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Technology Foresight Ireland

Report of the Natural Resources Panel

Forfás

Established by the Government and Forfás to advise on Science, Technology and Innovation

Foreword

With the objective of reflecting a broad spectrum of views in its compilation, the Technology Foresight Report on Natural Resources was prepared under the aegis of a Panel which comprised senior personnel drawn from both private and public organisations involved in the agri-food, marine and forestry industries (see Appendix for Panel Membership).

In addition, working group meetings were held with key players from the agri-food, marine and forestry sectors. Also, a presentation of the draft report was made at a meeting of the Irish Research Scientists Association held in Portumna on 25 – 27 September, 1998.

The consultation process was further expanded by making the draft report available to a number of senior executives involved with the agri-food industry and other sectors of natural resources. The incisive observations received from the following are gratefully acknowledged: Dan Browne (Dawn Meats (Exports) Ltd.), Liam Connellan, Michael Dowling (Dowling Consultancy Ltd.), Kieran Fitzgerald (Food Drink and Tobacco Federation, IBEC), Liam Igoe (Goodbody Stockbrokers), Dick Kavanagh (Industry Research and Development Group, IBEC), Philip Lynch (IAWS), Bill McCumiskey (Environmental Protection Agency), Dan MacSweeney (Carbery Milk Products Ltd), Pat O'Neill (Avonmore Waterford Group) and Dr. Brian McCarthy (UCC).

The three sub-sectors which comprise the natural resources sector, in the context of this report, are very different in terms of their stage of development in Ireland, their present economic status, their prospects for growth and expansion, and their 'predictability'. Within the overall framework of the Natural Resources Panel, the work on the Technology Foresight Initiative has been undertaken by three distinct groups, and this report reflects that process in that it comprises three sections addressing each of the sub-sectors. While the format of each sub-report is similar, the content varies in nature and scope and no attempt has been made to artificially 'standardise' the material.

Executive Summary

The Agri-Food Industry

Scenario for the Agri-Food Industry in 2015

The agri-food industry will be operating in an environment characterised by:

- A sustained focus on competitiveness
- Reduced price supports for agricultural products
- More liberal world trade, with much reduced protection from global competition
- From 2010 onwards, improved world food prices resulting from the increased demands of a more affluent world population
- Substantially greater requirements in relation to food safety and quality, protection of the environment and animal welfare allied to changing lifestyles, resulting in more stringent controls over the entire food chain
- Ubiquitous application of information technology and biotechnology.

With the necessary strategic management, marketing, scientific, technological and innovative capacities, the output of the agri-food industry can be maintained and may be expanded. However, in response to the pressures highlighted above, the pace of structural changes in the sector will be accelerated. The scale of individual farms and food processors will be substantially expanded and the number of operating units significantly reduced. In the 1998

Labour Force Survey, 100,000 people are enumerated as farmers. Further escalation of the ongoing downward trend would reduce this number to something in the region of 50,000-60,000 by 2015.

It is envisaged that the agri-food sector in 2015 will comprise:

- Up to 25,000 commercial farmers, predominantly dairy producers, (some 15,000 each producing at least 100,000 gallons of milk per annum) together with about 5,000 drystock farmers, possibly 2,000 arable/horticultural producers and less than 500 pig producers
- Some 25,000-35,000 part-time livestock producers deriving a significant portion of their income from farming - many will have farm-forestry enterprises
- Possibly 50,000 other landholders, whose primary income will not be derived from farming
- A small number of Irish-based multinational food companies. There may be just four, and possibly no more than two major dairy companies, each processing about a half to one billion gallons of milk annually, and supplying dairy and meat products, dairy-based ingredients and consumer foods. The beef processing sector will undergo even greater rationalisation, resulting in no more than five, and probably less, beef groups (each with three or four plants) handling at least 80 per cent of beef exports
- Some 100 small- and medium-scale food companies (each employing 50 to 250 people) supplying niche markets for prepared and semi-prepared consumer foods
- The marketplace will be dominated by the globalisation, or at least the Europeanisation, of the food retail sector

- An expanded market for horticultural products, in particular nursery stock and mushrooms.

Strategic issues likely to impact on the Agri-Food Industry

- Further reform (commencing in 1999) of the Common Agricultural Policy (CAP) leading to reduced price supports for agricultural products, combined with new agreements under the World Trade Organisation, resulting in more liberal world trade in agricultural products and much greater globalisation of markets
- The other major drivers of change will be:
- the increasingly exacting requirements of consumers
- the need to achieve economic and environmental sustainability
- advances in science and technology, including information technology and, more especially, biotechnology.

Core Technologies and other Competencies that need to be built up

- Strategic management, marketing, scientific and technological capabilities to ensure competitiveness in farm production and in the manufacture and marketing of innovative food products and processes that meet consumer demands.
- To strengthen these fundamental competencies, priority needs to be given to building up the following capabilities:
- Production and processing technologies and systems (combined with the necessary training programmes) that meet consumer demands for guaranteed food safety, and assured freshness and consistent quality
- Economically competitive and environmentally sustainable farm production and food processing technologies and systems
- The capacity to monitor, evaluate and harness appropriate developments in biotechnology
- Comprehensive marketing intelligence supported by the necessary market surveillance and associated research capability on changing consumer attitudes and purchasing behaviour in Ireland and selected export markets.

Strategies for the development of the necessary Core Competencies

- There is a critical need for a national manpower programme for science and technology, including mechanisms to ensure more effective training and encourage greater mobility of researchers
- Establishment of centres of excellence with the necessary critical mass of the next generation of scientists and technologists in areas of vital strategic importance, including biotechnology
- Both grants and tax incentives for the agri-food industry need to be directed more to building the core strategic, management, marketing, scientific, technological and innovative capabilities, both in-company and through joint ventures between industry and public research and educational institutions
- Arrangements need to be put in place to ensure greater industry ‘ownership’ of public research programmes, with particular regard to co-operative priority-setting and to ensuring more effective inter-institutional collaborative research programmes and securing value for money

- Product development research should be undertaken by private companies, with public research programmes concentrating on technology development and public good issues.

The Marine Sector

Scenario for the Marine Sector in 2015

Recent research[1] indicates that the marine sector, represented by food, tourism and technology, contributes IR£900 million per annum to the economy and supports over 32,000 jobs. This represents 2 per cent of GNP. Expansion in these sectors and the addition of shipping, ports and seabed resources significantly increases the importance of the marine sector to the Irish economy. In addition:

- Growing world population and greater knowledge and technological capability in respect to the oceans will lead to increasing utilisation of marine resources
- Ireland's marine territory covers 900,000 sq. km, over 10 times the land area, and is the second largest Member State marine territory in the EU
- Marine resources sustain a diverse range of economic activities
- The high quality of the Irish marine and coastal environment provides a major competitive advantage in the fields of marine food and tourism.

By the year 2015 it is envisaged that activity in the Irish marine sector will include:

- The utilisation of energy resources, renewable and fossil fuel, from the Irish offshore sector
- Aquaculture will account for a large percentage of Irish marine food production
- Seaweed production and processing, and the extraction and use of marine bio-products, will be significant sources of employment and revenue
- A marine technology sector will have developed and will export niche, high-value products to world markets
- Management regimes will have developed to meet the demands associated with multi-user pressure on the coastal zone.

Strategic Questions

For historical reasons, compounded by a continued lack of awareness of the value of our marine resources, Ireland is a late starter in the development of a marine economy. Some critical strategic questions for Ireland, in realising the development potential of the marine resource are:

- How do we secure public understanding of, and commitment to, the role of the marine sector in national economic development?
- What are the broad marine RTDI* competencies necessary to achieve a profitable and sustainable marine economy in the year 2015?
- How to secure appropriate public and private investment in strategic marine RTDI competencies, establish critical mass and maintain continuity?

Strategic Issues Likely to Impact on the Sector

- The terms and conditions of the Review of the Common Fisheries Policy and the future evolution of international coastal resource management regimes will greatly influence the scope of Irish marine resource development
- Sustainable resource management considerations to cope with stock overfishing, environmental impacts, competition for space and energy consumption will influence future development scenarios
- Activity will increase in aquaculture (including seaweeds and shellfish), extraction of bio-products from marine organisms, offshore hydrocarbon production and renewable ocean energy - the extent of these activities will be determined by economic, environmental and technological factors operating at the international level
- As an 'island' of the EU, there is a strategic need to improve RTDI related to maritime transportation.

Core Technologies and Competencies Required

In identifying key technologies for the year 2015, the Panel felt it unwise to try to identify one or two key technologies, preferring to highlight the broad range of technologies necessary to support development in the marine sector.

The Panel did, however, identify a range of 'horizontal technologies' - those that are highly relevant to the development of the marine sector and are relevant to the natural resource sector in general and 'specific technologies' - those relevant specifically to the marine sector. In doing this no order of priority is implied. These include:

Horizontal Technologies

- Marine food processing
- Information technology, including remote sensing, geographical information systems, modelling and forecasting, data management
- Biotechnology, including disease detection and management, bio-screening of marine organisms for bio-active products.

Specific Technologies

- Sustainable harvesting and production, including cleaner production technologies, fish-finding technology, net design and manufacture, cage and tank design
- Sensor development, including instrumentation development, anti-fouling techniques, materials technology
- Wave Energy, including power take-off and control, structural design and mooring
- Maritime Transport, including inter-modal transport.

Strategies for the Development of Core Competitiveness

Given the historic and relatively disadvantaged position of the marine sector in relation to public investment in RTDI and the potential for real economic growth and development in this sector, the Panel considered that there is a need for sustained public and private investment **in all aspects of marine S&T.** This should specifically focus on:

- Implementation of appropriate mechanisms to support critical mass, to maintain international competitiveness and to underpin continuity (at least in the medium term) of established and required cores of expertise
- Support for targeted education, training, R&D and support infrastructures in the marine sector
- Implementation of efficient mechanisms for technology transfer, increased R&D application/uptake in SMEs and better industry/research institute co-operation.

The Forestry and Forest Industries Sector

Scenario for the Forest and Forest Industries Sector in 2015

At the present time the sector is growing at some 10 per cent per annum and under existing conditions is targeted to reach values for production and added value of IR£1.3 billion and IR£800 million respectively by 2030.

By 2015:

- The level of timber production will have risen to 4.5 million m3 per annum
- Non-timber forest products such as leisure, recreation, hunting etc. will be in greater demand
- The use of forestry as a carbon sink will assume greater significance
- Sustainable forest management will be normal practice
- Planting and harvesting will be fully mechanised.

Strategic Issues likely to impact on the Sector

- Ireland will operate in increasingly competitive European and world markets
- With a large annual increment to Europe's forests there is a need to increase consumption of wood products
- The multi-functional use of forests and their role in the rural economy is growing in importance
- Sustainability concerns are increasingly impacting on the forest industry
- There is a trend towards (a) a small number of integrated, high technology and highly capitalised European forest product groups, and (b) an increasing number of small scale forest owners
- Technological advances in engineered wood products are creating new opportunities for wood to compete with non-renewable materials.

The Strategic Question for the Sector

How can we ensure that the wood and non-wood products which Irish forests will be producing can be competitively produced for domestic and international markets, and that the national forest estate is economically, environmentally and socially sustainable?

Core Technologies

- Wood science, materials science and applied engineering skills
- Genetic and other biotechnologies to improve the properties of Irish timber
- Information technology and communications skills
- Environmental management skills
- Planning and appraisal models
- Advanced marketing capabilities and skills.

Strategies for the Development of Core Competencies and Technologies

- Consolidate and expand the management and co-ordinating mechanism for the application of R&D in the forest and forest industries sector
- Develop education modules and information systems to promote awareness and skills, in the use of wood, among architects and engineers
- Invest in information technology to enable effective technology transfer into the Irish forest and forest industries sector.

The Agri-Food Industry in 2015

1.1 Profile of the Agri-Food Industry

The aim of the Technology Foresight Initiative is to identify national strategies and key technologies necessary to ensure the development of Ireland's science and technology capability so as to enhance Ireland's socio-economic well-being into the new millennium. In this context the horizon which is being targeted is the year 2015.

The sector currently has the following characteristics:

- The total area farmed is 4.43 million hectares (1997), which is 64 per cent of the land area
- Total employment in the agriculture sector is 130,000, with a further 45,000 engaged in food processing (1996). While the percentage of the work force accounted for by agriculture has been declining steadily, it still remains more than twice the European average (11.7 per cent in Ireland compared to 5.1 per cent in Europe)
- Gross agricultural product is valued at IR£2.6 billion (1996), which is 5.3 per cent of GDP. The food industry accounts for a further estimated IR£1.7 billion
- Agri-food exports account for 32 per cent of the net inflow of funds from international trade (1995). The volume of exports of food and live animals as a percentage of total exports is 10.3 per cent (1997).

1.2 World Developments to 2015

- World population will grow from 5.3 billion in 1990 to 7.0 billion in 2010 and possibly to 7.5 billion by 2015. This will be attended by a corresponding increase in the demand for food products
- In predicting continuing long-term economic growth, particularly in Asia and South America, cognisance must be taken of the likelihood of regional and short-term fluctuations
- The two main upcoming developments that will determine the future of the Irish agri-food industry are:
    - the further reform, commencing in 1999, of the EU Common Agricultural Policy (CAP)
    - the outcome of agreements under the World Trade Organisation (WTO) where further negotiations to remove trade barriers will start in 1999.

The main strategic questions facing the agri-food industry derive from these inter-related upcoming developments:

- The growth of world agricultural production (at 1.8 per cent per annum) will be slower than in the recent past but will still exceed the projected rise in the world population
- There will be continued globalisation of markets. World free trade in agricultural products could be substantially achieved by 2015
- Food sales in developed countries will grow in value but hardly at all in volume

- More developing countries may evolve from being net agricultural exporters to becoming net agricultural importers. The resultant growth in market volume will be at comparatively low world prices
- The consumption of livestock products will continue to grow, particularly in developing countries
- The production of cereals for use as animal feed will increase. In trade terms, much will depend on the capacity of China to meet its own growing needs for cereals and the extent to which it will become dependent on imports.

1.4 What will the Agri-Food Industry look like in 2015?

- Consumer demands for assured food safety, protection of the environment and animal welfare will increasingly be enshrined in legislation. These developments will pose growing constraints on European food producers and processors and may affect their world-wide competitiveness. Alternatively, they may provide market opportunities for those sectors and enterprises which can meet consumer demands at least cost
- A related issue is the extent to which the EU accepts biotechnology, including genetically modified crops and animals. With a limited growth in world production and consumption, these new technologies could result in reduced land utilisation throughout the world, with beneficial effects on the environment
- Fresh produce will be available from world-wide sources
- Household size will continue to decline. Pensioners will be more numerous and constitute a larger segment of the population. With the ageing population and increasing interest in the health attributes of food, there will be a growing market for functional foods
- Growth in urbanisation and international contacts, higher living standards and changing consumer preferences, habits and lifestyles will lead to a much more dynamic consumer market for niche food products. The growth in catering and convenience foods will continue
- Through the more widespread use of information technology, the market intelligence available to food companies and retailers will be much increased, enabling them to target individual consumers. Equally, a substantial proportion of consumers will shop for food and other products on the Internet, leading to the creation of a global market. Other developments will include home shopping/delivery and extended opening hours
- Changing family and leisure demands may have a significant impact on farming practices and systems.

1.4 What will the Agri-Food Industry look like in 2015?

Scenario for the agri-food industry

Key features of the sector will be a sustained focus on competitiveness in a more liberal free trade and reduced price-supported environment, backed by innovations that have regard for growing consumer, environmental and animal welfare demands, together with changing lifestyles. In response to these and other pressures detailed in sections 1.2 and 1.3 above, structural changes in the sector will be accelerated, leading to a further escalation of the ongoing downward trend in farmer numbers. In the 1998 Labour Force Survey 100,000 people are enumerated as farmers. By 2015, this number will have dropped to something in the region of 50,000 - 60,000.

With the necessary strategic, management, marketing, scientific, technological and innovative capacities, the output of the agri-food industry can be maintained and may be increased. The scale of individual farms and processors will be significantly expanded. However, the number of operating units will be reduced.

In the changed circumstances it is envisaged that the agri-food sector in 2015 will comprise:

- Up to 25,000 commercial farmers, predominantly dairy producers (some 15,000 each producing at least 100,000 gallons of milk per annum) together with about 5,000 dry stock farmers, possibly 2,000 arable/horticultural producers and less than 500 pig producers
- Something of the order of 25,000-35,000 part-time livestock producers deriving a significant portion of their income from farming - many will have farm-forestry enterprises
- Possibly 50,000 other landholders whose primary income will not be derived from farming
- A small number of Irish multi-national food companies. There may be just four, and possibly no more than two, major dairy companies, each processing about a half to one billion gallons of milk per annum, and supplying dairy and meat products, dairy-based ingredients and consumer foods. The beef processing sector will undergo even greater rationalisation, resulting in no more than five, and probably less, beef groups (each with three or four plants) handling at least 80 per cent of beef exports
- Some 100 small and medium-scale food companies (each employing 50 to 250 people) and supplying niche markets for prepared or semi-prepared consumer foods
- Irish businesses will continue to develop strong market positions in the processing of food in Ireland and in the UK, in a market dominated by globalisation, or at least europeanisation, of the retail sector
- An expanded market for horticultural products, in particular nursery stock and mushrooms.

1.5 Strategic Questions facing the Agri-Food Industry

- How will the sector improve its strategic, management, marketing, scientific, technological and innovative capabilities so as to respond to growing food safety and quality requirements, allied to the increasing need to operate within environmental and animal welfare requirements and accommodate rapid continuous change?
- To what extent will European markets accept foods produced through the use of biotechnology?
- What markets and products will be targeted by the Irish agri-food sector?

1.6 Capacity Building in the Agri-Food Industry

What core technologies and other related competencies need to be built up to optimise the position of the agri-food industry in 2015?

- The strategic, management, marketing, scientific and technological capabilities to achieve competitiveness and, by continuous innovation, to deliver products and processes that meet consumer demands.

To put in place these fundamental competencies, priority should be given to building up the following capabilities:

- Production and processing technologies and systems (together with the necessary training programmes) that meet consumer demands for guaranteed food safety, assured freshness and quality. Such technologies include: ingredient technology; food microstructure, flavour and quality; minimal processing technologies; pathogen control systems, including risk analysis methodologies; high pressure technology; food irradiation; robotics and information technology
- Production systems for the agri-food industry that are economically and environmentally sustainable and which have regard to animal welfare and tourism developments, including: reduced input farming systems; waste reduction and management technologies; environmental modelling; risk assessment technologies and information technology
- The capability to monitor and evaluate and, where appropriate, harness developments in biotechnology in crops and livestock production and food processing, including: diagnostics; genetic and breeding technologies; environmental impact assessment and risk analysis methodologies
- Comprehensive marketing intelligence supported by the necessary market surveillance and research modelling of changing consumer attitudes and purchasing behaviour in Ireland and selected export markets.

1.7 Strategies to Build these Capacities

- To raise Ireland's scientific and technological capacity to the level necessary to become an effective 'receptor' of new technologies and not just receivers of 'recipes' for products, there is a critical need for a national manpower programme for science and technology including mechanisms to ensure more effective training and encourage greater mobility of researchers
- The establishment of centres of excellence, both in the public and private sectors (including SMEs), with the critical mass of scientists and technologists to develop and harness emerging technologies in areas of vital national interest, especially biotechnology. An important issue in regard to biotechnology is the need to put in place a more effective mechanism for communication between the scientific community and consumers
- Research leading to new products should be largely carried out by private companies and, in general, should not be undertaken by public institutions, except on a contract basis. Research in public bodies should concentrate on technology development and public good issues such as food safety, quality, nutrition, environment and animal welfare
- The creation of a national capability to support market surveillance and analysis, by developing co-ordinated inter-institutional linkages and programmes
- Surveillance and laboratory infrastructures to monitor food safety, establish public health priorities, and to detect and deal with food safety concerns, including emerging pathogens
- To ensure that the research and educational institutions meet both the national and international needs of the Irish food industry, arrangements need to be put in place to secure greater 'ownership' by industry of public research programmes through real involvement in priority setting, and ensuring effective inter-institutional co-operation and securing value for money. Allied to this is the growing need for joint ventures between industry and public institutions in building up research capabilities, as is already

happening in dairy processing and, more recently, in developing an econometric model of the agri-food industry in Ireland

- Public institutions should produce multi-annual research programmes and should put in place arrangements to facilitate greater mobility of personnel.

The Marine Sector in 2015

2.1 Introduction

Marine S&T priorities over the next five years (1999 - 2003) have been identified in a recent Marine Institute publication 'A Marine Research & Technology Development and Innovation Strategy for Ireland - A National Team Approach' (September 1998). The priorities and strategies outlined in this document for selected marine sectors (marine food, water-based leisure and tourism, and marine technology) were approved by the Cabinet in July, 1998 and launched by the Minister for the Marine and Natural Resources, at a press briefing, on 15th September 1998.

In forecasting future development opportunities and the strategies necessary to underpin them, one cannot anticipate major technological breakthroughs, which could radically change the way we perceive or utilise a marine resource or predict major natural or man-made disasters (a marine equivalent of BSE). Nonetheless, in many areas of development, we can identify trends (overfishing, competition for space, demands for higher environmental quality, life style changes, innovative applications of existing or emerging technologies) with which we will have to deal. Regardless of what the future brings, an S&T capability which is flexible and adaptable to change is essential.

Given the historic and relatively disadvantaged position of the marine sector in relation to public investment in RTDI and the potential for real economic growth and development in this sector, the Panel considered that there is an need for sustained public and private investment in **all aspects of marine S&T.** Against this background, the Panel felt it unwise to try to identify one or two key technologies, preferring to highlight the range of technologies necessary to support development in this sector.

2.2 Profile of the Marine Sector

- Ireland's marine territory covers some 900,000 sq. km. of seabed, which is over 10 times the land area
- A recent assessment of the marine resource, (Marine Institute, 1998), reveals that the sectors comprising marine food (fishing, aquaculture and food processing), water-based tourism and leisure and marine technology currently contribute over IR£900 million per annum to the economy and support over 32,000 jobs and that turnover in these sectors could be increased to IR£1,375 million per annum in five years time
- Turnover and employment in shipping, ports and harbours and seabed resources would significantly increase the above figures and these areas also have substantial scope for expansion
- The high quality of the Irish marine and coastal environment provides a unique competitive advantage allowing Ireland to export food products under a 'clean/green' label and to attract tourism
- In spite of being the third largest fishing power in the world after China and Peru, the EU has a trade deficit of up to 60 per cent in marine food products, estimated at e6.5 billion in 1995. This offers huge potential markets for Ireland as a marine food producing nation within the European Union.

2.3 World Developments to 2015

- The oceans are the last 'frontier' on Earth. The demands of a growing world population for food, minerals, energy and chemicals, allied with a growing knowledge of the seas and sea-beds and enhanced technological capabilities, will lead to increasing utilisation of marine resources
- Increased utilisation pressure increases the need to understand, monitor and manage the marine environment. To do this we need to develop the knowledge and technology to be able to forecast ocean dynamics (metocean studies) and predict and monitor patterns of global change in the same way that we currently predict the weather (meteorology)
- The growing demand for active rather than passive recreational activities and the focus on health, leisure and improved lifestyles, etc. have combined to put marine tourism on the brink of rapid expansion. Worldwide, these trends are manifested in the increasing pressure for leisure development in coastal zones, the requirement for greater physical access to the sea, the emergence of multi-user conflicts, impacts on biodiversity and other environmental quality issues and increasing levels of traffic and leisure activity offshore. Such activities are increasingly being addressed through strategies embracing the principles of Integrated Coastal Zone Management (ICZM) and supported by new developments in data management and communications (IT)
- Developing niche markets for added-value and health foods will increase the marketing importance of the quality of the environment in which the product was reared/caught and technologies to monitor and confirm environmental quality and traceability
- Greater public concerns on issues of environmental quality and sustainable development will stimulate even greater growth in the environmental sensor technology market (currently $5 billion world-wide per annum and growing at 5 per cent per annum)
- The sea is a major source of both renewable (wave and offshore-wind) and fossil (hydrocarbons, gas hydrates) energies and their exploitation will depend on market prices for alternatives and the development of new technology for harnessing these energy resources. Energy, both renewable and fossil fuel, will be extracted from the sea using new floating and subsea technologies in increasingly deeper water and hostile environments. In calculating real costs, environmental costs (pollution, environmental impacts, disposal of wastes, etc.) will increasingly be taken into account thus favouring a movement to renewable energies (e.g. wave and offshore wind energy) and transport options (e.g. short sea shipping/inland waterways as opposed to road transport).

2.4 European Developments to 2015

- Wild fisheries will be constrained, not only by limitations of the Common Fisheries Policy, but also by sustainability issues such as stock depletion, environmental impact and fuel consumption. These constraints will dictate that individual fishermen adopt more environmentally acceptable techniques of fishing
- Aquaculture will account for a growing proportion of the marine food harvest. While in-shore and inter-tidal areas will continue to be developed, research must also focus on alternatives such as on-shore recirculation and deep water units. 'Geographic' and 'eco-labelled' niche products will become increasingly important
- Seaweed production, by harvesting or aquaculture, will increase to feed the growing demand for food, health and natural products
- Exploration and development activity in the coastal and offshore oil and gas sector is increasing, and moving into deeper water environments such as the west coast of Ireland. Economic and technological developments will be both the facilitating and driving factors

- The demand for diversified, pollution-free and sustainable energy supplies will lead to a significant intensification of wave and offshore wind energy extraction technologies and systems
- Increasingly strict EU environmental legislation will demand a more sustainable approach to resource utilisation and management. This in turn will provide opportunities for cleaner production technologies, environmental monitoring and assessment technologies and new approaches to marine resource development
- Though shipping and ship-building has declined in Europe in the face of competition from other regions of the world, the internalisation of environmental costs and continued traffic gridlock on Europe's roads will lead to opportunities and developments in the use of short sea routes and inland waterways. Supporting this will be a parallel development in shipbuilding, intermodal transport and high technology cargo tracking systems (e.g VTMIS - Vessel Traffic Management and Information Systems)
- Increasing wealth in the EU, and growing leisure time, will result in greater demands for access to, and facilities for, marine tourism and leisure. Cruising, sailing and water sports will compete with fisheries, aquaculture and infrastructure development within the coastal zone.

2.5 The Context for Development of the Sector

For historical reasons, compounded by a continued lack of awareness of the value of our marine resources, Ireland is a late starter in the European context, in the development of a marine economy.

- With respect to the fishing/aquaculture sector the situation is currently that:
- Many species of wild fish in Irish waters are in danger of being fished to maximum, and even beyond, sustainable levels and the fishing industry operates within the tightly constrained parameters of the Common Fisheries Policy
- While aquaculture provides an alternative means of increasing fish and seaweed production and Ireland has been a pioneer in offshore aquaculture techniques, we are now starting to lose this status due to lack of R&D and investment
- Further, while Irish finfish aquaculture has lagged behind that of Norway and Scotland, for a variety of reasons, it stands to go even further behind as Chile comes on line with salmon and new countries such as the Faroe Islands enter the field.
- Taking a more positive perspective, the growing demand for the products derived from the marine resource, combined with advances in science and technology, offer a range of new opportunities for Irish marine industry:
- Ireland has developed a highly competitive and efficient sea fishing fleet, which is at the cutting edge of deep water sea fishing. Recent initiatives for the renewal of the white-fish fleet represent a positive step in this direction
- New materials and technologies can make a significant contribution to expanding finfish farming, including the farming of new species, in an economic and environmentally sustainable way
- Ireland has experience and significant natural advantages in shellfish cultivation
- The water-based tourism and leisure sector is growing rapidly in Ireland. From an Irish tourism marketing and policy perspective it is important to note that water-based tourism participants are broadly considered to be dominated by relatively high spenders and they also contribute to economic development on a regionally dispersed basis

- Technology developments facilitating the extraction of renewable and hydrocarbon energies from the sea and seabed, and increased commercial activity in these areas provide opportunities for Irish enterprise
- Energy opportunities include wave energy and offshore-wind (medium term) and gas hydrates (long term) and would provide energy security, reduction in atmospheric pollution and internationally tradeable products and services
- Marine biotechnology and the exploitation of marine biodiversity in terms of utilising marine bio-products have major potential for the future. A recent EU/US Task Force on Biotechnology Research (1996) has identified real potential in the area of marine micro-organisms
- As an island dependent on shipping for the transport of imports and exports, opportunities exist to develop shipping, intermodal transport, vessel traffic management and information systems based on new technological developments
- While human activities have resulted in a progressive degradation of the marine environment, much of the excesses seen in the more industrialised countries are not evident in Ireland
- Ireland's relatively high quality marine environment is the delicate thread that links the sustainable development of its marine resource. All marine resource development activities are dependent on maintaining environmental quality and must be supported by a level of research, monitoring, assessment and regulation and enforcement appropriate to meet existing needs and the increased pressure on the resource which will accompany a growing marine economic sector
- The global sensor technology market, both for environmental sensors and new forms of monitoring and exploration, is estimated at $5 billion per annum and is growing at 5 per cent per annum
- The net benefit of ocean forecasting is predicted to be of the order e500 million per year in five to ten years time (EuroGOOS (1996)). Ireland's existing IT expertise and strategic geographic location on the western periphery of the European Union provides a competitive opportunity to take advantage of emerging opportunities in this field
- The increased application of advanced technologies in the marine environment creates opportunities to build on Irish capabilities in IT, ocean forecasting, engineering, biotechnology and materials engineering.

2.6 Strategic Questions Facing the Marine Sector

- How do we secure public understanding of and commitment to the role of the marine sector in national economic development?
- What are the broad marine RTDI competencies necessary to achieve a profitable and sustainable marine economy in the year 2015?
- How to secure appropriate public and private investment in strategic marine RTDI competencies, establish critical mass and maintain continuity?

2.7 Key Uncertainties Affecting Development of the Marine Sector

- The degree of public and government perception of the potential of the marine sector will be critical to the sector's future development
- The outcome of the Common Fisheries Policy Review will have a major impact on the development frameworks for the fishing industry
- Future EU Policies on Framework Programme and on CSFs (Community Support Framework) for RTDI will influence the rate and scale of marine resource development
- Future EU and national environmental regulations will demand a new approach to sustainable resource management, recognising both development and conservation objectives
- We are vulnerable to market collapse because of dependence on a limited range of fish species
- In the case of aquaculture we are vulnerable to disease due to lack of a co-ordinated national management programme
- The provision of adequate coastal infrastructure (e.g. roads, harbours, slips, piers, etc.)
- Our ability to identify, assess and sustainably manage resources is limited and its future evolution remains uncertain
- Availability of core expertise and facilities and the means to support and develop these facilities, at least in the medium term, remains uncertain.

2.8 Opportunities and Strategies for Irish Marine Resource Development

In focussing on the opportunities for marine resource development in Ireland and the core RTDI competencies and skills required to underpin development, a number of sectoral activities are identified. These are supplemented by horizontal activities in the areas of environmental technology and education and training.

2.8.1 Marine Food and Bio-Products

In the marine food sector, opportunities lie in the primary production sector (sustainable fishing and aquaculture), value added food processing and specialist/niche foods. The strategies necessary to develop this sector include:

- Seek greater access to, and share of, the fish resources within, and beyond, the 200 mile zone for coastal fishing communities under the Review of the Common Fisheries Policy and other international agreements
- Develop sustainable fishing and aquaculture activities by providing the underpinning scientific, technological, training, financial and marketing support
- Develop value added marine food products, supported by research on food safety and bio-products (pharmaceuticals, food ingredients etc.), accelerate promotion of Total Quality Management systems and develop integrated distribution systems
- Evaluate and develop offshore and environmentally acceptable land-based aquaculture systems
- Improve environmental monitoring, health management and disease control.

The core capabilities required in this sector are primarily in the areas of sustainable marine harvesting technologies, food processing and the application of biotechnology to the marine food processing sector.

2.8.2 Leisure and Tourism

In marine leisure and tourism, opportunities exist for the development of angling,sailing/boating/ cruising and activity-based tourism. The strategies necessary to develop this sector include:

- Identify, access and manage marine tourism and leisure resources, promote water based tourism and provide appropriate facilities for its development
- Strengthen education and training activities in marine tourism and leisure.

The core capabilities required in this sector relate to coastal zone management and catchment management, the application of IT, education and training, and the protection of the marine and coastal environment.

2.8.3 Marine Technologies

In the marine technology sector, opportunities exist to develop indigenous technological capability to support the sustainable development of marine resources i.e. engineering technologies for fishing and aquaculture, sub-sea technologies (e.g. ROV/AUV), application of biotechnology for non-food products, instrumentation and sensors, IT applications and cleaner production technologies. The strategies necessary to develop this sector include:

- Promote greater awareness among engineers/technologists of opportunities in marine technologies
- Promote information and communication technologies (ICT) and their applications to sustainable marine resource development. This is already a highly competitive area in which Ireland has real skills. The opportunity now exists to direct this skill to the marine sector
- Provide economic/financial incentives for the application of existing technologies to the marine sector
- Promote development of new (targeted) technologies.

The core capabilities required in this sector involve a broad range of engineering and technological skills, from traditional engineering to the application of new and emerging technologies to marine resources.

2.8.4 Marine Energy

In the marine energy sector opportunities range from support technologies for the location and extraction of oil and gas from coastal and offshore waters, to new opportunities for the exploitation of renewable wave and off-shore wind energy and environmental technologies which reduce adverse impacts of development. The strategies necessary to develop this sector include:

- Improve Irish participation (through inclusion in licence agreements) in offshore exploration and identify and develop niche technologies suitable for oil and gas exploration

- Identify and develop niche technologies for renewable marine energy and increase the contribution of marine renewable energy to national energy needs.

The core capabilities required in this sector embrace a broad range of specialist engineering and technological skills in the exploration and production fields, ocean energy (wave and offshore wind) and environmental technologies.

2.8.5 Seabed Resources

- Develop the technical capability to identify and quantify seabed resources (including exploitable sand and gravel deposits) and research and develop appropriate technologies for their sustainable exploitation
- Develop marine bioprospecting/bioscreening programmes in conjunction with biotechnology-based enterprises.

2.8.6 Shipping

- Identify and develop niche markets in shipping and related services, including port facilities, navigation aids, intermodal transport and ship repair and fitting out
- Develop a world class design capability in marine leisure craft and components
- Vessel traffic management and information systems (VTMIS).

Horizontal Activities

2.8.7 Environmental Technology

Marine environmental research and technology development, drawing on the expertise and capabilities of the sectors outlined above (e.g. fisheries and aquaculture, biotechnology, sensor development, IT, etc), will be essential in order to maintain and improve environmental and product quality and to develop sustainable development strategies which facilitate multiple use and reduce conflict.

2.8.8 Education & Training

- The development of expertise to service the above sectors and provide for future capabilities will require a parallel development of appropriate postgraduate courses (Diploma/MSc) for marine engineers
- Educational issues should also be extended to the general public to ensure improved communications to provide accurate and timely information on S&T issues so as to contribute to informed public debate.

2.9 Core Technologies and Competencies for Marine Sector Development

In identifying key technologies for the year 2015, the Panel felt it unwise to try to identify one or two key technologies, preferring to highlight the broad range of technologies necessary to support development in the marine sector. The Panel did, however, attempt to identify a range of ‘horizontal technologies’ - those that were relevant to the natural resource sector in general and ‘specific technologies’ - those relevant specifically to the marine sector.

2.9.1 Horizontal Technologies

Horizontal technologies which are broadly applicable to the natural resources sector and which require specific expression in the marine sector are detailed below:

- Food Technology
- The core capabilities required in this sector relate to food processing, food quality and safety and the application of biotechnology to the marine food-processing sector in order to produce new value added products and niche products
- Information Technology
- The application of existing IT technologies: remote sensing, Geographical Information Systems (GIS), data management, communications, modelling and forecasting
- Biotechnology
- The application of biotechnology techniques to disease detection and management, bio-screening for bio-extracts from marine flora and fauna and to food processing.

2.9.2 Specific Technologies

These technologies are considered crucial but are specific to the marine sector:

- **Sustainable Harvesting and Production Systems**
  The development of harvesting technologies and systems, including cleaner production technologies, fish-finding technology, net design and manufacture, cage and tank design, which are selective, minimally destructive and sustainable
- **Sensor Development**
  The identification and utilisation of marine resources is dependent on technical intervention (remotely controlled vehicles, robots). Undersea activities are heavily dependent on sensors to feed back information to the operator or control instruments and robots. Considerable opportunities exist in the field, including instrumentation development, anti-fouling techniques and materials technology. In addition, emphasis on environmental quality will demand ever more sophisticated environmental monitoring sensors, linked to real time IT systems
- **Wave Energy**
  Strengthen existing wave energy expertise in Ireland in order to exploit the proven national wave energy resource and export wave technology products and services. Opportunities include power take-off and control and structural design and mooring
- **Transport**
  No detailed assessment on the RTDI needs in the shipping/ports sector has been undertaken to-date in Ireland. Given a dependence on shipping and port infrastructure for imports and exports and a potential trend, on environmental grounds, to the increased use of maritime transport, such an assessment is essential and should form an important component of any marine S&T Foresight Initiative.

2.10 Key Strategies for the Development of Core Competencies and Technologies

Given the historic and relatively disadvantaged position of the marine sector in relation to public investment in RTDI and the potential for real economic growth and development in this sector, the Panel considered that there is a need for sustained public and private investment in **all aspects of marine S&T**. This should specifically focus on:

- Implementation of appropriate mechanisms to support critical mass, to attain international competitiveness and to underpin continuity (at least in the medium term) of established and required cores of expertise and centres of excellence
- Support targeted education, training, R&D and support infrastructures in the marine sector
- Implement efficient mechanisms for technology transfer, increased R&D application/uptake in SMEs and better industry/research institute co-operation.

3. Forestry and Forest Industries in 2015

3.1 Profile of the Sector

- Total forest cover in Ireland is c. 600,000 hectares or approximately 8 per cent of land area. This is the lowest proportion in the EU. Some two thirds of the forest estate is owned by the State
- Total employment in the forest and forest products sector is c. 16,000, of which 7,000 is direct and 9,000 indirect
- Production from Irish forests is valued at IR£90 million with value added to industrial input timber and furniture of IR£170 million
- The sector is growing at some 10 per cent per annum and is targeted to reach values for total production and value added of IR£1.3 billion and IR£800 million respectively by 2035, with an increase in employment of 11,000 by 2020
- Principal features of the sector in 2015 will include the following:
    - Planting and harvesting will be fully mechanised
    - The level of timber production will have risen to approximately 4.5 million m3 per annum.
    - Sustainable forest management will be normal practice
    - Non-timber forest products such as leisure, recreation and forest tourism, hunting etc., will be of greater significance
    - Forests as carbon sinks will assume much greater significance
    - Milling capacity will be in place to meet increased production
    - Co-operation mechanisms will have developed as a feature of the Irish farm-forestry sector.

3.2 World Developments to 2015

- Forests cover 3,454 million hectares or 26 per cent of the total land area of the world. Between 1980 and 1995 world forests decreased by 180 million hectares. The developing world has lost over 200 million hectares through deforestation
- While the world's forest area has been steadily decreasing, there has been a continued increase in demand for wood products. It is estimated that the global consumption of wood increased by 36 per cent between 1970 and 1994
- Demand continues to grow by about 1.2 per cent per annum. The world economy is the key driver for the forest products industry. Annual growth in the various sub-sectors ranged from 0.4 per cent in coniferous softwood to 3.5 per cent in panel boards
- The construction, pulp and paper and engineered wood product sectors principally determine the demand for timber. The outlook for these sectors is generally favourable. Different agencies (U.N., F.A.O., Woodbridge Reed & Associates etc.) predict an average annual world growth of 1 to 2.6 per cent for sawnwood, 2.3 to 3.2 per cent for pulp and paper and 2.3 to 5.5 per cent for engineered wood products from 1995 to 2010
- Overall international supply and demand for softwood are broadly in line
- There will be an increase in fibre-based composite timber products, as well as a growing use of laminated products. There will be an increasing need for short rotation fibre crops to support the fibre market. Traditional rotation lengths, particularly for broadleaves, will

tend to shorten as markets develop for smaller diameter material for lamination processes

- There will be a growing protectionist attitude to the remaining areas of natural forest, leading to pressure on foresters to produce timber from species with shorter rotations. The non-timber benefits of forestry, carbon sequestration, amenity, wildlife and recreation will become more important and may exceed the value of the actual timber products.

3.3 European Developments to 2015

- European forestry covers approximately 200 million hectares and accounts for approximately 5 per cent of the world's forests. About 135 million hectares are exploitable. Fellings average about 420 million m3 per annum representing about 70 per cent of the net annual increment. The enlargement of the EU, involving Central and Eastern European countries with large forest resources, will lead to the sector assuming an increased strategic significance within the European economy
- Rationalisation of the timber harvesting and processing sector within Europe will result in cheaper and more versatile timber products
- Products produced from sustainably managed forests, coupled with technological advances in engineered wood products, will create opportunities for wood to compete, to a greater degree, with products from non-renewable resources e.g. cement and plastic
- The sector will be characterised by the emergence, at one level, of a small number of integrated, high-technology and heavily capitalised European (multinational) forest product groups and, at the other, by an increasing number of small-scale forest owners
- While a Common European Forest Policy is unlikely to emerge, sustainability concerns will become increasingly important, resulting in the forest industry operating within a more restrictive regime
- The multi-functional use of forests and their role within the rural economy, will assume growing importance.

3.4 The Context for Development of the Sector

- Ireland has the lowest percentage of forest cover in Europe at 8 per cent but has ambitious plans outlined in the Government's strategy document on the development of the forestry sector ‘Growing For The Future’, to increase this to 17 per cent by 2030
- Ireland will operate in increasingly competitive world markets. The total exploitable forests of Europe contain 20,000 million m3 of which 63 per cent is coniferous. The total annual increment is 630 million m3 of which 435 million m3 is harvest wood (F.A.O.). In a situation where there is growing pressure to increase cutting in the Nordic countries, there is a need for the European industry to work to increase average consumption of wood in central and southern Europe from 0.1m3 per person per annum, to the Nordic average of 0.5m3 per person per annum
- Current production in Ireland is 2.6 million m3 and is predicted to rise to about 4.5 million m3 by 2015. It is estimated that there is sufficient capacity in the saw-milling sector in place to deal with current production but it is under-utilised and this needs to be addressed now.

3.5 Uncertainties Affecting the Development of the Sector

- Continuing, and possibly growing, uncompetitiveness of Irish timber
- Cheaper and better quality timber from the Baltic, Russian and other Eastern European countries
- Inefficiencies in the Irish saw-milling sector
- The threat of disease associated with large-scale monoculture of tree species
- Life-cycle analysis of wood products may reveal critical issues, affecting the use of wood.

3.6 The Strategic Question for the Sector

How can we ensure that the wood and non-wood products which Irish forests will be producing can be competitively produced for domestic and international markets and that the national forest estate is economically, environmentally and socially sustainable?

3.7 Opportunities for Development of the Sector

- Increased population and wealth will create an expanded potential market for timber products and growing public awareness about sustainability will provide a favourable potential market for wood products
- There is a potential for Ireland to capitalise on developments associated with the carbon sink concept - i.e. trade credits, carbon tax
- There is an opportunity to expand the Irish share of the European market through added value products and to increase the percentage of the Irish market served by the indigenous forest industry sector
- Improved technology transfer can enhance value added, particularly in the utilisation of Irish wood in engineered wood products
- There may be opportunities, utilising new dispersed energy generation technologies, to capitalise on the energy resource which has been created in the Irish forest resource
- There are opportunities to develop niche IT and engineered technologies for the domestic and international market
- Professional forestry skills and expertise can be developed and sold abroad
- There are value-added opportunities for high-value furniture, decorative and craft products.

3.8 Strategies for Realisation of these Opportunities

The forest and forest products industry will face major problems unless there is substantial development and application of appropriate technologies. The targets set out in the Government's forest strategy document, 'Growing for the Future', will only be achieved if land suitable for afforestation is utilised. This will require a new perception of land use potential and the development of information and other associated technologies.

In respect to timber processing, unless technologies are developed to assist the Irish saw-milling industry to add value, it will lose opportunities in export markets.

Similarly, the panel industry, while having excellent fibre source, continues to operate in severely competitive markets. RTDI is an absolute prerequisite if this sector is to prosper.

In order to provide the technology needs for this growing industry and to ensure its potential, the priorities as outlined below must begin to be addressed under 'Agenda 2000':

- The consolidation and expansion of the management and co-ordinating mechanism to ensure that applied research and development over the whole forest and forest products sector is consistent and that there is adequate funding
- The development, promotion and application of technologies related to the multiple use of forestry will be essential to ensure that the restoration of our forest cover is seen to be widely beneficial to society
- Investment in appropriate technologies in forest operations, transport and logistics so as to ensure that Irish timber remains competitive
- Investment in information technology to strengthen links with the international forest and wood sector, and improve domestic strategies for land use
- Development of appropriate information systems, based on technology developments to ensure Irish timber is competitive
- Development of education modules and information systems to raise awareness and skills among engineers and architects to expand the use of wood.

3.9 Core Competencies and Technologies Required for Development of the Sector

- Wood science, materials science and applied engineering skills
- Genetic and other biotechnologies to improve the properties of Irish timber
- Information technology and communication skills
- Environmental management skills
- Planning and appraisal models
- Advanced marketing capabilities and skills.

Appendix I - Natural Resources Panel

Dr. Liam Downey, Chairman	Director	Teagasc
Pat Ridge, Deputy Chairman	Chairman	Bord Iascaigh Mhara
Noel Cawley	Managing Director	Irish Dairy Board Co-operative
Frank Convery	Director, Environmental Institute	NUI - Dublin
Matt Dempsey	Editor and Chief Executive	The Farmers Journal
Liam Donnelly	Director of Operations	Teagasc
Michael Feeney	Manager, Food, Timber and Consumer Products	Enterprise Ireland
Gerald Fitzgerald	Professor of Food Microbiology	NUI - Cork
Jim Flanagan	Chief Inspector	Department of Agriculture and Food
Paddy Glennon		Glennon Bros Timber Ltd
Professor Michael Guiry	Professor of Botany	National University of Ireland, Galway
Peter Heffernan	Chief Executive Officer	Marine Institute
Pat Keogh	Chief Executive	Bord Iascaigh Mhara
Martin Lowery	Chief Executive	Coillte Teoranta
Michael Duffy	Chief Executive	An Bord Bia
Denis Lucey	Chief Executive	Dairygold Co-operative Society
Fergal Mulloy	Director	COFORD
Larry Murrin	Lecturer	Dawn Farm Foods
John O'Callaghan	General Manager	Kerry Agri-Business
Dennis O'Connor	Head, Business Strategy, Consumer Foods Group	AWG
Maire Mulcahy	Professor of Zoology	NUI - Cork
Paddy O'Keeffe	Chairman	FBD Insurance
Joe Sreenan	Head, Animal Reproduction Department	Teagasc
Dr. Patrick Wall	Chief Executive	Food Safety Authority of Ireland
Brian Wickham	Chief Executive	Irish Cattle Breeding Federation
Owen Sweeney, Secretary		The Circa Group Europe Limited