

ANNEX 3: IRELAND

Contributors

Partner 3:

**University College Cork, Coastal & Marine Resources Centre, Presentation Buildings,
Western Road, Cork, Ireland**

Ollscoil na hÉireann, Ionad Acmhainní Cósta is Mara, Corcaigh, Eire

Ms. P. Clayton, Ms. C. Buchanan, Ms. V. Cummins, Mr. H. Sealy, Mr. D. O'Leary, Mr. C. O' Mahony, Mr. N. Pfeiffer.

CONTENTS

1. INTRODUCTION.....	3
2. SITE DEFINITION.....	5
3. ENVIRONMENTAL LEGISLATION.....	7
3.1 LEGISLATION	7
3.2 AUTHORITIES INVOLVED IN ENVIRONMENTAL MANAGEMENT	16
4. ENVIRONMENTAL CHARACTERISTICS OF THE SITE.....	23
4.1 CLIMATE.....	23
4.2 FRESHWATER CATCHMENTS	25
4.3 MARINE WATERS	30
5. HUMAN ACTIVITIES AND SOURCES OF POLLUTION	34
5.1 AGRICULTURE	34
5.2 INDUSTRY	35
5.3 TOURISM.....	37
5.4 SHIPPING.....	42
5.5 OTHER SOURCES OF POLLUTION.....	45
6. AQUACULTURE ASSESSMENT	48
6.1 AQUACULTURE PRODUCTION.....	48
6.2 IMPACT ASSESSMENT	56
6.3 RELATIVE IMPORTANCE OF AQUACULTURE NUTRIENT LOADS	73
7. FISHERIES ASSESSMENT	81
7.1 LANDING SITES AND INSHORE FLEETS.....	82
7.2 FISHING METHODS	83
7.3 TONNAGE AND VALUES OF INSHORE SPECIES LANDED	84
8. CONCLUSIONS.....	94
9. RECOMMENDATIONS.....	99
REFERENCES.....	100
APPENDIX I.....	108

1. INTRODUCTION

The aim of the Enviroreview work package in Ireland is to identify and quantify the effects of aquaculture development on the local physical marine environment at the two study sites in Bantry Bay and the Dingle Peninsula. Information on environmental quality in these two sites has been assembled from a variety of sources, including relevant research projects, and reports and data from government departments and agencies, and local authorities eg. Kerry County Council (KCC), Kerry County Development Board, Cork County Council (CCC), Cork County Development Board, Bord Iascaigh Mhara (BIM), Central Fisheries Board (CFB), South Western Regional Fisheries Board (SWRFB), Department of Communications Marine and Natural Resources (DoCMNR), Department of Arts, Heritage, Gaeltacht and the Islands (DAHGI), Department of Environment and Local Government (DoELG), Dúchas, Environment Protection Agency (EPA), Central Statistics Office (CSO), Nautical Enterprise Centre Ltd. (NECL), Aberdeen University, etc. This report presents a review of that information. Included are data on water quality and marine biota, inputs/outputs from aquaculture facilities and other anthropogenic and natural sources; data on bathymetry, sediment types and marine currents; information on environmental legislation, regulation, monitoring and the statutory bodies responsible.

Types of data accessed include:

- Existing data on aquaculture production, feed usage and emissions at fish farms (nutrients, chemicals);
- Water quality and sediment composition measurements;
- Information on freshwater inputs: river systems;
- Organic enrichment from agricultural run-off and sewage;
- Other types of pollution, e.g. pathogens, heavy metals, organochlorine compounds, oil spills, ballast water from shipping;
- Results of studies on the marine biota, particularly indicator species (benthos, plankton, fish communities etc);
- Information on local marine current systems and bathymetry - information on the degree to which land-based and coastal inputs of pollutants and other materials are likely to be transported from (or into) the study area;

- Environmental protection regulations, monitoring schemes and contingency plans for dealing with environmental contamination; identification of the bodies responsible for these functions. Information on compliance with environmental regulations and typical environmental conflicts related to aquaculture.

2. SITE DEFINITION

The Define work package report (WP2) described the two Irish study areas which are located in the south-west of the country (Figure.1) The first site is the more southerly of the two study areas, Bantry Bay in County Cork. The second site, in County Kerry, is made up of the coastal area extending from Kerry Head to Valentia, incorporating Dingle Bay. Together the two sites contain approximately 250km of coastline.

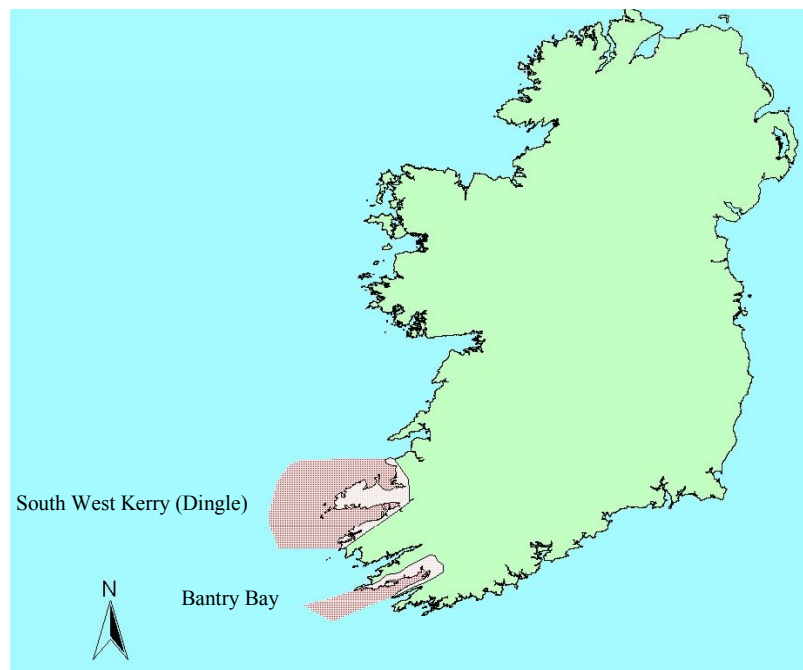


Figure.1 Location of Irish case study areas. (Source: CMRC).

The Bantry Bay and Dingle sites share certain geographical and demographic features. The coastline in the south-west of Ireland is rocky, highly indented and characterised by relatively long bays running along a north-east to south-west axis. Each study site includes one of these long bays, Dingle Bay and Bantry Bay. The population is sparse in both sites: between 21 and 32 people per square kilometre, compared with an average of 38 people per square kilometre for Counties Cork and Kerry as a whole (Central Statistics Office, 1996).

The Bantry Bay site can be defined as the waters and coastal lands east of a line from Dursey Island (northern shore) to Sheep's Head (southern shore) and extending 20 km seawards from the these two points. The Dingle site includes Dingle Bay with the stretch of more open coastline up to 20 km north of the Dingle peninsula. Water flushing in Bantry

Bay is slow being wind-driven in an anti-clockwise direction (which has implications for nutrient availability for shellfish culture). This is not an issue in the Dingle area.

There is a long tradition of fishing throughout the region. Aquaculture activity is also present at each site, with large-scale intensive operations in Bantry Bay and small-scale extensive methods in use in the Dingle area. Shellfish farming is predominant – salmon is the only finfish species produced. Bantry Bay hosts Ireland's greatest concentration of rope-mussel culture (Marine Institute, 1999), several caged salmon farms and other aquaculture operations in addition to a significant fishing fleet. In contrast the Dingle area has little or no intensive aquaculture but a number of stock enhancement schemes are underway. Dingle also has a significant fishing fleet.

Marine tourism is an important component of the local economy along the southwest coast, and includes shore and deep sea angling, diving, sailing, and coastal and island eco-tours. Other sources of income in the region are agriculture, land-based tourism, various manufacturing industries, building construction, fish processing, sales and service industries. Of the two study sites, Bantry Bay is home to heavier industrial activities, including an oil terminal and a major stone quarry. Whiddy Island, at the north east of Bantry Bay, is the site of Ireland's largest oil terminal which holds a large proportion of the country's strategic oil reserve. Oil tankers of up to 350,000 dwt (dead weight tonnage) service the terminal. The Tarmac Flemming road stone quarry, the largest of its kind in Ireland with mineral reserves estimated to be 120 million tonnes, is situated on the northern coast of Bantry Bay. There is also a maerl processing plant in Bantry Bay.

3. ENVIRONMENTAL LEGISLATION

3.1 Legislation

The following section deals with the principle international conventions, European directives, and national and local legislation of relevance to the Irish study sites. Three broad categories have been identified: fishing and aquaculture, water quality and waste disposal, and environmental protection. Some overlap exists between legislation pertaining to each of these categories. Examples of some of the more significant acts and directives within each of the categories are also described in greater detail.

Fishing and Aquaculture

The principle legislation regarding sea fisheries matters in Ireland is the Fisheries Consolidation Act 1959, under which EC regulations relating to conservation and management of fisheries are enforced. Many of the national policies relating to fishing aim to balance the objectives of the EU Common Fisheries Policy (CFP), due to be renegotiated in 2002. National Technical Conservation Measures (TCMs) provide enabling mechanisms for the fishing regulations defined by the CFP. The present TCMs were set down in Regulation 850/98 (1998), there have been six amendments since then.

The licensing of aquaculture in Ireland is governed by the Fisheries (Amendment) Act, 1997 (No. 23), as amended by the Fisheries and Foreshore (Amendment Act, 1998 (No. 54) [Fisheries (Amendment) Bill, 2000]. This provides for consultation with the public and with expert organisations on all licence applications, and for a right of appeal to the independent statutory Aquaculture Licences Appeals Board against Ministerial decisions to license or to refuse to license.

Table.1: Fishing and Aquaculture Legislation

Conventions	Directives	National Legislation
<ul style="list-style-type: none"> • 1983 Common Fisheries Policy (CFP); • Convention on Biological Diversity (1992); • UN Convention on the Law of the Sea UNCLOS (1994); • UN agreement on Straddling and Highly Migratory Fish Stocks (1995); • Convention for the protection of the Marine Environment of the Northeast Atlantic (OSPAR Convention, 1997); • Convention on International trade in Endangered Species of Wild fauna and Flora (CITES) EU regulation (3626/82 EEC). 	<ul style="list-style-type: none"> • Shellfish Waters Directive (79/923/EEC), Surface Waters (shellfish) classification regulations 1997, and Surface Waters (shellfish) Directions 1997; • Shellfish Hygiene Directive (91/492/EEC) and Food Safety (Live Bivalve Molluscs and other shellfish) Regulations 1992; • EC Directives 91/492 and 91/493 Shellfish Waters toxin monitoring; • EC Directive 91/67 Restrictions on movement of Shellfish. 	<ul style="list-style-type: none"> • Harbours Act 1946; • Fisheries Acts, 1959 - 2000; • Fishery Harbour Centres Acts, 1968 - 1998; • Foreshore Acts, 1933 to 1998; • Marine Institute Act, 1991; • Continental Shelf Act, 1968; • Maritime Jurisdiction Act, 1959; • Whale Fisheries Act, 1937; • Quality of Shellfish Waters Regulations, 1994.

Common Fisheries Policy

The Common Fisheries Policy (CFP) is the European Union's instrument for the management of fisheries and aquaculture. In 1970, the first rules on access to fishing grounds, markets and structures were set in the common measures of the fishing sector. A coastal band was reserved for local fishermen who have traditionally fished these areas, in order to ensure that smaller vessels could continue to fish close to their home ports.

The CFP was fully implemented in 1983 after much negotiation, taking into account the biological, economic and social dimension of fishing. The common measures were agreed in four main areas:

- *Conservation* - regulation and control of fish catches;
- *Structures* - aid the adaptation of equipment and organisations from the fishing and aquaculture industries;
- *Markets* - maintain a common organisation of the market in fish products and to match supply and demand for the benefit of both producers and consumers;
- *Relations with the outside world* - set up fisheries agreements and negotiate at the international level for common conservation measures in deep-sea fisheries.

The first review of the CFP took place in 1992. It was found that overfishing cannot be prevented through technical measures and control alone if there are too many vessels for the available resources. The link between the component parts of the CFP was reinforced to increase its effectiveness. New technologies and control measures were (and are) being developed to ensure that fishing regulation rules are respected throughout the country (European Union, 2002).

A second review of the CFP is to be carried out in 2002. The Commission will carefully examine contributions and views of the Member States that it has received during the consultation period before presenting its proposals to the Council and the European Parliament. The Irish Minister for the Marine and Natural Resources set up a Strategy Review Group on the Common Fisheries Policy in December 1998, in order to develop strategies and policies for the 2002 review of the CFP. A report by the group on “Proposals and recommendations for the review of the CFP 2002”, the sixth document published by the review group, was presented to the Minister in November 2000. The proposals outline the need for a far seeing approach to technical conservation measures, allowing young fish a chance to grow and replicate. It also emphasises that better control and enforcement is required for these measures to work, and that the Irish fishing industry is ready for such increased enforcement across the Community in the interests of flourishing stocks (Irish National Strategy Review Group on the Common Fisheries Policy (CFP), 2000). The report covered 12 main areas: socio-economic importance of the industry, access and the acts of accession, allocation of fishing rights, structures, marketing, technical conservation measures, control and enforcement, third country agreements, aquaculture, the environment, research, and regionalisation.

Quality of Shellfish and Shellfish Waters

Under the EC Shellfish Waters Directive (79/923/EEC) member States are required to monitor designated shellfish waters to ensure that the quality of the edible species is maintained or enhanced. The Quality of Shellfish Water Regulations 1994 transposes the requirements of the EC Council Directive into Irish law. Similarly, due to the rapid expansion of the Irish shellfish industry, shellfish production areas are classified by the Department of Communications, Marine and Natural Resources in order to enforce the EC Directive laying down the health conditions for the production and the placing on the market of live bivalve molluscs (EC Directive 91/67). The water quality classification categories, A, B, and C, correspond with the criteria as laid down in the directive.

Since 1984, the Marine Institute's Fisheries Research Centre has operated a national monitoring programme for detecting phycotoxins, from planktonic algae, in shellfish. Samples are collected regularly from all shellfish production areas, and are monitored using a laboratory bioassay. If toxin results are found to be positive in a production area, restrictions on the harvesting and sale of the shellfish are put in place corresponding to Directive 91/492/EEC on shellfish hygiene.

Water Quality and Waste Disposal

There is an extensive amount of national legislation dealing with water quality in Ireland. Many of the acts described in this section provide enabling legislation for policies agreed at international and European level. There have been significant improvements in waste management in Ireland since 1995 due to the implementation of the Waste Management Act (1996) and Integrated Pollution Control Licensing (EPA, 2000). Local planning policies reflect compliance with the EU Urban WasteWater Treatment Directive, and efforts are being made at all levels to improve water quality for the benefit of local communities, aquatic life, and tourism and recreation.

Table.2: Water Quality and Waste Disposal Legislation

Conventions	Directives	National Legislation
<ul style="list-style-type: none"> • UN Convention on the Law of the Sea UNCLOS (1994); • Convention for the protection of the Marine Environment of the Northeast Atlantic (OSPAR Convention, 1997). • International Convention for the Prevention of Pollution from Ships (MARPOL 73/78) 	<ul style="list-style-type: none"> • Dangerous Substance Directive (76/464/EEC) and Paris Convention 1974; • Directive on Waste Disposal (75/442/EEC); • Directive on Disposal of Waste Oil (87/101/EEC); • Directive on Disposal of Polychlorinated Biphenyls and Polychlorinated Terphenyls (96/59/EEC); • Integrated Pollution Control (96/61/EEC) and Pollution Prevention Control Act (1999); • Nitrates Directive (91/676/EEC); • Urban Waste Water Treatment Directive (97/27/EEC); • Water Framework Directive 2000; • Bathing Waters Directive (76/160/EEC); • EC Directive on Environmental Impact Assessment (97/11/EC). 	<ul style="list-style-type: none"> • Environment Protection Agency Act, 1992; • Waste Management Act, 1996; • Harbours Acts, 1936 and 1996; • Air Pollution Act, 1987; • Radiological Protection Act, 1991; • Sea Pollution Act, 1991; • Sea Pollution Amendment Act, 1999; • Dumping at Sea Act, 1996; • Oil Pollution of the Sea (Civil Liability and Compensation) Acts, 1988 to 1998; • Merchant Shipping (Salvage and Wreck) Act, 1993; • The Local Government (Water Pollution) Acts, 1977-90.

Sea Pollution Act, 1991 (No. 27 of 1991)

The Sea Pollution Act, 1991, enables the Minister for the Marine to prohibit or regulate the operational discharge of oil or oily mixtures from Irish registered ships anywhere at sea or from other ships in the territorial waters of the State. It further enables the Minister to require an Irish registered ship to be constructed, fitted or operated in such a way as to

prevent control or reduce discharges into the sea. The main purpose of this act is to enable Ireland to ratify MARPOL (Convention for the Prevention of Marine Pollution from Ships). (www.enfo.ie)

EU Water Framework Directive (WFD)

The EU Water Framework Directive (2000/60/EC) came into force in December 2000, establishing a new framework for Community action in the field of water policy. The WFD takes a holistic approach, addressing inland surface and transitional waters, estuarine and coastal waters and groundwater. A co-ordinated approach will therefore be required for the implementation of programmes and measures to achieve the objectives of the Directive. A 15-year period is allowed to each Member State, by which time the state must ensure compliance. Objectives of the Directive include:

- The protection and enhancement of the status of aquatic ecosystems (and terrestrial ecosystems and wetlands directly dependent on aquatic ecosystems);
- Provision for enhanced protection and improvement of the aquatic environment by reducing / phasing out of discharges, emissions and losses of priority substances;
- Protection of territorial and marine waters, and
- Establishing a register of protected areas e.g. areas designated for protection of habitats or species.

The WFD is based on the river basin as the natural unit for management, and will require the development of River Basin Management Plans. As the competent authority, under the Articles 13-16 of the WFD the Central Fisheries Board is required to:

Ensure that a River Basin Management Plan is produced for each River Basin District lying entirely within their territory... at least nine years after the date of entry into force of this Directive (i.e. July 2000).

Ireland has been developing a comprehensive, catchment-based national strategy towards combating eutrophication in rivers and lakes since 1997. Through the help of EU Cohesion Fund support, major monitoring and management projects were established for key water bodies throughout the country. This successful catchment-based strategy is currently being extended to include groundwaters, estuaries and coastal waters. There are five regional

River Basin Districts for which local authorities are establishing projects. These projects aim to provide much of the basic data for river basin management plans under the WFD (Dempsey, 2002). The two study sites for the Aqcess project fall into the South Western Basin District, for which Cork County Council is responsible. Proposals for the development of river basin management systems are currently under review.

The WFD is moving towards ecological quality by incorporating within its environmental objectives quality in biology, hydrology, morphology and chemistry. As well as maintaining water quality, the objectives specifically refer to protecting ecosystems:

- Protect ecosystems and achieve compliance with any standards and objectives for protected areas (e.g. areas designated for protection of habitats/ species).

Measures adopted must include:

- Reviewing human activity on the status of the waters.

The WFD is viewed by the EC as part of the mechanism within which to adopt Integrated Coastal Zone Management (ICZM). Its application to waters up to one nautical mile offshore goes some way to minimising the current sectoral approach to water quality and biological quality management. In Ireland, the EPA is the regulatory body charged with competence in implementing the WFD. The WFD uses biological communities as long-term indicators of health of the water. This will be a particular challenge in estuarine and coastal waters.

The WFD is regarded as the most important legal stimulus at EU level for integrated planning, both coastal and inland. The Commission will produce detailed guidelines for Member States, indicating how policies related to coastal zones can be incorporated into river basin management plans.

Water Services Bill

Facilitating the future establishment of such management plans is the pending release of new draft legislation, aiming to overhaul the existing regulatory environment for water services and procurement in the Republic of Ireland. The Water Services Bill, due to be released in the coming months, will consolidate and modernise the existing large and

diverse body of water services legislation which currently extends back to the nineteenth century. It will also provide for joint plans covering all or part of combined water services authority areas in anticipation of the establishment of river basin management districts under the EU Water Framework Directive.

The main points of the proposed water services bill include:

- The setting up of a national water services authority to oversee investment of about four billion euros over the course of the National Development Plan (2000 – 2006);
- The introduction of a licensing system for all group water schemes;
- The national rural water monitoring committee to be put on a statutory basis;
- Improved management of city and county council water schemes;
- The consolidation and modernisation of diverse legislation dating from the 1800s.

Under the proposals for the new water services authority, group water schemes must ensure that EU standards for drinking water are met, or else face closure. The authority will also have an important role in monitoring municipal drinking water and sewage services, and will have an inspecting role similar to that of the EPA (Irish Times, Sept 15th 2001).

Environmental Protection

Ireland's nature conservation policies in recent years have focused on the identification, designation and conservation of protected areas. This arose from the need to protect sites designated under EU regulations on wild birds and habitat protection. In Ireland, the Wildlife Act of 1976, updated by the Wildlife (Amendment) Act 2000, is the foundation legislation for the protection of flora and fauna. For example, all cetaceans in Irish waters are protected under the 1976 Wildlife Act and in 1991 the Irish government declared the Irish economic exclusion zone a whale and dolphin sanctuary. In addition, cetaceans are protected by European legislation and are listed Annex IV of the EU Habitats Directive. There has also been increased awareness towards the preservation of Ireland's historic environment, which is primarily covered by the Heritage Act 1995, and is also recognised by the local County Development Plans. Legislation dealing with waste disposal and water pollution, such as the Water Framework Directive, also play an important part in environmental protection (Section 3.1.2).

Table.3: Environmental Protection Legislation

Conventions	Directives	National Legislation
<ul style="list-style-type: none"> • Convention for the protection of the Marine Environment of the Northeast Atlantic (OSPAR Convention, 1997); • Ramsar Convention on Wetlands of International Importance (1984); • Convention on Biological Diversity (1992); • UNCLOS (1994); • Washington Global Programme of Action for the Protection of the Marine Environment from Land-based Activities (UNEP, 1995); • Bonn Convention (1979); • Bern Convention (1979); • UN agreement on Straddling and Highly Migratory Fish Stocks (1995); • FAO Code of Conduct for Responsible Fisheries (1995); • Convention on International trade in Endangered Species of Wild fauna and Flora (CITES) EU regulation (3626/82 EEC). 	<ul style="list-style-type: none"> • Directive on the Conservation of Wild birds (97/49/EEC) – Special Protection Areas (SPAs); • Habitats Directive (92/43/EEC) and the Conservation (Natural Habitats) Regulations 1994; • Directive on Other Substances: Protection of the Aquatic Environment of the Community (76/464/EEC); • Strategic Environmental Assessment (SEA) Directive (2001/42/EC); • Birds Directive (79/409/EEC); • Council Directive 96/82/EC, the Control of Major Accident Hazards Involving Dangerous Substances (COMAH). 	<ul style="list-style-type: none"> • Environment Protection Agency Act, 1992; • Wildlife Act, 1976 and Wildlife Amendment Bill, 1999; • Heritage Act, 1995; • Irish whale and dolphin sanctuary declaration 1991; • European Communities (Environmental Impact Assessment) Regulations, 1989 and Amendment Regulations 1994; • Foreshore Acts, 1933-1998; • Continental Shelf Act 1968.

Wildlife Act and Wildlife Amendment Act

The Wildlife Act, 1976, the Wildlife (Amendment) Act 2000 and the European Communities (Natural Habitats) Regulations, 1997 is the most important legislation on nature conservation in Ireland is the. The national, European and global designations are administered by Dúchas, the national statutory conservation body. The national designation in Ireland, the National Heritage Area (NHA) is currently a proposed designation, replacing the earlier Area of Scientific Interest (ASI). All other national, European and global nature designations overlap with and are subsets of the NHA designations. The Wildlife Amendment Act was finally enacted in December 2000, providing a legal basis for the

protection of NHAs, SACs (Special Areas of Conservation) and SPAs (Special Protection Areas). The geographic locations and coverages of NHAs, SACs and SPAs are available in digital format from <http://www.heritagedata.ie>

A recent report carried out for the DoCMNR (DoCMNR, undated) recommends a major expansion in aquaculture to encourage potential growth in value of 305% by 2015. The government is committed to an ambitious programme over the coming years with funding allocated to aquaculture development under the NDP amounting to €26.5 million. Some conflict may therefore arise between the designation of aquaculture sites and conservation sites. Dúchas is currently compiling conservation plans for SPAs, taking into account all activities within each site. An aquaculture zoning plan will be included for any sites that include shellfish farming, with the aim of minimising the environmental impacts while allowing for development.

In Ireland, the legislation and management structure for environmental protection of the coastline is often insufficient. The Irish Government is under increasing pressure from the European Commission, and from national and international NGOs, to uphold its duty to protect the environment while facilitating sustainable development.

3.2 Authorities involved in environmental management

Government Departments

Within the Aqcess Irish study sites, there are three Government Departments that have particular local responsibilities. These are the Departments of Communications, Marine and Natural Resources, the Department of Environment and Local Government, and the Department of Arts Heritage, Gaeltacht and the Islands. Mean High Water Mark (MHWM) is the jurisdictional boundary between landward and seaward planning. However, exceptions to this rule include the extension of Cork County Council's planning jurisdiction into part of Bantry Bay following the Betelgeuse disaster of 1979.

The Department of Communications, Marine and Natural Resource

The Department of Communications, Marine and Natural Resources (DoCMNR) has jurisdiction on the seaward side of the mean high water mark, providing a wide range of services directly to the public sector. This includes planning and legislation, policy development, licensing and the provision of information. The licensing requirements include processing license applications for fishing and passenger vessels; licensing and regulating of aquaculture operations; and processing licenses for minerals and hydrocarbon exploration and development. The Department and the agencies under its aegis (such as Bord Iascaigh Mhara (BIM) and the Marine Institute) have responsibility for regulating, protecting and developing the marine and natural resources. Within the structure of the DoCMNR, primary activities licensed by the Department such as foreshore activities, dumping at sea and aquaculture are controlled and licensed by the Coastal Zone Administration Division of the Department. These activities are all regulated by relevant legislation e.g. Dumping at Sea Act 1996, Fisheries Acts 1959 to 1997.

Department of Arts, Heritage Gaeltacht and the Islands

The Department of Arts, Heritage, Gaeltacht and the Islands (DAHGI) is responsible for conservation of all aspects of national heritage at government level. The mandate of the Department is to foster, promote, conserve and present culture and heritage in the broadest sense and to provide the necessary management and institutional tools to assist and develop this commitment (National Report Ireland, 1998, DAHGI). There are two constituent services within the department with direct responsibility for coastal areas are the National Parks and Wildlife Service and Dúchas the Heritage Service. The local operation of the service in the study area is currently carried out by two executive officers (<http://www.gov.ie/ealga/>).

Department of the Environment and Local Government

The mission of the Irish Department of the Environment and Local Government (DoELG) is to ensure partnership with a strengthened Local Government system. This department has responsibility for policy formation and legislation relating to the landward side of the mean high water mark. It is primarily responsible for securing the implementation of European Union (EU) environmental legislation, co-coordinating Irish policies on environmental matters, and presenting these policies at EU and international levels. Implementing policy

on behalf of the Department of the Environment is the responsibility of government at local level through a system of local authorities. (<http://www.environ.ie/>).

State agencies

The Environment Protection Agency

The Environmental Protection Agency Act, 1992, was enacted on 23 April 1992, and under this legislation the Agency was formally established on 26 July 1993. The EPA has a statutory responsibility in relation to environmental modelling, environmental data management and reporting, and the co-ordination of environmental research. By this it aims to improve, standardise and expand the quality of the environmental database and improve the scientific basis for better decision making and evaluation of the state of the environment (EPA Annual Report and Accounts, 2000). The main responsibilities of the EPA include: the licensing and regulation of large complex industrial and other processes with significant polluting potential on the basis of integrated pollution control and the application of best available technologies for this purpose; the monitoring of environmental quality; advising public authorities; and assisting local authorities in their environmental protection functions. (www.epa.ie)

The Marine Institute

The Marine Institute, a constituent of the DoCMNR, is Ireland's national agency charged by the government with the responsibility for promoting, directing and co-ordinating marine research and development across the marine spectrum. Comprehensive monitoring programmes are carried out by the Marine Institute on a regional basis. The Marine Monitoring Programme is designed to monitor: contaminant levels in seafoods for the protection of human health; distribution and trends of contaminants in the marine environment; mercury in commercial fish catch; the quality of shellfish and shellfish growing waters; residues in farmed produce; spatial and temporal trends of metals, PCBs and organochlorine pesticides in biota and sediments from Irish waters; and spatial and temporal trends of nutrients in the Irish Sea. Service divisions of the Marine Institute include Marine Environment and Health, Marine Fisheries, Salmon Management, Irish Maritime Development Office and the Marine Science, Technology and Innovation Division. (www.marine.ie)

An Bord Iascaigh Mhara

An Bord Iascaigh Mhara (BIM, the Irish Sea Fisheries Board) is the state agency with primary responsibility for the development of the seafood industries. Its operational activities include fleet development, aquaculture and planning, market development and marine services. BIM also operates periodic local training courses for fishing personnel from its mobile training units. (www.bim.ie).

The Heritage Council

The Heritage Council is an independent body which has a statutory responsibility to propose policies and priorities for the identification, protection, preservation and enhancement of national heritage. National heritage is defined as including: monuments, archaeological objects, heritage objects, architectural heritage, flora, fauna, wildlife habitats, landscapes, seascapes, wrecks, geology, heritage gardens and parks, and inland waterways. (www.heritagecouncil.ie/mainpage.html)

Dúchas and the National Parks and Wildlife Service

Dúchas and the National Parks and Wildlife Service are responsible for the management of designated areas, national parks, nature reserves, monuments and heritage. Designations include Natural Heritage Areas, Special Areas of Conservation, Special Protection Areas, Nature Reserves and National Parks.

(<http://www.heritagedata.ie>).

An Taisce

The aim of An Taisce is to advance the conservation and management of Ireland's natural and built endowments in manners that are sustainable. It has responsibility in co-ordinating the implementation of the Blue Flag beaches scheme of the EU (there are no designated bathing beaches in the Bantry Bay area).

Commissioners of Irish Lights

The Commissioners of Irish Lights are appointed to act as the General Lighthouse Authority for Ireland. The Commissioners are responsible for the superintendence and management of the marine aids to navigation. (www.cil.ie/).

South West Regional Fisheries Board

The Central Fisheries Board (CFB) is the state agency responsible for the coordination of the work of the seven regional fisheries boards, (including the South West Regional Fisheries Board which covers the areas of the Irish study sites). This board has the responsibility for the management, conservation, protection, development and promotion of inland fisheries and sea angling resources within the coastal zones of the study sites. The statutory powers of the Board extend seawards to the twelve-mile limit.

South West Regional Authority

The function of regional authorities is to promote the co-ordinated delivery of public services in the region. This includes the promotion of co-operation, joint action and cohesion between local authorities, public authorities and others. The South West Regional Authority (SWRA) covers an area of approximately 14,200km² in the south west of Ireland, incorporating counties Cork and Kerry. The SWRA has 24 elected representatives consisting of city and county councillors appointed by local authorities. It also has an ongoing responsibility for a sustainable development strategy at a regional level. The SWRA is assisted by an operational committee, which consists of the city and county managers together with the chief executives of all state agencies and third level educational institutions in the region (Administration Yearbook and Diary, 2000).

Údarás na Gaeltachta

Údarás na Gaeltachta is the state agency with the remit to establish and develop job creating industries and services in Gaeltacht regions, and to support social and cultural initiatives. Taighde Mara Teo is a technical support subsidiary, whose brief involves the commercial development of marine resources, with particular reference to inshore fisheries and aquaculture.

Local authorities

County Councils

Cork County Council, and Kerry County Council, are the local authorities responsible for the delivery and the shaping of objectives and strategies of the Department of Environment

and Local Government at a local level within the study sites. The functions of local authorities are mainly concerned with the physical environment, through planning and development, environmental management and control. The Councils are statutorily obliged to draw up a plan indicating the development objectives for its area. These plans (known as County Development Plans) deal with the physical, economic and social development within their jurisdictional boundaries. In practice however, County Development Plans provide for much more than the above, and are increasingly moving towards the European model for plans based upon wider socio-economic criteria. The implementation of the Planning and Development Act, 2000, will bring further significant changes to this policy framework, including a housing and conservation areas strategy for the first time. While the period for review of development plans is extended to six years, the review process must start after four years. The role of local Development Plans and regional planning guidelines were formalised by the Planning and Development Act, 2000.

Harbour Commissioners

The Harbour Commissioners were established under the Harbours Act in 1976. The Harbour Commissioners are responsible for all harbour operations, for strategy, for maintenance and upkeep of structures and equipment, and for ensuring that proper facilities are provided for vessels, goods and passengers. They are entitled to levy charges for services and to issue licences for vessels plying trade within the harbour. Harbour Commissioners can also make charges and byelaws for the harbour, which must be approved by the Minister.

The Bantry Bay Harbour Commissioner's jurisdiction includes the Bay area inside a line between Dursey Island and Sheep's head, but excludes the Castletownbere Fisheries Harbour. They maintain a strict control over oil and water transfers as well as vessel movements. The Dingle Harbour Commissioner's jurisdiction includes the waters of Dingle Harbour.

Castletownbere Fisheries Harbour

The Castletownbere Fisheries Harbour has jurisdiction over the waters inside Bere Island in Bantry Bay. The harbour is managed directly by the Department of Marine and Natural Resources through the local Harbour Master.

Bantry Bay Town Commissioners

The Town Commissioners are directly elected representatives by the residents of Bantry. They lobby the County Council on local issues, organise and undertake local initiatives in the town, and grant aid specific local projects. They also have representatives on the Bantry Harbour Bay Harbour Commissioners and on the Strategic Policy Committees of Cork County Council.

4. ENVIRONMENTAL CHARACTERISTICS OF THE SITE

4.1 Climate

Ireland's western maritime climate is influenced mainly by the Atlantic Ocean's North Atlantic Drift. This current is a continuation of the Gulf Stream and bathes the west coast with relatively warm water compared to eastern Atlantic seabords of similar latitude. The prevailing wind direction is south westerly and the maritime influences mean there is little significant temperature variation throughout the country. Ireland does not experience extremes in temperatures associated with other European countries. The average national temperature is 9°C, with winter and summer averages of 2.5°C and 19°C respectively. January and February tend to be the coldest months while July and August are the warmest. Nationally, annual average rainfall is highest in the more mountainous western regions (2,800mm/yr) compared to that the average for the eastern half of the country (800mm/yr). Similarly, winds are strongest in the northwest of the country (7m/sec) compared to the more sheltered East coast areas (4m/sec) (Met-Eireann (Irish Meteorological Agency), *pers. comm.* 2002).

Both study sites are open to the Atlantic and are separated only by a short distance of approximately 40km. There is little significant difference in climate between the two sites (Met-Eireann (Irish Meteorological Agency), *pers. comm.* 2002). Met-Eireann maintains a meteorological monitoring station on Valentia Island (51°56'N 10°15'W, 9m above sea level), which is approximately equidistant from the most northerly and southerly points in the combined study areas. Climatic values from this station are regarded as representative of the overall climate of the study areas. The most recent official 30-year long-term data set available provides averages for various climatic variables for the period 1961-1990 (Table.4).

Table.4: Meteorological data for Valentia, Ireland (1961-1990).

Month	Average Annual Temperature (°C)	Maximum Annual Temperature (°C)	Minimum Annual Temperature (°C)	Relative Humidity (%) [■]	Average Rainfall (mm)	Prevalent Wind	Days of rainfall per year	Days of snowfall* per year	Days of wind Level >6 on the Beaufort scale	Days of wind level >8 on the Beaufort scale ^
January	6.8	9.3	4.2	84	166.6	SW	N/A	1.5	N/A	2.5
February	6.6	9.3	3.9	83	123.0	SW	N/A	1.7	N/A	2.0
March	7.6	10.5	4.6	83	122.9	SW	N/A	1.1	N/A	1.3
April	8.9	12.2	5.5	79	76.2	SW	N/A	0.3	N/A	0.3
May	10.9	14.3	7.5	78	89.6	SW	N/A	0.1	N/A	0.4
June	13.3	16.4	10.1	81	79.2	SW	N/A	0.0	N/A	0.0
July	14.8	17.9	11.7	84	74.0	SW	N/A	0.0	N/A	0.0
August	14.8	18.0	11.6	85	110.8	SW	N/A	0.0	N/A	0.1
September	13.5	16.6	10.3	85	123.8	SW	N/A	0.0	N/A	0.5
October	11.5	14.3	8.6	86	156.4	SW	N/A	0.0	N/A	0.8
November	8.7	11.4	6.0	84	148.3	SW	N/A	0.1	N/A	1.5
December	7.6	10.1	5.0	85	159.2	SW	N/A	0.8	N/A	1.8
TOTAL	10.4	13.4	7.4	83	1430.1	SW	N/A	5.6	N/A	11.2

■Relative Humidity is taken as the mean at 0900UTC.

*Days of the year with snowfall represent the mean number of days with snow or sleet.

^Represents the mean number of days with gales (Beaufort 8 represents gale conditions).

4.2 Freshwater catchments

The entire island (including Northern Ireland) is divided into a total of 40 hydrometric areas of which 37 are in the Republic of Ireland. These 37 areas are grouped into seven Water Resource Regions. Bantry Bay lies within Hydrometric area 21, the Southern Water Resource Region. The Dingle study area is more complicated as it spans hydrometric areas 22 and 23 lying within the Southern and Mid-Western Water Resource Regions respectively.

The Environmental Protection Agency (EPA) monitors the biological water quality of the river catchments and estuarine waters. The local council is required by law to monitor water quality and submit an annual report to the EPA. The study sites both feature mountainous terrain adjacent to coastal waters. Land practices have an impact on water quality in the two study areas. Neither site has any large centre populations, although Bantry Bay does have some heavy industry in the form of the oil terminal and large quarry. Sheep farming and coniferous forestry plantations account for the majority of the land use in both areas. Many of the freshwater systems flow relatively short distances (<10km) from the surrounding uplands to the sea. Generally the quality of freshwater systems in the study region is good and improving (P. O'Connor, South Western Regional Fisheries Authority (SWRFA), *pers. comm.*, 2002).

Water Quality of Rivers

The biological diversity of Ireland's freshwater systems is assessed once every three years (usually during the period June-October) as a further indication of water quality. The methodology used to establish the "Q" value is comprehensively described in Appendix 1 of the EPA report entitled Water Quality in Ireland 1998-2000 (EPA, 2002). In summary, flora and fauna (usually macroinvertebrate species) are sampled from fast flowing sections (riffle) of the river. The macroinvertebrate species are then identified, and assigned a "Q" value. Certain species are known to be pollution

tolerant (Q1), while others are extremely sensitive to pollution (Q5). The biotic index used is described below (Table.5 and Table.6).

Table.5: Relationship of biological quality “Q” values and water quality.

“Q” Value	Community Diversity	Quality	Condition*
Q5	High	Good	Satisfactory
Q4	Reduced	Fair	Satisfactory
Q3	Low	Low	Doubtful
Q2	Very Low	Poor	Unsatisfactory
Q1	Little / None	Bad	Unsatisfactory

(Source: EPA, 2002)

*Condition refers to the likelihood of interference with beneficial or potential beneficial uses.

Table.6: Relationship of transitional “Q” value status and water quality.

Biotic Index	Quality Status	Quality Class
Q5, Q4-5, Q4	Unpolluted	Class A
Q3 – 4	Slightly Polluted	Class B
Q3, Q2 – 3	Moderately Polluted	Class C
Q2, Q1 – 2, Q1	Seriously Polluted	Class D

(Source: EPA, 2002)

Analysis of the physico-chemical parameters of rivers is also carried out by the EPA. The most commonly measured parameters include DO, BOD, Ammonia, Oxidised Nitrogen (Nitrites plus Nitrates) and Phosphates, which are assessed to determine organic pollution. Ideally, analysis of both physico-chemical and biological parameters should be carried out. Biological assessment techniques provide a reasonably accurate assessment of the water quality. They can be easily carried out, twice a year to provide an accurate assessment. Knowledge of the pollutants likely to be present is a prerequisite for effective chemical monitoring. There is also considerable cost involved, and a greater number of samples are needed. Irregular

discharges may not be detected by chemical monitoring, while it more likely a change in the macroinvertebrate community will be noted (EPA, 2002).

There are approximately eighteen freshwater systems flowing into the waters around the Dingle Peninsula, eight of which flow northwards and ten of which flow southward into the waters of Dingle Bay. The most recent survey of biological quality of the freshwater systems in the Dingle study site was conducted in 1998. The majority of the systems have been classified by the EPA as being *unpolluted*. Samples from the Rivers Tyshe, Lee and Milltown Kerry Samples showed *moderate* pollution in 1998. The River Tyshe, north of Tralee was *moderately polluted*, showing an improvement in quality from its *seriously polluted* status of 1987. The Rivers Caragh and Laune were *slightly polluted*, both reflecting a deterioration in quality from their *unpolluted* status of 1994.

The River Lee flows through Tralee and into Tralee Bay, while the River Tyshe flows into the Atlantic north of Tralee at Banna Strand. Tralee Bay hosts significant oyster beds. The EPA surveys Water Quality in Ireland 1998-2000 refers to the waters of the Upper Lee Estuary being classified as eutrophic. The water quality of the upper estuary is unlikely to be remediated as a leachate from a decommissioned, local landfill site in Tralee *will probably continue to contribute contaminated water for the foreseeable future* (EPA, 2002). The waters of the Lower Lee Estuary and Inner Tralee Bay were classified as non-eutrophic (EPA, 2002). A new wastewater treatment plant in Tralee discharges secondary treated effluent to the lower estuary.

At least five freshwater systems, including the Laune flow into the semi-enclosed Castlemaine Harbour, which also host the main bottom mussel culture operations in the area. While the quality of the freshwater systems flowing into Castlemaine Harbour is generally good, the coastal water is classified as Class B under the regulations of Shellfish Hygiene Directive, which pertains to the levels of bacteriological contamination in the harbour. A number of sewage treatment plants are located in the area.

There are approximately eight freshwater systems flowing into the waters of Bantry Bay, most concentrated in the Upper/Inner area of the bay. The most recent survey of these systems occurred in 2000 and all were deemed to be *unpolluted*. This marked an improvement in the quality of the River Melagh, which had been *slightly polluted* in 1987. The town of Bantry is situated on the River Melagh, which is probably the main contributing factor to its lower water quality. There is little sewage treatment in Bantry Bay.

A summary of the main freshwater systems in the study areas and their biological quality, are provided in Table.8. See Appendix I (Table.9) for general characteristics of River Quality Classes.

Table.7: Percentage surveyed river-channel in four quality classes

Hydrometric Area (National Ranking)	Class	1987-1990	1991-1994	1995-1997	1998-1990
21 Dunmanus-Bantry- Kenmare <i>Rank: 4th</i>	A	98	99	97	93
	B	1	1	2	5
	C	0	0	1	2
	D	0	0	0	0
22 Laune Maine-Dingle Bay <i>Rank: 9th</i>	A	91	85	87	85
	B	5	10	10	13
	C	3	4	3	3
	D	0	0	0	0
23 Tralee Bay-Feale <i>Rank: 17th</i>	A	76	83	81	78
	B	8	8	6	10
	C	16	10	13	12
	D	0	0	0	0

Source: EPA, 2002.

Table.8: Summary of water quality of freshwater systems in the study sites.

Area	Name	Last Surveyed	Chemical Data Available	Unpolluted Q = 4-5	Slightly Polluted Q = 3-4	Moderately polluted Q = 2-3	Seriously Polluted Q = 1-2	
Dingle	Derreen	1998						
	Behy	1998	-	X				
	Caragh	1998	-	1994	X			
	Laune (Cottoners Laune)	1998	-	1994	X			
	Groin	1998	-	X				
	Maine	1998	1991-1997	X				
	Emlagh	1998	-	X				
	Owenscaul	1998	-	X				
	Owenalondrig	1998	-	X	1996			
	Milltown Kerry	1998	-			X		
	Feeonagh	1998	-	X				
	Owenafeanna	1998	-	X				
	Owenamore	1998	-	X				
	Glenahoo	1998	-	X				
	Owencashla	1998	-	X				
	Finglas	1998	-	X				
	Lee (TRALEE)	1998	-	1994	1987	X		
	Tyshe	2000	-			X	1988	
	Bantry Bay	Glengarrif	2000	-	X			
		Coomhola	2000	1995-1997	X			
Owvane		2000	1995-1997	X				
Melagh		2000	-	X	1987			
Magannagan		2000	-	X				
Adrigole		2000	1995-1997	X				
Trafrask Stream		2000	-	X				
Cloghane	2000	-	X					

Source: EPA, 2002

Catchment Management

Catchment Management Systems are being introduced across the country by the Central and Regional Fisheries Boards. This initiative is to improve the quality of the inland fisheries by improving the water quality of the catchment area. A holistic, integrated approach is adopted to ensure all possible influential factors are incorporated to the management system. Catchment management is therefore supporting the implementation of the WFD (Section 3.1.2).

For example, the Southwest Regional Fisheries Board established the Laune Catchment Management pilot programme in 1998. In 1999 the draft plan for the programme was released. The main issues of concern regarding the Laune catchment include serious reduction in fish stocks, poaching and predation (Central Fisheries Board, 2002). A working group on water quality has been established under the Bantry Bay Charter Programme. While Bantry Bay is not included in an official Catchment Management Programme, the Bantry Bay Charter Project has set up a working group to examine and suggest resolutions on water quality issues in the bay.

4.3 Marine waters

Hydrodynamics

The hydrodynamics of the waters off the southwest coast of Ireland are quite complex. As mentioned in Section 4.1, the southwest coast of Ireland is subject to the influences of the North Atlantic Drift, meaning the winter surface water temperature is rarely below 9°C (Lee and Ramster, 1981). Upwellings of nutrient enriched colder waters (averaging 4°C cooler than surrounding temperatures) are believed to occur near the mouth of Bantry Bay. In storm conditions waves can reach 30m in height off the southwest coast (Moore *et al*, 1997).

The tidal cycle occurs on a standard semi-diurnal basis. The more restricted waters of Tralee Bay experience an average Spring tidal range of approximately 3.6-4.0m, and 1.5-1.8m on neaps. However, elsewhere the tidal range averages approximately 3.1m

on Springs and 1.6 on Neaps. Both study sites are rias (drowned river valleys). Tidal currents are particularly rapid around Sleah Head (2.5m/sec) on the Dingle Peninsula and around Dursey Head (3.0m/sec) on the Beara Peninsula.

Academic institutions have developed hydrodynamic models for various coastal regions around Ireland. For example, the Coastal Resources Centre has been working on the development of a nested version of the Ifremer MARS 2D model for Bantry Bay (Cummins *et al*, 2001). Commercial hydrographic surveys have been conducted for small specific areas (i.e. Dingle Harbour and Whiddy Island, Bantry Bay). However, there are very limited tidal stream data available for the west (and southwest) coast of Ireland, much of the current descriptions being based on old Admiralty Pilots. The following description summarises the local tidal regime as described in *Sailing Directions for the South and West Coasts of Ireland*.

At Low Water, Galway (corresponding with High Water Dover): tidal streams flow in a clockwise pattern around the southwest coast of Ireland until they meet a southerly flow of water approximately along a line extending Northwest from Brandon Head on the Dingle Peninsula.

Four hours before High Water Galway (three hours after High Water Dover): there is slack water off the southwest coast, with a northerly tidal stream from south of Valentia Island, veering northeast (following the coastline) as it rounds the Dingle Peninsula.

Two hours before High Water Galway (four hours after High Water Dover): a separation seems to appear in tidal stream direction once more along a line extending west from Valentia Island. Tidal streams flow northwest from Valentia and flow anticlockwise around the southwest coast away from Valentia. The tidal streams continue flowing in this manner for about two hours after High Water in Galway, with the separating line gradually moving clockwise around the coast towards Brandon Head.

Three hours after High Water Galway (three hours before High Water Dover): there is a net anticlockwise flow of water from Galway (past Kerry Head) down the west and southwest coast.

Four hours after High Water Galway (two hours before High Water Dover): the slack water off the south coast has begun to flow clockwise once again around the southwest coast, while there is still an anticlockwise flow direction around the Dingle peninsula. The meeting line of the opposing flows reappears along a southwestly line off Valentia Island.

Tidal stream rates average about 1 knot in the Mouth of Dingle Bay, increasing to 2 knots nearer the Basket Islands off the tip of the Dingle Peninsula. There are also strong tidal streams nearer the Castlemaine Harbour Bar and, in the absence of navigation aids, these waters are dangerous without local knowledge.

There are no significant tidal streams in Bantry Bay (UK, Hydrographic Office, 1997), with currents rarely exceeding 0.1 knots in speed. Most of the water circulation is wind blown to a depth of approximately 6-10m (J.Murphy, HMRC, 2002 *pers. comm.*).

Marine Water Quality Status

Coastal waters of southwest Ireland are generally clear and unpolluted (Moore *et al.*, 1997) hence their popularity as a scuba-diving destination. The hydrodynamic characteristics of the coastal waters, described above, have a role to play in water quality. The dynamic environment results in high dispersion rates in most coastal waters. There are no major estuaries discharging seriously polluted waters due to the absence of heavy industry and major centres of population within the catchment areas. The quality of the estuarine waters has been described in Section 4.2.1.

Food safety regulations demand continual monitoring of water quality in shellfish production areas. Shellfish production areas are classified by the DoCMNR. Upgrading or downgrading occurs according to the results of local water quality

analysis. The classification parameters are described in Table.10, while Table.11 lists the current classifications in the study area:

Table.10: Summary of Requirements for water quality of Shellfish Production areas.

Classification	No. of Faecal coliforms (Or <i>E.Coli</i>) per 100g of shellfish flesh*	Requirements
A	<ul style="list-style-type: none"> < 300 Faecal coliforms 230 <i>E.coli</i> 	None-Sale for direct human consumption permitted.
B	<ul style="list-style-type: none"> < 6000 faecal coliforms 4,600 <i>E.coli</i> in 90% of samples 	Purification in an approved plant for 48 hours prior to sale for human consumption
C	<ul style="list-style-type: none"> < 60,000 faecal coliforms 	Relaying for a period of at least 2 months in clean seawater prior to sale for human consumption

(Source: Dept. of Communications, Marine and Natural Resources)

Table.11: Current Classification of Designated Bivalve Mollusc Production Areas.

Production Area	Boundaries	Bed Name	Species	Classification
Tralee Bay	Kerry Head to Brandon Point	All beds	Oysters	B
Castlemaine Harbour	Inch Point to Rossbeigh Point	All beds	Oysters Mussels	B
Valentia River	Bray Head to Reencaheragh Point and Douglas Head	All beds	Oysters	B
Bantry Bay	Sheep's Head to Black Ball Head	Castletownbere All other beds All beds	Mussels Mussels Sea-Urchins	A B A

(Source: Dept. of Communications, Marine and Natural Resources).

Human activities and sources of pollution which have an impact on water quality status are described in more detail in Section 5.

5. HUMAN ACTIVITIES AND SOURCES OF POLLUTION

Human activities within both study sites are described in this section, according to the following headings: agriculture, industry, tourism, shipping and others. The sources of pollution arising from these activities and their impact on the environment are examined within the context of each activity. If pollution loads were available these were included, however, in most cases exact figures were not available.

5.1 Identification of uses

5.1.1 Agriculture

Agriculture in Ireland encompasses 82% of all land use. Agriculture has changed rapidly since Ireland joined the European Community in 1973, and traditional mixed farming has given way to specialisation and increased mechanisation. There has also been a trend towards diversification, with many farmers moving from agriculture to forestry, agri-tourism and deer farming, or alternative crops such as oil-seed rape (Boelens *et al*, 1999). Agriculture accounted for 3.9% GDP, 8.7% employment and 5.8% of all exports in 1999 (Department of Foreign Affairs, 2002).

Agriculture in Cork and Kerry

There are a total of 17,450 farms in Co. Cork, and a further 10,720 in Co. Kerry. In the Bantry study site agriculture is the most widespread use of coastal land and the largest employer, accounting for over 21% of the workforce. Most of the land is made up of rough grazing and pasture. Many of the farms in Co. Kerry are less than 30 hectares in size. The average farm size in the Dingle study site is 27.66 hectares (www.cso.ie). The type of agriculture is mostly sheep farming, with some dairy and non-dairy herds of cattle and, in the northern region of the study site (Tralee and its environs, north to Kerry Head), cereal growing. The south Kerry region has a tradition of sheep farming, with six times as many sheep in the region compared with

North Kerry. The Dingle study site has a total of 170,053 hectares under pasture, and 1,052 hectares under crop (www.cso.ie).

Sources of Agricultural Pollution and Impacts on the environment.

The change in farming practice has increased the potential for run-off and leaching of animal manures, compound fertilisers and silage liquor, all of which can seriously downgrade water quality. Nutrients and organic wastes may be carried downstream in some catchments, which results in enrichment or deoxygenation in estuaries, coastal lagoons and bays. Silage effluent is often considered the most serious water pollutant, due to its high BOD demand (Boelens *et al.*, 1999). Silage liquor, manure slurries and sewage can often result in fish kills, caused by rapid deoxygenation and sometimes direct toxicity due to the presence of compounds such as ammonia and hydrogen sulphide. After flooding, run-off pollution of nitrates increases, and the bacterial count increases. The Upper Lee estuary (Tralee) is seriously polluted, due to run-off and the discharge of untreated organic effluent. The recent EPA survey indicates very high concentrations of BOD, ammonium and phosphate in the estuary (EPA, 2002).

5.1.2 Industry

Industries in Ireland have traditionally been attracted to coastal areas, due to the large proportion of the population that resides in these areas, and the resulting available workforce, well-developed services and transport infrastructures. The study sites in this project are however rural and industry has not developed on a similar scale as it has done in the major port areas such as Cork, Dublin and Shannon (Boelens *et al.*, 1999).

Types of Industry in the Region

The types of industries within both study sites are quite varied. The main industries in the Dingle site include craft and woodwork, electrical and household, and agricultural based manufacturing units (Kerry County Council, 2002). There are 20 information

technology industries within the study site, the majority of which are based around Tralee. There are 13 industries, which have been set up by foreign companies. A power generating station is located in Caherciveen in the Dingle site.

The Department of Communications, Marine and Natural Resources issues dredging and dumping licenses. Licenses for maintenance dredging operations are regularly provided for Fenit Harbour and Castletownbere Harbour.

One type of seaweed, Maerl (calcareous red algae), is dredged in a 30-hectare site east of Bere Island. It is used as a fertiliser, soil conditioner, poultry food additive, in water filters and in dietary supplements for humans and livestock. Extraction of the Maerl commenced in the early 1990's at Lonehart Point, Bantry Bay. The license allows no more than 5,000 tonnes to be extracted annually.

Bantry Bay is home to the only oil transshipment terminal in Ireland. Bantry Bay Terminals, which operate the Whiddy terminal, are holders of an IPC licence. There are a number of privately owned quarrying operations in Bantry Bay. Chippings are exported by sea from Bantry Bay to the UK, France, Germany, Holland Poland and Spain. Tarmac Quarries is located on the Beara Peninsula, at Leahill, east of Adrigole. The quarry is the largest of its kind in Ireland, with mineral reserves estimated at 120 million tonnes. The ships which service the quarry arrive unladen, meaning they are in ballast. There are two quarries within the Dingle study site, one in Tralee and another in Killorglin.

Sources of Industrial Pollution and Impacts on the Environment

Effluent discharging and licenses

Industrial discharges are generally small and most are included with the local sewage discharges. It is not permitted to dump waste at sea. In the past industries considered that proximity to the sea offered an advantage as regards waste disposal (Boelens *et al.*, 1999). Today industries must apply for Integrated Pollution Control licenses

(Section 3.1.2). This process will result in a reduction of waste load to the environment.

Licenses to discharge effluent into Bantry Bay have been issued by Cork County Council to a number of industries. The majority of these are aquaculture based, e.g. the processing plants. Others include discharges from an oil storage depot, sewage from a hotel, hostel and visitor centre and effluent from a milk creamery.

There have been 116 IPC licenses issued in Co. Cork by the EPA (Environmental Protection Agency), however, only one of these has been issued to a company in the Bantry Bay study site: Bantry Terminals Ltd., for the handling and storage of crude petroleum. Approximately 2,000 tonnes of water are discharged each year, containing some suspended solids (49kg in 1999, and 60kg in 2000) and a minor BOD (9.4kg in 1999 and 3.8kg in 2000). The licence also permits discharge of small amounts of mineral oils and phenols. In Co. Kerry 14 such licenses have been issued, 6 in the study site, for a range of activities such as the treatment or protection of wood using preservatives; the rearing of pigs in installations; the slaughter of animals in installations; the dyeing and treatment of fabrics and textiles; and the manufacture of synthetic fibres. Both quarries operating within the Dingle study site have licences to discharge into the nearby estuarine waters. Other industries licensed to discharge to nearby coastal waters include the power station, a safety bolt and zinc plating operation and a plastics manufacturer (www.kerrycoco.ie).

5.1.3 Tourism

Ireland's main attractions for visitors are the scenery, the people and the way of life. There are facilities to suit the active holidaymaker and the passive visitor. An estimated €3,174 million was earned nationwide in tourism during 1999. The number of people employed in tourism rose by 62% from 82,000 to 135,000 between 1990 and 1999 (Department of Foreign Affairs, 2002).

The Southwest Region

The southwest coast of Ireland, containing the two study sites, is among the most popular destinations in the country. Major tourist resorts in the study sites include Bantry, Glengarriff, Dingle, Castlegregory and Tralee. The coastal landscape is rugged with dramatic scenery. There are a large number of proposed Natural Heritage Area's (NHA's) within both sites. The sites were previously referred to as ASI's (Areas of Scientific Interest), which were mapped in the 1970's and numbered 1,500 by 1989. The majority of these sites were re-surveyed between 1992 and 1994 and listed as proposed NHA's. All proposed sites are important ecologically and the main conservation interests include plants and vegetation, birds and seals. Two NHA's in the Dingle site are particularly important, as they are habitats of the endangered Natterjack toad, *Bufo calamita*. Recreation pressure has been cited as one of the more frequent causes of damage to NHA's.

Blue Flag Beaches

Bathing beaches are one of the main tourist attractions to an area. The Bantry Bay site does not have any sandy beaches, due to the exposed nature of the site. The Dingle Bay site, however, is renowned for its extensive sandy beaches. Ten of the beaches in the site were awarded the Blue Flag in 2001. This is a European award, presented annually to beaches and marinas, which have high water quality standards, and are subject to fortnightly testing; industrial effluent and sewage must not affect the water of the beach or marina; beaches must be kept clean of algae and other vegetation accumulated in stormy weather; litter bins and garbage containers must be secure and properly maintained and first aid must be available. Water quality is monitored for Total Coliforms, Faecal coliforms, Faecal streptococci, Salmonella and Enterovirus. Table.12 below gives the EU mandatory limits and guideline limits for water quality.

Table.12: EU Water Quality Requirements (see notes below).

	Total Coliforms/100ml	Faecal Coliforms/100ml	Faecal Streps/100ml
EC Guideline Values	500	100	100
EC Mandatory Values	10,000	2,000	-
National Values	5,000	1,000	300

1. At least 80% of results are to be within E.C. Bathing Water Directive Guideline Values for Total and Faecal Coliforms.
2. At least 95% of results are to be within E.C. Bathing Water Directive Imperative Values for Total and Faecal Coliforms.
3. At least 90% of results are to be within E.C. Bathing Water Directive Guidelines for Faecal Values for Faecal Streptococci.

Source: www.corkcoco.com/ccmmm/services/envir/blueflag/wqresult.htm

Angling

Ireland's fresh and salt water sport fisheries are a natural resource with potential for further development. In 1999, 129,000 overseas visitors engaged in angling and contributed €64.12 million to the economy. The southwest coast is a popular area for sea angling (shore angling, inshore and deep-sea fishing). The main fishing boat season is from April-October, while shore angling extends to November. Boats can be chartered at Valentia, Dingle, Ventry, Ballydavid, Brandon and Fenit. The Bantry Bay site has good rock fishing and shore fishing. Deep-sea angling boats are based in Valentia.

Watersports

The southwest coast of Ireland is also a popular sailing and watersport holiday area, and is noted as a fine cruising area. The marinas at Dingle and Fenit provide a safe, sheltered location for mooring of yachts. Watersports such as sailing, surfing, windsurfing, and scuba diving are important tourist attractions. There are sailing clubs in Bantry, Dingle and Fenit. There are watersport activity centres in Ventry and Castlegregory offering surfing, windsurfing, sailing and canoeing etc. The southwest coast is an excellent surfing area, due to its exposure to the Atlantic swells. Kerry in particular has good year-round conditions, particularly beaches such as Inch, Sleat

Head, Brandon Bay, Banna strand and Ballyheigue. The southwest coast is also one of the best dive sites in Ireland, due to the clear waters. The most popular areas are west Cork; Valentia and the Skelligs; the western end of the Dingle Peninsula and the Blasket Islands; and the Magharee Islands and peninsula.

Walking Trails and Bird Watching

The scenery and rugged coastline are ideal for nature trails and hill walking. The Cork-Kerry tourism board has marked out a number of long distance trails, such as the Dingle Way (on the Dingle Peninsula), the Kerry Way (on the Iveragh Peninsula), the Beara Way (Beara Peninsula) and the Sheep's Head Way (Sheep's Head Peninsula). Each of the walks includes some coastal sections along cliffs and beaches. Bird watching is also an important tourist attraction. Colonies of seabirds can be observed on the Skelligs and in the Tralee Bay estuary. Tralee Bay and Castlemaine Harbour are internationally important wintering sites for waterfowl and as a result are considered special areas of protection (SPA's).

Resident Dolphin

A bottlenose dolphin, *Tursiops truncatus*, called Fungie, has been living in Dingle Bay since the mid-1980s. This has generated a number of local enterprises based around dolphin watching. Many visitors come to the area to enjoy a close encounter. One of the popular bathing areas, Sladeen, is an ideal vantage point to watch Fungie. He is also known to swim with those in the water and interacts with boats, which come out into the bay on dolphin watching trips. It is feared however, that tourism in the Dingle area is too dependent on Fungie, and alternative attractions are being developed. It is estimated that Fungie attracts over half a million visitors to the area each year. It is estimated that €381,000 is generated annually for the combined income of Fungie boat trips (Connolly *et al.*, 2002).

Irish coastal waters were declared a Whale and Dolphin Sanctuary in 1991. There has been an increased awareness of cetacean species in Ireland, possibly due to the arrival

of Fungie. Reports of stranded cetaceans are recorded by the Dept. Zoology & Animal, University College Cork, and post-mortems are carried out when possible. Stranded cetaceans are often recorded at both study sites. The most recent stranding was a live stranding event, which took place on March 23rd, 2002 in Castlegregory, Co. Kerry. A total of 39 Pilot whales, *Globicephala melas*, stranded on the beach. Locals managed to refloat 22 individuals, however 17 animals died. A further two animals died on the following day. A similar event took place in the same area, again involving Pilot whales, in 1965 when 66 animals live stranded.

Aquariums

There are two aquariums within the Dingle site: Fenit Seaworld and Mara Beo, Dingle Oceanworld. Both have fish on display, which are found locally, often caught by fishermen and returned to the aquariums. Both use seawater pumped in from the sea to fill their tanks. Oceanworld uses millions of gallons of seawater daily. In 1999, 100,000 tourists visited Oceanworld, while in 1996 55,000 visited Fenit Seaworld (www.kerrycoco.ie/ATLAS).

Sources of Pollution and Impact on the Environment

The increase in popularity of remote rural areas such as West Cork and Kerry, can impact on the environment in a number of ways. The increased number of holiday homes and caravan parks can put waste water facilities, which are often inadequate for the resident population, under added pressure. This can also put pressure on water supplies, and rubbish disposal, which can result in local pollution.

Water Quality and Sewage Systems

Tourism in Bantry Bay and the Dingle Bay is concentrated in the summer months. The resulting increase in population, if only temporarily, puts increased pressure on the local sewage systems. Bantry Bay has primary sewage treatment facilities, i.e. maceration. In Bantry town, sewage is pumped out into the Bay south of the town in a traditional bathing site. Septic tanks are the main waste disposal method in

Ballylickey and Glengarriff. Raw sewage is pumped out from the town into the harbour in Castletownbere (L. Duffy, Cork County Council, *pers. comm.*, 2002). The population of Castletownbere in the winter is approximately 1,500. In order to qualify for a treatment plant, the resident population must be over 2,000. However a Consultant Engineer has been appointed by Cork County Council to work on a sewage scheme for 2005. Septic tanks are the main form of sewage disposal in rural areas. This can cause problems if the tanks overflow and leach out into the ground.

A new wastewater treatment plant, capable of secondary treatment, opened in 1999/2000 in Tralee. The water quality in Tralee Bay has been examined on a number of occasions. Prior to the development of the treatment plant, untreated sewage had been pumped into the bay. There is also a disused dump on the estuary from which leachate is known to arise, the composition and quantities of which are unknown. (Boelens *et al.*, 1999). An ultra-violet facility for the treatment plant is also planned to further enhance the quality of the water being released into Tralee bay. There is also a wastewater treatment plant in Dingle, capable of primary and secondary treatment. The resident population in Dingle of 1,500 can rise to 8,000 in the July and August (Connolly *et al.*, 2002a). Primary sewage treatment works are located in Rossbeig, Castlemaine, and Milltown, with secondary treatment works located in Glenbeigh and Killorglin.

5.1.4 Shipping

Ireland has traditionally been dependent on maritime transport due to its geographical location. Seaports account for 95% of all trade in volume and handled 45 million tonnes in 1998 (Department of Foreign Affairs, 2002). Dublin and Cork are the main shipping ports in the country. The ports in the study sites mainly service fishing vessels and pleasure craft, such as yachts, angling charters, tour boats etc. Ports in the Dingle study site, e.g. Valentia, Cromane, Dingle, and Castlegregory do not carry out commercial shipping, but are often host to yachting competitions, such as the Dingle to Fenit events; Dun Laoghaire (Co. Dublin) to Dingle Race, which is held every two years; and the South Coast Cruising Association Annual race from Cork to Dingle. Fenit is the only port in Co. Kerry to carry out commercial shipping, exporting crane

parts and wood. In contrast, Bantry Bay experiences relatively large volumes of shipping traffic.

Bantry Bay

Bantry Bay is the location of Irelands only transshipment oil terminal, at Whiddy Island. It provides storage facilities for the Irish strategic oil reserve and for output from offshore oil fields in Irish coastal waters. The terminal handles both crude oil and refined oil products such as kerosene, gas oil and fuel oil.

The total number of vessels utilising Bantry Bay in 2001 was 170 (Bantry Harbour Commissioners, *pers. comm.*, 2001). The majority of these (67.65%) turned around in one day, the remainder departed after one to four days. These vessels originated in 18 different countries, with 35 visits from Norwegian vessels, and 30 visits from vessels originating in Antigua, the most frequent visitors. Data on the type of cargo and whether vessels were loading or unloading was not available.

Oil Spills

A number of significant oil spills have occurred in Bantry Bay, but there are few recorded spills in the Dingle study site. Table.13 below shows the major oil spills that have occurred in Bantry Bay.

Table.13: Known oil spills in Bantry Bay.

Date	Source	Volume of Oil (barrels)
Oct 1974	Tanker Universe Leader	18,000
January 1975	Tanker Afran Zodiac	3,000
January 1979	Tanker Betelgeuse	51,000
February 1990	Ore Carrier Tribulus	750

Source: Moore *et al.*, 1997

The most serious of these oil spills was the Betelgeuse disaster, when 50 lives were lost as a result of the associated fire. The large quantity of oil spilled resulted in

considerable damage to marine and bird life. The Whiddy terminal closed following the Betelgeuse disaster and reopened in 1998. Un-attributed oil spills are thought to be the result of illegal washing of tanks by oil tankers at sea.

Fishing vessels can also lose diesel fuel during incidents and this can result in localised pollution, e.g. up to 5,000 litres of diesel fuel were lost in one incident in Castletownbere in 1997 (Boelens *et al.*, 1999). The Celestial Dawn ran aground in Dingle Bay, in bad weather on February 3rd, 2002. The fishing vessel was carrying 39,000 tonnes of diesel and it was feared this would spill out into the Harbour. Immediate action was taken and booms were placed around the vessel to contain any spill. Only a small amount of oil spilled from the Celestial Dawn and the remainder was removed from the vessel using a special suction pump. The vessel was eventually removed from the rocks on March 5th 2002.

Oil is often perceived to be the major pollutant in shipping incidents, but it is not the only hazardous substance carried by sea. Other dangerous substances carried by sea include chemicals such as insecticides, herbicides, and fertilisers. The Irish Coast Guard, ICG, (formerly known as IMES: Irish Marine Emergency Services) are responsible for reporting and responding to marine pollution incidents. A zone has been set up around Ireland, within which the ICG responds to incidents. This is referred to as the IMPRZ (Irish Marine Pollution Responsibility Zone). Stocks of pollution equipment are stored in three sites around the country, including Castletownbere. There are 52 Coast Guard units around Ireland, with three located within the study sites; Dingle, Knightstown (Valentia) and Castletownbere.

Ballast Water

Discharge of ballast water from commercial ships and tankers is not controlled at present. It is suggested that ballast water be pumped ashore to protect the aquaculture in the area. Ballast water is normally taken on board in the country of origin and may contain living organisms and other substances. If released in Irish waters, these could pose a threat to the existing marine communities. Discharge of ballast water within Bantry bay is not permitted.

Marine Litter

The main sources of marine litter are sea-based sources, such as merchant ships, fishing vessels and land-based sources. Most of the Irish coast is continually littered with material from both sources. Remote and more exposed beaches are likely to have litter from sea-based sources, while on coasts near urban and tourist areas it is more likely to be from land-based sources (Boelens *et al.*, 1999). Plastics are the most common litter material, due to their widespread use and persistence.

5.1.5 Other sources of pollution

TBT

Tributyltin (TBT), an organotin, was used in the manufacture of antifouling paints during the 1970s. Organotins are very effective at preventing the settlement of fouling organisms on marine structures. However, they are also toxic to a range of animals and plants. It is now known that TBT can cause adverse effects such as poor growth and shell deformation and imposex (where females develop a penis) in molluscs. A ban was imposed in 1987 on the use of TBT paints on all vessels below 25m in length and on aquaculture installations. Concentrations of TBT have been found to be quite high in the Bantry Bay area, with concentrations highest in Castletownbere Harbour, Glengarriff Harbour, Leahill Terminal and Bantry Harbour. Within Castletownbere Harbour, TBT levels were found to be the most significant. Dogwhelks, *Nucella lapillus*, used as an indicator of TBT pollution, were absent from the inner Harbour. The four sites are perhaps the busiest as regards boat traffic within the area, with large numbers of pleasure craft, fishing vessels, merchant ships and oil tankers utilising the area. TBT has a half-life of a 1-6 months to 2 years in water, but sediments may act as a reservoir. As a suitable alternative has not been found, in some cases vessels larger than 25m continue to use TBT as an antifoulant (www.seanine.com/hull/impact/impactstudy/)

Heavy Metals

During a study of the sediments in Bantry Bay, high concentrations of mercury and lead were found in the surface sediments (Nixon, 1997). Such contamination would be expected to have detrimental effects on sediment-dwelling species. The reason for the high metal concentrations is not clear. Concentrations of copper, zinc and lead were found to be high in Tralee Bay. This was thought to be as a result of residues remaining in the sediment from an electroplating industry in the 1970s (Moore *et al.*, 1997).

Harmful Algal Blooms

Phytoplankton species occasionally multiply rapidly and can be found in high densities called a “bloom”. Blooms are sometimes visible at the surface as coloured patches. A small number of phytoplankton species produce toxins. These toxins can adversely affect any organism, which directly or indirectly feeds on them. This can affect humans, as shellfish accumulate the toxins. The toxins can result in a number of illnesses, such as Diarrhetic Shellfish Poisoning (DSP), Paralytic Shellfish Poisoning (PSP), and Amnesic Shellfish Poisoning (ASP). Foam caused by blooms of certain species can foul beaches and lead to their closure. Water around the coast is tested for the presence of the phytoplankton species, particularly in areas where shellfish are cultured. Bantry Bay was been closed on average 23.1% of the year between 1991 and 1997 due to the detection of harmful algal toxins in the water (Section 6 for details on impact of HAB’s on shellfish industry in Bantry Bay).

Fishing

There are six important fishing ports within the study sites, Bantry and Castletownbere in the Bantry Bay site and Portmagee, Dingle, Castlegregory and Fenit in the Dingle site, along with a number of smaller ports. In the Bantry site it is estimated that there are approximately 70 vessels in the local inshore fleet. There are an estimated 155 vessels in the inshore fleet in the Dingle site. Offshore boats and

foreign fishing vessels also use the ports in the study sites to land their catches. For further details on fishing activity see Section 7.

Sources of Fishing Pollution and Impacts on the Environment

As mentioned previously, fishing vessels can potentially pollute the environment in a number of ways. They can be the cause of localised oil spills, either accidentally or following impacts with other vessels; they may also be sources of marine litter. Fishing boxes and discarded fishing nets are frequently washed up on coasts. A “startling rise” has been noted by Dubsy *et al.* (1998), since 1989, in the quantities of fishing related plastic waste items such as fragments of ropes, floats and ropes found on beaches.

Aquaculture

There are aquaculture installations in both study sites, with shellfish and fish species being farmed. The Bantry Bay site farms mussels, oysters, salmon, and scallops. Oysters, mussels, scallops are farmed in the Dingle site. For further details see Section 6.

Sources of Aquaculture Pollution and Impacts on the Environment

Shellfish and finfish farms were identified as large contributors of litter on adjacent shores (Dubsy *et al.*, 1998). Along with litter from the fishing industry, articles such as oyster bags were also found on beaches. There are also concerns due to the visual impact of aquaculture installations in scenic areas. This is particularly of concern in areas such as the southwest coast of Ireland, where the scenery is of importance as regards tourism revenue. Rearing of fish such as salmon in cages carries the risk of some fish escaping. This could lead to problems of genetic pollution of the local fish stocks. However, the effects of escapes on wild populations have not yet been identified.

6. AQUACULTURE ASSESSMENT

6.1 Aquaculture Production

The environmental impacts of aquaculture depend greatly on the methodology of production and on the location of the aquaculture site. There are two major forms of aquaculture production, extensive and intensive. Extensive aquaculture production involves growing stock on the seabed at relatively low densities, without the aid of supporting artificial structures. This method of aquaculture production is carried out in the Kerry study site. Intensive aquaculture production involves growing stock at high densities within artificial structures, such as ponds, cages or on lines. If the species being farmed intensively is a fish species, they are completely dependent on the farmer for feed and often treatment with antibiotics to maintain a healthy population at high densities. This method of aquaculture production is carried out in the Bantry Bay study site.

Aquaculture farm site selection is influenced by factors such as water quality, exposure, access and competition for use of resources. The environmental impacts of aquaculture farms will be reduced in areas of good depth, and adequate tidal flushing, compared with sheltered sites, where waste may accumulate.

Aquaculture production in Bantry Bay

Table.14 gives aquaculture production by species (tonnes and '000 euro) for Bantry Bay in recent years.

Rope grown mussel culture

There are 21 licenced mussels growers operating within Bantry Bay. Some of these have more than one site; however the majority of production takes place in and around Whiddy Island and Glengarriff Harbour/ Garinish. Culture techniques are

intensive and involve the use mainly of floating surface long lines which are moored in sheltered waters. Production is heavily concentrated in some areas and in recent years competition for space has meant that mussel growers are moving out from the sheltered areas of the inner Bay and placing long lines in more exposed areas (Garforth and FitzGerald, 1996). This has necessitated the implementation of new production techniques so as to ensure the security of stocks grown in the more exposed environment outside of the inner bay. Most notably this has centered on the use of sub-surface long lines, whereby mussel lines are suspended at a depth below the surface which ensures less damage or influence from the surface conditions. New techniques have largely been successful and have improved the potential of Bantry and other less sheltered sites within Bantry Bay and other areas for increasing output from the sector. In 1998, the total volume of production of rope grown mussels within Bantry (inner and outer Bays) was 3,058 tonnes at a value of €2.4 million. A slight decrease was observed in 1999 when 3,001 tonnes were produced at a value of €1.5 million (www.bim.ie).

Bantry Bay Seafood's Ltd. and Fastnet Mussels Ltd. are the two largest commercial rope mussel growing companies in Bantry Bay. Bantry Bay Seafood's was established in 1991 and produces over 4,500 tonnes of mussels annually. These are vacuum packed and frozen with the natural juices within the shell, enabling a year round supply. A new manufacturing facility was opened in 1999 at a cost of €10.2 million, and this is expected to double the production capacity of the company to 50 tonnes per day and increase the current workforce from 60 to 120 (Bantry Bay Seafood's, 2002). Fastnet Mussels Ltd. was established in 1983 in Gerahies, Bantry. The production capacity is 1,000-1,500 tonnes per annum for markets in the UK, Europe and Asia. There are currently 19 full-time employees and 5-25 part-time (Fuchsia Brands Ltd., 2002).

Problems facing the existing mussel industry within Bantry Bay are competition for space for further expansion, and of greater importance, toxic algal blooms ('red tides'). Naturally occurring toxins from phytoplankton accumulate in filtering bivalves and may cause Diarrhetic Shellfish Poisoning (DSP) resulting in sickness and diarrhea in affected persons. Routine testing of shellfish (rat bioassay) is

undertaken by the Marine Institute and may result in closure of the shellfish waters for weeks, or longer in extreme circumstances, for example 10 months over the 1993-94 season (Garforth and FitzGerald, 1996). As well as causing marketing and production problems, closure for considerable periods of time may lead to losses encountered through mussels slipping off lines under their own weight and through tube worm fouling. Losses encountered in the South West region in 1994 were estimated at £1.3 million, prompting BIM to offer emergency aid to the most affected mussel growers (Garforth and FitzGerald, 1996). Compensation for further losses sustained by producers during 1999 was once again paid to producers in 2000. Nevertheless, the continuance of the red tide and toxicity problems poses greater threats to the industry in the long term and its overall viability. Compensation packages while perhaps mitigating some of the short term implications of closures to some degree will not of them selves deal with the issue of closures, which are a significant threat to the future stability of the mussel growing sector.

Table.14: Aquaculture production by species & value, Bantry Bay for recent years

	Production Data						
	Tonnes/nos smolts			Value 000 euro			no. establishments/operators
	1998	1999	2000	1998	1999	2000	
Finfish Aquaculture							
Salmon On growing	4514	2665	680	14962.56	9509.442	2476.5	2
Salmon Hatchery	150,000	150,000	150,000	190500	190500	190500	1
Shellfish Aquaculture							
Mussel (<i>Mytilus edulis</i>)	3058	3001	369	2411.75	1488.13	226.6	25
Pacific Oysters (<i>Crassostrea gigas</i>)	4	2	0	5715	2540	0	3
Scallops (<i>Pecten maximus</i>)	0	5	N/A	0	16510	N/A	3
Black sea-urchin (<i>Paracentrotus lividus</i>)	0	0	0	0	0	0	0

Oyster culture

While mussels are the major aquaculture species in Bantry Bay, three companies cultivate oysters. All are situated in Castletownbere and one, Shellfish de la Mer, undertakes joint mussel and oyster cultivation. BIM production figures for the Pacific oyster (*Crassostrea gigas*) in Bantry Bay for 1998 are four tonnes, with a value of €5,713. In 1999, this fell to a volume of two tonnes with a value of €2,539 (Mr. J. Clarke, BIM, pers. comm., 2002). Whilst some indigenous hatchery-produced Pacific oysters are available within the South West region, quantities are not sufficient to support the industry. Most juveniles are imported from the UK and France, ranging from 3mm in size. These then undergo nursery rearing until they reach approximately 30mm, when they are placed in bags on inter-tidal trestles (Garforth and FitzGerald, 1996).

Scallop culture

Three companies cultivate scallops within Bantry Bay. Bantry Bay Inshore Fishermen's Association undertakes extensive scallop cultivation. Beara Inshore Fishermen's Co-op Society Ltd. undertake intensive scallop production (and also lobster enhancement) while Seal Harbour Enterprises cultivate scallops with mussels. BIM production figures for mature scallops in 1999 were five tonnes with a value of €16,506 (Mr. J. Clarke, BIM, pers. comm., 2002). Though a relatively new culture species within the South West, interest has been aided through the provision of pilot and capital grants from BIM (Garforth and FitzGerald, 1996).

Sea urchin culture

Cultivation of sea urchins is at present on a very small scale, using techniques similar to those in abalone culture. Sea urchin hatchery and on-growing are being investigated at pilot scale in a small number of sites within the South West, including Bere Island (Garforth and FitzGerald, 1996).

Fin-fish culture

Salmon (*Salmo salar*) is the only fin-fish species cultured at four sites within Bantry Bay. Two sites are owned by Eir Nor Teoranta, Cuan Baoi Fisheries Ltd. are a salmon hatchery, whilst Cuan Baoi Seafarm Ltd. are salmon on-growers. Beara Atlantic Salmon Ltd. in Castletownbere also on-grow salmon, whilst Coomhola Salmon Trust Ltd. provide a salmon hatchery. In order to avail of economies of scale for the purposes of farming the largely exposed sites, Salmon are reared in very large flexible rubber sea-pens which are designed to withstand the level of exposure encountered at these sites within Bantry Bay and which may hold up to 300 tonnes of fish per cage. Coomhola Salmon Trust were engaged in sea ranching investigations for Atlantic Salmon and ran a restocking programme for local rivers feeding to Bantry Bay.

Prior to 1996, approximately one fifth of Irish Atlantic salmon production originated from the South West (Garforth and FitzGerald, 1996), this being mainly from Bantry Bay. BIM production figures for salmon production in Bantry Bay in 1998 are 4,514 tonnes at a value of €14.96 million. In 1999, these figures had dropped to 2,665 tonnes at a value of €9.5 million (Mr. J. Clarke, BIM, pers. comm., 2002). As a component of overall national salmon production, it is likely that Bantry Bay has lagged behind the other main areas of production in more recent years which has seen significant growth in the sector in Co.'s Galway, Mayo and Donegal. Restrictions on production and difficulties with licensing issues for new sites will constrain further growth within this sector in the future in Bantry Bay.

Aquaculture production on the Dingle Peninsula

As with Bantry Bay, conditions found along the Dingle Peninsula support mussel culture, and indeed, this is the dominant species of culture within the study area. However, as will be illustrated, production figures for aquaculture along the Dingle Peninsula are much lower than those encountered within Bantry Bay. Table.15 gives

aquaculture production by species (tonnes and '000 euro) for Dingle Peninsula in recent years.

Mussel culture

There are 20 mussel operators along the Dingle Peninsula. Of these, the majority are centred in Cromane (12 operators) and all undergo extensive cultivation. The remaining operators are found in Castlemaine, six listed as extensive, one as bottom reared (extensive) and one using the 'bouchot' method of culture.

Table.15: Aquaculture production by species and value, Dingle peninsula for recent years

	Production Data									
	Tonnes/no of smolts					value 000 euro				
Finfish Aquaculture	1996	1997	1998	1999	2000	1996	1997	1998	1999	2000
Salmon On growing	0	0	0	0	0	0	0	0	0	0
Salmon Hatchery	1,000,000	1,000,000	1,000,000	1,200,000	1,200,000	1,270,000	1,270,000	1,270,000	1,524,000	1,524,000
Shellfish Aquaculture										
Mussel (<i>Mytilus edulis</i>)	550	3300	2445	1208	1787	219.646	1212.85	922.274	467.017	761.8
Oysters (<i>Crassostrea gigas</i>)	131	74	222	232	122	165.036	935.99	278.542	291.338	271604

Oyster cultivation

There are eight oyster cultivators to be found along the Dingle Peninsula and production figures for those in Castlemaine alone are far greater than from Bantry. There are five oyster production sites in Castlemaine and three in Cromane. Those in Cromane combine both mussel and oyster culture, whilst two sites in Castlemaine grow oysters alone.

Clam culture

One smallholder cultivates clams in conjunction with oysters. There is only a limited production of clams in the South West and only some 30 clam producers in Ireland in total. The majority of these grow clams as a second species alongside other shellfish as the dominant species (Garforth and FitzGerald, 1996).

Fin-fish culture

Mussel cultivation is predominant along the Dingle Peninsula. Only one fin-fish farm is listed in the Irish Aquaculture Guide (La Tene Maps, 2001), Eir Nor Teoranta in Ballyhea, which is a salmon hatchery.

6.2 Impact Assessment - Environmental Review of conditions relating to Aquaculture in Bantry Bay and Dingle Peninsula.

Marine finfish and shellfish cultivation has increased in Ireland over the past 35 years to the point where it is now a significant industry in terms of output and therefore potential environmental impact. Development has taken place largely on the western and southern coasts, with localized activity in other areas also outside of these. At many locations both finfish and shellfish cultivation occurs in close proximity to each other. Shellfish cultivation techniques employed are in the main extensive and rely on natural systems for primary food production and do not utilize chemotherapeutics or pellet feed. Finfish cultivation involves inputs of commercially prepared fish diets, chemotherapeutics and antifouling chemical treatments.

Inputs to the marine environment from mariculture can be classed into three main types:

- Organic matter inc. waste food, dissolved nutrients and faeces
- Chemotherapeutics such as dichlorvos, antibiotics
- Chemical antifoulants such as copper based applications

This section of the report concerns environmental sustainability and aims to identify positive and negative effects of aquaculture development on the local physical marine environment. The report collates and reviews data available on environmental quality in the vicinity of aquaculture developments in the study areas. This includes data on water quality and marine biota, inputs/outputs from aquaculture facilities and other anthropogenic and natural sources, data on bathymetry including sediment types and marine currents. Gaps in knowledge in relation to environmental data will be identified where these are found to exist.

6.2.1 Data on existing aquaculture production, feed input and nutrient/organic emissions

Production data

The method of production greatly influences the impacts of aquaculture on the environment. Production data for the various species produced by aquaculture from Bantry Bay and Dingle Peninsula are presented previously in Table.14 and Table.15 (section 6.1).

Bivalve culture generates faecal and pseudofaecal material (biodeposits) and large scale culture can generate considerable quantities of organic particulate material. Grentz *et al.* (1991) have estimated that approximately 600 kg of particulate biodeposits (faeces and pseudofaeces) are generated for each tonne of production (measured as wet weight). Table.16 and Table.17 give estimated production of faeces and pseudofaeces for Bantry Bay and Cromane for recent years based on Grentz, C. *et al.*, 1991. Figures are for mussels only, other species produced are oysters and scallops however production volumes are insignificant (<10 tonnes).

Table.16: Production of mussels, Bantry Bay and particulate biodeposits *based on Grentz *et al.* (1991)

<i>Year</i>	1998	1999	2000
Production <i>Mytilus edulis</i> (t)	3058	3001	369
Faeces & Pseudofaeces* (t)	1835	1800	221

Table.17: Production of mussels, Cromane and particulate biodeposits *based on Grentz *et al.* (1991)

<i>Year</i>	1996	1997	1998	1999	2000
Total production (oysters and mussels) (t)	681	3074	2667	1440	1909
Faeces & Pseudofaeces* (t)	407	2024	1600	864	1145

Within the study sites, shellfish production could have a number of potential environmental impacts. These depend on the method of cultivation, and method of harvesting. Potential impacts include:

- Loss of non-target organisms, when dredging;
- Loss of food in the form of washed-up small mussels;
- Damage to the mussel bed;
- Changes in the composition of the sediment and benthic community;
- Disturbance to birds by boats (disturbance to, or loss of, roosting/nesting sites);
- Increased food supply to predators;
- Phytoplankton depletion;
- Clearance of rocks and seaweed to allow access to farms;
- Introduction of exotic organisms.

Feed Usage

Whereas shellfish production tends to utilise natural productivity in the water column, fin-fish farming is usually intensive and relies on nutrient addition to the water. Waste feed from fish cages, faecal matter, and soluble nitrogen compounds in urine lead to a net addition of nutrients in the water column. Organic waste tends to accumulate beneath and in the vicinity of cages, resulting in nutrient enrichment and may lead to changes in the benthic community. The impact of organic enrichment may be localised or widespread, varying from site to site depending on rates of tidal flushing.

Intensive salmonid aquaculture in Bantry bay is the only aquaculture activity dependent on inputs of manufactured pellet feed in both study sites. These are normally high protein (<45%) commercially prepared fish diets. While precise figures for quantities of feed utilized in this type of aquaculture are not available, estimates can be derived by relating industry norm food conversion ratios (FCR) for the salmon industry in Ireland to total output of the sector (tonnage); where

$$\text{FCR (Food Conversion Ratio)} = \frac{\text{weight of fish produced (whole) tonnes}}{\text{weight of feed utilized (tonnes)}}$$

It has been estimated (see Ackefors and Enell, 1994, and references cited therein) that production of one tonne of Atlantic salmon in Scandinavian countries generates more than 80 kg of soluble nitrogen (ammonium), 7.5 kg soluble phosphorus and 1300 kg particulate carbon. Table.18 below shows figures for salmon production and corresponding input of commercially prepared feeds based on an FCR of 1.25, and emissions of ammonia, soluble phosphates and particulate carbon based on the above output figures for recent years for Bantry Bay. No salmonid aquaculture takes place in the marine environment of the Dingle Peninsula.

Table.18: Production and estimated emissions for salmonid culture, Bantry Bay (*: based on Ackefors & Enell, 1994).

<i>Year</i>	1998	1999	2000
Salmonid Production (t)	4514	2665	680
Feed usage (t) est.*	5642	3331	850
NH3 (t)	361	213	54
PO3 (t)	34	20	5
Particulate Carbon (t)	5868	3465	884

It must be considered that since many of the inputs into commercially prepared salmonid diets originate from marine foodstuffs, to an extent salmonid culture acts as a net remover of nutrients from the sea. While this is the case on a general scale, the siting of aquaculture operations in coastal waters and embayments may result in the addition of nutrients, primarily through feed wastage, to the local ecosystem.

The loss of food and fish products (faeces and ammonia) from fin fish cultivation represents significant input of nutrients and organic material to the local environment. Boelens *et al.* (1999) estimate that the total organic waste from salmonid mariculture is estimated to have a population equivalent of between 250,000 and 500,000 fish. The first comprehensive review of the impacts of mariculture in Ireland was carried out by Gowan (1990). Similar assessments have been carried out in Scandinavia and North America where broadly similar conditions for salmonid mariculture exist. The overall consensus from these studies is that the hydrodynamics of mariculture sites dictate the potential for organic enrichment and associated impacts. Stratified, semi-enclosed water bodies with poor water exchange are most at risk from mariculture

activity. In Ireland, the majority of salmon farms are located in shallow bays with good tidal exchange facilitating the dispersal of wastes and waste by-products and this helps to maintain the water quality. Bantry Bay would be a prime example of the siting of such mariculture sites. At such sites impacts tend to be confined to the area directly beneath the cages (Boelens *et al.*, 1999).

Nutrient/ Organic Emissions

The most complete record of water nutrient chemistry and related characteristics for salmonid culture sites in Bantry Bay is that compiled by Hensey Glan Uisce Teoranta. This monitoring was conducted as part of a routine monitoring programme for sites belonging to Beara Atlantic Salmon. Data is available for temperature, oxygen levels, chlorophyll, salinity, silicate, ammonia, nitrate, nitrite, total Nitrogen, phosphate and total phosphorous for stations sampled at depths of 0, 10 and 20m, as well as for a control station in Bantry Bay. These records are corroborated by annual environmental impact assessments by the Environmental Group, Institute of Aquaculture, Stirling University between 1989 and 1994. The following observations, applying to sites in Bantry Bay were made by Watermark Aqua-Environmental in their Environmental Impact Assessment for Beara Atlantic Salmon based on the data available:

Ammonia is the main nitrogenous excretory product of fin fish culture. In cage measurements of ammonia suggest a seasonal peaking of ammonia levels to the maximum safe level of $4.3\mu\text{g-at/l N}$, at pH 8.1 and 13.4°C at times between April and August. Peaks in levels are thought to be short-lived and largely mitigated by diurnal tidal movements and changes in weather conditions. Ammonia concentration peaked at a control site in Bantry Bay at up $7.4\mu\text{g-at/l}$ in August-September 1993. Along with a chlorophyll peak the previous month and unseasonally a peak in silicates in August, the most likely explanation for this is a dinoflagellate bloom occurrence. Apart from this isolated observation, ambient ammonia concentrations lie within the range expected in northern temperate waters. Summer in-cage peaks while undesirable from a fish husbandry point of view, appear to be rapidly dispersed and

assimilated into the local environment. Nitrate and nitrite levels all show strong natural, seasonal variation. This natural flux dwarfs any aquaculture input and is due mainly to winter upwelling of deeper waters.

There is no data available to suggest either that ambient nitrite has been elevated by oxidation of ammonia of fish farm origin or that nitrite, nitrate or total nitrogen have occurred above normal background levels.

Phosphate and total phosphorous exhibit a normal seasonal fluctuation, with a tendency to peak during the winter months. This is due to the contribution of shallow water nutrients rising from upwellings in deeper water and subsequent assimilation of inorganic phosphate into primary production the following spring.

The data reveals a difference between inorganic phosphate and total phosphorous. This indicates the ambient level of organic phosphorous containing compounds. While these may originate from a number of sources including freshwater discharges into the bay or fish farming activity. Seasonal fluxes in these differences suggest that the dominant source of organic nitrogen and phosphorous is primary production. There does not appear to be any evidence which suggests an unsustainable contribution to nitrogen and phosphorous levels from aquaculture.

Chlorophyll levels indicate phytoplankton abundance. Organic nutrients, particularly those emanating from fish farm sites in Bantry Bay are not at levels that are likely to sustain high densities of phytoplankton.

Taking the water nutrient record overall, there is a strong similarity between farm and control site levels in Bantry Bay for all nutrients, with no upward trend expressed over the period of monitoring. This suggests that the discharge levels from salmonid aquaculture are well within sustainable levels. Nevertheless, there may be a need for farms to address seasonal acute farm-generated ammonia peaks by altering and husbandry techniques and farm management.

Hensy Glan Uisce Teo has also monitored physico-chemical features of the waters at fish farming sites in Bantry Bay on behalf of Beara Atlantic Salmon since 1990.

Parameters monitored include dissolved oxygen, salinity, temperature, clarity (by Secchi depth) and silicate. As a whole, monitoring was monthly until 1994, by which time clear patterns of variation had been established. After this, the monitoring was reduced to cover the most important periods of the year and this generally excluded the winter months. Once again, a control site was monitored also for the purposes of comparison. Control site data demonstrate that the majority of data collected at the sites result from natural trends rather than as a result of any influence arising from the sites themselves.

The data sets that have been amassed for sites belonging to Beara Atlantic Salmon are unique to the area. The data would appear to support the belief that finfish aquaculture is sustainable in the area from the point of view of water quality.

Estimates of nutrient inputs from mariculture are mostly based on finfish farming activities where prepared fish diets are utilized. Nutrient input from shellfish cultivation activities are not generally considered as significant as these rely totally on food availability from primary productivity. Moreover, shellfish cultivation can be seen as a net remover of nutrients from the culture area.

Use of Chemotherapeutics

No data are available for types or quantities of chemicals used in fin fish aquaculture in Bantry Bay. However the situation with regard to types of chemicals used is likely to be similar to that of other parts of Ireland and other countries with significant marine fin fish cultivation industries. In Norway, where information on chemical use in aquaculture is compiled, it is apparent that antibiotic use fluctuates significantly from year to year. However in terms of unit production, the general trend is downward in Norway due to an increasing reliance on vaccination, improved husbandry techniques and improvements in drug efficacy. The trend in this regard in Ireland is less clear due to the lack of data collection, however informal discussion and anecdotal information with aquaculturists suggest that the case would be similar for Ireland and Bantry Bay with respect to use of chemotherapeutics in recent years.

Use of organophosphates such as dichlorvos (the main active ingredient in NUVAN) is of concern as these are known to have adverse environmental effects (Gesamp, 1991). However the use of dichlorvos has declined significantly in recent years due largely to the licensing of Cypermethrin (product name EXCIS) and Emamectin benzoate (product name SLICE), which can be incorporated into prepared fish diets, for use in parasite control in finfish mariculture in Ireland. In 1990 one farm in northern Donegal was known to have used 1642 litres of organophosphate pesticide (Boelens *et al.*, 1999). In 1994 the same farm used only 4 litres. In 1994 a farm in Bantry Bay utilized only 1.6 litres of dichlorvos for pest control. This supports indications of an overall decrease or elimination of the use of dichlorvos in mariculture in Bantry Bay. Table.19 lists chemicals used in Irish mariculture (from SIME2a. 1997). This data is somewhat outdated in that Dichlorvos and Ivermectin are no longer used within the industry in Ireland.

Table. 19 Chemicals used in Irish mariculture (from SIME2a. 1997)

In Feed	Bath	Antifoulants
Oxolinic Acid*	Dichlorvos*	Copper*
Oxytetracycline*	Cypermethrin	
Amoxicillin*		
Sulphadiazine/thimethoprim*		
Fenbendazole		
Ivermectin		
Diflubenzuron		
Teflubenzuron		

*: authorized chemicals

In the case of antibiotics administered in the feed, it is difficult to estimate net inputs from faeces as these depend on uptake rates in fish under an intermittent administration regime. Inputs of antibiotics to the marine environment of Bantry Bay via routes associated with mariculture are likely to be highly variable and dependent on a number of influencing factors. Nevertheless, levels of antibiotics have been measured in the vicinity of Irish salmonid farms (Coyne *et al.*, 2001) suggesting that inputs may have been significant at some sites in the past. No data are available to highlight recent trends.

The widespread use of inhibitory compounds in aquaculture has generated fears about the potential release of the bioactive component into the aquatic environment. In the case of antibiotics, this could damage biological filters in recirculating systems. Recent published data suggest that only 20-30% of antibiotics are actually taken up by fish from medicated food; thus, approximately 70-80% reaches the environment (Samuelsen, 1989), notably from uneaten medicated food (Jacobsen and Berglund, 1988). With oxytetracycline in seawater, it has been established that degradation proceeds rapidly (Samuelsen, 1989). However, most oxytetracycline becomes bound to particulates, and is deposited at the bottom of (or beneath) the fish holding facilities in the case of marine cage sites. Within the sediments, oxytetracycline may remain in concentrations capable of causing antibacterial effects for 12 weeks after the cessation of treatment (Jacobsen and Berglund, 1988). Such antibiotic containing sediment affects the fauna. For example, detectable levels of oxytetracycline have been found in blue mussels (*Mytilus edulis*) which were located 80 m from a fish farm using this antibiotic (Møster, 1986). The fate of oxytetracycline (OTC), the most commonly utilized antibiotic in salmon aquaculture in Ireland, and its impacts on the environment around a salmon farm in Outer Bertraghboy Bay, Co Galway was investigated Coyne *et al* (2001). In the case of the salmon farm investigated in this work, there were clear indications that sediment deposition was not the fate of the greater part of the OTC used in therapy. However, analysis of the data obtained suggested that the greatest concentrations in the environment, and therefore the greatest biological impacts, occurred in the sediment beneath the cages. Moreover, all but traces of these residues disappeared within one month after the end of therapy. Estimates of the concentration that may occur in the water column would suggest that even if all the OTC were to remain in the water column, it is unlikely that it would ever reach biologically significant concentrations. The overall conclusion from this study is that OTC residues do not persist or disperse so widely that their use in the treatment of cage-reared salmon offers negligible risk to the marine environment, or to human health.

Use of Antifoulants

The use of antifoulants occurs in mariculture operations in Ireland for the purposes of maintaining good water circulation in fish cages and for preventing the fouling of plant and equipment such as boats, feed rafts and barges by marine organisms. Use of antifoulants occurs both in marine shellfish and finfish cultivation activities in the study areas. Prior to 1987, the biocide TBT (tributyltin) was commonly used in antifouling paints. While this has become illegal and the use of these compounds has ceased in mariculture, copper based antifoulants have replaced TBT based compounds for use in mariculture antifoulants. Nets are frequently dipped in an antifoulant wax before being put in place on sea cages. Anecdotal information suggests that nets treated in this manner may be put to sea for periods of up to 9 months without being significantly fouled. No data are however available for use of copper (5%) based antifouling paints and other preparations in mariculture in Bantry Bay. Boelens *et al.* (1999) estimated that for a 1000 tonne farm based in Lough Swilly, Co Donegal up to 33,000 litres of copper based antifoulant was applied annually to nets in recent years. Based on a leaching rate that resulted in a loss rate of 20% of copper to the aquatic environment it is estimated that 330kg of copper would be added to the environment every year.

Review of Benthic conditions and seabed characteristics

Benthic organisms, and most especially the macrobenthos, are important to overall ecosystem structuring and functioning. They have little or no locomotory powers. Therefore, in order to survive they must be capable of tolerating prevailing local environmental conditions or they will die. As a result, these organisms are good indicators of the health of the benthic ecosystem. Their taxonomy is well documented and there is available a large body of research literature on their responses to pollution and disturbance effects. It is mainly for these reasons that benthic organisms are useful in marine environmental impact assessments. As sediment type and grain size are considered to be the most obvious correlative factor for studies of sedimentary

infauna, benthic surveys need to address not just the faunal components, but also the sedimentary profile of a study area.

Neiland and McMahon (1999) collected samples from 18 different stations in and around Bantry Harbour, Glengarriff Harbour and along the north shore of Whiddy Island in Bantry Bay, for analysis for grain size, organic carbon and the presence of benthic infauna. Two of the locations (Bantry Harbour and Glengarriff Harbour) correspond with the location of large numbers of mussel longlines and indeed these areas are the centre of mussel farming industry in south-west Ireland. Both these areas are known to have relatively weak water currents (Barry *et al.*, 1988) being typically <10cm/sec. The third sampling location lay some distance between the two locations and away from any mussel farming activity.

The study generated granulometric data for all sample locations. This identified both Bantry and Glengarriff Harbours as being non-dispersive sites where fine sedimentary material may accumulate. In contrast, samples collected off Whiddy Island contained relatively high amounts of medium to coarse sand. Data generated in respect of benthic communities reveals that despite the occurrence of echinoderms which are known to be very sensitive to increased organic enrichment, when viewed as a whole Bantry Harbour appears to be in an intermediate phase between slight environmental stress and broadscale pollution.

Similarly, the authors found that the benthic community in Glengarriff Harbour also appeared to be at a transitory phase between normal and polluted conditions. This was reinforced by an absence of echinoderms from the study area. In this location the dominance of polychaete worms and cirratulids in particular is indicative of high environmental stress. All three stations sampled off the northern shore of Whiddy Island exhibited a very healthy faunal composition, with no evidence of environmental stress being detected in the study.

The authors acknowledge previous research which links mussel cultivation to the production of large amounts of pseudo-faeces and faeces which effectively increases organic enrichment. This can lead to a decrease in the diversity of infaunal assemblages with the original macrofauna (especially echinoderms) being replaced by

opportunistic polychaetes. The authors do not ascribe the dominance of polychaetes encountered in Bantry and Glengarriff Harbours entirely to the presence of the mussel farming industry. Polychaete dominance was noted not only in the vicinity of mussel longlines, but also at stations some distance from mussel longlines. Additional inputs of organic matter into Bantry Bay come from domestic, agricultural and industrial waste discharges as well as from mussel production. The relative importance of each of these sources of enrichment have however to date not been quantified.

No data on benthic conditions were available to the author for the purposes of examining the impacts of aquaculture around the Dingle Peninsula, the other area of study. However, given that the main water body in this study area – Dingle bay- is also a Ria and is somewhat similar to Bantry Bay from a geographical and hydrographic point of view, it would be reasonable to suggest that fin fish farming activities would have a similar environmental impact as those encountered generally at sites Bantry Bay. If this activity were to commence in Dingle Bay, similar constraints and similar technologies and practices as existing fin fish farms in Bantry Bay should be practised.

Shellfish production is the main aqua cultural activity on the Dingle Peninsula. This is focused on production of mussels and to a lesser extent oysters. Mussel production techniques in Castlemaine and Cromane are fundamentally different to those employed in Bantry Harbour and Glengarriff Harbour. Whereas mussels are grown in suspended culture in Bantry Bay, production techniques in Cromane and Castlemaine rely on the management and reseedling of established natural mussel beds in these areas. Mussels are grown on large intertidal and sub-littoral flats and are harvested using mechanical harvesters. The fact that the mussel beds are naturally occurring implies that the fishery is sustainable and that the emissions of organic wastes and faeces as well as pseudofaeces are within the carrying capacity of the area. The mechanical harvesting process in itself ensures to some degree that the seabed is harrowed on an annual basis and this helps to prevent the build up of excessive pseudo faeces and associated enrichment. Other than the harvesting of supplementary seed mussel by dredging further out in the Bay for relaying on inshore beds there is little or no inference with the natural production process of mussels in Cromane and

Castlemaine. Consequently there is a complete lack of environmental data availability for this area.

Redox Potential & Organic Carbon

Between 1990 and 1994, Stirling Institute of Aquaculture measured Redox potential and the percentage of total carbon and total nitrogen in the sediments at a number of Beara Atlantic Salmon sites in Bantry Bay. The ratio of C:N was used as one measure of organic enrichment. Redox potential and organic carbon were measured as part of the study on diver collected samples. In some case there were no sediments to be collected as the farm was located over patches of rock. In other cases sediments were so coarse and well compacted that only shallow samples could be collected. The sampling transect ran straight through the Roancarraig site starting 100m west of the cages and finishing 100m east of the cages. Results showed all redox profiles being positive at the surface, with the discontinuity layer (point at which redox values change from positive to negative) variously occurring between 2 and 7 cm depth. Organic carbon percentage varied from 0.82 – 1.16%. Samples at each extremity of the transect gave the most positive redox values, whilst those under some of the cages gave the most negative with the discontinuity layer occurring at between 2 and 3 cm. No matching trend was seen in organic carbon readings, which overall showed little impact and variation across the transect. In August 1990, cages had only been on site for a few months. A transect line conducted through the cage area revealed reduced species diversity and increased individual abundance, dominated by pollution indicating taxa, including *Capitella* and *Malacoceros*. The numbers of individuals found and the redox and carbon data suggest highly localized, minor nutrient loading at the time. In August 1991, the pattern was found to be similar although worsening redox indicated a higher impact. Results in February 1993 revealed a small improvement but this is attributable at least in part to the winter weather conditions prevailing. By August 1993, redox measurements were all negative revealing anoxic conditions in under cage sediments to the extent that background fauna had been completely excluded and that fallowing was required. The situation worsened by July 1994 conditions were the poorest on record judged in terms of Redox which showed anoxia C:N ratios, outgassing, the presence of *Beggiatoa*, presence of feed and faeces

and the coincident reduction in species diversity and high numbers of opportunistic polychaetes.

Some minor visual evidence of impact could be seen under some of the cages during the taking of redox measurements, with darkened sediments, isolated patches of *Beggiatoa* spp., H₂S gas smell and feed and faeces present.

Additional data for this site reveals that the Redox measurements taken in 1998 represent an improvement over those last taken in 1994, when data shows the redox level to be at 2cm. Levels in 1998 compared best with those taken in 1989, when fish biomass on the site was lower. It must be said however, that at the time of sampling in 1998, most fish had been harvested from the site and sampling took place one month later than in 1994. Nevertheless, redox measurements would appear to have improved on this site over the years 1994-1998.

In summary, the redox and total organic Carbon levels in September 1998 at Roanarraig were better than those on most previous occasions. The degree of organic enrichment of the seabed was indicative only of a minor level of impact resulting from fish farming activities.

The possibility exists that the presence of a large seasonal fleet of factory processing ships which anchored in the Roanarraig/Berehaven Sound area in the early part of 1998 and also previous years resulted in the addition of nutrients and organic detritus and fish offal to environment. The possible scale of this is unknown but is considered to be potentially large as up to 50 large processing vessels have been anchored there on occasion for periods of up to 3 months. This phenomenon no longer occurs as the fleets have moved off to other areas and no longer come to Bantry Bay. However the possibility that these vessels contributed significantly to the enrichment of the sea bed in and around the site of Beara Atlantic Salmon must be considered. No Redox or organic carbon data were collected from the Doonbeg site due to the lack of bottom sediments at this site, as this site is located over rock.

The location of the vast majority of salmonid aquaculture sites off the Irish coast is fundamentally different compared to that of Norway and Scotland. Irish salmon farms

are in the main located in shallow waters where there is significant tidal flushing and moderate current speeds, and this applies to conditions at fish farm sites in Bantry Bay. The major impacts of fin fish farms are generally confined within a localized area around the farm site. The Irish Salmon Growers Association commissioned a review of benthic conditions on marine fin fish farms in Ireland in 2002 (see ISGA, 2002). The aim of the review is to report on benthic conditions under as many fish farm sites in the country for which information is available. In reviewing benthic conditions and data for fish farm sites in Bantry Bay, the report concludes that these sites are located in exposed to semi-exposed areas. Consequently, moderate currents (0.1-0.5m/sec) prevent the accumulation of fine material. Redox depths are 5-10cm and most under cage locations have relatively healthy benthic status.

Phytoplankton

Boelens *et al.* (1999) reviews available data in relation to the marine biota of Irish waters and contains information of relevance to the study areas of Bantry Bay and the Dingle Peninsula. The phytoplankton ecology of the stratified off shore waters of the Atlantic shelf to the west and south-west of the study areas have been studied in reasonable detail (e.g. Dooley, 1973; Roden, 1984; Roden and Raine, 1994; McMahon *et al* 1995). The later study reports diatoms to be predominant in the waters of the shelf area to the south west of Ireland in spring. There is also some evidence of the existence in April of a flora representative of warm waters underlying the dominant species (McMahon *et al* 1995). The summer phytoplankton of the stratified Atlantic shelf has been described by Raine *et al* (1993b) and be divided into early (June to mid July) and late (mid July to September) phases reflecting the gradual development of the thermocline which occurs at 35-40m off the coast. In the late summer dinoflagellates, particularly *Ceratium* species, and the diatoms *Rhizosolenia alata* and *Leptocylindricus mediterraneus* dominate the phytoplankton. Further inshore, microflagellates are common (Roden and Raine, 1994), but phytoplankton is generally sparse.

Two distinct phytoplankton communities (offshore and inshore) can be observed due to the presence of an offshore ocean front. This has been described in the southwest

region by Raine and Joyce (1995). The summer phytoplankton at stations west of the front comprise small dinoflagellates and microflagellates. Diatoms have also been recorded here. Inside the front the phytoplankton exhibit a greater species biomass and diversity, with dinoflagellates being the dominant group.

The prevailing hydrographic conditions of the western seaboard of Ireland typically exhibit offshore summer stratification, while inshore waters tend to be shallower and exhibit more mixing. An exception to this however is the complex physical and biological oceanography that occurs at the south western tip of Ireland, the area with which this study is concerned. Phytoplankton ecology within this area has been particularly well described (e.g. Raine *et al.*, 1990; Goward and Savidge, 1993). Phytoplankton biomass and general productivity in this area is enhanced by periodic episodes of coastal upwelling and associated fronts that can cause rich blooms of diatoms (Raine *et al.*, 1990). Exceptional dinoflagellate blooms in the bays and inlets of the south-west coast can contribute further to the complexity of the phytoplankton biology of the area (Raine *et al.*, 1993b). Episodes of upwelling at the mouth of Bantry Bay may support higher levels (up to three times more) of biomass and primary production during summer months than offshore waters (Raine *et al.* 1990). Highest water column biomass and daily production values in the south-west of Ireland have been recorded at the mouth of Bantry Bay. These high levels have been associated with dense populations of the dinoflagellates, *Gyrodinium aureolum*, and to lesser extent diatoms.

The impacts of the occurrence of blooms with potential toxicity for humans from the point of view of consumption of shellfish are significant, in that official monitoring of shellfish waters frequently results in whole bays and areas being closed to the harvest of shellfish for extended periods. In some cases closures have been in place for 10 consecutive months. This has had significant economic impacts on the aquaculture industry in the study areas, where a large portion of the value of aquaculture production comes from mussels. While serious for mussel farmers, blooms of the dinoflagellates, *G. aureolum* have in the past resulted in kills of fin fish (both wild and cultured) and invertebrates in some bays in the south west of Ireland (O'Sullivan, 1978; Ottway *et al.* 1979). These kills have been attributed primarily to the deoxygenation of waters during the decay of the bloom; however there appears to be

evidence of the involvement of biotoxins. *Gyrodinium* related kills of caged rainbow trout in Dunmanus Bay to the south of Bantry Bay during 1978, 1979 and 1981 led to the abandonment of the bay as a site for finfish production.

The Marine Institute has an ongoing monitoring programme for phytoplankton since the 1980's. There are three monitoring centres around the country; Bantry is one of these sites. This allows shellfish waters to be monitored closely for the presence of toxic algae. Closures of shellfish waters due to algal blooms can cost the industry significant amounts annually. In 2001, a model was used the Marine Institute to forecast algal bloom events. Plankton monitoring (on a weekly basis) was supplemented by current meters, and temperature sensors deployed in Bantry Bay. Analysis of the physical data with local meteorology (wind speed and direction) showed the influence of wind direction on water exchanges, as well as the link between corresponding influx of toxic species and contamination and closures of shellfish operations. This provided a reliable method indicating exchanges of water and phytoplankton. In July 2001, for example, a shift in water temperature near the seabed of 3°C was accompanied by an influx of *Dinophysis* spp. and resulted in shellfish harvest closure due to DSP toxin contamination (www.marine.ie). This pilot study in Bantry Bay in summer 2001 demonstrated the benefit of having a continuous record of temperature at various depths beneath salmon cages and mussel lines in the bay. The Marine Institute propose to extend the temperature logger work to other sensitive aquaculture bays around the Irish coast. It is hoped that within a year a comprehensive database of temperature changes will be established and related to routine phytoplankton sampling and biotoxin monitoring (www.marine.ie).

6.3 Relative Importance of Aquaculture Nutrient Loads

6.3.1 Environmental impacts of aquaculture in the study areas

Impacts of aquaculture activities on the natural environment in any area are assessed under a broad range of topics including physical and chemical impacts on the water column, impacts on the sea bed, visual and aesthetic considerations, impacts on and interactions with indigenous flora and fauna including potential genetic interference with wild populations and control of animal diseases, the introduction of new and/ or unwanted species, waste and litter management considerations, navigational and spatial issues.

Ultimately, all of these issues play a role in determining the long term sustainability of aquaculture in any area. Many of these issues are relevant in relation to any onshore installations as well as to any sea based installations and need to be considered in this context as part of an overall assessment. In the case of the study area, there are well established finfish and shellfish farming industries in these areas.

From the point of view of the natural environment, there are clear impacts on the benthic environments of Bantry and Glengarriff Harbours from the data, which show both areas to be on the brink of broadscale pollution based on assessments of the benthos. It would appear that there is a need for fallowing of mussel farming sites in addition to harrowing of the sea bed to mitigate impacts associated with the buildup of faeces and pseudofaeces in this area. The intensity of output of mussels and the density of longlines themselves need to be reviewed. Many mussel farmers are aware of this and have begun to take remedial action by moving to more exposed locations in outer Bantry Bay. It is considered essential that changes be introduced in order to protect the environment and ensure that there is no drop in output from longline mussel culture in Bantry Bay. In the case of these harbours however it must be considered that significant inputs of nutrients and suspended solids also occur from discharges of municipal sewage, and that these have a relative role to play in the pollution of the harbours also. This may be particularly true in the case of Bantry Bay, which has only recently commenced primary treatment of sewage entering the bay.

In terms of fin fish aquaculture, problems have been encountered in the past with organic build up beneath fish cages in Bantry Bay, particularly at sites near Roanarraig. These chiefly occurred in the mid 1990's and since then improved fish husbandry practices and rotation of sites have served well in mitigating localised nutrient loading impacts. Studies on the dispersal properties of the hydrographic conditions prevailing in the area suggest that finfish farming is sustainable but requires proper management and control.

From the point of view of physico-chemical properties of the waters of Bantry Bay there appears to be no detectable environmental impact from available data. Inputs of nutrients into the bay associated with aquaculture activity are not significant and indeed the shellfish industry is effectively a net remover of nutrients from the waters. Occasional temperature related oxygen deficiencies within fish cages associated with raised ammonia levels have caused difficulties for finfish culture in the past; however this occurrence has been eliminated largely through improved husbandry practices.

Inputs of chemicals into the environment are associated in particular with finfish culture activities. As mentioned previously, overall reductions in quantities of chemicals utilized have been achieved in general through the use of vaccination and improved practices such as year class separation and reduced stocking densities. However quantities of antibiotics principally oxytetracycline (OTC) continue to be used on finfish farms. While this is not an enduring chemical once introduced into the marine environment, research work in other areas has shown that this chemical can become a contaminant in mussels located some distance from farms. Past indiscriminate and illegal use of Ivermectin for control of lice in farm salmon has ceased with the licensing of effective similar treatments for use in salmon farming. Strict controls on inputs of this chemical are maintained by the authorities. The use of organophosphate compounds such as dichlorvos has now ceased completely as a treatment for sea lice infestation in fin fish aquaculture in Ireland, and inputs of this chemical through aquaculture have consequently been eliminated. Separation of year classes has reduced lice infestation levels and ensured improved health in stocks of finfish by reducing the potential for the transfer of disease between year classes.

TBT based antifoulants are no longer used in aquaculture, although levels of this metal continue to be raised in Bantry Harbour sediments in particular, along with concentrations of other heavy metals. Reasons for this are unclear and investigations of this phenomenon are ongoing by the Fisheries Research Centre (Marine Institute, Dublin). There is no data to suggest that this has its origins in aquaculture activity. Copper based antifoulants are utilized in the antifouling of nets and farm plant and equipment. Significant inputs of copper may occur in the region due to the presence of the fish farm and more importantly a very large fleet of large offshore fishing vessels in the nearby harbour of Castletownbere, however this needs further investigation before a full assessment of this factor can be made. The actual input of copper emanating from aquaculture is however likely to be small when compared to that resulting from the presence of the fishing fleet nearby.

From the point of view of land based installations and impacts on infrastructure, finfish farming operations in Bantry Bay largely utilize existing infrastructure in the fishery harbour of Castletownbere, and the largest company has its land base on Dinish Island in the harbour, an area zoned for commercial development. A smaller company utilizes a largely disused fishery pier on the southern shore of Bantry bay at Gerahies as its base for operations, as well as the main pier in Bantry. The mussel farming industry utilizes existing infrastructure at Bantry and Glengarriff Harbours and to a lesser extent that of Gerahies pier. Several processing plants have been established to carry out mussel production in the Bantry area. There are waste management and disposal issues associated with these processing facilities. The Irish authorities are presently reviewing the handling of seafood processing waste on a national strategic scale and this is likely to have implications for the shellfish processing industry as a whole.

Interactions between aquaculture and indigenous marine biota have not been the subject of extensive investigation in the study areas; however the data that are available do not support major general concern over this issue. To some degree this may be due to effective measures aimed at controlling this impact being operated by fish farms. In the absence of appropriate measures aimed at limiting interactions between wild and farm biota however, there is potential for negative impacts. For example, experience in other areas has shown that where escapes of farm stock occur,

significant long term impacts on native salmonid populations can result from the interbreeding of wild and farmed fish. This has potential to spread disease and may weaken the genetic identity of discrete strains of salmonids. These concerns are the subject of extensive research on an international level. There are wild salmonid rivers entering Bantry Bay, most notably the Coomhola River. Anecdotal data suggest that salmon originating from fish farms have been caught in this river. This supports the findings in many other locations along the western seaboard of Ireland. Localised impacts on sedimentary and macrobenthos directly beneath fish cages have also been recorded, and this is also the case in relation to mussel longlines. Impacts are believed to be temporary and persist only for a limited time after farms have been fallowed or moved to another location. Some concerns have been expressed in the past in relation to the location of the site of Cuan Baoi Fisheries in the context that this may actually be in the area of a significant herring spawning bed in Bantry Bay.

No data are available which would allow an assessment of the impacts of aquaculture on phytoplankton communities in the study areas. Apart from possible localised impacts on phytoplankton biomass and productivity associated with the release of relatively small amounts of nitrate and phosphate nutrients into the water column from finfish farms, there is nothing to suggest that aquaculture activities in the study areas are having a noticeable or detectable effect on the phytoplankton of the areas as a whole, although it is likely that phytoplankton biomass is reduced in areas close to shellfish farming operations due to the filter feeding activity of these organisms. Evidence in support of this is largely circumstantial and no confirmation of this can be made without further investigative work.

In the case of finfish farms, diving birds such as gannets and cormorants can cause significant losses especially of salmon smolts, as can herons. All these species are protected and therefore cannot be destroyed legally. Measures aimed at limiting their impacts must therefore be taken and implemented. Large numbers of gulls have been attracted to finfish farms also where they have proved successful scavengers of excess feed and feed which does not sink and remains on the surface. Effects of this can be mitigated by controlled feeding and improved quality control in the feed manufacture process.

The aquaculture activities of Castlemaine Harbour and Tralee Bay are not known to be of any general concern from the point of view of chemical inputs or nutrient loading of the environment and no data exist to support any concern. In the case of Castlemaine, the management and enhancement of naturally occurring mussel beds are the main focus of aquaculture. Therefore impacts of this on the environment are believed to be fully sustainable. The presence of oyster trestles in the intertidal zone does create some visual impact, but in general these are of necessity located beneath Mean Low Water Spring tide level and are therefore visible only during short periods around the lowest spring tides. Effects of predation can be mitigated by the location of mussels beds so as that they remain covered by the tide most of the time. It is therefore felt that little impact on seabird populations result from aquaculture activities in the study areas. Few if any known interactions occur with respect to indigenous biota. The decline in populations of the Light-bellied Brent Goose, which over winters in both Castlemaine Harbour and Tralee Bay, are not believed to be associated with aquaculture activity.

Aside from the SPA's and SAC's mentioned previously, other coastal areas have been designated with conservation status in the Bantry Bay area including Roanarraig Island and Sheeps Head, and the tip of the Beara Peninsula and Dursey Island. A contentious issue in the context of protected areas and aquaculture in Ireland at the moment is the fact that the European Commission is taking legal action against Ireland for failing to comply with EU environmental legislation in its aquaculture licensing process. In two separate legal warnings, the Commission has outlined that Ireland failed to implement the Environmental Impact Assessment (EIA) Directive in the Kenmare River Special Area of Conservation (SAC). Ireland also failed to apply the requirements of the Wild Birds and Habitats Directive in its Fisheries legislation to protect designated habitats and species. The main issues covered by the first warning letter sent by the Commission on the EIA Directive are the lack of compulsory EIA for trial licenses and the use of arbitrary thresholds in sensitive areas. The Commission explains "impacts will arise from the outset, through factors such as use of chemicals and build up of waste sediments on the sea-bed". The main issues covered in the second legal warning, relating to non-compliance with the Wild Birds and Habitats Directive, are the lack of reference in the Irish legislation on Fisheries to

respecting and implementing the requirements of these major Directives. Referring to a Birdwatch survey published in 2000, the Commission states that 26 per cent of aquaculture operations were located in Special Protected Areas (SPAs) and shell fish farming operations were licensed in 84 per cent of SPA's. These issues are of relevance to the areas which are the focus of this study and are likely to result in further tightening of controls placed on shellfish activities in particular in these areas.

While many important issues are addressed in the data, there remain some issues which have fallen outside the focus of this review as little or no hard data exist in relation to these. For example, there are ongoing concerns in relation to the location and density of mussel longlines in both Bantry and Glengarriff Harbours. Many people and users of the waters in the area feel that there are too many longlines present and that they have been granted permission without due consideration for other users and established navigational rights. There are also legitimate concerns in relation to visual impacts. To this end, the pilot Bantry Bay Charter (www.bantrybaycharter.ie) project has designed and implemented a conflict resolution forum which provides a means for local participation in the management of the coastal zone in and around Bantry Bay. As regards visual impact, the mussel barrels are being changed from blue in colour to grey. This colour change has improved the visual impact of the barrels considerably.

Measures to mitigate the impacts of coastal aquaculture have been taken by most operators in the study areas. In the case of siting of installations, finfish cages have been located in positions that reduce their potential effect on navigation and which reduce their visual impact. Sites selected are correspondingly offer varying degrees of shelter from waves and storm conditions in order to minimize potential escapes of fish into the natural environment. Finfish cage installations are in the main all of the Bridgestone type flexible rubber cage which has proved extremely enduring and capable of withstanding the worst conditions. Sites selected for use for finfish culture in Bantry Bay all have current speeds in excess of 0.1m/sec. This optimizes sustainable dispersion and dilution of farm wastes.

Recent trends in the positioning of mussel lines have seen some operators move out of the sheltered calm waters of Glengarriff and Bantry Harbours and into more exposed locations with improved current flow in outer Bantry Bay. This should aid the dispersion of faeces and pseudofaeces from the lines which has become a valid environmental issue and concern with respect to present farming sites. New technologies in mussel line operation have assisted farmers in producing sub-surface longlines. These significantly reduce visual impacts, which has been cause for concern amongst the wider populace and tourism interests in these areas. The moving of some mussel lines out of the confined harbours will also mitigate navigational concerns as outer Bantry Bay has considerable capacity and is a larger expanse of water.

Visual impacts of salmon cages are kept to a minimum by the siting of cages and the use of appropriate colours and larger cages (which reduce the number of cages required). Mooring systems are in general kept within the confines of licensed site areas and visual impacts associated with surface buoys have been minimized by the use of appropriately sized and coloured buoys.

In order to reduce disease, environmental impacts and risks of mass fish mortality, finfish farms have adopted single generation site operation and fallowing of sites and improved overall fish husbandry techniques which see environmental conditions within the cage structures themselves being maintained at optimum levels. This also serves well in controlling sea lice infestations and mitigates organic loading and allows for site recovery. The vaccination of fish against certain diseases reduces antibiotic usage and goes some way to mitigating potential fish health problems. Regular veterinary support also assists in stock health management and disease prevention on fish farms.

While all efforts are taken to avoid mass mortality of fish on fish farms in the areas, responsibility for dealing with such an occurrence however remains with the operator of the farm. Once an event has been registered with the Department of Communications, Marine and Natural Resources and the South Western Regional Fisheries Board, finfish farms generally have standing arrangements with renderers for the disposal of mass mortalities in such an emergency. Procedures to deal with the

occurrence of an escape of farm stock require similar reporting as above. Finfish farms are required to work with the authorities to determine the exact nature and scale of any escapes of stock and must co-operate with any programme to attempt to recapture the stock which may be ordered by the regional fisheries board. Similar requirements apply in terms of notification should farms discover unexplained shortfalls in stocks during harvest or other farm operations.

Anti predator measures employed now utilize bird nets to prevent predation from the surface and reduce the interactions with birds, which often involve protected species such as herons and gannets. The use of underwater predator nets assists in the prevention of predation by seals on fin fish farms. Occasional nuisance seals however do still cause losses and in the past individual seals have been destroyed under licence, as seals are protected species in Irish waters.

7. FISHERIES ASSESSMENT

Both study sites lie along the North East Atlantic seaboard within the International Council for the Exploration of the Seas (ICES) Sector VIIj, the Great Sole. While this situation affords local fleets ready access to the area's deep-water fisheries, the AQCESS project focuses on activities in inshore waters.

In Ireland, inshore fisheries are officially defined as those prosecuted within twelve nautical miles of shore. Inshore vessels are defined as those 15m and less in length (BIM, 1999). However, the operational range of vessels officially defined as inshore (particularly those greater than ten metres in length) frequently extends beyond twelve nautical miles from the coast (BIM, 1999). Equally, vessels regarded as offshore may also fish in waters within the twelve nautical mile limit. While individual log sheets must be completed daily for each vessel fishing for quota species under the CFP, official records are aggregated to show only total landings by port. In addition, current legislation requires only vessels of greater than ten metres in length to complete log sheets. Therefore the definition and analysis of fisheries within the waters of the study sites cannot be carried out with precision.

The majority of fish landings into both study areas originate from offshore waters, ranging from Rockall in the northwest Atlantic, to the Azores and including all Irish coastal waters. These landings and their associated economic benefits cannot easily be separated from those originating in local inshore waters. For example, there were 55 offshore vessels operating from Castletownbere in Bantry Bay in 1999, with an average crew per vessel of six men. These vessels provide full-time employment for 335 fishermen on whom an estimated 250 local families are dependent (Nautical Enterprise Centre, 2000). As such, the offshore fleet contributes significantly to the economic sustainability of the area directly, and also indirectly via related processing and service industries. The volume of activity generated by the fleet also contributes to the survival of the inshore fleet, through the fish sales and processing infrastructure that would not be viable based on the volume of inshore landings alone. Conversely, there may also be conflict between the two sectors competing for the same stocks of fish.

7.1 Landing sites and inshore fleets

Bantry Bay

There are four official fish landing sites in Bantry Bay, included in the DoCMNR fisheries landing statistics. They are Bantry, Castletownbere, Glengarrif, and Garnish/Travara. Castletownbere is the largest of these and is nationally significant, in particular for whitefish landings. As a designated Fisheries Harbour Centre, Castletownbere is under the direct management of the DoCMNR.

Inshore fishing in Bantry Bay is concentrated in the waters along the south coast of the Beara Peninsula from Adrigole to Dursey Head and around three rocky islets lying northwest of Dursey Island at the western end of the bay (Figure.2). In 1999, there were estimated to be 40 inshore vessels under 10m and 30 vessels over 10m in length operating in the vicinity of Bantry Bay. These vessels are berthed at Castletownbere, Garnish, Bere Island, Adrigole, Lehanbeg and Ballycrovane (north coast of the Beara peninsula). The vessels generally operate within three nautical miles of the shore with a maximum operational distance of 18 nautical miles, targeting mainly crustacean species, though pelagic and demersal fish species are also caught. Table.20 provides a summary of inshore fishing activities in Bantry Bay throughout the year. The inshore vessels are generally crewed by one or two persons. The industry is believed to be the sole source of income for sixty families in the Bantry Bay region and represents over 50% of the income for a further ten families. (V. McCarthy, Bantry Inshore Fishermen's Co-op, *pers. comm.*, 2000).

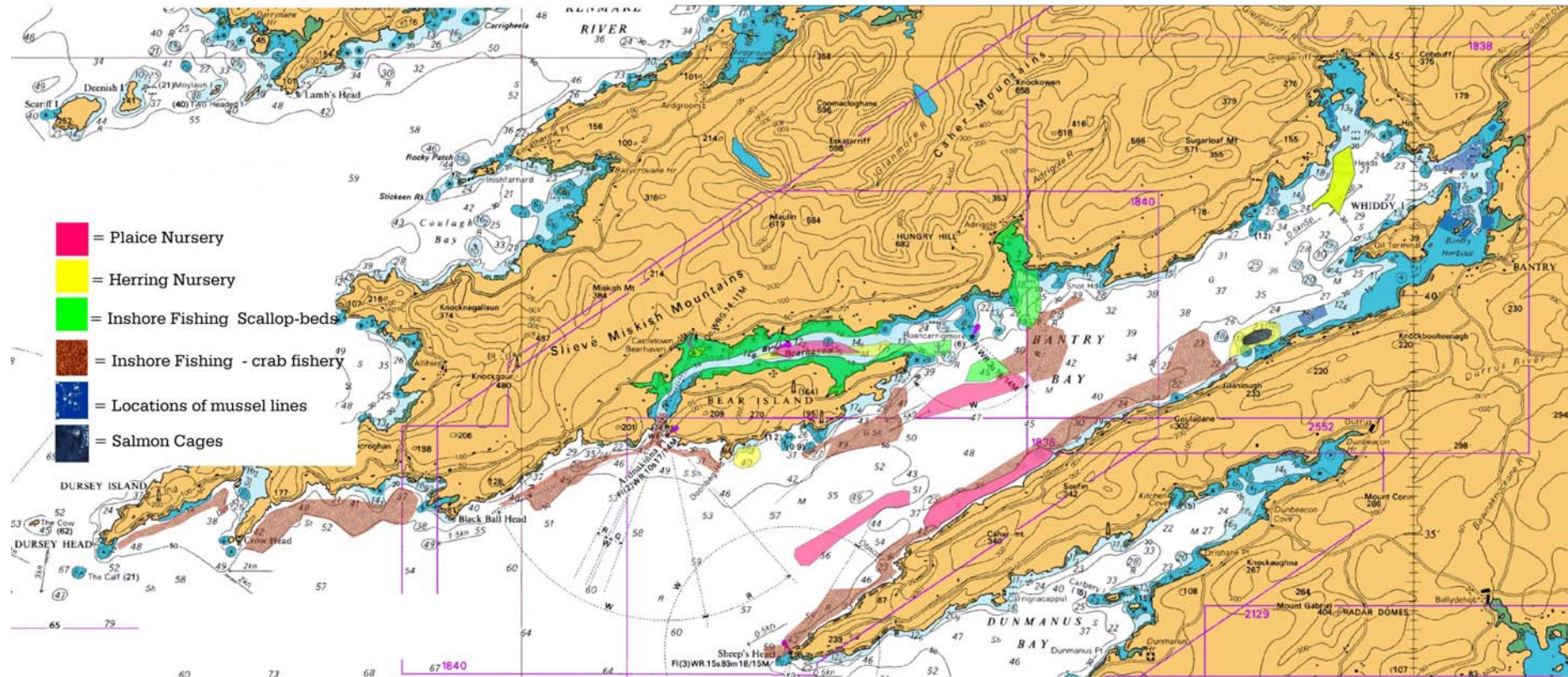


Figure.2 Chart of Bantry Bay showing approximate location of mussel lines and the approximate inshore fishing grounds and their respective species (Source: Nautical Enterprise Centre, 2000).

Table.20: Target species and season for inshore fisheries in Bantry Bay (listed in order of importance, as identified by local fishermen).

Order of Importance	Target Species	Fishing Season
1	Scallops	October – March
2	Shrimp	August – January
3	Lobsters	May – December
4	Brown crab	May – December
5	Velvet crab	All year
6	Prawns	April – May
7	Salmon	June – July
8	Herring	October – March
9	Sprat	November – March
10	Mackerel	May – October
11	Ray/skate	All year
12	Plaice, Dover sole, megrim, pollack, etc.	All year

Fish processors in Castletownbere provide the most important immediate market for catches from the inshore fishing industry followed by fishmongers. Europe represents the greatest export market for produce from inshore fishing in the bay; France is the most important market, followed by Spain, the UK, Germany and the Netherlands.

Dingle area

The official fish landing sites in the Dingle area include Fenit, Ballyheigue, Castlegregory, Cromane, Dingle, Portmagee, and Valentia (Knightstown). Local DoCMNR officials were consulted for details of the local inshore fleet. In the Dingle area, there are estimated to be approximately 85 vessels engaged in lobster potting; 45 vessels fishing predominantly with gill nets or trawls and 25 vessels officially licensed to fish salmon.

7.2 Fishing methods

The types of fishing gear deployed in the study areas and the respective target species are summarised in Table.21. Active fishing methods using mobile gear include the

deployment of demersal otter and midwater pair trawls, seine nets, draft nets and dredges. Vessels greater than 12m typically engage in trawling, operating at speeds of between three and six knots. Static gear used in the study area consist of gillnets and a variety of pots with occasional use of tangle nets, long lines and jigging lines.

7.3 Tonnage and values of inshore species landed

The inshore fleet targets high value finfish and shellfish species (crustaceans and molluscs) from fishing grounds typically within three nautical miles of the shore. In order to overcome the difficulty of disaggregating inshore catches from the total catches of all sectors recorded in the official DoCMNR landing data, it was decided to examine catch trends of species from habitats that were most likely to occur within twelve nautical miles of the shore. A total of one molluscan (king scallop), eight crustacean (crayfish, lobster, spider crab, edible crab, velvet crab, Nephrops and palmeaon shrimp) and six fin fish species (herring, mackerel, whiting, Dover sole, plaice and salmon) were selected. The recorded blue mussel landings relate to aquaculture and were therefore excluded. The analysis is based on statistics from 1990-1997 and 1999 (reflecting data availability) for the selected species extracted from the national landings statistics provided by the DoCMNR.

Table.21: Selected characteristics of the inshore fishing fleets in the Irish study areas. (Sources: BIM, 2001; DoCMNR landing statistics).

Target species	Gear type	Number of vessels	Season	Catch, where available (1999) (tonnes)
Bantry Bay				
<i>Nephrops</i> ; Demersal species	Demersal	4	All year	10 280
Sprat	Mid-water pair trawl	2	November - March	
Scallop	Dredges	20	October - March	68
	Gill nets	2	Spring/summer	40
	Tangle nets		December	6
Crab	Creel	20	April – September	83
Lobster				56
Crawfish				1
Palemonids	Shrimp pot	20	September – January	89
Periwinkles	Hand picking	17	All year with emphasis September – January	16
Dingle area				
Sole, whiting, monkfish, ray, etc.	Demersal	8	November-September	
Salmon	Drift nets	22	June – July	75
Salmon	Draft nets	26	June – July	12
Oyster, scallop	Dredges	30	November – January	
Dogfish, hake	Gill nets	15	April – October	
Turbot, crayfish	Tangle nets	15	January – September	
Spider crab, lobster, brown crab	Creel	70	March – November	
Shrimp	Shrimp pot	25	July – November	

Molluscan species

The king scallop (*Pectin maximus*) is the main molluscan species targeted by inshore fishermen in the study areas. Figure.3 shows a sharp decrease in king scallop landings after 1993. This is attributed to a decline in the availability of seed spat in

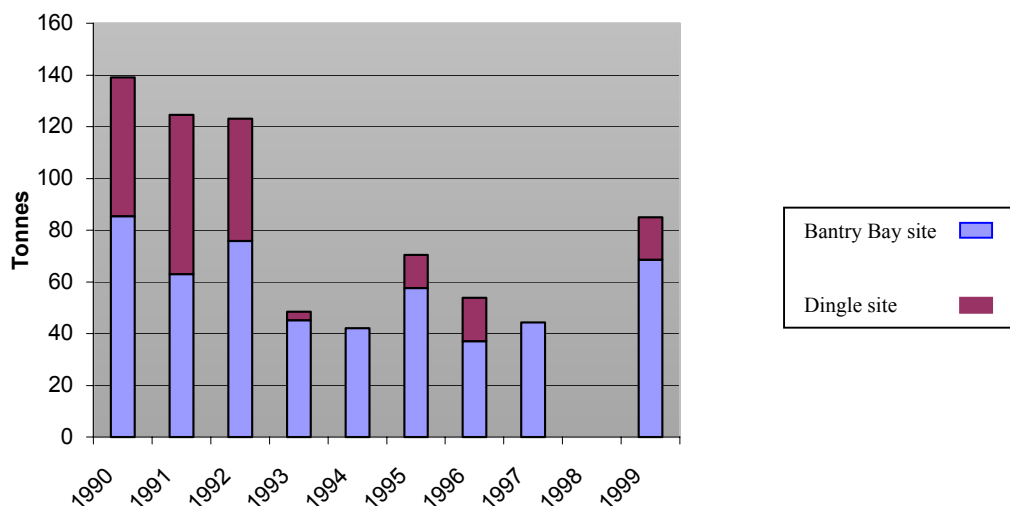


Figure.3 Landings of king scallops in Irish study sites. Source: DoCMNR

the area. Collection of scallop spat in Bantry Bay is not believed to be commercially viable (Maguire and Burnell, 1999) due to significant annual variation and marine fouling of collectors. Spat is purchased from Mulroy Bay in the north of Ireland for the scallop fisheries in both study areas.

The Valentia Harbour Fisheries Co-operative Society operates an enhancement programme for the local scallop fishery. The society has 30 local inshore fishermen as members, working 15 boats. Scallop spat is laid out in trays and put out to sea. The trays are graded in November and in the spring, before the beds are seeded. Licences to dredge scallops are issued to individuals who have also invested their time in the preparation of spat trays and seeding of scallop beds. A licence entitles each fisherman to fish 910 (75 dozen) scallop per week. The scallop-dredging season runs from December to January, targeting the Christmas market. A minimum size of 13cm has been set by the co-operative, above the European Council minimum size of

11cm, to increase the marketable quality of the scallops and improve the sustainability of the fishery. Undersized scallop are returned to allocated nursery beds to prevent them from being damaged by further dredging. Once an area is fished it is left fallow for two to three years to allow recovery.

Crustacean species

Crayfish (Palinurus elephas):

National stocks of crayfish have decreased by 70% since 1990 to 40 tonnes in 1999. Landings in the study areas show a reduction of over 56% to 26 tonnes in 1999 (Figure.4), made predominantly in the Dingle site. The indiscriminate use of tangle nets is cited locally as the cause of this rapid decline.

Lobster (Homarus gammarus):

The lobster fisheries showed a national increase of over 8% from 1990 to 1999 to a total of 597 tonnes. Landings in the study areas increased by almost 25% between 1990 and 1999 to over 167 tonnes or almost 30% of the national total (Figure.5). The use of pots ensures a high quality of individual specimens and little by-catch with the exception of crab species.

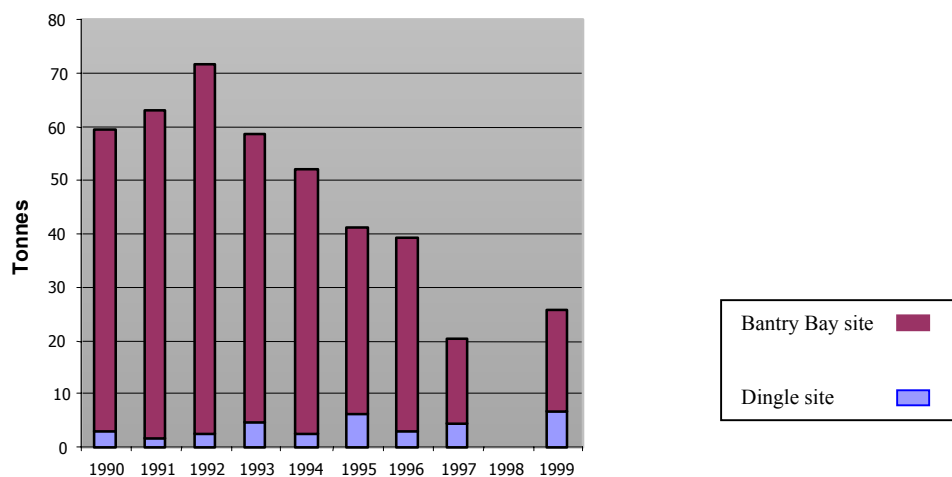


Figure.4 Landings of crayfish in Irish study sites. Source: DoCMNR

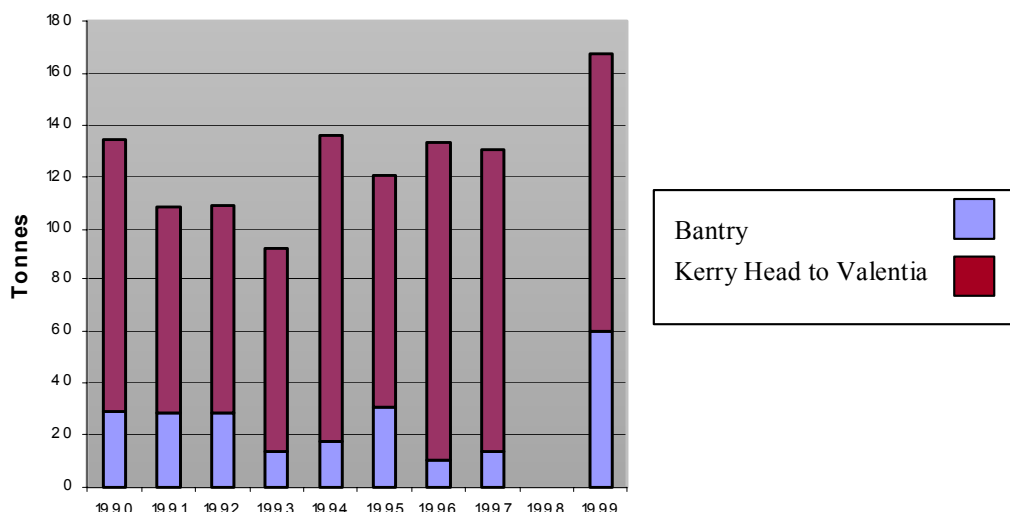


Figure.5 Landings of lobster in Irish study sites. Source: DoCMNR

Spider Crab (*Maja squanado*):

The spider crab fishery within the Dingle study site at Tralee and Brandon Bays represents approximately 80-100% of the fishery in Ireland (DoCMNR landing statistics). National landings have increased by 51% over the ten-year period while landings in the study area rose by 22% (Figure.6). BIM recognised spider crab as a new fishery in 1981, prior to which the species was discarded as bycatch in tangle-nets set for crawfish (Fahy, 2001). Production rose tenfold from 3 tonnes in 1981 to 30 tonnes in 1984 (Fahy, 2001), and reached 299 tonnes in 1999.

The current fishing effort is estimated to be a total of 10,000 pots from 20 half-decker vessels (averaging 10m in length) during the summer (Fahy, 2001). Current estimates suggest that the stock is sustainable and that the size limit could be increased to a carapace length of 130mm (Marine Institute, 2000). The export market for Irish spider crab is strongest when the dominant Channel Island fishery decreases (L. O’Cinneide, *Pers. comm.*, BIM, 2001).

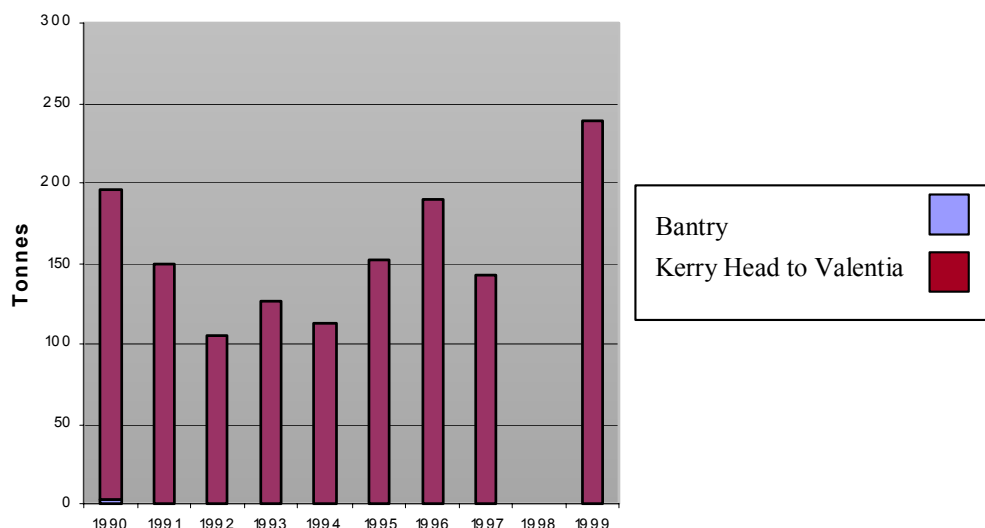


Figure.6 Landings of lobster in Irish study sites. Source: DoCMNR

Other Crab Species:

Catches of edible crab are landed predominantly as a by-catch of the lobster fishery and are relatively stable. The sudden increase in edible crab landings in the Bantry Bay site in 1999 corresponds with the introduction to the fleet of three dedicated crabbing vessels. Catches of velvet crab (*Necora puber*) are landed predominantly in the Bantry Bay area. The catches are small relative to the other crustacean species and are typically shipped to live markets in Europe. There are no statistics for the numbers of green crab (*Carcinus maenas*) and brown crab (*Cancer pagarus*) fished in the region. These species, particularly the former, are regarded as pests, preying on juvenile scallops and mussel beds. Green and brown crabs are used for bait and are ground down for use in fishmeal.

Fin fish species

The DoCMNR provided landing data for the selected fin fish species. Data was not available for 1993 and 1998.

Salmon (*Salmo salar*):

The salmon fishery encompasses the use of draft and drift nets and rod based angling both at sea and on the inland waterways. Stocks of Atlantic salmon in Irish waters have suffered a steady decline since 1985 (Figure.7).

The National Salmon Commission was established in March 2000, comprising representatives of both the fishing industry and the relevant management authorities, to discuss the conservation of the wild salmon stocks. Previous reports highlighted the fact that there were insufficient statistics available on the salmon fishery in Ireland (Anon, 1987; Anon, 1996). The DoCMNR introduced a salmon-tagging scheme in April 2001 in an effort to quantify the numbers of salmon being caught, the method of capture and the distribution of the salmon.

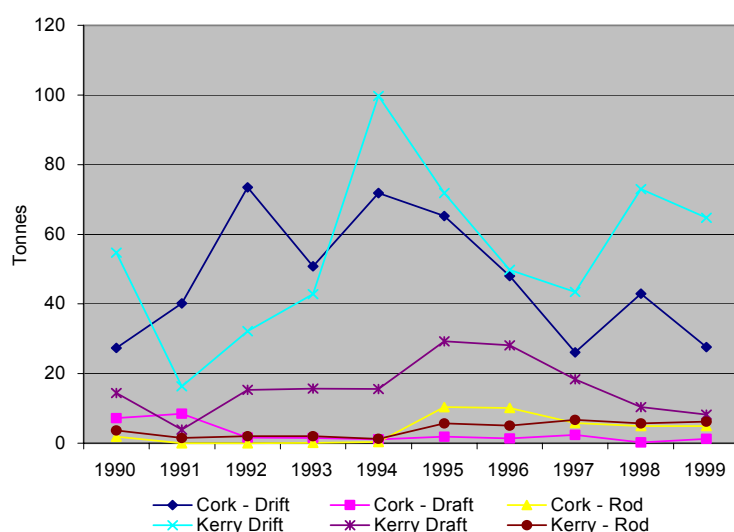


Figure.7 Salmon landings in Counties Cork and Kerry (tonnes). Source: South Western Regional Fisheries Board.

Whiting (*Merlangius merlangus*)

Whiting is a demersal fish species and is generally taken in mixed trawl fisheries. Landings were greater in the Bantry study site than in Dingle site. Landing data increased during the early 1990s, but the landing weights have decreased in both study sites since 1995 (Figure.8). This trend is also reflected in the national landing data (www.cso.ie). Low recruitment and high fishing mortality have reduced the spawning stock biomass of whiting, particularly in the Irish Sea

(www.cefas.co.uk/fsmi/Irish-Whiting.htm). There are restrictions on landings sizes of Whiting caught in ICES Area VIIj, all fish must be larger than 27 cm in length (BIM, 2000). This minimum size also relates to the size of fish, which may be kept on board the vessel.

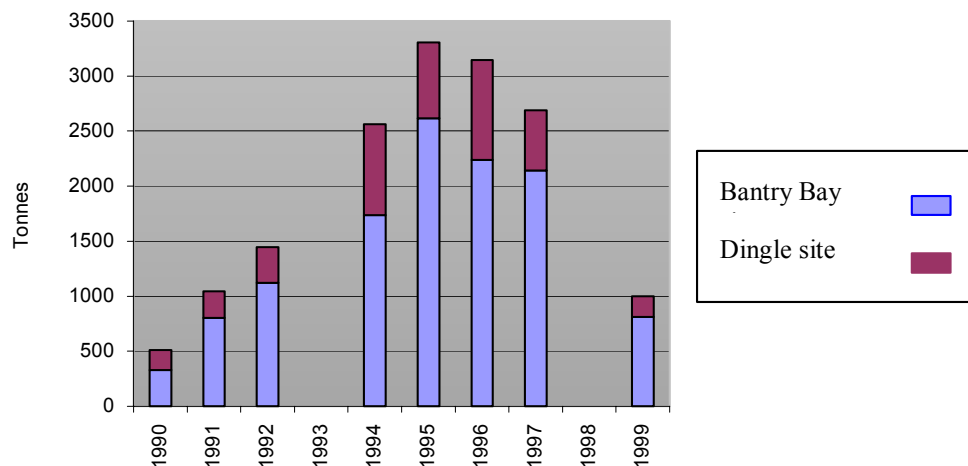


Figure.8 Whiting landings in Counties Cork and Kerry (tonnes) from 1990-1999. (Source: Dept. of Communications, Marine & Natural Resources, 2001).

Mackerel (*Scomber scombrus*)

Mackerel landings, a pelagic fish species, show a marked increase in landings in 1992, followed by a decrease in the following years. Landings were significantly higher in the Bantry Bay study site, for all data available (Figure.9). A minimum landing size of 20 cm applies for Mackerel.

Herring (*Clupea harengus*)

Herring landings were higher in the Dingle study site than the Bantry Bay study site. Herring is a pelagic fish species, and was not landed in the Bantry Bay site in 1995 or 1999 (Figure.10). Restrictions are now in place in the study sites (ICES Area VIIj) to protect the fish stocks. The fishery was closed in 2000 and will close every three years, from 1st Friday in November and for a period of 16 consecutive days (BIM, 2000). A minimum landing size of 20 cm applies for Herring in ICES Area VIIj.

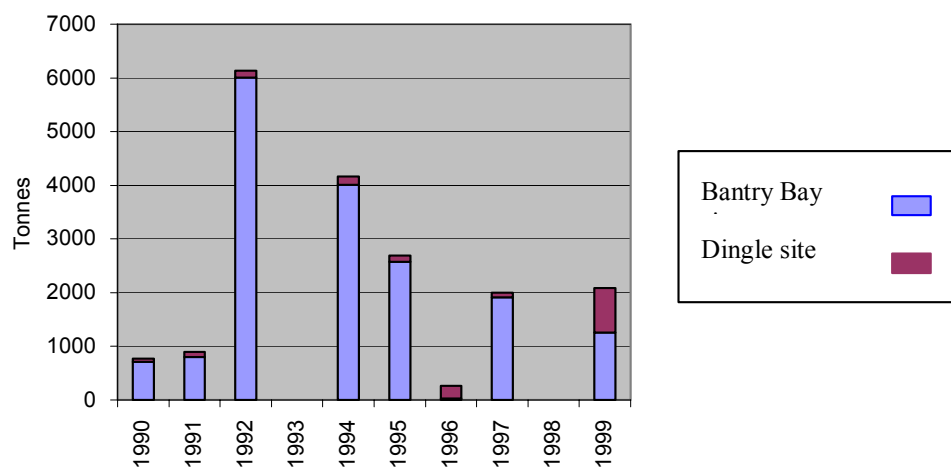


Figure.9 Mackerel landings in Counties Cork and Kerry (tonnes) from 1990-1999. (Source: Dept. of Communications, Marine & Natural Resources, 2001).

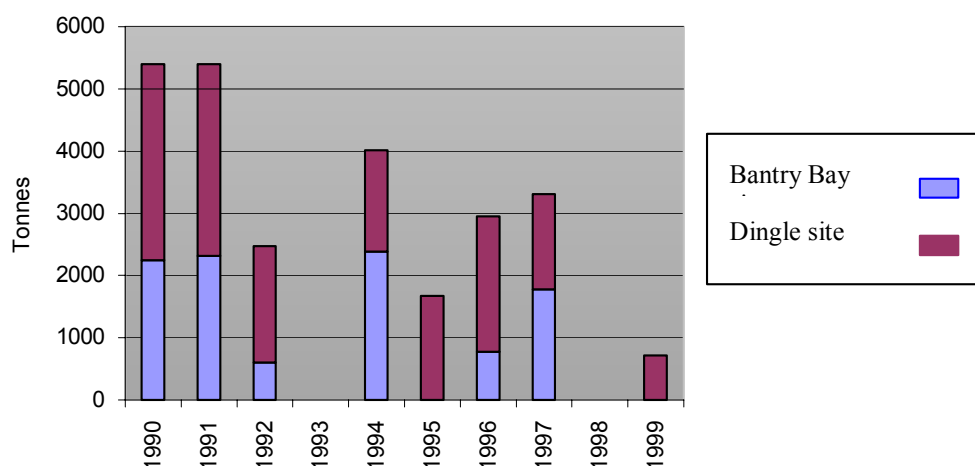


Figure.10 Herring landings in Counties Cork and Kerry (tonnes) from 1990-1999. (Source: Dept. of Communications, Marine & Natural Resources, 2001).

Dover sole (*Solea solea*)

Dover sole, a demersal fish species, is landed in smaller quantities than the other selected fish species. Dover sole is generally taken in the beam trawl fishery. A minimum landing size of 24 cm applies to Dover sole. Landings of Dover sole increased sharply in 1992 (Figure.11). This has been attributed, for the Irish Sea, to high spawning levels in the 1989 (www.cefas.co.uk/fsmi/Irish-sole.htm).

Plaice (*Pleuronectes platessa*)

Plaice, a demersal fish species and is normally taken as bycatch in the beam trawl fishery for sole, and in the otter trawl fishery for whitefish species. A minimum landing size of 22 cm applies. Landings vary between ports in both study sites. Catches were higher in the early 1990s followed by a decrease in landings (Figure.12). This is possibly due to high recruitment in the late 1980s. Recruitment then declined in the early 1990s. Beam trawl surveys in the Irish Sea suggest an increase in recruitment since 1995 (www.cefas.co.uk/fsmi/Irish-place.htm).

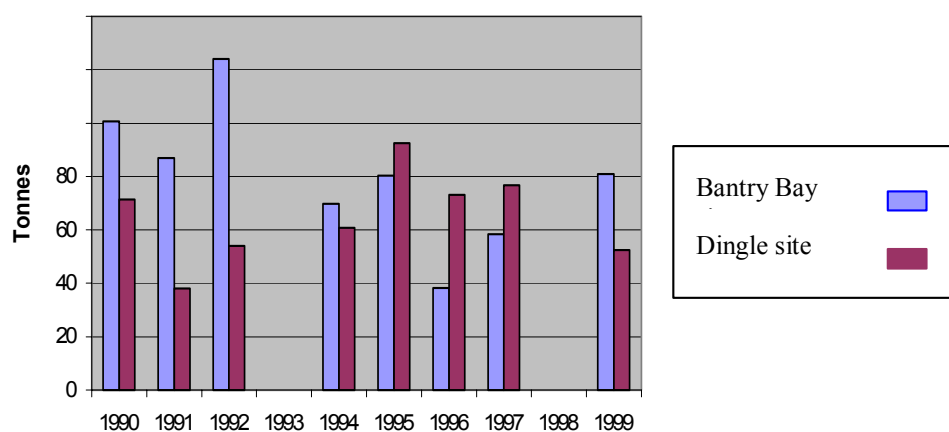


Figure.11 Dover sole landings in Counties Cork and Kerry (tonnes) from 1990-1999. (Source: Dept. of Communications, Marine & Natural Resources, 2001).

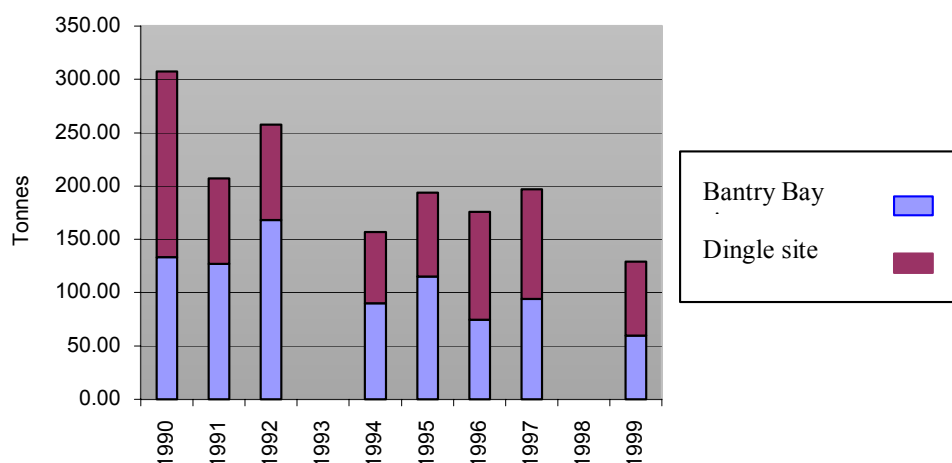


Figure.12 Plaice landings in Counties Cork and Kerry (tonnes) from 1990-1999. (Source: Dept. of Communications, Marine & Natural Resources, 2001).

8. CONCLUSIONS

Both Irish study sites are renowned as areas of scenic beauty. Neither site has large-scale industry; as a result tourism plays an important role in the local economy. The maintenance of the environment in a pristine condition is essential in such an area. Both sites are remotely located at the southwest tip of the island. More traditional such as fishing and farming are prominent and add to the attraction for tourists. The suitability of the region for water sports, ranging from sailing, diving, surfing to swimming, is helped by the image of a clean environment. There has also been an increase in the number of eco-friendly activities in recent years, combined with beaches retaining blue flags (the European symbol of a clean beach), particularly in the Dingle site, further promote the cleanliness of the environment.

However industry is not absent for either of the study sites. There are a wide variety of industries in both sites, all of which have obtained licences to allow discharge of the waste products. Much of this waste enters the sewage system and is disposed of along with other waste. The Bantry Bay site however, does have some heavy industry utilising the bay. Ireland's only oil terminal is located on Whiddy Island and in the past this has been the source of a number of oil spills. Another oil spill is of concern, as this would have severe consequences for the aquaculture industry in the bay as well as for the organisms living in and around the bay.

Much of the agriculture in both sites is sheep farming. There are some dairy and non-dairy farms within the study sites. There is also potential for agricultural pollution in the form of run-off or leaching of fertilisers and silage liquors. One bay within the study site, the Lee estuary in Tralee Bay is polluted as a result of this.

While the populations are not large in the study sites they are concentrated in the larger towns. In the summer the populations in all the towns and villages increases significantly with the influx of visitors. This puts increasing pressure on the waste and water treatment systems. The Kerry site has a number of primary and secondary sewage treatment plants. This should help decrease the level of pollution in areas like Tralee Bay. The Bantry Bay site however has only recently built a treatment unit

capable of primary treatment. Previously all sewage was pumped into the bay, close to a traditional bathing site. Castletownbere continues to pump sewage out into the bay, but a treatment facility is planned in the near future. The use of septic tanks throughout both study sites is widespread, as many homes are in remote locations.

Shipping is important in both study sites, with many ports servicing fishing boats, sailing boats, and commercial vessels. As mentioned Bantry hosts the only oil terminal in the country and vessels also export chippings from the Leahill quarry. Fenit is the only commercial port within the Kerry study site, exporting parts for cranes and wood. One of the main environmental concerns is that many of the vessels arrive empty and in ballast, to take on their loads in port. Ballast water should be discharged out at sea before entering port to prevent the release of exotic organisms into the Irish marine environment.

TBT concentrations in Bantry Bay are quite high, particularly in areas of high boating activity. Despite being banned on smaller vessels, TBT is still in use as an antifoulant on vessels larger than 25m as an alternative is not available. While the half-life of TBT in water varies from a few months to two years, sediments can act as a reservoir. Until a suitable alternative is developed, TBT levels in Bantry Bay are likely to remain high. Heavy metals concentrations were also found to be high in Bantry Bay and Tralee Bay, the reason for which is unclear. As a result it is difficult to determine how detrimental an effect they may have on the environment.

Both study sites have important fishing ports, particularly Castletownbere and Dingle. Fishing vessels can potentially have an adverse effect on the environment, due to accidental oil spills, and as sources of marine litter, the quantity of which has increased in recent years.

Aquaculture is an import industry for the local economy of both study sites, Bantry in particular, and is also an important source of employment in both sites. Aquaculture does not appear to have a major environmental impact on the Dingle peninsula site. In this site, fish farming is extensive, often relying on natural stocks of mussels and oysters. It is not visually intrusive as it uses the natural oyster and mussel beds on the seabed.

Aquaculture in Bantry Bay however has a significant visible impact, particularly in the inner bay, where the majority of mussel rafts are situated. While most mussel farmers have begun to change the colour of the barrels from the traditional blue, to a more inconspicuous grey, not all have been changed and most are quite visible from all aspects of the bay. The salmon cages are located in more remote areas of the bay and are not as visually intrusive. Anecdotal evidence indicates that the salmon cages have been placed over traditional herring spawning grounds.

While mussel farming does not require the addition of either feed or chemicals such as antibiotics to the water, salmon farming on the other hand does. Feed must be used, antifoulants are used on the cage surfaces, dyes are included to turn the flesh pink and antibiotics & vaccines are administered. The addition of such chemicals to any environment is not desirable. Maintaining low stock densities in salmon cages can reduce the incidence of disease, stress and mortalities. This would allow a reduction in the level of chemicals used, and could potentially increase production for the farm. The build up of sediment under cages can act as a reservoir for these chemicals, which would otherwise disperse in water. A build up of sediment is also found beneath, and in the vicinity of, mussel lines. This accumulation of waste over time will result in the development of an anoxic layer, low dissolved oxygen content of the water, and hydrogen sulphide emissions. The impact of organic enrichment can be localised or widespread, depending on the rates of tidal flushing.

Salmon can potentially escape from the cages and this can have serious consequences for the wild salmon population. The genetic diversity of the wild population can be compromised, escapees are known to enter rivers later than wild salmon, and can over cut the redds of wild salmon when spawning. There is also the risk that farmed salmon will spread diseases to the wild population.

Shellfish and finfish farms were found to large contributors of litter on adjacent shores. An increase in marine litter, including litter from the fishing industry, has been noted over recent years. This is not only a source of pollution, but is also unsightly and turns many visitors off returning to the area.

There have been regular outbreaks of Harmful Algal Blooms around the south and west of Ireland in recent years. These result in the closure of the bay and a ban on shellfish harvesting. Further study on the occurrence of these outbreaks is recommended, as these have been indicated by Rodhouse & Roden (1987) to be an indication that a site has exceeded its carrying capacity for shellfish production.

Aquaculture is an important source of income for the local economy in both sites. Remote rural areas, such as both study sites, often have low population numbers as most of the young people leave to find employment in the larger towns and cities around Ireland. An employer such as the aquaculture industry offers locals the choice to remain in the local area.

The Bantry Bay Charter (www.bantrybaycharter.ie) is an excellent example of all stakeholders coming together to manage and develop their area. All stakeholders have been involved since the beginning of the charter, offering them the chance to voice their opinions and take part in the decision making process.

However many people feel the bay has been shut off to users as the mussel lines cover most of the inner bay. Navigation around the lines is difficult and this restricts the use of the bay by swimmers, canoeists and other pleasure craft. Local groups, who have submitted objections to the planning applications of new mussel lines, find their appeals turned down. They feel their applications are dismissed, because they are appealing against an industry, which brings revenue to the country, and they, as parties who wish the use the bay for pleasure purposes, are being ignored.

There is also the question of whether the activities in both study sites are sustainable. The Kerry site appears to be sustainable. The activities carried out throughout the site do not appear to have an adverse effect on the environment. The aquaculture activities in this site harvest species from naturally occurring beds. The current method of harvesting benefits the environment as it prevents the build up of biodeposits beneath the mussel/oyster beds. If the aquaculture industry were to be developed in this study site, a detailed baseline environmental study should take place beforehand.

The Bantry Bay site is also probably sustainable at present. However if further mussel lines are to be put in the bay, it may be recommended to use the outer bay. This would resolve conflict with other users of the inner bay and also alleviate pressure on the environment of the inner bay. Kaspar *et al.* (1985) expressed concerns for the sustainability of high mussel production rates as nitrogen is removed by the mussel harvest or locked up in the sediment. The bay has probably reached or is close to reaching its carrying capacity for mussel production and care must be taken not to exceed this capacity. Poor growth rates would result, the mussel may also be susceptible to disease and as Rodhouse & Roden (1987) mention there may be a more frequent occurrence of red tides.

In order to adequately compare the impact of pollution from other sources and aquaculture, pollution loads would need to be available from all activities. At present, without information available on nutrient loads etc., it is difficult to make a decision on whether one activity in the study sites has a greater impact than another. The addition of nutrients to the aquatic environment of both study sites is possibly the most significant impact other sources of pollution have on the environment, from agricultural, industrial and sewage sources. While shellfish remove nutrients from the water, a build up of biodeposits occurs beneath and in the vicinity of mussel lines and salmon cages. Burnell (1996) highlights the conflicting views of how organic enrichment as a result of mariculture affects the environment and suggests that the complacency regarding the environmental disturbance caused by shellfish culture is ill founded. A draft Marine Monitoring Plan (2003-2006) is to be published before the end of 2002. The maintenance of a clean environment is essential, not only to continue to attract tourist and therefore revenue to the study sites, but also to maintain the industries already present.

9. RECOMMENDATIONS

In order to maintain present levels of all activities within the study areas, current legislation must be enforced. Monitoring of the discharges from all human activities must be carried out to achieve or maintain healthy ecosystems. The maintenance of a healthy environment is of benefit to all stakeholders involved. Further study is needed to identify and quantify the environmental impacts of all human activities in the study sites.

Environmental Impact Assessments should be carried out prior to the siting of fish or shellfish farms. This is particularly important in the case of the Dingle site where at present aquaculture operations are utilising naturally occurring mussel and oyster beds. An EIA should be carried out prior to the introduction of e.g. salmon farms in the study site.

In the case of Bantry Bay, which has an established aquaculture industry, present aquaculture guidelines must be strictly enforced. Harrowing of the seabed beneath mussel lines, and leaving sites fallow may alleviate concerns over the build up of deposits beneath mussel lines.

In the case of finfish farming, the moving of cages annually will prevent the build up of deposits in one site. The separation of age classes will also reduce the incidence of disease and as a result the use of antibiotics. This practice is already in use by many salmon farmers around the country. Escapes from salmon cages must be reported immediately to all parties concerned.

REFERENCES

Ackefors, H. and M. Enell, 1994. The release of nutrients and organic matter from aquaculture systems in Nordic countries. *J.Appl.Ichthyol.*, 10:225-41

Administration and Yearbook Diary, 2000

Anon, 1987. *Report of the Salmon Review Group*. Government Publications, Dublin.

Anon, 1996. *Report on the implementation of the recommendations of the Salmon Task Force*. Government Publications, Dublin.

Bantry Bay Seafoods, 2002. URL: www.bantrybayseafoods.com

Barry J.B and partners in association with Irish Hydrodata Ltd and Reid and McHugh and Partners, 1988. Water quality plan for Bantry Bay. *Report to Cork County Council*. 3 Vols.

Boelens, R.G.V., Maloney, D.M., Parsons, A.P. & Walsh, A.R., 1999. Ireland's Marine and Coastal Areas and Adjacent Seas: An Environmental Assessment. Quality Status Report. *Prepared by the Marine Institute on behalf of the Department of Environment & Local Government and the Department of Marine and Natural Resources*. 381pp.

Bord Iascaigh Mhara, URL: www.bim.ie

Bord Iascaigh Mhara, 1999. Irish Inshore Fisheries Sector – Review and Recommendations. *BIM, Dublin*.

BIM, 2001. Fisheries, Inshore Diversification and Safety Programme pp12. *BIM, Dublin*.

Burnell, G., 1996. The Environmental impact of marine bivalve mollusk exploitation: A brief review of the disturbances caused by mariculture and fishing. In Giller, P.S. and Myers, A.A. (eds.) *Disturbance and recovery in ecological systems*, 84-97. Royal Irish Academy, Dublin.

Central Fisheries Board, URL: www.cfb.ie

Central Statistics Office. URL: www.cso.ie

Central Statistics Office, 1996. Small Area Population Statistics. *CSO, Dublin*.

Commissioners of Irish Lights. URL: www.cil.ie/

Connolly, N., Buchanan, C., O' Leary, D., and O' Mahony, C., 2002. Dingle Harbour: A Resource Scoping Study. *Unpublished report for Dingle Harbour Commissioners*.

Coyne, R., Smith, P. & Moriarty C., 2001. The fate of oxytetracycline in the marine environment of a salmon cage farm. *Marine Environment and Health Series, No. 3, Marine Institute*.

Cummins, V., Dumas, F., Franklin, F., Kershaw, P., Le Roux, J.F., Loubersac, L., Mortimer, G., Populus, J., and Sutton, G., 2001. A Scoping Study to Establish a Common Approach to Examining the Impact of Atlantic Arc Water Quality and Dynamics on Coastal Activity and Sensitive Marine Environments. *INTERREG-IIC report*.

Dempsey, N., 2002. Speech by Mr. Noel Dempsey, T.D. Minister for the Environment and Local Government at the launch of the Environmental Protection Agency Report on Water Quality in Ireland 1998-2000. URL: <http://www.environ.ie/press/epaspeech02.html>

Department of Arts, Heritage, Gaeltacht and the Islands. URL: www.gov.ie/ealga/

Department of Foreign Affairs, 2002.

URL: www.gov.ie/iveagh/pmunny/facts_irl.htm

Department of the Environment and Local Government, 2002. URL:

<http://www.environ.ie/dept/deptindex.html>

Department of the Marine & Natural Resources (undated). Irish aquaculture the future: strategies for meeting the global seafood challenge. *Prepared by The Circa Group Europe Ltd., DoCMNR, Dublin.*

Dooley, M. 1973. Preliminary investigations on the phytoplankton from the west coast of Ireland. *Br.Phycol. J.* 8,79-94.

Dubsky, K., Larraghy, J., and Richter, K., 1998. Coastwatch Europe – Autumn 1998. Results for all Ireland. *Coastwatch Europe*, Trinity College, Dublin, Ireland.

Dúchas the Heritage Service URL: <http://www.heritagedata.ie>

ENFO Information on the environment, URL: www.enfo.ie

Environmental Protection Agency. URL: <http://www.epa.ie/>

Environmental Protection Agency, 2000. EPA Annual Report and Accounts, 2000. *Produced by the Environmental Protection Agency.*

Environmental Protection Agency, 2002. Water Quality in Ireland, 1998-2000. *Environmental Protection Agency, Ireland.*

Fahy.E., 2001. The Maharees spider crab, *Maja squinado*, fishery in 2000. *Irish Fisheries Investigation Series*, No. 9. Marine Institute, Dublin.

Fuchsia Brands Ltd., 2002. URL: www.fuchsiabrands.com/fastmussels1.htm

- Garforth, D.B. and FitzGerald, R. 1996 Opportunities in the Aquaculture Industry in the South West of Ireland. *Report commissioned by South Western Services Ltd. and West Cork Leader Co-operative Society Ltd.* 124pp
- Gesamp, 1991 Reducing environmental impacts of coastal aquaculture) GESAMP reports and Studies No.47. *Food and Agriculture Organisation of the United Nations*. Rome, 1991.
- Gowan, R.J., 1990. An assessment of the Impact of Fish Farming on the Water Column and Sediment ecosystem of Irish Coastal Waters. *Report prepared for the Department of the Marine*, 75pp.
- Goward, R. and Savidge, G., 1993. The influence of cool water incursions on phytoplankton populations in Bantry Bay, south-west Ireland. *ICES CM 1993/C:31*.
- Grentz, C. et al., 1991. An estimate of the energy budget between cultivated biomass and the environment around a mussel-park in the northwest Mediterranean Sea. *ICES Mar.Sci. Symp.*, 192:63-7
- Heritage Council, URL: www.heritagecouncil.ie/mainpage.html
- European Union, 2002. URL: http://europa.eu.int/comm/fisheries/policy_en.htm
The Common Fisheries Policy (CFP).
- Irish National Strategy Review Group on the Common Fisheries Policy (CFP), 2002, *Proposals and Recommendations for the Review of the CFP 2002 (October 2000)*.
URL: http://www.intrafish.com/laws-and-regulations/cfpdocument2_7.pdf
- ISGA, 2002. Review of benthic conditions at Irish Fish farms. *Report commissioned by the Irish Salmon Growers Association*, Irish Farm Centre, Bluebell, Dublin 12. Ireland.

Irish Times 2001, September 15th 2001. *Water Authority to Quality Improvement* article by Tim O'Brien, Regional Development Correspondent. URL:

<http://www.Ireland.com/newspaper/archive/>

Jacobsen, P. and L. Berglind, 1988. Persistence of oxytetracycline in sediments from fish farms. *Aquaculture*, 70:365-70

Kaspar, H.F., Gillispie, P.A., Boyer, I.C. and Mackenzie, A.L., 1985. Effects of mussel aquaculture on the nitrogen cycle and benthic communities in Kenepuru sound, Marlborough Sounds, New Zealand. *Marine Biology* 85, 127-136.

Kerry County Council, 2002. URL: www.kerrycoco.ie/ATLAS

Lee, A.J. and Ramster, J.W. (eds.), 1981. Atlas of the Seas around the British Isles. *Lowestoft: Ministry of Agriculture, Fisheries and Food*. IBSN 0 907545 00 9.

McMahon, T., Raine, R., Titov, O. and Boychuk, S., 1995. Some oceanographic features of north-eastern Atlantic waters west of Ireland. *ICES J. Mar. Sci.* 52, 221-232.

Maguire. J. and Burnell. G., 1999. The potential for scallop spat collection in Bantry Bay, 1999. *Biology and Environment: Proceedings of the Royal Irish Academy*, 99B, 3, 183-190.

(<http://journals.eecs.qub.ac.uk/RIA/ProcBI/1999/PB99I3/PDF/99319BI.pdf>).

Marine Institute, URL: www.marine.ie

Marine Institute, 1999. Socio-economic evaluation of the impact of aquaculture industry in counties Donegal, Galway, Kerry and Cork. Marine Insitute, Dublin, *Marine Resources Series*, No.7, 1999.

Marine Institute, 2000. The Stock Book – Annual Review of Fish Stocks in 2000 with Management Advice for 2001. *Marine Institute, Dublin*.

- Moore, J., Hobbs, G., Elliott, R., Nairn, R., & Partridge, K., 1997. The South West Coast of Ireland: An Environmental Appraisal. *BHP, Chevron, Marathon, Occidental, Statoil and Total*. 64pp.
- Møster, G., 1986. Bruk av antibiotika i fishkeoppdrett Sogn og Fjordane Distriktshogskole, 5800 Sogndal, Norway
- Nautical Enterprise Centre, 2000. Maritime Operations – Internal Project report for Bantry Bay Charter Project, *Nautical Enterprise Centre Limited, Cork*. Unpublished internal report.
- Neiland, S. & McMahon, T., 1999. A Benthic Survey of Inner Bantry Bay. *Fisheries Bulletin (Dublin)* No. 18, Marine Institute.
- Nixon, E., 1997. Bantry Harbour Sediment Survey. *Fisheries Research Centre* (Marine Institute), Dublin.
- O’Sullivan, A.J. 1978. Red tides on the south coast of Ireland. *Mar. Pollut. Bull.* 9 (12), 315-316.
- Ottway, B., Parker, M., McGrath, D., and Crowley, M., 1979. Observations on a bloom of *Gyrodinium aureolum* Hulbert on the south coast of Ireland, summer 1976, associated with the mortalities of littoral and sub-littoral organisms. *Irish Fisheries Investigations Series B* No. 18. 9pp
- Raine, R. and Joyce, B., 1995. The summer phytoplankton ecology of waters off south-western Ireland. In *Irish Marine Science: Proceedings of the Irish Marine Science Symposium*, Galway, September, 1995. Edited by Keegan, B.F. and O’Connor, R., Galway University Press, pp 131-142.
- Raine, R., McMahon, T., and Roden, C., 1990. Hydrography and phytoplankton of waters off South-west Ireland. *Estuar. Coast. Shelf Sci.* 30, 579-592.

Raine, R., Joyce, B., Patching, J.W., McMahon, T., and Roden, C., 1993. Upwelling and the phytoplankton ecology of south-west Irish coastal waters. *ICES CM 1993/L:18*.

Roden, C., 1984. The 1980/1981 phytoplankton cycle in the coastal waters off Connemara, Ireland. *Estuar. Coast. Shelf Sci.* 18, 485-497.

Roden C. and Raine, R. 1994. Phytoplankton blooms and a coastal thermocline boundary along the west coast of Ireland. *Estuar. Coast. Shelf Sci.* 39 (5), 511-526.

Rodhouse, P.G. and Roden, C., 1987. Carbon budget for a coastal inlet in relation to intensive cultivation of suspension-feeding bivalve molluscs. *Marine Ecology Progress Series* 36, 225-236.

Samuelsen, O.B., 1989. Degradation of oxytetracycline in seawater at two different temperatures and light intensities and the persistence of oxytetracycline in the sediment from a fish farm. *Aquaculture*, 83:7-16

SIME(2a) 1997. Chemicals Used in Aquaculture (Presented by the UK and Ireland). *SIME (2) 97/4/1-E, OSPAR*, 9pp

APPENDIX I

Table.9: General characteristics of the various Biological Quality Classes

Quality Classes	Class A		Class B	Class C	Class D	
Quality Ratings (Q)	Q5	Q4	Q3-4	Q3	Q2	Q1
Pollution Status	Pristine, Unpolluted	Unpolluted	Slight Pollution	Moderate Pollution	Heavy Pollution	Gross Pollution
Organic Waste Load	None	None	Light	Considerable	Heavy	Excessive
Maximum B.O.D.	Low (< 3 mg/l)	Low (< 3 mg/l)	Occasionally elevated	High at times	Usually high	Usually very high
Dissolved Oxygen	Close to 100%	80%-120%	Fluctuates from <80% to >120%	Very unstable Potential fish-kills	Low, sometimes zero	Very low, often zero
Annual Median ortho-Phosphate	~0.015 mg P/l	~0.030 mg P/l	~0.045 mg P/l	~0.070 mg P/l	usually > 0.1 mg P/l	usually > 0.1 mg P/l
Siltation	None	May be light	May be light	May be considerable	Usually heavy	Usually very heavy and anaerobic
'Sewage Fungus'	Never	Never	Never	May be some	Usually abundant	May be abundant
Filamentous Algae	Limited development	Considerable growths Diverse communities	<i>Cladophora</i> may be abundant	<i>Cladophora</i> may be excessive	May be abundant	Usually none
Macrophytes	Diverse communities Limited growths	Diverse communities Considerable growths	Reduced diversity Luxuriant growths	Limited diversity Excessive growths	Tolerant species only. May be abundant.	Usually none or tolerant species only.
Macroinvertebrates (from shallow riffles)	Diverse communities. Normal density. Sensitive forms usually numerous.	High diversity. Increased density. Sensitive forms scarce or common.	Very high diversity. Very high density. Sensitive forms scarce.	Sensitive forms absent. Tolerant forms common. Low diversity.	Tolerant forms only. Very low diversity.	Most tolerant forms. Minimal diversity.

Water Quality	Highest quality	Fair quality	Variable quality	Doubtful quality	Poor quality	Bad quality
Abstraction Potential	Suitable for all	Suitable for all	Potential problems	Advanced treatment	Low grade abstractions	Extremely limited
Fishery Potential	Game fisheries	Good game fisheries	Game fish at risk	Coarse fisheries	Fish usually absent	Fish absent
Amenity value	Very high	High	Considerable	Reduced	Low	Zero
Condition	Satisfactory	Satisfactory	Transitional	Unsatisfactory	Unsatisfactory	Unsatisfactory

Source: EPA, 2002