites (including raised bogs, atlantic salmon, otter, floating river vegetation and fresh water pearl mussel).

It is evident from the data review that channels maintained by OPW and local authorities are of limited extent within TraC waters. This is confirmed by OPW (2007); “Normally none or limited maintenance is required in tidal areas”. However, the boundaries of some TraC water bodies, reaching to river-like tidal channels are defined by the alterations of the original Drainage Scheme embankments and channels, which “are maintained at status quo” (OPW, 2007).

Within the series of ecological impact assessments, OPW define the differences between the construction and maintenance of Arterial Drainage Schemes.

- Construction of the original schemes required major hard engineering and typically involved widening and deepening of existing channels. Of potential relevance to downstream TraC waters; arterial drained channels have 'significantly more uniform flow velocities and a reduction in connectivity to floodplains'.
- Maintenance works are undertaken using environmental work practices to minimise ecological disturbance. Work generally consists of the removal of silt and vegetation, repairing bank damage or slippage and removal of obstructions such as trees encroaching at low levels on the banks. No excavation of virgin ground is required and generally the majority of the riparian vegetation is left intact.

To reflect this, the attributes impacted on by 'Dredging – Low Impact' were used to estimate the overall impacts of drainage channel maintenance on TraC waters.

Table 5.11: Likelihood of the pressures Dredging – High & Low Impact, Other Alterations to Seabed, and Sea Disposal, resulting in an impact on the defined eco-geomorphic attributes (extract from SEPA version a4 (2007))

Eco-geomorphic Attributes	Dredging - High Impact	Dredging - Low Impact	Other alterations to bed or substrate	Sea Disposal
Hydrodynamics				
Tidal Range	Low	Low	Low	Low
Currents	Moderate	Moderate	Moderate	Moderate
Waves	Low	Low	Low	Low
Flushing/exchange	Low	Low	Low	Low
Salinity/mixing/stratification	Low	Low	Low	Low
Freshwater Flow	Low	Low	Low	Low
Intertidal Zone				
Planform	Low	Low	Low	Low
Profile (lateral)	High	Moderate	Low	Moderate
Nature and extent of coastal features	High	Moderate	Moderate	Moderate
Natural sediment size range	High	Moderate	Moderate	High
Longitudinal sediment transport processes	High	Moderate	Moderate	Moderate
Lateral sediment transport processes	High	Moderate	Moderate	Moderate
Subtidal Zone				
Planform	Low	Low	Low	Low
Profile	High	Moderate	Low	Moderate
Nature and extent of coastal features	High	Moderate	Moderate	Moderate
Natural sediment size range	High	Moderate	Moderate	High
Longitudinal sediment transport processes	High	Moderate	Moderate	Moderate
Lateral sediment transport processes	High	Moderate	Moderate	Moderate

For the purpose of this study 'Other Disturbances to Seabed' represents ferry movements, licensed shellfish dredging areas, pipelines and cables, and wind farms.

This pressures type is defined by the SEPA MImAS study as "any other temporary disturbances to bed morphology or substrate character where the impacts are likely to be restricted to the area of bed directly disturbed and where the bed is likely to recover significantly over time".

As noted in Chapter 3, it is assumed that areas zoned for wind farms are currently undergoing investigative surveying prior to development. However, on development of these sites, the pressure on the water bodies containing these sites may be increased to account for potential impacts such as seabed area loss due to the footprint of turbine foundations (similar impacts associated with land claim), scouring, erosion and sedimentation of the seabed (dredging high/low impact) and cables and traffic. The potential ecological effects of off-shore wind farms are discussed in Hiscock *et al* (2002). The extent of licensed aquaculture sites were mapped and reviewed as a component of this pressure (estimated areas dredged for shellfish). However, detailed assessment of aquaculture is outside the scope of this study.

5.3.3 Piled Structures

TraC-MImAS addresses this pressure in the form of total area covered by the structure and not the footprint of the individual piles. Alternative footprints were assessed during the trials of TraC-MImAS, e.g. sum of the area of individual piles supporting a structure, but these proved difficult to use due to the lack of oblique coastal imagery and field trials to confirm the number and extent of piles. This method resulted in the estimation of many structures footprints in the trials, and was concluded as an inappropriate method of assessment and was therefore revised.

The technical review of TraC-MImAS found that the overall scour effects of piled structures are greater if the piles are close together (A. Edwards, 2007). This indicates that TraC-MImAS would benefit from a more refined pressure footprint for piled structures. In order to do this detailed coastal images or field trials would be required.

The construction of piled structures, such as bridges, can result in the direct loss of habitat at the footprints of the piles, whilst their presence has the potential to alter

estuarine processes and natural sediment dynamics depending on the size and number of piles.

Table 5.12: Likelihood of the pressure ‘Piled Structures’ resulting in an impact on the defined eco-geomorphic attributes (extract from SEPA version a4(2007))

Eco-geomorphic Attributes	Piled Structures
Hydrodynamics	
Tidal Range	Low
Currents	Moderate
Waves	Moderate
Flushing/exchange	Low
Salinity/mixing/stratification	Low
Freshwater Flow	Low
Intertidal Zone	
Planform	Moderate
Profile (lateral)	Moderate
Nature and extent of coastal features	Moderate
Natural sediment size range	Moderate
Longitudinal sediment transport processes	Moderate
Lateral sediment transport processes	Moderate
Subtidal Zone	
Planform	Moderate
Profile	Moderate
Nature and extent of coastal features	Moderate
Natural sediment size range	Moderate
Longitudinal sediment transport processes	Moderate
Lateral sediment transport processes	Moderate

5.3.4 Flow and Sediment Manipulation Structures

Flow and sediment manipulation structures are defined for the assessment within TraC-MImAS as ‘hard engineering structures built to stabilise waterways for navigation and to counter the effects of longshore drift’ such as piers, groynes and training walls.

Table 5.13: Likelihood of the pressure ‘Flow and Sediment Manipulation Structures’ resulting in an impact on the defined eco-geomorphic attributes (extract from SEPA version a4 (2007))

Eco-geomorphic Attributes	Flow and Sediment Manipulation
Hydrodynamics	
Tidal Range	Low
Currents	Moderate
Waves	Low
Flushing/exchange	Low
Salinity/mixing/stratification	Low
Freshwater Flow	Low
Intertidal Zone	
Planform	Low
Profile (lateral)	Moderate
Nature and extent of coastal features	Moderate
Natural sediment size range	Moderate
Longitudinal sediment transport processes	Moderate
Lateral sediment transport processes	Moderate
Subtidal Zone	
Planform	Low
Profile	Moderate
Nature and extent of coastal features	Moderate
Natural sediment size range	Moderate
Longitudinal sediment transport processes	Moderate
Lateral sediment transport processes	Moderate

These structures have the potential to disrupt tidal flow and interaction, alter estuarine processes and natural sediment dynamics. The construction of piers and slipways etc can result in direct habitat loss at the footprint of the structure.

5.3.5 Impounding Structures & Causeways

These are defined as follows:

- **Impounding Structures:** A temporary or permanent structure that extends across a channel that is used to impound, measure or alter flow (e.g. weirs, sluices).
- **Causeways:** A physical barrier projecting from the shore whose foundations extend to the bed and where gaps in the foundations represent <20% of the total length. Typically used to support transport routes.

TraC-MImAS differentiates between these pressures by assigning a lower value in the impact assessment of Causeways to indicate that the ‘likelihood’ that Causeways will

result in an impact on an eco-geomorphic attribute is less than that of impoundments. The only exception to this is for waves; both pressures are considered very likely to result in an impact on waves. This distribution of impact was queried by the Marine Morphology Steering Group, who noted that Causeways may have a more significant impact than 'moderate'.

Table 5.14: Likelihood of Impoundments resulting in an impact on the defined eco-geomorphic attributes (extract from SEPA version a4 (2007))

Eco-geomorphic Attributes	Impounding Structures	Causeways
Hydrodynamics		
Tidal Range	High	Moderate
Currents	High	Moderate
Waves	High	High
Flushing/exchange	High	Moderate
Salinity/mixing/stratification	High	Moderate
Freshwater Flow	High	Moderate
Intertidal Zone		
Planform	High	Moderate
Profile (lateral)	High	Moderate
Nature and extent of coastal features	High	Moderate
Natural sediment size range	High	Moderate
Longitudinal sediment transport processes	High	Moderate
Lateral sediment transport processes	High	Moderate
Subtidal Zone		
Planform	High	Moderate
Profile	High	Moderate
Nature and extent of coastal features	High	Moderate
Natural sediment size range	High	Moderate
Longitudinal sediment transport processes	High	Moderate
Lateral sediment transport processes	High	Moderate

As noted in Chapter 3 of this report, the footprint for impounding structures was unconfirmed by the TraC-MImAS development team (SEPA) at the time of writing. The most recent assessment method considered the proportion of the assessment area impounded, for example, if a water body was impounded for less than 25% of its area, a footprint score of 5 is entered to TraC-MImAS. These scores were not trialled sufficiently and at present all footprint scores result in a risk to the achievement of any status class. To progress the assessment of impoundments within Irish TraC waters, the following table was presented to the Marine Morphology Steering Group for discussion.

Table 5.15: Summary of thresholds and footprints proposed or used for the assessment of impoundments

Initial Risk Assessments (2004 - 2005)					
Irish Thresholds		2b - Not at Risk	2a - Probably Not at Risk	1b - Probably at Risk	1a - At Risk
		No impoundment			Impoundment present
UK-TAG Thresholds		High/Good Boundary	Good/Moderate Boundary		Identification of provisional HMWB
		Main channel free of impoundments, if tributary channels impounded, <5% of water body area affected, no critical areas affected	Main channel free of impoundments, if tributary channels impounded <10% area affected, no critical areas affected		
		<5% of intertidal areas lost due to raised water levels upstream of impoundments in tributaries	<15% of intertidal areas lost due to raised water levels upstream of impoundments in tributaries		
TraC-MImAS (2007)					
SEPA (proportion of assessment area impounded)	Impoundment	No impoundment	<25% (footprint = 5)		
			25-50% (footprint = 10)		
	Semi-permeable barrier	<25% (footprint = 0)	>50% (footprint = 25)		
			<25% (footprint = 5)		
			25-50% (footprint = 10)		
TraC-MImAS Technical Review (A.Edwards, 2007)		Ratio of impoundment entrance area to impounded surface area			

Table 5.15 summarises the thresholds/footprints used or proposed for the assessment of impounding structures. It was agreed that the definitions provided by UKTAG for the initial risk assessments were useful, but that defined by A. Edwards (2007) was most appropriate for the assessment of impounding structures, but more suited to freshwater impoundments. For the purpose of this study it was agreed that the area impounded, i.e. not expressed as a ratio, was most suitable for the assessment of areal pressure footprints within TraC-MImAS.

Within the TraC-MImAS definition of impounding structures are sluices. The assessment of these structures using the above footprint is not possible, in many cases as sluices are generally associated with embankment schemes and therefore a backup to drainage channels, or with lagoons. It was agreed that where identified, these structures should be reported on separately to the results of TraC-MImAS. For example, the following sluices are reported in Chapter 6 of this report but not assessed within TraC-MImAS:

- Swilly Estuary - has an extensive network sluices associated with the 23km of embankments identified
- Blanket Nook Lough - the flow exchange between this lagoon and Swilly estuary occurs via a sluice.

The presence of impounding structures such as barrages, causeways and sluices can alter the bathymetry in a water body, disrupt tidal flow and interaction, and alter natural sediment dynamics via loss of continuity. Impacts to ecology can include destruction and alteration of benthic habitats, loss of faunal nursery, refuge and feeding areas, as well as disruption of habitat connectivity/continuity such as fish population movements.

5.3.6 Shoreline Reinforcement

Hard shoreline defences such as sea walls fix the coastline to its position at the time of construction restricting it from naturally migrating landward or seaward in response to sea level rise, wave action etc.

Protection or defence of a shoreline can disrupt beach/dune interactions, restrict or prevent sediment inputs to the sediment budget, and more significantly, restrict the shoreline's ability to respond to sea level changes (coastal squeeze).

TraC-MImAS considers two forms of shoreline reinforcement; **high** and **low impact**. This allows the distinction between those structures which have persistent influence over the intertidal or subtidal zones such as sea walls, sheet piling and revetments, and those of 'softer' material or 'set back' with less influence on the water body.

Within TraC-MImAS, the likelihood that the following morphological attributes will be impacted by shoreline reinforcement is higher for persistent, hard engineering type structures (high impact):

- **Waves** – less persistent, or 'softer' reinforcement is less likely to restrict wave impact on the shore.
- **Nature and extent of coastal features** – the restriction of wave impact on a shoreline via the use of hard coastal structures can reduce the natural erosion/deposition of a shore.
- **Longitudinal sediment transport processes of the intertidal zone** – the restriction of waves breaking at the shore can in turn reduce the transport of material parallel to the shore (littoral drift).
- **Lateral sediment transport processes within the subtidal** – restriction of sediment input from processes such as littoral drift and shoreline erosion can impact on this sediment transport process.

Ecological impacts potentially resulting from such alterations to morphological attributes and processes include disruption to natural habitats, loss of faunal nursery, refuge and feeding areas.

Table 5.16: Likelihood of the pressure ‘Shoreline Reinforcement’ (High & Low Impact) resulting in an impact on the defined eco-geomorphic attributes (extract from SEPA version a4 (2007))

Eco-geomorphic Attributes	Shoreline Reinforcement - High Impact	Shoreline Reinforcement - Low Impact
Hydrodynamics		
Tidal Range	Low	Low
Currents	Low	Low
Waves	Moderate	Low
Flushing/exchange	Low	Low
Salinity/mixing/stratification	Low	Low
Freshwater Flow	Low	Low
Intertidal Zone		
Planform	Low	Low
Profile (lateral)	Low	Low
Nature and extent of coastal features	Moderate	Low
Natural sediment size range	Moderate	Moderate
Longitudinal sediment transport processes	Moderate	Low
Lateral sediment transport processes	Moderate	Moderate
Subtidal Zone		
Planform	Low	Low
Profile	Moderate	Moderate
Nature and extent of coastal features	Moderate	Low
Natural sediment size range	Moderate	Moderate
Longitudinal sediment transport processes	Moderate	Moderate
Lateral sediment transport processes	Moderate	Low

5.3.7 Flood Embankment

Flood embankments, similarly to shoreline reinforcement can restrict landward movement and potentially result in coastal squeeze. The restriction of flow to flood areas behind embankments can adversely impact on the condition of estuarine marsh where present i.e. impact on the nature and extent of coastal features. A reduction in sediment supply to an embanked water body can alter the morphology of that water body's intertidal and subtidal zone.

Table 5.17: Likelihood of the pressure ‘Embankments’ resulting in an impact on the defined eco-geomorphic attributes (extract from SEPA version a4 (2007))

Eco-geomorphic Attributes	Flood Defence Embankment
Hydrodynamics	
Tidal Range	Low
Currents	Low
Waves	Low
Flushing/exchange	Low
Salinity/mixing/stratification	Low
Freshwater Flow	Low
Intertidal Zone	
Planform	Low
Profile (lateral)	Low
Nature and extent of coastal features	Moderate
Natural sediment size range	Low
Longitudinal sediment transport processes	Low
Lateral sediment transport processes	Moderate
Subtidal Zone	
Planform	Low
Profile	Low
Nature and extent of coastal features	Moderate
Natural sediment size range	Low
Longitudinal sediment transport processes	Low
Lateral sediment transport processes	Moderate

5.3.8 Intensive Land Use

Assessing intensive land use quantitatively as a single pressure on marine morphology is complex. As noted in Chapter 3, a land use category inherently ‘contains’ many of the more specific and distinct pressures that have been identified and reviewed in more detail throughout this study. For example, the pressure of ‘Land Claim’ can be related to urban and industrial use, development of port infrastructure, and also to agriculture (usually historically) such as enclosure for grazing or arable production. Such pressures arise as a result of land use change acting as a ‘driver’. Another specific pressure identified as associated with ‘intensive use’ in Ireland but not directly accounted for by the current version of TraC-MImAS is that of saltmarsh grazing.

The identification of the impacts that result from these intensive use pressures has proved difficult for the following reasons:

- Difficulties determining whether the impact results from a land use pressure at the shoreline or from further upstream in the water body (for example increased sediment delivery associated with wider catchment inputs such as run off from

agricultural land or forestry). A good deal of scientific/theoretical information is available on the impacts of agricultural intensification in the uplands on river morphology and flow, but much less for estuarine and coastal environments;

- That the 'intensive use' today often results from a historical change in use up to hundreds' of years ago, resulting in legacy impacts;
- Much 'scientific' information relates to the water quality impacts of pollution resulting from land use, rather than morphological impacts;
- Current paucity of data to permit a comprehensive and consistent assessment of the pressure to all water bodies, e.g. more data is available for designated sites such as SACs.

Links between 'intensive use' and other pressures identified in this study

This issue is well illustrated by an example of the Shannon Estuary given by Healy and Hickey (2002), where approximately 6,500ha of the estuary lowlands have been reclaimed for agriculture and other purposes. Urban development and port and harbour infrastructure have had significant impacts on this estuary. Early reclamation enclosed salt marshes and mudflats with earth banks for agricultural purposes (details of which are quantified for assessment with TraC-MImAS). More recently, reclamation for industrial, commercial and recreational uses has taken place, as well as works for suburban expansion and housing development with associated embankments and revetments as flood protection devices. The 'footprints' of these pressures have been digitised for these areas in the form of 'land claim', 'flow and sediment manipulation' structures, and shoreline reinforcement. Pasture and marsh/saltmarshes have been partially drained, using channels leading to flap sluices and other outlets to artificial drainage channels and tidal creeks (the presence and maintenance of such drainage channels is quantified using estimated footprints of low impact dredging for assessment within TraC-MImAS). Further dredging of the shipping channel through the estuary was envisaged by Healy and Hickey (2002), as well as large-scale infrastructural developments. The maintenance of this tidal channel has been quantified using the footprint of the shipping channel as an indication of maintenance dredging.

The table below summarises the association of specific pressures assessed within this study with land cover types identified by the EPA CORINE 2000 land cover dataset.

Table 5.18: Matching TraC-MImAS pressures with intensive land use and land cover data

		Associated pressures (assessed independently within TraC-MImAS)										
CORINE (2000) land cover class		Initial Risk Assessment 'Intensive use'	Land Claim	Tidal channel realignment	Dredging	Disposal at Sea	Piled structures	Flow & sediment manipulation structures	Impounding structures	Causeways	Shoreline reinforcement	Flood defence embankment
111	Continuous urban fabric	Urban fabric	√	√	√		√	√	√	√	√	√
112	Discontinuous urban fabric											
133	Construction sites											
141	Green urban areas											
142	Sport and leisure facilities											
121	Industrial and commercial units	Industrial, commercial, transport	√	√	√	√	√	√	√	√	√	
122	Road and rail networks and associated land											
123	Sea Ports											
124	Airports											
131	Mineral extraction sites											
132	Dump	Arable	√						√		√	
211	Non-irrigated arable land											
241	Annual crops associated with permanent crops											
244	Agro-forestry	Coniferous forest	√									
312	Coniferous forests											

5.3.8.1 Salt Marsh Grazing

Reclamation, drainage and overgrazing have led to a marked depletion in the number of saltmarshes in Ireland, indicating that their conservation is an urgent requirement (Curtis & Skeffington, 1998).

Following land claim/enclosure, saltmarshes were historically used for grazing domestic stock. This was considered a traditional use of the land, without ploughing or agrochemicals, and created habitats of wildlife interest (grazing marsh). When unimproved permanent pasture is used for low intensity grazing, it often develops a vegetation structure attractive to nesting birds. Rare species of plants are often found in association with pasture and the brackish water drainage ditches, the latter being particularly important for a number of rare invertebrates. More recently, these semi-natural habitats have in some cases been claimed for intensive agriculture.

Grazing can still occur extensively on marshes and has a major effect on the structure and species composition of a marsh (e.g. through the grazing process itself and also soil compaction and poaching/trampling by animals). In general, as grazing intensity increases, there is a loss of structural and species diversity. Several levels of grazing, with different levels of impact, can be defined:

Light	most of the standing crop is not removed
Moderate	maximum standing crop almost completely removed
Heavy	height <10 cm, all standing crop removed
Abandoned	matted vegetation, no standing crop removed.

The intensity of grazing of saltmarsh can be estimated by matching livestock density reported by the Central Statistics Office (CSO) with the saltmarsh areas defined by the EPA CORINE 2000 dataset. A study titled 'Visual Environmental Data on Soils and Landuse' publish by Teagasc in 1999 included information and maps on the total stocking density of livestock across Ireland, using information obtained from the 1991 Agricultural Census which report density per District Electoral Division, and therefore easily mapped. However, the most recent Agricultural Census (2000) only provides livestock data per county and excludes the land types marsh, bog and unused rough grazing. These limitations prevented the identification of grazed saltmarsh areas neighboring TraC waters.

The NPWS are currently undertaking a review of Ireland's saltmarsh, with the aim to map all areas identified. It was agreed with the Marine Morphology Steering Group that on completion of this NPWS study the mapped saltmarsh extents should be compared with the outputs of this study, and more detailed census of livestock density.

5.3.8.2 Peat Bogs

The initial risk assessments completed in 2005 identified a strong correlation between mapped Bord na Mona peat extraction areas and CORINE information, therefore, CORINE data was used in this assessment.

Exploitation and severe over-grazing of bog can result in extensive loss of plant cover which in turn can lead to erosion of the surface peat by wind and rain. However, changes in the management of agricultural and peat lands over the past decade has introduced supportive measures (as outlined below) that have reduced impacts on TraC waters from exploitation of peat bogs. These pressures are therefore not considered significant for the morphological quality of Ireland's TraC waters.

A conference titled 'The state of biological diversity in the European Union' held in May 2004 reported that wetlands cover 16% of the surface of Ireland and peat-bogs represent 95% of this total. The main peat-bog areas are concentrated in the West and North West of Ireland. In addition to land disturbance associated with exploited bogs, these areas are drained to facilitate cutting. Once the land is drained, it is suitable for other purposes such as coniferous forests. The conversion of peat-bogs to transitional shrub land as a result of drainage is also common. This change in land use can contribute to the pressures on wetland ecosystems.

The introduction of the EU Headage Payment Scheme led to large increases in sheep numbers with a near "three-fold increase nationally since 1980" (MacGowan, 2002). Several studies have reported the impact of over grazing, but generally focus on lakes and rivers. The loss of plant cover leads to the erosion of peat (down to the mineral soil in some places) which are known to result in the siltation and acidification of lakes, which in turn impacts on spawning beds of salmon and trout. It can be assumed therefore, that similar impacts were likely of estuaries and lagoons bordering such lands. However, in 1994 the voluntary Rural Environmental Protection Scheme (REPS) was initiated to 'reward farmers for carrying out their farming

activities in an environmental friendly manner and to bring about environmental improvement on existing farms'. This scheme has gone some way in reducing over grazing of peat bogs. However, arable and intensive grassland are not recognised as REPS habitats.

Recent research by Teagasc involves 16 projects focused primarily on research strategies to reduce pollution from agriculture. This indicates that the current practices surrounding agriculture and peat-bogs do not severely impact on the morphology of transitional and coastal waters and are more significant to the degradation of water quality.

Many raised and blanket bogs are designated Special Areas of Conservation or proposed Natural Heritage Areas, and under REPS peat lands are protected from their main threats of land improvement (turf cutting and afforestation), and sustainable grazing is promoted.

In 2003 the Department of Agriculture, Food and Rural Development (DARD) published Commonage Framework plans in agreement with the DEHLG. These include grazing regimes for the commonage.

On review of the existing management schemes and statutory protection of sensitive habitats, the impact of agricultural land use is not considered as a significant impact to the morphology of TraC waters. However, this is with the exception of saltmarsh; the further assessment of saltmarsh grazing is recommended on completion of the NPWS study to help quantify the extent of intensive grazing of these habitats.

5.3.8.3 Intensive Sea Use

In addition to the range of intensive land uses at the margins of estuarine and coastal areas, the sea itself is subject to increasing human activities and uses. Where these uses involve building structures or dredging, the pressure will be assessed as appropriate using TraC-MImAS. The types of activity that could result in morphological pressures include:

- Aggregate extraction or navigation dredging;
- Deposition of waste/dredgings at sea;
- Cable and pipe laying;

- Energy projects including marine wind turbine generators, wave energy generators and tidal barrages;
- Marine aquaculture and fishing
- Shipping

The morphological impacts associated with these pressures are discussed above. Although highly site and activity specific, the potential impacts could be generically summarised to include: substrate removal; scour and alteration of bed topography; altered turbidity/light levels; sediment mobilisation and plumes; re-suspension and smothering by fine sediment.

The most significant intensive sea use within Ireland is that of aquaculture, with licensed areas occupying approximately 17 % (2548km²) of the TraC water body area, 15084km². Detailed assessment of the impact of aquaculture practices is outside the scope of this study (refer to Chapter 2, Section 2.1).

5.4 Development & Use of TraC-MImAS for the Purpose of Risk Assessments

TraC-MImAS uses the concept of system capacity to estimate the risk of a water body failing to meet WFD status classes. The following is an example of how this system estimates this risk using the five modules detailed in Sections 5.2.1 – 5.2.5 above.

5.4.1 Clonakilty Harbour (SW_100_0100)

This water body was characterised by the initial risk assessments as ‘probably at risk’ from combined sewer and treatment plant overflows, and ‘probably not at risk’ from point source discharges of waste water treatment plants and intensive land use. Further characterisation of the pressures on this water body and assessment using TraC-MImAS indicate that this water body is at risk of not achieving GES due to physical alterations. If the pressures associated with point source discharges were mitigated with the aim of achieving GES, the results of TraC-MImAS indicate that physical (morphological) alterations in this water body may prevent the attainment of GES.

Module 1 – Attribute Module & Module 2 – Typology Module

Clonakilty Harbour was classed as a water body type TW2 (polyhaline, mesotidal and sheltered), which when using TraC-MImAS translates to a transitional, meso to macrotidal water body. All eco-geomorphic attributes assessed within TraC-MImAS are considered relevant to this type of water body.

Module 3 – Sensitivity Assessment

Table 5.19 below details the sensitivity values estimated for the ecology and morphology of this type of water body, i.e. transitional meso to macro tidal. The key to this table outlines the meanings of the values assigned.

Table 5.19: Sensitivity values estimated for the ecology and morphology of Clonakilty Harbour (transitional meso – macro tidal water body)

Ecogeomorphic Attributes	Ecological Sensitivity	Morphological Sensitivity - Resistance	Morphological Sensitivity - Resilience	Morphological Sensitivity (Min of Resistance & Resilience)
Hydrodynamics				
Open Water				
Tidal Range	0.5	0.5	0.5	0.5
Currents	0.5	0.5	0.5	0.5
Waves	0.5	0.5	0.5	0.5
Freshwater Influence				
Flushing/exchange	0.5	0.5	0.5	0.5
Salinity/mixing/stratification	0.5	0.5	0.5	0.5
Freshwater Flow	0.5	0.5	0.5	0.5
Intertidal Zone				
Geometry				
Planform	1.0	1	1	1.0
Profile	0.5	0.5	0.5	0.5
Morphological features & substrate				
Nature and extent of coastal features	1.0	0.5	0.5	0.5
Natural sediment size range	0.5	0.5	0.5	0.5
Continuity and sediment supply				
Longitudinal sediment transport processes	0.5	0.5	0.5	0.5
Lateral sediment transport processes	0.5	1	0.5	0.5
Subtidal Zone				
Geometry				
Planform	1.0	1	1	1.0
Profile	0.5	0.5	0.5	0.5
Morphological features & substrate				
Nature and extent of coastal features	1.0	0.5	0.5	0.5
Natural sediment size range	0.5	0.5	0	0
Continuity and sediment supply				
Longitudinal sediment transport processes	0.5	1	0	0
Lateral sediment transport processes	0.5	0.5	0	0
KEY:				
0	Insensitive	System/feature unlikely to respond to disturbance	System/feature will likely recover to a pre-disturbance state or dynamic	Insensitive
0.5	Sensitive	System/feature will potentially respond to disturbance	System/feature will potentially recover to a pre-disturbance state or dynamic	Sensitive
1	Highly Sensitive	System/feature likely to respond to disturbance	System/feature unlikely to recover to a pre-disturbance state or dynamic	Highly Sensitive

The morphological features of least sensitivity in this type of water body are subtidal natural sediment size range, longitudinal and lateral sediment transport. It is considered that although these features are likely to respond to disturbance, they are resilient and likely to recover. The morphological attribute considered most sensitive is planform. A change to the spatial extent and / or intertidal zone as a result of prevailing coastal processes or realignment of the high water mark due to physical alterations (pressures) is considered difficult to resist in such a water body, and changes to these attributes are likely to prevent recovery to a pre-disturbed state/dynamic.

Module 4 – Impact Assessment (Pressure) Module

Now that the sensitivity of changes to the morphological attributes relevant to a meso to macrotidal transitional water body such as Clonakilty Harbour is estimated, the 'likelihood' that pressures will have an impact on these attributes can be determined (see table 5.20).

The physical alterations (pressures) identified for Clonakilty Harbour are listed below, and Table 5.21 shows how these pressures are distributed between the intertidal and subtidal zones.

- High impact land claim
- Structures that manipulate flow / sediment – non-piled piers and slipway
- High impact shoreline reinforcement – associated with the harbour and surrounding roads
- Embankments

The following key is used to estimate the likelihood of these pressures impacting the attributes relevant to this water body:

- 1** In most cases, this activity will result in an impact on a eco-geomorphic attribute
- 0.5** In some cases, this activity will result in an impact on a eco-geomorphic attribute
- 0** In most cases, this activity will not result in an impact on a eco-geomorphic attribute

Table 5.20: Likelihood of pressures identified in Clonakilty Harbour resulting in an impact on the defined attributes

Ecogeomorphic Attributes	Land Claim - High Impact	Flow and Sediment Manipulation Structures	Shoreline Reinforcement - High Impact	Flood Defence Embankment
Hydrodynamics				
Open Water				
Tidal Range	1	0	0	0
Currents	1	0.5	0	0
Waves	1	0	0.5	0
Freshwater Influence				
Flushing/exchange	1	0	0	0
Salinity/mixing/stratification	1	0	0	0
Freshwater Flow	0	0	0	0
Intertidal Zone				
Geometry				
Planform	1	0	0	0
Profile (lateral)	1	0.5	0	0
Morphological features & substrate				
Nature and extent of coastal features	1	0.5	0.5	0.5
Natural sediment size range	0.5	0.5	0.5	0
Continuity and sediment supply				
Longitudinal sediment transport processes	1	0.5	0.5	0
Lateral sediment transport processes	1	0.5	0.5	0.5
Subtidal Zone				
Geometry				
Planform	1	0	0	0
Profile	1	0.5	0.5	0
Morphological features & substrate				
Nature and extent of coastal features	1	0.5	0.5	0.5
Natural sediment size range	0.5	0.5	0.5	0
Continuity and sediment supply				
Longitudinal sediment transport processes	1	0.5	0.5	0
Lateral sediment transport processes	0.5	0.5	0.5	0.5

As discussed in Chapter 3, the extents of pressures are calculated for the intertidal and subtidal zones of a water body, i.e. the pressure 'footprint' (see Table 5.21). The pervasiveness of these pressures to attributes outside this footprint is then identified by estimating its 'zone of impact' (see Table 5.22).

Table 5.21: Pressure footprints identified for Clonakilty Harbour

Pressures		Meso - macro Tidal	
		Location of Activity	
		Intertidal	Subtidal
Land claim- High impact	Area (km ²)	0.030933	0.001091
Land claim- Low impact	Area (km ²)		
Dredging- High Impact	Area (km ²)		
Dredging- Low impact	Area (km ²)		
Other disturbances to seabed	Area (km ²)		
Sea disposal of dredgings	Area (km ²)		
Structure to manipulate flow/sediment	Area (km ²)	0.002029	
Structures with piled supports	Area (km ²)		
Shoreline reinforcement- High impact	Length (km)	5.108	0.07
Shoreline reinforcement- Low impact	Length (km)		
Flood defence embankment	Length (km)	2.01418	
Tidal channel realignment- High Impact	Length (km)		
Tidal channel realignment- Low impact	Length (km)		
Impounding structure	Footprint rules		
Causeway	Length (km)		

Table 5.22: Estimated Zone of Impact for the pressures identified in Clonakilty Harbour

Activity	Zones		
	Hydrodynamics	Structure of the Intertidal	Structure of the Subtidal
Land claim - High Impact	2	2	2
Flow & sediment manipulation	1	1.5	1.5
Shoreline reinforcement - High Impact	1	1	1.5
Embankment	1	1	1

Module 5: Capacity Based Scoring System

Section 5.2.5 above introduced how the output values from the first four modules are used to calculate an impact score for each attribute relevant to the existing pressures within a water body.

Table 5.23 shows how the impact ratings were estimated for 'Shoreline Reinforcement – high impact' in a transitional meso to macro tidal water body type, using the equation below. The impact values for each attribute are first calculated and are then averaged to provide an impact score for each of the three water body zones.

Relevance	X	Ecological Sensitivity	X	Morphological Sensitivity	X	Likelihood of Impact
<i>Output from typology module</i>		<i>Output from sensitivity module</i>		<i>Output from sensitivity module</i>		<i>Output from pressure module</i>

Table 5.23: Impact Assessment of Shoreline Reinforcement (High Impact) in a water body typed as Transitional meso to macro tidal

	Transitional				
	Meso - macro tidal				
Ecogeomorphic Attributes	Relevance	Ecological Sensitivity	Morphological Sensitivity	Likelihood of Impact	IMPACT
Hydrodynamics					0.06
Open Water					0.125
Tidal Range	1	0.5	0.5	0	0
Currents	1	0.5	0.5	0	0
Waves	1	0.5	0.5	0.5	0.125
Freshwater Influence					0
Flushing/exchange	1	0.5	0.5	0	0
Salinity/mixing/stratification	1	0.5	0.5	0	0
Freshwater Flow	1	0.5	0.5	0	0
Intertidal Zone					0.17
Geometry					0
Planform	1	1	1	0	0
Profile	1	0.5	0.5	0	0
Morphological features & substrate					0.25
Nature and extent of coastal features	1	1	0.5	0.5	0.25
Natural sediment size range	1	0.5	0.5	0.5	0.125
Continuity and sediment supply					0.25
Longitudinal sediment transport processes	1	0.5	0.5	0.5	0.125
Lateral sediment transport processes	1	0.5	1	0.5	0.25
Subtidal Zone					0.21
Geometry					0.125
Planform	1	1	1	0	0
Profile	1	0.5	0.5	0.5	0.125
Morphological features & substrate					0.25
Nature and extent of coastal features	1	1	0.5	0.5	0.25
Natural sediment size range	1	0.5	0.5	0.5	0.125
Continuity and sediment supply					0.25
Longitudinal sediment transport processes	1	0.5	1	0.5	0.25
Lateral sediment transport processes	1	0.5	0.5	0.5	0.125

The impact score calculated for Shoreline Reinforcement (high impact) in each tidal zone of this water body type is then multiplied by the Zone of Impact to estimate the overall Impact Rating for the pressure.

Example: Intertidal zone of Clonakilty Harbour subject to shoreline reinforcement (high impact)

Impact Rating	=	Relevance	X	Ecological Sensitivity	X	Morphological Sensitivity	X	Likelihood of Impact	X	Zone of Impact
		Output from typology module		Output from sensitivity module		Output from sensitivity module		Output from pressure module		Output from pressure module
0.17	=					0.17			X	1

The percentage capacity used within Clonakilty Harbour is then estimated by combining the impact ratings of all existing pressures for each tidal zone. Table 5.24 below shows how this was calculated using the equation below. As noted in Section 5.2.5 of this report; the 'assessment unit' is the total water body area for the hydrodynamics, shoreline length and intertidal area for the intertidal zone, and shoreline length and subtidal area for the subtidal zone.

$$\text{Capacity Used (\%)} = \sum n \left(\frac{\text{Impact rating} \times \text{Footprint of morphological alteration}}{\text{Length/area of assessment unit}} \right) \times 100$$

Table 5.24: Summary of how the % System Capacity was calculated for Clonakilty Harbour

	Pressure Footprints		Impact Ratings			Impact Rating x Pressure Footprint		
	Intertidal	Subtidal	Hydrodynamics	Intertidal Zone	Subtidal Zone	Hydrodynamics	Intertidal Zone	Subtidal Zone
Shoreline Reinforcement (High)	5.108	0.070	0.06	0.17	0.31	0.32	0.85	0.02
Land Claim (High)	0.030933	0.00109	0.50	1.33	1.33	0.02	0.04	0.00
Embankment	2.014	0	0.00	0.17	0.13	0.00	0.34	0.00
Flow and Sediment Manipulation Structures	0.002029	0	0.06	0.31	0.31	0.00	0.00	0.00
Total Impact Rating per Tidal Zone						0.34	1.23	0.02
Shoreline Length (km)	10.478		Water Body Areas (km ²)			1.80	1.69	0.11
			% Capacity Used - Areal Pressures				2.48	1.29
			% Capacity Used - Linear Pressures				11.33	0.21
			Total % Capacity Used			18.8	13.8	1.5

5.4.2 Development and approval stages of TraC-MImAS for use as a morphological assessment tool in Ireland

The development of TraC-MImAS has been ongoing within SEPA since mid-2006. Prior to TraC-MImAS, the Marine Morphology study investigated the use of 'Metrics' which were being developed by the Environment Agency in association with SNIFFER. This project, titled 'Development of Hydromorphological Reference Conditions and Draft Classification Scheme for Transitional and Coastal Waters', aimed to develop hydromorphological reference conditions and a draft classification scheme for TraC waters, defining only high status and the boundary between high/good. As with TraC-MImAS, the threshold limits proposed by this study were largely based on expert judgement due to the "considerable limitations in current understanding and availability of data" (SNIFFER, 2007). Table 5.25 below summarises the nine metrics proposed by this project for the classification of TraC waters.

Table 5.25: Summary of Metrics and thresholds

Metric	Description	Assessment Threshold
1	Habitat loss	% habitat loss
2	Changes in sediment budget & composition	Length of frontage influenced by reinforcement or beach management/ total length of WB frontage.
3a	Changes in morphology: Bed disturbance	Relative bed disturbance in relation to WB sensitivity (take account of fishing gear type)
3b	Changes in sediment budget & composition	Qualitative assessment based on expert judgement of available evidence & locations/extent of dredging/ reclamation activities
4	Hydromorphological element: hydrological conditions / Changes in forces: Waves	Area influenced by structures/ area of WB
5	Changes in forces: Tides	Presence/ absence of artificial barrages etc.
6	Changes in forces: River flow	Is river flow at downstream assessment point of the adjacent river WB at high status (10%less than QN95)?
7a	Changes in forces: Stratification/flushing	Sea lough
7b	Salinity	% of area or length influenced

As these metrics were developed for high/good boundary assessments only; greater emphasis was required for "ensuring that the biological classification scheme

incorporated metrics that were sensitive to hydromorphological changes” (SNIFFER, 2007).

In July 2006, a UKTAG Special Transitional and Coastal Water Body meeting was held in Edinburgh to determine if, and how, environmental standards could be developed for TraC waters within the time scales required of the first river basin planning cycle. Both the River MImAS tool and the Metrics tabulated above were presented by SEPA and the EA respectively. It was concluded at this meeting that the framework currently being developed for the Metrics would require further development within a more structured framework to allow environmental standards to be developed and approved. UKTAG requested that SEPA and the EA compare the two assessment methods and determine if the MImAS framework could be successfully adopted for TraC waters. It was confirmed to UKTAG that the scientific principles underpinning MImAS were transferable to TraC waters; therefore work on the draft tool commenced.

As part of the development process, and to provide consistency throughout Ireland and the UK, SEPA requested that TraC-MImAS was trialled for a selection of water bodies. As of August 2007, both Scotland and Ireland had completed trials for 34 water bodies. The purpose of the trials was to test the appropriateness of the MCLs and the also the framework in which MImAS is applied to support regulation.

Trial workshops were held by RPS Consulting and Jacobs in Belfast and Dublin. Representatives from the EPA, Marine Institute, and Environment Heritage Service (EHS) provided guidance and feedback on the proposed TraC-MImAS tool and trial results. Following the trials in Irish water bodies, TraC-MImAS was approved by the Marine Morphology Steering Group as a risk assessment tool suitable for the further characterisation of TraC water bodies.

The results of the RoI trials, outlined in Appendix 6-1, were submitted to SEPA in September 2007 for incorporation with those of Scotland and Northern Ireland to assist with further development/refinement of the tool.

TraC-MImAS was updated on completion of both these trials and an external technical review undertaken by Anton Edwards of Metoc Environmental Consultants. In November

2007, the UK-Ireland Marine Task Team endorsed TraC-MImAS as a **regulatory support tool** and also agreed that in the absence of other assessment tools TraC-MImAS is **suitable as a support tool for classification** pending further development. The further development of the typology module of this tool was a key recommendation of this group. With regard to the further development of the MCLs; further field assessments including investigative monitoring are required to refine the association of these values with morphological and ecological status class, this is discussed further within Chapters 9 and 10.

Following endorsement by the both the Marine Morphology Steering Group and Marine Task Team, TraC-MImAS was applied to Irish TraC water bodies for the purpose of further characterising the risk associated with anthropogenic physical alterations.