National Development Plan 2007 - 2013

Environmental Protection Agency
An Ghníomhaireacht um Chaomhnú Comhshaoil

STRIVE
Report Series No. 7

WATER FRAMEWORK DIRECTIVE – Marine Ecological Tools for Reference, Intercalibration and Classification (METRIC)

STRIVE

Environmental Protection Agency Programme

2007-2013

SSTI Strategy for Science, Technology and Innovation

Comhshaol, Oidhreacht agus Rialtas Áitiúil
Environment, Heritage and Local Government

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ÁR bhFREAGRACHTAÍ

CEADÚNÚ

Bíonn ceadúnais á n-eisiúint againn i gcomhair na nithe seo a leanas chun a chinntiú nach mbíonn astuithe uathu ag cur sláinte an phobail ná an comhshaol i mbaol:

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- Cur i bhfeidhm na Treorach um Thrádáil Astuithe, a bhfuil baint aige le hos cionn 100 cuideachta atá ina mór-ghineadóirí dé-ocsaíd charbóin in Éirinn.

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BAINISTÍOCHT DRAMHAÍOLA FHORGHNÍOMHACH

- Cur chun cinn seachaint agus laghdú dramhaíola trí chomhordú An Chláir Náisiúnta um Chosc Dramhaíola, lena n-áirítear cur i bhfeidhm na dTionscnamh Freagrachta Táirgeoirí.
- Cur i bhfeidhm Rialachán ar nós na treoracha maidir le Trealamh Leictreach agus Leictreonach Caite agus le Srianadh Substaintí Guaiseacha agus substaintí a dhéanann ídiú ar an gcrios ózóin.
- Plean Náisiúnta Bainistíochta um Dramhaíl Ghuaiseach a fhorbairt chun dramhaíl ghuaiseach a sheachaint agus a bhainistiú.

STRUCHTÚR NA GNÍOMHAIREACHTA

Bunaíodh an Ghníomhaireacht i 1993 chun comhshaol na hÉireann a chosaint. Tá an eagraíocht á bhainistiú ag Bord lánaimseartha, ar a bhfuil Príomhstiúrthóir agus ceithre Stiúrthóir.

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Tá Coiste Comhairleach ag an nGníomhaireacht le cabhrú léi. Tá dáréag ball air agus tagann siad le chéile cúpla uair in aghaidh na bliana le plé a dhéanamh ar cheisteanna ar ábhar imní iad agus le comhairle a thabhairt don Bhord.

EPA STRIVE Programme 2007–2013

WATER FRAMEWORK DIRECTIVE – Marine Ecological Tools for Reference, Intercalibration and Classification (METRIC)

(2005-W-MS-36-M1)

STRIVE Report

Prepared for the Environmental Protection Agency

by

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The EPA STRIVE Programme addresses the need for research in Ireland to inform policymakers and other stakeholders on a range of questions in relation to environmental protection. These reports are intended as contributions to the necessary debate on the protection of the environment.

EPA STRIVE PROGRAMME 2007–2013

Published by the Environmental Protection Agency, Ireland

ISBN: 1-84095-271-7

Price: Free

Online version

ACKNOWLEDGEMENTS

This report is published as part of the Science, Technology, Research and Innovation for the Environment (STRIVE) Programme 2007–2013. The programme is financed by the Irish Government under the National Development Plan 2007–2013. It is administered on behalf of the Department of the Environment, Heritage and Local Government by the Environmental Protection Agency which has the statutory function of co-ordinating and promoting environmental research.

The authors wish to thank all those who provided historical data for this study including Glan Uisce Teo (Mary Hensey), the Environmental Protection Agency (Shane O'Boyle), Dublin City Corporation (Tim O'Higgins and Bartholomew White), Marine Harvest (Catherine McManus), University of Sterling, National University of Ireland, Galway (Robert Kennedy and James Dunne), Trinity College Dublin (Jim Wilson), Galway–Mayo Institute of Technology (Pauline King), Eli Lilly, Aquafact, Edward Fahy and Russell Poole (Marine Institute). Special thanks to Shane O'Boyle and Robert Wilkes (EPA) for assistance with fieldwork and advice on the plant classification tools and Alison Miles and Graham Philips (Environment Agency, UK) for their support and advice on the benthic portion of the project. The authors are grateful to Kieran Lyons and Glenn Nolan (Ocean Science Services, Marine Institute) for the valuable comments and data quality control assistance. The authors thank the seven Regional Fisheries Boards for their assistance with the fish investigations. Particular thanks are due to the Northern Regional Fisheries Board for facilitating the fisheries gear intercomparison work. The authors appreciate the comments and suggested changes by the METRIC Scientific Steering Committee, Micheál O'Cinnéide and those who reviewed the report.

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Executive Summary

Water quality monitoring programmes exist in many of the Member States throughout the European Union (EU). With the implementation of the Water Framework Directive (WFD, Council Directive 2000/60/EC) all Member States must harmonise their national monitoring methods for each common metric (parameter indicative of a biological water quality element) used to determine the state of the aquatic environment to ensure consistent and comparable classification results for all biological community quality elements used (WFD Annex V, 1.4.1). The Marine Ecological Tools for Reference, Intercalibration and Classification (METRIC) project, therefore, was designed specifically to support the Irish role in the EU Intercalibration Exercise of biological quality elements (BQEs) in order to set harmonised ecological quality criteria for the assessment of water quality in the transitional and coastal (TraC) waters of Europe.

The BQEs investigated by METRIC included:

- Plants (phytoplankton, macroalgae and angiosperms)
- Benthic macroinvertebrates (soft-bottom habitat)
- Fish (estuarine).

The normative definitions as set out in the WFD were used to determine reference conditions and the classification boundaries between high–good (H-G) (i.e. what constitutes high and good ecological quality status of a waterbody) and good–moderate (G-M) ecological quality status (WFD Annex V). The ecological quality status of a waterbody (management unit) is an overall expression of the structure and function of its biological community, taking into account geographical and climatic factors, together with physical and chemical conditions, including those resulting from anthropogenic influences. An important step in this process was the quality of the reference condition data since this standard determines the levels at which all quality class boundaries are set. Collated data of Irish aquatic plants (phytoplankton, macrophytes and angiosperms), benthic macroinvertebrates and estuarine fish data, best contemporary data plus historic records from undisturbed waterbodies, and expert advice were used to set the values for reference conditions (pristine conditions, i.e. no human influence) or near-reference conditions (unimpacted sites, i.e. assumed to be in reference condition).

These biological values and expert opinion were then used to determine acceptable levels for the H-G and G-M ecological quality status class boundary for each common biological metric (parameter indicative of a BQE) using the tools (assessment method through data analysis of collected measurements) put forward by the North-East Atlantic Geographical Intercalibration Group (NEA-GIG). The ecoregion intercalibration groups must make every effort to identify the boundaries of the good ecological class status as a numerical value called the Ecological Quality Ratio (EQR) value for all the waterbody-type/BQE/pressure combinations. Irish scientists, including members of the METRIC project team, participated in the intercalibration meetings. Essential processed and analysed data (species composition, taxonomic abundance, diversity, sensitive disturbance taxa spatial extent, etc.) were provided to assist with the harmonisation of data analysis across all participating EU Member States. All Member States must demonstrate that the selected H-G and G-M class boundaries in their national assessment method are comparable with the same level of ecosystem alteration determined by the tools used by the NEA-GIG.

A report called the NEA-GIG *Milestone 6* report (available online at: http://circa.europa.eu/Public/irc/env/wfd/home) explains in detail how reference values were determined by each Member State using data from undisturbed waterbodies and expert opinion, and how the ecological class boundaries were decided. It also describes in detail how the national assessment method of each Member State was harmonised with the NEA-GIG metrics and tools. Ireland fulfilled the requirements of this exercise and provided valuable data from near-reference sites which assisted other EU Member States.

Data collected throughout the project were also used to test and validate the United Kingdom–Republic of Ireland (UK-Ire) WFD Marine Task Team's (MTT) classification tools (data analysis methods) with their selected metrics, developed to determine the ecological quality status of TraC waters. Close co-operation between scientists in Ireland, including members of the METRIC project, and the UK has developed through the MTT charged with advancing the aims and obligations of the Directive. A comparison and testing of the different tools developed were performed on data collected and processed during the METRIC project to evaluate the suitability of the proposed MTT tools.

This report is divided as follows:

- Chapter 1 is an introduction
- Chapter 2 presents a summary of Irish data sources that fed into the EU-wide NEA-GIG intercalibration process
- Chapter 3 explains the classification tools developed by the UK-Ire MTT for each BQE investigated. In the event that this was not possible, as was the case for the fish subgroup, detailed information on an EU-wide Intercalibration/Intercomparison Exercise on different sampling methods is described
- Chapter 4 explains how type-specific (habitat-specific) reference conditions and ecological quality status classification boundaries were determined for Irish waterbodies, and
- Chapter 5 outlines the Main Recommendations from the project.

1 Introduction

The European Union Water Framework Directive (EU WFD) was published in 2000 and was transposed into Irish law in 2003 (S.I. No. 722 of 2003). Under this Directive, Ireland is obliged to carry out monitoring to ensure that its waters retain a set quality status or are improved to achieve a target status. The criteria for water quality have been expanded beyond the traditional narrow chemical criteria to include a range of biological indicators or quality elements. Waters are divided into groundwater, rivers, lakes, transitional and coastal waters. Under Article 5 of the WFD Member States were required to designate waterbodies within River Basin Districts (RBDs) according to specific types. These waterbody types were characterised by a series of obligatory and optional factors identified within the Directive and included:

- Mixing characteristics – transitional and coastal waters
- Salinity – transitional and coastal waters
- Mean tidal range – transitional and coastal waters
- Wave exposure – transitional and coastal waters
- Depth – transitional waters only
- Substratum – transitional waters only.

An output of the typology process carried out jointly for marine and transitional waters by the UK and Ireland was a range of waterbody types for transitional (n = 6) and coastal waters (n = 12) (see http://www.wfduk.org/tag_guidance/Article_05). For Ireland, two transitional water types and five coastal water types were identified and these are summarised in Table 1.1 (see http://www.wfdireland.ie/).

In transitional and coastal waters there is an obligation to monitor biological criteria or quality elements including plants (phytoplankton, macroalgae and angiosperms), benthos, and fish (transitional waters only). For all the ecological quality elements, there is a broad obligation to monitor the composition and abundance of all taxa (WFD Annex V, Part I.I) as well as a requirement to identify type-specific species and disturbance-sensitive species (WFD Annex V, Part I.2). Under the Directive there is a requirement to set class boundaries for the Ecological Quality Ratios (EQRs) of all Biological Quality Elements (BQEs). The EQR is the numerical mechanism for reporting on the quality of waters under the Directive. It is defined as the relationship between the reference value and the observed value after a water quality assessment (WFD = 6-year cycle) has been carried out (Fig. 1.1 presents an EQR). A waterbody must score satisfactorily (good

Table 1.1. Waterbody typologies designated for Irish transitional and coastal waters.

Irish type	European type	Name	Mixing	Salinity	Tidal range	Exposure	Depth	Substratum
TW2	CW-NEA11	n/a	n/a	Meso/Polyhaline	Strongly mesotidal	Sheltered	n/a	n/a
TW6	n/a	Transitional lagoons	n/a	Oligo/Polyhaline	Mesotidal	Sheltered	n/a	n/a
CW2	n/a	n/a	n/a	Euhaline	Mesotidal	Exposed	n/a	n/a
CW5	CW-NEA1	n/a	n/a	Euhaline	Mesotidal	Moderately exposed	n/a	n/a
CW6	n/a	n/a	n/a	Euhaline	Microtidal	Moderately exposed	n/a	n/a
CW8	CW-NEA2/6	n/a	n/a	Euhaline	Mesotidal	Sheltered	n/a	n/a
CW10	n/a	Coastal lagoons	n/a	n/a	n/a	n/a	n/a	n/a

TW, transitional waters; CW, coastal waters; NEA, North-East Atlantic.

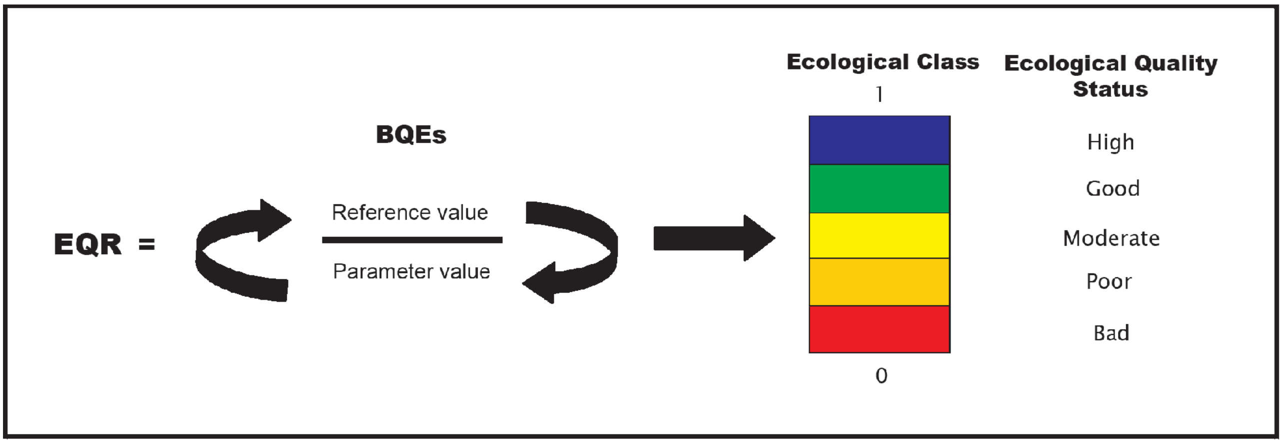

Figure 1.1. Ecological Quality Ratio (EQR) used to determine the ecological water quality status. The parameter value is divided by the reference value in cases where, for example, species richness is investigated: the lower the diversity the lower the EQR value. The opposite is the case in biomass of, for example, chlorophyll, i.e. the reference value is divided by the parameter value: the higher the chlorophyll levels the lower the EQR value.

or higher) under all of its measured quality elements – if one quality element does not attain the appropriate standard for a status level (good or high) then the water does not qualify as having that status.

In 2005, the Environmental Protection Agency (EPA), conscious of the shortfalls identified by the Irish personnel involved with TraC waters, allocated funding to facilitate development of capacity to implement the WFD in such waters. The project undertook to examine methods for data collection and metrics (parameters indicative of a biological water quality element) for data interrogation with a view to developing further the classification tools (data analysis methods) and establishing boundary criteria for the various EQRs.

The Marine Ecological Tools for Reference, Intercalibration and Classification (METRIC) project was also designed to meet an additional key WFD deliverable for Irish TraC waters. This objective was to further develop classification tools for the metrics specified in the Directive and to support the EU Intercalibration Exercise in order to set harmonised ecological quality criteria for the assessment of TraC waters in Ireland. The aim of the intercalibration exercise was to acquire a series of harmonised classification systems throughout Europe based on EQRs. This project enabled Ireland to participate (by providing large quantities of data) in the exercise that also requires Ireland to have supporting quantitative EQR derived and validated using classification tools developed by the UK–Republic of Ireland (UK-Ire) WFD Marine Task Team (MTT). Intercalibrated and harmonised ecological marine water quality assessment systems involve:

(a) Networking of national and international research activities,

(b) Provision of guidance for the competent authority regarding implementation and compliance with the WFD

(c) Development of ecological water quality indicators.

As indicated, this study focused on components of the three (plants, benthos and fish) ecological quality elements required for water quality assessment under the WFD. The preliminary portion of the study work required considerable data mining and collation. These data were assessed for their use in achieving the tasks defined by the specific goals of the project. For each ecological quality element, data are required in order to fulfil certain implementation obligations under the WFD. These are:

(a) To provide detailed information from selected sites to feed into the EU-wide intercalibration process to ensure compatibility of classification processes and tools

(b) To generate type-specific reference conditions (in the case of benthos this may be refined to describe habitat-specific conditions)

(c) The refinement of classification tools to be used to quantify the ecological quality of waterbodies.

The project was divided into three separate work packages:

1. Work package 1 – Plant Ecological Quality Elements
2. Work package 2 – Benthic Macroinvertebrate Ecological Quality Element
3. Work package 3 – Fish in Transitional Waters Ecological Quality Element.

The scientific approach to these three work packages is outlined in Chapters 2, 3 and 4, respectively.

2 Irish Data Input to EU-Wide Biological Quality Element Intercalibration

The main purpose of the WFD Intercalibration Exercise is to establish acceptable and realistic values for the class boundaries of High–Good (H-G) and Good–Moderate (G-M) ecological quality status. Ireland is a member of the North-East Atlantic Geographical Intercalibration Group (NEA-GIG). Participating countries in this group include Belgium, Denmark, France, Germany, Ireland, the Netherlands, Norway, Portugal, Spain and the Basque Region, Sweden and the United Kingdom.

2.1. Compilation and Processing of Quantitative Scientific Data (for Selected Metrics) for the Intercalibration Process

One of the primary tasks performed by the METRIC project was to identify and review available Irish data sources (literature, e.g. MERC (2006a); databases (Table 2.1); samples; etc.) for each BQE. For this purpose, consultation with key personnel in relevant agencies (National Parks and Wildlife Service, private consultancies, commercial and non-commercial bodies, the National University of Ireland, etc.) was carried out to identify any existing data. Historical data were then collated for each of the BQEs. Extracted data were quality assured, deemed suitable for the NEA-GIG intercalibration and used to test and refine the UK-Ire MTT classification tools. When insufficient data were available, a sampling programme to collect baseline data was initiated (Fig. 2.1). Sampling methodologies used were recognised and accepted by other EU Member States. A sampling programme was not initiated to collect additional baseline phytoplankton data because of the short duration of

Table 2.1. Data sets collected during the Marine Ecological Tools for Reference, Intercalibration and Classification (METRIC) project.

BQE	Time period	Parameters	Data set owners
Plants	1991–2005	Phytoplankton (cells/l) Chlorophyll (µg/l) Phosphate (PO_4) (µmol/l and µg/l) Nitrogen (NH_3, NO_2, NO_3) (µmol/l and µg/l) Silicate (SiO_4) (µmol/l and µg/l) Temperature (°C) Salinity (PSU) Oxygen saturation (%, ml/l and mg/l) Secchi depth (m)	Marine Institute Dublin City Council Glan Uisce Teo Marine Harvest Ireland
Benthos	1997–2006	Total benthic invertebrate macrofauna identified to species and enumerated Bottom temperature (°C) Bottom oxygen saturation (%, ml/l) Bottom salinity (PSU) pH Redox (mV) Particle size (mm) Benthic infaunal distribution	Marine Institute Marine Harvest Ireland Eli Lilly NUI Galway National Parks & Wildlife Service Dublin City Council
Fish		Species composition and abundance from sites in estuaries and lagoons sampled by: (a) beach seine (b) fyke netting (c) beam trawling Temperature (°C), salinity (PSU) and oxygen saturation (%) collected at beach seine sites All site locations recorded on GPS to permit GIS mapping.	Central Fisheries Board

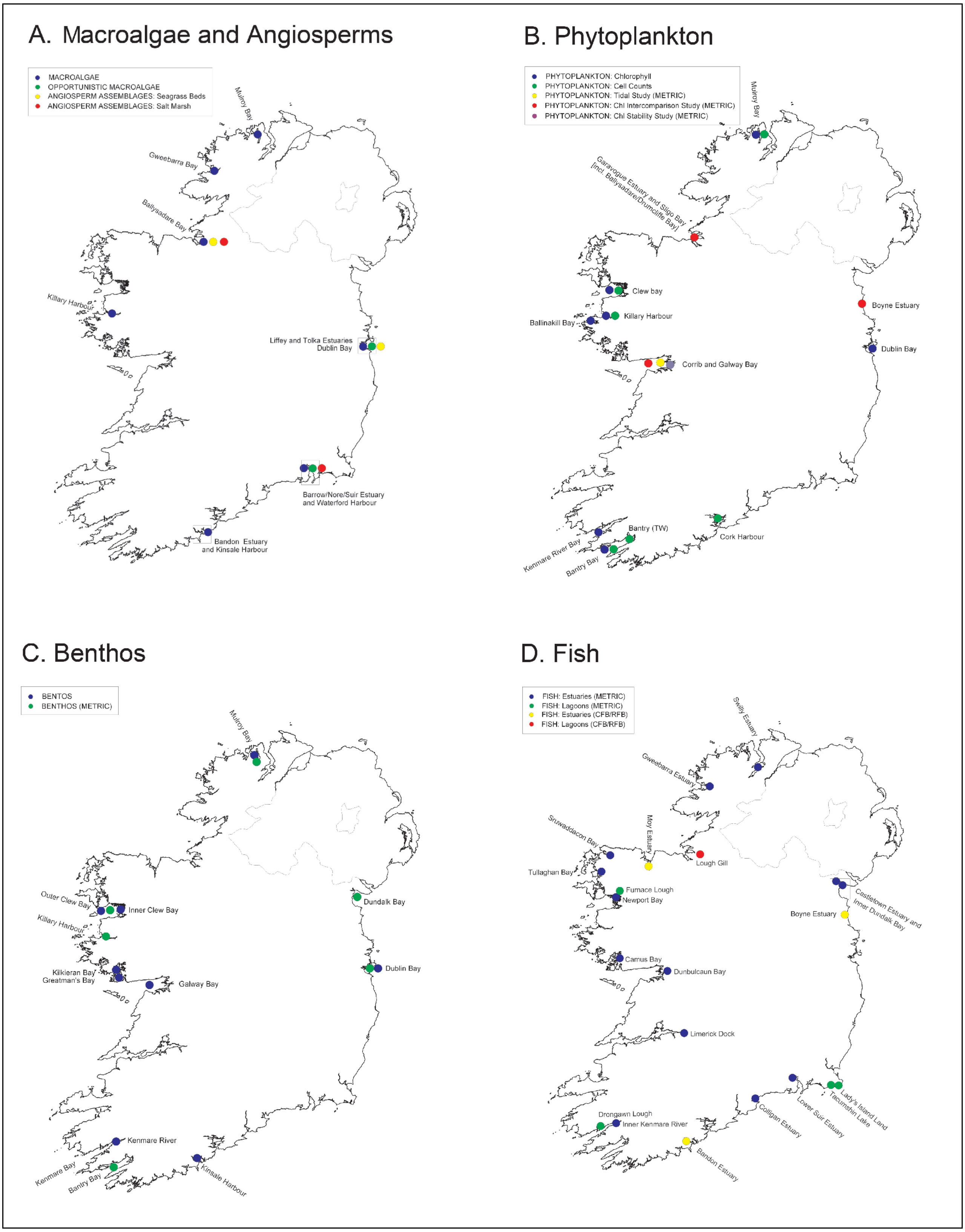

Figure 2.1. Marine Ecological Tools for Reference, Intercalibration and Classification (METRIC) survey sites, 2006, for each Biological Quality Element (A, B, C and D) and other waterbodies for which data sets were collected. Data collected were used in the North-East Atlantic Geographical Intercalibration Group Intercalibration Exercise (CFB/RFB, Central Fisheries Board/Regional Fisheries Board).

the project. Instead an intercomparison of chlorophyll measurement methods by the Marine Institute and the EPA, a stability study on chlorophyll samples stored under different temperature regimes, and a tidal cycle study to investigate two types of water sampling techniques were undertaken. The results from these investigations are not discussed in this document as they are beyond the scope of the report. They can, however, be obtained on request from francis.obeirn@marine.ie.

All relevant data collected during the project were submitted to the EU Communication and Information Resource Centre Administrator (CIRCA) database via the NEA-GIG chair. For information on the intercalibration work carried out by Ireland please refer to the NEA-GIG *Milestone 6* report (Jowett, 2006). All other data (including photographic data) collected throughout the duration of this project and externally acquired data have been submitted to the EPA and will be made available at http://coe.epa.ie/safer. On the basis of METRIC project experiences, a draft WFD implementation programme, staff and budget requirements were submitted to the EPA on 9 June 2006 (Hennessy *et al.,* 2007). An additional output from the METRIC project was that in-house standard operating procedures (SOPs) for each BQE were drawn up for sampling and laboratory analysis of samples when Comité Européen de Normalisation (CEN) protocols or other internationally recognised methods were unavailable.

3 Description of BQE Classification Tools (Plants and Benthos) and the EU Intercalibration Exercise on Fish Sampling Methodologies

Marine Task Teams have developed a number of water quality assessment tools for each of the BQEs. Descriptions of these tools along with examples of the results and any refinements are described below. Please note, for Section 3.1 (Plants), only tools that have been fully developed are described in detail. The tools in this section have yet to be weighted and combined. All references to the literature relating to the tools in this section only reflect work carried out up until the time of publication. The tools, therefore, may be subjected to future amendments (addition and corrections) as more data become available and further rigorous testing is carried out.

3.1 Plants (Macroalgae, Angiosperms and Phytoplankton)

Transitional Waters: WFD Annex V, Part 1.1.3, BQE = phytoplankton and other aquatic flora (angiosperms and macroalgae)

Coastal Waters: WFD Annex V, Part 1.1.4, BQE = phytoplankton and other aquatic flora (angiosperms and macroalgae)

3.1.1 Macroalgae

The macroalgal tools are described below. The first tool uses macroalgal species richness as an indicator of ecological changes. A reduced species list is used in this tool since this does not require a high level of taxonomic expertise in the field. The use of this list is very practical since the field investigator does not need to be an expert in macroalgal identification. The method, therefore, allows good comparability of results. The second tool uses green opportunistic macroalgal blooms as an indication of anthropogenic pressures.

3.1.1.1 Tool A: Intertidal Coastal Waters Macroalgal Reduced Species List (RSL) – Rocky Shore Tool (Wells, 2006)

INTRODUCTION TO TOOL A

- **Investigates:** Composition and taxonomic abundance.
- **Tool status:** Under development (subject to further revision). Continually being refined as new data become available.
- **Habitat:** Intertidal (littoral) rocky (sedimentary) shores.
- **Irish data tested:** Coastal waterbodies presented in Fig. 2.1.

DATA REQUIRED

1. To run this tool the following information must be collected in the field. The EQR is then calculated.
   - **Metric 1:** A shore description (Fig. 3.1). If more then one shore type and one habitat type are observed at a site, use the highest score. Calculate the final shore description score, i.e. 'de-shoring factor' (Fig. 3.1). The 'de-shoring factor' is based on predicted levels of species richness using an exponential-type model.
   - **Metric 2:** Species richness, measured as the number of taxa from the reduced species checklist on the shore sampled (Table 3.1). Three reduced species checklists totalling approximately 90 species have been developed by the Marine Plants Task Team (MPTT) for different geographic areas in Ireland and the UK. The Irish RSL has ~70 species (R. Wilkes, EPA, personal communication, 2006).
   - **Metric 3:** Ratio of algae in the Ecological Status Groups (ESGs), ESG 1 versus ESG 2 (Orfanidis *et al.,* 2001). Seaweed species are

A

General Information			
Shore Name		Date	
Water Body		Tidal Height	
Grid Ref.		Time of Low Tide	

Shore Descriptions							
Presence of Turbidity (known to be non-anthropogenic)	Yes	=0	Sand Scour	Yes	=0	No	=2
	No	=2	Chalk Shore	Yes	=0	No	=2

Dominant Shore Type		Subhabitats				
Rock Ridges/Outcrops/Platforms	=4	Wide Shallow Rock Pools (>3m wide and <50cm deep)				=4
Irregular Rock	=3					
Boulders large, medium and small	=3	Large Rockpools (>6m long)				=4
Steep/Vertical Rock	=2	Deep Rockpools (50% >100cm deep)				=4
Non-specific hard substrate	=2	Basic Rockpools				=3
Pebbles/Stones/SmallRocks	=1	Large Crevices				=3
Shingle/Gravel	= 0	Large Overhangs and Vertical Rock				=2
Dominant Biota		Others habitats (please specify)				=2
Ascophyllum						
Fucoid						
Rhodophyta mosaics		Caves				=1
Chlorophyta		None				=0
Mussels		Total Number of Sub-habitats				
Barnacles		>4	3	2	1	0
Limpets						
Periwinkles						
General Comments						

B

FINAL shore description score	
Shore Description	De-shoring Factor
5	1.72
6	1.65
7	1.58
8	1.51
9	1.44
10	1.36
11	1.29
12	1.21
13	1.14
14	1.07
15	1.00
16	0.93
17	0.87
18	0.80
19	0.74
20	0.69

Figure 3.1. Shore description. (A) Macroalgal field sampling sheet used to record basic shore descriptions (SDS, Shore Description Sheet). A predetermined score is awarded to each attribute on the sheet and these are circled using a pencil when applicable in the field. (B) Final shore description scores awarded. The sum of the shore description scores is cross-referenced with the final shore description score sheet and the final shore description value is awarded. This is used to weight the species richness metric in the classification tool.

Table 3.1. Reduced species checklist (presence or absence of algal species) and associated scoring system. G, green algae; B, brown algae; R, red algae; ESG, Ecological Status Group. Please note that this table is still undergoing refinement as agreement has not yet been reached by the Marine Plants Task Team on the number of species that should be in this list.

No.	Species name	UK-ROI	Algae colour	Opp	ESG	No.	Species name	UK-ROI	Algae colour	Opp	ESG
1	*Blidingia* sp.	1	G		2	**48**	*Audouinella* sp.		R		1
2	*Bryopsis plumosa*	1	G		2	**49**	*Calcareous encrusters*	1	R		1
3	*Chaetomorpha linum*	1	G	1	2	**50**	*Callophyllis laciniata*		R		2
4	*Chaetomorpha mediterranea*	1	G	1	2	**51**	*Catenella caespitosa*	1	R		2
5	*Chaetomorpha melagonium*	1	G	1	2	**52**	*Ceramium nodulosum*	1	R		1
6	*Cladophora albida*		G		2	**53**	*Ceramium shuttleworthanium*	1	R		1
7	*Cladophora rupestris*	1	G		2	**54**	*Ceramium* sp.	1	R		1
8	*Cladophora sericea*	1	G		2	**55**	*Chondrus crispus*	1	R		1
9	*Enteromorpha* sp.	1	G	1	2	**56**	*Corallina officinalis*	1	R		2
10	*Monostroma grevillei*		G		2	**57**	*Cryptopleura ramosa*	1	R		1
11	*Rhizoclonium tortuosum*		G		2	**58**	*Cystoclonium purpureum*	1	R		1
12	*Spongomorpha arcta*		G		2	**59**	*Delesseria sanguinea*		R		1
13	*Sykidion moorei*		G		2	**60**	*Dilsea carnosa*	1	R		1
14	*Ulothrix* sp.		G		2	**61**	*Dumontia contorta*	1	R		1
15	*Ulva lactuca*	1	G	1	2	**62**	*Erythrotrichia carnea*	1	R		1
16	*Alaria esculenta*	1	B		1	**63**	*Furcellaria lumbricalis*	1	R		1
17	*Ascophyllum nodosum*	1	B		1	**64**	*Gastroclonium ovatum*	1	R		2
18	*Asperococcus fistulosus*		B		1	**65**	*Gelidium* sp.	1	R		2
19	*Chorda filum*	1	B		1	**66**	*Gracilaria gracilis*	1	R		2
20	*Chordaria flagelliformis*		B		1	**67**	*Halurus equisetifolius*	1	R		1
21	*Cladostephus spongious*	1	B		2	**68**	*Halurus flosculosus*	1	R		1
22	*Desmarestia aculeata*		B		1	**69**	*Heterosiphonia plumosa*	1	R		2
23	*Dictyosiphon foeniculaceus*		B		1	**70**	*Hildenbrandia rubra*	1	R		1
24	*Dictyota dichotoma*	1	B		1	**71**	*Hypoglossum hypoglossoides*	1	R		2
25	*Ectocarpus* sp.	1	B	1	1	**72**	*Lomentaria articulata*	1	R		1
26	*Elachista fucicola*	1	B		1	**73**	*Lomentaria clavellosa*		R		1
27	*Fucus serratus*	1	B		1	**74**	*Mastocarpus stellatus*	1	R		1
28	*Fucus spiralis*	1	B		1	**75**	*Melobesia membranacea*		R		1
29	*Fucus vesiculosus*	1	B		1	**76**	*Membranoptera alata*	1	R		2
30	*Halidrys siliquosa*	1	B		2	**77**	*Nemalion helminthoides*	1	R		1
31	*Himanthalia elongata*	1	B		1	**78**	*Odonthalia dentata*		R		1
32	*Laminaria digitata*	1	B		2	**79**	*Osmundea hybrida*	1	R		1
33	*Laminaria hyperborea*	1	B		2	**80**	*Osmundea pinnatifida*	1	R		1
34	*Laminaria saccharina*	1	B		2	**81**	*Palmaria palmata*	1	R		1
35	*Leathesia difformis*	1	B		2	**82**	*Phycodrys rubens*		R		2
36	*Litosiphon laminariae*		B		2	**83**	*Phyllophora* sp.	1	R		1
37	*Pelvetia canaliculata*	1	B		1	**84**	*Plocamium cartilagineum*	1	R		2
38	*Petalonia fascia*		B		2	**85**	*Plumaria plumosa*	1	R		2
39	*Pilayella littoralis*	1	B	1	2	**86**	*Polyides rotundus*	1	R		1
40	*Ralfsia* sp.	1	B		1	**87**	*Polysiphonia fucoides*	1	R		2
41	*Saccorhiza polyschides*	1	B		1	**88**	*Polysiphonia lanosa*	1	R		2
42	*Scytosiphon lomentaria*	1	B		1	**89**	*Polysiphonia* sp.	1	R		2
43	*Sphacelaria* sp.		B		1	**90**	*Porphyra leucosticta*		R	1	2
44	*Spongonema tomentosum*		B		1	**91**	*Porphyra umbilicalis*	1	R	1	2
45	*Aglaothamnion/Callithamnion*	1	R		2	**92**	*Ptilota gunneri*		R		2
46	*Ahnfeltia plicata*	1	R		2	**93**	*Rhodomela confervoides*	1	R		2
47	*Audouinella purpurea*		R		1	**94**	*Rhodothamniella floridula*	1	R		2

used to indicate shifts in the ecosystem from a pristine state (ESG 1 – late successional species or perennial species) to a degraded state (ESG 2 – opportunistic species or annual species).

- **Metrics 4–5:** Proportions of red and green algae – the overall percentage of the number of species in each group compared with the total number of algal species present.

- **Metric 6:** Proportion of opportunistic algae – the overall percentage of opportunistic species compared with the total number of algal species present.

2. Carry out survey twice in each 6-year RBD assessment cycle.

3. Survey should be carried out between late April and September.

4. The index scoring system in Table 3.2 for species richness, ESG ratio, proportions of red, green, and opportunist algae and shore description are used to determine the classification boundaries for each metric (MPTT most recent update).

Equations and Tables Required for Classification

A sliding scale is used to determine the EQR value and classification status for each metric (Eqns 3.1 and 3.2). The classification of each site is determined by calculating the average EQR value from all metrics. The final overall classification of a waterbody is determined by calculating the average EQR value of all sites assessed in the waterbody.

Equation 3.1 calculates the EQR value for species richness, proportion of red algae and the ESG ratio. (Note: The values for these metrics **increase** as the EQR value increases.)

$$\text{EQR} = (((\text{value} - \text{lower CR})/(\text{CW})) \times \text{EQR BW}) + \text{lower EQR BR} \qquad \text{(Eqn 3.1)}$$

where CR is the class range, CW is the class width, BW is the EQR band width, and BR is the EQR band range.

Equation 3.2 calculates the EQR value for proportion of greens and opportunistic algae and shore description. (Note: The values of these metrics **decrease** as the EQR value increases.)

$$\text{EQR} = \text{Upper EQR BR} - (((\text{value} - \text{lower CR})/(\text{CW})) \times \text{EQR BW}) \qquad \text{(Eqn 3.2)}$$

where CR is the class range, CW is the class width, BW is the EQR band width, and BR is the EQR band range.

Worked Example

An example of results from Mulroy Bay, 2006, is presented in Table 3.3. This example presents data collected using an amended version of the MPTT sampling strategy which will be used in the Irish monitoring programme. The Irish EPA field sampling methodology conforms to the draft international standard (see International Standards ISO/DIS

Table 3.2. Class boundaries score values for species richness, Ecological Status Group (ESG) ratio, proportions of green, red and opportunist algae and shore description for Northern Ireland and the Republic of Ireland (Marine Plants Task Team most recent update). Bad classification generally refers to those shores with potential hard substrate for attachment but no algal species present. EQR, Ecological Quality Ratio.

	Ecological quality status				
	Bad	**Poor**	**Moderate**	**Good**	**High**
EQR	0.0–0.2	>0.2–0.4	>0.4–0.6	>0.6–0.8	>0.8–1.0
Species richness	0–3	4–10	11–20	21–34	35–68
Proportion of Rhodophyta	0–10	11–25	26–35	36–45	46–100
Ecological Status Group ratio	0.00–0.19	0.20–0.39	0.40–0.59	0.60–0.79	0.80–1.20
Proportion of Chlorophyta	81–100	46–80	31–45	21–30	0–20
Proportion of opportunists	51–100	36–50	26–35	16–25	0–15
Shore description score	0–0	16–18	11–15	7–10	1–6

Table 3.3. Example result from a survey carried out in coastal waters of Mulroy Bay (CW-NEA2/6, draft reference = G-M) in June 2006.

	Sites surveyed		
	Fannys Bay	Wee Bay	The Narrows
Number of green species	5	5	5
Number of brown species	7	5	9
Number of red species	7	10	11
Total number of species recorded	19	20	25
Number of opportunists	4	3	4
ESG1 (number of species present)	11	11	12
ESG2 (number of species present)	8	9	13
Summary			
Species richness (total number of species recorded)	19.00	20.00	25.00
Proportion of Chlorophyta (% green algae present)	26.32	25.00	20.00
Proportion of Rhodophyta (% red algae present)	36.84	50.00	44.00
ESG Ratio (ESG1/ESG2)	1.38	1.22	0.92
Proportion of opportunist (% opportunists present)	21.05	15.00	16.00
Shore description score	7.00	10.00	9.00
De-shoring factor	1.58	1.36	1.44
Corrected species richness Value adjusted using the 'de-shoring factor' (i.e. species richness $\times$ de-shoring factor)	30.02	27.20	36.00
Scores (EQRs)			
Species richness	0.739	0.695	0.806
Proportion of Rhodophyta (red algae)	0.619	0.815	0.778
ESG ratio	1.088	1.011	0.862
Proportion of Chlorophyta (green algae)	0.682	0.711	0.800
Proportion of opportunists	0.688	0.800	0.787
Final score (average of above scores)	**0.763**	**0.806**	**0.806**
Final classification	**Good**	**High**	**High**
Overall EQR score and classification (average)		**0.792**	**Good**

19493:2005). Transects with quadrats are carried out. Photographs of sampling location and GPS information are recorded to allow sampling sites to be repeated from year to year. There is no change, at present, in the method used to calculate the EQR values. The tool will perform poorly when applied to a waterbody that is subjected to intervals of highly variable salinity (e.g. Ballisodare Bay, Ireland, reference waterbody) and it, therefore, should not be used in such cases. The reason for this is that some macroalgal species will not survive under such conditions.

3.1.1.2 Tool B: Macroalgal Blooming Tool (abundance and biomass of opportunistic green macroalgae, e.g. Enteromorpha or Ulva) (Wells et al., 2007)

INTRODUCTION TO TOOL B

- **Investigates:** Abundance (spatial cover and biomass).

- **Tool status:** Under development (subject to further revision). Continually being refined as new data become available. The Tool as presented in Wells *et al.* (2007) was under development at the time.
- **Habitat:** Available intertidal habitat (AIH) – intertidal (littoral) shores with soft sediment (mud, sand, stony mud, mussel beds). Unsuitable areas where growth is unlikely to occur must not be surveyed.
- **Irish data tested:** Coastal and transitional waterbodies presented in Fig. 2.1.

DATA REQUIRED

1. To run this tool the following data on opportunistic algae should be collected in the field:
   - All opportunistic algal patches in a waterbody must be measured.
   - **Metrics 1 and 2:** Determine the area and percentage coverage of opportunistic algae (see Table 3.1) on the AIH of the waterbody. Map external perimeter of bed using GPS to measure extent of bloom. If the percentage cover is greater than 5% of the waterbody then proceed to next step (preliminary reference level ≤5% cover).
   - Record the percentage coverage of opportunistic algae within the affected intertidal area (transects, random quadrats 0.25 m^2).
   - **Metrics 3 and 4:** Record the biomass (wet weight in g/m^2) of the opportunistic algae (transects, random quadrats 0.25 m^2) in affected area and then calculate the estimated biomass of the AIH.
   - **Metric 5:** Record presence of entrained algae (>3 cm growth into underlying sediment – indicates the likelihood of regeneration).
   - Collect photographic evidence for future reference (areas with/without algal cover, ecological disturbances: depth of sediment anoxic layer, presence of smothered vegetation associated with algal mats, etc.).
2. Carry out survey once per year for every RBD assessment cycle.
3. Survey should be carried out in the summer time when algal growth is at its peak.
4. Classification is based on the entire waterbody.
5. Calculate the total available intertidal substrate area for the waterbody (e.g. use Ordinance Survey maps, Admiralty Charts or other maps with details on substrate type by tracing onto A3 graph paper and calculating the area or use aerial images).
6. Input data into the MS Excel calculation spreadsheet. To account for interannual variation use rolling means (3- to 5-year cycle) to assess the waterbody. Calculate yearly means to pick up unusually high levels in a particular year. The index scoring system in Table 3.4 for percentage cover of AIH, area, biomass of AIH, biomass of affected area and presence of entrained algae is used to determine the classification boundaries for each metric (MPTT most recent update).

Table 3.4. Class boundaries score values for percentage cover of available intertidal habitat (AIH), area, biomass of AIH, biomass of affected area and presence of entrained algae (Marine Plants Task Team most recent update). EQR, Ecological Quality Ratio.

	Ecological quality status				
	Bad	**Poor**	**Moderate**	**Good**	**High**
EQR	0.0–0.2	>0.2–0.4	>0.4–0.6	>0.6–0.8	>0.8–1.0
% Cover of AIH	75–100	25–75	15–25	5–15	0–5
Area (ha)	>1000(–2000)	100–1000	50–100	10–50	0–10
Biomass of AIH (g/m^2)	>3000 (–6000)	1000–2500	500–1000	100–500	0–100
Biomass of affected area (g/m^2)	>3000 (–6000)	1000–2500	500–1000	100–500	0–100
Presence of entrained algae (% of quadrats)	>75–100	>50–75	>20–50	>5–20	0–5

Table 3.5. Example result from an opportunistic algae survey carried out in estuarine waters of the Tolka Estuary (CW-NEA11 (TW2), draft reference = M) in July 2006. AIH, available intertidal habitat (ha).

Total area of AIH (ha)	240.54			
Opportunistic algal sites	**Patch 1**	**Patch 2**	**Patch 3**	**Patch 4**
Patch size (ha) (area covered by opp. algae)	0.62	2.52	23.39	15.97
Average percentage cover (%)[1]	85.50	85.50	76.50	93.00
Average biomass per patch (g/m^2)[1]	7652.00	7652.00	5880.00	5592.00
Sediment area covered (ha)[2]	0.53	2.15	17.89	14.85
Total biomass per patch[3]	4744.24	19283.04	137533.20	89304.24
Presence of entrained algae in quadrat	nr	nr	nr	nr
Total area of AIH (ha)	240.54			
Total affected area covered in AIH (ha) (all patches)	42.50			
Total biomass AIH (g/m^2) (all patches)	250864.72			
Total sediment area covered (all patches)	35.43			
Metric	**Value**	**EQR**		
Total percentage cover of AIH (%)[4]	14.73	0.61		
Total affected (ha)	42.50	0.64		
Average biomass AIH (g/m^2)	1042.92	0.40		
Average biomass affected area (g/m^2)	5902.70	0.01		
Percentage entrained algae	nr	nr		
Average EQR score		**0.41**		
Final EQR and classification	**0.41**	**Moderate**		

[1]Calculated from data collected from the random quadrats from a minimum of four transects.
[2]Sediment area covered = (patch size × average percentage cover) / 100.
[3]Total biomass per patch = patch × average biomass per patch (nr, not recorded).
[4]Total % cover = (total sediment area covered × 100) / available intertidal area.

Equations and Tables Required for Classification

A sliding scale is used to determine the EQR value and classification status for each metric (Eqn 3.3). The classification of each site is calculated by getting the average EQR value from all metrics. The final overall classification of a waterbody is calculated by getting the average EQR value of all sites assessed in the waterbody.

Equation 3.3 calculates the EQR value for percentage cover of AIH, area, biomass of AIH, biomass of affected area and presence of entrained algae.

$$\text{EQR} = \text{Upper EQR BR} - (((\text{value} - \text{lower CR})/(\text{CW})) \times \text{EQR BW}) \qquad \text{(Eqn 3.3)}$$

where CR is the class range, CW is the class width, BW is the EQR band width, and BR is the EQR band range.

Worked Example

A worked example of data collected during the METRIC project is presented in Table 3.5. Recommendations and conclusions are presented in Chapter 5.

3.1.2 Angiosperm (seagrass and salt marsh)

3.1.2.1 Introduction to the tools

The angiosperm tools are described below. The first relates to seagrass. *Zostera noltii* and *Z. marina* are very sensitive to anthropogenic influences (Short and Wyllie-Echeverria, 1996) such as eutrophication (Short and Burdick, 1996) and changes in land use (Kemp *et al*., 1983). An interannual variability of 30% is often observed in seagrass beds (Krause-Jensen *et al*., 2000). The second tool looks at changes in salt marsh assemblages as an indicator of anthropogenic pressure. Over 250 salt marshes have been identified around the Irish coast and classified according to their physical structure and origin (Curtis and Sheehy Skeffington, 1998). They can be classified into five main types: estuary, bay, sand flats, lagoon and fringe. The coastline of Ireland is particularly varied and the structure of salt marshes along the Irish coast, which is intrinsically linked with this variation, is equally varied and often difficult to define. The classic zonation associated with English marshes is often not present in Ireland. It is likely that the main factors controlling the salt marsh structure and vegetation in Ireland are climatic, especially rainfall and incidence of sunlight. These factors, along with differences in land-use practices (grazing, human management and fertiliser addition) between the east and west coasts are responsible for the strong east–west differences in Irish salt marsh. The general health of a salt marsh can be determined by the extent of the lowest zone of colonisation, or pioneer zone. Factors most likely to negatively impact on the extent and zonation of a salt marsh include anthropogenic influences such as grazing and physical factors such as erosion (wave action) and climate change (change in sea level) (MERC Internal METRIC report 2006b, available on request from francis.obeirn@marine.ie).

3.1.2.2 Tool A: Seagrass (intertidal Zostera sp.) Tool, Foden (2007)

INTRODUCTION TO TOOL A:

- **Investigates:** Taxonomic composition and abundance (bed extent and density).

- **Tool status:** Under development (subject to further revision). Current version published February 2007. Continually being refined as new data become available.

- **Habitat:** Littoral (intertidal).

- **Irish data tested:** Coastal waterbody presented in Fig. 2.1.

DATA REQUIRED:

1. To run this tool the following data on seagrass should be collected in the field:

   - **Metric 1:** Spatial extent and abundance of continuous seagrass beds within the waterbody (where multiple beds are present, map at least three). Determine the intertidal *Zostera* bed boundary (i.e. outer boundary limit is where seagrass ground cover is ≥5% shoot density) by mapping the external perimeter of the bed using differential GPS. Distinct patches should be isolated and identified separately. Plot out shape files in GIS software.

   - **Metric 2:** Taxonomic composition (presence/ absence *Zostera* sp.).

   - **Metric 3:** Record the percentage coverage of *Zostera* shoot density: estimation of percentage leaf cover per m^2 within the sampled area (transects with random quadrats 0.25 m^2, record percentage of *Zostera* within each quadrat).

   - Collect georeferenced photographic evidence (areas with/without seagrass cover, ecological disturbances: depth of sediment anoxic layer, presence of smothered vegetation associated with algal mats, etc.).

2. Carry out survey at least twice in each 6-year RBD assessment cycle. Initial surveys should be undertaken yearly to provide sufficient baseline data.

3. Survey should be carried out in late summer/early autumn when growth is at its peak but before grazing migratory birds arrive.

4. Ecological quality status is based on the degree of loss of extent and density compared with the baseline.

5. In the final classification all metrics carry equal weight.

TABLES REQUIRED FOR CLASSIFICATION

Table 3.6 presents three metrics to be implemented in UK seagrass beds, while Table 3.7 shows the mean score range for each ecological class.

Table 3.6. Three metrics to be implemented in UK seagrass beds, Water Framework Directive disturbance descriptors and corresponding range of metric scores for: (a) taxonomic composition, (b) shoot density, and (c) bed spatial extent. Note, if density or area increase above reference conditions the metric score will be 1.0 (redrawn from Foden, 2007). The mean score calculated from the three metrics relates to ecological quality status categories (Table 3.7).

Disturbance	Change in taxonomic composition from reference condition	Metric score ranges (mid-point of EQR ranges)
(a) Taxonomic composition		
No detectable change	All reference condition species present	0.9
Slight signs of disturbance	Loss of 1/4 to 1/3 species	0.7
Moderate distortions	Loss of 1/2 of species	0.5
Major distortions	Loss of 2/3 to 3/4 of species	0.3
Severe distortions	Loss of all species	0.1
(b) Seagrass shoot density	– exemplar metric scores for % loss of density from reference condition	
	Annual change	
No detectable change	0% density loss = 1.0, 1% loss = 0.98, 2% loss = 0.96… 10% loss = 0.80	
Slight signs of disturbance	11% density loss = 0.79, 12% loss = 0.78, 13% loss = 0.77… 30% loss = 0.60	
Moderate distortions	31% density loss = 0.59, 32% loss = 0.58, 33% loss = 0.57… 50% loss = 0.40	
Major distortions	51% density loss = 0.39, 52% loss = 0.38, 53% loss = 0.37… 70% loss = 0.20	
Severe distortions	71% density loss = 0.193, 72% loss = 0.187, 73% loss = 0.180… 100% loss = 0.00	
	5- or 6-year rolling mean change	
No detectable change	0% density loss = 1.00, 1% loss = 0.96, 2% loss = 0.92… 5% loss = 0.80	
Slight signs of disturbance	6% density loss = 0.78, 7% loss = 0.76, 8% loss = 0.74… 15% loss = 0.60	
Moderate distortions	16% density loss = 058, 17% loss = 0.56, 18% loss = 0.54… 25% loss = 0.40	
Major distortions	26% density loss = 0.38, 27% loss = 0.36, 28% loss = 0.34… 35% loss = 0.20	
Severe distortions	36% density loss = 0.197, 37% loss = 0.194, 38% loss = 0.191… 100% loss = 0.00	
(c) Seagrass bed spatial extent	– exemplar metric scores for % loss of area from reference condition	
No detectable change	0% area loss = 1.00, 1% loss = 0.98, 2% loss = 0.96… 10% loss = 0.80	
Slight signs of disturbance	11% area loss = 0.79, 12% loss = 0.78, 13% loss = 0.77… 30% loss = 0.60	
Moderate distortions	31% area loss = 0.59, 32% loss = 0.58, 33% loss = 0.57… 50% loss = 0.40	
Major distortions	51% area loss = 0.39, 52% loss = 0.38, 53% loss = 0.37… 70% loss = 0.20	
Severe distortions	71% area loss = 0.193, 72% loss = 0.187, 73% loss = 0.180… 100% loss = 0.00	

Table 3.7. Ecological classification: mean score ranges determined by the average value calculated from the three metrics described in Table 3.6 above.

Ecological class	Mean score ranges
High	0.80–1.00
Good	0.60–0.79
Moderate	0.40–0.59
Poor	0.20–0.39
Bad	0.00–0.19

Table 3.8. Comparison of the spatial extent and shoot density of two *Zostera* beds in Ballisodare Bay (CW-NEA2/6) between two separate assessments, NS share and METRIC. Surveys were carried out in 2004 and 2006, respectively. This waterbody was awarded a draft classification reference of H-G ecological quality status. EQR, Ecological Quality Ratio. *Caveat*: this tool cannot be used with a high level of confidence until the natural variability of each seagrass bed is determined. This requires sampling once per annum for 5 years minimum. A robust classification relies on using a 5-year rolling mean.

Seagrass bed	Central grid reference	Area				Spatial cover loss (%)	EQR	Transects % cover		Shoot density gain (%)	EQR
		2004 (ha)	2006 (ha)	2004 (%)	2006 (%)			2004	2006		
North (1)	G642313	9.30	–	–	–	–	–	47.40	–	–	–
North (2)	G644310	15.70	–	–	–	–	–	47.80	–	–	–
North (1+2)		25.00	20.41	100.00	81.64	18.36	0.64	47.60	51.96	4.36	1.0
South	G620291	14.60	13.54	100.00	92.74	7.26	0.86	12.20	28.08	15.88	1.0
Average							**0.75**				**1.0**
								Overall EQR (i.e. average of all EQRs): 0.88			
				Preliminary waterbody ecological quality status:						High	

WORKED EXAMPLE

Table 3.8 shows an example of seagrass bed spatial extent and shoot density (percentage cover) data collected in Ballisodare Bay 2006. These data are compared with historical data collected in the same waterbody. Results show an average decrease of 13% in the spatial extent of the *Zostera* beds. A 10% increase in percentage cover of shoot density was, however, observed. An EQR value of 0.88 (High ecological quality status) is awarded. Because only two metrics were used in this example the confidence in the class awarded is low. Recommendations and conclusions are presented in Chapter 5.

3.1.2.3 Tool B: Salt marsh, MPTT 2006

INTRODUCTION TO TOOL B

- **Investigates:** Abundance, composition and salt marsh spatial extent.
- **Tool status:** Not fully developed.
- **Habitat:** Littoral (intertidal).
- **Irish data collected:** Coastal and transitional waterbodies presented in Fig. 2.1 (spatial extent data).

DATA REQUIRED

1. To run this tool the following data on salt marsh assemblages should be collected in the field:
   - Habitat extent: mapped using GPS or aerial photography.
   - Physical structure of salt march, surveyed *in situ*.
   - Vegetation structure: zonation; sward cover.
   - Vegetation composition: characteristic species; indicator of negative trend.
2. Carry out survey once in each 6-year RBD assessment cycle.
3. Survey should be carried out in the summer time.

This tool is currently under development. It is likely that a classification scheme based on the one currently being developed for monitoring under the Habitats Directive (Council Directive 92/43/EEC) will be used. In Ireland this is being undertaken by the EPA and the National Parks and Wildlife Service (NPWS).

3.1.3 Phytoplankton

3.1.3.1 Introduction to the tools

Phytoplankton are an important food source for other trophic levels. If a waterbody becomes eutrophic, subsequently large blooms of phytoplankton can develop and become detrimental to the health of the ecosystem (Smayda, 2004). A reduction in water clarity and dissolved oxygen can result from high biomass blooms. This in turn will create unsuitable living conditions for animals and plants. Please note that the term bloom has been used in many past publications to describe different types of events, e.g. high biomass *versus* low toxic biomass harmful algal blooms (Smayda, 1997). In transitional and coastal waters the ecological quality status derived from phytoplankton data should be assessed using indicators of biomass, frequency and duration of blooms, the abundance and composition of phytoplankton taxa (see WFD, Annex V, Tables 1.2.3 and 1.2.4).

3.1.3.2 Tool A: Chlorophyll a – Growing Season 90th Percentile Tool, Devlin et al. (2007)

Introduction to Tool A

- **Investigates:** Abundance, phytoplankton biomass.
- **Tool status:** Ready to test in the first WFD RBD assessment cycle.
- **Habitat:** Planktonic (free floating).
- **Irish data tested:** Coastal waterbody completed (Fig. 2.1). Transitional waterbody (incomplete data).

Data Required

1. Use chlorophyll *a* (Chl *a*) as an indication of phytoplankton biomass (easier to measure than primary production in a monitoring programme).
2. Assessment period is 6 years.
3. Collect quantitative chlorophyll measurements on a monthly basis during the growing season, i.e. March to September.
4. Calculate the 90th percentile statistic of the data collected (Eqn 3.4).
5. Determine the EQR value (see Section 5.2.2 for more details).

The agreed Chl *a* 90th percentile values for the ecological quality class boundary between H-G and G-M ecological quality status for Ireland are 5 µg/l and 10 µg/l, respectively. These class boundaries were determined for Irish waters through the NEA-GIG process (*Milestone 6* report, Jowett (2006), see Section 5.2.2 for more details). The class boundaries mentioned above refer to values derived using the cold acetone Chl *a* extraction method. A second set of class boundary values between H-G and G-M of 10 µg/l and 20 µg/l, respectively, was proposed for the hot methanol extraction method used by the Irish EPA (for more information contact Shane O'Boyle soboyle@epa.ie). Further details on this can be found in the *Milestone 6* report (Jowett, 2006).

Equations and Tables Required for Classification

Equation 3.4 calculates the Chl *a* 90th percentile and Chl *a* median values, Devlin *et al.* (2007).

$$\text{Ichl} = X_{90th}\,[\text{C1..Ci}] \qquad \text{(Eqn 3.4)}$$

where the Chl *a* Index (Ichl) is the chlorophyll concentration calculated by the 90th percentile (X_{90th}) of all chlorophyll data ([C1..Ci]).

When X_{50th}, i.e. the 50th percentile, is used in the equation instead of X_{90th} the formula calculates the median.

Worked Example

Table 3.9 and Fig. 3.2 present results from seven Irish waterbodies. Results showed that Killary Harbour (WB 11–12) was closer to the H-G boundary then the other waterbodies examined. This result is in keeping with the expert opinion draft ecological quality status of H-G. Results from this method also awarded a High and Good ecological quality status to data collected in Mulroy Bay and Dublin Bay, respectively. Based on expert opinion, the draft ecological quality status of both these waterbodies was G-M. The differences observed may have been due to the use of other elements to determine the draft ecological status.

The Irish national method uses a second statistic based on the median value (50th percentile statistic). The accepted median values in Ireland for the ecological quality class boundaries are 2.5 µg/l (H-G) and 5.0 µg/l (G-M).

No refinement of this tool was deemed necessary. Tests were, however, run on variations of the tool. These included testing if the results would differ greatly when all water column depth samples were used instead of just surface samples and if the tool could be used over a shorter time period, for example from June

Table 3.9. Comparison of 90th percentile and median statistic results derived from several waterbodies over different sampling periods and sampling depths.

Bay number	Bay name	Time period	Mar.–Sept. Surface	Mar.–Sept. All depths	Jun.–Aug. all depths	Mar.–Sept. Surface	Mar.–Sept. All depths	Jun.–Aug. All depths
			90th percentile			Median		
1	Ballinakill	1999–2001	3.17	3.17	3.17	1.15	1.44	1.73
2	Bantry	1992–1999	3.01	3.05	2.98	1.07	1.11	1.15
3	Bantry	1993–2000	3.08	3.23	3.54	1.07	1.15	1.15
4	Bantry	1994–2001	2.88	2.88	2.89	0.79	1.15	1.15
5	Bantry	1997–2002	2.59	2.59	3.17	0.83	1.15	1.15
6	Bantry	1998–2003	3.14	3.17	3.17	1.44	1.44	1.44
7	Bantry	1999–2004	3.17	3.34	3.17	1.59	1.44	1.44
8	Bantry	2000–2005	3.17	3.46	3.17	1.73	1.73	1.44
9	Clew	1999–2002	4.03	3.74	4.20	2.02	2.02	2.02
10	Kenmare	1999–2004	3.46	3.46	2.88	1.44	1.44	1.73
11	Killary	1999–2004	4.32	4.03	3.89	2.02	2.02	1.73
12	Killary	2000–2005	4.32	4.32	4.32	2.02	2.02	2.02
13	Mulroy	1998–2004	3.03	3.03	n/a	1.64	1.59	n/a
14	Mulroy	1999–2005	2.93	2.88	2.28	1.26	1.13	1.08
15	Dublin	2001–2003	5.30	n/a	4.52	1.60	n/a	2.00

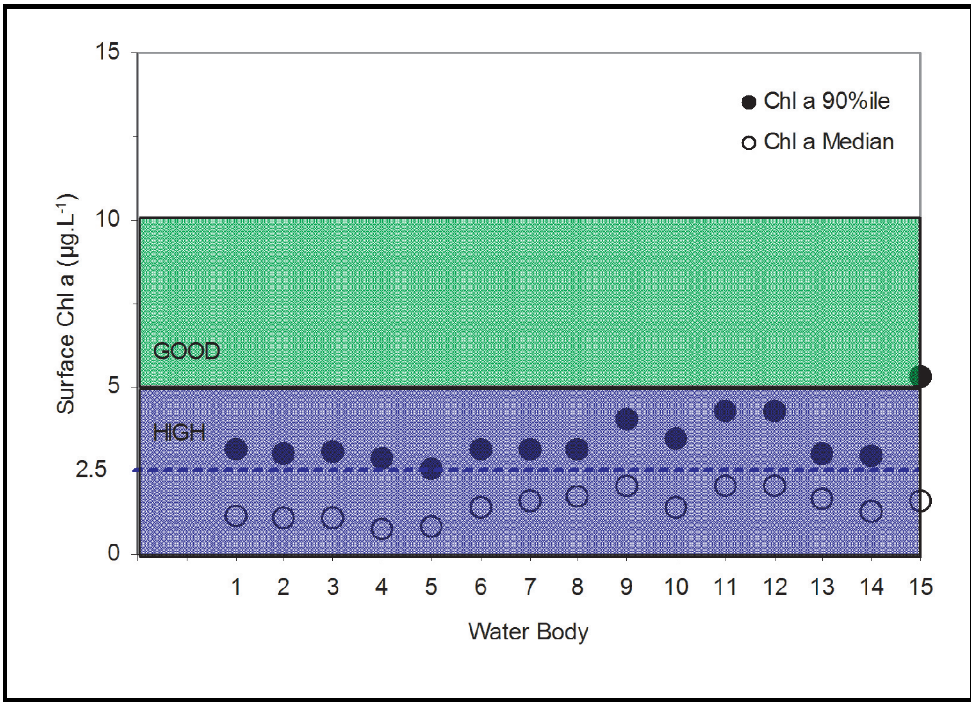

Figure 3.2. The 90th percentile and median values of surface Chl *a* concentrations (µg/l) over a number of years (maximum 6 years) from surface samples collected between March and September. Ballinakill, 1; Bantry Bay, 2–8; Clew Bay, 9; Kenmare Bay, 10; Killary Harbour, 11–12; Mulroy Bay, 13–14; Dublin Bay, 15.

to August when there is less variation in environmental conditions with a relatively steady phytoplankton standing crop (Fogg, 1965; Cartensen *et al.*, 2004; Larsson *et al.,* 2006). Results are presented in Table 3.9. The classification results in the cases presented in Table 3.9 are the same, i.e. High ecological status. Using data from only the summer months, however, will not detect anomalies if they occur at other times during the growing season. It is therefore important to monitor from March to September.

*3.1.3.3 **Tool B:** Elevated Phytoplankton (individual taxon) Counts Tool*

Introduction to Tool B

- **Investigates:** Bloom frequency and intensity, taxonomic abundance (dominant taxa).
- **Tool status:** Ready to test in the first WFD RBD assessment cycle.
- **Habitat:** Planktonic (free floating).
- **Irish data tested:** Coastal waterbodies completed (Fig. 2.1). Transitional waterbodies (incomplete data). Although there were not always 12 sampling events per annum and 6 years of data were not always available, this tool was tested on the data set.

Data required

1. Assessment period is 6 years.
2. Collect phytoplankton water samples on a monthly basis throughout the year, i.e. January to December.
3. Determine phytoplankton species or genera cell counts (cells/l) in each sample collected.
4. Exclude microflagellates and *Phaeocystis* from the phytoplankton quantitative data set generated.
5. Determine the highest taxon cell concentration in each sample occasion.
6. From this determine the highest taxon cell concentration for each month (i.e. this will give you one value to represent each month).
7. Record the number of times that the monthly concentration exceeds 250,000 cells/l (see Eqn 3.5).
8. Calculate the percentage frequency occurrence of cell densities above this threshold and assign an ecological quality status as per Borja *et al.* (2004) (Table 3.10).
9. The METRIC team introduced a *caveat* to this tool for Irish waters. It will be necessary to distinguish between phytoplankton populations that are known to originate offshore and show no response to local nutrient conditions and those resident populations that do. Blooms that are considered to have originated offshore (based on existing knowledge of the region's oceanography) rather than in response to *in situ* growth conditions will be omitted from the analysis. If, however, persistent blooms of species considered to have originated offshore occur, it may be necessary to investigate water quality deterioration. This *caveat* is based on results from a number of oceanographic research projects carried out off the south-west coast of Ireland (Goward and Savidge, 1993; Raine *et al.,* 1993; McMahon *et al.*, 1998; McDermott *et al.,* in preparation).

Table 3.10. Classification as per Borja *et al.* (2004): percentage frequency occurrence of cell densities recorded above the predefined threshold and associated ecological class.

Ecological class	% frequency above threshold
High	<20
Good	20–39
Moderate	40–69
Poor	70–90
Bad	>90

Equations and Tables Required for Classification

Equation 3.5 calculates the percentage frequency occurrence of taxa cell counts above predefined thresholds.

$$\frac{\text{No. of months that cell densities of any individual taxon >250,000 cells/l}}{\text{No. of months samples collected during the assessment period}} \times 100 = \text{Percentage over the threshold}$$

(Eqn 3.5)

Worked Example

Figure 3.3 presents results from six Irish waterbodies. Results showed that all the waterbodies were awarded a high ecological quality status with the exception of the coastal waterbody, Cork Harbour (WB 13) and the transitional waterbody, Inner Bantry Bay (WB 18). Cork Harbour and Inner Bantry Bay were given a draft ecological quality status classification of H-G (G) and H-G (H), respectively. The classification result using the tool is in keeping with expert opinion, although a different cell threshold value should be developed for transitional waters since these areas are naturally more productive then coastal waters. This tool also awarded a classification of High ecological quality status to Mulroy Bay, which was given a draft ecological quality status classification of G-M. In keeping with the results from the Chl *a* 90th percentile tool, Killary Harbour (WB 9–12) was very close to the H-G classification boundary.

The tool was initially tested on the total phytoplankton cell count per sample using different predefined cell thresholds. Difficulties in comparing results can arise with this version of the tool and include biovolume of cells, the counting method used (analyst *versus* instrument such as the flow cytometer) and the taxonomic expertise among analysts from laboratory to laboratory and within a laboratory can vary greatly. The dominant taxa should, however, always be recorded. Since individual species/genera often dominate the phytoplankton community under eutrophic conditions (Ismael and Halim, 2000, Sidabutar *et al.,* 2000), the METRIC team proposed a new version of the tool called the individual taxon above a given threshold. Tests were carried out on the Irish data set assessing bay ecological quality status when cell numbers were in excess of 100,000, 250,000, 500,000 and 1 million cells/l. Different class boundary levels (Percentage Frequency Occurrences) were also tested. The use of the modified version described by Borja *et al.* (2004) was agreed by NEA-GIG. Ireland proposed a value of 250,000 cells/l as the class boundary between High and Good ecological quality status for Irish coastal waters. This decision was based on results from samples collected in waterbodies considered to be at

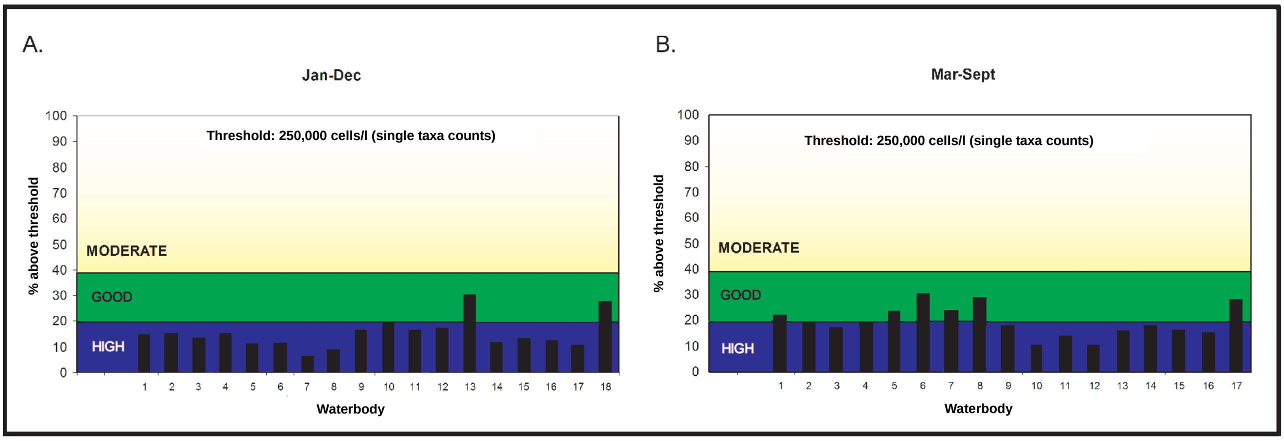

Figure 3.3. Percentage frequency of elevated counts (>250,000 cells/l) of individual taxon from three coastal (CW2, CW5 and CW8) and one transitional (TW2) waterbody typologies off the Irish coast. A percentage frequency of 20% and 39% was used for the High–Good and Good–Moderate class boundary, respectively. A, January–December; B, March–September. Bantry Bay, 1–4; Clew Bay, 5–8; Killary Harbour, 9–12; Cork Harbour, 13; Mulroy Bay, 14–17; Bantry Bay (transitional waterbody), 18.

High ecological status or near reference conditions. Recommendations and conclusions are presented in Chapter 5.

3.1.3.4 Other tools assessed

A number of other phytoplankton tools assessed in the course of the METRIC project were found unsuitable, at present, for application in the Irish WFD monitoring programme. A summary of these is given below.

Tool C: The Seasonal Progression of Phytoplankton Functional Groups throughout the Year (Devlin et al., 2007)

INTRODUCTION TO TOOL C

- **Investigates:** Taxonomic abundance, bloom frequency and composition (functional groups).

- **Tool status:** Under development (subject to further revision). Continually being refined as new data become available.

- **Habitat:** Planktonic (free floating).

- **Irish data tested:** Coastal waterbody completed (Fig. 2.1). Transitional waterbody (incomplete data). Although there were not always 12 sampling events per annum and 6 years of data were not always available, this tool was tested on the data set.

- **Reason for unsuitability:** Insufficient data were available to test this classification tool in depth. As a precautionary measure, it is recommended that this tool is tested with new data as they become available, to determine its usefulness in classifying a waterbody.

Tool D: Phaeocystis Blooms (percentage frequency counts above thresholds) (Devlin and Best, 2005)

INTRODUCTION TO TOOL D

- **Investigates:** Bloom frequency and intensity, indicator taxon of eutrophic conditions.

- **Tool status:** Ready to test in the first WFD RBD assessment cycle by Member States that have selected to use this tool.

- **Habitat:** Planktonic (free floating).

- **Irish data tested:** Coastal waterbody completed (Fig. 2.1). Transitional waterbody (incomplete data). Although there were not always 12 sampling events per annum and 6 years of data were not always available, this tool was tested on the data set.

- **Reason for unsuitability:** This classification tool works on the same principle as the Elevated Phytoplankton (individual taxon) Counts Tool with the exception that only one taxon, *Phaeocystis*, is included in the analysis. The tool requires that the frequency of occurrence of 10 million cells/l of *Phaeocystis* spp. is presented as a percentage frequency of occurrence over a 6-year cycle. This tool may be useful if water quality has deteriorated dramatically to Moderate ecological quality status as is the case in Holland. It is important to note, however, that there was some confusion as to how this tool was to be applied when only *Phaeocystis* colonies are counted. With regards to Irish data, the database contains references to either colonies or individual cell counts. Colonies were recorded when large blooms occurred. Due to the three-dimensional structures of the colonies and the depth of field available on the light microscope it is often too difficult for the analyst to count individual cells under a light microscope. Flow cytometers are used to count these haptophytes in other countries after the colonies are disturbed by gentle sonication (e.g. Holland).

Tool E: Top 30 Species List Tool (Devlin and Best, 2005)

INTRODUCTION TO TOOL E

- **Investigates:** Abundance and frequency of phytoplankton taxa and species composition (biodiversity).

- **Tool status:** Discontinued (see below).

- **Habitat:** Planktonic (free floating).

- **Irish data tested:** Coastal waterbody completed (Fig. 2.1). Transitional waterbody (incomplete data). Although there were not always 12 sampling events per annum and 6 years of data were not always available, this tool was tested on the data set.

- **Reason for unsuitability:** This classification tool was abandoned for a number of reasons. The MPTT Top 30 Species checklist was skewed toward Irish data. Phytoplankton species composition can vary greatly depending on their associated waterbody and the waterbodies around the Irish coast are influenced by very distinctly different water masses, e.g. warmer water off the south-west coast. Species lists need to be constructed for individual geographical areas, preferably for the individual waterbody (bays, estuaries, etc.). An example reason why this tool was not considered suitable is presented in Table 3.11 where List A shows a hypothetical Top 30 Species Reference List. List B demonstrates that if there were a complete reversal in species abundance the total score awarded would not change. List C demonstrates that if 20 species previously not recorded in the waterbody were to become the most dominant organisms, the tool would still allow a score corresponding to a classification of Good ecological quality status as long as the top 10 species in the Top 30 Species Reference List were able to get into the bottom 10 places of the list.

Tool F: Chlorophyll a Envelope of Growth Tool (Devlin and Best, 2005)

INTRODUCTION TO TOOL F

- **Investigates:** Biomass.
- **Tool status:** Under development (subject to further revision). Continually being refined as new data become available.
- **Habitat:** Planktonic (free floating).
- **Irish data tested:** Coastal waterbody completed (Fig. 2.1). Transitional waterbody (incomplete data). Although there were not always 12 sampling events per annum and 6 years of data were not always available, this tool was tested on the data set.
- **Reason for unsuitability:** This classification tool requires continuous data collection of Chl *a* or at least measurements on a daily basis to calculate the reference envelope for this bloom model. Historical data of this type were not available from Irish data sets to test the tool in depth. Monthly data were tested but were too variable to test the tool in full. If the large amount of data required to run this tool was available this method would provide information on the duration of poor water quality events. The fact that the autonomous instruments, often used to collect data of this type, are deployed usually at only one sampling point means that the waterbody is not sampled spatially.

Table 3.11. Results from a hypothetical test using the Marine Plants Task Team Top 30 Species Tool. Scores awarded by the tool are shown in parentheses.

A. Hypothetical Top 30 Species Reference List			B. Example 1. Total reversal in abundance			C. Example 2. Previously unknown species form location now most dominant		
Top 10 (3)	**Top 20 (2)**	**Top 30 (1)**	**Top 10**	**Top 20**	**Top 30**	**Top 10**	**Top 20**	**Top 30**
A	J	S	S (1)	J (2)	A (3)	AC (0)	AL (0)	A (3)
B	K	T	T (1)	K (2)	B (3)	AD (0)	AM (0)	B (3)
C	L	U	U (1)	L (2)	C (3)	AE (0)	AN (0)	C (3)
D	M	V	V (1)	M (2)	D (3)	AF (0)	AO (0)	D (3)
E	N	W	W (1)	N (2)	E (3)	AG (0)	AP (0)	E (3)
F	O	X	X (1)	O (2)	F (3)	AH (0)	AQ (0)	F (3)
G	P	Y	Y (1)	P (2)	G (3)	AI (0)	AR (0)	G (3)
H	Q	AA	AA (1)	Q (2)	H (3)	AJ (0)	AS (0)	H (3)
I	R	AB	AB (1)	R (2)	I (3)	AK (0)	AT (0)	I (3)
Total score 60 Status: High			**Total Score: 60 Status: High**			**Total score: 30 Status: Good**		

3.2 Benthic Fauna

Transitional Waters: WFD Annex V, Part 1.3, BQE = benthic invertebrate fauna

Coastal Waters: WFD Annex V, Part 1.4, BQE = benthic invertebrate fauna

3.2.1 Introduction to the tool

The Infaunal Quality Index (IQI) is the classification tool developed by the UK Environment Agency in co-operation with the Marine Institute (Ireland), the Scottish Environmental Protection Agency and the Environment and Heritage Service (Northern Ireland). This group called the Marine Benthic Invertebrate Task Team (MBITT) has operated under the aegis of the UK-Ire MTT which is a co-operative committee set up to provide guidance on the implementation of the WFD in transitional and coastal waters. The following summary draws heavily from reports of the MBITT as well a report of the NEA-GIG (Jowett, 2006).

The development of this multi-metric was primarily based on infaunal data from a pressure gradient (sewage sludge disposal site at Garroch Head, Firth of Clyde, Scotland) over a 20-year period. A total of 589 samples was supplied by Belgium, Germany, Ireland, Spain, Denmark, the UK and Norway. These data were used in the testing and validation of the IQI. The Irish data originated from Clew Bay (2003), Greatman's Bay (2003) and the Kenmare River (2003) which were used in the modification of the EQR boundaries during the initial Intercalibration and tool development stages (Marine Institute and Environmental Protection Agency, 2004).

3.2.1.1 TOOL: Benthic Macroinvertebrates: Infaunal Classification Systems

INTRODUCTION TO TOOL

- **Investigates:** Macroinvertebrate abundance, diversity and functional grouping.
- **Tool status:** Developed for soft sediment fine sands and muds (designated as Habitat Type A). Development for other habitat types ongoing.
- **Habitat:** All sedimentary habitats.
- **Irish data tested:** Coastal waterbody (Fig. 2.1).

DATA REQUIRED

Benthic macroinvertebrate replicate samples (n = 3 or 5) using a 0.1-m^2 (or larger) sampling device retained on a 1-mm sieve originating from subtidal sedimentary habitats EUNIS (European Nature information System) sands and muddy sands (A4.2) and muds (A4.3) (Table 3.12). Taxa must be identified to species level where possible with juveniles and epifauna removed (truncation carried out).

3.2.2 Equations and tables required for classification

3.2.2.1 Infaunal Quality Index

The IQI is a multi-metric comprising three component indices each reflective of those described under the normative definitions of the WFD (i.e. diversity, abundance and presence of disturbance-sensitive taxa). The three component indices are (i) Diversity, (ii) Functional, and (iii) Univariate statistic. These indices have been selected and combined as a consequence of their ability to respond to anthropogenic impact.

(I) DIVERSITY INDEX

The diversity metric chosen was Simpson's (1–λ') formula:

$$1 - \lambda' = 1 - \Sigma(N_i(N_i - 1)) / (N(N - 1))$$

where N is the overall invertebrate abundance in a sample and N_i is the abundance of taxa *i*.

This gives an indication of diversity by how evenly the taxa are spread throughout a sample.

(II) FUNCTIONAL INDEX – AZTI MARINE BIOTIC INDEX (AMBI)

The use of AMBI addresses the requirement for presence of indicator and sensitive taxa to be considered. Each taxon within a sample is assigned an ecological group from GI to GV, GI being sensitive to organic enrichment and GV being first-order opportunists. The intermediate groups, GII, GIII and G_{IV}, are described as indifferent, tolerant and second-order opportunistic taxa, respectively (Borja *et al.*, 2000). The species table identifying the functional group assigned to each taxon is continually updated and can be found at http://www.azti.es/.

$$\text{AMBI BC} = ((0 \times \%GI) + (1.5 \times \%GII) + (3 \times \%GIII) + (4.5 \times \%GIV) + (6 \times \%GV)) / 100$$

Table 3.12. Habitat types for which maximum values have to be defined.

Coastal waters (0.1 m^2, 1 mm)	
Habitat A	Sublittoral Shallow, muds
Habitat C	Sublittoral Shallow, muddy sands/sandy muds
Habitat F	Sublittoral Shallow, fine sand
Habitat G	Sublittoral Shallow, coarse sand
Habitat H	Sublittoral Shallow, marl
Habitat I	Sublittoral Shallow, gravel
Habitat*	Sublittoral Shallow, shell residue
Coastal waters (0.01 m^2, 1 mm)	
Habitat J	Littoral, fine sands
Transitional waters (0.1 m^2, 0.5 mm)	
Habitat K	Sublittoral, S = 20–30 PSU, muds/sandy muds
Habitat L	Sublittoral, S = 10–20 PSU, muds/sandy muds
Habitat M	Sublittoral, S = <10 PSU, muds/sandy muds
Habitat N	Littoral, S = 20–30 PSU
Habitat O	Littoral, S = 10–20 PSU
Habitat P	Littoral, S = <10 PSU
Habitat Q	Sublittoral, lagoons, muds

Note: Shallow is <30 m. S, salinity (PSU, practical salinity units). Habitat* refers to a particular habitat which has a large component of molluscan shells that provide a niche for a variety of fauna.

where BC is Biotic Coefficient, %GI–%GV represents the proportion of AMBI Ecological Groups where GI are sensitive taxa and GV are highly (disturbance) tolerant taxa.

Within the IQI this metric is calculated to give a value of between 0 and 1, where 0 indicates extreme bad conditions (azoic) and 1 represents high ecological quality status.

(III) UNIVARIATE METRIC

Number of taxa (S) is the univariate metric used. As the AMBI BC is based on proportions of the ecological groups present, it is possible for a sample with very low numbers of taxa to have the same BC as a sample with many taxa. Therefore, S is used to temper the AMBI BC calculated on low numbers of taxa within a sample. It is incorporated into the metric as 1 – 1/S, thus it penalises those samples with few taxa present, but has a negligible effect on samples with greater than 10 taxa.

The combination of the separate metrics in the most recent version of the IQI is presented as:

$$IQI = (((0.38 \times AMBI^{IQI}) + (0.08 \times (1-\lambda')^{IQI}) + (0.54 \times S^{IQI\ 0.1})) - 0.4) / 0.6$$

where $AMBI^{IQI}$ is the observed value of (1 – (AMBI/7)) divided by maximum expected value under reference conditions for a given habitat type; $(1-\lambda')^{IQI}$ is the observed value of Simpson's evenness index (1–λ') divided by the maximum expected value under reference conditions for a given habitat type; and S^{IQI} is the observed number of taxa divided by the maximum expected value under reference conditions for a given habitat type.

The weightings in the formula are assigned based upon the degree of variability explained by each character from trials with real data.

3.2.3 Worked example

Data from salmon farm sites (1997–2000) and a spoil site location (2001–2003) were analysed to validate the sensitivity of the IQI to anthropogenic pressures. The former represented data from an organic-enriched environment as a result of aquaculture activity, whilst the latter location was a result of physical disturbance due to spoil dumping. The outputs of these data are provided below and highlight a response.

EXAMPLE 1: SALMON FARM SITES

The data set analysed represents four consecutive years of biological data from eight fish farm sites within a single bay. Samples were taken along north–south transects away from the cages. For the purposes of this review, the samples taken at 25 m, 100 m, beneath the cages (mid) and a control, 500 m away from the site were analysed. The IQI was applied to the available data obtained from each site within each of the years from 1997 to 2000 and the results are presented in Table 3.13.

At each cage site, the IQI was observed to follow a strong spatial pattern from the centre of the cages

Table 3.13. Analysis of fish farm Infaunal data from eight sites in a single bay over a period of 4 years. Samples were taken along transects away from the centre of the cage arrays to control (unimpacted) sites.

Site 1	1997	1998	1999	2000
Control	Moderate	Moderate	Moderate	Moderate
100 m S	Moderate	Moderate	Moderate	Moderate
25 m S	Moderate	Poor	Bad	Moderate
Mid	Bad	Bad	Bad	Moderate
25 m N				
100 m N				

Site 5	1997	1998	1999	2000
Control	Good	Good	Good	Good
100 m S		Good	Good	High
25 m S		Moderate	Good	Good
Mid		Poor	Moderate	Moderate
25 m N		Poor		Good
100 m N		Good		Moderate

Site 2	1997	1998	1999	2000
Control	Moderate	Moderate	Good	Good
100 m S	High	Moderate	Good	High
25 m S	Good	Good	Good	High
Mid	Poor	Poor	Bad	Poor
25 m N	Moderate	Moderate	Bad	Moderate
100 m N	Moderate	Good	Good	Good

Site 6	1997	1998	1999	2000
Control	Good	Moderate	Good	Good
100 m S	Poor	Moderate	Good	Good
25 m S	Good	Moderate	Good	Good
Mid	Bad	Poor	Bad	Poor
25 m N	Moderate	Moderate	Moderate	Moderate
100 m N	Moderate	Moderate	Good	Good

Site 3	1997	1998	1999	2000
Control	Good	Good	Moderate	Moderate
100 m S				High
25 m S	High	High	Poor	Good
Mid	Bad	Bad	Bad	Bad
25 m N	Poor	Poor	Bad	Poor
100 m N	Moderate	Good	Moderate	Good

Site 7	1997	1998	1999	2000
Control	Moderate		Good	Good
100 m S	Moderate		Moderate	Good
25 m S	Moderate		Good	Good
Mid	Bad		Bad	Bad
25 m N	Moderate		Good	Good
100 m N	Moderate		Good	

Site 4	1997	1998	1999	2000
Control	High	Moderate		Good
100 m S			Moderate	
25 m S	Good	Bad	Moderate	Good
Mid	Poor	Bad	Bad	Poor
25 m N	High	Good	Bad	Moderate
100 m N			Good	

Site 8	1997	1998	1999	2000
Control		High	Good	High
100 m S	Good	High	High	High
25 m S	Good	Good	Bad	Moderate
Mid		Bad	Moderate	Moderate
25 m N	Good	Good	Good	Good
100 m N	Good	High	Good	High

(mid) to 25 m distance from the cages. The conditions under the cages, as expected, are of poor to bad ecological quality status; however, within 25 m distance from the cages there does appear to be marked improvement in the ecological quality status. This is as expected, as the majority of organic enrichment would be confined to this area. In summary, the IQI appears to be sensitive to the impacts of this anthropogenic activity, with the majority of detrimental impact largely confined to the zones of impact of the cages (within 25 m). In addition, the analysis using the IQI also demonstrates a general increase in ecological quality in the vicinity of the fish farm cages throughout the bay over the 4 years analysed.

EXAMPLE 2: DREDGE SPOIL DISPOSAL SITE (GALWAY BAY, CW-NEA1)

This data set consisted of infaunal grab sampling taken around a spoil disposal campaign in 2001, at a spoil site in the Inner Bay. The first year of data was prior to a once-off dump event in 2001 and the remaining data were obtained in the two subsequent years following this spoil disposal. Up to five replicates were taken at each of 13 stations (Fig. 3.4).

The IQI was applied to the data sets generated from the three sampling events and the resulting EQR values are presented in Table 3.14. Only four stations located in the spoil ground (3–6; highlighted in red) were sampled over each of the three sampling periods. Stations 13b and 14 were sampled following, but not prior to, the spoil event. Throughout the entire sampling area, the EQR values showed a slight increase in the 2 years following spoil dumping, the exception being Station 3 which showed a decrease in the first year, but had returned to a good quality 2 years after the dumping. Within each year it is obvious that the spoil may have impacted beyond the bounds of the spoil site and that there was a gradual increase in infaunal quality in Year 2 compared with Year 1, especially at the spoil sites and immediate surrounds. In summary, these data suggest that physical disturbance due to spoil dumping can be detected by the IQI as witnessed by the slight but noticeable increase in the EQR after Year 2 and the fact that the spoil site locations reflect lower EQRs within each year of sampling.

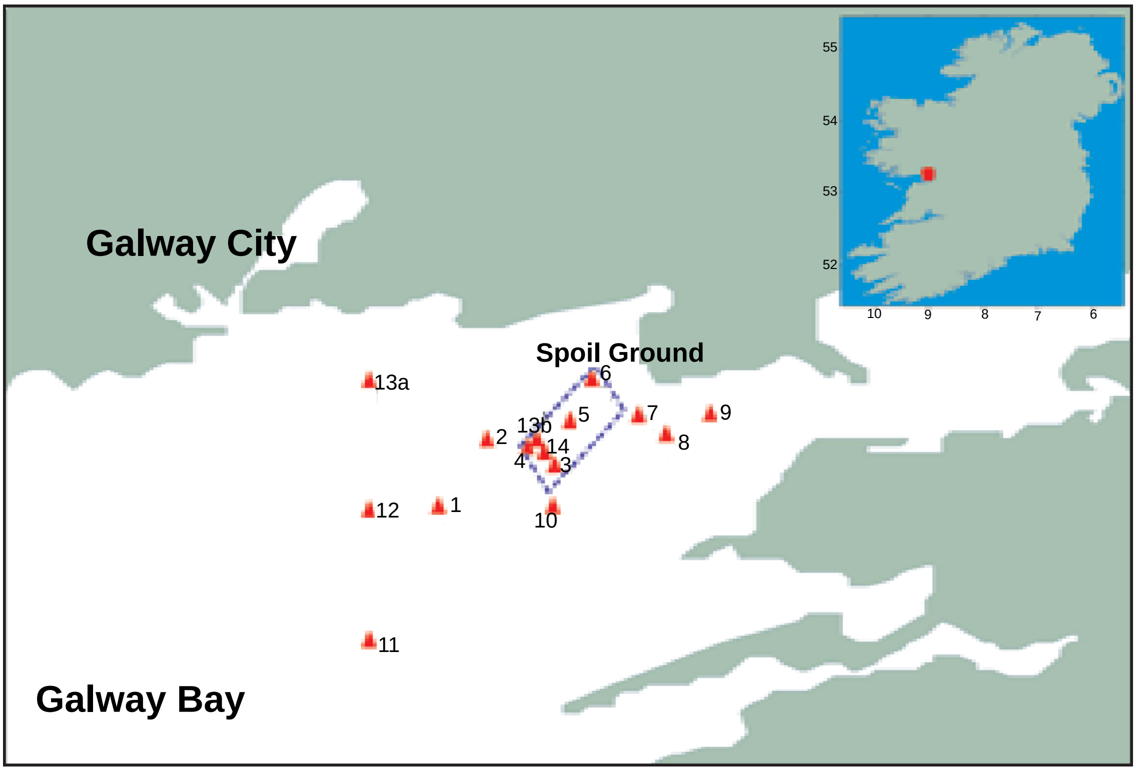

Figure 3.4. Location of the spoil stations. Spoil dumping ground is represented by the blue box.

Table 3.14. Mean Ecological Quality Ratios for the Galway Bay stations prior to, and 1 and 2 years following spoil dumping. Stations highlighted in red are those located in spoil ground.

Station	Pre-spoil (2001)	1 year post-spoil (2002)	2 years post-spoil (2003)
1	High (0.85)	High (0.76)	High (0.79)
2	High (0.8)	Good (0.72)	Good (0.74)
3	Good (0.71)	Moderate (0.62)	Good (0.67)
4	Moderate (0.63)	Good (0.67)	Good (0.7)
5	Moderate (0.6)	Moderate (0.61)	Good (0.66)
6	Moderate (0.51)	Moderate (0.64)	Moderate (0.65)
7	Good (0.74)		
8	Good (0.74)	Good (0.69)	Good (0.68)
9	High (0.8)		
10	High (0.79)	High (0.81)	Good (0.74)
11	High (0.79)		
12	High (0.81)		
13a	High (0.79)		
13b		Moderate (0.65)	Good (0.71)
14		Good (0.67)	Moderate (0.65)

3.3 Fish (Transitional)

Transitional Waters: WFD Annex V, Part 1.3, BQE = fish fauna

3.3.1 TOOL: Fish in transitional waters

3.3.1.1 Introduction to tool

- **Investigates:** Fish in transitional waters.
- **Tool status:** This tool is currently under development. For the purpose of the METRIC project the intercomparison of sampling methodologies in a variety of habitats was undertaken.
- **Habitat:** Transitional waters (mixed habitats).
- **Irish data:** Transitional water (Fig. 2.1).

3.3.1.2 Intercomparison of sampling methodologies

As part of the intercalibration exercise within the NEA-GIG transitional fish group, a need was clearly identified to standardise approaches in relation to the collection of data. This required the determination of fixed approaches regarding the suite of sampling tools to be used and the optimum location and time to employ specific tools. The fish component of the METRIC project was specifically designed to generate data to feed into the NEA-GIG intercalibration exercise as well as the development of fish metrics which are co-ordinated by the Belgian and UK fish teams. Thus, while Ireland has not developed metric classification tools, the Irish data set was considered to be a significant contribution to model testing.

In order to address some of these issues relating to sampling consistency outlined above and to assess comparability of data sets from Member States for same gear type, the Central Fisheries Board, within the METRIC project, convened a 1-week fish sampling workshop in October 2006. Five Member States from the NEA-GIG group (UK, France, Belgium, Northern Ireland and Republic of Ireland) participated in this initiative. The aims of the workshop were to:

- Carry out sampling in a pristine waterbody
- Carry out comparative sampling using a range of sampling equipment from respective NEA-GIG Member States.

The study was facilitated by the Northern Regional Fisheries Board and comparative sampling was undertaken in both the Gweebarra and Swilly transitional waters for the following series of gear:

- Beam trawl: Northern Ireland, Republic of Ireland, UK and France
- Beach seine: Ireland and UK
- Fyke nets: Ireland, UK, France and Belgium.

Additional comparative work for beach seines and fykes was subsequently undertaken under both the METRIC project and the Central Fisheries Board/Regional Fisheries Board National Research Programme in the Moy Estuary, Kenmare River, Drongawn Lough and in Newport Bay and Lough Furnace – the latter two in a comparative study with the Irish Marine Institute.

3.3.1.3 Results

Within each gear type utilised, the Donegal intercalibration exercise showed no significant differences in taxa diversity or abundance among the different national gear types. However, in the Newport intercalibration exercise the Marine Institute fyke net had significantly higher taxa diversity and abundance than the Central Fisheries Board fyke net. This is due to the fact that the Marine Institute fyke nets, although of the same design as the Central Fisheries Board fykes, were deployed in sets of five, as opposed to sets of three for the Central Fisheries Board fykes. In the Gweebarra Estuary exercise, a similar situation occurred with the French fyke nets, having the same diameter as the Central Fisheries Board fykes, were deployed in sets of two, resulting in significantly lower numbers of taxa than the Central Fisheries Board fykes. The finer mesh of the Belgian fykes meant that this net was able to effectively sample gobies unlike the other fykes.

There were some differences observed among gear types due to net design. The finer mesh on wings and heavier lead rope of the Central Fisheries Board beach seine were selected for smaller individuals and flatfish species hugging the substratum. Conversely, the lighter UK beach seine could be deployed faster and could, potentially, sample greater numbers of more mobile species such as sea trout and could also operate in areas of stronger currents. The Northern Irish beam trawl penetrated more on sand and thus was more effective at sampling plaice. The Central Fisheries Board beam trawl was more effective over muddy areas, where the Northern Irish trawl tended to penetrate too deeply into the sediment and bog down. The UK, French and Northern Irish beam trawls are light compared with the Irish and thus can be deployed manually and towed from a rib in upper estuary areas. The Central Fisheries Board beam trawl recorded significantly higher numbers of fish than the Marine Institute beam trawl for the Newport exercise. It is speculated that finer mesh on the upper panel closer to the entrance of the Marine Institute beam trawl contributed to a greater pressure wave at the mouth of the trawl, resulting in fish being deflected away from, rather than entering, the mouth of the trawl. In the Donegal estuaries there appeared to be a relationship between Catch Per Unit Effort (CPUE) and the time of tide. All gear types showed a higher CPUE in the hour before low water. Many of the most abundant fish taxa in estuaries such as gobies and flatfish, utilise the intertidal area and will drop off to the channel as the tide recedes. Thus, sampling should be standardised over a tidal cycle if results are to be comparable. It appears that the ideal time to sample with beam trawls is on the dropping tide.

Overall, similar length ranges were recorded between nets for the most common species within each gear type. Species composition was, in general, relatively similar both between and across the three gear types.

4 NEA-GIG: Generate Type-Specific Reference Conditions and Define the H-G and G-M Class Boundaries

Intercalibration is a process carried out to ensure that the boundaries defined by the Member State classification systems are consistent. In short, the process is designed to ensure that all classification systems are compatible and the standards set across the EU are consistent. Specifically, the intercalibration exercise was carried out to ensure that the H-G and the G-M class boundaries are consistent with the Normative Definitions in Annex V Section 1.2 of the Directive and that they are comparable among Member States. Table 4.1 presents the options that were made available to ensure a Common Implementation Strategy (CIS) for the WFD intercalibration approach (*WFD CIS Guidance Document No. 14*). The primary objective of the intercalibration exercise was to establish harmonised ecological quality criteria for the protection and restoration targets for all surface waters (inland and coastal) throughout the EU. Obviously, this requires a common interpretation of what is a "*good ecological quality status*" of water to be able to compare the results from the different Member States.

The proposed class boundaries for each metric were based on the analysis of biological data collected in waterbodies that are considered to be close to or at reference conditions, determined by expert judgement. Information on this aspect of the project is presented in summary form in the NEA-GIG publication (Jowett, 2006).

4.1 Plants (Macroalgae, Angiosperms and Phytoplankton)

4.1.1 Macroalgae and angiosperms (seagrass and salt marsh)

Ireland did not have sufficient data at the time of the NEA-GIG intercalibration exercise. Data collected during the METRIC project were, however, submitted to the NEA-GIG. Table 4.2 presents information on where macroalgal and angiosperm data were collected in 2006.

4.1.2 Phytoplankton

A combination of common metric methods, selected by the NEA-GIG Plants BQE phytoplankton subgroup (CIS for the WFD intercalibration approach, Option 2: national metric is the same as the GIG metric), were tested on Irish data. The three metrics and associated tools proposed included the Chl *a* (90th percentile statistic), the percentage frequency occurrence of *Phaeocystis* >10^6 cells/l and the percentage frequency occurrence of total phytoplankton (later changed to individual phytoplankton taxon) above a predefined threshold (Ireland = 250,000 cells/l). These metrics/tools were tested by each Member State using historical data for a range of sites designated as High, Good or Moderate status based on expert judgement. Results were compared with the existing national assessment programmes. If the results were not comparable, the Member State was asked to adjust the national method accordingly.

The METRIC team prepared phytoplankton biomass (Chl *a*) and abundance (*Phaeocystis* and other taxa

Table 4.1. Intercalibration and optimisation of boundaries: three different approaches to comparison were proposed for all Ecological Quality Elements.

Option	Description
1	Compare common monitoring systems for countries within each intercalibration group
2	Test one common metric and if suitable calibrate each Member State assessment system against it
3	Tests across individual country assessment systems should take place at a selection of sites across the GIG

Table 4.2. Waterbodies surveyed for macroalgae, seagrass beds, opportunistic algae and salt marsh.

Bay	Eurotype	Waterbody type (Ire)	Short description	Draft reference based on expert judgement	Survey dates (2006)
1. Macroalgae					
Dublin Bay	CW-NEA1	CW5	Moderately exposed	Moderate/Good (Good)	18–20 June
Waterford Harbour	CW-?	CW2	Exposed	High (potential ref.)	17–19 July
Kinsale	CW-NEA1	CW5	Moderately exposed	High (potential ref.)	20–21 July
Killary Harbour	CW-NEA1	CW5	Moderately exposed	Good/High	21–23 June
Ballisodare Bay	CW-NEA2/6	CW8	Sheltered	Good/High	
Gweebarra Bay	CW-NEA1	CW5	Moderately exposed	High?	15–17 June
Mulroy Bay	CW-NEA2/6	CW8	Sheltered	Moderate/Good	12–14 June
2. Opportunistic macroalgae					
Liffey and Tolka Estuaries (Dublin)	CW-NEA11	TW2	Stratified	Moderate	10–11 July
Waterford Harbour	CW-?	CW2	Exposed	High (potential ref.)	20 July
3. Angiosperm assemblages					
A. Seagrass beds					
Dublin	CW-NEA1	CW5	Moderately exposed	Moderate/Good (Good)	12 July
Ballisodare Bay	CW-NEA2/6	CW8	Sheltered	Good/High	13–14 July
B. Salt marsh assemblages					
Lower Suir (Waterford)	CW-NEA11	TW2	Stratified	Moderate/Good (Moderate)	21 July
Ballisodare Bay	CW-NEA2/6	CW8	Sheltered	Good/High	14 July

exceeding predefined threshold) data using the NEA-GIG proposed intercalibration phytoplankton tools. Insufficient data from the originally selected intercalibration sites were available to run the proposed intercalibration tools. Available data from other sites were, however, accepted. The Republic of Ireland successfully tested all three NEA-GIG phytoplankton tools/metrics using historical data for a range of sites designated as High, Good or Moderate status based on expert judgement. From the result it was decided that the *Phaeocystis* tool was not a suitable indicator of water quality in Irish waters and so was not intercalibrated by the Republic of Ireland. Results from the other tools were compared with thresholds of the existing national assessment programme in Ireland. Full agreement between the methods was found for the Irish data set examined. The number of ecological quality status classes in the national method was changed to complement the WFD classification scheme (please refer to the *Milestone 6* report for further information (Jowett, 2006)). No other adjustments were required to the national methods. It is worth mentioning, however, that two separate Chl *a* extraction methods, each with different extraction efficiencies are used in the Republic of Ireland. Separate class boundary criteria for both extraction methods, therefore, had to be developed (Marine Institute = Chl *a* acetone extraction; EPA = chlorophyll total pigments; methanol extraction). Ecological Quality Ratios were developed for percentage frequency occurrence of any individual phytoplankton taxon above a predefined threshold in addition to the Chl *a* acetone and chlorophyll methanol extraction methods (Table 4.3). While the absolute values for the class boundaries for the Chl *a* acetone and chlorophyll methanol extraction methods were different, the relative difference between the H-G and G-M boundaries was the same, resulting in the same EQR values. The NEA-GIG process is explained in Box 4.1.

Table 4.3. Proposed class boundary values of developed phytoplankton tools for the NEA-GIG. nd, not determined; *percentage frequency occurrence of elevated phytoplankton taxon counts above a predefined cell number; **the class boundaries are based on percentage frequency occurrence H = <20% and G = 20–39%.

NEA-GIG	Metric	Bad–Poor	Poor–Moderate	Moderate–Good	Good–High
Version 1	Chl *a*	0.20–0.40	>0.40–0.60	>0.60–0.80	>0.80–1.00
Version 2	Chl *a*	nd	nd–0.33	>0.33–0.67	>0.67–1.00
Version 1**	% frequency*	0.20–0.40	>0.40–0.60	>0.60–0.80	>0.80–1.00
Version 2**	% frequency*	nd	nd–0.61	>0.61–0.80	>0.80–1.00

Box 4.1. Establishment of Irish reference values, class boundaries and conversion to an EQR.

The NEA-GIG assessment was initially carried out on type-specific waterbodies. Results reflected differences in the BQE over a number of ecoregions, each defined by the oceanographic conditions of the associated water mass (e.g. Atlantic Ocean with upwelling areas and other areas).

A decision was then made to define a reference value for each ecoregion.

A reference value for Atlantic coastal waters (NEA-GIG WB Type 1/26a) was derived by each Member State using data from pristine near-reference sites. Irish Chl *a* data and associated indicators of pressure are presented in Table 4.4. The calculated reference value was increased by 50% to calculate the classification boundary between High and Good ecological quality status, following a common method used by OSPAR (Oslo–Paris Convention for the Protection of the Marine Environment of the North-East Atlantic (OSPAR, 2005)). Since there was an absence of good empirical data, 100% deviation was used to give a reasonable indication of a slight to moderate deviation from the H-G boundary. Agreement was then reached on the Chl *a* (µg/l) threshold levels and EQR values for the H-G (Ireland Chl *a* = 5 µg/l, EQR = 0.67) and G-M (Ireland Chl *a* = 5 µg/l, EQR = 0.33) ecological classification boundaries between Member States with the same coastal water mass type.

NEA-GIG WB Type 1/26a (NEA2/6): Name: Open oceanic, exposed or sheltered, euhaline, shallow oceanic. **Salinity:** fully saline (>30 PSU). **Tidal range:** mesotidal (1–5 m). **Depth:** shallow (<30 m). **Current velocity:** medium (1–3 knots). **Exposure:** coastline exposed or sheltered. **Mixing:** Fully mixed. **Residence time:** Days.

Chlorophyll *a* (Chl *a*): Growing Season 90th Percentile Tool: *Acetone extraction method*

NEA-GIG Type 1/26a (Eastern Cantabrian Coast, Canary Islands. Atlantic Coast, Western Irish Sea, Scandinavian Coast: North Sea Norway + Norwegian Sea)

Proposed reference condition values for the Republic of Ireland:

NEA-GIG Type 1/26a – Irish Sea (Acetone Method) = 3.74 µg/l

NEA-GIG Type 1/26a – Atlantic Sea (Acetone Method) = 3.40 µg/l

Agreed Chl *a* reference value for all Atlantic coastal water NEA GIG Type 1/26a WB with 5 µg/l and 10 µg/l for H-G and G-M class boundaries, respectively

3.33 µg/l (NEA-GIG reference) + 1.67 µg/l (50% of reference) = 5.00 µg/l (agreed NEA-GIG H-G class boundary)

Reference condition = 3.33 µg/l, EQR = 1.00

Example of how an EQR is calculated for data derived from the Chl *a* acetone extraction method, Ireland:

Hypothetical 90th percentile Chl *a* value calculated over a 6-year cycle for a selected waterbody = 4 µg/l

EQR = 3.33/4 = 0.83

H-G classification boundary = 5 µg/l (EQR = 0.67)

G-M classification boundary = 10 µg/l (EQR = 0.33)

Table 4.4. Summary statistics of selected parameters (salinity, Chl *a*, oxygen and ammonia) measured during the growing season (March–September) from surface samples at selected waterbodies listed below (numbers of samples measured are in parentheses). 1.5× Chl *a* median and 90th percentile values in squared parentheses are rounded off and displayed in bold font. Please note that data from Bantry Bay have been removed since the median oxygen percentage saturation value exceeded 120%. The closest information available to reference conditions is from Atlantic waters and includes data collected in Clew Bay, Ballinakill Bay, Killary Harbour and Kenmare Bay.

Waterbody	Salinity median (PSU)	Chl *a* median (µg/l)	Chl *a* 90%ile (µg/l)	O_2 median (% Sat.)	O_2 5% (% Sat.)	O_2 95% (% Sat.)	NH_4 median (µmol/l)	NH_4 95% (µmol/l)
Irish waterbodies examined (excluding Bantry Bay)	33.90 (778)	1.60 (1106)	3.48 (1106)	102.76 (296)	90.87 (296)	115.87 (296)	0.86 (1175)	5.09 (1175)
Value × 1.5		**2.5 [2.40]**	**5.0 [5.22]**					
Atlantic waters (excluding Bantry Bay)	33.6 (296)	1.64 (657)	3.40 (657)	102.76 (296)	90.87 (296)	115.87 (296)	0.83 (693)	3.53 (693)
Value × 1.5		**2.5 [2.46]**	**5 [5.10]**					
Irish Sea	33.90 (482)	1.60 (449)	3.74 (449)	–	–	–	0.93 (482)	6.06 (482)
Value × 1.5		**2.5 [2.40]**	**6.0 [5.61]**					
CW2 (CW-NEA2)	34.30 (94)	1.44 (81)	3.46 (81)	107.05 (94)	97.73 (94)	119.17 (94)	1.40 (94)	4.27 (94)
Value × 1.5		**2.0 [2.16]**	**5.0 [5.19]**					
CW5 (CW-NEA1)	33.80 (684)	1.7 (651)	4.00 (651)	100.90 (202)	89.10 (202)	112.85 (202)	1.14 (684)	5.28 (684)
Value × 1.5		**2.5 [2.55]**	**6.0 [6.00]**					
CW8 (CW-NEA2/6)	–	1.50 (397)	1.42 (397)	–	–	–	0.54 (397)	4.05 (397)
Value × 1.5		**2.0 [2.25]**	**2.0 [2.13]**					

4.2 Benthic Macroinvertebrates (Habitat Type A)

Assigning data to the IQI gives an EQR between 0 and 1. This range (0–1) is further divided into five different ecological quality status classes as required by the WFD, i.e. High, Good, Moderate, Poor and Bad. The initial boundaries between these classes were arbitrarily set at equidistant points (0.2) between 0 and 1, with 0 corresponding to heavily impacted classification or Bad and 0.8 being pristine non-impacted conditions and classed as High (Version 1 – Table 4.5). Expanded normative definitions (Table 4.6) were developed and subsequently employed to describe how the metrics will behave at each class and so further assisted in the setting of boundaries that best reflect the definitions. The boundaries for this initial phase of the development of the IQI are presented in Table 4.5 (Version 2). Further modification of the boundaries then ensued as a consequence of the EU-wide intercalibration process (Version 3: comparing four separate indices from Norway, Spain, Denmark, the UK and Ireland) and a subsequent assessment with METRIC data (Version 4).

The latest boundary values (Version 4 – Table 4.5) are acceptable upon publication of this report as they are a result of in-depth validation carried out separately by the METRIC team using Irish data and by the Environment Agency on UK data. The arrival at similar

Table 4.5. Changes in the proposed class boundary values with development of the Infaunal Quality Index for Habitat Type A (Fine Sands and Mud). V3, intercalibration optimised; V4, METRIC optimised.

UK-Ire	Index	Bad–Poor	Poor–Moderate	Moderate–Good	Good–High
Version 1	IQI	0.20	0.40	0.60	0.80
Version 2	IQI	0.20	0.43	0.65	0.80
Version 3	IQI	0.22	0.41	0.61	0.71
Version 4	IQI	0.24	0.44	0.64	0.75

Table 4.6. The expanded normative definition of AZTI Marine Biotic Index (AMBI) ecological group abundances in terms of each ecological quality status class.

	AMBI ecological groups				
Status	**Group I**	**Group II**	**Group III**	**Group IV**	**Group V**
High	Dominant	Absent or sub-dominant		Absent or negligible	
Good	High sub-dominant to absent	Low to sub-dominant	Dominant	Negligible to low to eqi-abundant with GII	
Moderate	Negligible or absent	Low sub-dominant	Co-dominance		
Poor	Negligible or absent		Sub-dominant	Co-dominance	
Bad	Absent			Sub-dominant	Dominant

boundary values suggests that these values have a sound ecological basis.

By their nature benthic communities are inherently variable. The effect of this natural variation was reduced in the development of the IQI by the use of a very large data set and the employment of a consistent approach in terms of sampling and analysing data from similar habitat types. In order to utilise specific data sets, rules regarding consistency of sampling and analysis were employed. Typically the data that contributed to this common data set had the following criteria:

- Samples from EUNIS A5.2 and A5.3:
  - Fully marine (salinity >30 PSU)
  - Subtidal
  - Substratum of sands and muddy sands (A5.2) and muds (A5.3) only
- Sample method: 0.1 m^2 (or close to) processed using 1,000 µm sieve
- Replicated samples (n = 3 or 5)
- Taxa identified to species level where possible with juveniles and epifauna removed (truncation).

In order to best describe the changes in the benthic invertebrate community due to natural and anthropogenic pressure, the metric has also been weighted using maximum values for each component (Max values). These Max values relate to the expected values for a metric in a given habitat, where that habitat has not been subjected to anthropogenic influence, i.e. pristine or as close to reference conditions as realistically measurable. They are set at the 95th percentile rather than at an absolute value which overcomes the problem of outriders. Original faunal lists from samples that provide these Max values were also cross-checked to ensure that these values reflect what would be considered reference conditions for that habitat type. The initial arbitrarily assigned Max values assigned to the IQI multi-metric tool for Habitat Type A (fine sands and mud) were AMBI = 1.0, Simpson's = 1.0 and No. of taxa = 82 (Table 4.7 – Version 1). The number of taxa was based upon expected number of taxa that might be found in fine sands and muds in undisturbed or pristine conditions.

Upon application of data to the IQI it became apparent that the selected Max values would never be achieved. Consequently, the standard set would be too high and the index would never truly represent reference conditions in a waterbody, even in the absence of any

Table 4.7. Two sets of maximum values used to describe reference conditions expected when utilising the Infaunal Quality Index (IQI) for benthic macroinvertebrate fauna.

IQI component	Index (version 4)	AMBI	Simpson's	No. of taxa
Version 1	IQI	1	1	82
Version 2	IQI	0.96	0.97	68

stress, anthropogenic or natural. Subsequent maximum values were then assigned to the IQI.

It was crucial that an accurate description of the reference conditions, which takes into account the degree of natural variation within the different habitats present, was represented when assigning maximum values. However, the problem for many Member States has been to find areas that represent reference conditions, as 200 years of industrialisation has meant that it is very difficult to find waterbodies that may be considered as unimpacted by anthropogenic activity. To this end, Ireland has played a crucial role in providing a variety of data sets from a number of bays that may be considered to represent pristine conditions, i.e. Clew Bay, Kenmare Bay, Greatman's Bay and Kilkieran Bay. The UK Environment Agency has already used these data sets to initially set the Max values for Habitat A (fine sand/muds) and will employ them in the future to set the Max values for reference conditions for the remaining coastal water habitat types. These will then be used to determine the final EQR boundaries for coastal waters that will be proposed to the other Member States. Subsequent review of these data (by the UK Environment Agency and METRIC project), particularly from areas free of known stressors, i.e. Kenmare River, Greatman's Bay, Clew Bay and Kilkieran Bay, provided a revised set of Max values for the Habitat A. This review consisted of a comparison of the Max values calculated with the actual species composition (and abundance). At present the most recent Max values for Habitat A (fine sand/mud) are presented as Version 2 (Table 4.7).

4.3 Fish (Transitional)

The WFD is designed to report on water quality in a holistic manner by providing status information on the various quality elements, with fish being one such element in transitional waters. The mass of information compiled in monitoring series must be compressed into a clear format that can be used by decision makers. In addition, the boundaries between categories must be clearly delineated. What is clear is that consistency must be achieved in terms of sampling methods. The fish sampling methodology intercomparison exercise highlighted inconsistencies in data captured using broadly similar sampling apparatus. Thus, while Ireland has not developed metric classification tools, the Irish data set (METRIC surveys and 16 estuarine waters sampled by the Central Fisheries Board during 2000–2005, Marine Institute juvenile bass surveys carried out annually since 1998 and estuarine studies in Westport Bay and Newport Bay in 2004) is considered to be a significant contribution for the purpose of model testing (http://www.cfb.ie/fisheries_research/estuaries/index.html). It is hoped that these model outputs on the Irish data can be validated against expert opinion in future deliberations. The hope is that these tools can be ultimately adopted to analyse and report on Irish fish data.

5 Main Conclusions and Recommendations

5.1 All Three Biological Quality Elements

- Irish data have been invaluable in the development of the UK-Ire MTT tools. Additionally, as certain Irish waters are considered mostly unaffected by anthropogenic pressures, Ireland was a primary contributor of data from pristine environments from which values for reference conditions were established.

- The collection of plants, benthic macroinvertebrate and fish data is a costly and time-consuming practice. The process requires that a sampling vessel 'fit for purpose' be used or, in the case of macroalgae and angiosperms, trained teams use a small shallow draft boat or walk the shoreline to collect data. Surveys should be carried out by suitably qualified teams with due cognisance of health and safety issues. In addition, suitably qualified personnel to oversee the collection of samples in the field are required as well as individuals with sufficient taxonomic expertise. Given the expense involved in collecting and producing biological data sets, it makes financial and scientific sense to produce them in such a format that allows their use for a variety of purposes. To this end, the importance of adopting standard sampling and analytical procedures is paramount. As standard practice, all programmes should be carried out according to Standard Operation Procedures. Participation in recognised proficiency schemes (e.g. BEQUALM: Biological Effects Quality Assurance in Monitoring Programmes) would ensure a consistent standard of taxonomic identification and would facilitate the development of taxonomic expertise. Laboratories should have an in-house quality system in place with accreditation from an internationally recognised authority such as the Irish National Accreditation Board (INAB; ISO 17025). This would assure precision, accuracy and repeatability of results of the techniques carried out in the laboratory. All of these factors would lead ultimately to the production of standardised biological records which would facilitate the clear and concise comparisons of flora and fauna over a variety of temporal and spatial scales.

5.2 Plants

5.2.1 Macroalgae and angiosperms

- **Intertidal Coastal Waters Macroalgal Reduced Species List (RSL) – Rocky Shore Tool:** This tool is ready to be tested in the first RBD assessment cycle.

- **Macroalgal Blooming Tool (abundance and biomass of opportunistic green macroalgae):** This tool is ready to be tested in the first RBD assessment cycle. The extent of intertidal area within a waterbody will impact strongly on the calculated results of the tool, the calculation of which has proven challenging. It is recommended that a protocol is developed to calculate accurately the intertidal area of a waterbody. This will assist in harmonising the tool. Methods could include dedicated aerial imagery or mapping surveys to be undertaken in the field by fieldworkers with a Differential Global Positioning System (DGPS).

- **Seagrass and Salt Marsh Tools:** To provide necessary data for classification based on this tool for the entire waterbody, a baseline survey mapping of all beds and assemblages within the waterbody should be carried out at the initial stage of monitoring. This would identify beds and assemblages lost either to anthropogenic or natural factors.

- Detailed mapping of salt marshes should be carried out to include lower salt marsh (Fossitt Habitat Classification Code CM1 (Fossitt, 2000) and upper salt marsh (Fossitt Habitat Code CM2). Zonation within Irish salt marshes is highly complex and a more detailed mapping methodology to include the zonation within the marsh would vastly contribute to the value of a salt marsh as a useful indicator.

- All data received and gathered in this project were collected in the Irish National Grid. However, if data were to be shared between countries latitude and longitude would be the recommended data to use instead of Irish National Grid.

5.2.2 Phytoplankton

- **The Chlorophyll *a* – 90th Percentile Tool** is fully developed and ready to evaluate the ecological quality status of Irish surface waters in the first cycle of the WFD. The monthly data during the growing season should provide important information on patterns of water quality variation. If sampling can only be carried out during the summer for transitional waters then this approach will require more intensive sampling during these months. One disadvantage in running the tool for just 3 months of the year is that if abnormalities in phytoplankton biomass occur at other times of the year, these events will be missed.

  Since the methanol extraction analytical method does not correct for pheo-pigments, results should not be directly compared with other Member States using different extraction methods. It is recommended that a standardised approach in the method is taken by all Member States in the EU. It is also recommended by the authors of this report that the chlorophyll acetone extraction method is employed for the WFD phytoplankton monitoring in Irish TraC waters (see internal METRIC report on a chlorophyll intercomparison study by Noklegaard *et al.* (2006), available on request from francis.obeirn@marine.ie). When changing to a new analytical method a number of factors must be taken into account including available resources. In particular, historical results may no longer be directly comparable with results generated using the new method. An in-depth comparison of the old and new methods should be carried out in tandem before the new method is employed.

- **Elevated Phytoplankton Counts Tool:** The identification of phytoplankton to species level, or alternatively, to a higher taxonomic rank in a sample is very much dependent on the taxonomic expertise of the analyst and/or the laboratory where the analysis is carried out. The sample fixative used will also decide if identification to species level is possible using light microscopy. Setting the predefined allowable thresholds, therefore, needs to be determined for each Member State separately. The UK-Ire phytoplankton checklist which is currently under review by taxonomic experts should be adopted.

- **The Elevated Phytoplankton (Individual Taxon) Counts Tool** is developed for Irish coastal waters and is ready to evaluate the ecological quality status of Irish surface waters in the first cycle of the WFD. A *caveat* must be incorporated into this tool to ensure that phytoplankton bloom species advected from offshore waters are not included in the analysis. Since the cell concentration threshold of this tool is based on excessive cell counts of single taxa from a small number of near-reference coastal waters it may need to be revised when more data become available to test this tool more rigorously. Cell concentration thresholds need to be determined for transitional waters since insufficient data were available during this project to investigate this.

- **Species Composition (Biodiversity) Tool:** The EU may insist that a biodiversity- or a more taxa-driven tool is developed for phytoplankton. It is therefore recommended that phytoplankton biodiversity is investigated further and a tool using a suitable statistical method is developed in order to investigate changes in phytoplankton species composition (species shifts). The EC 6th Framework Programme REBBECA project has been investigating species indices (Rekolainen, 2006). It is hoped that this project will assist with this issue if a second intercalibration exercise through the GIG is undertaken.

5.3 Benthic Macroinvertebrates: Infaunal Classification Systems

- The benthos component of this project has generated and sourced a number of benthic invertebrate data sets that have fed into the benthic ecology quality element tool development and EU (NEA-GIG) intercalibration exercise (to a lesser extent).

- The exercise of collection of benthic field samples and subsequent laboratory processing and analysis gave an indication of the time and effort required to fulfil a monitoring programme for the marine benthic invertebrate ecological quality element under the WFD. As the Marine Institute has been designated to carry out this portion of the monitoring under the WFD, it allowed them to provide realistic estimates in terms of costs that the programme would require. These details were provided to the EPA on 9 June 2006 (Hennessy *et al.*, 2006).

- The IQI multi-metric tool must fulfil the criteria as set out by the European WFD. In order to describe the ecological quality status of the benthos it must take into account changes in abundance and diversity, and also the presence of disturbance-sensitive and indicator taxa and taxa indicative of pollution in the marine benthic invertebrate community. The METRIC Benthic Team is satisfied that this multi-metric fulfils all of these criteria.

- The IQI has been proven to be sensitive to a variety of pressures in Irish waters, including organic enrichment from fish farms and physical disturbance from spoil dumping. Historical data sets from fish farms demonstrate the sensitivity of the IQI to a spatial pressure gradient. Azoic conditions did on occasion occur directly beneath the fish cages and in the past such samples would be disregarded (as is the case with AMBI). But with the IQI, rather than disregarding samples that are azoic, it utilises them to give a Bad ecological quality status to that sample.

- In addition, variations observed in the values of the IQI appear to closely reflect changes in redox measurements in the sediment. In infaunal benthic communities, the redox potential discontinuity layer, representing the boundary between oxic and anoxic sediments, is likely to have a strong and immediate effect on the distribution of the fauna. Given the close relationship observed between the EQR and redox values this demonstrates the usefulness of the multi-metric in detecting change in faunal distribution instantaneously.

- The boundary values reached following the harmonisation process have been formally accepted by Ireland. Given the in-depth validation process carried out separately by the Benthic Team on the Irish data and the arrival at certain boundary values independently by the UK Environment Agency, it would suggest that these boundary values have a sound ecological basis. Maximum values for IQI component indices and classification boundary values should be developed for a variety of other sedimentary habitats.

5.4 Fish (Transitional)

- The METRIC fish study has shown the value of using a suite of fishing gear in a multi-method approach, as advocated by the UK Environment Agency. The use of this range of sampling gear has added considerably to the taxa diversity listings of many of the estuaries examined.

- The project successfully highlighted the suitability of different sampling gear to sample different habitats. As a consequence, the project has highlighted the need for 'fit-for-purpose' sampling of estuarine areas with differing habitat characteristics.

- The METRIC fish programme has been successful in its primary aim – to populate a national database for Ireland in respect of fish in transitional waters. The project has facilitated a doubling of the number of estuaries for which information on the composition and abundance of the fish community is available in a standardised manner. The project has enabled Ireland to create a larger database for sharing with EU partners within the NEA-GIG forum. The data are to be used for cross-referencing and intercalibration in the Belgian and UK metric systems designed to generate EQRs. The METRIC project has facilitated the first shared field study examining gear intercalibration among the NEA-GIG team. It has also permitted sampling in estuaries around the entire Irish coast, including waters far from major human influences. The 'pristine' conditions encountered do not necessarily point to enhanced community composition or abundance. As such, these findings create considerable food for thought and a possible re-defining of what 'pristine' might mean. The recording of species such as red mullet and golden grey mullet point to a further factor that will render classification difficult – the onset of global warming and migration of fish species into latitudes and longitudes not previously occupied by them. These factors point to a changing rather than a fixed boundary system, something that WFD implementation must be cognisant of in future classification endeavours.

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National Development Plan 2007 - 2013

Science, Technology, Research and Innovation for the Environment (STRIVE) 2007-2013

The Science, Technology, Research and Innovation for the Environment (STRIVE) programme covers the period 2007 to 2013.

The programme comprises three key measures: Sustainable Development, Cleaner Production and Environmental Technologies, and A Healthy Environment; together with two supporting measures: EPA Environmental Research Centre (ERC) and Capacity & Capability Building. The seven principal thematic areas for the programme are Climate Change; Waste, Resource Management and Chemicals; Water Quality and the Aquatic Environment; Air Quality, Atmospheric Deposition and Noise; Impacts on Biodiversity; Soils and Land-use; and Socio-economic Considerations. In addition, other emerging issues will be addressed as the need arises.

The funding for the programme (approximately €100 million) comes from the Environmental Research Sub-Programme of the National Development Plan (NDP), the Inter-Departmental Committee for the Strategy for Science, Technology and Innovation (IDC-SSTI); and EPA core funding and co-funding by economic sectors.

The EPA has a statutory role to co-ordinate environmental research in Ireland and is organising and administering the STRIVE programme on behalf of the Department of the Environment, Heritage and Local Government.

Environmental Protection Agency
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