

# Oceans of Opportunity

## Exploring Ireland's Marine Resources

*Review of Projects 2000–2005*

*Supported under the Marine  
Research, Technology, Development  
& Innovation (RTDI) Measure  
(NDP 2000 - 2006)*

**The Marine Institute was created in 1991 with the following functions:**

“to undertake, to co-ordinate, to promote and to assist in marine research and development and to provide such services related to marine research and development, that in the opinion of the Marine Institute will promote economic development and protect the marine environment”

**Marine Institute Act - 1991**



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# Foreword



This publication gives an overview of projects and some of the achievements of the research and development activity funded under the Marine RTDI in the current National Development Plan (2000–2006). Approximately €52<sup>1</sup> million was originally committed to the programme and although the funding period is not fully complete, it is timely to look at the range of projects that have been supported and developed under the National Development Plan.

The marine sector in Ireland is now worth around €3 billion per annum and supports 44,000 jobs. As part of the national drive to develop a dynamic, technologically sophisticated knowledge-based economy, these investments under the NDP have the potential to make a significant contribution to Ireland's mission to be a player in valuable global markets for marine derived materials and technologies.

This investment, combined with marine research funds from other agencies such as Science Foundation Ireland, the Higher Education Authority, and IRSCET, has brought about significant changes in Ireland's marine research landscape. We are looking at a sector that is making an increasingly important contribution to the Irish economy by growing its strategic research capacity, and providing the spin-offs that can be exploited commercially by the growing number of small and medium enterprises in the marine sector.

The Applied Industry sub-Measure encouraged small indigenous firms to access R&D capacity in third-level/public research institutes and/ or develop their own in-house R&D capacity. It has helped to build collaborative networks that will be the foundation for their future growth.

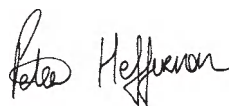
To date, 24 industry projects have been funded. Many of the projects funded, which, in some cases are collaborations between industry and research institutes, are focusing on emerging areas such as; Ocean Energy, Biodiscovery and Biotechnology, and Knowledge and Information Management.

The creation of three-year funding cycles provided the stability critical to support the research community to address strategic priorities, which has been difficult in the past, in a short-term funding environment. The support available, through scholarships and fellowships, is building our knowledge and skills base in a range of important policy areas such as the EU Marine Strategy, the EU Water Framework Directive and the Convention on Biological Diversity.

The programme supported 14 PhDs, (11 directly) and 12 post-doctoral fellowships.

Scientific outputs to date include 34 publications in peer-reviewed journals (Appendix II).

This funding from the NDP represents a significant and long-term financial investment in national marine science and makes a valuable contribution to Ireland's ability to be a global player in key areas of marine Research, Technology Development and Innovation.



**Dr. Peter Heffernan**  
Chief Executive - Marine Institute  
October 2006

<sup>1</sup> actual budget allocation as of the end of 2006 was €46.4m.

## Selected Highlights

Many of the research projects funded under the Marine RTDI Measure of the NDP are either nearing completion or will conclude in 2007. However, during 2006 there are already many strong commercial and scientific impacts emerging from the Research, Technology, Development and Innovation activity supported under this programme. Some examples include:

- **Dunmanus Seafoods** in Cork, collaborating with the Aquaculture and Fisheries Development Centre in UCC have patented the first land-based system for commercial sea urchin cultivation for aquaculture, estimated to be worth approximately €3 million. This will give them a strong foothold in the €264 million worldwide market for urchin roe.
- **Bonnar Engineering** in Donegal has patented an interactive modelling system, which will optimise the use of offshore fish cages. This is the first time worldwide that a fully integrated tool is available to match cage structure to the appropriate environmental conditions offshore and gives the company a strong edge in the market for specialist cages costing over €100,000 each.
- **ASTOX** - The successful completion of this multi-disciplinary leading edge research into Azapiracids, a toxin found in shellfish that can cause considerable harm to humans if contaminated shellfish are consumed, had led to strong technology/knowledge transfer from Japan and the U.S to Ireland and the production of certified reference material. The scientific outputs of this work provide the potential for commercialisation of the technologies and products developed by this project.
- **Ocean Energy** - the creation of a dedicated new research team in Ocean Energy in UCC's Hydraulics and Maritime Research Centre (HMRC) has the potential to make a major contribution to Ireland's future energy needs. By developing a critical mass of technical ability in renewable OE technologies, Ireland is creating a strong competitive edge in R&D activities.
- **Marine Informatics Ltd.**, a Limerick-based SME, anticipate an increase in sales of 30% by improving the telemetry modules for their data loggers. In a separate project, the company is looking at developing safer enclosures for deploying data systems at sea. The combination of these improvements should allow the company to increase its turnover significantly over the next few years.
- **Site Investigations into Pancreas Disease (SPDV)** – This research into the single most infectious disease agent affecting salmon aquaculture, which causes up to 50% mortalities at some sites, will make a significant contribution to reducing the economic loss to the industry from PD - estimated at €12.7 million during 2004.
- **Smart Coast (Water Quality Monitoring)** – The market for miniaturised, intelligent monitoring systems for freshwater and coastal waters is a growing one and currently valued at approximately €500 million. The National Centre for Sensor Research in Dublin, the Tyndall National Institute in Cork and the Microelectronics Application Centre in Limerick are collaborating to exploit the high-level capabilities at these Centres and meet the demand in international markets for advanced sensor and instrumentation packages.
- **Marine Biodiscovery** – The Marine Biodiscovery Proof-of-Concept project is an exciting example of what the future holds for the marine sector in Ireland. Eight different research teams are collaborating to study bioactive compounds derived from a range of marine organisms. Such compounds have the potential to be targeted as anti-cancer, anti-infective and therapeutic solutions to address diseases causing major quality of life issues in humans.
- **Publications** – To date, Marine RTDI funded research has produced 34 publications in peer-reviewed journals. A further 10 publications have been submitted, with 20-25 publications in preparation; including 10-12 articles to be published in a special edition of an international journal. In addition, a large number of non peer-reviewed publications and presentations at national and international conferences have arisen from the research.

# Introduction

This report provides an overview of the activities and achievements of the NDP Marine RTDI Measure to date. It focuses primarily on the range of projects supported under the Marine RTDI Fund sub-Measure, outlining the achievements of projects completed to date and highlighting the expected outcomes from research that will be completed in 2006 and 2007.

The Marine Measure is one of six measures on Research, Technology, Development and Innovation (RTDI) supported under the Productive Sector Operational programme of the National Development Plan 2000–2006. The Marine Institute, is the implementation agency on behalf of the Department of Communications, Marine and Natural Resources and the Department of Enterprise Trade & Employment.

The guiding objectives of the Measure are to:

- Enhance and consolidate the performance of the marine sector in Ireland through support for R&D and technology transfer activities; and
- Provide the RTDI capacity and infrastructure to enable Ireland to fully utilise its marine resource potential in a sustainable manner

Three sub-measures have been created to structure investment during the lifetime of the plan;

## **Enhanced Provision of Research Vessel Capacity (Sub-Measure 1)**

Under sub-Measure 1 the priority is to improve research vessel capacity to cover outer Continental Shelf activities. The Marine Institute took delivery of the 65 metre multi-purpose Celtic Explorer in December 2002 and since then the vessel has been involved in a broad range of research activity in Irish waters.

## **Upgrading Marine RTDI Infrastructure (Sub-Measure 2)**

This funding strand of the programme provides grant-aid for the upgrade of key national marine laboratories and facilities to provide the necessary capacity and infrastructure to support priority research activities.

## **Supporting Marine RTDI Fund (Sub-Measure 3)**

The Marine RTDI Fund supports project based RTDI in targeted areas. Sub-Measure 3 is divided into two programmes - Applied Industry and Strategic Projects. There are also a number of supporting initiatives such as desk studies, fellowships (post-doctoral and post graduate) and networking and technology transfer. Projects under the National Development Plan have been funded across the following key strategic areas;

### **Sustainable Marine Resource Development**

- Sustainable Sea Fisheries
- Salmon Management
- Aquaculture, including seaweed
- Associated Policy issues

### **The Health of the Oceans**

- Understanding and Modelling Marine Ecosystems
- Climate Change Monitoring, Assessment and Prediction
- Renewable Ocean Energy

### **Gateway to the World**

- Maritime Transport and Shipping

### **Knowledge-based Management**

- New Information Technologies
- Marine Diagnostics & Biodiscovery
- Applied Technologies

## Sub-Measure 1: Enhanced Research Vessel Capacity

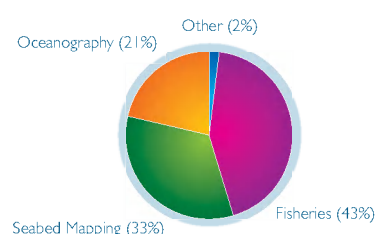
Ireland's marine resource encompasses an area of approximately 900,000 km<sup>2</sup>. Up until 2002, Ireland's only marine research vessel, the 31 metre Celtic Voyager, was capable of covering only a fraction of this territory. With support under this Measure the Celtic Explorer, a 65 metre multi-purpose research vessel, was designed and commissioned, on time and on budget, at a total cost of €31.7 million (including VAT). This acquisition has allowed Irish and European researchers to pursue research and survey activities within Ireland's entire Exclusive Economic Zone and beyond. In the mid-1990s, the ratio of international scientific survey activity in the Irish marine territory to survey activity undertaken by Irish research groups was 40 to 1. This ratio has decreased 10-fold since the acquisition of the Celtic Explorer.

The RV Celtic Explorer has a number of unique features that make it particularly suited for marine research and surveying, for example:

- The vessel is one of only three vessels worldwide that are fully compliant with ICES noise requirements for fisheries research. Consequently, the vessel is acoustically silent, which minimises fish avoidance and provides an ideal environment for the collection of high quality acoustic data with minimal interference from vessel noise.
- The vessel's scientific transducers are mounted on a drop keel such that (a) they can be lowered below the depth of hull interference and (b) the keel can be raised inside the vessel in order to service the transducers whilst underway and avoid the use of divers or having to dry-dock the vessel.



Every year a broad range of organisations use the Celtic Explorer (and Celtic Voyager) for research, development and monitoring programmes; these include government departments and agencies, universities, research institutes and industry. Both vessels are available to the national and international marine science community. In its first three years of operations (2003-2005), the Celtic Explorer averaged over 300 operational days at sea per annum on a range of survey types<sup>1</sup>.



Celtic Explorer Operations by Sector (2003-2005)

Some of the more high-profile surveys conducted since then include the National Seabed Survey, Orange Roughy Survey, trials of the MEBO Robotic Drilling Rig and the University of Hamburg's Meteorological Survey.



Track of the Celtic Explorer during 2005

<sup>1</sup> THIS AVERAGE INCLUDES 116 DAYS OF ACCEPTANCE TRIALS IN 2003



# Sub-Measure 1: Enhanced Research Vessel Capacity

## MEBO

In late 2005, the Celtic Explorer undertook trials with the MeBo Robotic Drilling Rig in the Baltic Sea in association with the MARUM Centre for Marine Environmental Sciences at the University of Bremen. The MeBo is a self-contained, remotely operated, deepwater drilling system. It will be used at depths of 2000m to drill holes and retrieve core samples up to 50m in length. It also uses sensor probes to perform in-situ measurements. It is hoped that several projects utilising MeBo will be conducted on board the Celtic Explorer.

## Seabed Survey

Between 2003 and 2005, the Celtic Explorer was involved in the Irish National Seabed Survey. This was an ambitious, multimillion-euro collaboration between the Geological Survey of Ireland and the Marine Institute, with the goal of mapping Ireland's seafloor. This work has given Ireland a global reputation for seabed mapping in just five years. We now possess the expertise and technologies necessary to support oceanic exploration. The Seabed Survey has mapped over 87% of the Irish continental marine area, producing over 300 paper-based charts and a total of 5.5TB (1TB = 1000 GB) of digital information.

## Orange Roughy

The aim of the Orange Roughy survey was to assess the populations of this species associated with Carbonate Mounds on the western and northern rises of the Porcupine shelf, an area off the West Coast of Ireland. This was a multi-disciplinary survey involving fisheries scientists, geologists and hydrographers. Data were collected using a scientific echo sounder mounted in a deep towed vehicle. Multibeam, ROV and fisheries acoustics methods were also used to map Orange Roughy habitats and deepwater corals and to investigate the possibility of identifying aggregations.

## University of Hamburg

In 2005, the RV Celtic Explorer carried out a meteorological and oceanographic survey off the Norwegian Coast with the University of Hamburg to investigate the characteristics and impacts of cyclones and air-sea interaction. The aim of the research is to understand the climatic interactions between the land, ocean, atmosphere and ice.

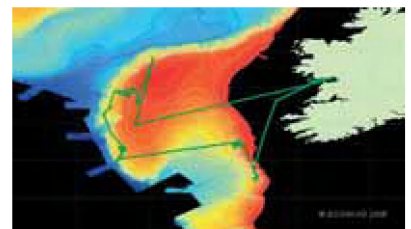


Image of Seabed Mapping showing cruise track for the NUI, Galway/University of Limerick cruise on the RV Celtic Explorer



Example of ROV-based multibeam bathymetry data (0.5m grid) with INSS multibeam bathymetry data (25m grid)

## Sub-Measure 2: Marine RTDI Infrastructure

The primary objective of this sub-measure is to upgrade key national marine laboratories to provide the necessary capacity and infrastructure to support priority marine RTDI activities.

Detail	Service Area	Grant-Aid
Upgrading of Laboratory at Dunmore East	Fisheries Science	€30,375
Upgrading of Laboratory at Castletownbere	Fisheries Science	€48,400
Scanmar Scanbas System	Fisheries Science	€49,610
Laboratory Downdraft System	Marine Environment and Food Safety	€28,270
Field Fluorometer	Marine Environment and Food Safety	€22,050
Suite of autonomous <i>in-situ</i> sensors	Aquaculture & Catchment Management	€32,169
Multifunctional workboat	General	€57,665

In 2002, a strategic review of infrastructure needs within the operating Divisions of the Marine Institute was carried out. As a result of this process, seven projects were approved for funding to a total value of €268,539.

An open call was issued in 2006 under this sub-measure of the RTDI to prioritise the infrastructure needs identified in the national Marine Research and Innovation Strategy 2007-2013. The following four areas were targeted:

- Specialist laboratory/equipment to address identified research priorities
- Provision of High-End Computing capacity
- Expansion of ocean & coastal monitoring capability
- Purchase of robotic platforms/ ROV/AUV.

## Sub-Measure 3: Marine RTDI Fund

The Research Technology, Development and Innovation fund supports projects across targeted areas. Sub-Measure 3 is divided into two programmes and a number of supporting initiatives.

### Applied Industry RTDI programme

This programme aims to support and strengthen the RTDI capacity of indigenous industry in the marine sector by providing grant-aid to support in-house and co-operative projects undertaken in conjunction with research partners such as third-level institutes. During the period 2000–2005, 22 applied industry projects were grant-aided at a total cost of €1.26 million.

### Strategic Marine RTDI programme

The Strategic programme aims to support national marine RTDI capacity building through grant-aid support for strategic marine R&D projects. During the period 2000–2005, 21 strategic projects were grant-aided at a total cost of €7.69 million. These include a combination of Marine Institute defined and applicant defined projects.

### Supporting Initiatives

These include the following:

- Desk Studies – 14 Studies grant-aided;
- Post-doctoral Fellowships – 12 Post-doctoral Fellowships;
- Post-graduate Scholarship – 11 PhD Fellowships; and
- Networking and Technology Transfer – 89 Networking and Technology Transfer grants awarded.

### Sub-Measure 3: RTDI Grant Aid, 2000–2005

Project Measure	Number	Grant-Aid Approved (€)
Strategic Projects	21	8,063,051
Applied Industry	22	1,262,176
Post-Doc Fellowships	12	1,859,023
PhD Scholarships	11	1,075,646
Desk Studies	14	696,462
Networking & Technology Transfer Grants	89	126,846
Micro Innovation Awards	2	14,000
Technical Assistance <sup>1</sup>	-	188,228
Appointment of Fish Vet <sup>2</sup>	-	140,000
<b>Total</b>	<b>171</b>	<b>€13,425,432</b>

1: Includes consultancy, monitoring & evaluation costs.

2: In 2004, the Marine Institute and the Faculty of Veterinary Medicine at UCD jointly funded a lectureship in Fish Pathology and Marine Science.

## Sub-Measure 3: Marine RTDI Fund

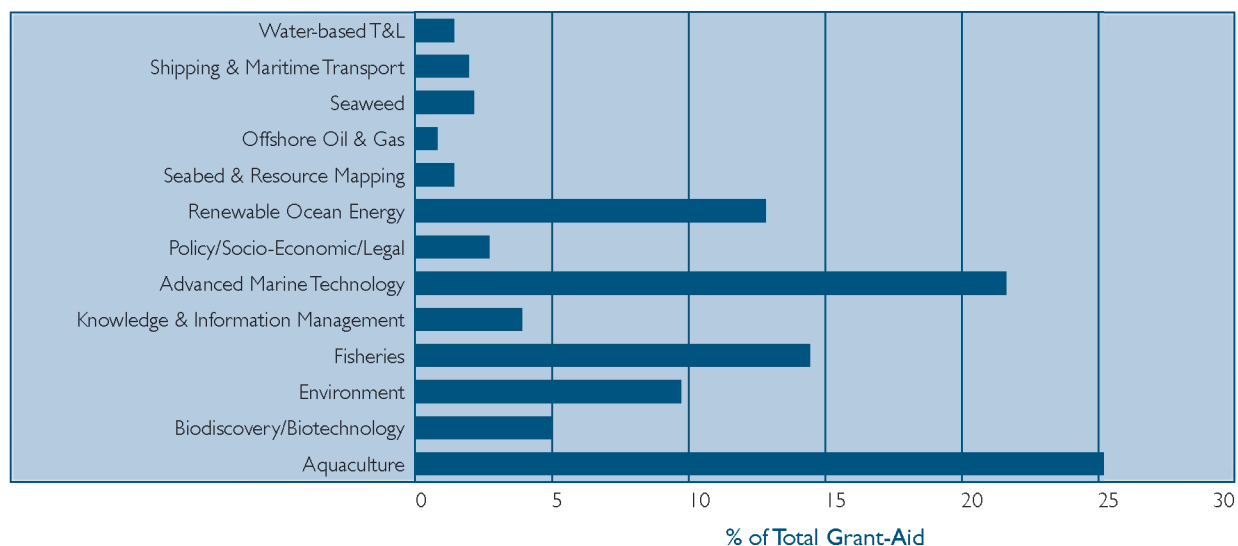


Figure 1: Marine RTDI Fund Allocation 2000–2005 - Breakdown by Sector<sup>2</sup>

The projects grant-aided under Sub-measure 3 cover a wide range of sectors as shown (Fig. 1). The large allocation of funding to aquaculture related projects is a reflection of the difficulties faced by the industry in recent years and the need to gain greater understanding of one

issue in particular; Harmful Algal Blooms. Advanced marine technology is another area that has received a relatively large funding allocation. This is partly indicative of the increased monitoring requirements imposed by the EU Water Framework Directive, but it is also a

reflection of the need to increase RTDI capacity in advanced marine technologies to position Ireland as a key player in this niche, high-value sector:



# Strategic Projects

The objective of the Strategic programme is to support strategic marine RTDI projects that build national marine research capacity and provide a firm scientific basis for the sustainable development of marine resources. This objective is achieved through providing grant-aid, on a competitive basis, for collaborative, problem-oriented marine RTDI projects. Twenty-one strategic projects have been funded over the period 2000–2005. These consisted of both Marine Institute defined and applicant defined projects. With defined projects the Marine Institute devised terms of reference for addressing specific research priority issues, such as the four projects funded in 2002.

Project	Grant-aid Approved
<b>2002</b>	
The Assessment of Orange Roughy Stocks in the Deep Waters off the West of Ireland Using Acoustic Survey Techniques	€490,000
Biological Oceanography of Harmful Algal Blooms off the West Coast of Ireland (BOHAB)	€399,500
Isolation and Purification of Azaspiracids from Naturally Contaminated Materials and Evaluation of their Toxicological Effects (ASTOX)	€419,854
Resource and Risk Assessment of Mussel Seed in Irish Waters	€361,362
<b>2004</b>	
SMART Water Quality Monitoring System	€903,780
Demonstration of a Miniaturised Multi-Channel Cytometry System & its Suitability for Autonomous Deployment	€472,220
Marine Monitoring System Based on Optical Oxygen Sensing and Respirometry	€450,108
Nucleic Acid Tests for Toxigenic Phytoplankton Species in Irish Waters	€419,314
Research Programme in Ocean Energy and Related Technologies	€1,125,000
<b>2005</b>	
The use of Genetic Stock Identification (GSI) Techniques to Determine the River of Origin of Irish Atlantic Salmon	€660,417
The Foraging Ecology of the Harbour Seal ( <i>Phoca vitulina vitulina</i> ) in Ireland	€206,299
Cold-water Carbonate Mound Development & Continental Margin Dynamics: a Contribution to IODP307	€199,845
Simulation & Forecasting System for Ecosystem Dynamics in Irish Waters	€151,729
Site Investigations and Disease Management of the Pancreas Disease Virus in Irish Farmed Salmon	€404,634
An Investigation into the Ability of Pacific Oysters, Scallops & Abalone to Act as Carriers of the Protozoan <i>Bonamia ostreae</i>	€160,102
Finding Aquatic Viral Epitopes for Production of Peptide-Based Vaccines	€186,714
Novel Vaccines for the Control of Sea Lice on Salmonids	€186,775
Marine Biodiscovery - Proof of Concept	€368,313
Extension of the Marine Institute's Marine Data Repository to Include Biological Data and Development of Supporting Tools	€255,503
Sea & Swell Spectra	€131,250
Phlorotannins in Irish Brown Seaweeds: Investigations of their UV-protective Effects and Potential as Natural Sunscreens	€110,332
<b>TOTAL GRANT-AID</b>	<b>€8,063,051</b>

# Strategic Projects

## The Assessment of Orange Roughy Stocks in Deep Waters off the West Coast of Ireland using Acoustic Survey Techniques

**Duration:** 2003-2006 (36 Months)  
**Grant-Aid Approved:** €490,000

"The main aim in this research was to provide the scientific information which the fishing industry needs in order to understand how Orange Roughy develop in Irish waters. The outcomes of this project will make an important contribution to help ensure the sustainable harvest of the fish in Ireland's deep waters."

**Dr. Emer Rogan**  
(UCC, Project Leader)

### Background

Throughout the world's major fishing nations, many traditionally targeted commercial fish species are in decline because of over-exploitation. Tighter quota restrictions have put fishermen under pressure to fish non-quota species. One such species is orange roughy (*Hoplostethus atlanticus*), which is found in deep waters off the west coast of Ireland. Orange roughy form dense spawning aggregations associated with seamounts and canyons. The species is slow-growing, achieving ages of up to 187 years in Irish waters, and matures at ages of 20–30 years.

This project investigated the Irish orange roughy fishery, establishing links with deep-water marine scientists worldwide and contributing to international understanding of orange roughy ecology. This challenging, multi-disciplinary project focused on assessing different acoustic methods for stock assessment; increasing our knowledge of the biology and distribution of the species; and developing robust management recommendations for the fishery that incorporates stakeholder input from fishermen, coral conservationists and fisheries scientists.

### Objective

The primary objective of this project was to develop acoustic expertise in the assessment of orange roughy stocks in the deep waters off the west of Ireland and assess the potential of acoustics surveys as a routine stock assessment tool that can provide the scientific advice required for an orange roughy management plan.

### Partner(s)

- Department of Zoology, Ecology and Plant Science, UCC (Lead Partner)
- Marine Resources Assessment Group Ltd., UK
- Seabed Surveys International Ltd., Ireland

### Outcomes

- This project involved significant knowledge transfer from New Zealand, where they have developed expertise over many years in acoustic methods for the assessment of orange roughy.
- The work carried out will contribute to the development of a management plan for orange roughy that will allow for its sustainable exploitation.
- The acoustic survey work has enhanced our national RTDI capacity in this technically complex and versatile technique. Two MSc theses were completed at UCC during the course of the work, contributing to the goal of building research capacity.

# Strategic Projects

## Biological Oceanography of Harmful Algal Blooms off the West Coast of Ireland (BOHAB)

**Duration:** 2003-2006 (36 Months)  
**Grant-Aid Approved :** €399,500

### Background

In the past three decades, Harmful Algal Bloom (HABs) events have been recorded in Irish waters, resulting in the closure of fish farms and severe economic losses for the shellfish sector. Previously, it affected just a few coastal areas but it has now become a problem in almost every coastal county in Ireland. Harmful algae can cause problems when the toxins they produce are accumulated by filter-feeding shellfish, making them unsafe for human consumption. In other cases, they can cause mortalities of wild and farmed finfish and discolouration of seawater.

### Objective

The primary goal of this project was to determine and measure baseline ecological and biological oceanographic parameters in two areas of intensive shellfish culture, Killary Harbour and Bantry Bay, in order to develop the necessary data for the biological component of a conceptual HAB model.

### Partner(s)

- Martin Ryan Institute, NUI Galway (Lead Partner)
- Woods Hole Oceanographic Institute, USA
- Marine Institute, Galway

### Outcomes

- The study makes a direct contribution to the economic and environmental sustainability of the aquaculture industry, supporting a holistic approach to the management of shellfish toxins.
- Future studies will benefit through the provision of essential baseline data and a conceptual framework to continue the task of generating a robust and accurate predictive model for HABs.
- The outputs from this project are due to be compiled for publication in a special edition of an international journal.
- Investment in the BOHAB project has leveraged additional competitive EU R&D funding.

"This project has succeeded in its aim to track the movements of algal blooms around Ireland's coastline. It has outlined the broad-brush strokes and has given us significant insights into movements in Killary and Bantry Bay. The challenge now seems to be to create an economic model which would allow the mussel farms in bays most affected by toxicity to become the seed repository, for the wider mussel industry."

**Tim Coakley**  
(Bantry Harbour Mussels Ltd.)

"BOHAB has provided a platform for a cluster of excellent projects around understanding HABs in Irish waters. The papers presented at the final workshop in March 2006 were of a very high quality and I would urge all the partners to ensure this work is published on a collective basis in an international journal!"

**Dr. Don Anderson**  
(Director Coastal Ocean Institute, USA)

# Strategic Projects

## Isolation and Purification of Azaspiracids from Naturally Contaminated Materials and Evaluation of their Toxicological Effects (ASTOX)

**Duration:** 2003-2006 (36 Months)  
**Grant-Aid Approved:** €419,854

"Azaspiracid shellfish poisoning problems have been a major issue for the Irish shellfish industry since 1995. This project has allowed the Marine Institute to find science-based solutions through the building of new expertise at the Institute and both national and international collaborations."

**Dr. Philip Hess**  
(Marine Institute, Project Leader)

### Background

Azaspiracids (AZAs) have become a major problem to the Irish shellfish industry over the last decade. The toxins accumulate in shellfish to levels that cause human illness. The customary test methods cannot detect toxins that occur at toxicologically relevant concentrations in shellfish. The use of liquid chromatography coupled to a mass spectrometry (LC-MS) has made it possible to detect small quantities of azaspiracids and in this way to help ensure the safety of Irish shellfish products. Although these toxins are of great significance to the shellfish industry, few data are available on their toxicity. Therefore, studies to determine the no-observed-adverse-effect-level (NOAEL), mode of action and chronic effects are required.

Although there exists strong traditions for the isolation of these compounds in Japan and, more recently, the US and Canada, there had been very little work conducted in this area in Europe. This isolation capacity is also of strong interest to the pharmaceutical industry - natural marine compounds are a rich source of bioactive material and have a wide array of beneficial effects.

### Objective

The primary objectives of this strategic project were: the isolation and purification of standards for the toxins Azaspiracids 1 to 3, and DTX-2; preparation of reference materials (shellfish matrix) for these compounds; and the evaluation of their toxicological effects.

### Partner(s)

- Marine Institute, Galway (Lead Partner)
- Conway Institute for Biomedical Sciences, UCD
- Centre for Coastal Environment Health & Biomolecular Research, NOAA, USA
- Chiba University, Japan
- Japan Food Research Laboratories, Tamashi, Japan
- Graduate School of Agricultural Science, Tohoku University, Japan.

### Outcomes

- The project has established safe limits for recently discovered AZAs in the shellfish sector; therefore making a major contribution to the sustainability of the shellfish sector.
- Results are available to the European Network of National Reference Laboratories (NRLs) to benefit the entire European scientific community and health and food safety organisations across Europe.
- The multidisciplinary research team has developed considerable technology/knowledge transfer between Japan, Canada, the US and Ireland.
- Some of the purified compounds were shared with the National Research Council Canada (NRCC). They have been certified by NRCC and will be distributed on a non-commercial sustainable basis, in support of legislation.
- The scientific outputs provide the potential for commercialisation of the technologies and products developed by this project. Additionally, these technologies and associated competence developed could contribute significantly to the Marine Biodiscovery programme proposed in 'Sea Change: A Marine Knowledge, Research and Innovation Strategy for Ireland 2007-2013.
- 2 students working on this project were awarded PhDs.

# Strategic Projects

## Resource and Risk Assessment of Mussel Seed in the Irish Sea

**Duration:** 2003–2006 (36 Months)  
**Grant-Aid Approved :** €361,362

### Background

The Irish mussel industry accounts for 80-90% of shellfish aquaculture production, by volume. In 2004, it was worth €27.8m, or 64% of the total value of shellfish production. The industry consists of two sectors that operate very different production strategies. Rope producers grow seed on suspended ropes. The bottom mussel sector relays seed in enclosed bays such as Lough Swilly, Carlingford and Cromane and dredges the adult mussels. Much of the seed requirement of this sector comes from the seedbeds along the east coast. The location of these seedbeds varies every year and settlement may only occur in the same area every 10 years or so. Although BIM carries out annual surveys of the mussel seed in the Irish Sea, there is a lack of comprehensive research on the life cycle and environmental factors underlying this major shellfish resource.

### Objective

The primary objective of this research was to develop a stronger understanding of the ecology of such seed beds, in order to provide the basis for a quantitative and risk assessment of the abundance and sustainability of the existing mussel resource, thereby allowing harvesting in a cost-effective and sustainable way.

### Partner(s)

- Aquaculture Development Centre, UCC (Lead Partner)
- South East Shellfish Co-Op Ltd., Co. Waterford
- Aqua-Fact International Services Ltd., Galway
- Seabed Surveys International Ltd., Cork
- Department of Zoology, UCD
- School of Biology and Biochemistry, Queen's University Belfast

### Outcomes

- A new digital survey system (ECHOplus) was used to improve efficiencies and accuracy in identifying mussel seedbeds. This technology has been transferred between Seabed Surveys and local fishermen from the south and east region.
- The recommendations in this work will form the basis of a management plan for mussel beds in the Irish Sea and support the sustainable development of the industry.
- Two PhD students employed full-time on the project have gained valuable specialist skills in the processes of larval identification and mussel ageing.

"This project is delivering a set of scientifically based recommendations for the sustainable management of the mussel seed in the Irish Sea. New insights into larval behaviour have been incorporated into a hydrodynamic model which should improve our ability to predict where seed beds will form."

**Dr. Tasman Crowe**  
(UCD, Project Partner)

"This is a starting point for the collection of scientific data on mussels in the Irish Sea. This work will help to protect and enhance this important resource."

**Mary Ferns**  
(South East Shellfish Co-Op)



# Strategic Projects

## SMART Water Quality Monitoring System

**Duration:** 2004-2007 (36 Months)  
**Grant-Aid Approved :** €903,780

"This has two major commercial implications for us as an SME. It can provide a solution to the Water Framework Directive and this technology is very transferable to other areas, such as monitoring power quality. We see a lot of opportunity there."

**Dr. John O'Flaherty**  
(National Microelectronics Applications Centre)

"We are at the stage of starting field trials at the moment. Down the line we see this consortium has the potential for developing an innovative and very valuable technology."

**Dr. Fiona Regan**  
(NCSR, DCU)



Front row (l to r): Aisling McEvoy, Fiona Regan, Brendan O'Fynn, Ken Whelan.  
Back row (l to r): Brian MacCraith, John O'Flaherty, John Wallace, Brett Paull, Tom Prendergast, Sean Hartigan, Gary Crawley, Dermot Diamond, Eoghan Allen.

### Background

Ireland is currently implementing the European Union Water Framework Directive, which requires EU Member States to implement management strategies for pollution control from diverse sources. This poses a major challenge for Local Authorities in Ireland to measure an ever-expanding list of pollutants and to develop cost-effective methods for continuous environmental monitoring. This work brings together a multi-disciplinary team from industry, third-level institutes and local authorities with a track record of excellence.

### Objective

The primary goal of this project is to combine low-cost, low-power sensors with wireless communications in novel networked systems that would put Ireland to the forefront of sensor technology worldwide.

### Partner(s)

- National Centre for Sensor Research, DCU (Lead Partner)
- South West Regional Authority
- Marine Informatics, Co. Clare
- Tyndall National Institute, UCC
- National Microelectronics Applications Centre Ltd, Limerick
- Marine Institute, Galway

### Outcomes

- By providing reliable systems for monitoring water quality, the bedrock of marine and inland fishing will be protected.
- Through identifying nitrate vulnerable areas, the work is a critical support to the agriculture industry.
- A range of commercial opportunities exist for SMEs, e.g. to access growing international markets for advanced environmental technologies.

# Strategic Projects

## Demonstration of a Miniaturised Multi-Channel Cytometry System & its Suitability for Autonomous Deployment

**Duration:** 2004-2007 (36 Months)  
**Grant-Aid Approved :** €472,220



Front row (l to r): Dr. Barbara Fogarty, Dr. Sarah Culloty, Moira Mc Carthy.  
Back Row: (l to r): Dr. John Alderman, Prof. John Davenport.

### Background

There are many situations where in-situ autonomous remote sensing for micro-organisms or microbe populations would be beneficial, e.g. where faecal coliforms or toxic algal species need to be counted/monitored. Spot sampling can be infrequent and consequently may miss transient events or details of initiation of events that could be used to give warnings and allow preventative measures to be taken. Although satellite imagery using remote sensing of infrared radiation can give indications of water currents and temperature and the location and intensity of algal blooms, manual collection of water samples is typically still needed.

An alternative, although presently predominately laboratory-based technique, is to use cell counting (cytometry) coupled with suitable immunological (antibody) markers coupled with fluorescence markers in a

cytometry apparatus. These fluorescently labelled antibodies can selectively mark target microbes that can then be counted in a flow unit and give direct counts of abundance and ratio to other particles. This direct 'whole cell' analysis can potentially help minimise the amount of sample pre-treatment required. In addition, micro-fluidic and 'lab-on-chip' methodologies and components are available and can be used to construct small, potentially low-cost, platforms to perform the proposed immunological-based assays. Demonstrations of a prototype flow cytometry unit utilising micro-fluidic and 'in house' fabricated optical components has been performed as part of an earlier Enterprise Ireland funded project.

"The value of the proposed multi channel cytometry unit would be in the early detection of pollution or toxic bloom events. The aim of this project is to demonstrate a miniaturised unit suitable for detection in sea, estuarine and fresh water environments and to look at overcoming the difficulties of bio-fouling, allowing extended deployment between maintenance visits."

Dr. John Alderman  
(UCC, Project Leader)

### Objective

It is proposed to construct a laboratory-based demonstration/proof of principle cytometry unit showing the required sensitivity for a proposed autonomous system.

### Partner(s)

- Tyndall National Institute, UCC (Lead Partner)
- Department of Zoology, Ecology & Plant Science, UCC

### Outcomes

Although this proposal is for a 'proof of concept' development, it is envisaged that this system, will be fully developed to a commercially available unit coupled to a complimentary communications package. This would become a powerful aid in supporting environmental issues in several areas. The main role would be in allowing cost-efficient, autonomous monitoring of potential micro-organisms or microbe pollutants; thereby, enhancing both human health and the environment.

# Strategic Projects

## Marine Monitoring System Based on Optical Oxygen Sensing and Respirometry

**Duration:** 2004-2007 (36 Months)  
**Grant-Aid Approved:** €450,108

"There are important commercial applications to the development of this technology that we hope to work with our partners in industry to progress."

**Dr. Dimitri Papkovsky**  
(UCC, Project Leader)

"One key advantage of this project is it will allow us immediate access to the market for environmental monitoring technologies, which is worth about €500 million."

**Dr. Richard Fernandes**  
(CEO Luxcel Biosciences Ltd.)

### Background

Environmental monitoring is one of the priority areas of National and European research programmes. Monitoring encompasses a wide range of technologies, including a variety of testing and risk assessment methodologies, some of which involve the use of higher animals such as mice and fish. The new approach to screening of toxicity and contamination of water samples proposed in this project addresses the ethical and environmental issues of environmental monitoring. It provides new, highly efficient and innovative methodology and corresponding technical solutions that will complement or, in some cases, replace methods that are tedious, inefficient and expensive.

### Objective

The main objective of the project is the further development of optical oxygen respirometry methodology by applying it to the area of environmental monitoring.

### Partner(s)

- Department of Zoology, Ecology and Plant Science, UCC (Lead Partner)
- Luxcel Biosciences Ltd., Cork

### Outcomes

- A dedicated laboratory facility capable of rapid processing of a large number of samples from different sites and from national and international customers will be established.
- Some key components of this technology developed by UCC and Luxcel are in the process of commercialisation.



# Strategic Projects

## Nucleic Acid Tests for Toxigenic Phytoplankton Species in Irish Waters

**Duration:** 2004-2007 (36 Months)  
**Grant-Aid Approved :** €419,314

### Background

Several species of marine algae produce potent toxins and these toxins can lead to human poisoning, if contaminated shellfish are consumed. The European Union has specific rules governing the hygiene of shellfish. The Marine Institute provides a routine service for phytoplankton monitoring to satisfy the legislative requirement for the production and sale of Irish shellfish products. As part of the monitoring service, water samples are collected from shellfish production sites and examined for the presence of toxic phytoplankton species. Current identification of species relies on microscopy, which is very useful but has limitations in identifying some toxic species that appear in Irish waters. Nucleic acid tests can be applied to precisely identify toxic species and to discriminate between closely related species. The National Diagnostics Centre in NUI, Galway is working with the Marine Institute to develop nucleic acid tests to detect and identify toxic phytoplankton species.

This project will contribute to the current national phytoplankton monitoring services and so has relevance to all stakeholders in the shellfish industry.

### Objective

The aim of this project is to develop nucleic acid tests for application in assuring the safety of shellfish for human consumption. By doing so, it will build R&D expertise in the area of nucleic acid technologies.

### Partner(s)

- National Diagnostics Centre, NUI Galway (Lead Partner)
- Marine Environment & Food Safety Services, Marine Institute

### Outcomes

- Portfolio of nucleic acid tests for the identification of key toxic phytoplankton species;
- Application of tests in the Marine Institute phytoplankton monitoring service; and
- Development of a critical mass of expertise in nucleic acid technologies relevant to the Irish Marine and wider biotechnology sectors.

"This work gives us a strong opportunity to build R&D capacity in the area of shellfish food safety and to build expertise in technologies with broad-ranging future applications."

**Dr. Majella Maher**  
(NUI Galway, Project Leader)

# Strategic Projects

## Research Programme in Ocean Energy and Related Technologies

**Duration:** 2004-2007 (36 Months)  
**Grant-Aid Approved:** €1,125,000

"The ocean energy resource can make Ireland independent of energy crises in the future. This indigenous resource is capable of meeting all of the current electricity demand.

There are no commercial machines available for ocean energy conversion at present. However, Ireland has the potential to become a world leader in this new industry with the support of the research team for Ocean Energy under the Blue Power Initiative, at HMRC."

**Dr. Tony Lewis**  
(HMRC, Project Leader)

### Background

The European Union Energy Directive requires member states to produce over 22% of electricity from renewable sources by 2010. Renewable ocean energy (e.g. tidal and wave) has a critical part to play in securing Ireland's economic future by reducing our dependence on imports and giving us control over an indigenous supply of energy. However, over-dependence on one form of renewable energy can cause grid supply problems due to variability. Therefore, a mix of renewable energy technologies is advised to overcome this issue.

This project is aimed at establishing a world-class centre for Ocean Energy research in the Hydraulics and Maritime Research Centre (HMRC), including the appointment of an internationally renowned principal investigator. The proposed research themes include Ocean Energy climatology, Hydro-Aerodynamics of OWC-Systems (oscillating water column), Floating Systems, Power Take-off Systems and electrical control and generic and related technologies.

### Objective

The specific objective of this work is to provide grant-aid for a Strategic Team and Research programme in the area of Ocean Energy and related technologies, in order to build a critical mass of world-class Irish RTDI capacity and excellence in this field.

### Partner(s)

- Hydraulics and Maritime Research Centre, UCC

### Outcomes

- A critical mass of technical ability in renewable ocean energy technologies will give Ireland a strong competitive edge in R&D activities;
- HMRC will provide the technical reference and support services for the renewable ocean energy industry; and
- An Industry Liaison Group will be established to incorporate the needs of device developers in the research programme.

# Strategic Projects

## The Use of Genetic Stock Identification (GSI) Techniques to Determine the River of Origin of Salmon

**Duration:** 2005–2007 (24 months)

**Grant-Aid Approved :** €660,417

### Background

The Salmon Management Task Force (1996) recommended that Ireland's salmon research be managed on the basis of achieving spawning escapement targets for each individual river stock and maintaining those individual river stocks above pre-determined conservation limits. The essence of fisheries management is to ensure that stocks attain conservation limits. Only by ensuring that a surplus of stock exists can harvesting take place. Genetic Stock Identification has become a widely used tool in fisheries biology. In this study, it will be used to map salmon spawning areas in Irish rivers; work which has not been undertaken to date.

### Objective

The primary objective is to provide fisheries managers with information regarding the contribution of the main Atlantic salmon producing rivers to the commercial salmon fishery operating off the west coast, thereby ensuring a sustainable management strategy for this valuable resource.

### Partner(s)

- Department of Zoology, Ecology & Plant Science, UCC (Lead Partner)
- Central Fisheries Board

### Outcomes

- The outcomes from this project will have a significant impact on how commercial Atlantic salmon fisheries are managed in the Irish context.
- The completion of the research will provide major baseline datasets where data are currently unavailable and will contribute to national RTDI capacity in the field of salmon management.
- There will be significant technology transfer between UCC, Central Fisheries Board and the Marine Institute, putting these partners at the forefront of international salmon genetics research.

"We are using state-of-the-art genetic technology to generate information on stock composition in commercial drift net fisheries. The outputs will help to support the conservation of stocks."

**Dr. Eileen Dillane**  
(UCC, Post-Doctoral Researcher)

"Once the river-specific salmon genetic baseline is established, it will be possible to assign salmon caught in the mixed stock commercial fishery at sea or inshore to home rivers, with a high degree of certainty. This would allow salmon exploitation in Ireland to be managed on a single stock basis and allow the rational management of salmon stocks into the future."

**Dr. Paddy Gargan**  
(Central Fisheries Board)

# Strategic Projects

## The Foraging Ecology of the Harbour Seal in Ireland

**Duration:** 2005-2007 (24 Months)  
**Grant-Aid Approved :** €206,299

"We intend to disseminate the results to as wide an audience as possible ...the findings will be of interest to the whole fishing community. The key here is fisheries interaction and we hope this research will address some of the contentious issues that have not been looked at previously."

**Michelle Cronin**  
(UCC, Project Leader)

### Background

The interaction of seals and fisheries is a long-standing and contentious issue. There have been calls for controlled culling of seals in Ireland, arising from concerns over damage caused by seals to fisheries. Seals interact with commercial fisheries on a number of different levels. On a physical level, they can cause direct damage to both gear and catch. On another level, they interact directly by competing for target fish species in the commercial range or indirectly by removing smaller fish before they are recruited into the commercial fishery. It is estimated that they can eat up to their body weight in fish on a daily basis. Both the grey seal (*Halichoerus grypus*) and the harbour seal (*Phoca vitulina vitulina*) are protected under the Wildlife Acts and the EU Habitats Directive. There is currently no data available on at-sea movements or behaviour of Irish harbour or grey seals. Such data is essential to quantifying the spatial overlap between seals and fisheries. An ecosystem approach to this study is proposed which would combine ecology data, fisheries data and national seabed survey data to identify foraging areas.

### Objective

The primary objective of this work is to identify the spatial overlap between seals and fisheries and to provide a means to estimate the predation pressure on vulnerable or economically sensitive fish stocks.

### Partner(s)

- Coastal and Marine Resources Centre, UCC (Lead Partner)
- Department of Zoology, Ecology and Plant Science, UCC
- Sea Mammal Research Unit, St. Andrews University, Scotland

### Outcomes

- The study has potential direct commercial benefits for the fishing industry and the dissemination of results to all stakeholders, including the public, will be a priority.
- The fieldwork will use a novel telemetry system to address seal foraging ecology, thus enhancing marine technology expertise in Ireland.
- The collaboration with leading experts in Scotland will significantly enhance Irish research capacity in marine mammal science.

# Strategic Projects

## Cold-water Carbonate Mound Development and Continental Margin Dynamics

**Duration:** 2005-2007 (24 Months)  
**Grant-Aid Approved::** €199,845

### Background

Irish waters host numerous giant carbonate mounds, ranging in size from tens of meters to several kilometres across and rising to up to 200 m above the surrounding seafloor. Some of the mounds are buried under hemipelagic sediments but many of them are exposed and colonised by cold-water corals. Coral coverage can be so extensive that these lately discovered ecosystems challenge the general opinion of coral reefs occurring exclusively in shallow waters of the lower latitudes. At water depths ranging from 600 to 1200m, cold-water coral reefs thrive in permanent darkness at ~8°C water temperature, rivalling their tropical counterparts in terms of species richness and diversity. The carbonate mounds along the Irish continental margin are important ecosystems for various fish species, including commercial stocks.

Despite the major advances and interest in cold-water coral research over the past 10 years, little is known about carbonate mound formation. This project builds on the scientific opportunities arising from the inward investment to Ireland from the Integrated Ocean Drilling programme Expedition 307 (IODP), which has recovered, for the first time, a complete sequence through a cold-water coral carbonate mound

and adjacent sediment drift sequences in Irish waters. This project will analyse these cores to address previously unanswerable research questions, namely: how do carbonate mounds grow; what high resolution records do they contain of past climates; and what is the sensitivity of the ecosystem to changes in external forcing?

### Objective

The overall aims are to develop a model for carbonate mound growth by determining the parameters for internal and external forcing factors; develop a high resolution palaeoclimatic reconstruction for the offshore Ireland; and define environmental thresholds for ecosystem vulnerability and collapse.

### Partner(s)

- Department of Geology, UCC

### Outcomes

- This study will provide basic information that will further our understanding of this important deepwater habitat.
- Information obtained will inform future European Union policy on fishery management, the creation of biologically sensitive areas and, possibly, the definition of Marine Protected Areas.

"This funding allows us to produce high quality science in collaboration with European, American and Japanese partners, putting Ireland on a global scientific stage. We hope to make an important contribution to understanding how climate change has affected the Irish continental margin and how these systems, including the sensitive coral ecosystems, may respond to future climate shifts."

**Dr. Andy Wheeler**  
(UCC, Project Leader)



# Strategic Projects

## Simulation & Forecasting System for Ecosystem Dynamics in Irish Waters

**Duration:** 2005-2007 (24 Months)  
**Grant-Aid Approved:** €151,729

"This project will advance our understanding of how the physical dynamics influence the biological systems within Irish waters and provide a framework to allow better sustainable management decisions to be made in the future."

**Dr. Martin White**  
(NUI Galway, Project Leader)

### Background

The Celtic Sea is a shallow shelf sea separating the warm saline Atlantic waters to the west of the Irish shelf edge and the colder waters of the Irish Sea. The circulation in this sea is marked by strong seasonal variations; wind forcing in winter and thermal stratification in summer; resulting in a number of frontal system boundaries. The Celtic Sea is recognised as an important marine area with a high biodiversity and important spawning and nursery areas for commercial species. Hake, mackerel and megrim are abundant in the southwestern Celtic Sea and Goban Spur area, and cod and herring are concentrated in the eastern Celtic Sea. In 2000, a baseline survey carried out by the Marine Institute showed the importance of the Celtic Sea/Goban Spur area as spawning and nursery grounds for these species. However, detailed information on the relation between frontal and ecosystem dynamics is still sparse.

### Objective

The primary objective of this research is to assess the oceanographic (especially climate) influence on the bio-physical interaction within Irish waters and to quantify the resultant effects on commercially or environmentally important ecosystems residing therein.

### Partner(s)

- Department of Earth & Ocean Sciences, NUI Galway (Lead Partner)
- Marine Institute, Galway

### Outcomes

- An integrated physical and biological model of coastal oceanographic processes in strategic regions in Irish shelf and oceanic areas;
- The deliverables of this project have immediate relevance to the EU Habitats Directive and the establishment of the Irish fisheries conservation box and will make a direct contribution to selection of Marine Protected Areas under the OSPAR Convention; and
- The research will build on existing productive collaborations between research groups in the University of Helsinki, the Marine Institute, Galway-Mayo Institute of Technology and NUI Galway.

# Strategic Projects

## Site Investigations and Disease Management of the Pancreas Disease Virus in Irish Farmed Salmon

**Duration:** 2005-2007(24 Months)  
**Grant-Aid Approved :** €404,634

### Background

Disease outbreaks have the potential to seriously curtail the growth of the finfish aquaculture sector. They cause high mortalities, affect the growth rate of stocks and restrict movement. Pancreas Disease (PD) is the single most significant infectious disease agent affecting salmon aquaculture in Ireland. Although it has been prevalent in Ireland for nearly twenty years, very little is known about this viral disease. The problem has been particularly severe in Connemara, where 30-50% of fish have been lost on individual sites. This research programme proposes to carry out detailed epidemiological and longitudinal studies into outbreaks of PD. PD has also emerged as a significant problem in Norway and Sweden and a collaborative tri-nation approach has been adopted to solve the problem.

### Objective

The primary objective is to provide the necessary information (e.g. aetiology, life-cycle, environmental and farm risk factors) on the PD virus in Irish sites, to develop proper management strategies to mitigate the effects of PD, thus ensuring the long-term viability of the industry.

### Partner(s)

- Marine Institute, Galway (Lead Partner)
- Queens University Belfast
- Vet-Aqua International, Galway
- Muir Gheal Teo., Galway
- Eany Fish Products Ltd. Donegal

### Outcomes

- A Code of Practice, which will be a valuable management tool for the industry and vets;
- Increased national RTDI capacity in the area of screening and establishing early warning systems for PD; and
- Enhanced research and diagnostic capacity within the National Reference Laboratory (NRL), with available technologies being transferred between partners.

"This project brings together industry, state bodies and third-level institutions in a co-ordinated manner, using both lab and field based studies to increase our knowledge of the disease. By the end of the study, it is our aim to produce practical measures on PD management and mitigation."

**Dr. Neil Ruane**  
(Marine Institute, Project Leader)

"I believe this PD research, co-ordinated by the Marine Institute, is probably the most important industry research undertaken in the field of aquaculture and this programme has our full support."

**Damien O'Ceallacháin**  
(Director, Muir Gheal Teo.)

# Strategic Projects

## An Investigation into the Ability of Pacific Oysters, Scallops & Abalone to Act as Carriers of the Protozoan *Bonamia ostreae*

Duration: 2005-2007 (24 Months)

Grant-Aid Approved : €160,102

"Examining this question – whether these shellfish species play any role in the transmission of *B. ostreae* – will clear up any concerns in relation to movements of these animals and possible transmission of this parasite and pave the way for future expansion of the aquaculture of these species."

Dr. Sarah Culloty  
(UCC, Project Leader)

### Background

Bonamiosis is a major problem in native oyster (*Ostrea edulis*) culture in Ireland. It also creates a problem for the movement of other cultured bivalves in Ireland, because of EU regulations which prevent the movement of certain shellfish which are possible vectors of the parasite, e.g. abalone and scallops. An EU-funded study, carried out in 1996, showed that the Pacific oyster (*Crassostrea gigas*), mussels (*Mytilus edulis*) and clams (*Ruditapes decussatus* and *Venerupis* (=Ruditapes) *philippinarum*) could not be naturally or experimentally infected with Bonamiosis and did not appear to act either as vectors or intermediate hosts for the parasite. Since then, new analytical techniques have been developed. This project will, for the first time, use molecular-based techniques to screen Pacific oysters, abalone and scallops for the presence of *B. ostreae*. Clarification of the possible role of these molluscs as carriers, or otherwise, for the *B. ostreae* parasite would allow the industry to respond according to the outcome.

### Objective

The primary objective of this study is to increase the understanding of the life cycle of the parasite *Bonamia ostreae*. Specifically, it will examine the role, if any, of pacific oysters, abalone and scallops as carriers of the parasite.

### Partner(s)

- Department of Zoology, Ecology and Plant Science/Aquaculture Development Centre, UCC

### Outcomes

- If it can be shown that these three species do not act as carriers for *B. ostreae*, the expansion of the shellfish industry will be supported by allowing freer movement of shellfish around the coast.
- This project adds additional capacity to the Department of Zoology, Ecology and Plant Science, in the field of shellfish health.
- The collaborative work will strengthen the links that exist between the research team and members of the Irish shellfish industry.



# Strategic Projects

## Finding Aquatic Viral Epitopes for Production of Peptide-Based Vaccines

**Duration:** 2005–2007 (24 Months)  
**Grant-Aid Approved :** €186,714

### Background

Disease outbreaks are a major threat to the profitability of the European aquaculture industry and threaten the livelihoods of farmers. Disease prevention and control is a major issue that affects the environmental and economic sustainability of the industry. During the last ten to twenty years, vaccination has been established as an important method for prevention of infectious disease. To date, most commercial vaccines are inactivated vaccines administered by immersion or injection.

The development of a modern, recombinant vaccine against fish viral diseases is complicated by the limited knowledge of the host immune mechanisms and the viral antigens involved in the induction of immunity. A major concern in relation to recombinant DNA vaccines is the safety aspect relating to the use of DNA. The issue of gene manipulated food supplies is a controversial one. Peptide-based vaccines represent a safer approach, without the possibility of transfer of genetic material from foodstuff to consumer.

### Objective

The project aims to identify the potential vaccine epitopes for viral pathogens of significant importance to the Irish aquaculture industry.

### Partner(s)

- National Diagnostics Centre, NUI Galway (Lead Partner)
- Norwegian School of Veterinary Sciences
- Institute for Animal Health, UK

### Outcomes

- The project will improve the national body of knowledge regarding effective vaccine strategies in Atlantic salmon;
- The work will help protect the existing Irish finfish aquaculture industry. Further expansion of the finfish aquaculture industry through species diversification will also benefit from the development of peptide-based vaccines.
- This technology is transferable to a broad range of consumer foodstuffs and therefore has important commercial implications for the food industry.

"There is general concern over the use of DNA-based vaccines, due to the transfer of genetic material to the consuming population. Peptide-based vaccines offer a significant advantage as they are highly immunogenic and protective but cannot pass rogue DNA elements into the fish meat."

**Dr. Iain Shaw**  
(NUI Galway, Project Leader)

# Strategic Projects

## Novel Vaccines for the Control of Sea Lice on Salmonids

**Duration:** 2005-2007 (24 Months)  
**Grant-Aid Approved :** €186,775

"We see this as a very important project in consolidating the collaborative relationship between UCD and the Marine Institute and the results could have considerable benefit for the farmed salmon industry worldwide."

**Dr. Grace Mulcahy**  
(UCD, Project Leader)

### Background

The fish farming industries of Ireland, Scotland and Norway, together with those on the coast of Canada and the USA, are faced with a serious sea lice problem. New European Union regulations concerning the development and use of chemical products has put pressure on the animal health industry to move away from using chemical treatment to control sea lice in salmon farms. In addition, there are growing consumer and environmental concerns regarding the presence of chemicals in food and the introduction of chemicals into the marine environment.

Vaccination is a well-accepted means of boosting immunological resistance to disease in many species, including fish, and it is envisaged that a single vaccination of the appropriate sea lice antigen would enable the salmonid to generate an immune response sufficient to prevent infection with the parasite. Vaccines offer a preventative, rather than a control, solution for sea lice; leave no residues in fish meat; and are easier and less costly to bring through the regulatory process.

### Objective

This project will identify and isolate novel sea lice vaccine candidates and identify the immunological parameters associated with immunity to infection in vaccinated fish. It will also develop new antibody and cellular assays to characterise the immunological basis of immunity in salmonids.

### Partner(s)

- Faculty of Veterinary Medicine, UCD

The project involves collaboration with the Marine Institute and the University of Technology, Sydney.

### Outcomes

- A successful outcome would result in a means to vaccinate Atlantic salmon against sea lice, thereby providing a preventative treatment, as opposed to just controlling infestation levels, resulting in major economic and environmental returns for Ireland.
- Immunological studies in salmon will also yield invaluable new data for bringing sea lice and other vaccines forward into a developmental phase.
- The UCD team is building on its earlier vaccine development work, which attracted the interest of several pharmaceutical firms, to target new vaccine solutions at sea lice.

# Strategic Projects

## Marine Biodiscovery – Proof of Concept

**Duration:** 2005–2006 (7 Months)  
**Grant-Aid Approved:** €368,313

### Background

This project is an exciting example of what the future holds for the marine sector in Ireland. Marine ecosystems provide a major source of bioactive compounds derived from a range of organisms, including diverse micro- and macro-organisms such as sponges, microalgae and cyanobacteria. Recent studies have identified a large range of potential anti-cancer, anti-infectives and therapeutic substances from such sources. The development of this programme involves collaboration across eight research teams in third-level institutes and the National Cancer Institute, USA. An experienced biodiscovery expert has been appointed to ensure that the complex set of inter-disciplinary and inter-institutional working relationships are co-ordinated in order to ensure the success of each component and the overall programme.

### Objective

The ultimate objective of this work programme is to identify what materials from the marine environment can be exploited to develop vaccines and anti-viral drugs that can play a part in addressing diseases that cause major quality of life issues in humans.

### Partner(s)

- Martin Ryan Institute, NUI Galway
- Analytical and Biological Chemistry Research Facility, UCC
- Department of Microbiology, UCC
- Department of Clinical Medicine, St. James Hospital, TCD
- Institute for Molecular Medicine, St. James Hospital, TCD
- Conway Institute of Biomedical Research, UCD
- International Centre for Neurotherapeutics, DCU
- Department of Zoology, NUI Galway
- Dr. Joe Baker; former Director of AIMMS Australia (Project Manager)

### Outcomes

- This Proof-of-Concept will identify the bioinformatics capabilities that will be necessary in the longer-term to build a full Programme of work.
- The process will target additional national and international synergies and collaborations that will be an essential part of building national capacity.
- By developing this collaborative network which links each individual 'cluster' within a serial project, we are making maximum use of major research infrastructure funded by other national programmes.
- The outcomes will include a full project proposal for submission to appropriate funding agencies.

"This project adds value to a range of national investments in marine science, biotechnology and medicine, creating innovative research capabilities that will underpin the biopharmaceutical industry sector in Ireland."

**Eoin Sweeney**  
(Marine Institute)

# Strategic Projects

## Extension of the Marine Institute's Marine Data Repository

**Duration:** 2005-2007 (24 Months)  
**Grant-Aid Approved :** €255,503

"It is envisaged this project will have a significant impact on increasing national capacity to add value to marine datasets for improved science and, consequently, marine area management. The work also allows us to consolidate international links and keeps Ireland at the forefront of marine information and data management."

**Valerie Cummins**  
(CMRC-UCC, Project Leader)



(l-r) Josu Ramirez, Yassine Lassoued, Eamonn O Tuama, Valerie Cummins, Declan Dunne

"We are very happy with the results of the first phase of this project; the challenge was to create a system that could integrate a wide range of different information types measured in the four dimensions of longitude, latitude, depth and time and then produce a result which could be viewed easily on a chart or map."

**Martina Hennessy**  
(Marine Institute)

formats and standards. One of the most significant challenges arising from this is the collation and integration of these datasets in order to present them in an accessible and intuitive way.

### Objective

The primary objective of this project is to evaluate technical approaches that allow the extension of the Marine Institute's existing data repository in order to include biological data, e.g. fisheries and biotoxins. Biological input is essential baseline data and it underpins many marine activities from shellfish harvesting, to oil spill response, to the licensing of offshore developments.

### Partner(s)

- Coastal and Marine Resources Centre, University College Cork

- Department of Geosciences, Oregon State University, USA
- Marine Institute, Galway

### Outcomes

- This work will provide a system that allows seamless incorporation of biological datasets into the data repository, thus improving dissemination of data and information and making a critical contribution to national policy on issues such as fisheries management, energy policy and spatial planning.
- The results will contribute to Ireland's building R & D capacity in marine informatics and creating knowledge transfer to SMEs for commercial software applications.
- As EU projects demand data integration capacity and expertise, Irish institutes will be well positioned to compete for an increased share of EU research funds as a result of this work.

### Background

Management of the marine resource is moving from a single discipline to a more holistic or 'ecosystem approach' and is driving the demands for greater integration of data in order to derive information about the overall status of our environment. The Marine Institute's work programmes gather and produce a wide variety of datasets: oceanographic, environmental, biological and chemical data, in a diverse range of

# Strategic Projects

## Sea and Swell Spectra

**Duration:** 2005-2007 (18 Months)  
**Grant-Aid Approved :** €131,250

### Background

This study follows on from two wave data projects already undertaken on behalf of the Marine Institute to extend the knowledge base on the Irish wave climate. Wave generation computer models offer a cost-effective method for predicted data in the frequency domain. This service will be the foundation for the wave energy resource atlas produced by ESB International on behalf of the Marine Institute. However, this database is constructed around the sea state summaries rather than any individual wave information. Ocean energy extraction technology requires a greater level of detail and the aim of this work is to increase our understanding of the actual wave energy states already reported. Such information is essential to marine engineering activity but up until now it has been conducted on a site specific and/or ad-hoc basis.

### Objective

The primary objective is to improve our knowledge base of the ocean environment and to provide the data for future modelling requirements for marine engineering activity, particularly in relation to the requirements of the renewable ocean energy sector.

### Partner(s)

- Hydraulics and Maritime Research Centre, UCC (Lead Partner)
- Irish Hydrodata Ltd.
- National University of Ireland, Maynooth
- ESB International
- Met Éireann

### Outcomes

- This project will look to identify knowledge gaps in this area of ocean energy and address these.
- There is strong commercialisation potential in providing a service that will supply the tools to make Irish marine engineering companies more competitive in European and global markets.

"Electricity generated from ocean energy has the potential to contribute significantly to the national power supply mix but more detailed information about the resource is required. This project will help fill the current knowledge gaps and develop Ireland's expertise in sophisticated wave data techniques."

**Brian Holmes**  
(HMRC, Project Leader)

"By having data from buoys we can compare the model spectra against the observed spectra and thereby improve the models we are working on."

**James Hamilton**  
(Met Éireann)



# Strategic Projects

## Phlorotannins in Irish Brown Seaweed - Investigations of their UV-protective Effects and Potential as Natural Sunscreens

**Duration:** 2006-2007 (18 months)

**Grant Aid Approved:** €110,332

"This research has a strong commercial focus and has the potential to deliver significant new insights to seaweed as a source of novel materials at a relatively low cost."

**Dr. Dagmar Stengel,**  
(NUIG, Project Leader)

### Background

A number of natural compounds such as vitamin E and carotenoids are used as active ingredients in sunscreens as alternatives to synthetic chemicals – some of which are of concern. Green tea polyphenols have also been tested for their antioxidant capacity against damage induced by UV radiation and offer some potential.

Marine organisms, particularly intertidal and high subtidal species, are exposed to direct solar radiation and UV radiation that penetrates the water column. This radiation can cause significant depression of photosynthesis and decreases productivity in marine plants. Brown algae synthesise and accumulate phenolic compounds, which protect them from UV damage. The composition and the structure of phenolic compounds contained in brown seaweeds differ significantly from those in higher

plants so that a direct comparison between the effects of the green tea phenols observed under UV radiation is scientifically inappropriate. However, as brown macroalgae contain very high levels of phenols, which fluctuate naturally according to irradiance and UV-exposure, a focused assessment of their potential protection against DNA damage induced by UV radiation is both reasonable and promising. Advances in the understanding of the environmental control of phenol production are therefore essential in optimising the applications of such compounds on a commercial scale.

### Objective

This project aims to characterise naturally occurring phenols in brown algae from the Irish west coast and assess their potential future commercial application as natural sunscreen products based on the natural UV-protection in seaweeds. Hence the project will evaluate the significance of natural variation in phenol in brown algae by means of a field survey and laboratory manipulation, and investigate the UV-absorbing properties of brown algal phenolic compounds on human cancer cell lines.

### Partners

- Department of Botany, MRI, NUI Galway (Lead Partner)
- Department of Biochemistry, NUI Galway

### Outcomes

This project will provide the scientific basis for the development of a range of innovative products which can be exploited by SMEs in the organic bodycare product market.

The research enhances the scientific understanding of characteristics of seaweed extracts that occur naturally in Irish species; it uses this knowledge to optimise the yield and composition of valuable compounds and therefore contributes to the sustainable development of the Irish seaweed industry.

# Applied Industry

## Applied Industry Projects

The Applied Industry measure is designed to facilitate small and micro companies who because of size are generally unable to participate in other R&D grant-aid programmes. Brokering is a feature of the programme where companies who do not have in-house R&D staff are encouraged to link up with third level institutes to carry out research.

The maximum grant-aid payable under this scheme is €100,000. From 2000-2005, 22 Applied Industry projects were supported. The total grant-aid awarded was €1,262,176, representing 55% of the total cost of the projects (€2,305,857). Participating companies provided the balance of the total cost.

Project	Grant-aid Approved
<b>2002</b>	
Prediction of Ocean Wave Energy for Resonant Extraction Devices	€66,563
High Pressure Seawater Pump for Use in Wave Energy Converters	€100,000
Validation Of Non-Contact Techniques for Marine Water Characterization	€23,632
A Novel On-growing System for Abalone	€44,484
Technological and Scientific Development of Turbot Broodstock Management and Larviculture in Ireland	€97,236
<b>2003</b>	
Technological and Scientific Development of Turbot Broodstock Management and Larviculture in Ireland (Part II): Further Development and Commercial Application	€58,100
A Novel System for Intensive Larval Culture of the Sea Urchin ( <i>Paracentrotus lividus</i> )	€38,958
Development of an Artificial Roe Enhancement Diet Based on Waste Products from the Fishing Industry	€54,308
Establish a Commercial Use for Starfish	€66,264
Dunlop Offshore Cage Development Programme	€42,868
The Development of Soil-Structure Interaction Models for Deepwater Environments (SOILSIM)	€54,067
Pre-prototype Testing of the B2D2 Wave Energy Converter	€59,925
<b>2004</b>	
Acclimatization Potential of Arctic Char ( <i>Salvelinus alpinus</i> ) to a Marine Environment	€59,685
Development of an Alternative Natural Source of Astaxanthin for the Aquaculture Market	€58,500
Evaluation of Selected Biophysical Properties of Salmon Pancreas Disease Virus (SPDV)	€58,595
Investigation of the Bioactive Potential on Animal Health of Fucoidan-rich Products Manufactured at Different Process Levels from Irish Brown Macro-algal Resources	€60,300
The Research, Development and Implementation of Alternative, Reliable Materials and Methods for Creating Significantly Less Costly and/or Better Designed Marine Electronic Enclosures	€30,923
The Development of the Next Generation of Heterogeneous Telemetry Modules for Marine Informatics Data Loggers	€48,338
<b>2005</b>	
Development & Assessment of the First Hatchery-Stager Artificial Diets for Sea Urchins (Hatch Feeds)	€59,430
Control Systems for ROVs	€60,000
Power Take-off Systems for the OE Buoy Wave Energy Converter (PTOBUOY)	€60,000
Development of Cost-effective Gravity Based Foundation System to Support Wind Energy Converters in Deeper Waters	€60,000
<b>TOTAL GRANT-AID</b>	<b>€1,262,176</b>

# Applied Industry

## Prediction of Ocean Wave Energy for Resonant Extraction Devices

**Duration:** 18 Months  
**Grant-Aid Approved:** €66,563  
**Industry Partner:** Wavebob Ltd., Co. Wicklow  
**Research Partner:** Hydraulics and Maritime Research Centre, UCC

The offshore energy resource is several times greater offshore than at the shoreline. In order to tap into this energy efficiently a practical real-time wave forecasting tool is needed. The design of a wave energy device is site dependant and detailed knowledge of the local wave resource and its variations as well as a capability to provide both mathematical and physical modelling is required. Short-term prediction over 2-3 waves is most valuable for a device to operate efficiently, e.g. damping of Power Take-off systems. On a medium-term basis, half an hour to several days, wave prediction is also important for an alteration in water ballast.

The aim was to assess the practical usefulness of all sources of information including satellites and wave riders to develop a forecasting system, which will be programmed and tested against historical data. This includes utilising test tank models of a wave energy converter, Wavebob, to assess accuracy of prediction models.

"The Wavebob is a point absorber with several innovative features, including an autonomous control system. The first 1/4-scale prototype was deployed in March 2006 by the Marine Institute's Celtic Explorer on the Institute's test site in Galway Bay."

**William Dick**  
(Wavebob Ltd./Clear Power Technologies)

## High Pressure Seawater Pump for use in Wave Energy Converters

**Duration:** 18 Months  
**Grant-Aid Approved :** €100,000  
**Partners:** Marine Technology Ltd. Co. Meath,  
Joe Murtagh & Associates, Engineers

The development of this special purpose, high-pressure seawater pump for use in wave energy converters is a cost-effective and environmentally acceptable step to bringing renewable wave energy into the real world. The pump incorporates high technology materials and a novel design approach to creating high pressure seawater for use in the generation of electricity and or production of desalinated potable water from the sea. The 'pump' will replace an existing design, which incorporates two fluids, one of which is hydraulic oil.

"The successful outcome of this C-Pump could have huge implications for the development of PTO-BOUY as this technology is suitable for most existing wave energy converters."

**Joe Murtagh**  
(Engineer)



# Applied Industry

## Validation of Non-Contact Techniques for Marine Water Characterization

**Duration:** 9 Months  
**Grant-Aid Approved :** €23,632  
**Industry Partner:** Spectral Signatures Ltd., Dublin

The OSPAR Convention and the EU Water Framework Directive require member states to monitor their marine waters, including quantifying anthropogenic inputs. Marine fouling limits in-vivo sensing of marine optical properties. Spectral Signatures Ltd. have developed new non-contact optical instrumentation that has been primarily developed to quantify near surface chlorophyll but has the potential to quantify additional parameters such as total organic matter and suspended matter.

The objective of this project was to validate the technical and scientific performance of the *ChloroPod* system as an effective tool for current international water quality requirements. This involved using the system on several research platforms including a medium-sized research vessel, mooring system and a small inshore vessel that would be available in most bays and estuaries. In addition, scientific and technical validation of the system was also carried out to ensure international acceptance of *ChloroPod* as a method of measuring chlorophyll.

"Spectral Signatures' patented systems are the only systems that can measure chlorophyll concentration in real time without the need for bottle sampling, back-up calibration or lab measurement. These products now provide the standard method for Chlorophyll monitoring in UK waters. Support from the Marine Institute at the prototype validation stage of new instrument development is essential to allow small Irish companies enter the global market for these systems."

**Eon Ó Mongain**  
(Spectral Signatures Ltd.)

## A Novel On-growing System for Abalone

**Duration:** 18 Months  
**Grant-Aid Approved :** €44,484  
**Industry Partner:** Awabi Teo., Co. Galway  
**Research Partner:** Aquaculture and Fisheries Development Centre-ERI, UCC

Commercial cultivation of the abalone (*Haliotis discus hannai*) began to develop in Ireland with the introduction of quarantined founder populations in the 1980s. Today, there is considerable interest from the Irish aquaculture industry in farming this valuable shellfish species, with several hatcheries and aquaculture facilities on the West and Southwest coast.

On-growing systems are currently principally all of the same design. Abalone are placed on hanging plastic sheets and consume macroalgal feed that is placed in the water column. This system has several disadvantages, including low food availability.

This project aimed to develop a novel, more efficient method for on-growing abalone that would lead to significantly reduced costs for abalone farms.

"We now have a worldwide patent after re-designing our feeding system for sea urchins. Although the on-growing system did not work for abalone, it has been successfully adapted for sea urchins, and there are strong global markets for this shellfish that Irish companies can exploit."

**Dr. Gerry Mouzakitis**  
(Aquaculture and Fisheries Development Centre)

# Applied Industry

## Technological and Scientific Development of Turbot Broodstock Management and Larviculture in Ireland

<b>Duration:</b>	12 Months
<b>Grant-Aid Approved:</b>	€97,236
<b>Industry Partner:</b>	Turbard lathar Chonamara Teo, Co. Galway
<b>Research Partner:</b>	Aquaculture Development Centre-ERI, UCC

Turbot (*Scophthalmus maximus*) farming began in Europe in the 1970s and hatchery and on-growing techniques have been developed. The lack of turbot broodstock and larviculture facilities in Ireland results in increased costs, commercial inflexibility and excludes research and development into local Irish conditions.

This project aimed to use established techniques for the hatchery production of turbot and develop turbot hatchery facilities in Ireland. This included the induction of spawning in locally-held turbot broodstock, the testing and optimisation of larviculture methods, the manipulation of photoperiod to ensure year-round egg supply and utilisation of domestically produced eggs and methods for the production of juveniles for on-growing in existing Irish facilities.

## Technology and Scientific Development of Turbot Broodstock Management and Larviculture in Ireland (Part II)

<b>Duration:</b>	12 Months
<b>Grant-Aid Approved :</b>	€58,100
<b>Industry Partner:</b>	Turbard lathar Chonamara Teo. Co. Galway
<b>Research Partner:</b>	Aquaculture and Fisheries Development Centre-ERI, UCC

This project established the first collaborative turbot hatchery in Ireland. It also established a local turbot broodstock population and developed dedicated hatchery and live feed production facilities for marine finfish.

Part II of the project involved the examination, assessment and incubation of large numbers of egg batches and performance comparison of several controlled broodstock groups, coupled with investigations of performance of genetically discrete family groups of turbot.

"The two turbot projects funded under the Marine RTDI programme demonstrated that turbot could be reared from egg to grow-out phase in Ireland. This enabled the Aquaculture and Fisheries Development Centre, UCC to build an algal rearing unit, develop flatfish rearing facilities and learn skills that achieved weaning to the stage at which young turbot could be moved to farms."

**Prof. John Davenport**  
(Aquaculture and Fisheries Development Centre, UCC)

## Applied Industry

### A Novel System for Intensive Larval Culture of Sea Urchin (*Paracentrotus lividus*)

<b>Duration</b>	12 Months
<b>Grant-Aid Approved:</b>	€38,958
<b>Industry Partner:</b>	Dunmanus Seafoods, Co Cork.
<b>Research Partner:</b>	Aquaculture and Fisheries Development Centre-ERI, UCC

Dunmanus Seafoods, Ireland's only sea urchin hatchery, has been providing sea urchin juveniles for local ranching purposes. Even though the hatchery production of *Paracentrotus lividus* is well understood, it has continued to be relatively extensive, requiring large tanks and large hatchery premises. The development of an intensive system would assist in reducing capital and running costs of the urchin hatchery. The Aquaculture Development Centre developed a novel solution to some of the problems relating to intensive sea urchin larviculture, based on the clinical technique of blood dialysis.

The project aimed to apply the techniques of dialysis to the culture of sea urchin pre-metamorphic larvae, thus providing a low waste and high oxygen environment for growing sea urchins. This involves the removal of soluble wastes and provision of oxygen through diffusion in the tubing in a re-circulated system. Validation of the Dialysis Assisted Recirculation (DAR) system with current culture methods was also carried out.

"The successful completion of this project has allowed Dunmanus to increase its hatchery stocking densities which gives us the opportunity to increase capacity and over time reduce running costs."

**John Chamberlain**  
(Dunmanus Seafoods)

### Development of an Artificial Roe Enhancement Diet Based on Waste Products from the Fishing Industry

<b>Duration:</b>	12 Months
<b>Grant-Aid Approved:</b>	€54,308
<b>Industry Partner:</b>	Red Mills, Co. Kilkenny
<b>Research Partner:</b>	Aquaculture and Fisheries Development Centre-ERI, UCC

Sea urchin, such as the European or Purple sea urchin, which are native to Ireland, are considered a delicacy in many countries including Japan, Italy, France and Spain. With the worldwide demand for this roe increasing and wild fisheries in decline, there is an increasing interest in aquaculture to supply this demand. Aquaculture allows the modification and enhancement of diets and by feeding sea urchins an artificial diet containing suitable ingredients, roe quality and quantity can be significantly enhanced. The National Institute of Water and Atmospheric Research (NIWA) in New Zealand have produced an artificial diet based on readily available fishery industry waste products, including fish skins.

The aim of this project was to transfer a novel diet production technology from New Zealand (National Institute of Water and Atmosphere) into Ireland and develop a series of diets using 'clean wastes' from the fishing industry. This included the testing of diets in sea cages and investigations into the techniques needed for the commercial production of the artificial diet.

"There is a real and immediate need to develop composite diets for sea urchins in Ireland in order to support existing roe enhancement and farming initiatives. The experience, knowledge and technological know-how gained in this project will greatly assist in the development of a self-sustaining sea urchin industry in Ireland."

**Gerry Mouzakitis**  
(Aquaculture and Fisheries Development Centre, UCC)

# Applied Industry

## Establishment of a Commercial Use for Starfish

**Duration:** 12 Months  
**Grant-Aid Approved:** €66,264  
**Industry Partner:** Connemara Seafood Ltd., Co. Mayo  
**Research Partner:** The National Food Centre, Teagasc

Connemara Seafoods grow and process shellfish species including oysters and mussels mainly for export. Included in their portfolio of activities is the bottom cultivation of mussels in Belfast Lough, along the Northern coast and in the Irish Sea. Growth rates have been found to be good but predation by starfish, primarily the common starfish (*Asterias rubens*), is a problem. Research has shown that these starfish kill their body weight of mussel per day and boats clearing the mussel beds can remove up to four tons of starfish per day. It is estimated that a suitable removal methodology and use of starfish could contribute to a saving of up to €2 million.

The project's aim was to find viable end uses and especially value-added uses for starfish. This included assessing starfish composition, the fractionation of starfish tissue to produce extracts for industry e.g. food, pet food and pharmaceutical. In addition, the anti-microbial activity of extracts was assessed. Although the work demonstrated limited potential for dried starfish powder as a hydrocolloid or as a source of PUFAs, carotenoids or dietary fibre, the high calcium content may provide potential for the development of new products.

"Connemara Seafoods have an active R&D department with a strong commitment to new product development. It is the company's intention to continue with research on the Starfish and explore further possibilities for the economic extraction of Omega-3, while establishing a use for this problem predator."

**Andy Mulloy**  
(Connemara Seafood Ltd.)

## Dunlop Offshore Cage Development programme

**Duration:** 8 Months  
**Grant-Aid Approved:** €42,868  
**Industry Partner:** Bonnar Engineering Ltd., Co. Donegal

The trend in finfish aquaculture has been to try and operate more offshore sites due to the limited number of inshore sites and the proven fact that the quality of fish produced on offshore sites is better. Bonnar Engineering in conjunction with Dunlop Oil and Marine, has been a leader in the field of cages for offshore aquaculture for some time but has come to realise that it is not just the cage that has to be designed for offshore use but also the nets and moorings.

The aim of this work was to gather data to allow the production of a predictive model for the evaluation of cages for offshore sites, in addition to identifying areas of the cage system that could be improved. The data gathered allows for an assessment of the loads being created by the various forces on the entire cage system. This involved the installation of a cage, with varying mesh sizes, in an offshore site during winter months and strain gauges at various key points on the cage, net and moorings. Data collection also involved the gathering of wind speed, current, wave height and used wave climate analysis.

The model generated by this work has potential commercial application as a design tool for offshore fish farms.

"The Dunlop Tempest cage is one of the market leaders for offshore aquaculture. This project has been essential in keeping Bonnar at the forefront of offshore cage development and will give the company a competitive edge in the specialist sector of cage units costing over €100,000 each."

**Mark Kilroy**  
(Bonnar Engineering Ltd.)

# Applied Industry

## The Development of Soil Structure Interaction Models for Deepwater Environments (SOILSIM)

**Duration:** 12 Months  
**Grant-Aid Approved:** €54,067  
**Industry Partner:** Marine Computation Services Ltd., Galway

Due to the operational difficulties in the exploitation of deepwater hydrocarbon reserves, the industry is becoming increasingly reliant on the use of catenary riser systems. These systems, a large proportion of which lie on the seabed, transfer the hydrocarbon fluid from the subsea well head to the floating production system. As a result of both the hydrodynamic and vessel loading acting upon the riser; the touchdown point of the riser is not fixed and is thus susceptible to fatigue damage.

This project has developed linear and non-linear mathematical models for the interaction between slender structures such as marine risers and pipelines and clay soils that are typical of the on-bottom conditions in deepwater (>500m) environments in the Gulf of Mexico and in harsh environments such as those experienced offshore Ireland. These models are being implemented into the MCS software programs FLEXCOM-3D and FREECOM-3D and validated using industry data. The models are generic in nature and are therefore applicable to any marine applications involving the interaction between slender structures and the seabed.

"This research has been an integral part of our growth strategy giving us a strong competitive edge in the global markets for software in the offshore hydrocarbon industry. Between R&D and our consultancy division we now have over 100 staff which is an increase of 100% in the past 3 years."

**Michael O'Sullivan**  
(MCS)

## Pre-Prototype Testing of the B2D2 Wave Energy Converter

**Duration:** 7 Months  
**Grant-Aid Approved:** €59,925  
**Industry Partner:** Ocean Energy Ltd., Co. Cork  
**Research Partner:** Hydraulics and Maritime Research Centre, UCC

The Backward Bent Duct Device (B2D2) is a floating oscillating water column device, developed by Ocean Energy Ltd., which converts wave energy into mechanical energy via an air turbine system. Design studies carried out on the device have led to a modified hull layout. Prior to the development of the prototype system the output performance of the device needed to be determined.

The objective was to construct a physical model of the device including dynamic representations of weight distributions. In addition, power performance maps were to be determined and the economic viability of the device assessed.

"The technology developed from the B2D2 project has been incorporated into the OE buoy and the OE buoy is now the focal point of Ocean Energy's development strategy. It has strong export potential"

**John Keating**  
(Ocean Energy Ltd.)



# Applied Industry

## Acclimatisation Potential of Arctic Char (*Salvelinus alpinus*) to a Marine Environment

<b>Duration</b>	18 Months
<b>Grant-Aid Approved:</b>	€59,685
<b>Industry Partner:</b>	Stofniskur (Ireland) Ltd., Co. Galway
<b>Research Partner:</b>	Department of Zoology, NUI, Galway

Less than 3,000 tonnes of Arctic Char are produced annually worldwide, with Iceland accounting for 65% of production. Arctic Char is mainly reared in brackish waters where salinities range from 8ppt to 14ppt. These salinities are achieved by mixing geothermal freshwater with seawater pumped ashore. Such resources are not available in Ireland. Initial work on Arctic Char cultivation in Ireland in the 1990s in freshwater and brackish water units showed promise. This project aims to determine if Arctic Char can be cultured in the marine environment, either gradually or immediately from freshwater conditions, and the optimum concentration of seawater in which they can be commercially grown. In addition, the project is to establish the optimal time for transfer to the marine environment and examine the usefulness of the feed additive MariCal in assisting in the smoltification and transfer processes.

By examining the potential for Arctic Char production this work is helping to fulfil an identified priority for the finfish aquaculture industry, namely, species diversification to reduce the current overwhelming reliance on a single species, salmon.

"This project is very important to the Irish aquaculture industry, as it explores the possibility of establishing marine farms to rear this novel species of salmonid in association with the development of ecologically friendly and commercially sound freshwater recirculation units."

**Peter McGovern**  
(Stofniskur, Ireland Ltd.)

## Development of an Alternative Source of Natural Astaxanthin for the Aquaculture Market

<b>Duration:</b>	12 Months
<b>Grant-Aid Approved:</b>	€58,500
<b>Industry Partner:</b>	Cybercolours Ltd., Co. Cork
<b>Research Partner:</b>	Department of Zoology, Ecology and Plant Science, UCC

Astaxanthin is a red-coloured carotenoid pigment, most commonly encountered in the flesh of salmonids (e.g. salmon, trout) and crustacea (e.g. shrimp), where it imparts the characteristic pink coloration. The pink flesh colour of salmonids contributes significantly to consumer appeal and astaxanthin has to be added to the artificial feed given to farmed fish. Currently, nearly all the astaxanthin used in aquaculture is chemically synthesised, and at €2,000/kg represents 6-8% of the total cost of rearing farmed salmon. There is considerable interest in the sourcing of natural astaxanthin.

There are currently two commercially available natural sources of astaxanthin, from yeast and microalga. An additional source of natural astaxanthin, from the plant *Adonis palæstina*, is being investigated in this project. The work carried out included assessment of the stability of the extracted astaxanthin under storage and cooking conditions and the potential toxicity, through the estimation of the content of cardenolides (potential toxins found in the plant) in the fish. This project is almost complete and has provided some promising results. An organic source of fish/shrimp feed additive would give the company access to a global market for this product.

"We project an increase in sales of between €500,000 and €1 million as a direct result of this product development. The market for food colouring is worth about €180 million, most of which is synthetic at the moment. There is strong demand in the market for switching from synthetics to natural colourings which we can meet with this product"

**Noel Sexton**  
(Cybercolours Ltd.)

## Applied Industry

### Evaluation of Selected Biophysical Properties of Salmon Pancreas Disease Virus (SPDV)

**Duration:** 9 Months  
**Grant-Aid Approved:** €58,595  
**Industry Partner:** Irish Salmon Growers Association Ltd., Co. Galway  
**Research Partner:** Department of Veterinary Science, QUB

Pancreas disease is a serious problem in farmed Atlantic salmon in Ireland. Despite the fact that pancreas disease has been recognised for many years in Ireland, the causative agent, Salmon Pancreas Disease Virus (SPDV), has only been isolated in the last decade. In recent years however, the severity of outbreaks has increased and pancreas disease has become a significant cause of mortality in the marine phase of production of farmed Atlantic salmon; reaching 30-50% on some sites. Such losses threaten the economic viability of some producers.

Additional knowledge of the biophysical properties of SPDV is required to assist industry in dealing with the problem. The outcomes of this study will have immediate relevance to industry in combating pancreas disease and improving the long-term sustainability of the industry.

"Irish salmon farmers take the issue of PD very seriously. In order to prevent the disease in future we need to find ways to prevent cross-contamination. The results of this should give farmers very practical tools to prevent and contain a financially significant problem."

**Richie Flynn**  
(Irish Salmon Growers Association)

### Investigation of the Bioactive Potential on Animal Health of Fucoidan-Rich Products Manufactured at Different Process Levels from Irish Brown Macro-algal Resources

**Duration:** 18 Months  
**Grant-Aid Approved:** €60,300  
**Industry Partner:** Oilean Glas Teo. Co. Galway  
**Research Partner:** Molecular Glycobiotechnology Group, NUI Galway

In light of recent concerns relating to human health and microbial contaminants in the food chain, questions have been raised over the use of conventional antimicrobials in animal husbandry. There is increasing interest in natural therapeutic products for the control of disease in animal production. Brown macro-algae (seaweed) are a potential source of novel antimicrobial compounds.

Oilean Glas Teoranta is developing new products based on the bioactive compounds in the brown seaweed *Ascophyllum nodosum*, which is rich in a variety of natural bioactive compounds, including polyphenols, vitamins, other micronutrients and polysaccharides. Fucoidans are natural macro-algal polysaccharides with a potential range of bioactivities. This collaborative project is carrying out trials (both *in-vitro* and *in-vivo*) on the bioactivity properties of fucoidan-rich commercial products derived from *A. nodosum*, manufactured via an innovative cold-process line, to determine their impact on (a) animal viral diseases in pigs and poultry and (b) anti-microbial effects in these animals.

The project is due to complete in 2006 and the results to date have been promising. The development of new value-added markets for macro-algal products is essential for the future survival and development of the seaweed industry in Ireland.

"Because EU regulations tend to limit use of chemical molecules in animal production systems there is a need for therapeutic extracts based on a natural resource. These studies are conducted to investigate and evaluate the anti-microbial impact of these extracts on key diseases in poultry and cultivated aquatic animals. The results should have wide commercial application."

**Franck Hennequart**  
(Oilean Glas Teo.)

# Applied Industry

## The Research, Development and Implementation of Alternative, Reliable Materials and Methods for Marine Electronic Enclosures

**Duration:** 9 Months  
**Grant-Aid Approved:** €30,923  
**Industry Partner:** Marine Informatics Ltd., Co. Clare  
**Research Partner:** The Materials Ireland Research Centre, UL

Marine Informatics has been developing and implementing data acquisition systems with telemetry for use in marine environments since 1997. Applications for such systems include data buoys, shore-based systems and remotely operated vehicles. In recent years they have been working on sensor technology. However, as they have continued to miniaturise their electronics and reduce cost, the enclosures that are readily available to protect these electronic systems have become disproportionately expensive and bulky.

The project aims to develop a low-cost enclosure system for smaller electronics at an initial depth rating of 500m. In addition, it needs to be appropriate to develop small quantities of enclosures at one time. A design for bigger, deeper enclosures will also be developed, thus enhancing in-house expertise and reducing costs, making data acquisition systems more competitive.

"In partnership with Materials Ireland, this project is providing great options for low cost and smaller enclosures and instrument interfaces with our Data Acquisition Systems. We anticipate this work will make the company more competitive by helping us to sell our products at a better margin."

**John Wallace**  
(Managing Director, Marine Informatics)

## The Development of the Next Generation of Heterogeneous Telemetry Modules for Marine Informatics Data Loggers

**Duration:** 18 Months  
**Grant-Aid Approved:** €48,338  
**Industry Partner:** Marine Informatics Ltd., Co. Clare  
**Research Partner:** Adaptive Wireless System Centre, Cork Institute of Technology

Data acquisition technology has developed considerably in recent years but telemetry systems such as wireless transmission of acquired data like environmental parameters have not kept pace. The technology currently available to Marine Informatics includes SMS messaging on the GSM network, data packet transmission on third party VHF and UHF radio modules (e.g. Wood & Douglas module) or third party satellite modules. Arising out of a combination of technical and business issues (e.g. bandwidth, cost, power consumption and transmission range) Marine Informatics have identified the need to bring their telemetry technology in line with their core system technology, thus maintaining competitiveness in this fast-changing market.

This project will develop a modular telematics system for the family of data loggers developed by Marine Informatics. This would include utilising a range of transmission methods (GSM, GPRS, SMS, VHF, satellite and some longer range RF systems), while ensuring the system is small, power efficient and built at a relatively low cost.

"This project will make a strong contribution to increasing our turnover and we plan to recruit another full-time engineer in the short to medium-term."

**John Wallace**  
(Managing Director, Marine Informatics)

## Applied Industry

### Development and Assessment of First Hatchery-Stage Composite Diets for Sea Urchins (Hatch Feeds)

<b>Duration:</b>	18 Months
<b>Grant-Aid Approved:</b>	€59,430
<b>Industry Partner:</b>	Dunmanus Seafoods, Ltd.
<b>Research Partner:</b>	Aquaculture and Fisheries Development Centre-ERI, UCC

This research is a follow-on to the successful project on intensive larval cultivation of sea urchins, which was supported in 2003. A major obstacle in the hatchery process is the lack of artificial diets. The provision of diets consisting of live diatoms for newly settled spat and fresh macroalgae for juvenile on-growing is time and labour intensive and contributes significantly to the running costs of the hatchery.

The Aquaculture & Fisheries Development Centre has recently developed a series of novel, moist-diet formulations (KX diets) for the on-growing stage of sea urchins under an INTERREG IIIB-funded project. The current project proposed will produce three hatchery-stage artificial diets based on the original KX formulations. These artificial hatchery diets will be assessed both individually and collectively in a commercial setting. The ultimate aim is to produce 'storable' diets for sea urchin hatchery production. The successful completion of this project will have an immediate impact on the running costs at Dunmanus and give them a strong foothold in the lucrative €264 million world market for urchin roe.

"Hatchery stage food is a major obstacle. When larvae metamorphose, continuous food supply is essential. Diatom coating on plates is consumed quicker than can be replaced. A prepared diatom diet which can be applied to plates so it can last for weeks would help overcome this."

**John Chamberlain**  
(Dunmanus Seafoods Ltd.)

### Control Systems for Remotely Operated Vehicles (ROVs)

<b>Duration:</b>	15 Months
<b>Grant-Aid Approved:</b>	€60,000
<b>Industry Partner:</b>	Marine Informatics Ltd., Co. Clare
<b>Research Partner:</b>	Mobile and Marine Robotics Laboratory, UL

In underwater scientific operations the control of Remotely Operated Vehicles (ROVs) and Autonomous Underwater Vehicles (AUVs) can be extremely difficult, especially when factors such as varying currents, drag from the umbilical (in the case of ROVs), and pilot skill are taken into account. A range of environmental and/or operational factors can impact on the vehicle, causing it to veer off course or off station. The net effect of this type of vehicle behaviour is that trajectories are less smooth than required for good survey data, missions take longer and therefore cost more.

This project aims to develop and implement computer assisted control systems significantly more advanced than what is currently available, and in doing so provide a framework for successful and cost-effective mission execution for ROVs and, ultimately, AUVs. The proposed technology also has significant potential in manned vehicles using autopilot and DPS applications and also has application for unmanned surface vehicles.

"In partnership with the Marine Robotics Lab at the University of Limerick, this project will build significantly on recent research to provide us with a foundation for several products for unmanned underwater vehicles."

**John Wallace**  
(Managing Director, Marine Informatics)



# Applied Industry

## Power Take-off Systems for the OE Buoy Wave Energy Converter

**Duration:** 12 Months  
**Grant-Aid Approved:** €60,000  
**Industry Partner:** Ocean Energy Ltd., Co. Cork  
**Research Partner:** Hydraulic and Marine Research Centre, UCC

The OE Buoy is a wave energy device that uses an oscillating water column principle that has been developed by Ocean Energy Ltd. Previously funded work has been carried out to develop an optimised hull configuration for the OE Buoy. An air turbine power take-off system (PTO) was initially envisaged with this system, but it was felt that a more efficient power take-off system could be available and would optimise the energy output from the device.

The aim of the project is to investigate alternative PTO systems, including an alternative self-rectifying air turbine, or hydraulic and linear electrical generator systems. Modelling, both physical and numerical, of these devices will be carried out and the optimal power take-off system designed. The economics of this system will also be calculated using typical wave climates from the Irish coast.

"Ocean Energy is breaking new ground in energy technology. Energy has become a hot topic nationally and internationally. This innovation will be from an Irish company creating wealth and employment in the Irish economy".

**John Keating**  
(Ocean Energy Ltd.)

## Development of Cost-effective Gravity Based Foundation System to Support Wind Energy Converters in Deeper Waters

**Duration:** 12 Months  
**Grant-Aid Approved:** €60,000  
**Industry Partner:** Sure Engineering (Europe) Ltd. Dublin  
**Research Partner:** Hydraulics and Maritime Research Centre, UCC

Offshore wind energy offers significant potential in terms of reaching Ireland's renewable energy targets. The foundation systems of wind turbines are a significant proportion of the installation costs. These consist of either a gravity-based structure, constructed on shore and de-ballasted on site to sit on the seabed, or a monopile structure, tubular steel up to 7m in diameter that is driven into the seabed. Gravity-based systems are cheaper to install as they can be built on land, but have only been used in relatively shallow water (<20m).

The aim of the project is to assist in the development of a reinforced concrete gravity based system that can be used in water depths up to 50m. This system is of immediate relevance to the Clogherhead (Co. Louth) wind farm and also in other areas where additional depth limits are sought. The study will examine issues relating to the floatation of the structure for tow out to the site under different wave conditions and to investigate the forces and stability of the structure during installation, operation and survival. The study will include model testing.

"The research funding provided through the RTDI is essential to validate the design concept of this project. Self-installation of gravity foundation systems will deliver significant benefit to the marine sector by recreating new opportunities for involvement in the installation and subsequent operation and maintenance works associated with offshore wind farms."

**Chris Hannevig**  
(Sure Engineering)



## Post-Doctoral Fellowships

The aim of the Marine RTDI Post-doctoral Fellowship Award Scheme is to build Irish RTDI capacity and excellence in selected marine sectors. A total of 12 fellowships have been awarded.

Fellowship	Grant-aid Approved
<b>Michael Manahan Fellowship 2002</b>	
Michael Manahan Fellowship: The Law and Policy of Marine Resources in Ireland	€100,000
<b>2002</b>	
Modelling and Simulation of Fish Stock Dynamics in the Waters around Ireland	€150,800
Sea Lice Biology and Interactions	€157,400
Investigations into the Hatchery Rearing of Cod ( <i>Gadus morhua</i> ) in Irish Conditions	€210,000
Investigations into a Reliable Supply of Scallop ( <i>Pecten maximus</i> ) for the Inshore Fishery and Aquaculture Industries	€209,280
Iodine in Commercially used Irish Seaweeds	€172,700
Monitoring and Predicting the Influence of Climate Change on the Marine Flora and Fauna of the Islands of Great Britain and Ireland using Intertidal Indicators	€174,365
An Integrated Bioscreening Approach for the Identification and Cloning of High Value-added Biocatalysts of Biotechnological Importance from Marine Algae	€210,503
<b>2004</b>	
Identification of Key Non-technical Issues and Challenges and Recommendations for an Appropriate Governance Framework for Biodiscovery Activities	€119,986
<b>2005</b>	
Advanced Technologies for Aquaculture	€119,928
Instrumentation Interface, Communication & Data Management Architecture Issues for Marine Sensor Systems, Including Sea-floor Observatories	€124,719
Integrated Modelling using Real-time Data Assimilation and High-end Computing Resources	€109,341
<b>TOTAL GRANT-AID</b>	<b>€1,859,022</b>

### Michael Manahan Fellowship: The Law and Policy of Marine Resources in Ireland

**Duration:** 2002–2004 (24 Months)  
**Grant-Aid Approved:** €100,000  
**Fellow/Host Institute:** Dr. Ronan Long, NUI, Galway

The Michael Manahan Fellowship is awarded to an outstanding Irish scholar to promote research and development in priority areas in the fields of Marine Science Policy, Socio-Economics or Law of the Sea, and to establish links with international institutes in the chosen field of research. The Fellowship was instigated in memory of Michael Manahan who played a pioneering role in all aspects of marine science and technology over three decades and was a member of the Board of the Marine Institute.

*The 2002 Fellowship was awarded to Dr Ronan Long of the School of Law, NUI Galway. It allowed Dr Long to focus on the preparation of a reference book on the law and policy relating to the utilisation and management of marine resources in Ireland. 'Marine Resource Law' is due for publication in 2006.*

*This award complemented the establishment of the Marine Law and Ocean Policy Centre at NUI Galway and enabled strengthening of links with similar centres for marine law around the globe.*

# Post-Doctoral Fellowships

## Modelling and Simulation of Fish Stock Dynamics in the Waters around Ireland

**Duration:** 2002–2005 (42 Months)  
**Grant-Aid Approved:** €150,800  
**Fellow/Host Institute:** Dr. Ed Codling, UCC

Modelling and simulation are critical tools in fish stock assessment and management. This fellowship, due for completion in 2006, is focusing on modelling and simulation of the stock dynamics of commercially exploited fish species in the waters around Ireland. Particular attention is being given to the relevance of simulation studies on fish stock recovery plans (Cod and Hake); simulation and modelling studies on various harvest control rules; and modelling work related to improved fish stock assessments for stocks with limited data.

Key elements of the project included examination of the sensitivity of fisheries assessments to various parameter assumptions; carrying out medium-term analyses of harvest control rules; and simulation studies to examine the impact of technical measures (closed areas; mesh size increases) used in stock recovery plans on the medium-term status of the stocks.

*The work has led to the development of a stochastic simulation tool (F-PRESS) that can be used to develop probabilistic assessment advice or to evaluate management strategies and harvest control rules. F-PRESS has been used internally by the Marine Institute and at several working groups of the European Commission's Scientific, Technical and Economic Committee for Fisheries (STECF).*

## Sea Lice Biology and Interactions

**Duration:** 2002–2005 (42 Months)  
**Grant-Aid Approved:** €157,400  
**Fellow/Host Institute:** Dr. Lorraine Copley, GMIT

Effective sea lice (*Lepeophtheirus salmonis*) control is one of the major problems facing the sustainable development of the Irish finfish aquaculture industry. Under the Sea Lice Monitoring and Control Protocol managed by the Department of Communications, Marine and Natural Resources, all fish farms are required to control lice infestations within specified levels. As sea lice are endemic in both wild and farmed salmonids, eradication is not possible. Sea lice control using physical and chemical means is an on-going management issue for salmon farmers in Ireland. Gaps in the knowledge concerning lice biology and behaviour, particularly of the infective larval stage, represent an obstacle to more efficient control.

This fellowship examined developmental and survival rates of sea lice on farmed salmon in the west of Ireland; the efficacy of sea lice treatments by field oriented measures and by past records; treatment strategies, with a view to developing a resistance management plan.

*An important conclusion from the project was the need for fish farms to factor in information on sea lice intensities, water temperature, and timing and duration of treatments, when determining the type of treatment to be used. These factors were shown to be important in the relative efficacy of treatments used. The use of bioassays to determine treatment resistance should be considered as a useful tool to assist in the planning of treatment regimes.*

*The work contributes to the development and expansion of expertise in sea lice biology and behaviour, a key requirement in the development of more effective management strategies for sea lice control and for the sustainable development of the aquaculture industry.*

## Post-Doctoral Fellowships

### Investigations into the Hatchery Rearing of Cod (*Gadus morhua*) in Irish Conditions

**Duration:** 2002–2005 (36 Months)  
**Grant-Aid Approved:** €210,000  
**Fellow/Host Institute:** Dr. Ronan Brown/Dr. Mark Harvey, NUI, Galway

Salmon account for 90-95%, by volume and value, of finfish aquaculture production. This dependence on a single species leaves the industry vulnerable to significant reduction in production levels in the event of, for example, disease outbreak. The need for diversification into new species has been recognised by a number of fora. Cod are farmed commercially in Norway and Scotland and could potentially be a viable species in Ireland.

The specific objective of this fellowship was to identify and harness potentially exploitable research and technology so as to enable the establishment of a commercially viable cod hatchery in Ireland. The deliverable is a detailed methodology, developed in collaboration with industry, for the hatchery production of juvenile cod in commercial conditions.

*This project has played a significant role in stimulating the fledgling cod farming industry in Ireland. The work undertaken has resulted in the successful rearing of juvenile cod. The first commercial cod farm company was set up in 2005 and cod have now been supplied to two commercial farms and three aquaria. Survival and growth rate data available from both the hatchery and sea site indicate that cod can be successfully farmed in Ireland.*

### Investigations into the Reliable Supply of Scallop (*Pecten maximus*) for the Inshore Fishery and Aquaculture Industries

**Duration:** 2002–2005 (42 Months)  
**Grant-Aid Approved:** €209,280  
**Fellow/Host Institute:** Iarfhlaith Connellan, UCC

Scallop farming and ranching cannot progress in Ireland without an adequate, reliable seed source. Interest in scallop culture in Ireland was sparked off in the late-1970s by an exceptionally heavy natural spatfall in Mulroy Bay, Co. Donegal. However, after a number of good years of spat collection, and a reasonable supply to grow-out trials in Ireland and elsewhere, the spatfall ceased and now varies considerably from year-to-year. Hatchery-produced spat are an alternative source of spat. There are technological and cost-effectiveness obstacles to hatchery production.

This fellowship aimed to provide a detailed methodology, developed in collaboration with industry and other relevant agencies, for the production, transport and on-growing of scallop spat in commercial quantities for re-stocking and aquaculture ventures.

*The project has resulted in successful hatchery production of juvenile scallops, intermediate and bottom cultivation and progress in the use of mesocosms (enclosed culture systems) for larval rearing. There has also been very good progress on addressing the causes of culture collapse in pre-settlement larvae and defining parameters involved in wild spatfall events.*

# Post-Doctoral Fellowships

## Iodine in Commercially used Irish Seaweeds

**Duration:** 2002–2005 (42 Months)  
**Grant-Aid Approved:** €172,700  
**Fellow/Host Institute:** Dr. Emma Burbridge/Dr. George Cloughley, UCD

The beneficial health effect of the iodine content of seaweeds is well established. Iodine from the diet is taken up by the thyroid gland as iodide (I<sup>-</sup>) and used in the formation of thyroid hormones. Although other organs can also trap I<sup>-</sup>, the thyroid gland has the greatest affinity. It can concentrate I<sup>-</sup> to 20-40 times its concentration in the bloodstream. Likewise, various species of seaweed can accumulate I<sup>-</sup> against a concentration gradient - by a factor up to 10<sup>5</sup> times that of seawater. The mechanism through which this is achieved is not fully understood. Studying the seaweed model of iodine intake and handling could significantly assist in our understanding of mammalian control of I<sup>-</sup> uptake/efflux.

This fellowship aimed to determine the iodine content of Irish seaweed (reds, greens and browns); study the ability of different anatomical sites in seaweeds to take up and retain iodide; and investigate the molecular basis for iodide uptake and retention in different seaweeds. The overall aim was to formulate an understanding of iodide control mechanisms, upon which future prophylactic or therapeutic uses of seaweed might be based.

*The work has found that:*

- Iodine content of Irish seaweeds varied widely on the basis of species, with the highest levels in the kelps;
- The biochemical form of iodine in seaweeds and rates of uptake and efflux is species specific; and
- Uptake of iodide by seaweeds is of the same order of magnitude as the human thyroid but accumulation in kelps is much higher.

*Further work is suggested that may lead to the use of seaweed extracts in cancer therapy.*

## Monitoring and Predicting the Influence of Climate Change on the Marine Flora and Fauna of the Islands of Great Britain and Ireland using Intertidal Indicators

**Duration:** 2002–2005 (42 Months)  
**Grant-Aid Approved:** €174,365  
**Fellow/Host Institute:** Dr. Anne-Marie Power, UCC

Ireland is particularly well placed to use inter-tidal organisms as indicators of climate change, as it straddles a biogeographic boundary between warm water Lusitanian species and colder water Boreal species. Temperature changes, resulting from global climate change, may alter the relative abundances of these species and possibly their geographic ranges and distribution. Potential intertidal indicators include barnacles, limpets, top shells and some of the more common seaweeds.

This fellowship carried out an extensive review of existing intertidal data; re-surveyed sites surveyed in 1954 to determine any changes occurring in the last 50 years; developed and tested hypotheses on the impact of climatic change on marine biodiversity; forecast future marine community change; and identified future long-term monitoring sites and key inter-tidal species. It formed part of the much larger MarClim project ([www.mba.ac.uk/marclim/](http://www.mba.ac.uk/marclim/)), a four-year multi-partner project created to investigate the effects of climatic warming on marine biodiversity.

*The findings of this work indicate a reduction in Northern intertidal species over the last 50 years but no corresponding increase in Southern species. The conclusions of the larger MarClim study show that only sustained, broad-scale and long-term decadal observations can separate global environmental change from regional and localised impacts from the natural spatial and temporal variability of marine ecosystems. Rocky shores provide an ideal sentinel system to monitor such changes in a cost-effective manner.*



## Post-Doctoral Fellowships

### An Integrated Bioscreening Approach for the Identification and Cloning of High Value-added Biocatalysts of Biotechnological Importance from Marine Algae

**Duration:** 2002–2006 (42 Months)  
**Grant-Aid Approved:** €210,503  
**Fellow/Host Institute:** Dr. Alice Grassick/Dr. Patrick Murray, NUI Galway

The marine ecosystem offers enormous diversity and magnitude in terms of biotechnological potential, which, if fully realised, could generate and sustain a vibrant, high value-added marine biotechnology industry. Seaweeds represent a vast and 'generally regarded as a safe' (GRAS), under-utilised resource of high-value bio-pharmaceuticals, agro-chemicals, nutraceuticals, veterinary and healthcare products. The identification of high value-added seaweed extracts could revitalise the declining traditional seaweed industry and stimulate the seaweed culture sector.

*By bioscreening a range of red, green and brown algae for production of carbohydrate-active enzymes, this work has generated a portfolio of enzymes with detailed information on their temporal expression and biochemical information of direct relevance to their biotechnological application. It is also cloning genes for selective key enzymes. Ultimately, it will provide a detailed database of information for further bioscreening studies and for the successful exploitation of the enzymes in the biotechnological, biopharmaceutical and biomedical industries, and propose a strategy for future bioscreening programmes. Finally, it has provided preliminary protocols for industry and information on optimum harvesting times.*

### Identification of Key Non-Technical Challenges and Recommendations for an Appropriate Governance Framework for Marine Biodiscovery Activities

**Duration:** 2004–2006 (24 Months)  
**Grant-Aid Approved:** €119,986  
**Fellow/Host Institute:** Dr. Ronan Long, NUI, Galway

Marine biodiscovery and biotechnology are frontier sciences, which present exciting new opportunities for Ireland. Biodiscovery involves the collection of small amounts of biological resources such as those found in plants, animals, fungi and micro-organisms and subsequent screening to identify bioactive compounds that may be used for commercial purposes (e.g. pharmaceuticals and insecticides). Despite the considerable interest in the biological resources in Irish waters, no specific legislation has been enacted to regulate biodiscovery activities. The focus of this post-Doctoral award is to identify and recommend an appropriate framework to govern marine biodiscovery activities, taking into account international agreements on, for example, access to marine resources/organisms, intellectual property rights related to genetic material and ethical and environmental concerns. It will identify the core legal and policy elements that need to be adopted for establishing such a framework and will contribute to legislative and policy development at national and international level.



# Post-Doctoral Fellowships

## Advanced Technologies for Aquaculture

**Duration:** 2005–2007 (24 Months)  
**Grant-Aid Approved:** €119,928  
**Fellow/Host Institute:** Dr. Levente Molnar, UL

Aquaculture employs a wide range of technologies. Although there is continuous debate on how and when offshore aquaculture will become a significant commercial activity, a range of increasingly sophisticated technologies (sensors, materials and ICT) continue to evolve both for use in the existing industry and with potential applications in novel aquaculture systems. Potential applications include fish behaviour and health monitoring, feed delivery and uptake, security, biomass estimation and cage construction. Ireland has two leading cage manufacturing companies and a range of technology research capabilities that can be harnessed to address these needs.

The core objective of this fellowship is to establish an overview of technological development as it applies to offshore aquaculture and aquaculture in exposed or high-energy sites. It will identify niche technology areas for further research and development and relevant Irish research and technical groups and capabilities, and shortlist potential projects for development.

## Instrumentation Interface, Communication and Data Management Architecture Issues for Marine Sensor Systems, Including Sea-floor Observatories

**Duration:** 2005–2007 (24 Months)  
**Grant-Aid Approved:** €124,719  
**Fellow/Host Institute:** Dr. Jer Hayes, DCU

Operational activities and research projects increasingly involve the development and use of sensor systems and novel data acquisition; for example, for marine environmental monitoring. These include the national Data Buoy network and advanced technology projects funded under the NDP, e.g. the development of intelligent sensing networks for implementation of the Water Framework Directive. In addition, there is a growing level of international activity focused on the use of seabed observation systems to replace/supplement many traditional approaches to marine research and monitoring. Ireland has a developing profile, and potential involvement, in respect to the establishment of a seabed observation system in the Porcupine Abyssal Plain area and is leading a project to develop a business model for cabled ocean observatories. A key issue in all of these areas is instrument-user interfaces and functions that allow for interoperability and utilisation of different datasets.

This fellowship will identify niche areas of innovation; identify and assess Irish technical and industry capabilities in the technologies involved; provide solutions to the emerging interface between sensor systems development and operational requirements under the Water Framework Directive; and provide solutions for linking the data acquisition platforms currently in use and planned by the Marine Institute. Finally, it will prepare a proposal for a research project or linked suite of projects that will help to deliver on Ireland's objective of becoming an international player in this field of technology.

# Post-Doctoral Fellowships

## Integrated Modelling Using Real-time Data Assimilation and High-end Computing Resources

**Duration:** 2005–2007 (24 Months)  
**Grant-Aid/Approved:** €109,341  
**Fellow/Host Institute:** Dr. Heather Cannaby, NUI, Galway

The need for model simulations of the ocean has never been more acute. Even with the myriad of buoys, floats and vessels that measure the oceans, it is not practical to cover every location at all times. Supplementing these measurements with information from satellites and realistic ocean models is the key to providing a comprehensive picture of what occurs on an hour-to-hour basis in Irish waters and beyond. This combined use of tools allows scientists/managers to adequately look at the ocean and assess issues that may threaten the sustainable use of the resource.

This study will develop a 3-dimensional broad scale model of Irish waters that will reproduce the known circulation features around Ireland. The model will be tested for use within the Irish national grid-computing environment and further developed to produce realistic model simulations for Irish bays. Incorporation of data from sources such as satellites, buoys, ships of opportunity, coastal tide gauges and wider area models will be an integral part of the work.

## PhD Scholarships

The aim of the Marine RTDI Postgraduate Scholarship Award Scheme is to build Irish RTDI capacity and excellence in selected marine sectors through the provision of grant-aid for PhD scholarships. A total of 11 PhD scholarships have been awarded.

Scholarship	Grant-aid Approved
<b>2002</b>	
The Biology, Dynamics and Fisheries for Hake ( <i>Merluccius merluccius</i> ) in the Waters around Ireland	€118,083
The Impact of Discarding on the Management Advice for Key Irish Fisheries	€120,623
The Larval Ecology of Selected Fish Species in the Waters around Ireland	€102,041
The Biology, Dynamics and Fisheries for Blue Whiting ( <i>Micromesistius poutassou</i> ) in the Waters around Ireland	€103,563
Modelling of Alexandrium Bloom Dynamics in Cork Harbour	€98,350
Health and Disease in Clams ( <i>Ruditapes philippinarum</i> ) in Ireland, with Particular Reference to Brown Ring Disease	€118,136
<b>2004</b>	
Irish Maritime Shipping Cluster - Maritime Economics	€102,350
<b>2005</b>	
Stock Assessment in Large Riverine Catchments	€81,100
Assessing Ecosystem and Ocean Climate Changes in the Sea Area West of Ireland Using the Continuous Plankton Recorder and Oceanographic Measurements	€81,400
Use of Multiple Source Hydro Acoustics Data as a Tool in Ocean Management	€70,000
Benthic Mapping of the Biologically Sensitive Area as a Tool in Ocean Management	€80,000
<b>TOTAL GRANT-AID</b>	<b>€1,075,646</b>

# PhD Scholarships

## **The Biology, Dynamics and Fisheries for Hake (*Merluccius merluccius*) in the Waters around Ireland**

Aishling Lannin, University College Cork  
(Submission - 2006)

This PhD Scholarship is addressing the following in relation to Hake in the waters around Ireland:

- Biology (age structure, growth, reproduction, diet);
- Dynamics (seasonal movements between spawning areas and nursery areas); and
- Commercial fisheries (countries, gears, areas).

It will fill gaps in the knowledge of the biology of this species that will assist in re-building the stock.

## **The Impact of Discarding on the Management Advice for Key Irish Fisheries**

Lisa Borges, University College Cork  
(Completed – PhD Awarded)

Discards are that portion of the catch returned to the sea as a result of economic, legal or other considerations. This Scholarship considered the following - with particular emphasis on stocks of hake, haddock and whiting in the waters around Ireland:

- An analysis of Irish and international discard sampling protocols;
- Spatial and temporal distribution of discards in Irish waters;
- Selection of appropriate discard estimators; and
- The impact of discarding on assessment and management advice.

## **The Larval Ecology of Selected Fish Species in the Waters around Ireland**

Oonagh Dwane, National University of Ireland, Galway (Submission - 2006)

This project is addressing the following issues, with respect to selected species:

- Spatial and temporal distributions of their larvae in waters around Ireland;
- Larval age determination and production of larval age length keys;
- Vertical distribution of larvae; and
- Larval feeding ecology.

The results of this project will help formulate existing and future recovery plans in terms of identifying spawning areas for candidate closed areas.

# PhD Scholarships

## The Biology, Dynamics and Fisheries for Blue Whiting (*Micromesistius poutassou*) in the Waters around Ireland

Gavin Power, Galway-Mayo Institute of Technology (Submission - 2006)

This PhD Scholarship is addressing the following in relation to blue whiting in the waters around Ireland:

- Biology (age structure, growth, reproduction, diet, stock identity);
- Dynamics (seasonal movements between spawning areas and nursery areas); and
- Commercial fisheries (countries, gears, areas).

The results will feed into management measures aimed at ensuring the sustainable exploitation of the stock.

## Modelling of *Alexandrium* Bloom Dynamics in Cork Harbour

Aoife Ni Rathaille, National University of Ireland, Galway (Submission - 2006)

*Alexandrium tamarense* is a dinoflagellate that produces toxins that can accumulate in bivalve shellfish and cause Paralytic Shellfish Poisoning (PSP) in consumers of contaminated shellfish. This Scholarship aims to:

- Determine the environmental factors (e.g. temperature, salinity, light) that govern the growth of *Alexandrium tamarense* in Cork Harbour;
- Determine the environmental factors that govern the encystment/encystment of *A. tamarense* in Cork Harbour; and
- Develop a model of *A. tamarense* growth and bloom dynamics in Cork Harbour.

## Health and Disease in Clams, *Ruditapes philippinarum*, in Ireland, with Particular Reference to Brown Ring Disease

Linda Drummond, University College Cork (Completed - 2006)

The farming of clams in Ireland suffered a setback in the 1990s following heavy losses, believed to have been caused by Brown Ring Disease. This PhD Scholarship investigated survival/mortality, causes of disease and death, whether Brown Ring Disease is involved, and the factors contributing to the health, survival, and successful culture of the clam *Ruditapes philippinarum*.



# PhD Scholarships

## Irish Maritime Shipping Cluster– Maritime Economics

Valerie Brett, National College of Ireland  
(2005-2007)

This PhD scholarship is carrying out research aimed at building and clustering of the Irish Maritime Sectors. The research is focusing on:

- Designing a robust model that will determine the variables necessary to strengthen Ireland's economic efficiency in the development of the maritime transport mode in the supply chain;
- Assessing the economic impact that such a model of maritime logistics operations would have on Ireland's international trade outputs; and
- Identifying opportunities and threats for future freight flows, against the backdrop of global developments, which may benefit or hinder the development of maritime transport links to/from Ireland.

## Stock Assessment in Large Riverine Catchments

Louise Brennan, National University of  
Ireland, Galway (2006-2009)

The focus of this PhD Award will be to develop stock assessment methodologies for a selection of large, complex riverine systems. The study will carry out an assessment of hydrological and environmental data for the catchment and will include the use of state-of-the-art technologies such as hydro-acoustic counters, electronic data storage and tracking tags, and GIS (Geographical Information Systems).

## Assessing Ecosystem and Ocean Climate Changes in the Sea Area West of Ireland Using the Continuous Plankton Recorder and Oceanographic Measurements

Colm O'Shea, National University of  
Ireland, Galway (2005-2008)

This scholarship aims to use data from the Continuous Plankton Recorder (CPR), a plankton sampling instrument designed to be towed by ships of opportunity, and historical oceanographic data in the context of CPR observations, to contribute to the assessment of ecosystem and climate changes in the shelf area to the west of Ireland.

# PhD Scholarships

## Use of Multiple Source Hydro Acoustics Data as a Tool in Ocean Management

Edward Thurman, University of Limerick (2005-2008)

This scholarship will examine the use of data gathered in the Biologically Sensitive Area (BSA) off the south coast of Ireland, established by the EU, by a range of acoustic instruments from multiple sources in order to optimise data acquisition for the development of a management plan for the BSA.

## Benthic Mapping of the Biologically Sensitive Area as a Tool in Ocean Management

Jason Clarke, Galway Mayo Institute of Technology (2005-2008)

There is ample data that suggests fisheries exploitation affects not only target stocks but also communities of organisms, ecological processes and even entire ecosystems. This study will examine the role of the benthos in the ecosystem of the Biologically Sensitive Area off the south coast of Ireland. It will use a combination of hydrographic, physical and biological data to identify the habitats within the area and their role within the system, e.g. acting as feeding and nursery areas for fish or larval sinks and sources.

## Desk Studies

The primary aim of the desk studies funded under the Marine RTDI Measure of the NDP is to provide grant-aid for desk research on identified and priority RTDI topics of relevance to the sustainable development of marine resources. Desk studies are typically six to nine months in duration.

In 2002–2003, 11 desk studies were funded with grant-aid to a total value of €532,866. A further three desk studies were funded in 2005 with grant-aid totalling €163,596. These are due for completion in 2006.

Study	Grant-Aid Approved
<b>2002</b>	
Identification and Evaluation of Appropriate Marine S&T Performance Indicators	€65,000
Marine RTDI (Research, Technology, Development & Innovation) Foresight Review	€17,000
Disposal and Re-utilisation of Fish and Fish Processing Waste (including Aquaculture Waste)	€26,185
A Review of the Origins and Appropriateness of the Current Fish Stock Assessment and Management Areas for the Waters around Ireland	€52,539
The Use of Recovery Plans to Rebuild Depleted Fish Stocks – A Review	€47,622
Review and Evaluation of Marine Environmental State/Impact Indicators and their Application in Ireland	€47,213
Feasibility Study on the Establishment of a Large-Scale Inshore Resource Mapping Project	€89,453
Strategic Review of the Feasibility of Seaweed Aquaculture	€39,797
Scoping Study to Assess the Feasibility, Potential Use and Methodology for Establishing a National Marine Leisure Infrastructure Database to Support Planning and Development	€54,622
Development of Guidelines for the Integration of Marine Recreational Activities in the Rejuvenation/Regeneration of Small Harbours and Ports	€48,436
<b>2003</b>	
Irish Short Sea Shipping Inter-European Trade Corridors	€45,000
<b>2005</b>	
Platforms for Marine Monitoring	€48,475
The Use of Data Mining Techniques for the Quality Control of Scientific Data	€60,121
Fast Ro-Pax Ferries	€55,000
<b>TOTAL GRANT-AID</b>	<b>€696,463</b>

# Desk Studies

## Identification and Evaluation of Appropriate Marine S&T Performance Indicators

**Grant-Aid Approved:** €65,000  
**Grantee:** Oikos Environment Resources, France  
**Status:** Completed (2003)

Science, technology, innovation and human capital have an increasingly important and complex role to play in the knowledge-based economy. To understand the role of science and technology and to assist in designing and assessing existing and new development policies and strategies, appropriate indicators—so-called Science & Technology (S&T) indicators—are required. This study was designed to provide the Marine Institute with an array of appropriate and usable marine S&T performance indicators, to facilitate in monitoring and assessing the effectiveness of increased Marine RTDI investment under the National Development Plan 2000-2006 and future RTDI programmes. It included a general presentation of S & T indicators; an identification of S & T indicators used in marine research evaluation; a synthesis of existing S&T indicators used for assessing and monitoring marine S & T performances; and recommendations for the use of S & T indicators by the Marine Institute.

*The report identified suitable S&T Indicators, which will allow the Marine Institute to:*

- *Assess its activities and bring to the fore the impacts of the work of the Institute to Government;*
- *Assess the national marine programme and national marine research activity; and*
- *Compare Irish marine research to other countries' marine research in a benchmarking perspective.*

## Marine RTDI (Research, Technology, Development and Innovation) Foresight Review

**Grant-Aid Approved:** €17,000  
**Grantee:** CIRCA Group, Ireland  
**Status:** Completed (2003)

Foresight is a systematic process for identifying future market opportunities (e.g. marine biotechnology) and emerging strategic issues (e.g. global climate change) and the scientific and technological priorities necessary to underpin and address them. Thus, foresight initiatives provide a strategic direction for state investment in science, technology and innovation.

As part of an on-going strategic marine RTDI assessment, this desk study was initiated in order to identify key recent Marine Foresight Studies undertaken worldwide; provide a comparative review and analysis of the conclusions and recommendations of those studies; and identify key sectors (niche areas) and strategic RTDI issues that need to be addressed in Ireland over the coming years.

*The outcomes and recommendations of this study fed into the foresight process, undertaken in 2005, that led to the framing of 'Sea Change: A National Marine Knowledge, Research & Innovation Strategy for Ireland 2007-2013'. This Strategy will build on the progress made during the period of the current NDP and ensure that Ireland fully maximizes the economic, social and environmental contribution of its marine resources.*

# Desk Studies

## Disposal and Re-utilisation of Fish and Fish Processing Waste (including Aquaculture Wastes)<sup>3</sup>

**Grant-Aid Approved:** €26,185  
**Grantee:** Nautilus Consultants (Ireland) Ltd.  
**Status:** Completed (2003)

In accordance with modern waste management practice, there is an increasing demand to move from disposal of fish/aquaculture waste in landfill sites, towards a more proactive 'reduce, reuse and recycle' approach. Current problems relating to waste management are compounded by the lack of available data on the waste quantities, seasonality of waste production and the likely future trends.

This desk study compiled statistics on current and projected fish/aquaculture waste; reviewed fish/aquaculture waste management options; and evaluated new developments in waste minimisation and the application of reuse/recycling options, especially the use of new technologies (e.g biotechnology), to extract valuable products from fish and shellfish waste.

*The data and information presented by this study provide a sound basis for the development of future national, regional and local fish waste disposal and re-use plans. Recommendations include the need for:*

- Clear guidelines on the relevant legislation;
- Technical and financial assistance to undertake waste audits and establish waste treatment facilities;
- Waste management guidelines (including disposal of high risk waste) for the aquaculture industry; and
- Research into the use of waste in the production of novel by-products.

## A Review of the Origins and Appropriateness of the Current Fish Stock Assessment and Management Areas for the Waters around Ireland

**Grant-Aid Approved:** €52,539  
**Grantee:** Marine Resources Assessment Group, London  
**Status:** Completed (2003)

Fisheries science plays a key role in the formulation of management advice to the EU on the annual TACs (Total Allowable Catches), the main management instrument for commercially exploited fish stocks in the waters around Ireland. Annual stock assessments are carried out at ICES (International Council for the Exploration of the Seas) and form the basis of the scientific advice to the EU. ICES define various 'boxes' (ICES Divisions) in EU waters, established at the start of the last century, to facilitate stock definition and the assessment process. Annual stock assessments are carried out on set 'assessment areas'. TACs are applied to set 'management areas'. These assessment areas and management areas are often very different and generally comprise different combinations of ICES Divisions. This desk study examined the origins and appropriateness of the ICES divisions and the assessment and management areas for the major commercially exploited fish stocks in the waters around Ireland in the context of the review of the Common Fisheries Policy.

*This desk study provided a valuable input to the ongoing debate on the appropriateness of the traditional ICES assessment areas and EU management areas and the revision of these areas.*

<sup>3</sup> PFEIFFER, N. (2003) DISPOSAL AND RE-UTILISATION OF FISH AND FISH PROCESSING WASTE (INCLUDING AQUACULTURE WASTES). NDP MARINE RTDI DESK STUDY SERIES DK/01/003.



# Desk Studies

## The Use of Recovery Plans to Rebuild Depleted Fish Stocks – A Review

**Grant-Aid Approved:** €47,622  
**Grantee:** Marine Resources Assessment Group, London  
**Status:** Completed (2003)

There are serious concerns about the state of many EU fish stocks. Many stocks are at low biomass levels, have had a series of low recruitments in recent years and are subject to high fishing mortality. Recovery plans to rebuild depleted stocks are now an integral part of EU fisheries management. Recovery plans are 'special measures' designed to reduce fishing pressure on the stock. They are generally initiated by a substantial reduction in TAC (Total Allowable Catch), followed by special 'emergency measures', e.g. 'closed areas' to protect spawning adult fish or measures to protect juvenile fish in nursery areas. Increased mesh sizes and the use of escape panels in trawl nets are used to reduce the catch of small fish. Recovery plans rely on close co-operation between fisheries scientists, managers and the industry in those countries exploiting the stocks concerned. There are three recovery plans operating in the waters around Ireland - Irish Sea cod, south west of Ireland hake and West of Scotland cod.

*This desk study provided a review of the methods used and an assessment of the success of various fish stock recovery plans; identified the most successful recovery strategies achieved to date; and designed a general template for Recovery Plans that could be adapted to assist recovery and sustainable exploitation of fish stocks in the future. The outcomes of this study have generated considerable international interest and led to a keynote presentation at the ICES Annual Science Conference in 2003. They will help guide the formulation of future recovery plans for fish stocks in the waters around Ireland.*

## Review and Evaluation of Marine Environmental State/Impact Indicators and their Application in Ireland<sup>4</sup>

**Grant-Aid Approved:** €47,213  
**Grantee:** Rick Boelens, Marine Environmental Consultant  
**Status:** Completed (2003)

Environmental impact/change indicators are increasingly used as tools for assessing the quality of the marine environment. They are broadly defined as any measurable feature or condition of the environment and are used to illustrate human environmental impact at global (e.g. the Human Ecological Footprint), regional and local scales. At the regional/local level they may be useful in detecting and quantifying deteriorating environmental quality so that appropriate action to halt or reverse the trend may be taken. Alternatively, they can be used for tracking the effect of a response to an environmental quality issue/impact.

*This desk study provided a comprehensive review of marine environmental indicators and their application, both nationally and internationally, in the assessment and monitoring of environmental impact/change; identified a suite of 19 key marine environmental indicators that should be used for the measurement and monitoring of environmental change in an Irish context; and identified related issues, e.g. data availability and requirements, methodology, quality assurance, etc. In doing so, the review considered current and future international requirements and developments of relevance to Ireland (e.g. OSPAR Convention, EU Water Framework Directive). Finally, the review considered the need to aggregate and integrate indicators to provide indices of environmental conditions for the purposes of management and modelling.*

*The outcomes of this study are of benefit to the newly established Marine Monitoring Forum in implementing a National Environmental Monitoring Programme for Coastal, Transitional and Marine Waters.*

<sup>4</sup> BOELENIS, R., GRAY, J. AND PARSONS, A. (2004) REVIEW AND EVALUATION OF MARINE ENVIRONMENTAL IMPACT INDICATORS AND THEIR APPLICATION IN IRELAND. NDCF MARINE RTDI DESK STUDY: SERIES DK/01/006.

# Desk Studies

## Feasibility Study on the Establishment of a Large Scale Inshore Resource Mapping Project<sup>5</sup>

**Grant-Aid Approved:** €89,453  
**Grantee:** Waterborne Geophysics Ireland Ltd.  
**Status:** Completed (2003)

The sustainable development of the inshore (0-50m depth) marine resource requires information on bathymetry, currents and living and non-living resources. Although a number of thematic and site specific marine resource mapping programmes have been undertaken, there has been no concerted programme to map Irish inshore resources. There is general agreement that a comprehensive inshore resource map/database would provide an invaluable tool for resource evaluation and sustainable development of the varied and, in some cases, competing resource uses in the inshore zone for example offshore wind farms, fishing and aggregate extraction.

This desk study was commissioned to identify inshore mapping requirements - based on legislative and stakeholder requirements; evaluate mapping techniques and 'best practice'; and recommend a prioritised and costed inshore mapping strategy for Irish coastal waters. As part of the study, a comprehensive consultation process was conducted in an effort to determine the current and future mapping requirements of stakeholders.

*The final report from this study recommended priority areas and bays for mapping and this fed into the development of a National Inshore Mapping Strategy. This strategy has been approved by Government and INFOMAR, a multiyear programme that will concentrate on mapping of priority bays and areas around Ireland, commenced in 2006.*

## Strategic Review of the Feasibility of Seaweed Aquaculture<sup>6</sup>

**Grant-Aid Approved:** €39,797  
**Grantee:** Irish Seaweed Centre, Martin Ryan Institute  
**Status:** Completed (2003)

The National Seaweed Forum, established by the Minister for the Marine and Natural Resources in October 1999, identified the Irish Seaweed Sector as being worth circa €8.8 million per annum to the economy, and providing employment to some 700 people on a full- or part-time basis. However, given the changing age-profile of seaweed gatherers, and the opportunities that exist for the production of seaweed for human consumption and other uses such as in the fast-growing biotechnology sector; aquaculture may provide the most cost-effective method of seaweed production in the years ahead.

This desk study examined the seaweed aquaculture experience in other countries and the opportunities that exist in Ireland for the development of a commercially viable seaweed aquaculture industry.

*The work carried out has led to the formulation of an outline strategy for the development of a national seaweed aquaculture programme over a ten-year period. The realisation of this programme is divided into three phases. The main objectives are to establish commercial seaweed aquaculture operations, to advance product development in different industrial sectors and to improve marketing structures. Some of the key areas for future R&D projects highlighted by the study include cultivation methods, research in bioactive substances and applications, and research in biomedicine and biotechnology.*

<sup>5</sup> PARSONS, A., BARTON, K., BROWN, C., BERRY, A., CURTIS, A., EMBLOW, E., HARTNETT, M., NASH, S. AND ROONEY, S. (2004) FEASIBILITY STUDY ON THE ESTABLISHMENT OF A LARGE SCALE INSHORE RESOURCE MAPPING PROJECT. NDP MARINE RTDI DESK STUDY SERIES DK/01/003.

<sup>6</sup> WERNER, A., CLARKE, D. AND KRAAN, S. (2004) STRATEGIC REVIEW OF THE FEASIBILITY OF SEAWEED AQUACULTURE IN IRELAND. NDP MARINE RTDI DESK STUDY SERIES DK/01/008.

# Desk Studies

## Study to Assess the Feasibility, Potential Use and Methodology for Establishing a National Marine Leisure Infrastructure Database to Support Planning and Development in the Sector

**Grant-Aid Approved:** €54,622  
**Grantee:** Hydraulics & Maritime Research Centre, UCC  
**Status:** Completed (2003)

Considerable investment has taken place in the past decade to upgrade and develop Ireland's marine access infrastructure, which includes over 1,000 piers/slipways and harbours. Much of this investment has been on improving the standard of access; better shelter; reduced tidal restriction and safety. However, the lack of detailed information on this infrastructure was seen as a constraint in evaluating our national marine resource and framing a coherent strategy for the development of marine tourism. The availability of a national database of marine leisure infrastructure as a planning and information tool would greatly facilitate the decision-making and prioritisation process at national and county level.

*This study reviewed the existing information base on coastal marine leisure infrastructure and assessed the feasibility, and potential use, of a national marine leisure infrastructure database. It concluded that such a database was feasible, both technically and operationally, and would generate widespread support from key stakeholders: local authorities, industry and recreational users. A methodology and Terms of Reference for the development of a National Marine Leisure Infrastructure Database was proposed.*

A prototype coastal infrastructure database was subsequently developed by the Marine Institute, in collaboration with the Department of Communications, Marine and Natural Resources; the Department of Community, Rural and Gaeltacht Affairs; and Galway, Mayo and Donegal County Councils.

## Development of Guidelines for the Integration of Marine Recreational Activities in the Rejuvenation/Regeneration of Small Harbours and Ports<sup>7</sup>

**Grant-Aid Approved:** €48,436  
**Grantee:** Brady Shipman Martin  
**Status:** Completed (2003)

The decline in some of the traditional uses and activities in small ports and harbours (SPHs) means that infrastructural and land/water resources in SPHs may be under-utilised. There is a clear need to find new and alternative uses for redundant infrastructure/assets. Coinciding with this is the growth in the leisure market, particularly in the demand for all forms of marine recreational activity, including activities that require facilities and services in SPHs. Small ports and harbours are a critical infrastructure to facilitate this leisure activity.

This study was aimed primarily at potential local initiators and facilitators operating in coastal areas and provided a review and evaluation of the issues, opportunities and obstacles surrounding the integration of marine leisure infrastructure and activities during regeneration/rejuvenation of small harbours and ports.

*The study provided a valuable resource document and recommends a number of actions to address constraints to the regeneration of ports and harbours in the context of marine recreation. These include the framing of a national policy on the development of marine recreation in SPHs; raising awareness of the opportunities; and providing funding for the initial feasibility and technical investigations and the implementation stage.*

<sup>7</sup> MARTIN, A. (2004) MARINE RECREATION AND THE PROCESS OF REJUVENATION OF SMALL PORTS AND HARBOURS. NDP MARINE RTDI DESK STUDY SERIES DK/01/010.

# Desk Studies

## Irish Short Sea Shipping Inter-European Trade Corridors<sup>8</sup>

**Grant-Aid Approved:** €45,000  
**Grantee:** Logistecon Economic Consultants  
**Status:** Completed (2004)

Over 99% by volume, of Ireland's imports and exports are transported by sea. The value of this has been growing rapidly over the past decade. The competitiveness of Ireland's transport linkages with the rest of the world, and in particular the rest of the EU, have a considerable bearing on the overall competitive performance of the economy. The enlargement of the EU, recent policy objectives of the European Commission to divert freight transport from roads to other modes, and the introduction of road charging in the UK and mainland Europe have the potential to impact on the decisions of freight forwarders in choosing routes and modes of transport to and from Ireland.

This study was commissioned by the Irish Maritime Development Office (IMDO) to examine the potential for new sea routes into and out of Ireland, with an emphasis on 12 economies in the North European and Baltic region. It analysed the structure of freight flows to and from Ireland; provided projections of changes in Ireland's trade with other countries in the study area; examined the determinants and cost variables of this structure; and provided indications of the potential response of the sector to changes in the policy and economic environment.

*The study concluded that there is an opportunity for new short sea routes if road charges are introduced widely but that national policy must promote change through providing information and research on new opportunities as they emerge; directly promote new routes through subsidies; and ensure that Irish ports are able to handle any new traffic.*

## Platforms for Marine Monitoring

**Grant-Aid Approved:** €48,475  
**Grantee:** Mobile & Marine Robotics Research Group, University of Limerick  
**Status:** Completion 2006

As Ireland's exploration, monitoring and development activities in coastal and offshore areas continue to grow, so will the need for capability in automated and underwater intervention. Robots and semi-robotic platforms, e.g. Autonomous Underwater Vehicles, Remotely Operated Vehicles and Surface Unmanned Vehicles, can be deployed for a wide range of activities in the ocean. In an Irish context, there are, and will continue to be, growing requirements to access and service on-going operation of weather buoy networks (and their extension to include coastal buoys), surface and underwater oceanographic equipment infrastructure, and future Seabed Observatories. There are also expected to be growing opportunities to develop commercial niche products and services in this technology area.

This desk study, which is due for completion in 2006, will:

- Review the current status of marine platform technology;
- Evaluate projected requirements in Ireland;
- Assess current and potential research and industrial capabilities in Ireland, in respect of such platforms; and
- Scope the potential to develop niche industrial capabilities in these technologies.

<sup>8</sup> LOGISTECON, (2004). IRISH SHORT SEA SHIPPING INTER-EUROPEAN TRADE CORRIDORS (ABRIDGED REPORT). NDP MARINE RTDI DESK STUDY SERIES DK/03/001.



# Desk Studies

## The Use of Data Mining Techniques for the Quality Control of Scientific Data

**Grant-Aid Approved:** €60,121  
**Grantee:** Coastal & Marine Resources Centre, UCC  
**Status:** Completion 2006

With the adoption of the so-called 'ecosystem approach' to marine resource management, suitable data models for integrated management of disparate data holdings (e.g. chemical, fisheries and oceanographic data) are required. In 2004, the Marine Institute carried out an assessment exercise on the design of a suitable data model. The Marine Data Model, developed over recent years by ESRI in collaboration with the marine community, was selected as a suitable platform and work has progressed in developing this. The first phase of work is focused on the management of physical oceanographic and chemical data, and development of semi-automated data loading tools and a web-GIS query interface. The datasets that feed into the marine data model can be very large and of varying quality. The application of data quality control to these datasets is currently a manual or semi-automated process involving a high degree of manual intervention. However, there is scope for the application of data mining techniques in the development of automated data quality control processes.

Data mining involves training a system to automatically flag data that is of questionable quality; identify relationships or trends in data sets; identify what is of interest and useful for further processing; and identify a processing path for the data. Some datasets are processed differently depending on the depth or operating area at which the data was acquired; for example CTD data.

This project will provide the MI with the information required to make an informed choice relating to the use of new technologies to assist in the ongoing delivery of high quality scientific data. It is due for completion during 2006.

## Fast Ro-Pax Ferries

**Grant-Aid Approved:** €55,000  
**Grantee:** Nautical Enterprise Centre Ltd., Cork  
**Status:** Completion 2006

Short sea shipping links are vital to the Irish Economy. In 2004, goods to the value of €120 billion, 99% (by volume) of all imports and exports, were shipped through Irish ports. As a result of increasing trade, demand for fast ships is increasing and vessel design is changing to provide faster, more efficient services. Fast Ro-Pax ferries combine the cargo capacity of RoRo vessels with the passenger amenities of modern ferries, making them versatile and well suited to coping with the annual peaks and troughs pattern on many passenger routes.

Ireland has no high-speed ro-pax connections with continental Europe. The only current ferry links to the Continent are in traditional ferry roll-on/roll-off services to France. This study was initiated to examine the structure of Irish trade flows and how these could be altered and/or improved by the provision of a direct super-fast ro-pax service linking Ireland and continental Europe. It will identify suitable vessels and potential routes and produce a detailed cost and business model for developing and operating such a vessel.



# Micro Innovation Awards

## Development of 3D Numerical Well Test Software

**Grant-Aid Approved:** €7,000  
**Grantee:** Kepler Engineering Software, Ltd.  
**Duration:** 2005 (4 Months)

Kepler Engineering Software Limited develops state-of-the-art finite element simulation software, which is used worldwide by the oil and gas industry. Panmesh software has generated €1.5 million in sales to China, South America and the Middle East. It is the only fully numerical well test package on the market and this work aims to significantly add to the power and utility of the software by incorporating accurate flow calculations as well as allowing the user to clearly see and understand flow patterns. This work has been initiated following demand from clients for the software in a variety of markets.

"This represents only a small percentage of the possible market. Future revenue will come from maintenance work and will help the company to grow market share and develop other products in the petroleum industry."

**Dr. Jim Robinson**  
(Kepler Engineering Software Limited)

## Research Study on Self-Adjusting Mooring Systems

**Grant-Aid Approved:** €7,000  
**Grantee:** Prolines Marina Ltd.  
**Duration:** 2005 (5 Months)

Prolines Marina Limited is based in Waterford. This research study aimed to devise an innovative solution to the problem of berthing in marinas at tidally affected ports. The company was formed to develop a self-adjusting mooring system that would allow for 'stern-to' berthing in tidally affected areas. They developed a working model that establishes the invention as a viable product that could provide an alternative to the more space-intensive traditional mooring methods.

"We gave the prototype a full sea test in a variety of environmental conditions and the results show conclusively that the device worked."

**Charlie Boland**  
(Prolines Marina Ltd.)

# Networking & Technology Transfer

The Marine RTDI Networking and Technology Transfer Scheme is designed as a flexible grant-aid scheme to support 'bottom-up', competitive and innovative networking, mobility and technology transfer initiatives. The primary aim of the awards is to support, enhance and consolidate the performance of the Irish marine sector by providing grant-aid support for networking activity. Facilitating participation in national and international conferences by the Irish marine research community is an important part of building our profile in international marine R&D projects and improving the ability of the Irish marine community to secure competitive international research funds.

Support is available under three categories:

- A. Attendance at workshops/conferences (to a maximum of €500);
- B. Travel/mobility (to a maximum of €5,000); and
- C. Other Networking (to a maximum of €500).

## Networking and Technology Transfer Awards 2000-2005

Category	Number	Grant-Aid (€)
Workshops/Conferences	24	€68,970
Travel/Mobility	51	€29,243
Other	14	€28,633
<b>Total</b>	<b>89</b>	<b>€126,846</b>

### Case Study

**Conference on Offshore Technology**  
Attendance at this conference in Houston, Texas in 2004 by the company Nowcasting International, based in Kilrush, Co.Clare was part of their plans to develop a 3D Ocean Modelling initiative in partnership with the Danish Hydraulic Institute and the University of Colorado. Their project requires building a network of strong contacts in the US oil and gas sector to secure real time ADCP data for model initialisation. This technology transfer from academia in the US to a private sector company in Ireland will be a major boost to RTDI capacity in-company and ultimately benefit marine industry and exports.

### Case Study

**Conference on Biofilms in Industry, Medicine and Environmental Biotechnology**  
This international conference in NUI Galway in August 2003 aimed to develop understanding, control and exploitation of biofilms in an interdisciplinary setting. The damage and cost associated with biofilm-induced corrosion in industrial and marine systems represents a large economic burden to European industry. This conference, hosted by the Microbiology Department in NUIG, was an important step in disseminating research aimed at controlling this phenomenon.

### Case Study

**3rd International Symposium on Deep Sea Corals**  
The 3rd International Symposium on Deep Sea Corals was the follow up to two successful conferences in Halifax, Canada (2000) and Erlangen, Germany (2003). Approximately, 250 deep-sea coral researchers from 30 countries attended, contributing 102 oral presentations over a week in Miami, Florida in 2005. Topics included deep-water corals as climate recorder and the mainly unknown biology of deep-water corals and management and conservation of deep-water habitats. Dr. Boris Dorschel, of the Geology Department of UCC, presented a paper on his work on deep-sea corals in Irish waters. According to Dr. Dorschel "This conference was attended by 90% of the experts in my field of research and provided me with a valuable opportunity to communicate my own research to the community of deep-water habitat researchers."

## Appendix I: Evaluation Experts

The aim of the Evaluation Process is to (a) ensure an open, fair and transparent assessment of competitive project proposals submitted in response to a published call for proposals and (b) to provide constructive feedback to project proposers.

Details of the evaluation procedures relating to individual programmes and initiatives are included in the Guidelines for Applicants. Each project proposal received is evaluated according to set criteria by an Evaluation Panel consisting of at least two independent external experts and one Marine Institute expert. All project proposals receive a written evaluation and 130 experts, external to MI, have been involved to date:

Evaluator	Institute/Company	Country
Dr. Suleiman Abu Sharkh	University of Southampton	England
Ms. Helena Acheson	Forfas	Ireland
Dr. Wayne Anderson	Food Safety Authority Ireland	Ireland
Dr. Michael Armstrong	CEFAS	England
Prof. Nigel Barltrop	Universities of Glasgow & Strathclyde	Scotland
Dr. Franck Berthe	Food Safety Authority Ireland	France
Mr. Egon Bjerregaard	RISØ National Laboratory	Denmark
Dr. Pierre Boudry	IFERMER	France
Dr. Patrick Boylan	The Loughs Agency	Northern Ireland
Mr. Edward Branson	Edward Branson Ltd	England
Mr. Graham Brennan	Sustainable Energy Ireland	Ireland
Mr. Christopher Bronsdon	Scottish Energy Environment Foundation	Scotland
Dr. Stephen Brown	National Oceanic & Atmospheric Administration	USA
Dr. Colin Browne	NUI, Galway	Ireland
Dr. James Buchanan	British Marine FinFish Association	Scotland
Dr. Grant Burgess	Heriot-Watt University, Edinburgh	Scotland
Mr. Ray Burke	Raymond Burke Consulting	Ireland
Prof. Issy Caffoor	Yorkshire Water	England
Dr. J.E.T. Channell	University of Florida	USA
Dr. Alan Chave	Woods Hole Oceanographic Institute	USA
Dr. Ed Chin	University of Georgia	USA
Dr. Malcolm Clark	National Institute of Water & Atmospheric Research	New Zealand
Dr. Roger Coggan	CEFAS	England
Dr. John Collier	Research & Enterprise Development Consultant	Ireland
Dr. Kieran Comerford	Comerford Technology Management Ltd	Ireland
Mr. David Connor	JNCC	England
Mr. Bill Cooper	APB Marine Environmental Research	England
Dr. Chris Cooper	University of Essex	England
Dr. Michael Crosby	National Oceanic & Atmospheric Administration	USA
Dr. Y. Ming Dai	University of Plymouth	England
Ms. Carmel Daly	Enterprise Ireland	Ireland

# Appendix I: Evaluation Experts

Evaluator	Institute/Company	Country
Dr. Anna K Danielsdottir	Technological Institute of Iceland	Iceland
Dr. Simon Davies	University of Plymouth	England
Dr. Yann-Hervé De Roeck	IFERMER	France
Dr. Rhona Dempsey	Forfás	Ireland
Mr. Brendan Dollard	Enterprise Ireland	Ireland
Mr. Kevin Donnelly	Enterprise Ireland	Ireland
Mr. Eamonn Doyle	ESRI Limited	Ireland
Dr. Brad Evans	James Cook University	Australia
Dr. Stephen Feist	CEFAS	England
Dr. Andrew Ferguson	Queens University Belfast	Northern Ireland
Dr. Liam Fernand	CEFAS	England
Dr. M.L. Fernandez	Centro Technological del Mar	Spain
Dr. Richard Fitzgerald	Shorescape Ltd.	Ireland
Mr. Tony Forde	CIRCA Group	Ireland
Dr. Jan Helge Fossa	Institute of Marine Research	Norway
Dr. Stein Fredriksen	University of Oslo	Norway
Dr. Andre Freiwald	University of Erlangen-Nuremburg	Germany
Prof. Christopher Frid	University of Newcastle	England
Mr. Peter Ganderton	University of Plymouth	England
Dr. Kevin Gaughan	Dublin Institute of Technology	Ireland
Prof. Gunter Gauglitz	Tubingen University	Germany
Ms. Gillian Glegg	University of Plymouth	England
Miss Lissa Goodwin	University of Plymouth	England
Dr. John Gordon	Scottish Association for Marine Science	Scotland
Dr. Ronan Gormley	Teagasc	Ireland
Dr. Paddy Gargan	Cental Fisheries Board	Ireland
Ms. Sigrídur Guðmundsdóttir	University of Iceland	Iceland
Mr. Kevin Hannigan	Economic Consultant	Ireland
Dr. Mike Hartnett	National University of Ireland, Galway	Ireland
Dr. A. Rus Hoelzel	Durham University	England
Dr. Manfred Höfle	GBF National Centre for Biotechnology, Braunschweig	Germany
Dr. Kevin Horsburgh	Proudman Oceanographic Laboratory	England
Prof. Tor Horsberg	Norwegian School of Veterinary Science	Norway
Dr. William Jordan	Institute of Zoology	England
Dr. Michel J Kaiser	University of Bangor	Wales
Mr. Gerard Keane	Keane Offshore Integrity Ltd	Ireland
Dr. Maeve Kelly	Scottish Association for Marine Science	Scotland
Dr. Ellen Kenchington	Bedford Institute of Oceanography	Canada
Dr. Dan Laffoley	English Nature	England
Dr. Ian Laing	CEFAS	England

## Appendix I: Evaluation Experts

Evaluator	Institute/Company	Country
Mr. Eugene Lavelle	Marine Technology Ltd	Ireland
Dr. Samantha Lavender	University of Plymouth	England
Dr. Paul Leonard	Defra	England
Dr. Carole Lewellyn	Plymouth Marine Laboratory	England
Dr. Jane Lewis	University of Westminster	England
Mr. Martin Lyes	Enterprise Ireland	Ireland
Mr. Joe Madden	PEI Technologies	Ireland
Mr. Donal Maguire	Bord Iascaigh Mhara	Ireland
Dr. Vlastimil Masek	University of Newfoundland	Canada
Dr. Patricia McAleron	Techlink UK- Ireland	England
Prof. Brian McCraith	NCSR, Dublin City University	Ireland
Mr. Ronald McHugh	Heriot-Watt University	Scotland
Prof. Sean Mc Namara	Dept. of Mechanical Engineering, NUI, Galway	Ireland
Dr. Gerrit Meinecke	University of Bremen	Germany
Mr. Alex Midlen	Colchester Borough Council	England
Mr. Keiran Millard	HR Wallingford	England
Dr. David Montagnes	University of Liverpool	England
Dr. Karl Moore	Independent Consultant	Ireland
Dr. Maire Mulcahy	University College Cork	Ireland
Mr. Michael Murphy	Irish Rail	Ireland
Dr. Carter Newell	Great Eastern Mussel Farms	USA
Dr. David Newman	National Cancer Institute, USA	USA
Mr. John Nicols	Independent Consultant	England
Mr. Mark Norman	Taighde Mara Teoranta	Ireland
Dr. Brendan O'Connor	Aqua-Fact International Services	Ireland
Mr. Ciaran O'Driscoll	Dublin Institute of Technology	Ireland
Dr. Erik Olsen	Institute of Marine Research	Norway
Mr. Nick O'Neill	CSA Group Ltd.	Ireland
Mr. John O'Sullivan	Providence Resources PLC	Ireland
Mr. Michael O'Sullivan	Marine Computation Services Ltd	Ireland
Dr. Antonio Pascoal	Instituto Superior Tecnico	Portugal
Dr. John H. Paul	University of South Florida	USA
Mr. Paul Phelan	Independent Consultant	Ireland
Dr. Paulo Prodohl	Queen's University Belfast	Northern Ireland
Dr. David Pugh	Southampton Oceanography Centre	England
Dr. David Reddin	Dept. of Fisheries & Oceans	Canada
Dr. Chris Reid	SAHFOS	England
Dr. Dave Reid	FRS Marine Laboratory	Scotland
Dr. Vincent Rigaud	IFERMER	France
Dr. Jean Robin	IFERMER	France



## Appendix I: Evaluation Experts

Evaluator	Institute/Company	Country
Prof. Michael Roe	University of Plymouth	England
Dr. Paul Ross	Teagasc	Ireland
Donal O'Connor	Cruickshank Ltd.	Ireland
Mr. James Ryan	Killary Salmon	Ireland
Dr. Jim Ryan	Circa Group	Ireland
Prof. Stephen Salter	University of Edinburgh	Scotland
Dr. Richard Santer	Universite du Littoral	France
Dr. F.A. Schmidt	Maritime & Supply Chain Solutions Ltd	England
Prof. Ray Seed	School of Ocean Science, UCNW	Wales
Dr. Kevin Sellner	Chesapeake Research Consortium	USA
Dr. Michael Shaw	Kirk McClure Morton	Northern Ireland
Mr. John Slater	Letterkenny Institute of Technology	Ireland
Dr. Jamie Taylor	University of Edinburgh	Scotland
Dr. Ole J. Torrisen	Institute of Marine Research	Norway
Dr. Peter Tyndall	BIM	Ireland
Dr. Koen Verbruggen	Geological Survey of Ireland	Ireland
Mr. John Walker	Fujitsu	Ireland
Dr. Randal Walker	University of Georgia	USA
Dr. Gary Waterworth	Alcatel	England

## Appendix II: Publications

### Peer-reviewed publications arising from NDP Marine RTDI-funded research projects:

#### Fisheries

Borges, L., Rogan, E. & Officer, R. (2005). Discarding by the demersal fishery in the waters around Ireland. *Fisheries Research*, **76**(1): 1-13.

Borges, L., Zuur, A.F., Rogan, E. & Officer, R. (2004). Optimum sampling levels in discard sampling programs. *Can. J. Fish. Aquat. Sci.*, **61**(10): 1918-1928.

Borges, L., Zuur, A.F., Rogan, E. & Officer, R. (2005). Choosing the best sampling unit and auxiliary variable for discards estimations. *Fisheries Research*, **75**(1-3): 29-39.

Borges, L., Zuur, A.F., Rogan, E. & Officer, R. (2006). Modelling discard ogives from Irish demersal fisheries. *ICES J. Mar. Sci.*, **63**: 1086-1095.

Caddy, J.F. & Agnew, D.J. (2004). An overview of recent global experience with recovery plans for depleted marine resources and suggested guidelines for recovery planning. *Reviews in Fish Biology and Fisheries*, **14**(1): 43-112.

Kelly, C.J. & Codling, E.A. (2006). 'Cheap and Dirty' Fisheries Science and Management in the North Atlantic. *Fisheries Research*, **79**: 233-238.

Kelly, C.J., Codling, E.A. & Rogan, E. (2006). The Irish Sea cod recovery plan: some lessons learned. *ICES Journal of Marine Science*, **63**: 600-610.

Lannin, A., Rogan, E. & Connolly, P. (In Press). Reproductive bet-hedging strategy in European hake (*Merluccius merluccius*) in the waters around Ireland enables maximum viable egg production. *J. Fish Biol.*

Power, G.R., King, P.A., Kelly, C.A., McGrath, D., Mullins, E. & Gullaksen, O. (2006). Precision and bias in the age determination of blue whiting, *Macromesistius poutassou* (Risso, 1810), within and between age-readers. *Fisheries Research*, **80**: 312-321.

Shephard, S., & Rogan, E. (2006). Seasonal distribution of orange roughy (*Hoplostethus atlanticus*) on the Porcupine Bank west of Ireland. *Fisheries Research*, **77**: 17-23.

Shephard, S., Connolly, P. & Hareide, N-R. (In Press). Establishing stakeholder connections for fisheries co-management – the example of the Irish orange roughy (*Hoplostethus atlanticus*) fishery. *ICES J. Mar. Sci.*

Shephard, S. & Rogan, E. (In Press). Age and growth of orange roughy (*Hoplostethus atlanticus*) from Irish waters. *Fisheries Research*.

#### Shellfish

Knights, A.M., Crowe, T.P. & Burnell G. (In Press). Mechanisms of larval transport: vertical distribution of bivalve larvae varies with tidal state. *Mar. Ecol. Prog. Ser.*

Slater, J. (2005). Spawning of the scallop, *Pecten maximus* (L.) in Mulroy Bay and the relationship with spatfall intensity. *J. Shellfish Res.*, **24**(4): 951 - 958.

Slater, J. (2005). Morphological identification of larval king scallops, *Pecten maximus* (L.) from natural plankton samples. *J. Shellfish Res.*, **24**(4): 937 - 949.

#### Fish & Shellfish Health

Copley, L., O'Donohoe, P., McGrath, D. & Jackson, D. (2005). Sampling errors in examining salmon (*Salmo salar* L.) for sea lice (*Lepeophtheirus salmonis* (Krøyer) and *Caligus elongatus* Nordmann) burden: a comparison of methods. *Fish Veterinary Journal*, **8**: 32-44.

Copley, L., Tierney, T.D., Kane, F., Naughton, O., Kennedy, S., O'Donohoe, P., Jackson, D. & McGrath, D. (2005). Sea lice, *Lepeophtheirus salmonis* and *Caligus elongatus*, levels on salmon returning to the west coast of Ireland, 2003. *J. Mar. Biol. Ass. U.K.*, **85**(1): 87-92.

Copley, L., O'Donohoe, P., Kennedy, S., Tierney, D., Naughton, O., Kane, F., Jackson, D. & McGrath, D. (In Press). Sea lice infestation pressures on farmed Atlantic salmon smolts (*Salmo salar* Linnaeus) in the west of Ireland following a SLICE® (0.2% emamectin benzoate) treatment. *Fish Veterinary Journal*.

Drummond, L., Mulcahy, M. & Culloty, S. (2006). The reproductive biology of the Manila clam, *Ruditapes philippinarum*, from the North-West of Ireland. *Aquaculture*, **254**(1-4): 326-340.

Sevatdal, S., Copley, L., Wallace, C., Jackson, D. & Horsberg, T.E. (2005). Monitoring of the sensitivity of sea lice (*Lepeophtheirus salmonis*) to pyrethroids in Norway, Ireland and Scotland using bioassays and probit modeling. *Aquaculture*, **244**(1-4): 19-27.

# Appendix II: Publications

## Marine RTDI Projects 2000-2005

### Climate Change

Davenport, D. & Davenport, J.L. (2005). Effects of shore height, wave exposure and geographical distance on thermal niche width of intertidal fauna. *Mar. Ecol. Prog. Ser.*, **292**: 41-50.

Davenport, J., Berggren, M.S., Brattegard, T., Brattenborg, N., Burrows, M., Jenkins, S., McGrath, D., MacNamara, R., Snell, J.-A., Walker, G. & Wilson, S. (2005). Doses of darkness control latitudinal differences in breeding date in the barnacle *Semibalanus balanoides* (L.). *J. Mar. Biol. Ass. U.K.*, **85**: 59-63.

Power, A.M., Delany, J., McGrath, D., Myers, A.A. & O' Riordan, R.M. (2006). Patterns of adult abundance in *Chthamalus stellatus* (Poli) and *C. montagui* Southward (Crustacea: Cirripedia) emerge during late recruitment. *J. Exp. Mar. Biol. & Ecol.*, **332**: 151-165.

Simkanin, C., Power, A.M., Myers, A., McGrath, D., Southward, A.J., Mieszkowska, N., Leaper, R. & O' Riordan, R. (2005). Using historical data to detect temporal changes in the abundances of intertidal species on Irish shores. *J. Mar. Biol. Ass. U.K.*, **85**: 1329-1340.

Simkanin, C. (2004). The invasive seaweed *Sargassum muticum* (Yendo) Fensholt in Lough Hyne Marine Nature Reserve, Co. Cork. *Ir. Nat. J.*, **27**(12): 481-482.

### Biotoxins

Aune, T., Larsen, S., Aasen, J., Rehmann, N., Satake, M. & Hess, P. (In Press). Relative toxicity of dinophysistoxin-2 (DTX-2) compared with okadaic acid, based on acute intraperitoneal toxicity in mice. *Toxicon*.

Colman, J.R., Twiner, M.J., Hess, P., McMahon, T., Satake, M., Yasumoto, T., Doucette, G.J. & Ramsdell, J.S. (2005). Teratogenic effects of Azaspiracid-I identified by microinjection of Japanese medaka (*Oryzias latipes*) embryos. *Toxicon*, **45**: 881-890.

Hess, P., McCarron, P. & Quilliam, M.A. (In Press). Fit-for-purpose shellfish reference materials for phycotoxins in internal and external Quality Control. *Anal. & Bioanal. Chem.*

Hess, P., Nguyen, L., Aasen, J., Keogh, M., Kilcoyne, J., McCarron, P. & Aune, T. (2005). Tissue distribution, effects of cooking and parameters affecting the extraction of azaspiracids from mussels, *Mytilus edulis*, prior to analysis by liquid chromatography coupled to mass spectrometry. *Toxicon*, **46**: 62-71.

Kulagina, N.V., Twiner, M.J., Doucette, Hess, P., McMahon, T., Satake, M., Yasumoto, T., Ramsdell, J.S., Doucette, G.J., Ma, W. & O'Shaughnessy, T.J. (2006). Azaspiracid-I inhibits bioelectrical activity of spinal cord neuronal networks. *Toxicon*, **47**: 766-773.

McCarron, P. & Hess, P. (2006). Tissue distribution and effects of heat treatments on the content of domoic acid in blue mussels, *Mytilus edulis*. *Toxicon*, **47**: 473-479.

Twiner, M.J., Hess, P., Bottein Dechraoui, M.-Y., McMahon, T., Samsons, M.S., Satake, M., Yasumoto, T., Ramsdell, J.S. & Doucette, G.J. (2005). Cytotoxic and cytoskeletal effects of Azaspiracid-I on mammalian cell lines. *Toxicon*, **45**: 891-900.

Wilkins A.L., Rehmann N., Torgersen T., Rundberget T., Keogh M., Petersen D., Hess P., Rise F., Miles C.O. (2006). Identification of fatty acid esters of pectenotoxin-2 seco acid in blue mussels (*Mytilus edulis*) from Ireland. *J. Agric. Food Chem.*, **54**: 5672-5678.

### Marine Law

Long, R. and O'Hagan, A.M. (2006). Ocean and Coastal Governance The European Approach to Integrated Management: Are There Lessons for the China Seas Region? In: Nordquist, M.H., Moore, J.N. & Kuen-chen Fu (Eds.) *Recent Developments in the Law of the Sea and China*. Brill Academic Publications, pp. 85-142.

Long, R. (In Press) Marine Resource Law. Thomson Round Hall.

## Appendix III: Contact Details for Further Information

Strategic Projects			
Reference No.	Title	Contact Person	Email
ST/02/01	Biological Oceanography of Harmful Algal Blooms off West Coast of Ireland	Dr. Robin Raine	robin.raine@nuigalway.ie
ST/02/02	Isolation and Purification of Azapiracids (ASTOX)	Dr. Phillip Hess	phillip.hess@marine.ie
ST/02/03	Resource & Risk Assessment of Mussel Seed in the Irish Sea	Dr. Gavin Burnell	g.burnell@ucc.ie
ST/02/04	Assessment of Orange Roughy Stocks in Deep Waters using Acoustic Survey Techniques	Dr. Emer Rogan	e.rogan@ucc.ie
OE/04/001	Strategic Team in Ocean Energy & Related Technologies	Dr. Tony Lewis	hmrc@ucc.ie
AT/04/01/06	SMART Water Quality Monitoring System	Dr. Fiona Regan	fiona.regan@dcu.ie
AT/04/01/07	Demonstration of Miniaturised Multi-Channel Cytometry Unit	Dr. John Alderman	j.alderman@ucc.ie
AT/04/01/01	Monitoring System based on Optical Sensing & Respirometry	Dr. Dimitri Papkovsky	d.papkovsky@ucc.ie
AT/04/02/02	Nucleic Acids Tests for Toxigenic Phytoplankton Species	Dr. Majella Maher	majella.maher@nuigalway.ie
ST/05/01	Site Investigations & Disease Management of SPDV in Irish Farmed Salmon	Dr. Neil Ruane	neil.ruane@marine.ie
ST/05/02	Use of GSI Techniques to Determine the River of Origin of Irish Atlantic Salmon	Prof. Tom Cross	t.cross@ucc.ie
ST/05/03	Extension of the Marine Institute's Data Repository to include Biological Data	Valerie Cummins	v.cummins@ucc.ie
ST/05/04	Marine Biodiscovery "Proof-of-Concept"	Dr. Eoin Sweeney	eoin.sweeney@marine.ie
ST/05/07	Phlorotannins in Irish Brown Seaweeds	Dr. Dagmar Stengel	dagmar.stengel@nuigalway.ie
ST/05/08	Sea & Swell Spectra	Brian Holmes	hmrc@ucc.ie
ST/05/09	Cold-Water Carbonate Mound Development	Dr. Andy Wheeler	a.wheeler@ucc.ie
ST/05/10	Novel Vaccines for Control of Sealice	Dr. Grace Mulcahy	grace.mulcahy@ucd.ie
ST/05/11	Finding Aquatic Viral Epitopes for production of peptide based vaccines	Dr. Iain Shaw	iain.shaw@nuigalway.ie
ST/05/12	The Foraging Ecology of the Harbour Seal in Ireland	Michelle Cronin	michelle.cronin@ucc.ie
ST/05/17	Simulation & Forecasting System for Ecosystem Dynamics in Irish Waters	Dr. Martin White	martin.white@nuigalway.ie
ST/05/25	An Investigation into the ability of Pacific Oysters, Scallops & Abalone to act as Carriers of the Protozoan Bonamia	Dr. Sarah Culloty	s.culloty@ucc.ie

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Post-Doctoral Fellowships			
Reference No.	Title	Contact Person	Email
Michael Manahan Fellowship	The Law & Policy of Marine Resources in Ireland	Dr. Ronan Long	ronan.long@nuigalway.ie
PDOC/01/001	Modelling & Simulation of Fish Stock Dynamics	Dr. Emer Rogan	e.rogan@ucc.ie
PDOC/01/002	Sealice Biology & Interactions	Dr. Lorraine Copley	lorraine.copley@marine.ie
PDOC/01/003	Investigations into the Hatchery Rearing of Cod	Declan Clarke	declan.clarke@nuigalway.ie
PDOC/01/004	Investigations into a Reliable Supply of Scallop	Dr. Gavin Burnell	g.burnell@ucc.ie
PDOC/01/005	Iodine in Commercially used Irish Seaweeds	Dr. Peter Smyth	peter.smyth@ucd.ie
PDOC/01/006	Monitoring the Influence of Climate Change on the Marine Flora & Fauna using Intertidal Indicators	Dr. Anne-Marie Power	annemarie.power@nuigalway.ie
PDOC/01/007	An Integrated Bioscreening Approach for Identification of High Value-Added Biocatalysts	Dr. Maria Tuohy	maria.tuohy@nuigalway.ie
PDOC/03/001	Identification of Key Non-Technical Issues/Challenges for an Appropriate Framework for Biodiscovery Activities	Dr. Ronan Long	ronan.long@nuigalway.ie
PDOC/05/001	Advanced Technologies for Aquaculture	Dr. Dan Toal	daniel.toal@ul.ie
PDOC/05/002	Instrumentation Interface, Communication & Data Management Architecture Issues for Marine Sensor Systems	Prof. Dermot Diamond	dermot.diamond@dcu.ie
PDOC/05/006	Integrated Modelling using Real Time Data Assimilation	Dr. Martin White	martin.white@nuigalway.ie

PhD Scholarships			
Reference No.	Title	Contact Person	Email
PhD/01/001	The Biology, Dynamics & Fisheries for Hake in the Waters Around Ireland	Dr. Emer Rogan	e.rogan@ucc.ie
PhD/01/002	The Impact of Discarding on the Management Advice for Key Irish Fisheries	Dr. Emer Rogan	e.rogan@ucc.ie
PhD/01/003	The Larval Ecology of Fish Species in the Water around Ireland	Dr. James Dunne	james.dunne@nuigalway.ie
PhD/01/004	The Biology, Dynamics & Fisheries for Blue Whiting	Dr. Pauline King	Pauline.king@gmit.ie
PhD/01/005	Modelling of Alexandrium Dynamics in Cork Harbour	Dr. Robin Raine	Robin.raine@nuigalway.ie
PhD/01/006	Health & Disease in Clams in Ireland	Dr. Sarah Culloty	s.culloty@ucc.ie
PhD/IMDO/04	Irish Maritime Shipping Cluster-Maritime Economics	Prof. Michael Roe	mroe@plymouth.ac.uk
PhD/05/001	Stock Assessment in Large Riverine Catchments	Tiernan Henry	Tiernan.henry@nuigalway.ie
PhD/05/002	Assessing Ecosystem & Ocean Climate Change using CPR	Dr. Martin White	Martin.white@nuigalway.ie
PhD/05/004	Hydro Acoustics	Dr. Dan Toal	Daniel.toal@ul.ie
PhD/05/005	Benthic Mapping	Dr. Ian O'Connor	ian.oconnor@gmit.ie



## Appendix III: Contact Details for Further Information

Desk Studies			
Reference No.	Title	Contact Person	Email
DK/01/001	Identification & Evaluation of Appropriate Marine S&T Performance Indicators	Oikos Environmental Resources	oikos@oikos.ee
DK/01/002	Marine Foresight RTDI Review	Circa Group	info@circa.ie
DK/01/003	Disposal & Re-utilisation of Fish & Fish Processing Waste	Nautilus Consulting	mail@nautilus-consultants.co.uk
DK/01/004	Review of the Origins & Appropriateness of the Current Fish Stock Assessment for Irish Waters	MRAG Ltd.	enquiry@mrags.co.uk
DK/01/005	The Use of Recovery Plans to Rebuild Depleted Fish Stocks	MRAG Ltd.	enquiry@mrags.co.uk
DK/01/006	Review & Evaluation of Marine Environmental Indicators	Rick Boelens	rickboelens@eircom.net
DK/01/00	Feasibility Study on a Large Inshore Resource Mapping Project	Kevin Barton	info@gs.ie
DK/01/008	Strategic Review of the Feasibility of Seaweed Aquaculture	Dr. Stefan Kraan	stefan.kraan@seaweed.ie
DK/01/010	Scoping Study to Assess Potential Use & Methodology For Establishing a National Marine Leisure Infrastructure	Dr. Jimmy Murphy	hmrc@ucc.ie
DK/01/011	Development of Guidelines for the Regeneration of Small Ports & Harbours	Brady Shipman Martin	mail@bsmconsult.com
DK/03/001	Short Sea Shipping Desk Study	Logistecon Ltd.	www.imdo.ie
DK/05/001	Platforms for Marine Monitoring	Dr. Edin Omerdic	edin.omerdic@ul.ie
DK/05/003	Data-Mining	Val Cummins	v.cummins@ucc.ie
DK/05/004	Fast Ro-Pax Ferries	Gerry Trant	

## Appendix III: Contact Details for Further Information

Applied Industry			
Reference No.	Title	Contact Person	Email
IND/02/01	A Novel Ongrowing System for Abalone	Dr. Gerry Mouzakitis	g.mouzakitis@ucc.ie
IND/02/05	Technological & Scientific Development of Turbot Broodstock Management (Part I)	Prof. John Davenport	aquaculture@ucc.ie
IND/02/06	Validation of Non-Contact Techniques for Marine Water Characterization	Dr. Eon O'Mongain	spectral@ucd.ie
IND/02/10	Prediction of Ocean Wave Energy for Resonant Devices	William Dick	info@clearpower.ie
IND/02/11	High Pressure Sea Water Pump for use in wave Energy Converters	Eugene Lavelle	martech@indigo.ie
IND/03/02	Development of Soil Structure Interaction Models for Deepwater Environments (SOILSIM)	Michael O'Sullivan	galway@mcs.ie
IND/03/04	Technological & Scientific Development of Turbot Broodstock Management (Part II)	Prof. John Davenport	aquaculture@ucc.ie
IND/03/05	Establish a Commercial Use for Starfish	Andy Mulloy	amulloy@connemarafoods.com
IND/03/06	Dunlop Offshore Cage Development programme	Mark Kilroy	info@bonnarengtd.ie
IND/03/07	A Novel System for Intensive Larval Culture of the Sea Urchin	John Chamberlain	seaurchins@eircom.net
IND/03/11	Development of An Artificial Roe Enhancement Diet based on Waste Products from Fishing Industry	Dr. Gerry Mouzakitis	g.mouzakitis@ucc.ie
IND/03/13	B2B2 PROT Wave Energy Converter	John Keating	oceanenergy@o2.ie
IND/04/02	Acclimatization Potential of Artic Char	Peter McGovern	fiskur@stofnfiskur.is
IND/04/05	Development of Alternative Natural Source of Astaxanthin for the Aquaculture Market	Noel Sexton	noelsexton@cybercolors.ie
IND/04/03	Research & Development of Alternative Reliable Material and Methods for Marine Electronic Enclosures	John Wallace	info@marineinformatics.ie
IND/04/13	Investigation of the Bioactive Potential on Animal Health of Fucoidan-Rich products	Franck Hennequart	oileanglasteo@eircom.net
IND/04/04	Development of Next Generation of Heterogenous Telemetry Models for Data Loggers	John Wallace	info@marineinformatics.ie
IND/04/12	Evaluation of Selected Biophysical Properties Of Salmon PDV	Richie Flynn	richieflynn@ifa.ie
IND/05/01	Assessment of First Hatchery Stage Artificial Diets for Sea Urchins	John Chamberlain	seaurchins@eircom.net
IND/05/03	Control Systems for ROVs	John Wallace	info@marineinformatics.ie
IND/05/05	Power Take Off Systems for the OE Buoy Energy Converter	John Keating	oceanenergy@o2.ie
IND/05/06	Development of Cost Effective Gravity Based Foundation System	Chris Hannevig	sureng@iol.ie
MIA/05/04	Development of the Next Generation of 3D Numerical Well Test Software <i>PanmEsh</i>	Kepler Engineering Ltd.	info@kepler-systems.com
MIA/05/001	Development of Innovative Marina Mooring System	Prolines Marina Ltd.	charlie@prolines.ie





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