

4.2 Knowledge & Information Management Research Programme

4.2.1 Introduction

The transformation of data into information and then on into knowledge is a process that we must manage effectively to ensure that maximum value is gained from research investment. In this document we use the term 'Knowledge and Information Management' to describe those activities that make this transformation process possible.

In order to achieve this transformation, the many sources of data must be linked physically and by a common language, so that information becomes readily accessible. Once this is done, computation resources, analytical tools and human expertise can be applied to create knowledge products for use by a wide range of interests.

Many organisations are actively involved in the collection of marine data. In the past, the approach taken internationally has been to archive copies of data in marine data centres. These centres then took responsibility for reporting to organisations such as the International Council for the Exploration of the Seas (ICES). Recent advances in communications technology, together with issues relating to the currency of data, the duplication of archives and funding, have led to the emergence of a more distributed approach to information management. This sees individual organisations maintaining data that they have collected and making it accessible on-line or off-line through on-line data catalogues. This change in practice in relation to the management of data makes achievable the goal of having readily available knowledge products, irrespective of where the users, or the data sources used to create the products, are located.

The challenge that now faces Ireland is the establishment of effective mechanisms to allow for ease in the discovery of, and access to, data. To meet this challenge, there is a national need for investment; development of policies; and the co-ordination of expertise, data and technologies.

4.2.2 Current Status

There are a number of distinct data holdings that collectively represent the national marine data asset. A number of ongoing research, monitoring and management programmes highlight the need for the management and co-ordination of these data sets. The relevant organisations, programmes and data sets are summarised in Tables 4.5 and 4.6.

Efforts to integrate data holdings have only started recently, with inter-agency projects such as the Marine Data Exchange project, this is being conducted by the Marine Institute with the GSI, the EPA and UCC participating as project partners. The project is linking the spatial data catalogues in each organisation in order to move toward a national Marine Data Exchange Service. At the same time, the Ordnance Survey of Ireland (OSI) are conducting a pilot project to establish a national spatial data catalogue.

Table 4.5 Irish Organisations with Significant Marine Data Holdings

<p>Department of Communications, Marine and Natural Resources (DCMNR) DCMNR is the central government department with responsibility for the Marine. It is responsible for regulatory enforcement and licensing of commercial marine activities and holds data on, for example, fish landings, aquaculture licenses and foreshore leases and licenses. Much of the monitoring work carried out by the MI is on behalf of DCMNR. Data is submitted to the EU.</p>
<p>Petroleum Affairs Division (PAD) PAD is a line division of DCMNR and its remit is to license private enterprise to conduct petroleum and hydrocarbon exploration and production (E&P). An online inventory containing information on hydrocarbon exploration and development data from offshore Ireland, as well as summary information on individual wells and surveys, is operated by PAD. It is available from www.informatic.ie/paddi.</p>
<p>Geological Survey of Ireland (GSI) The GSI is the National Earth Science Agency. The GSI produce a range of products including maps, reports and databases and acts as the knowledge centre and project partner in all aspects of Irish geology. The GSI works in collaboration with the Marine Institute in the Irish National Seabed Survey programme and manages the data produced by that programme.</p>
<p>An Bord Iascaigh Mhara (BIM) BIM collects data relating to commercial fisheries and aquaculture. This includes economic data relating to marine activities. Data is exchanged with central government, ICES, the EU and other assessment bodies.</p>
<p>Marine Institute (MI) The Institute carries out a variety of monitoring and research programmes, including operation of the national weather buoy network, management of two national research vessels, nutrient monitoring, biotoxin monitoring, contaminants monitoring, fisheries stock assessment, sea lice monitoring, and salmon tagging. Data is submitted to national and international organisations. An online inventory of marine data sets and projects is available from www.marinedataonline.ie.</p>
<p>The Environmental Protection Agency (EPA) The EPA participates in the National Marine Monitoring Programme and has responsibility for implementation of the Water Framework Directive, including assessment of transitional waters.</p>
<p>National Parks and Wildlife Service (NPWS) The NPWS (Department of the Environment, Heritage and Local Government – DoEHLG) conduct and commission surveys of marine habitats and species in support of its remit to designate and manage conservation sites (NHAs, SACs and SPAs).</p>
<p>Third-level Sector A number of Irish universities and Institutes of Technology participate in a range of research programmes at national and international level. The data produced by these programmes is managed on an ad-hoc basis and is not reported or retained centrally.</p>
<p>Radiological Protection Institute of Ireland (RPII) RPII have a marine monitoring programme in place since the early 1980s. It involves the routine sampling and testing for radioactivity in fish, shellfish, seaweed, sediments and seawater. Both DCMNR and MI staff are also involved in this work. Sampling data is available from their website (www.rpii.ie) and results are published.</p>

Within the Third-level and public sectors, Grid consortia provide research organisations with access to data and appropriate computational resources across the country. The National Centre for High-end Computing has recently been established, with the support of Science Foundation Ireland (SFI), to provide a national High-End Computing (HEC) resource. Within the HEC research community, the marine domain is increasingly regarded as providing large-scale civilian computational problems for investigation.

Increasingly, geo-spatial technologies are being applied to the marine area. The Marine Institute has developed a Marine Data Warehouse based on the internationally developed Marine Data Model. This model provides a geo-referenced schema for all marine related data. Nationally, SFI have established the National Centre for Geo-computation as a centre of excellence at NUI Maynooth.

Table 4.6 Programmes Driving the Management and Co-ordination of Marine Data

<p>E-Government Services Programme (DCMNR) The E-Government Services Programme, being conducted by the Department of Communications, Marine and Natural Resources, is streamlining the process of conducting business in the marine sector. Through a range of projects, including the Integrated Fisheries Information System (IFIS), DCMNR are providing customer services to stakeholders, reducing lead times and simplifying processes.</p>
<p>Ocean Explorer Programme (Marine Institute) Through its Ocean Explorer Programme, funded by the Information Society Fund, the Marine Institute has been delivering a number of services including a metadata catalogue to provide an inventory of research data, projects, and collaborators; a data repository of oceanographic and related marine information; and a set of on-line services that provide discovery tools, simple analysis and data delivery.</p>
<p>EU Data Collection Regulation (ICES/DCMNR/MI/BIM/Industry) The EU Data Collection Regulation (1543/2000), introduced by DG Fisheries, is driving the standardisation and co-ordination of fisheries stock assessment data. The Directive covers a range of parameters, including stock data, discard data and socio-economic data. The Marine Institute co-ordinates Irish reporting activities on behalf of DCMNR.</p>
<p>Water Framework Directive & The National Marine Monitoring Programme (DoEHLG/EPA/MI) The Water Framework Directive, currently in a data-gathering phase, is establishing baseline data sets for the future monitoring of water quality in Irish rivers, lakes, estuaries and coastal areas. The EPA estimates that some thirty-six monitoring programmes will be required, with participation from five state agencies and local authorities.</p>
<p>The Irish National Seabed Survey (GSI/MI) The Irish National Seabed Survey, being led by the Geological Survey of Ireland (GSI) in partnership with the Marine Institute, has completed Phase 1 of operations. This five-year programme (outlined in the Seabed & Resource Mapping section) has generated a very large core data set, together with a number of ancillary data sets. These are being managed principally by the GSI, with support from the Marine institute and the third-level sector.</p>
<p>The Irish Spatial Data Infrastructure The Irish Spatial Data Infrastructure (ISDI) is an initiative being led by the Department of the Environment, Heritage and Local Government. The ISDI is developing a national strategy for the management of data of all types with a spatial component.</p>
<p>The Information Society (Department of An Taoiseach) The Information Society agenda is promoting the use of ICT to enable the provision of government services. The development of public service information infrastructures, such as the Public Services Broker (Reach Agency), is providing focal points for data integration activities.</p>
<p>INSPIRE (INfrastructure for SPatial InfoRmation in Europe) This EU programme is endeavouring to make more and better spatial data, including marine related data, available for Community policy making and implementation in Member States at all levels. It focuses particularly on information needed to monitor and improve the state of the environment. The proposed approach to implementation (2009–2013) is based on infrastructures for spatial information established and operated by the Member States. Within Ireland, the ISDI project will develop this infrastructure.</p>

4.2.3 Key Opportunities and Challenges

How can Knowledge products enable decision support?

The provision of decision support systems will be a key deliverable in the establishment of a knowledge management infrastructure. Such systems will underpin the assessment and management of marine resources and activities. For example, within fisheries management the approach has changed from consideration of a single species, e.g. cod stocks in the Irish Sea, to the so-called 'ecosystems approach' where the interaction between multiple species and habitats is considered. This approach aims to achieve sustainable development by assessing interactions and cumulative effects of specific actions, with a view to maintaining fully functional ecosystems. The key to this approach is the ability to turn disparate data sources into the information and knowledge required to support effective management decisions. It requires data from a wide spectrum of disciplines, themes and organisations to be packaged, structured and made accessible to support integrated analysis.

In order to provide this, a number of technology strands will have to be brought together, namely:

- > Data Discovery and Retrieval Tools—allowing data in diverse organisations to be searched and brought together as required;
- > Data Mining and Warehousing Tools—allowing specific data patterns to be searched for, and discreet sets of data from multiple sources to be queried together; and
- > Visualisation Tools—allowing users view the data interactively, in both a spatial context and a modelled representation.

How best can the management of Marine Data be co-ordinated?

Given the dispersed nature of marine-related data, how best can activities taking place in public bodies, central government, private companies and third-level research institutes be co-ordinated? Mechanisms for identifying opportunities to re-use data collected elsewhere and sharing of technical resources will need to be identified. Technical issues to be addressed include publicising data already available, agreement on standards for data exchange, and approaches to maintaining historical archives.

What new technologies provide opportunities for Knowledge Management?

Because of parallel developments in other sectors, Ireland is likely to be well positioned to take advantage of a number of emerging technologies that can be applied to evolving research opportunities in the marine sector. An example is High-end Computing (HEC) centres. Given the very large volumes of data arising from marine research streams and sensors, including satellite and aerial remote sensing, the development of mechanisms to process and turn this data into knowledge in real- or near-real time will be of great importance to research programmes in the marine sector.

What new research opportunities will require a Knowledge Management infrastructure?

A number of emerging research opportunities (outlined in more detail in other parts of this document) will drive the requirement for significant knowledge management strategies in their own right. Proposed research in the following areas is likely to lead to the generation of large data sets requiring the use of new technologies as already discussed. Examples of such areas are:

- > Biotechnology/Biodiscovery

- > Seabed & Resource Mapping
- > Cabled Underwater Networks
- > Ocean Circulation and Climate Change Modelling

What legislative and policy initiatives will drive improved Knowledge products?

New approaches to data management, at national and international levels, are evolving through recognition of the need to reduce data duplication, improve efficiencies and increase return on investments made in data collection. The EU Directives on Re-use of Public Sector Information and INSPIRE (see Table 4.6) are two such approaches. Within this context, spatial information is seen as having particular advantages, given the potential to use it as a base for integration across a variety of disciplines.

4.2.4 2020 Vision

2020 VISION

By 2020, Ireland will be a leader in scientific knowledge management with information on Ireland's marine resources effectively managed, easily accessible and routinely used to support national and international policy and management decisions.

4.2.5 2013 Objectives

The following objectives have been identified as critical milestones to be achieved by 2013:

2013 OBJECTIVES

- 1 Develop a National Coastal and Marine Information Service, in order to:
 - > Deliver key demand-driven information services targeted to the specific needs of stakeholders and sectoral groups;
 - > Provide data and information for policy development and regulatory activities;
 - > Develop the capacity and expertise required to integrate data and information in order to improve the quality of scientific advice;
 - > Provide a single mechanism for capturing and reporting on the availability of marine data holdings; and
 - > Ensure that relevant data generated by research projects is passed, where appropriate, into use in monitoring and management programmes.
- 2 Promote an effective marine knowledge infrastructure and policy at a national level.
- 3 Identify and develop emerging technologies that will support knowledge and information management objectives in the marine sector.
- 4 Establish data management standards for new national strategic research programmes.
- 5 Ensure a high profile for marine data sets when data and information policy and legislation are being framed at national and international levels.

4.2.6 RTDI Requirements/Key Outputs

The identified RTDI requirements and key outputs for delivering on the 2013 Objectives of the research programme are presented below.

Table 4.7 Research Requirements & Key Outputs Related to Knowledge and Information Management to 2013

Objectives 2013	RTDI Requirements	Key Outputs
<p>1 Develop a National Coastal & Marine Information Service in order to:</p> <ul style="list-style-type: none"> > Deliver key demand-driven Information Services targeted to the specific needs of stakeholders and sectoral groups; > Provide data and information for policy development and regulatory activities; > Develop the capacity and expertise required to integrate data and information in order to improve the quality of scientific advice; > Provide a single mechanism for capturing and reporting on the availability of marine data holdings; and > Ensure that data generated by research projects is passed, where appropriate, into use in monitoring and management programmes. 	<p>Integrated Data Management</p> <p>Programmes that focus on the development of frameworks for the integration of data from multiple sources—areas to be addressed include diverse data types, varying spatial resolutions, varying temporal resolutions, currency, archival, large volumes, semantics & ontologies</p> <p>Data Discovery</p> <p>Programmes for the selection of appropriate standards, identification of technical approaches, and the selection of appropriate protocols</p> <p>Data Exchange</p> <p>Programmes to develop methodologies for the exchange of marine data between multiple organisations leveraging on existing programmes and mechanisms such as the REACH public service broker</p> <p>Geo-spatial Analysis</p> <p>Research programmes are required in the areas of hydrography, catchment management, local and global climate change, habitat modelling, and security & threat management</p>	<ul style="list-style-type: none"> > New inter-agency information services that target the needs of specific stakeholders and are linked in a single information portal > Data and information on Ireland's marine resources, managed by a diverse range of organisations, is easily accessible by all stakeholders > Improved quality of information delivered in support of policy development, including relevant archives of marine data being made accessible to support improved service delivery and generation of value-added products > Data collected under national research and monitoring programmes is documented, with descriptive metadata, and made available via the Coastal & Marine Information Service > Data resulting from research programmes is integrated with data from routine monitoring programmes to support generation of value-added products and services
<p>2 Promote an effective marine knowledge infrastructure and policy at a national level.</p>	<p>Policies and Best Practice:</p> <p>Programmes to respond to the rapid pace of change in the areas of data capture, dissemination and distribution are needed. A national review of policies and best practices in these areas is required. Such research will underpin the delivery of new data centred services and products and resolve issues such as IPR</p>	<ul style="list-style-type: none"> > The need for national standards to support the management and dissemination of marine data is supported by all relevant organisations/bodies > A policy clarifying the rights and responsibilities relating to ownership, custody and distribution of national marine data sets is in place

continued

Table 4.7 Research Requirements & Key Outputs Related to Knowledge and Information Management to 2013

Objectives 2013	RTDI Requirements	Key Outputs
<p>3 Identify and develop emerging technologies that can support knowledge and information management objectives in the marine sector.</p>	<p>Data Mining Programmes will assess how the practice of automatically searching large stores of data for patterns can be applied to environmental and physical data</p> <p>Data Visualisation Research areas that need investigation include 3D visualisation, sampling of large-scale data sets to allow timely rendering, firmware and hardware, and processing of algorithms for data transformation and display</p> <p>Bioinformatics Research programmes will support investigations in the areas of biotechnology and biodiscovery. These will investigate how best to provide information systems for such areas where large amounts of data are processed in an iterative fashion</p> <p>High-end Computing Investigate the use of techniques for parallel problem solving, coupled with computers operating at, or near, the current highest operational rate possible. This includes the areas of High Performance Computing and Grid Computing</p>	<ul style="list-style-type: none"> > Increased capacity to analyse large data volumes, through use of high-performance computing facilities and improved quality of information services > Improved ability to model and describe data relating to the 3-dimensional marine environment > Enhanced interfaces are available to support visualisation and interpretation of complex marine data sets by researchers, legislators and policy makers > Improved dissemination tools are available to support delivery of information needed by researchers, legislators and policy makers
<p>4 Establish data management standards for new national strategic research programmes.</p>	<p>Data Discovery</p> <p>Data Exchange</p> <p>Integrated Data Management</p> <p>Policies and Best Practice</p>	<ul style="list-style-type: none"> > Assessments completed to determine the scale and scope of the data resource to be managed and the associated costs and benefits > National standards agreed for marine data storage and archiving. > National standards agreed for marine metadata, data exchange and discovery > Research data is collected to common standards, facilitating integration with operational programmes > Marine data is accessible and more readily available for access and exchange between stakeholders
<p>5 Ensure a high profile for marine data sets when data and information policy and legislation are being framed at national and international levels.</p>	<p>Policies and Best Practice</p>	<ul style="list-style-type: none"> > Approaches and mechanisms for implementation of the INSPIRE Directive in relation to the marine sector have been established and agreed > Mechanisms for the inclusion of marine data within the national Irish Spatial Data Infrastructure have been agreed and are operational

4.2.7 RTDI Capacity/Capabilities

Current Research Capacity

Third-level Sector

In the third-level sector, two research groups are currently directly involved in marine-related knowledge and information management research. Together, these groups comprise approximately 10 researchers in marine knowledge and information management research (Table 4.8). Although many other marine research groups manage data generated through research projects, they are considered as IT users rather than innovators.

Table 4.8 Overview of Current Marine Knowledge & Information Management Research in the Third-level Sector

Institutes	No. Research Groups	No. Researchers*	Research Focus
UCC NUIG	2 Large Groups	10	<ul style="list-style-type: none"> > GIS > Modelling > Data management > Data visualisation

Large: >10 researchers; Medium: 5–10 researchers; Small: <5 researchers

* In some cases, research groups may focus on more than one theme and the total number of researchers in these groups is greater than indicated here. The total number of researchers in the groups identified is approximately 50.

In addition, a large number of research teams throughout the third-level sector have expertise/technologies in the broader field of knowledge and information management. A recent on-line survey of IT departments in the third-level sector identified 13 research groups, comprising over 100 researchers, with potential to contribute to the identified RTDI requirements (Table 4.9).

Table 4.9 Research Focus of Third-level Institutes with Potential to Contribute to Marine Knowledge and Information Management Research

Institute	Research Focus	Institute	Research Focus
UCC	<ul style="list-style-type: none"> > Integrated Data Management > Data Discovery > <i>Data Mining</i> > <i>Data Exchange</i> > <i>Marine Data Archival</i> > <i>Policies & Best Practice</i> > <i>Geo-spatial Analysis</i> > <i>Data Visualisation</i> 	NUIM	<ul style="list-style-type: none"> > Geo-spatial Analysis > Bioinformatics > (Data Mining) > (Data Visualisation) > (High-end Computing) > (Data Discovery)
Letterkenny IT	<ul style="list-style-type: none"> > Geo-spatial Analysis > <i>Data Discovery</i> > <i>Integrated Data Management</i> > <i>Data Visualisation</i> 	NUIG	<ul style="list-style-type: none"> > Data Exchange > High-end Computing > (Integrated Data Management) > (Data Visualisation) > (Data Mining) > (Marine Data Archival) > (Bioinformatics) > (Data Discovery) > (Policies & Best Practice)

continued

Table 4.9 Research Focus of Third-level Institutes with Potential to Contribute to Marine Knowledge and Information Management Research

Institute	Research Focus	Institute	Research Focus
TCD	> Data Visualisation > <i>Geo Spatial Analysis</i>	IT Tralee	> Radio Frequency Systems & Traceability
IT Sligo	> Data Visualisation > <i>Data Mining</i>	DIT	> Spatial Data > Interactive Digital Media
DCU	> Computational Modelling > Statistical Modelling Applications		

Note: (Topics in italics indicate secondary research focus or expertise). **N.B.** This is a non-exhaustive list. Other groups/institutes may have similar/additional skills/technologies.

State Sector

Where research and innovation capacity is required, state agencies normally utilise capacity that exists within the third-level sector. Direct research and innovation capacity in the state sector is normally the result of specialised requirements arising from operational programmes. Instances of such expertise in the marine area include:

- > The Geological Survey of Ireland—specialist knowledge in the field of dense data management and interpretation has been built up from the Irish National Seabed Survey.
- > The Marine Institute—research and innovative approaches have been taken in examining the issues surrounding data management, data exchange, geo-spatial analysis and marine related data modelling as a result of the Ocean Explorer programme funded by the Information Society.
- > The Environmental Protection Agency—requirements from programmes such as the Water Framework Directive are driving research. The EPA conducts such research in conjunction with research performers through the Environmental Research, Technological Development and Innovation (ERTDI) programme of the NDP.

Industry

A small number of private companies and individuals offer marine IT-related services and are involved in nationally and EU funded research programmes. Areas of expertise within these companies include data management, GIS and data visualisation.

Identification of Research Skills/Competencies to Meet Future RTDI Requirements

A summary, based on the identified future RTDI requirements, of the competencies required to meet the 2013 Objectives is presented in Table 4.10. Also included in Table 4.10 is an assessment of whether there are current strengths (S), areas that require strengthening (R), or gap areas (G), in relation to the identified requirements, within the existing research community; both in a general sense and, more specifically, in the marine field.

Table 4.10 Competencies Required to Meet Future Research & Innovation Requirements Related to Knowledge & Information Management

Objectives 2013	Competencies Required	Assessment	
		General	Marine
<p>1 Develop a National Coastal & Marine Information Service in order to:</p> <ul style="list-style-type: none"> > Deliver key demand-driven Information Services targeted to the specific needs of stakeholders and sectoral groups; > Provide data and information for policy development and regulatory activities; > Develop the capacity and expertise required to integrate data and information in order to improve the quality of scientific advice; > Provide a single mechanism for capturing and reporting on the availability of marine data holdings; and > Ensure that relevant data generated by research projects is passed, where appropriate, into use in monitoring and management programmes. 	<ul style="list-style-type: none"> > Data discovery > Data exchange > Integrated data management > Geo-spatial analysis 	R S R S	R R G R
<p>2 Promote an effective marine knowledge infrastructure and policy at a national level.</p>	<ul style="list-style-type: none"> > Data discovery > Integrated data management > Policies and best practice 	R R G	R G G
<p>3 Identify and develop emerging technologies that can support knowledge and information management objectives in the marine sector.</p>	<ul style="list-style-type: none"> > Data mining > Geo-spatial analysis > Data visualisation > Bioinformatics > High-end computing 	S S S R R	R R G R R
<p>4 Establish data management standards for new national strategic research programmes.</p>	<ul style="list-style-type: none"> > Data discovery > Data exchange > Integrated data management > Policies and best practice 	R S R G	R R G G
<p>5 Ensure a high profile for marine data sets when data and information policy and legislation are being framed at national and international levels.</p>	<ul style="list-style-type: none"> > Data discovery > Data exchange > Policies and best practice 	R S G	R R G

* S – Current Strength; R – Requires Strengthening; G – Gap Area.

Although general strengths exist nationally in relation to many of the competencies outlined in Table 4.10, the application of these skills to marine issues is vital for meeting the 2013 Objectives. Important areas in which gaps exist include integrated data management and policies and best practice (Figure 4.2). Areas that require strengthening include high-end computing, data exchange and data mining. Building competencies in these areas is vital for the successful delivery of many of the research programmes within the Industry, Discovery and Policy Support Measures.

Current Strengths	Require Strengthening	Gaps
	<ul style="list-style-type: none"> > Data discovery > Data exchange > Geo-spatial analysis > Data mining > High-end computing > Bioinformatics 	<ul style="list-style-type: none"> > Integrated data management > Policies and best practice > Data visualisation

Figure 4.2 Research Competencies Required to Meet 2013 Objectives for Knowledge & Information Management

4.2.8 Prerequisites for Achieving Objectives

> Stakeholder Co-ordination

A National Stakeholder Group to co-ordinate marine data management activities is required. Without such a group there is likely to be a fragmented approach to data management, resulting in a lack of data integration.

> High-end Computing Facilities

Given the volumes of data, and the nature of some of the problems to be analysed (including, but not limited to bioinformatics, climate change models and pollution prediction models), large computational resources will be required. These are discussed in detail in the Infrastructure Supporting Programme section of this document.

Computational resources will require intellectual capacity to support its use by research teams. In effect, this means that there is a need for centres of expertise in particular scientific domains with the capacity to utilise High-end Computing facilities. These centres of expertise will work with individual research teams seeking to model particular problems.

> Policies and Best Practice

Given the rapidity of change in the area of data capture, management and distribution, a review of policies and best practice in the areas of data management, dissemination and use are required. This is needed to underpin the delivery of new data services and resolve issues such as intellectual property rights.