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The Irish Sea: towards a more effective science strategy

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Abstract. The Irish Sea's distinctive hydrographic features present unique opportunities for research into the complex processes that regulate shelf-sea ecosystems. Such studies are essential in developing capabilities to detect and evaluate change in marine environments. A 1993 review showed almost 230 projects underway on the Irish Sea, spanning all the major fields of marine science. But a large proportion of research projects failed to indicate the purpose of the work; overall, there was a remarkable absence of clarity and specificity in the objectives. Progress in some fields is also hampered by insufficient coordination and cohesion; at present there are no standing arrangements between Ireland and the United Kingdom that provide for bilateral co-ordination of scientific work in the area. There is clearly a need for a more planned and integrated Irish Sea science programme to provide information for management purposes and also to advance scientific understanding of the components and functions of Irish Sea ecosystems, and how and why they change with time. There is a common belief that the first of these predominantly involves monitoring, and the second research. However, the paper cautions that this is a dubious and unnecessary distinction. A strategy aimed at better integration of research and monitoring (e.g. a framework of linked objectives and targets) could substantially increase the information dividend from current investments in Irish Sea science. Based on a joint Irish/UK review, this paper outlines studies and approaches that are seen as key elements of a future, more relevant and cost-effective research programme for the Irish Sea .

Keywords: Marine science; Monitoring; Research objective; Research programme.

Abbreviation: ISSCG = Irish Sea Science Co-ordination Group.

Introduction

In a number of respects the Irish Sea (Fig. 1) is well-suited to studies of marine ecosystem function. Its physical hydrography includes an array of complex, interacting features that are not only of great interest to hydrographers worldwide but also important in regulating biological production and modifying impacts of human activities including pollution. The structure and circulation of the waterbody are strongly influenced by forces propagated in the external Atlantic, as well as by local physiography and climate, and show considerable seasonal and inter-annual variability. The Irish Sea supports valuable fisheries, a wide variety of wildlife habitats, as well as a range of industrial, maritime and recreational activities. It's coastal and offshore areas are constantly altered by such activities. By no means least, the Irish Sea is a relatively small and accessible area bordered by countries with excellent marine research capabilities.

There could be genuine benefits from a more organized approach to marine science in semi-enclosed sea areas such as the Irish Sea. A structured regional programme, that targets important information needs within a realistic time-frame of, say, five-to-ten years, and encourages greater inter-disciplinary and inter-laboratory collaboration, would tend to make more efficient and productive use of scientific resources than an assemblage of independently planned studies.

This is the underlying premise of a three-year initiative by the Irish and United Kingdom governments that set out to identify gaps in scientific information on the Irish Sea, to define priorities for future work and to improve bilateral co-operation in marine science generally. The Irish Sea Science Co-ordination Group (ISSCG), which undertook the work on behalf of the governments, issued three reports (Anon. 1993; Boelens 1994; Boelens 1995) the last in July 1995. Boelens (1995) outlined a five-to-six year programme of integrated research and monitoring that, with proper support and co-ordination, should improve greatly the information used to assess environmental conditions in the Irish Sea (i.e. for preparing Quality Status Reports) and to manage and protect its resources.

The concept of integrated regional science programmes is certainly ambitious and such programmes could be difficult to implement. Nevertheless this paper argues that governments and science administrators should devote much greater effort to developing strategies that would progressively improve the output and value of marine science on regional scales. The

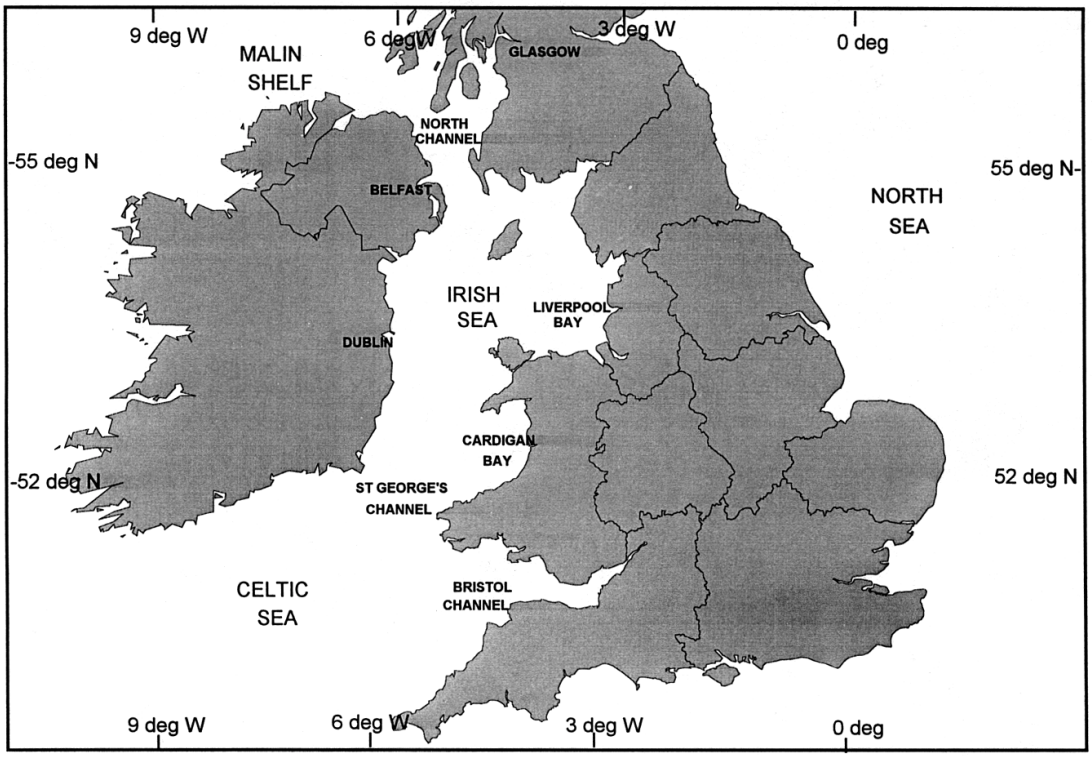

Fig. 1. The Irish Sea.

paper outlines ISSCG's proposals for future studies in the Irish Sea, as well as the procedures by which these proposals were developed. It also discusses managerial and other arrangements that will be needed to forge these studies into a coherent regional programme.

Current scientific activities

ISSCG's first report (Anon. 1993) summarized information from a questionnaire sent to over 60 laboratories and agencies with various involvements in Irish Sea science. The questionnaire focused on active projects, both research and monitoring, especially their objectives, temporal and geographical scope and the main science disciplines concerned. Information was received on approximately 230 projects and has been stored in a computerized database (dBase version IV). There are no plans at present to update the database. Nevertheless, the report identifies ways in which future project inventories might be improved.

Predictably, UK laboratories dominate scientific activity on the Irish Sea, outnumbering the Irish contribution by about 3:1. Public sector institutions account for almost two-thirds of the projects although in Ireland the universities play a substantial role. With respect to geographical distribution, coastal and near-shore areas receive most attention but estuaries and offshore areas are also well covered. Almost 70 % of the projects are in areas north of a line from Dublin Bay to Anglesey with the most intensive effort being directed at the northeast Irish Sea (Liverpool Bay to the Solway). Greatest attention is given to biology, followed by chemistry, physical hydrography and modelling, and radioactivity.

Table 1 summarizes responses from project leaders regarding their 1992/1993 projects and the information needs they aimed to address. Evidently most projects covered several topics in parallel, although it seems likely that in some cases the scope was overstated i.e. contributions were either indirect or consequential. A large proportion of projects focus on aspects of contamination and, in all fields of research, considerable attention was given to temporal change.

Defining a more productive programme

The mission

The challenges facing ISSCG in subsequent phases of its work were: (1) how to analyse and review current scientific activities and (2) how to identify priorities and

Table 1. Numbers of Irish Sea projects addressing selected information needs (Anon. 1993).

Subject area	Projects	(% total)
Temporal changes	128	57 %
Contaminant concentrations	91	40 %
Contaminant pathways	77	34 %
Population dynamics	76	34 %
Contaminant effects	70	31 %
Nutrient issues	58	26 %
Input fluxes	57	25 %
Hydrographic models	54	24 %
Resource inventories	41	18 %
Human health risks	37	16 %
Critical habitats	29	13 %
Disease in biota	9	4 %

Projects addressing one or more of the above information needs: 225.

to incorporate them into a programme that would be more useful and productive.

Programme structure

Requirements for marine environmental information fall into two broad categories: (1) information required by national and international agencies for management and protection purposes and (2) information that advances scientific understanding of marine ecosystems, their components and functions, and how and why they change with time. There is a common belief that the first of these predominantly involves monitoring, and the second research. As discussed below, this is a dubious and unnecessary distinction.

The list of routine data requirements mandated by EC-directives, national legislation and international agreements is substantial and focused to a large extent on inputs, distributions, trends and effects of contaminants. Categories of contaminant of particular interest and concern include heavy metals, radionuclides, nutrients, pathogens and persistent organohalogen compounds. There is also increasing demand for information on topics such as stocks of commercial species, abnormal phytoplankton blooms, mortalities of sea birds and mammals, fish diseases, beach litter, and changes in habitats and communities. Clearly, the underlying rationale for much of this information is the need to know how and why the marine environment is changing. It is here that the links between monitoring and research become all important.

A common fault in monitoring projects is that they fail to account for the inherent variability of marine systems. As noted by several marine science advisory bodies (Anon. 1989; Anon. 1990), this is often the reason why monitoring produces data of limited value. For example, when planning to compare datasets on contaminant levels at different times and locations, the assumption is too often made that appropriate standardized methods for sampling and analysis are all that is required. But the tools alone will not ensure successful monitoring. Without prior knowledge of spatial, seasonal and inter-annual variations in the media (i.e. water, sediment, species/tissue) to be sampled, it is unlikely that the sample numbers, sites and frequencies selected will be suited to the task. If monitoring programmes are to be designed correctly, some knowledge of variability in the sea areas concerned is essential.

It was thus apparent to ISSCG that a more productive and useful Irish Sea science programme would involve a carefully planned schedule of integrated research and monitoring. In other words, any serious attempt to assess the health or condition of the area would involve changes in the structure, as well as the content, of the present programme. Furthermore, the situation wherein laboratories and agencies pursue their individual and independent scientific interests would need to evolve into a more collaborative programme in accordance with a well-defined and agreed strategy.

Programme content - defining information needs

A prerequisite for identifying deficiencies in existing scientific activities is an inventory of information needs. Thus, a logical step for ISSCG was to define, as concisely as possible, the general objectives (i.e. statements of what should be achieved and why) of scientific studies needed to adequately understand, manage and protect marine environments. The aim was to create an optimized template for marine environmental science as a basis for evaluating current Irish Sea studies.

Having considered many options for cataloguing marine environmental information, ISSCG opted for a set of six broad categories: Physical processes, Chemical-Sedimentary processes, Marine life, Bio-processes, Contamination and Human health risks. It was emphasized that scientific progress in any one category would depend on outputs from other categories. Thus, ideally, the structure of marine science programmes would reflect the inter-dependencies between the major components and processes of marine ecosystems. Despite the wide array of potential techniques and approaches, ISSCG felt that all investigations of 'change' and 'quality' in the Irish Sea could be assigned to one or more of a small set of objectives linked to the six selected information categories. The resulting set of 14 *General Objectives* (Boelens 1994), which should be applicable to any sea area, is presented in Table 2. Clearly, subordinate and far more *specific* objectives are needed for individual studies.

Table 2. General objectives for investigation of environmental change and quality in the Irish sea (Boelens 1994).

1. Hydrographic properties

To elucidate processes and to quantify variables that will enable the circulation, transport, physical-chemical structure and production capacity of the Irish Sea to be simulated and predicted by means of computer-based models; to identify hydrographic conditions, their temporal and spatial patterns, that might mitigate or accentuate the effects of natural and man-made changes in the Irish Sea.

2. Chemical and sedimentary properties

2a. To define the input and output fluxes, spatial patterns and boundary-exchanges of trace elements, nutrients and other substances in the Irish Sea both to delimit ambient chemical properties and to support studies on physical and biological processes; to derive, initiate and maintain systems for identifying changes in these conditions with time.

2b. To define the structure, composition and dynamics of fine sediments in the Irish Sea, including net riverine fluxes; to identify areas with high rates of sediment accretion or mobility; to assess the implications of sediment transport for the stability of coasts, the distribution of hazardous (i.e. classified) contaminants and the maintenance of important benthic habitats.

3. Bio-processes

To define processes that regulate and sustain the productivity and diversity of Irish Sea ecosystems; to derive parameters for monitoring, and to develop systems for simulating and predicting, variations in these processes over time.

4. Marine life (biology)

4a. To describe the flora and fauna of the Irish Sea including species distributions, assemblages and habitat dependencies; to classify coastal, littoral and sub-littoral habitats on the basis of community structure (i.e. biotopes) identifying dominant or *key* species; to identify species and assemblages which: a) by virtue of their abundance, biomass, seasonality or location play a major role in energy transfer, and cycles of production or decay; or b) are inherently sensitive to human interference.

4b. To elucidate the population dynamics and behaviour of species, and the structures of communities, selected for their ecological and/or commercial importance; to identify trends or abnormalities and the factors involved.

4c. To determine the causes, extent and significance of temporal changes in habitats of ecologically or commercially important species and communities.

5. Contamination

5a. To obtain a more complete inventory of synthetic organic substances entering the Irish Sea from all sources;

5b. To identify chemicals entering the Irish Sea, and not currently 'listed' (EC directives; UK Red List; nationally *prescribed*) as hazardous substances, which on the basis of their physical and chemical properties, and existing toxicological data, are intrinsically hazardous to the marine environment;

5c-5f. To complement measures for the reduction of contaminant inputs to the Irish Sea with a programme of selective field research and monitoring comprising:

(5c) the identification (from field studies and/or predictive pathway analysis) of gradients and sinks for substances listed (or otherwise classified) as *hazardous*;

(5d) the monitoring of appropriate media within these gradients and sinks to determine concentrations and exposures;

(5e) the assessment of toxicological risks for the most highly exposed organisms and, accordingly, investigation of biological responses and development of relevant Environmental Quality Standards;

(5f) the incidence, distribution and origin of litter on beaches, floating materials and other marine debris.

6. Human health risks

To continuously review the risks to human health associated with exposures to substances (including toxins) and micro-organisms in seawater and marine produce; to monitor levels of hazardous substances and micro-organisms for compliance with relevant standards and, where standards do not exist, to establish the risks (i.e. probability) of harm to human health from current and predicted exposures.

A good reason to focus on objectives is that their importance is often underestimated. Although it should be obvious that every scientific project needs to be designed around a clear statement of what is to be achieved and why, and that this statement should be the main guide to project performance (i.e. completion, success), in many cases the thought and care given to the drafting of objectives is grossly inadequate. This is another common factor limiting the value of monitoring programmes. But the problem is not confined to monitoring. For example, a high proportion of Irish Sea research outlines reviewed by ISSCG failed to indicate the purpose of the work. Overall, there was a remarkable absence of clarity and specificity in the objectives. Apart from the implications for project design and efficiency, this can lead to serious difficulties when interpreting results.

Priority topics and activities

On the basis of the *General Objectives* (Table 2), ISSCG was able to review all current Irish Sea projects and to provisionally identify scientific topics that warranted greater attention including, in the case of existing studies, work that needed to be either expedited or expanded. This list of topics was included in ISSCG's second report (Boelens 1994) and is shown in Table 3. In its final report (Boelens 1995), ISSCG selected a group of studies to address these and related topics and showed how they could be incorporated into a revised, and more integrated, science programme. Each study is described in terms of specific objectives and principal work requirements.

Table 3. Areas of Irish Sea science requiring additional work (Boelens 1994).

- Accelerated development of hydrographic models
- Time-series datasets from selected reference sites
- Improved data on riverine contaminant inputs
- Measurement of atmospheric inputs
- Predictive models of sediment transport
- Contaminants in fish-eating birds
- Completion of a sediment quality survey
- Relationships between nutrients and primary production
- Mapping of offshore benthic communities
- Extension of coastal zone habitat surveys
- Abundances of non-exploited fish species
- Quantities and species of fish discarded by fisheries
- Inputs and concs of synthetic organic substances
- New strategy for monitoring contaminant distributions
- Relationships between contaminant inputs and concentrations
- Transport and fate of long-lived, man-made radionuclides
- Greater use of biological effects indicators
- Statistics (incl. trends) on human uses and activities
- Data on oil pollution incidents (incl. oiled birds)

Programme management

The output and value of a regional science programme involving different institutions and disciplines depends on good management as well as programme content. ISSCG's analysis revealed a number of shortcomings in current practices for the management of Irish Sea science.

At present there are no standing arrangements between Ireland and the United Kingdom that provide for bilateral co-ordination of scientific work on the Irish Sea. This applies even in the case of work conducted by government laboratories in response to international programmes to which both countries contribute. In recent years, however, there have been examples of bilateral collaboration on particular projects aided by European funding and several new initiatives of this kind are under active consideration. Possibilities for co-operation between the UK's National Rivers Authority (NRA) and Ireland's Environmental Protection Agency (EPA) are also being reviewed.

In ISSCG's view, the prospects for closer integration of Irish and UK scientific work on the Irish Sea would be improved if each side had a mechanism to co-ordinate national activities in marine research and monitoring. In this context, the Group emphasized that closer integration of research and monitoring (particularly research to improve the design of monitoring and the interpretation of monitoring data), was one of its key recommendations. At present, inter-agency co-ordination of marine science is much more advanced in the UK than in Ireland, but in both countries monitoring and research tend to be managed separately.

It is reasonable to suggest that an agreed common programme for Irish Sea science should stimulate both countries to review their national arrangements for co-ordination of marine science and to introduce mechanisms that would facilitate bilateral collaboration and co-ordination. There is no doubt that the viability of ISSCG's proposals for a programme that would integrate research and monitoring on a bilateral basis requires commitments from both governments, not only to the programme content but also to provision of the necessary resources and co-ordination mechanisms. Closer links between laboratories and agencies on both sides of the Irish Sea, embracing workshops and field activities as well as quality assurance, processing and storage of data will require on-going and efficient man-

agement systems supported by both governments.

In conclusion, the ISSCG process has shown how a regional programme in marine science may be evaluated and remodelled using a coherent set of objectives that encompass long-term requirements for marine environmental data. The resulting proposals afford a valuable opportunity for the Irish and UK governments to establish a new bilateral programme that would greatly increase the output and value of Irish Sea science and thereby improve the basis for protecting and managing the resources of the area.

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