# 2.3 Aquaculture

### Introduction

The Irish aquaculture sector is valued at approximately €100 million and employs approximately 1,600 people (2004). Aquaculture activity centres on salmon and trout as the main finfish species and on shellfish species such as oysters and mussels. Finfish farms typically employ around 20–30 and are located on the west coast. Shellfish operations are significantly smaller (averaging three employees), are typically family-owned, and are more dependent on part-time/casual labour. More than half are based in Cork, Kerry, Donegal and Galway.

At least 75% of aquaculture production is exported, mainly to France, Germany, the UK and Spain.

## 2.3.1 Finfish Aquaculture Research Programme

#### 2.3.1.1 Sector Profile

Salmon and rainbow trout are the two principal species farmed at sea. Salmon consistently accounts for 85–95%, by volume, of annual finfish production. Finfish farming is restricted to five western seaboard counties – Donegal, Mayo, Galway, Kerry and Cork. Production of turbot in land-based facilities has been conducted on a small-scale, and research is being carried out into the feasibility of culturing new species such as cod and halibut.

Over the period 2002–2004, farmed salmon production fell from 21,423 tonnes to 14,067—a 34% decrease. The decline resulted from a combination of factors forcing company receiverships and difficulties resulting from stock survival at sea. There was also a significant drop in sea-reared trout production over the same period—from 890 to 280 tonnes. The total value of finfish production in 2004 was €56.9m, with salmon accounting for €51.3m of this (>90%).

Some significant progress has been achieved in the cultivation of new species, with ongoing development of existing projects focused on the production of farmed cod.


**Key Facts:** Finfish aquaculture employment (2004) - 275 Full-time, 160 Part-time and 51 Casual = 366 FTEs
**Output:** Production peaked at 23,000 tonnes in 2001, dropping to 14,000 tonnes in 2004.

**Figure 2.4** Key Components of the Irish Finfish Aquaculture Sector

### 2.3.1.2 Key Opportunities and Challenges

#### Market Trends

World production of salmon is about 1 million tonnes and Ireland had about a 2% share of that market in 2002. The EU25 market for 2003 was approximately 500,000 tonnes. Over 80% of Irish salmon exports are sold in fresh form, the balance being mainly smoked with a small amount of frozen product. Irish salmon holds a high price compared to Norwegian and UK salmon but visibility in markets tends to be low because of low critical supply volumes. Quality schemes and labels have become very important. Irish organic salmon was a product leader in Europe and continues to enjoy an increasing margin. Higher margins are also a feature of the general increase in demand for organic products. The increasing trend towards organic products will put the EU market for organic seafood at over €300 million by 2009. BIM estimate that the main markets of Europe and USA offer significant opportunity for Irish exporters to market niche products.

#### Public Perception

The finfish aquaculture sector faces a continuing challenge to gain public acceptance as a sustainable use of the marine coastal resource. The operation of a well-regulated industry will require policy makers to assist a willing industry to operate within sensible environmental guidelines that ensure a secure future for the sector. The sector will face a continuing challenge to maintain and continue to update production methodologies to lead the way in environmentally sensitive operations.

#### New Species

Species diversification is vital to the further development of fish production in Ireland. A twin-track approach has been adopted to consolidate the production of high quality salmonids in addition to addressing a focus on the requirements of new species such as cod. A consortium of the Carna laboratory of NUIG, industry, Taighde Mara Teo., BIM and the Marine Institute have together initiated a programme to investigate cod hatchery and farm production methods. This group have now progressed to growth trials at sea, which are progressing well. This technical capability can also address the needs for the evaluation of other white fish species as required; as well as char, turbot and halibut.

New species production will also enhance supply and product development opportunities for the seafood processing sector.

The key to driving production forward on targeted species at a faster pace will be the execution of national R&D priorities on new species, in tandem with the use of technology transfer, and joint venture R&D approaches, to take advantage of husbandry techniques and new technologies developed in other countries.

### Development and Application of New Technologies

Technology development and application is of major importance to the aquaculture sector. New technologies have the potential to significantly impact on current production operations in the main species, e.g. salmonids. The economic and technical feasibility of offshore locations for finfish culture has yet to be proven.

In addition, there are development opportunities in new species production. New species production will have its own set of challenges, e.g. the use of land-based re-circulation technologies for the production of turbot and halibut, and the differing requirements for the cage culture of cod and other white fish species. Various species have specific challenges associated with them, providing a range of opportunities for technology companies. Requirements include new remote feeding, observational and telemetry systems; other automation-led requirements that come with the development of offshore locations for existing salmonid and new species (e.g. cod); and the advanced re-circulation systems that are required for the development of turbot production.

### Environmental and Food Safety Issues

The key challenges for the finfish sector are sea lice management and environmental monitoring to ensure that the seabed and water quality are sensibly managed. Ireland has a rigorous programme of aquaculture protocols that need to be regularly updated in the light of scientific advancements. The national surveillance of residues in farmed fish will become increasingly important for the production of organic fish.

### 2.3.1.3 2020 Scenario

**2020 SCENARIO**

By 2020, finfish aquaculture will be a vibrant industry supporting coastal communities to meet their social, cultural, environmental and economic objectives. The sector will be an important employer in the regional economy and will be a key supplier to the domestic seafood consumer and seafood processing markets.

The sector will be characterised by strong environmental practice and the application of science and technology to all key aspects of the production process.

Production will reach **45,000 tonnes**, valued at approx. €155 million, by 2015. This will consist of:

> 30,000 tonnes of salmon, grown in inshore sites, with a significant proportion grown to organic standards;

> 10,000 tonnes of superior quality salmon produced in existing/new offshore sites to Irish Quality Salmon or Label Rouge standards; and

> 5,000 tonnes of gadoids and marine flatfish (cod or other white fish species).

Further development to a level of 60,000 tonnes of salmonids (by 2020) will be dependant on overcoming challenges in the offshore sector.

The sector will be competitive, producing high quality product in land-based re-circulation systems and at sea. Domestic production of juvenile marine fish will be sufficient to meet the home market and there will be a growing export market to Europe. The production of salmonid smolts will stand at up to 20 million individuals. This will be sufficient to supply the home market and a small export market. There will be several small but profitable producers growing trout and char for high quality, niche markets.

The cost of production will be competitive. The key factors underpinning the unit cost of production and ensuring competitiveness will be:

> Production at an appropriate scale (5–10,000 tonne units);

> The strains being cultivated are the best available;

> Good vertical integration within the industry;

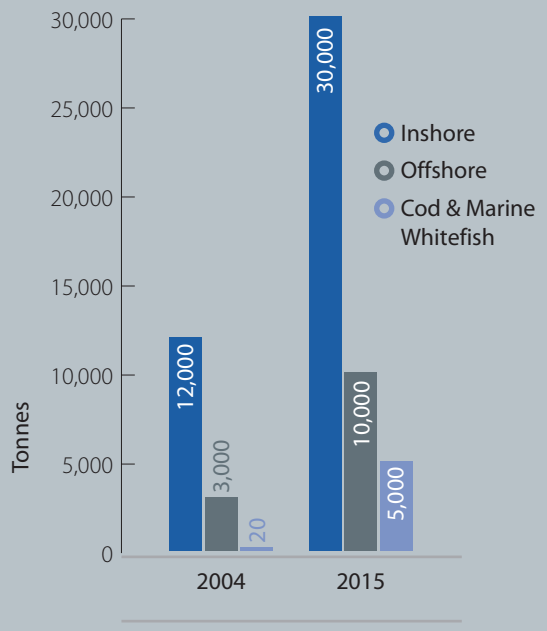



**Figure 2.5** 2015 Production Scenario for the Finfish Aquaculture Sector

> An industry organised in nodes or clusters with a high degree of co-operative use of common facilities, both within the industry and with related sub-sectors (fisheries, food processing);

> A highly automated industry with employees that have a high skills base;

> Remote telemetry as a key to monitoring, management and control of processes within the industry; and

> Health management has been developed and consolidated into a holistic code of practice that is underpinned by effective vaccines for key problems including sea lice, Pancreas Disease (PD) and Infectious Salmon Anaemia (ISA).

The industry will be attractive to international processors/venture capitalists and will attract significant inward investment. Key factors are:

> Good, sustained profitability;

> Transparent regulation, giving confidence to consumer and investor alike; and

> Licenses and regulations combining to ensure there is security of tenure and production sites are regarded as solid assets.

### 2.3.1.4 2013 Objectives

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

**2013 OBJECTIVES**

1 Focus on production and marketing of higher value, safe seafood (including organic).

2 Develop and refine Codes of Best Practice for farm management and fish health and establish an effective health management regime.

3 Improve marine planning and management of aquaculture, in order to optimise standards, maximise production and minimize negative interactions in the coastal zone.

4 Further develop and refine environmental monitoring and forecasting capabilities and develop environmental monitoring systems for aquaculture that will provide the basis for a new suite of indicators and incentive-based regulation.

5 Identify sites and develop technologies/management systems for offshore finfish aquaculture.

6 Transfer technology and commercialise hatchery, juvenile production and on-growing capabilities for char, cod, turbot and halibut.

7 Foster R&D in the production of other white fish and related technologies.

8 Build capability in onshore re-circulation technologies, in both sea and fresh water.

### 2.3.1.5 RTDI Requirements & Key Outputs

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

**Table 2.7** Research Requirements & Key Outputs for the Finfish Aquaculture Sector to 2013

| Objectives 2013 | RTDI Requirements | Key Outputs |
|---|---|---|
| 1 Focus on production and marketing of higher value, safe seafood (including organic). | > Market research for organic products and finfish produced by 'environmentally friendly' means<br>> Research opportunities to add functional food properties to organic production | > Increased product penetration in the growing consumer market category for healthy product |
| 2 Develop and refine Codes of Best Practice for farm management and fish health and establish an effective health management regime. | > Integrate monitoring, management and licensing regimes into a seamless process<br>> Evaluate and refine codes of practice/protocols for aquaculture management and monitoring<br>> Develop and refine Single Bay Management/CLAMS and the implementation of integrated single bay-based code of practice for on-farm health management<br>> Contribute to research, development and licensing of appropriate vaccines for key viral diseases and parasites (PD, ISA, sea lice) | > Series of protocols on monitoring and management directly linked to license requirements<br>> Agreed and enforceable health code in place<br>> Optimised fallowing and proactive management<br>> Effective vaccines available for the main disease and parasite threats |

*Continued*

**Table 2.7** Research Requirements & Key Outputs for the Finfish Aquaculture Sector to 2013

| Objectives 2013 | RTDI Requirements | Key Outputs |
|---|---|---|
| 3 Improve marine planning and management of aquaculture, in order to optimise standards, maximise production and minimize negative interactions in the coastal zone. | > Develop effective carrying capacity modelling capability to support environmentally sustainable aquaculture | > Inshore/near shore models in active use, contributing to sustainable use of the marine resource for aquaculture production; in line with good coastal zone management practice |
| 4 Further develop and refine environmental monitoring and forecasting capabilities and develop environmental monitoring systems for aquaculture that will provide the basis for a new suite of indicators and incentive based regulation. | > Improve environmental forecast monitoring methodology<br>> Develop management and mitigation measures for harmful phytoplankton and zooplankton (jellyfish)<br>> Assess system for development of an indicator/incentive based management system that will reward operators implementing environmentally sound best management practice, yet optimise production capacity | > Real-time monitoring and management systems for environmental variables<br>> Early warning systems for harmful species<br>> State approved incentive-based monitoring and regulatory system in operation |
| 5 Identify sites and develop technologies/ management systems for offshore finfish aquaculture. | > Develop/transfer technology to assist with cage development and management systems, including ancillary technology needs (cages/feed systems, telemetry and integrated marine engineering/design systems)<br>> Develop 'test-bed' sites for technology evaluation | > Offshore cage technology refined, creating business opportunities for industry<br>> Management systems and technology for operations offshore and in exposed locations |
| 6 Transfer technology and commercialise hatchery, juvenile production and on growing capabilities for char, cod, turbot and halibut. | > Use of R&D and technology transfer to commercialise hatchery, juvenile and on-growing stages of turbot, halibut and char production (f/w + s/w)<br>> Continue the development of perch production (f/w)<br>> Develop appropriate cage-based grow-out technologies for cod<br>> Scale up and commercialise existing shore-based hatchery technology<br>> Develop broodstock programmes for screening native species as suitable aquaculture strains | > Reliable Irish hatchery & grow out technology in a range of marine species giving increased diversification of species production<br>> Cage culture of cod established in existing licensed finfish sites<br>> Commercial cod hatchery and nursery facility, with an increasing production of other marine finfish<br>> Native whitefish strains available for aquaculture |
| 7 Foster R&D in the production of other white fish and related technologies. | > Promote R&D in other white fish and related technologies<br>> Develop the necessary broodstock programmes with view to culture potential | > The beginning of technological capability to farm other whitefish species including selected broodstock strains |
| 8 Build capability in onshore re-circulation technologies, in both sea and fresh water. | > Adapt and develop technology for Irish needs in development of onshore fish farming | > Suitable systems tested/ selected for a variety of finfish species in Irish conditions |

RTDI Capacity/Capabilities in Finfish Aquaculture is considered together with Shellfish Aquaculture in Section 2.2.3.

#### 2.3.1.6 Prerequisites for Achieving Finfish Aquaculture Objectives

The following are considered as prerequisites for the successful delivery of the objectives for the finfish aquaculture research programme:

> Building public understanding and support for aquaculture as a sustainable marine sector among consumers, local communities and Government bodies;

> Policy support for integration of management, monitoring, and regulation—a DCMNR forum/facilitator to resolve administrative and licensing issues should be considered;

> Market research and brand development support, based on quality assurance and Irish origin;

> Policy support to deliver on new species development; and

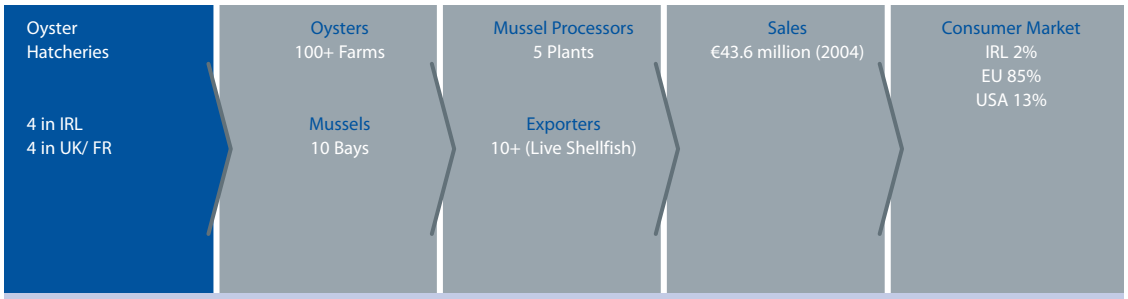
> Suitable international networks of experts/researchers/business interests to underpin and drive R&D and commercialisation in the sector.

## 2.3.2 Shellfish Aquaculture Research Programme

### 2.3.2.1 Sector Profile

Mussels, Pacific oysters (*C. gigas*), native oysters (*O. edulis*), clams and scallops are the main shellfish species produced in Ireland. Mussels, which are farmed using both suspended ropes (intensive) and bottom-culture (extensive), account for 80-90%, by volume, of annual shellfish production. Oysters (principally Pacific oysters) account for a further 10-15%. Other species farmed on a smaller scale include abalone and purple sea urchins. Shellfish farming takes place in every coastal county with the exceptions of Wicklow and Dublin. Steady progress made in shellfish production levels over the last few years was consolidated during 2004 because of favourable environmental conditions and continuing strength in market price and demand.

Production in the shellfish sector for 2004 amounted to 43,000 tonnes, of which mussels accounted for almost 37,300 tonnes (90%). The total value of shellfish production in 2004 was €43.6m, with mussels accounting for €27.9m, or 65%, of this. Bottom mussels alone accounted for almost 50% (€21m) of the total value of shellfish production in 2004.




**Key Facts:** Shellfish Employment (2004) - 443 Full-time, 584 Part-time and 419 Casual = 806 FTEs

**Output:** Production of bottom mussels has grown from 9,500 in 1999 to over 28,000 tonnes in 2004. Rope mussel output fell due to biotoxins in 1999/2000, recovering to 9,000 tonnes in 2004. *Gigas* oyster production has grown from 1,000 in 1991 to over 5,000 tonnes in 2004. Production of clams and scallops remains small at <300 tonnes in 2004.

**Figure 2.6** Key Components of the Irish Shellfish Aquaculture Sector.

### 2.3.2.2 Key Opportunities and Challenges

The main markets for Irish shellfish production continue to be Europe and the USA. The US market is heavily reliant on imports from Europe—estimated to have amounted to €154 million in 2004. Ireland's trade in seafood with the USA has dramatically increased from around €1 million in 1993, made up of salmon and related products, to over €5 million in 2004. The major contribution in 2004 came from frozen molluscs, which accounted for €3.4 million. These niche markets will remain very important to Irish producers. There are significant opportunities for expansion with retailers in the US; with Irish produce sold to high-end customers. A significant opportunity in the US market for Irish exporters is the development of the organic seafood sector. The consumer market in the US for organic seafood is worth an estimated €415 million[8]. Similarly, the European market for organic seafood will be worth an estimated €332 million in five years (Naturland, Germany).

The European market will continue to offer opportunities for shellfish and vacuum-packed frozen product will remain important. Bottom grown mussels will continue to be in good demand with a focus more on Modified Atmosphere Packaging (MAP) products, which even now account for 40% of the French market. Demand is likely to remain steady for good quality mussels in the main European outlets. However, producers will face increasing challenges from imports of frozen product from countries such as Chile. Demand for good quality Pacific oysters is expected to remain steady and new species such as clams and scallops will maintain niche market opportunities. Production of abalone and urchins are likely to offer high-end opportunities for quality Irish produce and demand will exceed supply for the foreseeable future.

Innovative production and processing technology will continue to pose challenges and, specifically, the 'fresh-frozen' patented technology used by several prominent mussel processors will come off patent in 2007, exposing Irish shellfish processors to increased competition from low-cost mussel producers such as Chile.

The shellfish sector will continue to face the challenge of maintaining product quality and safety, arising from factors such as harmful algal blooms and water quality in shellfish growing areas.

The sector has an opportunity to build on the 'green' image that Irish seafood currently enjoys and through the process of diversification, will provide many opportunities for developers and investors. Although challenging, there are potential opportunities for those willing to engage in new species development (e.g. abalone and urchins). The pace at which development occurs will depend heavily on the support of the third-level research community and state agency R&D support. A rational, concerted strategy between agencies, researchers and industry will assist in providing a sensible way forward towards expanding the shellfish aquaculture sector.

[8] Johnson, H.M. (2003). U.S. Seafood Market in 2020. Global Aquaculture Advocate.

### 2.3.2.3 2020 Scenario

**2020 SCENARIO**

By 2020, the sector will have continued its steady growth since the 1990s, with the benefits of science-based management systems, managed seed supply, integrated hatcheries and better farm efficiencies. The industry, researchers and state agencies will have evolved a framework for science-based, rational management of seed supply in the mussel sector. The industry, supported by key agencies, continues to build its reputation for a high standard of food safety. Ireland provides a source of top quality, fresh shellfish, including *Gigas* oysters for European markets, supported by pro-active management of shellfish water quality.

Shellfish will be a diversified sector, with four main species (mussels, oysters, abalone and urchins) and a volume of 96,000 tonnes (increase from 43,000 in 2004), valued at €135m.

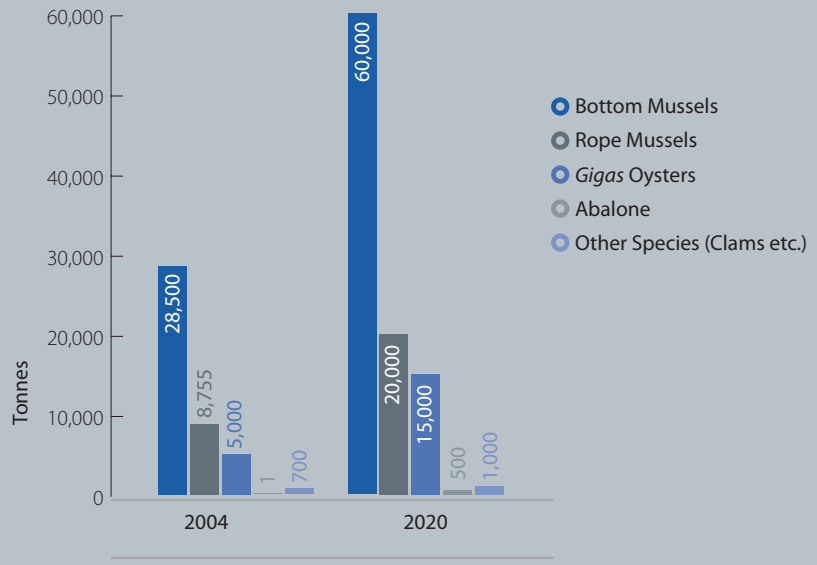



**Figure 2.7** 2020 Production Scenario for the Shellfish Aquaculture Sector.

### 2.3.2.4 2013 Objectives

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

**2013 OBJECTIVES**

1 Develop and implement a science-based management system for each species and each stage of production.

2 Provide dynamic carrying capacity models for each major shellfish bay and pro-actively facilitate the rationalisation of shellfish production sites.

3 Promote scale of production (including hatcheries) and processing.

4 Strengthen capability and foster international collaboration on shellfish health.

5 Improve efficiencies in production by application of technology.

6 Improve environmental monitoring and food safety capability in support of the industry.

### 2.3.2.5 RTDI Requirements & Key Outputs

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

**Table 2.8** Research Requirements & Key Outputs for the Shellfish Aquaculture Sector to 2013

| Objectives 2013 | RTDI Requirements | Key Outputs |
|---|---|---|
| 1 Develop and implement a science-based management system for each species and each stage of production. | > Carry out applied research on biomass, seed availability and optimisation of production methods (e.g. wild mussel seed) as inputs to a science-based management programme | > Agreed framework, involving industry, science and state agencies, for the management of the resource, based on scientific advice |
| 2 Provide dynamic carrying capacity models for each major shellfish bay and pro-actively facilitate the rationalisation of shellfish production sites. | > Develop dynamic nutrient and/or chlorophyll driven carrying capacity models for key production bays | > Optimisation of sustainable carrying capacity of shellfish production areas maximising shellfish productivity and yields<br>> Rationalisation of production sites in line with best management practice and the scope of legislation |
| 3 Promote scale of production (including hatcheries) and processing. | > Applied research and innovation in the mechanisation and improved efficiency of all shellfish culture systems<br>**Mussels**<br>> Basic research into all stages of life cycle<br>> R&D on juvenile production and handling methodology<br>> Monitoring of potential pathogens and pests (e.g. *Mytilicola*) in shellfish with an emphasis on mussels and the impact of ocean warming on these dynamics<br>***Gigas* Oyster**<br>> Develop integrated facilities for hatchery, nursery and on-growing of Irish *Gigas* strain<br>> Research into shellfish health management incl. viral diseases and unexplained mortalities (with international collaboration)<br>> Improve genetic stock with selective breeding programme<br>***Edulis* (Native) Oyster**<br>> Research into the life cycle of Bonamia and the breeding of resistant strains<br>**New Species**<br>> Selective breeding programmes for abalone<br>> Development of indigenous feed supply (seaweed based) for both abalone and urchins<br>> Refinement of re-circulation technology for shore-based cultivation | > Increased mechanisation of processes with associated drop in unit production cost<br>**Mussels**<br>> Improved management of juvenile supply and improved yield<br>> Strengthened protocols for protection of seed supply<br>> Predictive models for spat falls and seed supply<br>***Gigas* Oyster**<br>> Availability of reliable supply of seed of Irish origin with improved survival<br>> Improved survival of oysters based on a better understanding of shellfish health and environmental parameters<br>> Higher quality Irish oyster products<br>***Edulis* (Native) Oyster**<br>> Availability of resistant strains in bays that have been affected by *Bonamia*.<br>**New Species**<br>> Commercial strains of abalone with certified growth profile<br>> Commercially available high quality rations for abalone and urchins<br>> Efficient, cost effective shore-based production systems for urchins and abalone |

*Continued*
**Table 2.8** Research Requirements & Key Outputs for the Shellfish Aquaculture Sector to 2013

| Objectives 2013 | RTDI Requirements | Key Outputs |
|---|---|---|
| **4** Strengthen capability and foster international collaboration on shellfish health. | > Foster R&D linkages with international experts on shellfish health, including participation in joint international R&D projects on diseases such as *Bonamia* in native oysters, brown ring disease of clams, and Summer Mortality Syndrome (SMS) in *Gigas* oysters | > Increased national capability in shellfish health on foot of successful international collaborative R&D projects |
| **5** Improve efficiencies in production by application of technology. | > Adapt and/or develop continuing technology enhancement to improve production efficiencies<br>> Investigate/adapt new procedures/ technology for moving some production to offshore locations<br>> Identify areas of high productivity offshore to allow for further development | > More cost-effective farm production systems<br>> Increasing tonnage produced from offshore locations |
| **6** Improve environmental monitoring and food safety capability in support of the industry. | > Research into alternatives to bio-assays and development of rapid assays/field tests for biotoxins<br>> Remote monitoring/predictive systems for Harmful Algal Bloom (HAB) occurrences<br>> Interactions between shellfish aquaculture and the environment, with an emphasis on inter-tidal culture/bird interaction | > Improved rapid toxin detection methods leading to increased food safety levels and optimal production/marketing management for industry<br>> National HAB and environmental real-time data system (including pigment and nutrient data) available live to industry<br>> Codes of best practice for shellfish cultivation in sensitive areas |

### 2.3.2.6 Prerequisites for Achieving Shellfish Aquaculture Objectives

The following are considered as prerequisites for the successful delivery of the objectives for the shellfish aquaculture research programme:

> Appropriate consolidation of the sector either by rationalisation and/or the development of co-operative business units;

> State policy support to rationalise production, based on predictive models and data on carrying capacity of shellfish production areas; and

> Development of an Irish shellfish 'brand'.

### 2.3.3 RTDI Capacity/Capabilities (Finfish & Shellfish)

Aquaculture research draws on a wide range of disciplines including marine sciences (botany, zoology, microbiology and oceanography), engineering, veterinary science and genetics, and is currently being carried out within the third-level sector, state agencies and industry.

#### Current Research Capacity

##### Third-level Sector

In the third-level sector, 10 research groups are currently carrying out aquaculture research. Together, these groups comprise approximately 60 researchers in aquaculture research (Table 2.9). Current topics of research within these groups include Harmful Algal Blooms (HABs); biotoxin identification, isolation and analysis; salmonid genetics; new species development (e.g. cod and abalone); and fish and shellfish health and immunology. Other groups carry out research that is applicable, but not directly related to, aquaculture. Much of this is in the area of water quality modelling, marine biology/ecology; ecosystem functioning; and marine biodiversity conservation, and, as such, is of importance within the context of ensuring a sustainable aquaculture industry.

**Table 2.9** Overview of Current Aquaculture Research in the Third-level Sector

| Institutes | No. Research Groups | No. Researchers* | Research Focus |
|---|---|---|---|
| NUIG<br>UCC<br>UCD<br>LYIT<br>DIT<br>GMIT | 5 Large Groups<br>4 Medium Groups<br>1 Small Groups | 60 | > Finfish and shellfish aquaculture, aquaculture systems, new species<br>> Fish & shellfish health and immunology<br>> Salmonid genetics, genetic interactions<br>> HABs<br>> Seaweed culture, fish feed<br>> Biotoxin identification/testing<br>> Molecular biology of salmon<br>> Functional genomic approaches to stock selection<br>> Toxicology, development of *in vitro* tests for biotoxins<br>> Sea lice biology<br>> Biotoxin analysis & isolation<br>> Identification of bivalve larvae<br>> Shellfish spat production<br>> Salmon smoltification<br>> Shellfish histology and pathology<br>> Salmon disease and stress diagnostics |

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

* In some cases, research groups may focus on more than one theme and the total number of researchers in these groups is greater than indicated here. The total number of researchers in the groups identified is approximately 140.

In addition, a further 8–10 research groups and individual researchers (approximately 75–100 researchers) have relevant skills/technologies to become involved in aquaculture research, based on the identified future RTDI requirements. Many of these groups carry out research in the fields of technology and biotechnology with obvious potential for the transfer of skills/technology to aquaculture related research.

Aquaculture research facilities available within the third-level sector include re-circulation units, and finfish and shellfish hatchery and on-growing facilities.

### State Sector

The Marine Institute is involved in various ongoing nationally and internationally funded aquaculture research projects. Key areas include biotoxin research, disease and parasite control, new species development, and coastal zone management.

Researchers at the National Food Centre (Teagasc) carry out research on food quality and safety, and product and process innovations. This has obvious applications to the future RTDI requirements of the aquaculture sector; specifically, the objective of producing higher value, safe seafood.

Two other state agencies (BIM and Taighde Mara) have aquaculture research capacity/capabilities. Although primarily research funding and development agencies—e.g. providing grants towards the cost of feasibility studies and commercial trials on new species development, technology transfer and opening up of new locations for aquaculture—they are involved in aquaculture research with Irish and international partners.

### Industry

Aquaculture research is carried out by a small number of companies (3–5), and focuses on new species development (e.g. turbot, abalone, perch and char), fish health, and cage design. In addition, there is a strong tradition of innovation in the aquaculture sector including technical adaptations of equipment, site selection, and the development of suitable strains of finfish and shellfish for Irish conditions.

## Identification of Research Skills/Competencies to Meet Future RTDI Requirements

A summary, based on the identified future RTDI requirements, of the competencies required to meet the 2013 Objectives is presented in Table 2.10. Also included in Table 2.10 is an assessment of whether there are current strengths (S), areas that require strengthening (R), or gap areas (G), in relation to the identified requirements (2007–2013), within the existing research community. The competencies required are, in some cases, common to one or more objectives.

Table 2.10 Competencies Required to Meet Future Research & Innovation Requirements for the Aquaculture Sector

**Finfish Aquaculture**

| Objectives 2013 | Competencies Required | Assessment |
|---|---|---|
| 1 Focus on production of higher value, safe seafood (including organic). | > Food technology<br>> Human nutrition<br>> Fish nutrition | S<br>S<br>R |
| 2 Develop and refine Codes of Best Practice for farm management and fish health and establish an effective health management regime. | > Fundamental marine sciences<br>> Marine veterinary science<br>> Vaccine development<br>> Development of management systems/codes of practice | S<br>R<br>R<br>R |
| 3 Improve marine planning and management of aquaculture, in order to optimise standards, maximise production and minimize negative interactions in the coastal zone. | > Fundamental marine sciences<br>> Physical & biological modelling<br>> Development of carrying capacity models | S<br>R<br>G |
| 4 Further develop and refine environmental monitoring and forecasting capabilities and develop environmental monitoring systems for aquaculture that will provide the basis for a new suite of indicators and incentive-based regulation. | > Fundamental marine sciences<br>> Development of management systems<br>> Physical & biological modelling<br>> Statistical analysis of data sets | S<br>R<br>R<br>R |
| 5 Identify sites and develop technologies/management systems for offshore finfish aquaculture. | > Cage design/technology<br>> Advanced technologies (telemetry, robotics)<br>> Site assessment | R<br>R<br>R |
| 6 Transfer technology and commercialise hatchery, juvenile production and on-growing capabilities char, cod, turbot and halibut. | > Production of juveniles<br>> Commercialisation of hatchery technology & juvenile production<br>> Commercialisation of on-growing stages<br>> Development of grow-out technologies<br>> Broodstock programme development | R<br>G<br>G<br>G<br>R |
| 7 Foster R&D in the production of other white fish and related technologies. | > Aquaculture systems<br>> Broodstock programme development | R<br>R |
| 8 Build capability in onshore re-circulation technologies, in both sea and fresh water. | > Re-circulation technology<br>> Aquaculture systems | R<br>R |

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

*Continued*

Table 2.10 Competencies Required to Meet Future Research & Innovation Requirements for the Aquaculture Sector

**Shellfish Aquaculture**

| Objectives 2013 | Competencies Required | Assessment |
|---|---|---|
| 1 Develop and implement a science-based management system for each species and each stage of production. | > Fundamental marine sciences<br>> Resource assessment | S<br>R |
| 2 Provide dynamic carrying capacity models for each major shellfish bay and pro-actively facilitate the rationalisation of shellfish production sites. | > Fundamental marine sciences<br>> Physical & biological modelling<br>> Development of carrying capacity models | S<br>R<br>G |
| 3 Promote scale of production (including hatcheries) and processing in the shellfish sector. | > Fundamental marine sciences<br>> Shellfish juvenile production/handling<br>> Marine veterinary science<br>> Genetics/selective breeding<br>> Development of integrated culture facilities<br>> Development of shellfish diets | S<br>R<br>R<br>R<br>G<br>R |
| 4 Strengthen capability and foster international collaboration on shellfish health. | > Marine veterinary science | R |
| 5 Improve efficiencies in production by application of technology. | > Offshore technology<br>> Site identification/assessment | G<br>R |
| 6 Improve environmental monitoring and food safety capability in support of the industry. | > Biotoxin isolation & analysis<br>> Development of bio-assay alternatives for biotoxins<br>> Remote monitoring and prediction of HABS<br>> Assessment of aquaculture-environment interactions | S<br>R<br>R<br>S |

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

There are gaps in the competencies required for all stages of new finfish species culture, the development of carrying capacity models in support of environmentally sustainable aquaculture, and the development of integrated shellfish culture facilities.

Areas that require strengthening include competencies in support of onshore re-circulation technology (finfish and shellfish), offshore technologies, finfish and shellfish health, broodstock programmes/selective breeding, environmental monitoring and prediction, and development of fish and shellfish diets.

Areas with current strengths include biotoxin isolation and analysis, assessment of aquaculture-environment interaction and fundamental marine sciences.

Although individual disciplines and skills may be available, the challenge lies in aligning research capacity and the application of expertise to the specific issues that will address the RTDI requirements and meet the overall objectives set for 2013.

| Current Strengths | Require Strengthening | Gaps |
|---|---|---|
| > Assessment of aquaculture-environment interactions | > Development of management systems/codes of practice | > Commercialisation of hatchery technology & juvenile production (new finfish) |
| > Biotoxin isolation & analysis | > Site identification/assessment | > Commercialisation of on-growing stages (new finfish) |
| > Fundamental marine sciences | > Shellfish resource assessment | > Development of carrying capacity models |
| > Human nutrition | > Broodstock programme development | > Development of grow-out technologies (new finfish) |
| > Food technology | > Genetics/selective breeding (shellfish) | > Development of integrated culture facilities (shellfish) |
| | > Production of juveniles (new finfish) | |
| | > Shellfish juvenile production/handling | |
| | > Marine veterinary science | |
| | > Vaccine development | |
| | > Development of shellfish diets | |
| | > Fish nutrition | |
| | > Aquaculture systems | |
| | > Development of bio-assays alternatives for biotoxins | |
| | > Remote monitoring and prediction of HABS | |
| | > Physical & biological modelling | |
| | > Advanced technologies (telemetry, robotics) | |
| | > Cage design/technology | |
| | > Re-circulation technology | |
| | > Offshore technology (shellfish) | |
| | > Statistical analysis | |

**Figure 2.8** Research Competencies Required to Meet 2013 Objectives for Aquaculture