Status of Irish Aquaculture 2004

A report prepared
by
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All photos courtesy of Marine Institute and BIM.

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1. INTRODUCTION

Aim and Scope of Report

This report is the second annual report on the status of Irish aquaculture (see Parsons *et al.*, 2004). It has been produced in collaboration with the three main State agencies that provide support services in the areas of research and development to the industry – Bord Iascaigh Mhara (BIM), the Marine Institute and Taighde Mara.

The aims of the report are to:

- provide an objective and comprehensive source of information on the status of Irish aquaculture in 2004;
- show the main trends in the production, employment export and market statistics for the Irish industry in 2004;
- summarize the current licensing activity, which is the responsibility of the Department of Communications, Marine and Natural Resources;
- present the results of the wide range of monitoring programmes for farmed shellfish and finfish, which are carried out primarily by the Marine Institute, in accordance with Irish and EU food safety and environmental requirements;
- highlight the various research and development initiatives in the area of aquaculture that are underway in the various State agencies and third-level institutions; and
- report other issues/events/initiatives that occurred during 2004.

The overall aim of the report is to provide useful reference material for the industry, trade customers, investors, researchers and interested parties.

Brief Overview of Irish Aquaculture Industry

Since the initial developments in the early 1970s, the Irish aquaculture industry has grown to become an important contributor to the national economy. The diversity of sites used and the species farmed have also increased. The sector grew in output value from €37.2 million (26,500 tonnes) in 1990 to a peak in 2002 of €125 million (61,000 tonnes). Since then the industry has experienced mixed fortunes. The shellfish sector has continued to grow output, albeit with a small decline in 2004. Production in the finfish sector, on the other hand, has declined over the last four years. This reduction in finfish output, primarily in the salmon sector, which dominates finfish production – has been the result of a number of factors, including difficult market conditions (*i.e.* low prices) and disease problems (primarily Pancreas Disease). In addition, two of the three sites in south Donegal that experienced large-scale mortalities in 2003 (see Cronin *et al.*, 2004) did not re-commence production in 2004.

Mussels, Pacific oysters (*Crassostrea gigas*), native oysters (*Ostrea edulis*), clams and scallops are the main shellfish species being produced in Ireland at present. 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%. Shellfish farming is practiced in every coastal county with the exceptions of Wicklow and Dublin (Figure 1). Shellfish species farmed on a smaller scale include abalone and purple sea-urchins (Figure 2).

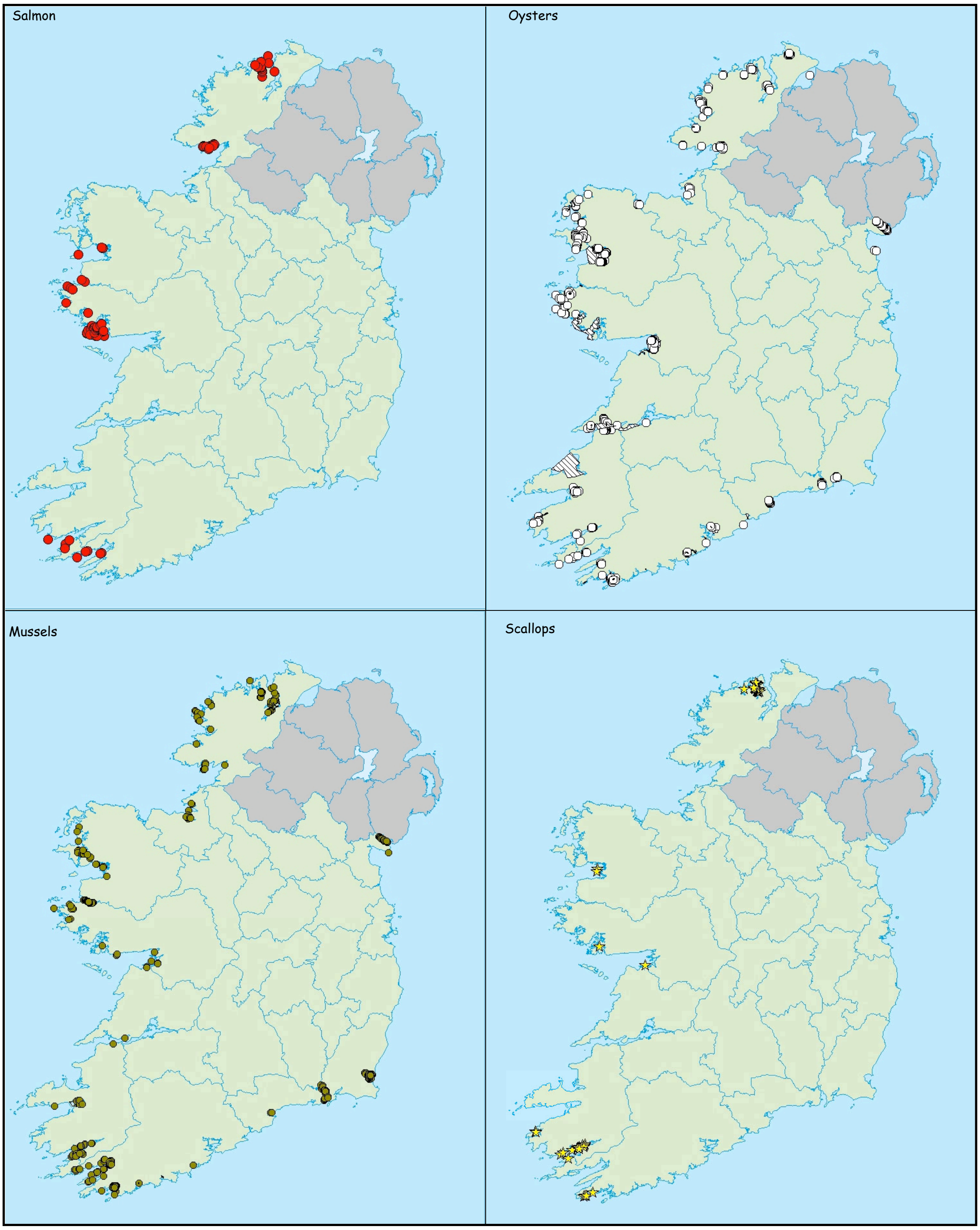


Figure 1. Location of aquaculture licences for the principal shellfish and finfish species. Hatched areas in oyster figure are areas subject to Native oyster orders (e.g. Clew Bay). (Courtesy BIM).

Salmon and rainbow trout are the two principal finfish species farmed at sea. Salmon consistently accounts for 85-95%, by volume, of annual finfish production. Marine finfish farming is restricted to five western seaboard counties – Donegal, Mayo, Galway, Kerry and Cork (Figure 1). Production of turbot in land-based facilities was ongoing on a small-scale during 2004 (but has since ceased) and research into the feasibility of culturing new species such as cod and halibut is also being carried out. Freshwater farming of perch is carried out on a small-scale in counties Cavan and Roscommon.

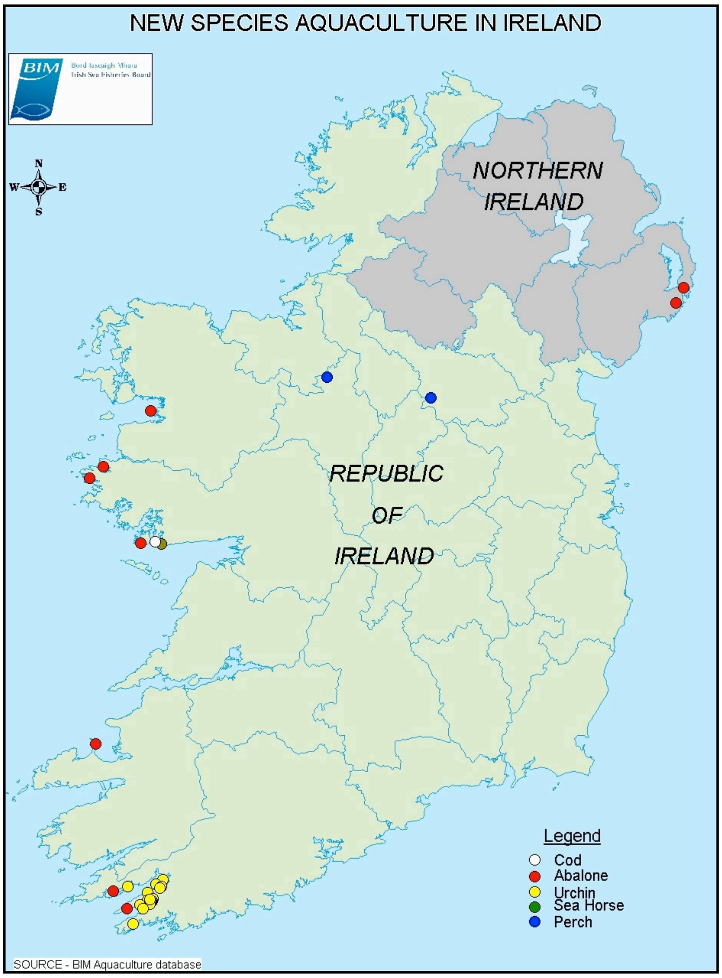


Figure 2. New species aquaculture in Ireland (Courtesy BIM).

Seaweed aquaculture is in its' infancy in Ireland but shows huge potential (National Seaweed Forum, 2000; Werner *et al.*, 2004). A number of species are suitable for cultivation in Ireland (e.g. *Alaria esculenta, Palmaria palmata, Asparagopsis armata, Chondrus crispus* and *Laminaria saccharina*). A market demand already exists for many of these for human consumption, nutraceuticals and cosmetics. A handful of licences have been issued for counties Cork and Galway and cultivation trials and pilot projects have been undertaken with a number of the species above.

2. PRODUCTION & EMPLOYMENT SUMMARY

Overview

BIM gathers data annually on production volumes and value, directly from aquaculture operators, and also conducts an annual employment survey.

In 2004, production volumes in both the shellfish and finfish sector were down on 2003 levels, with the greatest decrease in the finfish sector, continuing the decline since the production peak of 25,000 tonnes in 2001 (Appendix I and Table 1). Although the production volume in the shellfish sector decreased slightly on 2003 levels, the value of the harvest reached a record high of €43.6 million, primarily as a result of the improved prices achieved for Pacific oysters.

Table 1. Aquaculture production (volume and value) in 2004 versus 2003.

	Volume (Tonnes)		Value (€ '000)	
Species	2003	2004	2003	2004
Shellfish				
Rope mussel	9,313	8,755	7,568	6,871
Bottom mussel	29,976	28,560	21,653	21,014
Gigas oyster	4,830	5,103	9,920	12,204
Native oyster	325	390	1,324	1,636
Clam	154	181	795	711
Scallop	80	103	380	437
Total Shellfish	*44,678*	*43,091*	*41,782*	*43,600*
Finfish				
Salmon ova/smolts	-	-	2,000	2,337
Salmon	16,347	14,067	54,198	51,289
Sea-reared trout	370	282	1,200	860
Freshwater trout	1,081	889	2,318	2,116
Other Finfish	40	25	350	300
Total Finfish	*17,838*	*15,263*	*60,066*	*56,902*
Total Aquaculture	**62,516**	**58,354**	**101,848**	**98,127**

The number employed in the aquaculture sector during 2004 on a part-time, full-time and casual basis was 544, 718 and 474, respectively (Table 2). This amounts to a total of 1,936 – versus 2,611 in 2003. Almost all sectors experienced reductions in the numbers employed, but the largest decrease was in the native oyster sector, arising out of a re-classification of the numbers of fishermen versus aquaculture employees (see below).

Shellfish Production 2004

The shellfish sector had a varied year, with small decreases in some areas but significant increases in others. Overall, volume decreased to 43,091 tonnes against the 2003 volume of 44,678 tonnes; a decrease of 4% (Appendix I and Table 1). This was offset, however, by a 4% increase in total shellfish value from €41.8m to €43.6m (Appendix I and Table 1).

Production volume was once again dominated by mussels (Figure 3). Bottom-cultivated mussels accounted for 66%, and rope mussels for 20%, of total shellfish production in 2004. Pacific oysters accounted for a 12% share in volume production, compared with 11% in 2003. Native oysters held on to 1% and scallops and clams maintained their 0.5% share of total volume. In terms of production value, bottom mussels held the greatest share of the value at 48%, followed by Pacific oysters at 28% and rope mussels at 16% (Figure 3). The value of native oysters increased to 3.8% of total value, and scallops and clams combined accounted for 2.6% of the total value. Novel shellfish, which includes sales from abalone, urchins and spat, contributed 1.6% to total value.

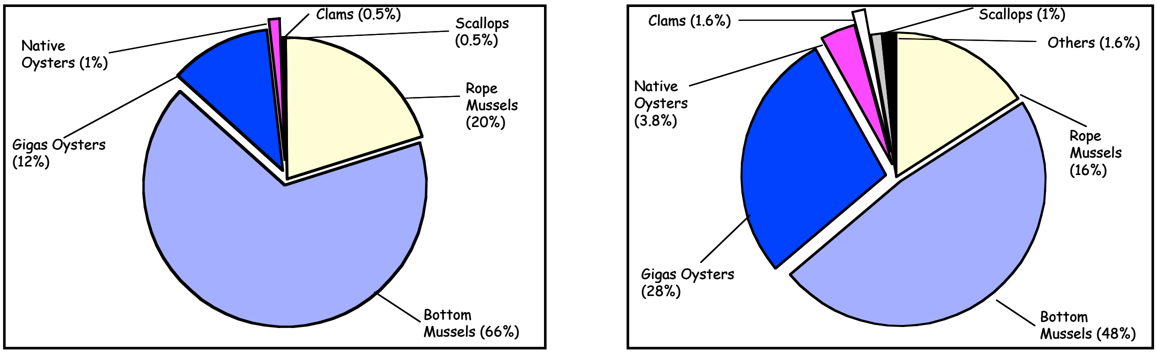


Figure 3. 2004 Shellfish production by percentage volume (left) and value (right).

Mussels

The bottom mussel industry enjoyed another healthy year, and although production was down 5% from 29,976 tonnes in 2003 to 28,560 tonnes in 2004, the associated value decrease was only 3%, from €21.6m to €21m (Figure 4). This loss of sales of bottom mussels resulted from reduced output from Lough Foyle and Waterford estuary. The average price per tonne increased from €722 in 2003 to €735 per tonne in 2004 (Figure 4). The rope mussel industry also faced a small decline in production; down 6% on 2003 values, from 9,313 tonnes to 8,755 tonnes (Figure 4). Of more consequence was the decline in value (-9%) to €6.9m, versus €7.5m in 2003 (Figure 4). Mean price per tonne also decreased, exacerbating the effects of the reduced production.

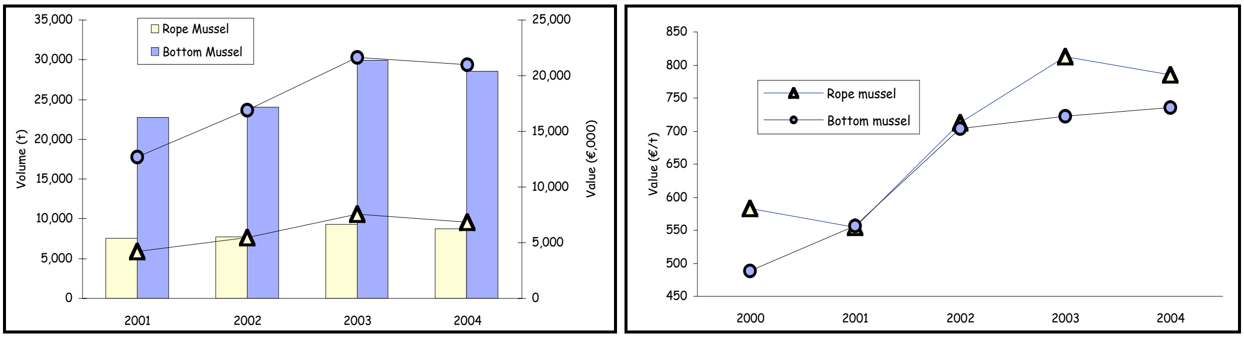


Figure 4. Left - Volume (bars) and value of mussel harvests from 2001 to 2004. Right - Mean price per tonne of mussels from 2000 to 2004.

Oysters

The Pacific oyster trade had a 6% increase in production growing from 4,830 tonnes in 2003 to 5,103 tonnes in 2004 (Figure 5). The associated production value increased by 23%, from €9.9m to €12.2m; highlighting the large increase in the price per tonne from €2,053/tonne to €2,392/tonne (Figure 5). Native oyster production increased by 20% - from 325 tonnes in 2003 to 390 tonnes in 2004 (Figure 6). The value increased by 24% to €1.6m from €1.3m the previous year (Figure 6). The price per tonne increased by just 3%, to €4,198/tonne.

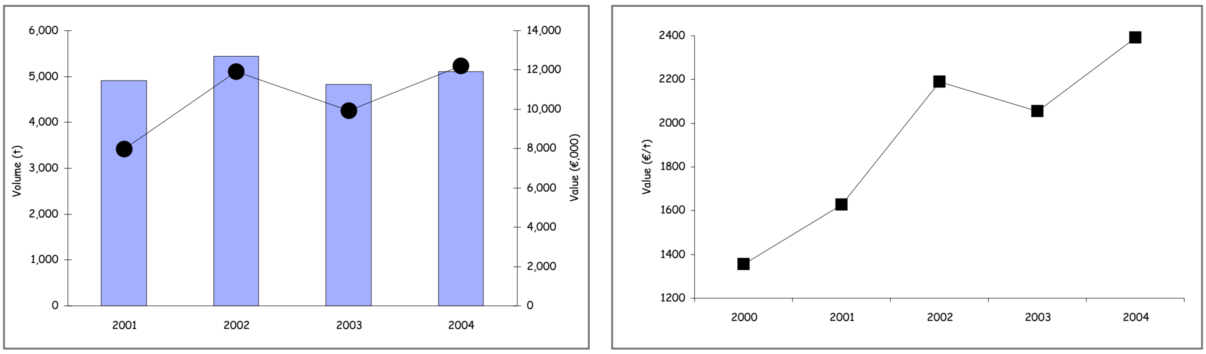
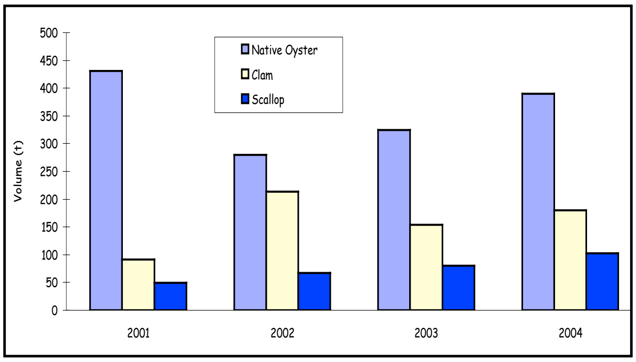


Figure 5. Left - Volume (bars) and value of Pacific oyster harvests from 2001 to 2004. Right - Mean price per tonne for Pacific oysters from 2000 to 2004.

Scallop and Clams

Scallop production increased by 29% compared with 2003, with a total harvest volume of 103 tonnes - worth €0.4m. Price per tonne decreased by 11% on 2003 prices, but this was offset by the increased yield culminating in a more productive year (Figure 6). Production of clams also increased in 2004, by 17%, to 181 tonnes (Figure 6). However, value per tonne decreased by 24%, resulting in an overall value loss of 11%, leaving total value at €0.7m.



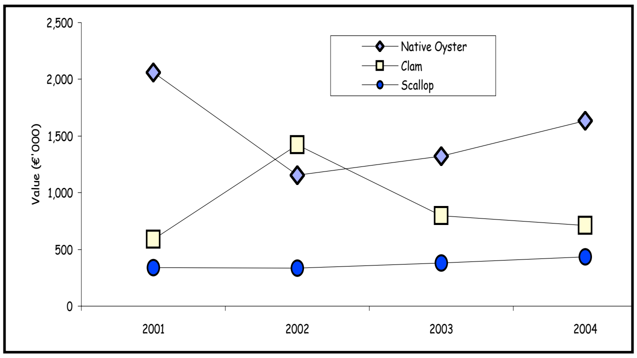


Figure 6. Left - Volume of native oyster, scallop and clam harvests from 2001 to 2004. Right - Value of native oyster, scallop and clam harvests from 2001 to 2004.

Novel Shellfish

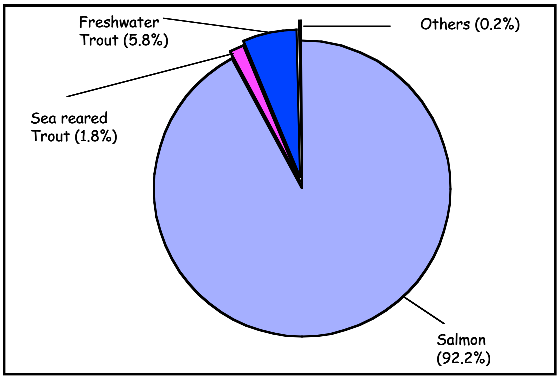
The following sales of 'novel' shellfish took place in 2004:

- Purple sea-urchin spat (150,000) and 3.5 tonnes of mature individuals, with a total value of €183,500;
- Juvenile and market size abalone worth over €37,000; and
- Pacific oyster and clam spat valued at €73,500.

Finfish Production 2004

2004 was another difficult year for the finfish sector. Total production came to 15,263 tonnes, down 14% on the 2003 figure of 17,838 tonnes (Appendix I and Table 1). All species showed a decrease in the tonnage produced. There was also a drop in total value to €56.9m (-5%), despite the 10% increase in the average price per tonne achieved for salmon.

Atlantic salmon accounted for 92% by volume and 90% by value of total finfish production in 2004 (Figure 7). The volume and value of sea-reared trout was 2% of total finfish production - the same as 2003. Freshwater trout also remained the same relative to 2003 with a 6% and 4% share of total volume and total value, respectively. Sales of smolts contributed 4% (by value) and 'other' finfish, which consists principally of turbot, accounted for just 0.5%.



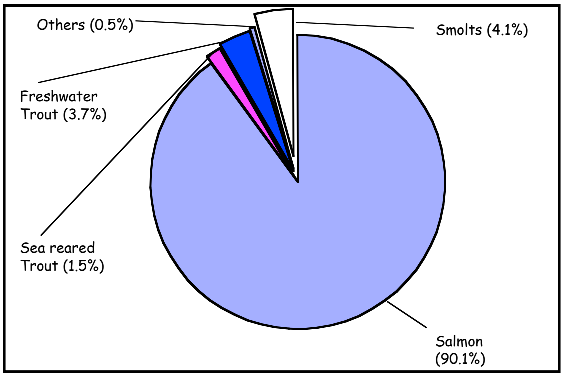


Figure 7. 2004 Finfish production by percentage volume (left) and value (right)

Atlantic Salmon[1]

Salmon production was still in the recovery phase in 2004 after the difficult year experienced in 2003. Production dropped for the third consecutive year to 14,067 tonnes, down 14% on the 2003 volume (Figure 8). This is the lowest annual production volume since 1996. The value in 2004 was €51.3m, down 5% on the 2003 value. The average price per kilo of €3.65 was up 10% on the 2003 figure (€3.32). This was mainly due to increased sales of organic-certified fish.

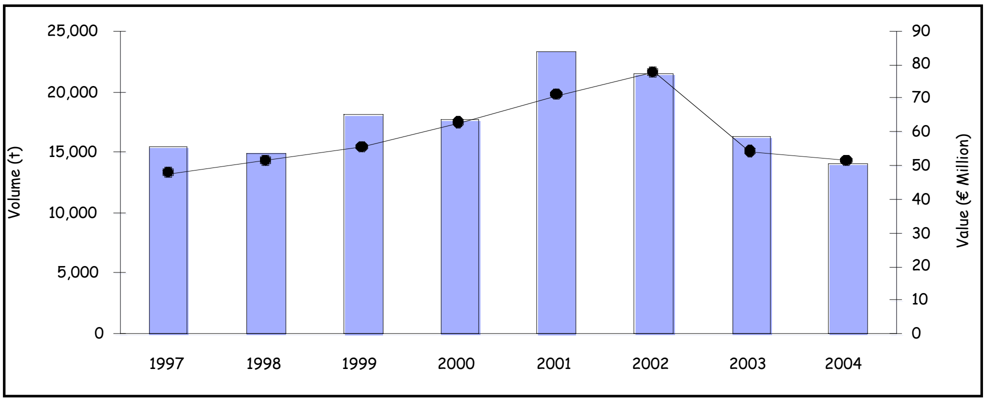


Figure 8. Volume (bars) and value of Atlantic salmon harvests from 1997 to 2004

Atlantic salmon smolts produced in Ireland can either go for restocking rivers, be sold internally for on-growing in salmon farms or be sold externally to companies outside Ireland for on-growing. The monetary values of internal sales are not included in the value of Irish aquaculture as the money is transferred from one producer to another. However, external sales are included and increased 17% from last year's value. Volumes are not given as smolts may be sold at variable weights or as parr.

Rainbow Trout

Rainbow trout (freshwater and sea-reared) production in 2004 was 1,171 tonnes – down 19% on the 2003 levels (Figure 9). Freshwater production fell to 889 tonnes (-18%) and sea-reared dropped by 24% to 282 tonnes. The value of rainbow trout production in 2004 was just under €3m - €0.9m for sea-reared trout and €2.1m for freshwater trout. This represents a 15% reduction on the 2003 value.

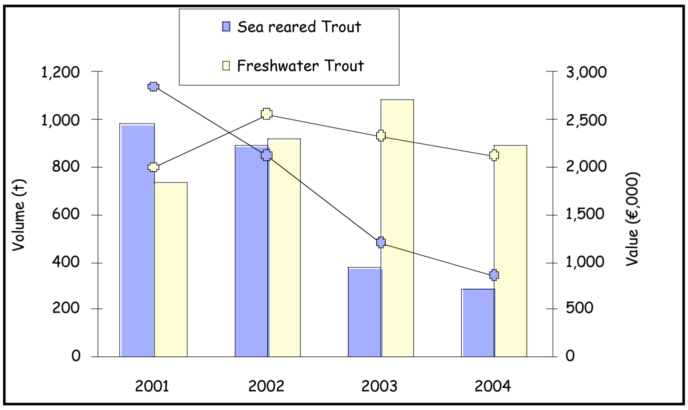


Figure 9. Volume (bars) and value of sea-reared and freshwater trout harvests from 2001 to 2004

Novel Finfish

The value of novel finfish sales (principally turbot) in 2004 was €0.3m. Some ornamental finfish and pike were also sold.

[1] For a more complete review of 2004 salmon production see Aquaculture Newsletter no.52 (BIM, 2005).

Employment

Recorded employment in the shellfish sector, which accounts for approximately 75% of the total employed in aquaculture (Table 2), took a serious downturn, with 1,984 staff recorded in 2003 against 1,446 in 2004, a 27% decrease. This represents a drop of 310 full-time equivalents (FTE), from 1,116 to 806. The largest drop was in the native oyster sector – from 217 FTEs in 2003 to 107 FTEs in 2004. The reason for this reduction is the re-classification of the term 'employment' in the annual employment survey. Most native oyster fishermen work on fishing boats full-time as part of co-operatives, and are consequently not employed as full time oyster fishermen.

In the bottom mussel sector, the decrease in the number of FTEs from 235 in 2003 to 155 in 2004 was mainly due to the purchasing or leasing of sites from smaller companies, which were therefore no longer creating employment, by larger companies with enough staff to cope with the increased work. In the rope mussel sector, employment decreased by 75 FTEs, from 2003, to 218. Part-time and casual staff numbers remained similar and the main losses occurred in the full-time jobs.

In the finfish sector the reduction in the numbers employed in 2004, compared with 2003, reflected the reduced production levels. The number of FTEs decreased by 27%, from 496 to 364. In the salmon sector there were 273 FTEs in 2004, compared with 392 in 2003 – a decrease of 30%. There was a 52% decrease in the number of FTEs in the rainbow trout sector - from 52 to 25 FTEs.

Table 2. Employment in the aquaculture industry during 2004 (Source – BIM)

Species	Full-time	Part-time[1]	Casual[2]	Total Staff	FTE[3]
Bottom mussel	118	67	19	204	155
Rope mussel	137	109	156	402	218
Gigas oyster	156	186	196	538	282
Native oyster	2	204	20	226	107
Clam	11	6	16	33	17
Scallop	8	8	8	24	13
Other Shellfish	11	4	4	19	14
Total Shellfish	*443*	*584*	*419*	*1,446*	*806*
Salmon	201	133	30	364	273
Sea-reared trout	3	1	1	5	4
Other Finfish	18	3	-	21	20
Freshwater trout	18	4	3	25	21
Salmon smolts	34	18	17	69	46
Ornamental	1	1	-	2	2
Total Finfish	*275*	*160*	*51*	*486*	*366*
Seaweed	-	-	4	4	1
Total Aquaculture	**718**	**744**	**474**	**1,936**	**1,173**

Notes: 1: 10-30 hrs/week throughout the year or 13-39 weeks of working 40 hrs/week.
2: <10 hrs/week throughout the year or <13 weeks of working 40 hrs/week.
3: FTE - Full-Time equivalent – (1 Full-time = 1FTE; 1 Part-time = 0.5 FTE; 1 Casual = 0.1667 FTE)

3. EXPORT AND MARKET SUMMARY

Finfish

In 2004, Irish farmed salmon was sold through four main companies, the largest volume going through the Irish Salmon Producers Group (ISPG). The bulk of the tonnage, nearly 73%, is sold in the fresh gutted format (Table 3). Organic salmon accounts for 16% of total volume and 29% of total value - a major increase on 2003 levels.

Table 3. Production category for Irish Atlantic Salmon in 2004

Species	Gutted	Head Off	Fillets	Frozen	Organic	PG† Gutted	Total
Volume (t) (RWE)*	10,241	188	696	1	2,243	698	14,067
Value (€,000)	31,862	710	3,006	2	14,921	788	51,289

*RWE – Round Weight Equivalent; † - Production Grade


Atlantic Salmon

Overall, approximately 40% of salmon production is sold to France with just over 30% being sold on the Irish home market and a further 10% sold to Germany. The balance goes mainly to other European countries. Of the salmon exported to Europe, approximately 50% ends up being sold for smoking, whereas of the sales in Ireland just over 30% of the volume is smoked.

In respect of fresh trout, nearly all the product in 2004 was sold on the home market - primarily through the retail sector.

Shellfish

In 2004, approximately 21% of the rope mussel production was sold to the fresh market with the remainder being processed; by contrast nearly 90% of the bottom mussels were exported live in bulk format. The market destination for fresh product is outlined in Table 4. Since 2001, the exports to the Netherlands has increased dramatically. This is primarily due to Dutch involvement with the Irish bottom mussel sector.

Table 4. Market distribution of fresh mussels in 2001 and 2004

	France	Netherlands	Spain	UK	Other
2001	63%	9%	13%	3%	12%
2004	45%	54%	0.5%	n/a	0.5%

A total of 9,720 tonnes of mussels were processed in Ireland in 2004 by five companies, with sales valued at over €24.7 million. The export destination profile of processed mussels has changed little since 2001 (Table 5).

Table 5. Market distribution of processed mussels in 2001 and 2004

	France	UK	Italy	USA	Germany	Ireland	Other
2001	38%	26%	13%	13%	N/a	N/a	10%
2004	42.2%	20.4%	12%	12.8%	9.2%	1.4%	2%

What is interesting, however, is the marked increase in supplies to the catering sector, primarily at the expense of the retail sector (Table 6). The catering sector is perceived as being the most competitive, particularly given the fact that it is being targeted by Chilean imports.

Table 6. Customer breakdown for processed Mussels in 2001 and 2004

	Catering	Retail	Manufacturing
2001	43%	39.3%	17.7%
2004	75%	18.7%	6.3%

Processed mussels consist essentially of two types of product, the vacuum packed product with and without sauce, both in a frozen and chilled format and the Individually Quick Frozen (IQF) whole shell product. In 2004, frozen and chilled vacuum packed product accounted for 87% and 7%, respectively, of processed mussels. The whole shell product accounted for the remaining 6% of processed mussels. Meat product ranges tend to increase when there have been excessive closures of bays (due to biotoxin contamination – see Chapter 5) and hence product becomes too fouled to be used in the other product lines.

The annual BIM production survey, (where the producer clearly stated the destination of product) reveals that over 85% of the sales of *Gigas* oysters went to France in 2004, with just over 3.5% being consumed on the home market and the rest mainly being sold to Italy, Spain, Holland and the UK. The bulk of the sales (78%) were in the size range from 66 to 110g, though there was a good trade in half grown stock (14%) both to France and within Ireland.

4. AQUACULTURE LICENCES AND APPEALS

Extant Licences

There are currently just under 600 aquaculture licences distributed amongst 11 coastal and eight inland counties (Table 7 - see notes). In addition, there are 100 lapsed licences. These are included in Table 3 as some lapsed licences may still be in operation pending ministerial decision on renewal applications. Of the 589 current licences, 55% are held in just three counties – Galway, Cork and Donegal. Mayo and Kerry account for a further 22% of current licences. On a species basis, oysters account for 45% of all current licences and mussels for a further 31%.

Table 7. Distribution of aquaculture licences by county for the principal aquaculture species (Source: DCMNR). N.B. Lapsed licences are indicated in (brackets).

	Salmon	Trout (FW & Marine)	Other Finfish	Oysters	Mussels	Clams	Scallops	Other Shellfish	Total
Louth	-	1	-	16 (5)	14 (3)	0 (1)	-	-	31 (9)
Wexford	2	-	-	6 (2)	9 (1)	-	-	-	17 (3)
Waterford	-	-	-	35	3	-	-	-	38
Cork	5 (2)	3 (1)	1	24 (4)	57 (2)	1 (1)	1	13 (2)	105 (12)
Kerry	4 (1)	-	-	25 (10)	19 (5)	3 (1)	3	-	54 (17)
Limerick	-	-	-	1	-	-	-	-	1
Clare	1	1	-	14 (2)	2	1	1	-	20 (2)
Galway	29 (9)	1	1	40 (7)	46 (3)	1	-	4	122 (19)
Mayo	2 (2)	1	1	57 (14)	7	4 (2)	3	2 (1)	77 (19)
Sligo	-	-	-	1 (1)	2	11 (4)	-	1	15 (5)
Donegal	11	-	-	47 (7)	23 (3)	9 (2)	5	2	97 (12)
Kildare	1	-	-	-	-	-	-	-	1
Leitrim	1	-	-	-	-	-	-	-	1
Tipperary	1	1	-	-	-	-	-	-	2
Westmeath	-	2	-	-	-	-	-	-	2
Carlow	-	1	-	-	-	-	-	-	1
Dublin	-	O (1)	-	-	-	-	-	-	0 (1)
Cavan	-	-	1	-	-	-	-	-	1
Kilkenny	-	1	-	-	-	-	-	-	1
Wicklow	-	3	-	-	-	-	-	-	3
Total	**57 (14)**	**15 (2)**	**4**	**266 (52)**	**182 (17)**	**30 (11)**	**13**	**22 (3)**	**589 (99)**

Notes: i) There may be multiple sites associated with one licence. Only the number of licences is shown.
ii) Lapsed licences are included as they may still be in operation.
iii) Other shellfish includes abalone and sea urchins.

Licence Applications and Decisions

Applications

Under the Fisheries (Amendment) Act 1997, all aquaculture operations must be licensed. Licences are issued by the Minister for Communications, Marine and Natural Resources. During 2004, new applications for aquaculture licences were submitted for 62 shellfish and eight finfish operations. Thirty licence renewal applications for existing licences (24 shellfish and six finfish) were also submitted. In addition, four applications for review of aquaculture licences were received in 2004 – all relating to shellfish.

Decisions

The ministerial decisions during 2004 in relation to aquaculture licences are summarised in Table 8. Of the 25 full licences issued during the year, just one was for marine finfish. The majority of licences issued were for shellfish culture.

Table 8. Aquaculture licence decisions by DCMNR during 2004.

Type Of Decision	Marine Finfish	Land-based Finfish	Marine & Land-based Shellfish & Aquatic Plants	Total
Full Licence Granted	1	2	22	**25**
Trial Licence Granted	0	2	6	**8**
Refusal to Grant Licence	1	0	4	**5**
Licence Renewed	4	0	6	**10**
Refusal to Renew Licence	0	0	1	**1**
Licence Amended	0	2	2	**4**
Assignment of Licence	6	5	6	**17**
Revocation of Licence	0	3	3	**6**
Total Decisions	**12**	**14**	**50**	**76**

N.B. Decisions made by the Aquaculture Licence Appeals Board (ALAB) are outlined below.

Of the 49 ministerial decisions reached during 2004 on full and trial licence applications and renewal applications, 27 were in relation to applications received in 2003 or 2004 (Figure 10). The remaining 22 decisions related to applications received in 2002 or earlier, with two of those applications outstanding since 1992 and 1995.

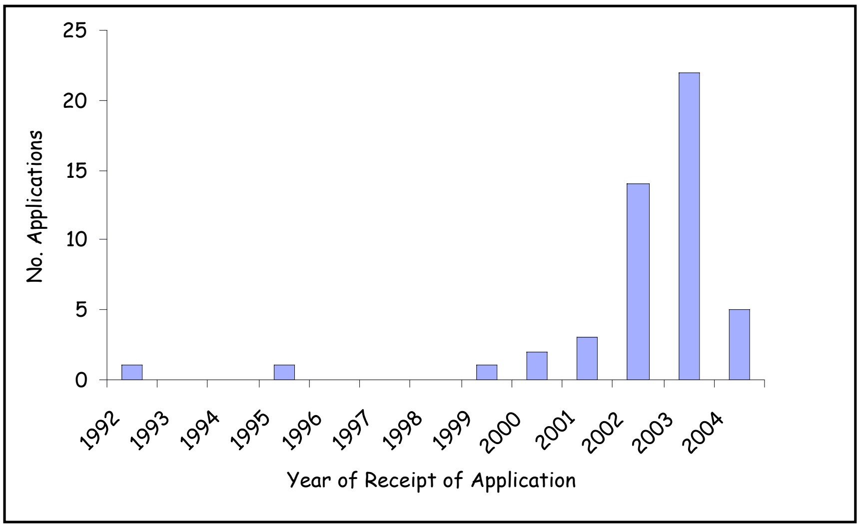


Figure 10. Year of receipt of aquaculture licence applications for ministerial decisions made in 2004. N.B. Only decisions relating to full and trial licence and licence renewal applications are included.

Aquaculture Licence Appeals

In 2004, the Aquaculture Licence Appeals Board ALAB (see Box 1) received a total of 21 appeals (all relating to shellfish), with a further one appeal outstanding from 2003, giving a total of 22 appeals for determination. Five of these were deemed either invalid or withdrawn. Fourteen determinations were made, including 12 licences granted, one decision to refuse and one decision to uphold the Minister's decision to refuse a licence (Table 9). At the end of 2004, three appeals were yet to be decided.

Box 1. Aquaculture Licence Appeals Board (ALAB)

Following the decision by the Minister for Communications, Marine and Natural Resources to grant, refuse, revoke or amend an aquaculture licence, an appeal can be lodged to the Aquaculture Licences Appeals Board (ALAB). ALAB was established in 1998 under Section 22 of the Fisheries (Amendment) Act, 1997. Its function is to provide an independent authority for the determination of appeals against decisions of the Minister for Communications, Marine and Natural Resources on aquaculture licence applications. A person aggrieved by a decision of the Minister on an aquaculture licence application, or by the revocation or amendment of an aquaculture licence, may make an appeal within one month of publication (in the case of a decision) or notification (in the case of revocation/amendment).

The Board, in determining appeals, has the option of:

a) confirming the decision of the Minister to grant or refuse a licence; or
b) determining and issuing its own aquaculture licence as if the application for the licence had been made to the Board in the first instance.

Additionally, the Board may alter the terms or conditions of a licence decision granted by the Minister by issuing its own licence with additional or altered terms and conditions.

Table 9. Aquaculture licence appeals received and Board determinations by the Aquaculture Licences Appeals Board 1999-2004. (Source – ALAB).

	Appeals Received	Withdrawn/ Invalid	Board Determinations	Licences Granted	Confirmed Minister's Decision	Appeals Upheld
1999	88	2	25	16	7	0
2000	38	2	83	37	5	2
2001	76	31	38	14	1	1
2002	13	5	29	24	0	2
2003	7	0	16	2	1	6
2004	22	5	14	12	1	1

N.B. The number of Board determinations in a given year is not necessarily the sum of the last three columns (licences granted, confirmation of ministerial decision and appeals upheld). For example, several appeals may be received against one ministerial decision, with the board having to make a determination on all appeals. This would result in just one of the three possible outcomes.

5. AQUACULTURE MONITORING – SHELLFISH

Biotoxin and Phytoplankton Monitoring

A number of phytoplankton species produce toxins (biotoxins) that can cause illness, and even death in extreme cases, through the consumption of contaminated shellfish. Monitoring for the presence of biotoxins in Irish shellfish and the sampling of seawater for the presence of toxin-producing phytoplankton is carried out by the Marine Institute. The monitoring - which consists of chemical analysis and bioassays (use of a biological organism to test for chemical toxicity) to detect toxins in shellfish and phytoplankton analysis to identify known toxin-producing species - is designed to detect toxicity in shellfish growing areas before harvesting; thereby providing the necessary information to restrict the placing of toxic shellfish on the market. Details of the National Marine Biotoxin Monitoring Programme are outlined in Box 2.

The results of the biotoxin and phytoplankton monitoring programmes are presented to industry and regulatory body representatives at an annual Shellfish Safety Workshop (e.g. Marine Institute, 2005).

Box 2. National Marine Biotoxin Monitoring Programme

Ireland is obliged under European legislation (Council Directive 91/492/EEC) to have a National Marine Biotoxin Monitoring Programme to monitor shellfish harvesting areas for the presence of toxins produced by several different species of phytoplankton. The objectives of the programme are:

a) to protect consumers of Irish shellfish by promoting food safety in the sector;
b) to work with industry partners in the development of the industry; and
c) to develop a harmonious biotoxin management system that provides for industry requirements in line with consumer safety.

Details of the Biotoxin Monitoring Programme are outlined in a Code of Practice produced by the Food Safety Authority of Ireland (FSAI) - available at http://www.fsai.ie/sfma/about_cop.asp. It includes information on how shellfish samples are to be collected and analysed; reporting procedures; and the procedures for opening and closing shellfish production areas. The Department of Communications Marine and Natural Resources (DCMNR), under a Service Contract with the FSAI, implements aspects of the Biotoxin Monitoring Programme in Ireland. The Marine Institute carries out marine biotoxin testing, also under a Service Contract with the FSAI. The four main toxin groups (and their causative agents) covered under the monitoring programme are:

1. Diarrhetic Shellfish Poisoning (DSP) ----> *Dinophysis* species
2. Paralytic Shellfish Poisoning (PSP) ----> *Alexandrium* species
3. Azaspiracid Poisoning (AZP) ----> *Protoperidinium* species
4. Amnesic Shellfish Poisoning (ASP) ----> *Pseudo-nitzschia* species

If toxins are detected at levels that are unsafe for human consumption, the harvesting and sale of shellfish from the production area in question is prohibited. The ban on harvesting and sale is lifted only after thorough scientific analysis of samples shows that the product is safe for human consumption. Before harvesting from any production area, two samples, taken a minimum of 48 hours apart, must have levels of biotoxins below the regulatory limit. With the first of these two clear samples the area is assigned a "Closed Pending" status and with the second the area is assigned an "Open" status. If a result is positive for biotoxins then the area in question is assigned a "Closed" status and the area will need two clear results, from samples taken a minimum of 48 hours apart, to return to an "Open" status. The minimum frequency of testing is laid down for each species and this may have a seasonal variation. If samples are not provided for testing at the minimum frequency the area can lose its "Open" status.

The results for the biotoxin monitoring programme are available on the websites of the Marine Institute (www.marine.ie/habs) and the FSAI (www.fsai.ie/sfma/default.asp).

Shellfish Production Area Closures

Closures of shellfish growing areas as a result of biotoxin contamination in shellfish typically occur between June and November, but are most common in the summer and autumn. The timing and duration of the closures can vary from year to year.

As in previous years, the majority of shellfish production area closures resulted from the presence of the DSP toxins Okadaic acid (OA) and it derivatives. Of the 11 areas where closures occurred, nine were in the southwest (Table 10). The duration of closures resulting from DSP detection ranged from one week to 11 weeks. In June, two samples of mussels from the North Channel area of Cork Harbour tested positive for the presence of PSP toxins resulting in the closure of the production area for two weeks.

Table 10. Location and duration of shellfish production area closures due to the presence of DSP during 2004

	Closed (week nos.)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Production Area													
Bruckless	36-41												
Killary Outer	34-36												
Ardgroom	32-44												
Kilmakilloge	32-45												
Castletownbere	26-44												
Bantry North	29-45												
Bantry Middle	30-45												
Bantry South	29-44												
Glengarriff	30-43												
Dunmanus Bay	33-38												
Roaringwater Bay	33												

While some production areas were closed for extended periods during 2004, closure duration alone does not represent an accurate picture of the potential impact on the industry. For example, in a number of cases a significant portion of the crop was harvested prior to closures so, while the production area may be closed for weeks/months, the overall impact is uncertain – e.g. how much of the potentially harvestable crop remained un-harvested as a result of the closures and if any crop and markets were lost?

DSP in 2004

During 2004, 2,262 samples were submitted for DSP bioassay and chemical confirmatory analysis. Mussel samples (1,331 samples – 58.8% of the total) were submitted weekly from April – October and fortnightly during the other months. Pacific and native oysters (666 samples – 29.4% of the total) were submitted on a fortnightly basis during the summer months and on a monthly basis during the winter period. The balance of the samples tested consisted of farmed clams and non-farmed species, e.g. Razor clams.

Overall, 3.5% of samples (80) tested positive in 2004. This compares with 3.3% in 2003, 3.5% in 2002 and 17.6% in 2001. All the positive results were obtained in mussel samples and, as in 2003, the vast majority of the positive results were obtained from production areas in the southwest. The number of samples testing positive for DSP toxicity increased from June to August, before decreasing during the late autumn/early winter (Figure 11). The maximum level of DSP toxins detected was 3.83 μg OA equivalents/g whole flesh compared to the regulatory limit of 0.16 μg OA equivalents/g whole flesh.

During 2004, samples were submitted from a total of 61 shellfish sites and 45 finfish sites. A total of 1,582 phytoplankton samples were analysed and potentially toxic species were identified in 488 of these samples. Toxic species identified included *Dinophysis acuta*, *Dinophysis acuminata*, *Alexandrium* spp., *Pseudonitzchia* spp., *Noctiluca scintillans* and *Prorocentrum minimum/balticum*. The highest concentration of *Dinophysis* spp. observed during 2004 (56,160 cells/litre) was in a sample taken in Bertraghboy Bay in August. In the southwest region, the highest concentration of *Dinophysis* spp. (9,760 cells/litre) was observed in Bantry Bay in August. The highest concentration of *Alexandrium* spp. recorded was 75,800 cells/litre, in the North Channel area of Cork Harbour in June. Mussels from the area tested positive for the presence of PSP toxins resulting in a two-week closure.

Phytoplankton monitoring results can be accessed through the Marine Institute's website (www.marine.ie/habsdatabase).

Sample Turnaround

Speedy turnaround of samples submitted for biotoxin analysis and issuing of reports of test results is essential for the industry, regulatory authorities and the consumer. The results of all sample analyses are issued by fax, e-mail and SMS text messages and are also published on the Marine Institute's web site (www.marine.ie/habs).

During 2004, results for 85.6% of the 2,262 samples analysed for DSP/AZP and PSP bioassay were available within three working days of sample receipt. This compares with a 92.4% turnaround within three days in 2003 and is slightly below the target (90% of results available within three days) set out in the Marine Institute's service contract with the FSAI. The reduced percentage report turnaround in 2004, compared with 2003, resulted from technical issues with the analytical equipment in the Marine Institute's Dublin facility.

In the case of ASP analysis, the results of 100% of samples received in 2004 were available within four working days and 87% within two working days; well within the target of 90% availability within four working days of sample receipt.

Advances in screening and monitoring during 2004

During 2004, a number of steps were taken by the Marine Institute to improve biotoxin and phytoplankton analysis and reporting, as follows:

- The AOAC (Association of Official Analytical Chemists) method for the PSP bioassay test method was implemented and Irish National Accreditation Board (INAB) accreditation has been applied for. This allows results to be expressed as g saxitoxin equiv/100g as opposed to just positive/negative for the presence of PSP toxins.
- A negative screening method, consisting of a rapid diagnostic test kit (the Jellet Rapid Test Kit), has been introduced in an effort to reduce the number of bioassays conducted.
- INAB accreditation was achieved during 2004 for ASP analysis (via HPLC) in Galway and for Okadaic acid analysis (via LC-MS) in Dublin. Application has been sought for a number of other analyses (DTX-1, DTX-2, OA Esters and Azaspiracids 1, 2 & 3) via LC-MS.
- Procedures have been introduced to reduce analytical equipment downtime in an effort to improve percentage report turnaround.
- INAB accreditation has been sought for the test method for phytoplankton analysis.

Microbiological Quality of Shellfish Waters

Bacteriological Contamination

Shellfish production areas are classified twice yearly by the Department of Communications, Marine and Natural Resources based on the results for monitoring of shellfish for bacterial contamination. This is carried out in accordance with European Directive 91/492/EEC, which dictates the requirements, where necessary, for controls on harvesting or the use of processes needed to reduce the level of bacterial contamination to acceptable levels (Table 11). Consequently, the production areas sampled in the monitoring programme are principally oyster and mussel cultivation areas, but some clam, sea urchin and razor shell areas are also included. A summary of designations in July and November 2004 is given in Table 11 (see also Figure 12). Some production areas are sub-divided and may have more than one classification. Additionally, production areas can have different classifications for different species, e.g. sea urchins from a production area can be harvested directly for consumption (Category A) but mussels need relaying/depuration prior to consumption (Category B).

Table 11: Criteria for microbiological classification of shellfish harvesting areas (European Directive 91/492/EEC) and 2004 production areas classification. *Note*: This includes four areas with non-aquaculture species (razor clams and cockles).

Category	Microbiological Standard	Treatment Required	July 2004[1]	Dec. 2004[2]
Total No. Production Areas			***59***	***61***
A*	<230 *E. coli* or 300 faecal coliforms per 100g flesh	May go direct for human consumption	13	14
B	<4,600 *E. coli* and 600 faecal coliforms per 100g flesh (90% compliance)	Must be depurated, heat treated or relayed to meet class A requirements	36	37
C	<60,000 faecal coliforms per 100g flesh	Relay for two months to meet class A or B requirements – may also be heat treated	1[†]	1[†]
D	>60,000 faecal coliforms per 100g flesh	Harvesting prohibited	0	0
A & B	As per relevant category	As per relevant category	8	8
B & C	As per relevant category	As per relevant category	1	1

1. - Live Bivalve Molluscs (Production Areas) Designation, 2004
2. - Live Bivalve Molluscs (Production Areas) (No 2) Designation, 2004
*Shellfish going directly for consumption must also be free from *Salmonella* spp.
[†] This is not an aquaculture area.

Virological Contamination

Monitoring for bacteriological contamination of shellfish is well established and carried out on a regular basis. However, outbreaks of viral illness associated with shellfish consumption are also known to occur; e.g. gastroenteritis caused by Noroviruses (NVs) and infectious hepatitis caused by hepatitis A virus (HAV). Monitoring for viral (and bacteriological) contamination of bivalve molluscs is the responsibility of the Marine Institute. Work has begun on the development of a virus testing facility for shellfish in Ireland and is being carried out under the auspices of the National Reference Laboratory (Box 3).

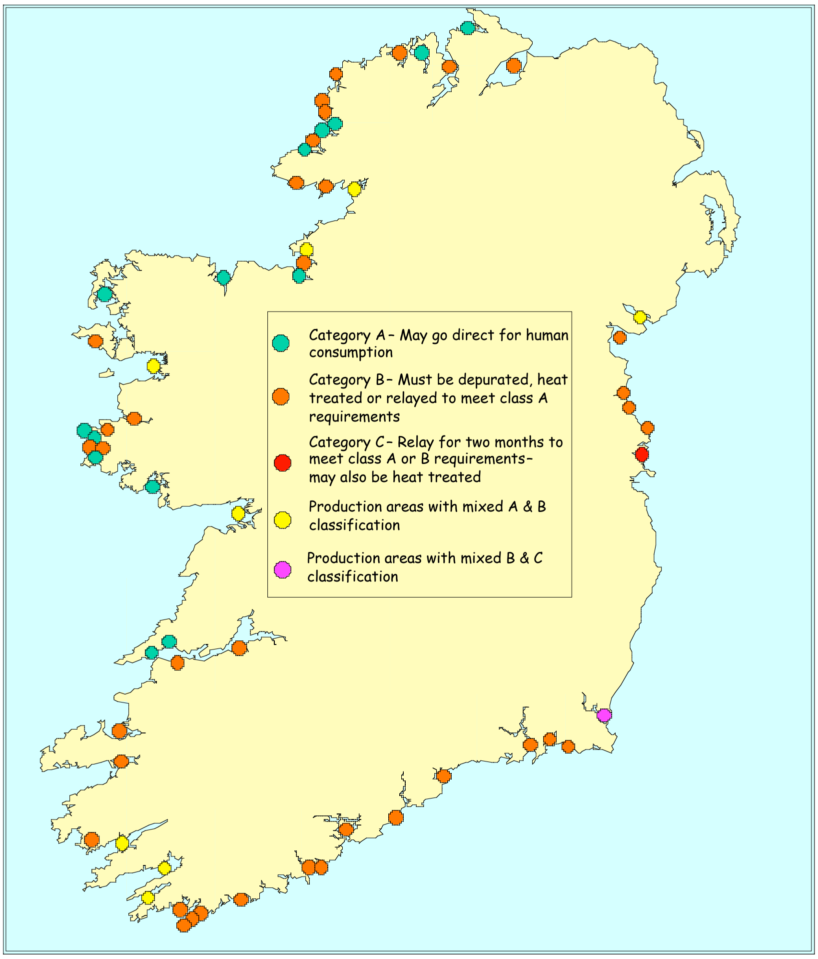


Figure 12. Microbiological classification of shellfish production areas December 2004 in accordance with Council Directive 91/492/EEC (See Table 7) *Source*: Live Bivalve Molluscs (Production Areas) (No 2) Designation, 2004.

Box 3. Irish National Reference Laboratory

The Marine Institute was designated as the National Reference Laboratory (NRL) for monitoring microbiological and virological contamination of bivalve shellfish for Ireland in accordance with European Council Directive 1999/313/EC. The process of discharging these responsibilities began in autumn 2004 with the recruitment of personnel.

The most critical task for the NRL is the *introduction of appropriate testing methods* for both bacterial parameters and virus testing into the Marine Institute

The NRL is responsible for *co-ordinating the activity of national laboratories* so that they provide an effective facility for testing shellfish. This includes laboratories carrying out testing for shellfish waters classification purposes (see main text) and those carrying out end-product checks for producers. In April/May 2004 the FSAI and MI carried out an audit of official laboratories carrying out testing for shellfish waters classification purposes. Corrective Action Plans were drawn up and implemented.

A significant role of the NRL is the *dissemination of information* from the Community Reference Laboratory to national testing laboratories, including information on technical developments in methods, advice on sampling and sample storage, and information on quality assurance schemes.

Finally, the NRL will assist DCMNR in the organisation of the national monitoring programme for viral and bacteriological contamination of bivalve molluscs. Such assistance will include the provision of scientific advice selection of appropriate sampling points, sample storage, and analysis and interpretation of monitoring data.

Contaminants in Shellfish and Shellfish Waters

Monitoring of a range of parameters in shellfish and shellfish growing waters is undertaken annually by the Marine Institute to ensure that the quality of edible species is maintained or enhanced.

Shellfish

Box 4. Contaminants in Shellfish

Trace metals exist naturally in the environment and many, including, copper, iron and zinc are essential elements for living organisms. However, some trace metals such as mercury, lead and cadmium are not required for metabolic activity and can be toxic at quite low concentrations. These three elements occur naturally in the earth's crust, but they can also be introduced into the aquatic environment from activities such as mining, industry and agriculture. Once in the aquatic environment these metals can be bio-accumulated in shellfish tissues. Chromium contamination results mainly from human activities.

Polychlorinated biphenyls (PCBs) and organochlorine pesticides (OCPs) are man-made compounds that are ubiquitous air and water-borne contaminants. They are persistent pollutants with a tendency to bio-accumulate in shellfish tissues and bio-magnify through the food chain.

The determination of trace metal and chlorinated hydrocarbon concentrations in shellfish growing areas is carried out by the Marine Institute in part fulfilment of the monitoring requirements of various EU legislation, including:

- EU Directive 79/923/EEC on the quality required of shellfish growing waters (as implemented in Ireland by Statutory Instrument No. 200 of 1994);
- EU Directive 91/492/EEC laying down the health conditions for the production and placing on the market of live bivalve molluscs and
- Commission Regulation 466/2001/EC (as amended by Regulation 221/2002/EC).

EU Commission Regulation 466/2001/EC (as amended by Regulation 221/2002/EC) sets maximum levels for mercury, cadmium and lead in bivalve molluscs of 0.5, 1.0 and 1.5 mg kg-1 wet weight, respectively. The UK is the only country at present to set down a guideline value of 50 mg kg-1 for zinc in food; however this excludes shellfish. There are no published guidelines for acceptable concentrations of chromium, silver and nickel in shellfish. Therefore, results are compared against other areas to assess for any obviously elevated results. Oysters accumulate silver to a higher concentration than mussels and this is evident from the results obtained. Oysters are also known to accumulate high levels of zinc, particularly in the digestive glands.

The level of contaminants in shellfish (Box 4) can provide valuable information on the quality of the shellfish and the waters in which they are grown.

During 2004, samples of shellfish (mussels, Pacific oysters and native oysters) from 30 locations where shellfish are grown were analysed for metals. The results for 2004 are presented in summary format in Table 12 and compared with guidance and standard values for the various contaminants. The principal points are as follows:

- Water quality parameters measured during sampling of the shellfish growing areas in 2004 generally conformed to the guidelines of Council Directive 79/923/EC with respect to pH, temperature, salinity and dissolved oxygen. Dissolved oxygen levels were outside the guideline values on a handful of occasions. pH values were also outside the mandatory range laid down in the Directive on a number of occasions. However, the Directive does not require 100% compliance for these parameters and breaches of the guidelines are not considered serious unless the conditions persist over an extended period.
- All shellfish samples tested for mercury and lead were well within the respective limits of 0.5 and 1.5 mg kg^{-1} wet weight, as set by European Commission Regulation 466/2001/EC, (amended by Regulation 221/2002/EC).
- All of the shellfish samples tested for cadmium were within the limit of 1.0 mg kg^{-1} wet weight, as set by European Commission Regulation 466/2001/EC, (amended by Regulation 221/2002/EC). One sample (*O. edulis* sampled in Tralee Bay, Castlegregory) was close to the limit (0.93 mg kg^{-1}). The second highest cadmium level was 0.64 mg kg^{-1}. A sample taken in Castlegregory in 2003 had a cadmium level of 0.97 mg kg^{-1}. There is little historical information for this shellfish growing area. Further testing of shellfish from this area is being undertaken to investigate whether these values are anomalous or reflect elevated cadmium in the area.
- No specific growing area stands out as having notably elevated levels of zinc, chromium, silver or nickel in comparison with other areas.

Table 12. Results of monitoring of shellfish-growing areas in 2004 and guidance and standard values for contaminants (Source – Marine Institute).

Contaminant	Species (No. Samples)	Range for 2004 (mg kg^{-1} wet wt)	No. Samples <LOQ	Guidance/Standard Value (mg kg^{-1} wet wt)	Qualifier	Country
Cadmium	*O. edulis* (2)	0.51 – 0.93	0	1.0	Max. Limit	EC[1]
	C. gigas (10)	0.11 - 0.64	0	1.0	Max. Limit	
	M. edulis (18)	0.07 - 0.35	0	1.0	Max. Limit	
Lead	*O. edulis* (2)	0.08 – 0.10	0	1.5	Max. Limit	EC[1]
	C. gigas (10)	<0.06 – 0.47	2	1.5	Max. Limit	
	M. edulis (18)	<0.06 – 0.58	4	1.5	Max. Limit	
Mercury	*O. edulis* (2)	<0.03 – 0.03	1	0.5	Max. Limit	EC[1]
	C. gigas (10)	<0.03 – 0.04	7	0.5	Max. Limit	
	M. edulis (18)	<0.03 – 0.03	15	0.5	Max. Limit	
Copper	*O. edulis* (2)	17.45 – 27.0	0	-	-	-
	C. gigas (10)	4.84 – 27.7	0	60	Standard	Spain
	M. edulis (18)	1.02 – 1.81	0	20	Standard	Spain
Zinc	*O. edulis* (2)	321 - 367	0	-	-	
	C. gigas (10)	87.9 - 252	0	-	-	
	M. edulis (18)	11.5 – 26.3	0	-	-	
Chromium	*O. edulis* (2)	<0.19	2	-	-	
	C. gigas (10)	<0.19	10	-	-	
	M. edulis (18)	<0.19 – 0.37	13	-	-	
Silver	*O. edulis* (2)	1.28 – 1.68	0	-	-	
	C. gigas (10)	0.16 – 2.38	0	-	-	
	M. edulis (18)	<0.03 – 0.07	16	-	-	
Nickel	*O. edulis* (2)	0.16 – 0.19	0	-	-	
	C. gigas (10)	<0.14 – 0.16	7	-	-	
	M. edulis (18)	<0.14 – 0.47	3	-	-	

Notes: 1. Commission Regulation 466/2001/EC (as amended by Regulation 221/2002/EC).
For values reported as "value", value = Limit of Quantitation (LOQ) for the relevant determinand

The results for 2004 are consistent with those from previous years (e.g. Glynn *et al.*, 2003a,b, 2004; McGovern *et al.*, 2001) and are evidence of the continued clean, unpolluted nature of Irish shellfish and shellfish producing waters.

Shellfish Waters

In accordance with the monitoring requirements of Council Directive 79/923/EEC, seawater samples were collected from 14 Irish shellfish waters designated under SI 200 of 1994 twice during 2004 (summer and winter) and analysed for trace metals (dissolved) and organohalogens (total). Analysis is co-ordinated by the Marine Institute and was subcontracted to the Environment Agency (EA) UK. Samples were collected by BIM officers. In addition, a one-off survey was carried out to gather baseline data for contaminant concentrations in Irish coastal waters with a view to informing the ongoing process of setting Imperative standards for contaminants in accordance with the requirements of the Shellfish Directive. This work was mandated by the DCMNR and is a collaboration between BIM and the Marine Institute.

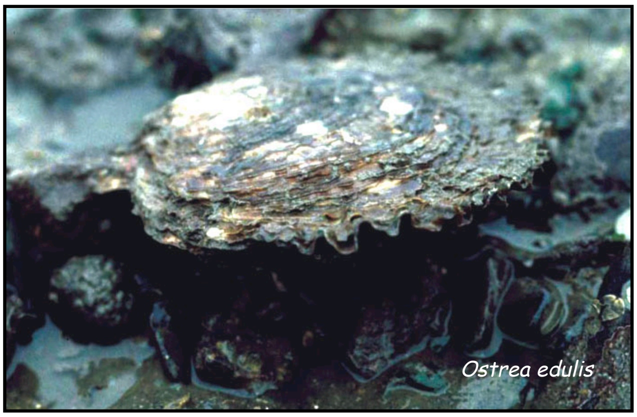
No organochlorine results were detected above the minimum reporting value (LoQ). The metal concentrations varied widely for some elements, e.g. zinc (Table 13).

Table 13. Contaminants in seawater - summary results for samples collected from shellfish growing waters during 2004.

	No. of Samples	Range (µg/l)	Median (µg/l)	No. <LoD
Hg	80	< 0.008 - 0.011	<0.008	78
Ag	80	<1.0 - 1	<1.0	80
Cd	80	<0.04 - 0.31	0.04	71
Cr	80	0.035 - 1.14	0.19	0
Cu	80	0.29 - 12.9	1.16	0
Pb	80	<0.024 - 17.4	0.78	3
Ni	80	0.09 - 20.3	2.05	0
Zn	80	0.77 - 215	15.1	0
As	80	<1.0 - 3.44	1.15	23

Shellfish Health Status

Sampling and testing for shellfish diseases in compliance with EU Directive 91/67/EEC and associated Commission Decisions (see Box 5) is carried out by the Fish Health Unit of the Marine Institute. At least 30 native oysters (*O. edulis*) are sampled from each growing area in the country twice per year, first in spring and again in autumn. In addition to this routine screening, abnormal mortalities must be notified to DCMNR/MI and an investigation into their cause is carried out immediately.


Ostrea edulis

All movements of shellfish within the country are strictly controlled by DCMNR. Shellfish may only be moved under permit and movements of susceptible species from *Bonamia* positive areas to *Bonamia* negative areas are prohibited. Movements of live molluscs into and out of the country are strictly controlled, as laid down in Council Directive 91/67/EEC.

The following are the main points relating to the shellfish disease monitoring programme during 2004:

- All *O. edulis* growing areas were tested twice during the year (spring and autumn) for the presence of the List II parasites *Bonamia ostrea* and *Marteilia refringens*. **1,618** oysters were tested in the course of this screening programme. There was no change in the disease status of oysters around the coast during 2004, compared with 2003. The entire coastline of Ireland remains free of *M. refringens*, but six areas are now infected with *B. ostrea*. These areas are Achill, Blacksod Bay, Clew Bay, Ballinakill, Inner Galway Bay and Cork Harbour.
- Only 21 samples were examined for diagnostic purposes, representing a decrease on recent years. These samples are generally submitted to the laboratory as a result of mortality events at aquaculture facilities.
- 461 individual Movement Documents were issued for the export of molluscs to other Member States, as required under Directive 91/67/EEC. In total, 75 kg of *O. edulis*, 1.5 tonnes of *C. gigas* and 19 tonnes of *M. edulis* were exported for relaying in 2004. All consignments were subjected to clinical examination by MI/DCMNR staff within 48 hours of movement.

Box 5. Listed Diseases of Finfish and Shellfish

EU Directive 91/67/EEC (as transposed into Irish Law by S.I. 253 of 1996) concerns the animal health conditions governing the placing on the market of aquaculture animals and products. It represents the main fish health legislation under which the Irish aquaculture industry is regulated. The aim of the Directive is to prevent the spread of fish and shellfish diseases whilst promoting trade in aquaculture animals and products, and providing protection for countries (such as Ireland), which have a very high health status. EU Directive 91/67/EEC categorises the main fish diseases into three lists:

List I diseases are exotic to the EU and must be eradicated from any place in which they are found. ISA (Infectious Salmon Anaemia) is the only disease on this list. The ISA virus was isolated from two rainbow trout farms in Ireland in 2002. The virus was isolated in the absence of clinical disease and was picked up as part of a routine screening programme. Both cases were managed as per the Irish ISA Withdrawal Plan, which was approved by the EU Commission in 2001. ISAV has not been isolated, nor clinical signs of the disease observed, since 2002.

List II diseases are present in certain parts of the EU but not in others. These diseases can cause a severe economic impact on infected sites. The List II finfish diseases are VHS (Viral Haemorrhagic Septicaemia) and IHN (Infectious Haematopoetic Necrosis). IHN has never been detected in Ireland but a marine strain of VHS (Genotype 3) was detected in turbot, which were cultivated at Cape Clear off the southwest coast, in 1997*. The farm was cleared and fallowed according to the procedures laid down in Council Directive 93/53/EEC.

The List II shellfish diseases are Bonamiosis and Marteliosis – both of which occur in the native (flat) oyster *Ostrea edulis*. Under Commission Decision 2002/300/EU, the entire coastline of Ireland obtained Approved Zone status with respect to Marteiliosis, and the entire coastline of Ireland with the exception of Clew Bay, Ballinakill, Galway Bay and Cork Harbour obtained Approved Zone status with respect to Bonamiosis. However, following the detection of *B. ostrea* in Achill and Blacksod Bays in late 2002, these bays have now been added to the list of *Bonamia* poisitive areas in the country; by Commission Decisions 2002/378/EC (Achill) and 2003/729/EC (Blacksod).

List III diseases are widespread in certain parts of the EU, but certain countries have farms or zones, which are free of these diseases. The finfish diseases of interest on this list are IPN (Infectious Pancreatic Necrosis), Furunculosis, ERM (Enteric Redmouth Disease), BKD (Bacterial Kidney Disease) and *Gyrodactylus salaris*. BKD and *G. salaris* have never been detected in Ireland. Furunculosis and ERM have been detected in Ireland in the past but are now generally controlled by the use of licensed vaccines. IPN has been isolated sporadically in Ireland since the 1980s, both in rainbow trout and Atlantic salmon. However, 2004 saw a sharp increase in the number of isolations of IPNV. The virus (Sp serotype) was isolated from five sites in the same geographical location. A sixth site was found to be infected with the Ab serotype, which may have originated from wild fish in the locale. Clinical disease was not observed in any of the six cases, but Risk Reduction Measures were instigated on all sites, in order to control the spread of the virus.

Although all the diseases outlined above are listed in Annex A of Council Directive 91/67/EEC, the diseases mentioned in List III were not fully recognized by the EU Commission until 2004. Late in 2003, Ireland and a number of other countries made applications to the EU Commission, for recognition of its disease free status in relation to the diseases BKD and *G. salaris*. This application was successful and was granted under Commission Decision 2004/453/EC. Ireland can now insist on freedom from these (and the other diseases in List 1 and List II) both in imports from other Member States and from Third Countries. Additional Guarantees were not granted for Furunculosis and ERM as these diseases are now routinely managed through vaccination and, therefore, do not warrant the implementation of trade controls. Although the EU Commission granted an Additional Guarantee for IPN, it was decided in collaboration with industry, that for various trade reasons, IPN could be best controlled through a joint industry/government Code of Practice. Drafting of the Code of Practice began in 2004 and will be completed in 2005.

* It is proposed that only VHS Genotype 1 will be listed under the new fish health legislation that is currently being drafted by the EU Commission. This genotype has never been detected in Ireland.

6. AQUACULTURE MONITORING – FINFISH

Sea Lice Monitoring

Sea lice (*Lepeophtheirus salmonis*), an external parasite on salmon, are regarded as having a serious damaging effect on cultured salmon, resulting in major economic losses to the fish farming community.

Box 6. The National Sea Lice Management Plan

In 1991, in response to concerns about the possible impacts of sea lice from salmon farms on wild populations of sea trout, a sea lice monitoring programme was initiated by the Department of the Marine. In 1992/1993 the programme was expanded and culminated in the publishing in May 2000 of the '*Offshore Finfish Farms - Sea Lice Monitoring and Control Protocol*' (Department of the Marine and Natural Resources, 2000).

The purpose of the National Sea Lice Monitoring Plan is to:

- provide an objective measurement of infestation levels on farms;
- investigate the nature of the infestations;
- provide management information to drive the implementation of the control and management strategy; and
- facilitate further development and refinement of control and management strategies.

The management strategy for sea lice control has five principal components:

- separation of generations;
- annual fallowing of production sites;
- early harvest of two sea-winter fish;
- targeted treatment regimes, including synchronous treatments; and
- agreed husbandry practices (including fish health, quality and environmental issues).

Together, these components work to reduce the development of infestations and to ensure the most effective treatment of developing infestations. They minimise lice levels whilst controlling reliance on, and reducing use of, veterinary medicines.

When lice levels exceed pre-set treatment figures (the **treatment trigger level**), advice is given to treat the affected stock. These are designed to minimise any risk of transmission of sea lice from fish farms to wild sea trout stocks. The current treatment trigger level is 0.3 – 0.5 egg-bearing (ovigerous) female lice per fish during spring. Outside the critical spring period, the treatment trigger level is set at 2.0 egg-bearing female lice per fish. Where numbers of mobile lice are high, treatments are triggered even in the absence of egg-bearing females.

The Marine Institute is charged with carrying out regular inspection of sea lice levels on finfish farms around the country in accordance with protocols set out under the National Sea Lice Monitoring Plan (Box 6). All fish farms undergo lice inspections 14 times per year. One lice inspection takes place each month at each site where fish are present, with two inspections taking place each month during the spring period of March to May. Only one inspection is carried out in the December/January period. The results of the sea lice surveys are reported to stakeholders (DCMNR, BIM, Irish Salmon Growers Association, individual farms and Regional Fisheries Boards) on a monthly basis and are published annually by the Marine Institute with detailed monitoring results by farm (e.g. O'Donohoe *et al.*, 2004, 2005).

In 2004, 350 sea lice inspections of four different stocks (2004 rainbow trout – 21 inspections; 2002 Atlantic salmon – 12 inspections; 2003 Atlantic salmon – 183 inspections; and 2004 Atlantic salmon smolts[2]– 133 inspections) were carried out at 38 sites in the three marine finfish growing areas around the coast – the west (Counties Mayo and Galway), the northwest (Co. Donegal) and the southwest (Counties Cork and Kerry).

The principal results for the 2004 sea lice monitoring programme, from O'Donohoe *et al.* (2005), are:

- Overall, lice levels were **below** the treatment trigger levels outlined in the DCMNR protocols (see Box 6) on 79.5% of all inspections - 78.6% of Atlantic salmon inspections and 95% of rainbow trout inspections. For Atlantic salmon this can be further categorised as follows – lice levels were below the treatment trigger levels on 94.7%, 66.7% and 50% of inspections of, respectively, smolt stocks, one-sea-winter salmon and two-sea-winter salmon.

[2] Routine monitoring of sea lice levels on smolts is not normally carried out until three months after transfer to sea, as lice numbers are not normally significant during the first few months after transfer. However, smolts transferred to sea cages in autumn 2003 and spring 2004 showed signs of early infestation of sea lice in some locations. Consequently, sea lice numbers on smolts were monitored to establish the infestation pressure immediately after transfer to sea cages. Counts were carried out monthly, starting one month after the fish were put to sea.

- On a regional basis, lice levels on one sea-winter salmon (representing 52% of all inspections) were **below** the treatment trigger level on 50.7% of inspections in the west region, 69.2% in the northwest region and 87.2% in the southwest region.
- During the critical spring period (March – May) lice levels were **below** the treatment trigger levels on 27.8% of inspections in the west, 67.6% of inspections in the northwest and 82.6% of inspections in the southwest.
- The monthly trend of lice levels in one-sea-winter salmon show that the southwest region achieved relatively good lice control throughout the year with a minor peak in September (Figure 13). Mean lice levels in the west region were relatively high for most of the year, with a peak in October. In the northwest region there were elevated lice levels in the early part of the year, very low levels for the summer and a return to high levels in September, October and November.
- There was no appreciable difference in mean levels of egg-bearing female sea lice recorded during May 2004, 2003 and 2002 (Figure 14). However, a decrease in the number of mobile lice in May 2004, compared with 2003 and 2002, is apparent.

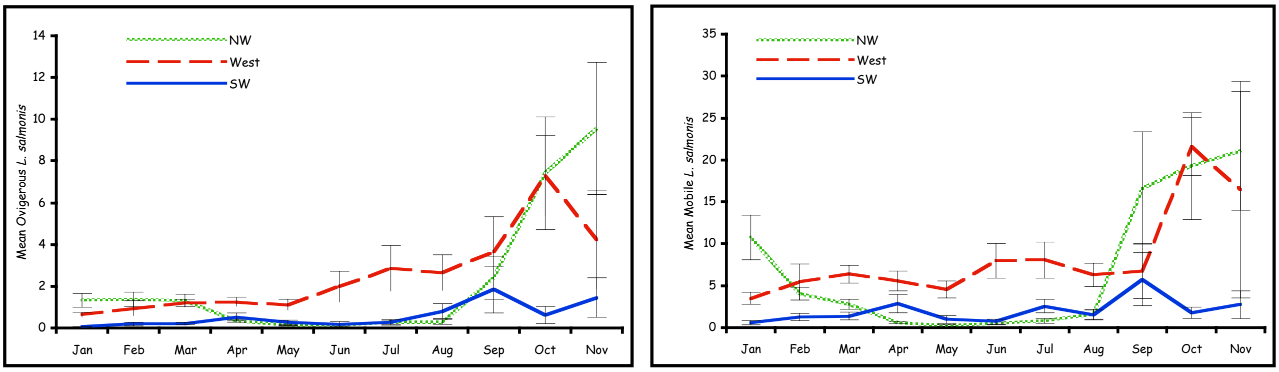


Figure 13. Mean (and standard error) egg-bearing (left) and mobile (right) sea lice (*L. salmonis*) per month in each region during 2004 (O'Donohoe *et al*., 2005)

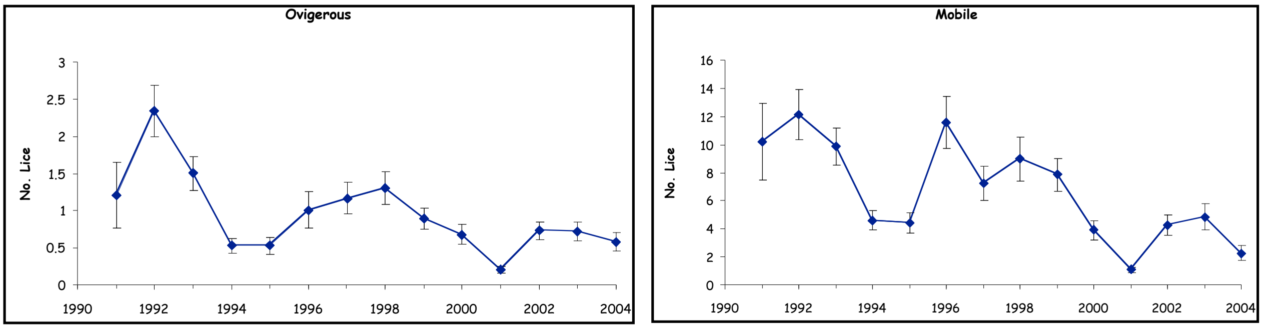


Figure 14. Mean (and standard error) egg-bearing and mobile sea lice (*L. salmonis*) on one sea-winter salmon during May 2004 (O'Donohoe *et al*., 2005)

The overall result for 2004 of lice levels **below** the treatment trigger levels on 79.5% of inspections compares with 80.7% in 2003, 87% in 2002 and 91% in 2001. This decrease in the overall number of inspections falling below the treatment trigger level may be evidence of a combination of increases in infestation pressure and increased difficulty in carrying out effective treatments due to other fish health issues. Increases in sea temperature accelerate the life cycle of the lice and lead to an increase in the number of generations of lice, thus increasing infestation pressure. For example, on average, mean monthly sea temperatures in 2004 were 0.3°C higher than 2002 and 1.1°C higher than the 30 year mean. Incomplete separation of generations can also lead to vertical transmission of lice within a site, also increasing infestation pressure.

Pancreas disease (PD) causes appetite suppression and can make it difficult to administer in-feed treatments effectively. Bath treatments are more affected by bad weather or high temperatures and in where in-feed treatments are not an option this can lead to reduced levels of lice control.

Benthic Monitoring

The Benthic Monitoring Unit of the Marine Institute compiles annual reviews of benthic monitoring (see Box 7) at finfish aquaculture sites, based on survey reports submitted by licence-holders to the Department of Communications, Marine and Natural Resources (e.g. O'Beirn, 2004, 2005).

During 2004, the number of sites subject to the benthic monitoring protocol increased from 61 to 65. However, just 50 of these sites were in use. Of these 50 sites, benthic monitoring reports were received for just 25 sites – a reporting compliance of 50%. This compares with 54% compliance in 2003 (see footnote to Table 14), 62% in 2002 and 65% in 2001 (Table 14).

Of the reports submitted for sites surveyed in 2004, all of the sites (100%) had conditions that were within agreed environmental standards and thus deemed acceptable as per the protocols. However, taking non-reported sites as non-compliant, decreases the compliance rate to 56% (Table 14). Audits were carried out at two sites by the Marine Institute to verify findings. The results from both sites of the Marine Institute report were consistent with the findings of the original surveys.

Table 14. Summary of benthic monitoring results from 2001 – 2004.

Year	*Number of Sites (subject to protocols)*	*Reporting Compliance*	*Environmental Compliance*	
			*Overall**	*Surveyed Sites*
2001	27	65% (17/27)	59%	94%
2002	55	62% (34/55)	58%	94%
2003	54	54% (29/54)†	54%	100%
2004	**50**	**50% (25/50)**	**56%**	**100%**

† Reporting compliance for 2003 was reported as 44% in the 2003 Aquaculture Status Report (Parsons *et al.*, 2003). This difference arises because a number of benthic monitoring reports were submitted to DCMNR after the 2003 report was compiled.
* Overall - assumes that unreported sites are non-compliant

Box 7. Benthic Monitoring at Finfish Sites

Finfish farming results in inputs to the marine environment in the form of uneaten feed and faecal material. This oxygen-consuming organic 'rain' falls to the seafloor and can result in stress on the benthic environment, i.e. de-oxygenated sediments. This, in turn, can lead to changes in the benthic community structure, including a decrease in faunal diversity and increases in the abundance of so-called 'opportunistic' species associated with deteriorated conditions (e.g. the polychaete worms *Capitella capitata* and *Malacoceros fuliginosa*). The hydrodynamics of cage sites dictate the potential for organic build-up and associated impacts on benthic communities. Stratified, semi-enclosed water bodies with poor water exchange are most at risk from such inputs.

In 2001, the Department of the Marine and Natural Resources introduced benthic monitoring protocols for finfish sites (Department of Marine and Natural Resources, 2001). Adherence to the benthic monitoring protocols are now included as a condition in all new (and renewed) marine finfish aquaculture licences. The sea bed under and adjacent to finfish aquaculture sites is monitored annually with a view to minimising the impact and ensuring environmental quality is within acceptable limits.

All finfish farms that are subject to the monitoring protocols must carry out an annual survey at each site (production and smolt) included in the relevant licence. The level of detail required in the benthic survey is dependent on the biomass held at the site and the local hydrographic conditions.

The monitoring protocols allow for a certain degree of impact on the seabed beneath and adjacent to the fish cages, with the acceptable level of impact decreasing with distance from the cages. In the event of a breach of the allowable impact levels, the licencee must submit a Benthic Amelioration Plan to the Department of Communications, Marine and Natural Resources with the aim of achieving an acceptable benthic standard in the licensed area as soon as possible. The plan may include actions such as a feed waste control plan; a reduction in the documented volumes of fish feed into the licensed area in question; movement of all production cages; and a reduction in production tonnage. A subsequent survey of the impacted area determines if the amelioration plan has been successful.

Residues Monitoring

The Marine Institute, through DCMNR, is charged with the responsibility of monitoring residues in farmed finfish as part of the (see Box 8).

The objectives of the residues programme are:

- to ensure that Irish farmed finfish are fit for human consumption and do not contain unauthorised substances or substances exceeding their Maximum Residue Limit (MRL)[3];
- to provide a body of data to assure that Irish farmed finfish is of a high quality - this is particularly important for supporting the export market; and
- to promote good practice in finfish aquaculture.

Box 8. Residues Monitoring

European Union (EU) Directive 96/23 requires member states to monitor certain 'substances and residues thereof' (e.g. steroids, therapeutic treatments and environmental contaminants) in live animals and animal products. The Department of Agriculture and Food (DAF) is responsible for implementing the Directive in Ireland. The Food Safety Authority of Ireland (FSAI) co-ordinates the activities of the various departments and agencies involved in delivering this programme.

The National Residues Control Plan (NRCP) for aquaculture is submitted annually to DAF for inclusion in the overall national plan. It outlines the sampling frequency and analysis that will be undertaken. For aquaculture, a wide range of substances are tested for (Table 15). These are specified in the NRCP and are reviewed annually.

Any species of farmed finfish that is produced in greater quantity than 100 tonnes annually is subject to analysis under the Residue programme. Based on this production level requirement, three farmed species (salmon, fresh-water trout and sea-reared trout) are currently monitored.

Samples of farmed finfish are collected at the time of harvest and at other stages of production by an officer authorised under the Animal Remedies Act, 1993. Samples are maintained under a strict chain of custody. Archive sub-samples are retained at the Marine Institute and are available for testing by reference laboratories in the event of a disputed result.

Directive 96/23 requires that following initial "screening" tests on samples, positive test results are confirmed using appropriate test methodology and according to EU guidelines. The Marine Institute reports all positives results to DCMNR, FSAI and DAF. Decisions in relation to the positive result(s) and follow-up action are made by the Case Management Group (CMG). The CMG is made up of representatives from DCMNR, FSAI and the Marine Institute. Follow-up action may involve further sampling, investigations and legal proceedings.

The results of the residues programme are submitted annually to DCMNR, DAF and FSAI. DAF compile the results for all farmed animals and products and submit the results to the EU. This report is also released into the public domain. The individual test results for specific aquaculture sites are also reported to the companies that supplied samples.

During 2004, target samples were collected on 35 sampling events (salmon were collected on 31 occasions, seawater trout twice and freshwater trout twice) from fish farms and packing plants, for residues testing in accordance with the NRCP. Generally, five fish were taken from each producer.

In total, 183 target samples were collected from fish farms and packing plants in accordance with the NRCP for 2004:

- 124 target samples taken at harvest - 111 farmed salmon, eight fresh water trout and five sea reared trout;
- 59 target samples were also taken at other stages of production for Group A and malachite green analysis - 50 salmon smolts; and nine freshwater trout from two farms.

A summary of the results for residues monitoring in 2004 is given in Table 11. The main findings of the 2004 residues target monitoring programme are:

i. No positive results were obtained for '*Unauthorised Substances*' (Group A).
ii. Of the 124 samples screened for '*Antibiotic Residues*' (Group B1), no positive results were obtained
iii. None of the samples tested for '*Other Veterinary Drugs*' (Group B2) - generally authorised or unauthorised sea lice treatments – were positive. However, a number of samples were found to contain emamectin benzoate below the MRL.

[3] Authorised compounds have Maximum Residue Limits (MRL) prescribed by the EU. This is the maximum concentration allowable in the edible portion of the animal at the time of harvest. Generally, MRLs will not be exceeded if withdrawal periods are adhered to; i.e. the fish are not harvested for a set period of time after treatment. Unauthorised substances have no MRL and should not be detected.

iv. "*Other Substances and Environmental Contaminants*" (Group B3) includes dyes (malachite green and its metabolite, leuco-malachite green), metals, PCBs and chlorinated pesticides. Five samples of salmon smolts from one freshwater site were shown to be positive for malachite green and leuco-malachite green. A follow up investigation was carried out by the DCMNR. For the remaining substances in this group, all samples tested were compliant with the relevant EC Regulations for metals and guidance levels for PCBs and chlorinated pesticides as set by a number of OSPAR member states - and were consequently reported as negative.

Table 15. Summary of 2004 Residue Monitoring Results for Target Samples. (Marine Institute)

RESIDUE	NUMBER EXAMINED	COMPLIANT	NON-COMPLIANT	Source of Maximum Level to assess compliance #
Group B – Unauthorised Substances				
Corticosteroids	91	91	0	(v)
Methyltestosterone	53	53	0	(v)
Betaestradiol	53	53	0	(v)
Beta-agonists	91	91	0	(v)
Chloramphenicol	91	91	0	(v)
Nitrofurans	51	51	0	(v)
Group B - Therapeutic treatments				
B1 - Antibacterial substances				
Antibacterial Screening:				
Tetracyclines	124	124	0	(i)
Nitrofurans	124	124	0	(i)
Quinolones	124	124	0	(i)
Sulphonamides	124	124	0	(i)
B2 - Other Veterinary Drugs				
Emamectin benzoate	130	130	0	(i)
Ivermectin	129	129	0	(ii)
Cypermethrin	121	121	0	(i)
Deltamethrin	91	91	0	(i)
Teflubenzuron	124	124	0	(i)
Diflubenzuron	124	124	0	(i)
B3 - Other Substances & Environmental Contaminants				
CB Congener 28	25	25	0	(iii)
CB Congener 31	25	25	0	
CB Congener 52	25	25	0	(iii)
CB Congener 101	25	25	0	(iii)
CB Congener 105	25	25	0	
CB Congener 118	25	25	0	(iii)
CB Congener 138	25	25	0	(iii)
CB Congener 153	25	25	0	(iii)
CB Congener 156	25	25	0	
CB Congener 180	25	25	0	(iii)
HCB	25	25	0	(iii)
a-HCH	25	25	0	
γ-HCH	25	25	0	(iii)
cis-Chlordane	25	25	0	
trans-Nonachlordane	25	25	0	
trans-Chlordane	25	25	0	
DDD-p,p'	25	25	0	
DDE-p,p'	25	25	0	
DDT-p,p'	25	25	0	
Lead	25	25	0	(iv)
Cadmium	25	25	0	(iv)
Mercury	25	25	0	(iv)
Aflatoxins	7	7	0	
Malachite Green	90	90	5	(ii)
Leuco-Malachite Green	90	90	5	(ii)
% Lipids	25	25	Not applicable	

i) Maximum Residue Limit set according to Council Regulation (EEC) No 2377/90; ii) These compounds are not authorised for use in finfish, and should not be detected.; iii) Strictest standards applied by OSPAR contracting countries (OSPAR, 1992). iv) Commission Regulation (EC) No 466/2001 as amended by Regulation (EC) 221/2002; (v) Substances banned by Council Regulation (EEC) No 2377/90 (Annex IV) and should not be detected.

Finfish Health Status

The disease classification outlined in EU Directive 91/67/EEC (see Box 5) forms the basis for trade in live fish within the EU. According to this framework, Ireland has obtained the highest classification possible for finfish and can trade freely with any country within the European Community, and beyond. The Fish Health Unit (FHU) of the Marine Institute supports the aquaculture industry and the inland fisheries sector in maintaining Ireland's superior fish health status. It provides both statutory services (in line with EU Directives), and diagnostic support.

It is on the basis of maintaining Ireland's Approved Zone Status (the highest health status achievable under the current regime) for Viral Haemorrhagic Septicaemia (VHS) and Infectious Haematopoetic Necrosis (IHN) that most of the statutory testing is carried out.

In 2004, Ireland also obtained 'Additional Guarantees' (see Box 5) in relation to the List III diseases *Gyrodactylus salaris*, Bacterial Kidney Disease (BKD) and Spring Viraemia of Carp (SVC) allowing it to insist on certification showing freedom from these pathogens prior to importation.

The work programme in relation to finfish diseases consists of three strands:

i. All marine and freshwater finfish sites in the country are inspected at least once per year. Farms holding broodstock are inspected twice per year. A farm visit consists of a full inspection of all ponds/cages and full post-mortem (including bacteriological, virological and histological analyses) of at least 30 fish.
ii. Under the terms of each Aquaculture Licence, any farm experiencing 'abnormal' mortality must report it to DCMNR/Marine Institute. All such mortalities are investigated by the Marine Institute, generally in conjunction with the farm veterinarian, and findings are reported back to DCMNR.
iii. In order to prevent the spread of disease through the movement of fish between sites (e.g. smolt transfers to sea), a movement permit is required. When an application is made to DCMNR for a movement permit, the health status of the fish is ascertained either by site inspection by the Marine Institute or via the submission of a recent veterinary report by the farmer's practitioner. Only clinically healthy fish may be moved.

The following are the main points relating to the finfish health monitoring programme during 2004:

i. All marine and freshwater finfish sites were inspected and sampled as outlined in Council Directive 91/67/EEC. **2,718** finfish were tested for the presence of diseases listed in Annex A of the Directive. Ireland continues to remain free of ISA (Infectious Salmon Anaemia), VHS, IHN, BKD and *G. salaris*. The IPN (Infectious Pancreatic Necrosis) virus was, however, isolated from post-smolts on six sites, as a result of routine screening. Clinical disease was not observed in any of the six cases. Nevertheless, risk reduction measures were instigated on all sites - in order to control the spread of the virus.
ii. **926** finfish were examined for diagnostic purposes, generally as a result of mortality events at aquaculture facilities. Atypical *Furunculosis* was identified on a single freshwater site in 2004. *Yersinia ruckerii*, the causative agent of ERM (Enteric Redmouth Disease), was isolated from two aquaculture facilities and *Vibrio* sp. were isolated on a number of occasions from salmon post smolts.
iii. The FHU carried out extensive testing and pre-movement clinical checks to facilitate the export of live fish and shellfish to other EU member states and to third countries such as Chile. In total, **35** Movement Documents were issued for finfish movements within the EU, and an estimated 5.2 million salmon ova, 282,500 salmon parr and 114,600 rainbow trout left the co.untry for on-growing, mainly in the United Kingdom. An additional 12 Movement Documents were issued for the export of salmon ova to Chile. In total, 12.5 million ova were exported to Chile in 2004.

For the fourth consecutive year, Pancreas Disease was the major cause of mortality on Irish finfish farms in 2004; affecting the majority of farms along the western seaboard, with varying degrees of severity. It has been estimated that one in every eight fish that went to sea died from Pancreas Disease; with mortalities ranging from 5 to 30% in affected farms.

A seminar in Galway in October 2004, convened by the Marine Institute, focused on the Pancreas Disease issue (Box 9).

Box 9. Pancreas Disease

In the early 1990s Pancreas Disease (PD), or salmonid alphavirus, was shown to be the most significant cause of mortality in farmed Atlantic salmon in Ireland. In the late 1990s it was a sporadic but minor cause of mortalities. However, for the fourth consecutive year, PD was the major cause of mortality on Irish finfish farms in 2004; affecting the majority of farms along the western seaboard, with varying degrees of severity. It has been estimated that one in every eight fish that went to sea died from Pancreas Disease; with mortalities ranging from 5 to 30% in affected farms.

A seminar in Galway in October 2004, convened by the Marine Institute, focused on the Pancreas Disease issue and agreed on research priorities, as follows:

- *Development of a Pancreas Disease Management Protocol* - This document would build on previous lessons learned in relation to PD and other infectious diseases and would represent an MI/ISGA protocol which would be promoted by vets/fish health professionals, supported by industry and put into widespread use across the country. Work commenced on this protocol in 2004 and is due for completion in 2005.
- *PD Co-ordinator* - It was suggested that the Marine Institute should pursue the appointment of a PD Co-ordinator, who would support the implementation of the PD Management Protocol and who would co-ordinate PD related research. This appointment should be made in 2005.
- *Epidemiological Studies* – An epidemiological study collating data from 2003 and 2004, similar to that carried out in 2002 (McLoughlin *et al.*, 2003), to commence in early 2005.
- *Development of PD Tolerant/Resistant Strains of Fish* - Work with commercial companies to establish and fund sentinel trials aimed at the development of PD Tolerant/Resistant strains of fish. This work commenced at two sites in south Connemara at the end of 2004, and will continue into 2005.
- *Biophysical Properties* - A joint research programme between QUB and the ISGA was established with funding from the NDP-funded Marine RTDI Applied Industry Measure. The aim of the 18 month project is to establish the biophysical properties of the PD virus in order to control its spread using disinfection and other biosecurity measures. Funding was allocated in 2004.
- *Diagnostic Tools/Pathogenesis* - This work will be carried out as part of an MI funded PhD project to be carried out at the Veterinary Faculty in UCD. The project commenced in 2004 and is aimed at the development and optimisation of diagnostic tools for the detection of the PD virus. This should ultimately result in speedier diagnosis, and may also be used to study pathogenesis and to search for vectors/carriers of the virus in the wild.
- *Further Research* - It was agreed that further research would be required in the short to medium term, and that the most appropriate funding mechanism would be through the submission of a Strategic Project under the NDP-funded Marine RTDI Programme. A call for research proposals for site investigations and disease management of the PD virus was issued in June 2005 under this programme.
- *Economic Analyses* - It was recommended that mortality data for the past number of years should be collated and translated into financial losses, so that the true impact of PD could be assessed. This work was completed and resulted in an estimated loss to the Irish industry in 2003 and 2004 of €12.7 million.

7. AQUACULTURE RESEARCH & DEVELOPMENT

Aquaculture Research 2004

Aquaculture research is carried out in the third-level, industry and state sectors and funded through a number of national and EU programmes.

National Development Plan (NDP) Marine RTDI Measure

The Marine Institute administers the NDP Marine RTDI Measure. Aquaculture research has been funded under a number of programmes within this measure, including applied industry awards, strategic research projects, post-doctoral fellowships and post-graduate scholarships. For the period from 2001 to 2004, a total of €2.5 million has been awarded through the Marine RTDI Measure to aquaculture research projects. During 2004, €118,000 was awarded to two aquaculture projects (Table 16). A number of projects funded in previous years were still active during 2004 (Table 16).

Table 16. Marine RTDI Measure (NDP) funded aquaculture research ongoing during 2004.

Start-Up Year	Title	Funding Type	Support (€)
2001	Sea lice biology and interactions	Post-doc	157,400
2001	Investigations into the hatchery rearing of Cod (*Gadus morhua*) in Irish conditions	Post-doc	210,000
2001	Investigations into a reliable supply of scallop (*Pecten maximus*) for the inshore fishery and aquaculture industries	Post-doc	209,280
2001	Health and disease in clams (*Ruditapes philippinarum*) in Ireland, with particular reference to brown ring disease.	PhD	118,137
2001	Modelling of *Alexandrium* blooms in Cork Harbour.	PhD	98,350
2002	ASTOX - Isolation and purification of azaspiracids from naturally contaminated materials, and evaluation of their toxicological effects	Strategic	419,854
2002	Resource and Risk Assessment of Mussel Seed in Irish Waters	Strategic	361,362
2002	BOHAB - Biological Oceanography of Harmful Algal Blooms off the west Coast of Ireland	Strategic	399,500
2003	Dunlop Offshore Cage Development Programme	Industry	42,868
2003	A Novel System for Intensive Larval Culture of the Sea Urchin *Paracentrotus lividus*	Industry	38,958
2003	Development of an artificial roe enhancement diet based on waste products from the fishing industry	Industry	54,308
2004	Acclimatization potential of Arctic Char (*Salvelinus alpinus*) to a marine environment	Industry	59,686
2004	Evaluation of selected biophysical properties of salmon pancreas disease virus (SPDV)	Industry	58,594

An overview of the three strategic projects is provided below. Descriptions of the Post-doctoral Fellowship, PhD Scholarship awards are included in Appendix III. Information on Industry awards and all Marine RTDI funding since 2001 can be obtained from the Marine Institute.

Project Title	**Resource and Risk Assessment of Mussel Seed in Irish Waters**
Project Leader	University College Cork - Aquaculture and Fisheries Development Centre
Partners	University College Dublin - Dept. of Zoology Queen's University, Belfast - School of Biology & Biochemistry South East Shellfish Co-op. Aquafact International Services Seabed Surveys International
Description	To date, there has been little basic research done of the life cycle and environmental factors that underlie the mussel (*Mytilus edulis*) populations in the Irish Sea. This source of seed plays a very important role in the bottom mussel culture industry in Ireland (worth €21m in 2004). This project attempts to fill some of the information gaps relating to mussels in the Irish Sea. The broad aim of this study is to determine the life-cycle, environmental factors and drivers of the mussel resource in Irish inshore waters, with particular focus on the south Irish Sea. The project commenced in March 2003, was fully operational through 2004 and will run until March 2006. This inter-disciplinary research project encompasses data review (incl. resource assessment and acoustic surveys) and analysis, a study of the key oceanographic factors and investigation of molluscan reproductive biology and ecology and some socio-economic factors. In addition, the feasibility of hatchery production and the collection of wild seed (using spat collectors) for bottom mussel culture will be assessed. The investigators work closely with a Steering Group comprising the Irish Shellfish Association, scientists from the Marine Institute and BIM, and international experts. The ultimate goal of this project is to provide scientifically based recommendations for the sustainable management of the mussel seed resource in the Irish Sea.

Project Title	**ASTOX - Isolation and purification of azaspiracids from naturally contaminated materials, and evaluation of their toxicological effects**
Project Leader	Marine Institute
Partners	University College Dublin - Conway Institute Centre for Coastal Environmental Health & Biomolecular Research, South Carolina Japan Food Research Laboratory Tohoku University, Japan Chiba University, Japan
Description	Over the past 8 years, azaspiracids (AZAs) have become a major problem to the Irish shellfish industry. The standard bioassay cannot detect toxins that occur at toxicologically relevant concentrations in shellfish. The use of liquid chromatography coupled to a mass spectrometer (LC–MS) has made it possible to detect small quantities of azaspiracids and in this way to help ensure the safety of Irish shellfish products. The overall objective of this project is the evaluation of the toxic effects of azaspiracids (AZAs) and the establishment of a "no-observable-adverse-effect-level" (NOAEL) of AZAs in shellfish. This priority was identified in the first risk assessment of AZAs in shellfish carried out by the Food Safety Authority of Ireland. The data obtained will contribute to the setting of a more scientifically based maximum allowable concentration of the toxin in shellfish for use by regulatory authorities in order to protect human health.

Project Title	**BOHAB - Biological Oceanography of Harmful Algal Blooms off the West Coast of Ireland**
Project Leader	Martin Ryan Institute, National University of Ireland, Galway.
Partners	Marine Institute Woods Hole Oceanographic Institute, USA.
Description	The strategic aim of this project is to determine and measure baseline ecological and biological oceanographic parameters in two geographic areas of high aquaculture importance (Killary Harbour and Bantry Bay) in order to develop the necessary data for the biological component of a conceptual HAB (Harmful Algal Bloom) model. Specific aims include: • Mapping harmful algal species as a function of water column parameters and establishing a measure of variability and patchiness of these species to differing environmental conditions. • Comparing the susceptibility of different types of local farmed fish and shellfish to toxic species as a function of environmental interaction. • Investigating the episodic nature of *Alexandrium* blooms to identify the environmental limits that control the germination of *Alexandrium* cysts and development of blooms. • Assessing the toxicity of *Alexandrium* in the two focus areas. • Determining the distribution of cyst beds of *Alexandrium* and *Protoperidinium*, and identifying the factors required in a predictive model of HAB incidence for all shellfish and finfish harmful species. • Studying oceanographic events in relation to dinoflagellate cyst germination, *i.e.* upwelling and downwelling events; transportation of cysts/new germinated vegetative stages in coastal areas. • Designing and implementing a cost effective in-situ monitoring system with appropriate sensors on fixed moorings to observe HAB events. In 2004, the BOHAB project focused on two activities; 1) processing and analysing data from field surveys carried out in 2003, and 2) a multi-national survey studying thin layers of phytoplankton within Killary Harbour (see description of the FP6-funded HABIT project below).

EU 6th Framework Programme

The 6th Framework programme is focused on competitive research and development involving partnerships of three or more Member/Associated States. Four projects of relevance to the aquaculture industry and involving Irish research groups have been supported under the FP6 programme and were ongoing during 2004[4].

Project Title	**SEAFOODplus (www.seafoodplus.org)**
Project Leader	Danish Institute for Fisheries Research, Denmark
Irish Partner(s)	Dr. Mairead Kiely/Dr. Conor Delahunty - UCC Dr. Ronan Gormley - Teagasc, The National Food Centre Prof. Séamus Fanning - UCD
Project Aims	This large, integrated project aims at reducing health problems and increasing well-being among European consumers by applying the benefits obtained through consumption of health promoting, safe, high quality seafood products. The aquaculture component of this project will study effects of dietary modulation, husbandry, fish physiology, genetics and pre-slaughter conditions on fish quality.

Project Title	**HABIT - Harmful Algal Bloom Species in thin layers**
Project Leader	National University of Ireland, Galway (NUIG)
Irish Partner(s)	Dr. Robin Raine – Martin Ryan Institute, NUIG
Project Aims	The HABIT project will research the development and dispersion of Harmful Algal Bloom (HAB) populations in sub-surface micro-layers - focusing on the genus *Dinophysis*, which frequently occurs in sub-surface, thin micro-layers and is associated with DSP Toxins. The overall objectives of HABIT are to resolve fundamental patterns in the occurrences of *Dinophysis* and quantify the processes that are important in governing their distribution.

Project Title	**BIOTOX - *Cost effective tools for risk management and traceability systems for lipophilic marine biotoxins in seafood***
Project Leader	Netherlands Institute for Fisheries Research (RIVO), Netherlands
Irish Partner(s)	Dr. Philipp Hess – Marine Institute National University of Ireland, Galway Food Safety Authority Oyster Creek Seafoods
Project Aims	This project aims to develop and validate alternative, reliable and cost-effective methods for the control of lipophilic toxins that can replace the current animal tests. In addition, early warning systems, improved decontamination procedures and traceability systems will be developed, and existing HACCP procedures will be adapted for these toxins.

Project Title	**SEED - Life history transformations among Harmful Algal Bloom species and the environmental and physiological factors that regulate them**
Project Leader	Consejo Superior de Investigaciones Cientificas, SPAIN
Irish Partner(s)	Dr. Robin Raine - Martin Ryan Institute, NUIG
Project Aims	The SEED project aims to understand how, and to what extent, anthropogenic forces influence the non-vegetative stages of the life cycles of harmful algal species thereby contributing to the increase in harmful algal blooms in European marine, brackish and fresh waters.

[4] These project descriptions were taken from '*Directory of Irish marine successes within the FP6 and INTERREG III Programmes*' (Mercer and O'Sullivan, 2004).

INTERREG III

INTERREG III is a European Regional Development Fund (ERDF) Programme designed to strengthen economic and social cohesion in the European Union (EU) by promoting cross-border co-operation. The various strands of the INTERRREG III programme are as follows:

Maritime INTERREG-IIIA Ireland/Wales (www.interreg.ie);
INTERREG IIIB Atlantic Arc (www.interreg-atlantique.org);
INTERREG –IIIB Northwest Europe (www.nweurope.org); and
INTERREG-IIIC (www.interreg3c.net).

While not an RTD Programme, INTERREG can support co-operative projects (with an R&D element), particularly in the areas of marine and coastal resource development and maritime transport. Seven aquaculture-related projects with Irish partners are currently being supported under three strands of the INTERREG programme[5].

INTERREG IIIA (Ireland/Wales)

Project Title	**Shellfish Aquaculture in the Irish Sea - Detection and prevention of diseases in *Crassostrea gigas***
Irish Partner	Dr. Sarah Culloty – Environmental Research Institute, UCC
Welsh Partner	Centre for Applied Marine Sciences, University of Wales, Bangor.
Project Aims	The primary objective of this project is to determine the potential environmental (biotic and abiotic) and biological (physiological, immunological and genetic) factors that lead to mass summer mortality of Pacific oysters (*C. gigas)*, and thereby facilitate the prediction and possibile prevention of future summer mortality events in Ireland and Wales.

Project Title	**SMART - Sustainable management of near shore water quality for aquaculture, recreation and tourism**
Irish Partner	Dr Bartholomew Masterson - Department of Biochemistry, UCD
Welsh Partner	Centre for Research into Environment & Health, University of Wales, Aberystwyth.
Project Aims	The overall aims of the project are to apply predictive tools developed for integrated pollution budget analysis and computer modelling of "point" and "diffuse" sources of pollution to ensure sustainable management of high quality shellfisheries and recreational water environments in Ireland and Wales. Specifically, the project will apply a joint "diffuse catchment sources" model to two areas, namely: Carmarthen Bay (Wales); and Dublin Bay and Bannow Bay (Ireland.)

Project Title	**Development of Mussel Hatchery Techniques in Ireland/Wales**
Irish Partner	Dr. Gavin Burnell – Environmental Research Institute, UCC
Welsh Partner	Centre for Applied Marine Sciences, University of Wales, Bangor.
Project Aims	The overall aim of this project is to develop an alternative source of mussel seed for the aquaculture industry to reduce reliance on wild sources of seed, which is unreliable. This can only be achieved through mussel hatchery production. Currently no such hatchery exists in the EU. Hatchery production of *M. edulis* would allow a more predictable supply of spat to the mussel growers, allowing optimisation of the industry.

[5] These project descriptions were taken from '*Directory of Irish marine successes within the FP6 and INTERREG III Programmes*' (Mercer and O'Sullivan, 2004).

INTERREG IIIB Atlantic Area

Project Title	**e-AQUA - Analysis penetration of ICT and promotion of e-commerce within the SMEs belonging to the aquaculture strategic sector of the Atlantic area**
Project Leader	CETEMAR – Centro Tecnologico del Mar-Fundacio, SPAIN
Irish Partner(s)	Dr. Terence O'Carroll – BIM Mr. David Murphy – Aqua TT
Project Aims	The project is intended to strengthen the aquaculture sector through promotion of the use of new information/communication technologies and e-business. This will be achieved in a three step approach, as follows: - establishing a research centre on IT use in the aquaculture sector; - establishing a training and information scheme for small and medium enterprises in the sector; and - performing feasibility studies on implementing an e-commerce strategy in identified businesses. In Ireland, a comprehensive survey of the information technology needs of the salmon, smolt and trout sector was undertaken. Findings from this survey clearly defined that each company should have access to one good working computer and identified training as a huge need. As a result, twenty-nine fish farmers in Carlow, Donegal, Galway and Cork enrolled in computer training courses (ECDL – European Computer Driving Licence). This was followed by a very successful workshop – 'Harvest Your Potential' - in Dingle Co. Kerry in November 2004. An action plan was framed for the remaining five months of the project, which includes websites and a web portal for the industry. For further details see www.e-aqua.org.

Project Title	**NEMEDA - Network for the diminution of the effects of *Dinophysis* in Aquaculture**
Project Leader	National Univeristy of Ireland, Galway (NUIG)
Irish Partner(s)	Dr. Robin Raine – Martin Ryan Institute, NUIG Mr. Joe Silke, Marine Institute
Project Aims	The NEMEDA project creates and develops a network of experts studying the life-cycle of *Dinophysis* (which is associated with DSP Toxins), the process by which it contaminates shellfish and current harvesting procedures. The aim is to address the disadvantages and shortcomings of current techniques for sampling, study and forecasting of *Dinophysis* blooms. The project will test a point sampling technology, perfected by IFREMER, in the coastal rivers of Galicia and in the south-eest of Ireland. On the basis of the results obtained, research proposals on *Dinophysis* will be formulated.

Project Title	**AAAG - The Atlantic Area Aquaculture Group**
Project Leader	University of Wales, Bangor, UK
Irish Partner(s)	Dr. Julie Maguire - Aquaculture and Fisheries Development Centre, UCC
Project Aims	The AAAG project aims to support the development and modernisation of the aquaculture industry, and to encourage practices that respect the environment of the Atlantic Area, by means of the creation of a network, the 'Aquaculture Group of the Atlantic Arc'. AAAG encompasses five sub-projects on the basis of two main themes - promoting aquaculture that respects the environment, and applying genetics to aquaculture. The sub-projects include the utilisation of micro-algae to reduce the quantity of nitrates in sea water, and the development of species of bivalve with rapid growth and resistance to disease.

INTERREG IIIC

Project Title	**AquaReg**
Project Leader	North Trøndelag and South Trøndelag, Norway
Irish Partner(s)	Marine Institute
Project Aims	The aim of Aquareg within the three partner regions (Galicia, Spain; Trøndelag, Norway; and BMW Region, Ireland) is to establish a long-term cooperation in aquaculture and fisheries and to make more efficient use of the experience and knowledge of aquaculturists, fishermen and scientists, across regional and national borders. Three strategies were developed to achieve these objectives: • *AquaLink* aims to link aquaculture business and research to promote the introduction of new species - focusing on juvenile production. • *AquaEd* addresses a critical issue for the aquaculture industry – recruitment and training of key personnel. • *AquaPlan* addresses the need for integrated spatial planning and management of the coastal zone. AquaReg project topics with Irish partners include: • Reducing the environmental impact of land based aquaculture through cultivation of seaweeds; • Optimisation of environmental conditions for cultivating marine finfish larvae; • Developing efficient transportation and storage requirements for live crustaceans; and • Developing a novel and simple method for cost-effective production of lobster juveniles. For further information on the AquaReg programme and a full list and details of individual projects see www.aquareg.com.

Third-Level Sector Research

Approximately 10 research groups in the third-level sector are currently carrying out research on a wide range of aquaculture-related topics (Table 17). Current topics of research within these groups include HABS; bio-toxin identification, isolation and analysis; salmonid genetics; new species development (e.g. cod and abalone); fish and shellfish health and immunology; development of finfish and shellfish diets; and water quality. Aquaculture research facilities available within the third-level sector include re-circulation units, and finfish and shellfish hatchery and on-growing facilities.

Many other research groups have skills/technologies in the fields of technology and biotechnology with obvious potential for their application to aquaculture-related research.

Table 17. Aquaculture research focus of third-level institutions

Institute	Research Focus	Institute	Research Focus
University College Cork	• Fin/shellfish aquaculture, aquaculture systems, new species • Fish & shellfish health and immunology • Salmonid genetics, genetic interactions • Water quality assessment and modelling • Marine ecology, biodiversity and ecosystem functioning	National University of Ireland, Galway	• Marine modelling • HABS • Aquaculture systems, New species • Seaweed culture, fish feed • Bio-toxin identification/testing • Molecular biology of salmon • Functional genomic approaches to stock selection
Galway Mayo Institute of Technology	• Broodstock and re-circulation systems • Storage, handling and transport protocols for shellfish • Population genetics • Sea lice biology, monitoring marine biodiversity • Novel species	University College Dublin	• Marine ecology, biodiversity, environmental monitoring • Molecular genetics • Toxicology, development of *in vitro* tests for bio-toxins • Microbial water quality • Water quality modelling
Letterkenny Institute of Technology	• Identification of bivalve larvae • Shellfish spat production • Shellfish toxins	Cork Institute of Technology	• Bio-toxin analysis & isolation
Dublin Institute of Technology	• Diagnostic tools for rapid detection of pathogenic organisms affecting finfish and shellfish • Salmon smoltification • Shellfish histology/pathology •	Trinity College Dublin	• Salmon genetics

Commercial Development 2004

Grant Payments & Approvals

Payments

The Aquaculture Development Measures of the two Regional Operational Programmes of the 2000-2006 NDP provided the overall framework for commercial aquaculture development programmes and activities in 2004. These grants are administered by BIM.

During 2004, BIM made grant payments of €4.32 million to 25 projects under the NDP, comprising €3.63 million in FIFG (Financial Instrument for Fisheries Guidance) grants and €0.69 million in exchequer grants (Appendix II). As in 2003, the breakdown by species of these payments reflects the current status of the industry, with significant expenditure in the shellfish sector. Of the total FIFG spend of €3.63 million, the extensive cultivation of mussels accounted for 68%. This comprised support toward the purchase of three new mussel dredgers. Oysters accounted for 14% of total FIFG support, while rope mussels accounted for 6%. Clams and salmon accounted for significantly smaller amounts; 0.6% and 0.8%, respectively. The balance (10.5%) went towards various environment (e.g. C.L.A.M.S.) and quality-related projects.

R & D and commercial grants, administered by Údarás na Gaeltachta and Taighde Mara, are available to operators in the Gaeltacht areas of counties Donegal, Mayo, Galway, Kerry, Cork and Waterford. In 2004, 19 projects in Donegal (7), Mayo (1), Galway (9), Cork (1) and Waterford (1) received financial support totalling €1.7 million (Appendix II). Six salmon projects in Galway and Donegal received 82% of the total funds, indicating the importance of salmon farming in these counties. The remaining funds were distributed amongst turbot, oyster, abalone, cod, seaweed and clams projects.

Small-scale aquaculture projects are promoted in a pilot development phase prior to full scale commercial development under the NDP. Funding is available under Pilot Aquaculture Grant Scheme, administered by BIM. The Aquaculture Grant Scheme also pilots the introduction of new technology and the opening up of new site locations for aquaculture. During 2004, BIM made grant payments of €0.97 million to 97 projects under these two schemes (Appendix II). Of note is the fact that the new species projects which would be defined as development projects other than those dealing with clams, oysters, mussels, trout and salmon are of increasing significance. Specifically, 26% of the total payment amount in 2004 went to projects concerned with new species.

Finally, 10 projects received funding worth €0.17 million under the Fish Handling Grant Scheme. This scheme aims to improve quality and hygiene in the marketing of fish and shellfish.

Approvals

In addition to grant payments made in 2004, significant funding was also approved. Overall, national investment approved for NDP grant assistance in the aquaculture industry during 2004 amounted to €26.24 million across 29 projects. This figure is the total approved eligible costs (€7.85 million in approved grant). The total investment in 25 projects prioritised by BIM amounted to €23.7 million (Appendix II). Of this amount, an investment of €10.63 million (€3.72 million in approved grant) was approved in respect of nine projects in the southern and eastern Region and an investment of €13.06 million (€4.13 million in approved grant) was approved in respect of 16 projects in the Border, Midlands and Western Region. A further four projects prioritised by Údarás na Gaeltachta in Gaeltacht areas, with an investment of €2.54 million were also approved for NDP grant assistance.

Under the Pilot Aquaculture Grant Scheme, 96 projects were approved for Exchequer grant assistance of €1.32 million on aggregate investment costs of €3.07 million (Appendix II). Significantly, there was continued good performance of the new species projects. Of the total 2004 grant approval of €1.32 million, the new species projects account for 27%, while traditional activity with salmon, trout, oysters and mussels accounts for the remaining 73%. Further development opportunities on alternative species such as cod and abalone, are also being investigated by Taighde Mara and Údarás na Gaeltachta, with significant investment being planned.

A further 15 projects were approved for Exchequer grants of €0.32 million on investment costs of €0.80 million, under the Fish Handling Grant Scheme.

Box 10. Integration of Salmon Businesses

A study of the Conamara salmon industry, commissioned by Údarás na Gaeltachta, was completed in 2004. The main findings of the study are that the viability of salmon farming in Ireland depends on a critical mass of high quality product, both fresh and processed, directed at lucrative niche markets (Corduff, pers. comm.). To achieve this, a focused production strategy is required to ensure continuity and consistency of supply is maintained. This can be more easily achieved by one operating company rather than a number of smaller producers who tend to cater to their own needs.

To address the issues of production gaps and over-supply, a new company (Maoiniú Mara Teoranta) was established in 2004, on a commercial basis, as a joint-venture between Irish Seafood Producers Group Limited and Údarás na Gaeltachta, to contract with producers to provide product on a timely basis to achieve premium prices. This benefits all producers, as prices and continuous market presence are maintained.

In parallel to this restructuring, the cost base of production is to be reduced by the clustering of support services in a new industrial estate in Cill Chiaráin, Co. Galway. It is proposed that harvesting and processing be streamlined by the provision of a dedicated well-boat, operating from a jetty adjacent to a new processing plant and that a complete suite of ancillary services be provided. The site that will become the business park to host these plants has been developed by Údarás na Gaeltachta.

The integration of the industry not only makes economic sense but also makes sense in terms of the development of the local economy and the maintenance of the community in an area where there are limited job opportunities.

Technical Development Programme 2004

The Technical Development Programme of the Aquaculture Development Division of BIM had an active year in 2004. Technical developments were tested and implemented across all sectors of the industry.

Rope Mussels

Trial of new Pergolari washer

A prototype machine for washing pergolari was developed and produced. The machine crushes the waste matter in used pergolari while feeding it into a drum washer, giving an end product clean enough for recycling. Discussions are underway with plastics companies with a view to recycling and in the meantime the cost of sending the waste pergolari to landfill is lowered, simply by reducing the volume of waste.

Adaptation of New Zealand farming systems

Trials with continuous longline cultivation continued in Bantry and Clew Bay, with excellent returns for both farms. The "hairy" rope used both for natural collection and thinning has resulted in increased yields and reduction in labour. A thinning machine which feeds cotton mesh onto the restocked rope cuts out the use of pergolari completely and the rope itself, whether used for collection or thinning, is reusable, thereby considerably reducing waste products for the farm. A number of farms have transferred to this technology.

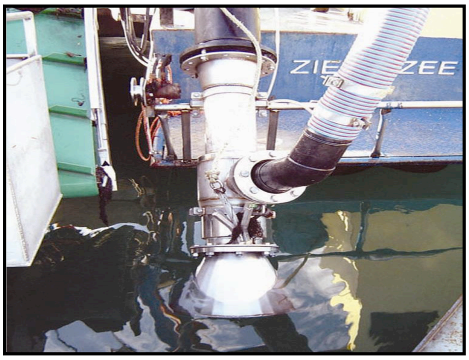
Continuation of Smart Farm trials

The Norwegian pipe based farming system on trial in Lough Swilly, Bantry and Kenmare continued to give encouraging results during 2004 (left). An average of 10 tonnes of seed per line was harvested from the three lines in Lough Swilly. This was transplanted to bottom culture sites in the Lough in September 2004 and performed well against seed transplanted both from the southwest and from traditional longlines in the southwest and the Swilly. It is the only rope mussel farming system to have survived the excessive currents characteristic of sites in the area.

Having acquired a trial licence for perhaps the most exposed rope mussel farming site in the country, eight lines were deployed in Kenmare Bay in October 2004. Four of these were taken from a temporary mooring in Cleandra and four were put out as new. This site will provide information on the performance of the system in Irish offshore conditions; the pros and cons of shooting lines both in line with and across the tide; and the potential variation on toxicity levels and performance of toxins in offshore sites. In 2005 it is planned to implement a more intensive management programme of the sites in terms of thinning, predator control and general line maintenance in order to determine the maximum possible return from the lines.

Seed grading trials
Further initiatives to improve yields from rope mussel farms were taken in 2004, including trials on grading seed. Three sites were selected for these trials covering the west and southwest and using naturally collected and rock seed. At the time of thinning, seed was returned to lines both graded and un-graded and measurements were recorded for each class. Samples will be taken again in 2005 to assess the potential for increasing returns through grading at this point and thereby reducing the level of reject at harvesting.

New venturi-based harvesting system
A new rope mussel harvesting system, which uses suction created by a self-priming centrifugal pump and a stainless steel venturi was purchased for trial in Clew Bay (left). The system is most effective for continuous longline farms. The system eliminates harvesting losses and, because of the reduced handling, water loss is minimal; thus offering the possibility for increasing the shelf life of a fresh product. Results of the trial to date have shown an improved yield and increased tonnage per man hour.



Bottom Grown Mussels

The bottom grown mussel industry is undergoing a major transformation with the introduction of new state-of-the-art dredgers into the fleet. Coupled with this major capital expenditure, is the requirement for the industry and the agencies and universities working in this area to understand and investigate mussel seed, the primary resource on which the whole industry depends. To this end, a major programme of technical work is carried out every year. During 2004, BIM undertook 36 days of mussel surveying in Carlingford Lough, east Coast (Wicklow and Wexford), Waterford Estuary, Castlemaine Harbour, Lough Swilly and Lough Foyle to locate and quantify seed beds. The survey techniques included acoustic technology (Roxswath ™) for seabed classification, grabs dredges, underwater cameras, ROVs and, in some cases, diver surveys.

In addition, an annual survey of individual grow-out sites is carried out to assess performance of mussel seed to ascertain return ratio, yield, predator control and overall husbandry. This is critical if the industry is to maximise return and ultimately profit from what is a limiting and scarce resource.

Mussel hatchery
BIM commissioned Cartron Point Shellfish Ltd. to carry out initial work into the potential for the feasibility of producing mussel spat in a hatchery. Mussels were successfully conditioned (in and out of season) and several successful spawnings and settlements were achieved using a variety of techniques. This work will continue in 2005.

Pacific Oysters

The development programme in relation to Pacific oysters focuses on efforts to increase mechanisation, reduce labour and improve quality, through working closely with individual farmers on innovative design concepts or technology transfer.

Oyster bag cleaner
A mechanical in-situ oyster bag cleaner modified from a silage cutter was developed and manufactured by an oyster company in Dungarvan, with support from BIM (left). It reduces the requirement for turning bags and cuts down on the labour involved in shaking. Again, this has generated considerable interest among producers around the coast.

Longline oyster farming

The BST Adjustable Longline oyster farming system, first introduced into Ireland from Australia in September 2002, continues to undergo trials to adapt it to Irish conditions. So far it has allowed for the successful utilisation of muddy and exposed deeper water sites, though not without problems. Working closely with the farms in question and BST, newer more robust components of the system are and will be developed and tested over the period of the trial. In the meantime, it has been shown to produce good quality, market size oysters as well as performing well as a nursery for both Pacific and native oysters.

Oyster holding system

Support was provided for the design of a cage holding system for market size oysters in the northwest. The main objectives were to decrease handling while increasing grading output. The cages are made from a galvanised steel frame and surrounding mesh, into which a total of 30 trays can be stacked, holding up to 510 kg. The trials carried out over 12 months provided very encouraging results, both in terms of saving on labour and increasing the productivity of the crew. In addition, there was no negative impact on conditioning or survival. By reducing the stocking densities, meats were found to improve over time. The success of this trial led to a number of farms incorporating this system into their husbandry protocols in 2004.

Scallops

In association with Cartron Point Shellfish Ltd., BIM carried out hatchery work on scallops in the research facility in Gerahies, Co. Cork. Several batches of brood-stock from the southwest were successfully conditioned and spawned onto mesh. Once the scallops had attached (at a size of 2-3 mm) they were then transferred to various on-growing sites. Though the hatchery aspects worked out very well, the inexperience of handling such small scallops at sea became apparent and mortalities were high. However, five scallop projects managed to over-winter stock ranging from 20 to 45 mm. The project was deemed successful enough to be repeated in 2005 with the emphasis being put on improving the survival once the scallop go to sea.

Salmon

VICASS (Video Image Capture and Sizing System)

Previous methods for biomass estimation used by Irish fish farms were deemed inaccurate and were also stressful to the fish. VICASS is a non-intrusive method for predicting fish weight and total biomass, using a digital stereo-camera system. The system was installed by BIM, in association with Silver King Seafoods Ltd, in 2004 on a trial basis. The results from the first phase of this project proved that biomass and individual weights can be predicted with a high degree of accuracy.

Water heating system

As part of the work programme to improve the efficiency of salmon smolt production, Pisces Engineering Ltd. supplied a heating system to Salmo Nova Ltd in Co. Carlow. The system installed uses a heat/cool recovery system whereby the outlet water from the system is passed through filters and then heat exchangers. This maintains a higher temperature from egg to 2g fry, reducing operating costs. Results so far indicate that it can be used to reduce the growing cycle by up to six weeks. The enhanced growth also gave better survival, a better quality of fish and less runt fish.

Trout

A freshwater trout farm was assisted in switching over its production system to modernise its growing practices and to improve quality and efficiency. Four earthen ponds were replaced with one circular tank and three rectangular grading and harvesting tanks. The capacity of the 18m diameter tank is 300 cubic meters of water, which in theory can hold more fish than the four ponds it replaced. The innovative aspect of the project is that the tank is fitted with a splitter unit which removes solids from the water as it leaves the tank; this means 75% of the water is retuned to the tank via an oxygenation system. The other 25% containing most of the solid waste is passed through a lamella system where the bulk of the solids are removed to a sludge tank. This system has the ability to produce an equivalent amount of stock but using only 25% of the water, yet discharging lower volumes of waste. The system is also fully alarmed for oxygen levels and flow etc.

Perch

Perch has been identified by BIM and the Aquaculture Initiative as a native species offering diversification potential for freshwater fish farmers and land owners. A detailed analysis of the market for perch was commissioned by BIM and showed a positive demand for small fillets in the Alpine regions of Central Europe, where this fish is considered a delicacy. Perch can be farmed using a variety of growing methods including both recirculation and traditional pond systems.

To-date great progress has been made with the development of the species. Three farms have been licensed and developed, one incorporating a broodstock and nursery unit. PDS Irish Waters Perch Ltd in Arvagh, County Cavan (left) was officially opened in April 2004 and is now supplying weaned perch juveniles to the other satellite grow-out farms. Five other projects on perch are at a well advanced stage.

Emlagh Fisheries Ltd in Castlecoote, Co Roscommon is nearing completion and will comprise a modern 40 tank farm with a capacity of 20 tonnes of perch. The farm is designed to recirculate water with a reed bed and polishing pond system to clean the water prior to its re-use on the farm.

The growing methods employed on these new perch farms include recirculation and traditional pond systems with a large settlement pond, a polishing pond and specially constructed reed beds to help treat waster water. This entirely natural and highly efficient water treatment system ensures that the discharge is maintained within the set parameters.

BIM and the Aquaculture Initiative held a two day international perch workshop in Arvagh, Co Cavan in July 2004. The workshop which was attended by delegates from throughout Ireland, highlighted the potential this species has for development in rural inland areas. The workshop focused on the progress made in culturing this species in recent times and included a practical on-site session (fish feeding, grading and processing) at the PDS Irish Waters Perch site in Knockaghy, Co Cavan.

Seaweed

A very successful seaweed cultivation project was undertaken in 2004 and will continue in 2005[6]. A strain of locally picked *Alaria esculenta* was successfully cultivated at Gearhies Marine Station in Bantry in 2004. Using a technique pioneered for the first time in Bantry by Jean-Francois Arbona and Magali Molla of C-Weed Aquaculture, St Malo, the weed was locally collected during October 2004, cultivated in the laboratory and the strain was finally sprayed onto collectors in the middle of November. The collectors, each with a line capacity of 30m, were held in controlled conditions in the cold room at Gearhies Marine Station for a further 21 days prior to being put to sea at locations in the southwest in mid-December. Further collectors were held on in Bantry over the Christmas period to be put to sea in January 2005. This will allow growth comparison of the two batches at sea. *Alaria* grows in cool temperatures until April. Lines were put to sea at Bere Island, Roaringwater Bay, Cape Clear and Galway Bay.

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[6] The technique is described fully in the BIM Aquaculture Explained Manual No 21 'Cultivation of Brown Seaweed (*Alaria esculenta*)'. This manual is due to be published during 2005.

8. QUALITY

In 2003, BIM launched the concept of the Quality Seafood Programme (Box 11), which was devised as a marketing tool to facilitate the communication of the industry quality standards directly to the buyer and consumer. This programme was piloted in 2003 with salmon certified under the Irish Quality Salmon scheme. During 2004, further refinements were made to the scheme and by the second half of the year the programme was made available to other aquaculture products which have achieved certification under one of the EN45011 certification schemes.

The schemes in place during 2004 for aquaculture products were Irish Quality Salmon, including an extension of scope to incorporate cold smoked salmon; Irish Quality Mussels; and Irish Quality Trout. Each of these standards has a number of specific key aspects which applicants must comply with to achieve certification under the schemes.

Box 11. Quality Seafood Programme

What is the Quality Seafood Programme?
BIM has devised a number of quality assurance schemes for Irish aquaculture products; Irish Quality Salmon (IQS), Irish Quality Mussels (IQM) and Irish Quality Trout (IQT) (see main text for further details of the schemes). The Quality Seafood Programme is the umbrella-marketing programme for these base schemes.

How does a consumer or trader recognise the Quality Seafood products?
Aquaculture products approved under the Quality Seafood programme will carry a distinctive symbol, which assures the buyer that products carrying this symbol have either been caught, or raised on farms with excellent standards of safety, hygiene and quality throughout the supply chain.

This symbol has been adapted accordingly for European, UK and US markets. In order to comply fully with EU labelling regulations, companies licensed to use the symbol will add the country of origin at the base of the symbol. The origin denotes the origin of the product, not the location of the country.

What are the benefits of the Quality Seafood Programme?
Placement of the QS symbol on a seafood product is an assurance that the product has been caught/reared, harvested, packed and processed under a strict quality assurance scheme. It is also an assurance that there is traceability of the product to retail store. For those retail stores stocking QS products, ensuring that only the best quality, fully traceable seafood products are offered for sale in their outlet enhances their reputation.

In order to place the QS symbol on a seafood product, all seafood within that product and the process through which it has been produced must be certified under a quality assurance scheme, independently audited by an EN45011 accredited body.

Irish Quality Salmon

This scheme is composed of four standards; freshwater rearing, saltwater rearing, packing and processing and cold smoking. In the two rearing standards the key technical aspects are very similar in respect of the need to ensure that programmes of environmental management and monitoring are adhered to and also that rearing practices comply with best industry practice and show conformance with health management; hygiene and disinfection procedures; stock sourcing; handling; and feeding practices. Applicants for certification under the saltwater standard also have to demonstrate adherence to the standards for pre-harvest checks for residues, quality parameters and grading and also show rigorous controls at harvest.

Once the fish have left the water, applicants wishing to have certification under the IQS scheme must conform to the standard covering the packing and processing of fresh salmon. The key aspects of this standard revolve around the implementation of their food safety management plan and compliance with HACCP. However, in addition to these pre-requisites, as all the standards are based on superior product quality, a strong focus of this standard is placed on the product management and criteria.

The most recent standard that has been developed and made available to the industry is a cold smoked salmon standard. This standard is moving the certification of Irish Quality Salmon further down the value-added chain, providing assurance of the highest quality of smoked salmon. The key areas covered by the certification under this standard are product preparation and presentation as well as high levels of microbiological testing.

Further details on the Irish Quality Salmon scheme and a current membership list can be found at: http://www.irishqualityfish.com/salmon/index.asp.

Irish Quality Trout

The scope of the trout scheme includes two rearing standards; one for freshwater rainbow trout production and the other for seawater production. A third standard covers the packing and processing of both forms of the trout. The standards for Irish Quality Trout are very similar to those for salmon and have the same key aspects in terms of rearing practices and good management. There is one major difference with the trout standards and that is the inclusion of sensory analysis. For applicants to achieve certification they must demonstrate that the product has been tested to ensure that it is free from taints and odours and also to ensure that the trout has a clean fresh taste without any earthy taints.

Further details on the Irish Quality Trout scheme and a current membership list can be found at: http://www.irishqualityfish.com/trout/index.asp.

Irish Quality Mussel

The scope of the Irish Quality Mussel scheme incorporates a farming and harvesting standard and a processing standard, and covers both rope and bottom grown mussels

The first point of audit under the Irish Quality Mussel Scheme is on the harvester with the key aspects under this standard being product specification where a range of parameters has to be checked as part of the product control. In addition to the product controls, in order for an applicant to receive certification they will have to also demonstrate conformance to protocols dealing with hygiene management, process control, harvesting operating standards and environmental management. Under the harvesting standard of the scheme, prior to product being released into the market place they have to show compliance with testing regimes for both biotoxins and microbes.

Whilst a large portion of mussels grown on the seabed are sold as fresh product, the majority of the rope grown mussels are processed in Ireland. Therefore, to continue the product certification system as far down the value chain as possible a processing standard is also available to the processing industry. Under this processing standard a fully certified member of the scheme will have demonstrated that they are in compliance with the products specification laid down in the standard, plus they will have shown that the systems relating to hygiene management, HACCP, process control, environmental management and product release are of a world class standard; confirmed by third party auditing.

Further details on the Irish Quality Mussel scheme and a current membership list can be found at: http://www.irishqualityfish.com/mussel/index.asp.

In addition to the various standards within the individual schemes, there is one important overriding principle - the requirement for full traceability of all products. Certified members of all of the schemes must define the scope of a traceability system, document this system and also show periodic review of the system. There is also the need to demonstrate that systems and procedures are in place to allow the complete tracking and tracing of product through the supply chain as required by EU legislation[7].

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[7] Regulation (EC) No 178/2002 of the European Parliament and of the Council of 28 January 2002 laying down the general principles and requirements of food law, establishing the European Food Safety Authority and laying down procedures in matters of food safety

9. LOCAL AQUACULTURE MANAGEMENT SYSTEMS

CLAMS Activity 2004

The Co-ordinated Local Aquaculture Management Systems (CLAMS) process is a nationwide initiative to manage the development of aquaculture in bays and inshore waters at a local level. It allows for the integration of aquaculture into the coastal zone, whilst recognising the need to improve environmental compliance, product quality and consumer confidence.

The process has been adopted, and CLAMS plans have been published, for nine bays around the coast:

- Bannow Bay
- Castlemaine Harbour
- Clew Bay
- The North Shannon Estuary
- Kilkieran Bay
- Roaringwater Bay
- Lough Swilly
- Killary Harbour
- Dungarvan Harbour

CLAMS groups were established in Ardgroom Harbour, Co. Cork and in the South Shannon Estuary during 2003.

There were no new CLAMS plans launched in 2004, although a draft plan for Carlingford Lough was compiled. However, during the year existing CLAMS groups around the coast carried out a considerable amount of highly productive work, demonstrating how a co-operative proactive approach can benefit all concerned. The following review gives some examples of the types of projects that are currently being run by six of the CLAMS groups around the coastline. All of the projects outlined involve long-term commitment by all agencies concerned as well as the operators. Based on the success of such projects, the CLAMS process can be considered a dynamic process in the areas it has been introduced into and will certainly be expanded into other bays around Ireland over the coming years.

Lough Swilly

As a result of the appointment of a new liaison officer, the Lough Swilly CLAMS group regained momentum in 2004 and began to deal with a number of issues (e.g. the issue of pier facilities). The constituent group members began working during the year on the implementation of the ECOPACT[8] concept to all the operations in the group. Colleagues in the Aquaculture Initiative delivered this implementation. With one large salmon farm operator in the Lough already certified under the ECOPACT scheme, this commitment by the rest of the growers in Lough Swilly is a positive step towards implementing best environmental practice by all operators.

Clew Bay

The development of a Code of Practice for the members of the group was one of the key points in the work programme described in the Clew Bay CLAMS document. In 2004, the two CLAMS liaison officers undertook the first round of audits against this document. The result of these audits is a programme of work for the individual growers to ensure that they are aiming towards meeting the Code of Practice. These audits will be carried out on an annual basis. In conjunction with the Code of Practice, two members of the CLAMS group were involved in the piloting of the ECOPACT programme and received certification under the scheme. The ECOPACT implementation will be rolled out to all the growers in the bay, and when combined with the Code of Practice will mean that the aquaculture producers of Clew Bay will be aiming towards achieving best working practices for their businesses.

In addition to this best practice work being carried out, 2004 also saw work commencing on the development of a navigation plan, which will meet the needs of all the marine resource users. During 2004, surveys were carried out for all new site markers and from this maps were produced of all the

[8] ECOPACT is an initiative developed by BIM to ensure the widespread introduction of environmental management systems in the Irish aquaculture industry. See http://www.bim.ie/templates/text_content.asp?node_id=700

existing sites, marker poles and buoys. Contacts were then made with all the relevant parties in terms of finding a cost effective solution that meets all licensing and safety requirements. This process is ongoing.

Killary Harbour

Since its inception in 2000 the Killary CLAMS group has been working on a programme to investigate the issue of reduced harvest yields and to examine grow-out times on sites around the harbour. Up to 2004 the group had been collecting biometric and chlorophyll data. In 2004 a further four year work programme was started to investigate the huge variations in harvest yields and grow-out times both within the bay as a whole and within individual farms. The Marine Institute, working with the CLAMS group, deployed current meters in order to investigate current movements around certain farms.

Ardgroom Harbour

Reduced growth rates and longer grow-out times are not unique to Killary Harbour. The Ardgroom Harbour CLAMS group have also noticed a similar pattern emerging. In 2004, the group collectively agreed to reduce the number of longlines per hectare within the Harbour. The producers have all signed a contract stating that until the set density of each farm is reached no further restocking will take place in the bay. In a further attempt to deal with the reduced yields, a predator removal programme was carried out using prawn pots to catch starfish and thus reduce the numbers settling on the mussel longlines. Positive results were achieved.

Dungarvan Harbour

The Dungarvan Harbour CLAMS group started one of the most ambitious projects undertaken under the CLAMS banner in 2004. By the end of 2004 the growers in the group had removed 1,000 abandoned oyster trestles and had realigned a further 20,000 trestles. This represents about 50% of the trestle work that has to be carried out in Dungarvan Harbour and by the end of 2005 the CLAMS group plan to have all work completed.

Bannow Bay

In 2004 the data logger that was installed in Bannow Bay continued to provide information on the oxygen and pH levels in the bay during the times of year when, in the past, large scale mortalities have been experienced. This information has been made available to other agencies for consideration of the events that have occurred in Bannow Bay. Because of the regular availability of this information a number of third level institutions have approached the Bannow Bay CLAMS group to express an interest in including the sites in research project proposals.

Single Bay Management 2004

Single Bay Management (SBM) plans are in place in all finfish producing bays in the country. These plans – an initiative started in the early 1990s shortly after the introduction of the sea lice monitoring programme (see Box 6, Chapter 6) - advise on codes of best practice for the industry in terms of sea lice treatments, harvesting procedures and good husbandry. Production plans, which give a three-year projection of stocking regimes in each site, form the basis for targeting strategic sea lice treatments in each bay. SBM meetings are held annually in each region and are facilitated by Marine Institute staff. Site fallowing plans are updated at least once a year.

In October 2004, SBM meetings were held in each region with the main emphasis on strategic autumn/winter sea lice treatments. In preparation for the meetings the production/fallow plans were updated. The meetings were attended by representatives from the relevant finfish production companies, DCMNR officials and chaired by a Marine Institute representative. All farms agreed to a synchronous sea lice treatment over the winter of 2004/05.

10. EVENTS & CONFERENCES

Ireland played host to two major international aquaculture conferences during 2004.

International Conference on Molluscan Shellfish Safety (ICMSS)

In June 2004 over 280 international experts and delegates from around the world attended the 5th International Conference on Molluscan Shellfish Safety (ICMSS) to debate new developments in the science of shellfish safety. The conference included sessions on water quality and microbiological contamination, viruses in shellfish, Harmful Algal Bloom (HAB) events and biotoxin contamination, Quality Assurance and consumer safety, regulation and management, and industry requirements and challenges.

A key theme of the conference was the impact of HABS on consumer food safety due to the potential toxicity they can cause in filter feeding shellfish. Among the issues discussed were early warning systems for harmful algae, new methods of minimising the negative impact of HABS and replacing animal testing with more advanced chemical testing methods.

The proceedings of the ICMSS conference will be published in late 2005.

Farming the Deep Blue

A major international conference -"Farming the Deep Blue" - on offshore finfish aquaculture, organised by BIM, took place in October 2004. The conference explored the key issues relating to development of offshore aquaculture: species and technology choice, markets, finance and economics, risk management, policy and regulation. The current status, feasibility and potential profitability of offshore marine finfish farming were assessed by leading international practitioners and experts.

A specially commissioned report presented at the conference - *Farming the Deep Blue* (Ryan, 2004) - concluded that the global aquaculture sector will have to increase output from its 2001 level of 37 million tonnes to between 80 and 90 million tonnes by 2030 to satisfy increased demand for seafood that cannot be met by capture fisheries. Furthermore, the levels of increased production required can only be achieved by developing offshore finfish farming at a large scale. From an Irish perspective, production of finfish could be increased by 150,000 tonnes per annum. The value to Ireland of this opportunity could be as high as €500 million per annum and the creation of 4,500 additional jobs. Another key finding of the report is that there are major environmental benefits to be gained from a move offshore.

Delegates to the conference agreed that there is a major market opportunity to fulfil future food requirements and that this can only be fulfilled by the development of offshore fish farming. However, they accepted that the challenges presented by offshore finfish farming are too great to be met by any single country or company. Accordingly, an agreement was reached to form an international body, the International Council for Offshore Aquaculture Development (ICOAD), to serve as a focal point for the development of offshore aquaculture.

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Appendix I – IRISH AQUACULTURE PRODUCTION 1990-2004

Table AI.1. Irish Aquaculture Production (Volume - tonnes) 1990 - 2004

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
Shellfish															
Rope Mussel	3,380	4,700	5,091	4,773	3,707	5,500	7,000	6,694	7,790	6,467	4,045	7,580	7,699	9,313	8,755
Bottom Mussel	15,000	11,200	8,731	8,884	9,260	5,500	7,500	11,458	11,306	9,644	21,615	22,793	24,000	29,976	28,560
Gigas Oyster	361	1,278	1,750	2,014	1,862	2,539	4,000	3,135	5,369	6,555	5,031	4,909	5,444	4,830	5,103
Native Oyster	420	366	334	450	590	400	400	400	516	696	266	431	280	325	390
Clam	60	50	79	84	110	103	125	218	233	121	92	91	214	154	181
Scallop	-	-	-	-	-	-	-	24	25	33	61	49	67	80	103
Others	-	-	-	-	-	28	-	-	-	-	-	-	-	-	-
Total Shellfish	*19,221*	*17,594*	*15,985*	*16,205*	*15,529*	*14,070*	*19,025*	*21,929*	*25,239*	*23,516*	*31,110*	*35,853*	*37,704*	*44,678*	*43,091*
Finfish															
Salmon ova/smolt	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Salmon	6,323	9,300	9,696	12,366	11,616	11,811	14,025	15,422	14,860	18,076	17,681	23,312	21,423	16,347	14,067
Sea reared Trout	324	560	432	677	613	470	690	1,020	1,046	1,077	1,360	977	888	370	282
Freshwater Trout	705	845	965	906	854	1,003	1,160	1,161	1,155	1,098	1,053	730	915	1,081	889
Others	0	0	0	0	0	15	30	0	24	89	76	63	54	40	25
Total Finfish	*7,352*	*10,705*	*11,093*	*13,949*	*13,083*	*13,299*	*15,905*	*17,603*	*17,085*	*20,340*	*20,170*	*25,082*	*23,280*	*17,838*	*15,263*
Total Aquaculture	**26,573**	**28,299**	**27,078**	**30,154**	**28,612**	**27,369**	**34,930**	**39,532**	**42,324**	**43,856**	**51,280**	**60,935**	**60,984**	**62,516**	**58,354**

Table AI.2. Irish Aquaculture Production (Value - €'000) 1990 - 2004

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
Shellfish															
Rope Mussel	1,717	2,343	2,974	2,727	2,118	3,143	4,000	4,252	5,094	4,298	2,358	4,205	5,489	7,568	6,871
Bottom Mussel	2,286	1,715	1,816	1,850	2,703	1,864	2,542	4,431	5,028	4,115	10,562	12,691	16,896	21,653	21,014
Gigas Oyster	646	1,379	3,000	3,197	2,837	2,095	4,571	4,020	7,025	9,231	6,813	7,993	11,912	9,920	12,204
Native Oyster	2,108	1,859	994	1,524	1,847	1,412	1,524	1,270	1,971	2,913	1,027	2,060	1,157	1,324	1,636
Clam	305	180	251	245	321	131	516	705	827	424	361	589	1,421	795	711
Scallop	-	-	-	-	-	-	-	216	93	127	338	339	333	380	437
Others	-	-	-	-	-	61	-		104	531	53	65	684	142	727
Total Shellfish	*7,061*	*7,476*	*9,035*	*9,543*	*9,827*	*8,705*	*13,152*	*14,894*	*20,142*	*21,639*	*21,512*	*27,941*	*37,892*	*41,782*	*43,600*
Finfish															
Salmon ova/smolt	-	-	-	-	-	-	-	-	-	2,616	4,401	2,905	4,848	2,000	2,337
Salmon	26,736	38,413	38,609	49,618	47,493	46,790	47,333	47,638	51,412	55,463	62,772	70,869	77,731	54,198	51,289
Sea reared Trout	1,131	1,671	2,150	1,371	1,947	2,598	1,927	2,720	2,980	3,525	4,831	2,837	2,108	1,200	860
Freshwater Trout	2,286	2,360	2,576	2,576	2,331	1,401	2,856	2,929	3,320	3,106	2,734	1,997	2,557	2,318	2,116
Others	-	-	-	-	-	95	211	-	217	301	429	556	82	350	300
Total Finfish	*30,152*	*42,445*	*43,335*	*53,565*	*51,771*	*50,883*	*52,327*	*53,287*	*57,929*	*65,011*	*75,167*	*79,164*	*87,326*	*60,066*	*56,902*
Total Aquaculture	**37,213**	**49,921**	**52,370**	**63,109**	**61,598**	**59,589**	**65,479**	**68,181**	**78,071**	**86,649**	**96,679**	**107,106**	**125,218**	**101,848**	**98,127**

APPENDIX II – AQUACULTURE GRANT PAYMENTS

Table AII.1. Aquaculture grant payments under the NDP in 2004, by species and region.

Project type	FIFG Grant Paid South & East (€)	FIFG Grant Paid BMW (€)	FIFG Grant Paid TOTAL (€)
Oysters	238,412	261,219	499,630
Rope Mussels	231,398	-	231,398
Bottom Mussels	1,522,079	928,938	2,451,017
Clams	-	23,555	23,555
Salmon	21,934	8,272	30,206
Environment & Quality	140,667	251,954	392,621
Totals	*2,154,490*	*1,473,937*	*3,628,427*

Table AII.2. Aquaculture grant payments (R & D and Commercial) to Gaeltacht-based projects by Údarás na Gaeltachta/Taighde Mara in 2004.

	South & East Region		BMW Region		TOTAL	
	Payments (€)	No. Projects	Payments (€)	No. Projects	Payments (€)	No. Projects
Salmon	-	-	1,411,486	6	1,411,486	6
Turbot	-	-	66,790	2	66,790	2
Native Oysters	-	-	52,531	1	52,531	1
Gigas Oysters	-	-	40,459	4	40,459	4
Abalone	26,089	1	24,750	1	50,839	2
Cod	-	-	10,000	1	10,000	1
Clam Farming	-	-	7,900	1	7,900	1
Aquatic Plants	-	-	77,500	1	77,500	1
C.L.A.M.S.	10,000	1	-	-	10,000	1
Totals	*36,089*	*2*	*1,691,416*	*17*	*1,727,505*	*19*

Table AII.3. Pilot project grant payments (non EU co-funded) in 2004, by species and region

Project type	Payments South & East (€)	Payments BMW (€)	Payments TOTAL (€)
Oysters	124,760	30,005	154,765
Rope Mussels	104,549	100,987	205,536
Bottom Mussels	-	1,734	1,734
Clams	10,668	-	10,668
Salmon	181,308	156,421	337,729
Abalone	43,380	61,408	104,788
Seaweed	1,173	47,617	48,790
Arctic Char	-	5,420	5,420
Tropical Shrimp	-	7,465	7,465
Trout	-	8,893	8,893
Scallop	8,071	-	8,071
Perch	45,187		45,187
Lobster	24,072	-	24,072
Urchins	-	9,952	9,952
Other new species	1,570	-	1,570
Totals	*544,738*	*429,902*	*974,640*

Table AII.4. Aquaculture grant approvals under the NDP in 2004, by species and region. This excludes Una G (€2.54m for four projects)

Project type	Approved Eligible Cost TOTAL(€)	Approved FIFG Grant South & East (€)	Approved FIFG Grant BMW (€)	Approved FIFG Grant TOTAL (€)
Oysters	2,570,041	186527	712,991	899,518
Rope mussels	969,006	208070	131,084	339,154
Bottom mussels	18,430,363	3325952	2,683,811	6,009,763
Clams	283,745	-	99,310	99,310
Salmon	1,439,240	-	503,734	503,734
Totals	*23,692,395*	*3,720,549*	*4,130,930*	7,851,479

Table AII.5. Summary of non EU co-funded pilot project investment and grant approvals in 2004.

	South & East (€)	Investment BMW (€)	Total (€)	South & East (€)	Grant BMW (€)	Total (€)
Oysters	56,546	305,977	362,523	22,619	125,426	148,045
Rope mussels	553,119	368,696	921,815	229,057	159,344	388,401
Bottom mussels	6,730	85,955	92,685	2,692	38,680	41,372
Clams		18,366	18,366		7,347	7,347
Salmon	278,984	543,999	822,983	124,693	244,036	368,729
Abalone	119,800	186,988	306,788	53,910	84,145	138,055
Seaweed	128,525	3,917	132,442	39,553	1,763	41,316
Arctic char		52,350	52,350		23,558	23,558
Tropical shrimp	20,097		20,097	9,044		9,044
Trout	22,234		22,234	8,894		8,894
Scallop	21,243	84,198	105,441	9,559	37,889	47,448
Perch		192,850	192,850		86,783	86,783
Lobster		6,400	6,400		2,880	2,880
Urchins	6,695		6,695	3,013		3,013
Others		4,300	4,300		2,250	2,250
Totals	*1,213,973*	*1,853,996*	*3,067,969*	*503,034*	*814,101*	*1,317,135*

APPENDIX III – AQUACULTURE RESEARCH PROJECTS

NDP Marine RTDI Measure-funded post-doctoral fellowship and PhD scholarship projects ongoing during 2004:

Project Title	**Sea Lice Biology and Interactions**
Award Type	Post-doctoral Fellowship
Host Institute	Galway Mayo Institute of Technology
Description	Effective sea lice (*L. salmonis*) control is one of the major environmental problems facing the sustainable development of the Irish finfish aquaculture industry. As sea lice are endemic in both wild and farmed salmonids, eradication is not a realistic option and sea lice control using physical and chemical means is an on-going management issue for salmon farmers in Ireland. Gaps in our knowledge concerning lice biology and behaviour, particularly the infective larvae, represent an obstacle to more efficient control. Research on this topic and the development of expertise in sea lice biology and behaviour is seen as a key to the development of more effective management strategies for sea lice controls nationally. This Post-doctoral fellowship will contribute to this activity and in particular will: 1) compile and review results of all available work on sea lice biology and larval development as it applies to the problem of control; 2) support original research on larval biology and development of sea lice with particular reference to host selection and location mechanisms of commercially relevant species in Ireland; 3) contribute to the development of enhanced management and control strategies for sea lice on cultivated salmonids based on a deeper understanding of lice biology and behaviour; and 4) transfer any commercially applicable results from this research to industry.

Project Title	**Investigations into the hatchery rearing of Cod (*Gadus morhua*) in Irish conditions**
Award Type	Post-doctoral Fellowship
Host Institute	National University of Ireland, Galway
Description	The Irish finfish aquaculture industry is currently vulnerable due to its heavy dependence on salmonids such as salmon and trout. In this context, both the aquaculture industry and government recognise the need for diversification into new species. The specific objective of this fellowship is to identify and harness potentially exploitable research and technology so as to enable the establishment of a commercially viable cod hatchery in Ireland. The deliverable is a detailed methodology, developed in collaboration with industry, for the hatchery production of juvenile cod in commercial conditions. This methodology will include a review of previous work and identification of, and practical solutions for, constraints encountered in the production chain.

Project Title	**Investigations into a reliable supply of scallop (*Pecten maximus*) for the inshore fishery and aquaculture industries**
Award Type	Post-doctoral Fellowship
Host Institute	University College Cork
Description	There is general agreement that scallop farming and ranching, cannot progress in Ireland without an adequate, reliable seed source. As an alternative to natural spatfall, hatchery-produced spat offer a reliable source for the industry. However technological and research expertise are required to overcome certain obstacles and increase the cost-effectiveness of production. The deliverable of this project will be a detailed methodology, developed in collaboration with industry and other relevant agencies, for the production, transport and on-growing of scallop spat in commercial quantities for restocking and aquaculture ventures. This methodology will include a review of previous work, identification of and practical solutions for, constraints encountered in the production chain.

Project Title	**Health and disease in clams (*Ruditapes philippinarum*) in Ireland, with particular reference to brown ring disease.**
Award Type	PhD Scholarship
Host Institute	University College Cork
Description	This project aims to investigate the survival/mortality of clams in existing and previously fallowed sites and the causes of mortalities, including environmental conditions and Brown Ring Disease (BRD) - a disease, so called because of brown colouration on the inside of the shell, that is believed to have caused clam mortalities in the late 1990s. Management practices to minimise mortalities will be investigated, in consultation with the shellfish industry.

Project Title	**Modelling of *Alexandrium* blooms in Cork Harbour.**
Award Type	PhD Scholarship
Host Institute	National University of Ireland, Galway
Description	The factors (e.g. temperature, light, nutrients) controlling the growth and development of blooms of *Alexandrium tamarense*, a dinoflagellate that produces toxins that can accumulate in bivalve shellfish and can cause Paralytic Shellfish Poisoning (PSP) in consumers of contaminated shellfish, are not well understood and predictive models are not available. The aims of this study are to: • determine the environmental factors that govern the growth of *A. tamarense* in Cork Harbour; • determine the environmental factors that govern the excystment/encystment of *A. tamarense* in Cork Harbour; and ultimately to • develop a model of *A. tamarense* growth and bloom dynamics in Cork Harbour.

APPENDIX IV – ROLE OF STATE AGENCIES

State Agency Roles in the Aquaculture Industry

Department of Communications, Marine and Natural Resources

www.dcmnr.gov.ie/Marine/

Aquaculture Policy Division

The Aquaculture Policy Section of the Department is responsible for the strategic, economic and sustainable development of the aquaculture sector, as well as the broad regulation of it, within the framework of the Common Fisheries Policy and the Fisheries (Amendment) Act, 1997.

The Department's overall goal for aquaculture is to support the sustainable development of the sector in order to maximise its contribution to jobs and growth in coastal communities and to the national economy. The key objectives underpinning this goal include:

- increasing employment, output value and exports;
- creating a sustainable and environmentally appropriate framework and critical mass for sectoral expansion; and
- securing increased competitiveness through enhanced quality, value added, technology acquisition and diversification.

The Aquaculture Policy section aims to identify and facilitate measures to securing these objectives. Key areas of involvement for the section include policy formulation, targeted investment support for aquaculture under the National Development Plan 2000 - 2006, the establishment of a national fish health policy framework and the pursuit of measures and action at EU and national level beneficial to the sector.

Coastal Zone Management Division

The Coastal Zone Division ensures that Ireland's coastal zone is used in a sustainable way to the best advantage of the Irish people from an economic, aquaculture, leisure, social and environmental perspective. As part of this wider remit the division is responsible for the licensing, monitoring and enforcement of aquaculture activities.

Údarás na Gaeltachta and Taighde Mara

www.udaras.ie **www.taighde.ie**

As a regional development agency, Údarás na Gaeltachta and its subsidiary Taighde Mara, bring an integrated approach to the development of aquaculture. The continuum of novel species, new techniques and business entities, from the research phase, through innovation and pilot scale trials to commercialisation is supported, as is the integration of the individual aquaculture enterprise into both the wider industry and the locale.

Both Taighde Mara and Údarás na Gaeltachta have offices and staff in each Gaeltacht region and between them can provide advice, technical support and financial support to new entrants and to expanding or diversifying aquaculturists. A broad range of support is available depending on the client's needs. Financial support may include investment by means of preference or redeemable shares as well as grant aid for capital, training and research and development. Technical support is equally broad and can include technology transfer, provision of technical staff while developing human resources within an enterprise as well as administration, IT, and business skill support. An overview of the industry's needs is maintained so that strategic planning and initiatives can be taken.

Bord Iascaigh Mhara (BIM)

www.bim.ie

BIM's mission is '*to promote the sustainable development of the Irish seafood industry at sea and ashore and support its diversification in the coastal regions so as to enhance the contribution of the sector to employment, income and welfare both regionally and nationally*'. BIM's role in aquaculture development is three tiered, with support being given by the Aquaculture Development Division, the Market Development Division and the Marine Services Division.

The *Aquaculture Development Division* is charged with promoting the sustainable development of the Irish aquaculture industry in terms of volume and value of output. It has three sections. The Technical Section provides a specialist technical support service to the aquaculture industry. The Project Development Section evaluates and prioritises investment proposals for grant assistance and assesses payment claims for draw-down of approved grants. The Environment and Quality Section promotes quality and environmental best practice in the aquaculture industry by providing specialist advice and guidelines and developing codes of practice and quality assurance schemes for the sectors.

The role of the *Market Development Division* is to promote Irish seafood at home and abroad and provide a range of market supports to assist clients capitalise on market opportunities. The Division provides a range of services to the sector. The Market Research and Intelligence Section provides market intelligence and targeted market research on products. BIM Overseas Officers located in Paris, Madrid and Dusseldorf provide support in business development including facilitating buyer and customer contact, providing market information and undertaking promotional activities. The Product Quality and Process Development Section provide a technical advisory service to clients through the Seafood Development Centre including the Laboratory facility. The Trade and Market Development Section operates two support programmes which help develop marketing expertise and skills in seafood companies and support market development efforts namely the Irish Seafood Business Programme and the Market Investment Programme. The Consumer Support Section focuses on encouraging consumer demand for Irish seafood. It manages a number of promotional initiatives at retail and food service level including consumer educational programmes to enhance the status of Irish seafood products.

The *Marine Services Division* is charged with developing the industry's human resources through the provision of training and educational programmes and to raise the quality of fish supplies through increased use of ice and improved fish handling practices. Training for the seafood industry is provided through a coastal service that includes the National Fisheries College, the Regional Fisheries Centre, and two mobile coastal training units. Courses for the aquaculture sector have been developed in consultation with industry and are accredited by statutory bodies. The Engineering Services Section manages BIM's ice plant network which provides a supply of ice to fish farms and fish processors to help ensure that fish and shellfish are maintained in top quality from time of harvest to market.

Marine Institute

www.marine.ie

The Marine Institute is Ireland's national marine R&D agency with the following general functions:

"to undertake, to co-ordinate, to promote and to assist in marine research and development and to provide such services related to marine research and development, that in the opinion of the Institute will promote economic development and create employment and protect the environment." - Marine Institute Act, 1991.

The Marine Institute is an agency of the Department of Communications Marine and Natural Resources. It was established under statute in 1992. In 2004, the Institute had a staff of 150 people, located in Galway, Newport, Dublin and in ports around the country.

The Marine Institute carries out a number of specific roles in relation to Aquaculture:

1 – **Monitoring and advice** . MI provides a range of key scientific services and advice to marine businesses and other State agencies that safeguard the quality of aquaculture products and the marine environment. These include statutory monitoring programmes in fish health, sealice, benthos, residues in finfish, shellfish toxins and shellfish microbiology. MI personnel provide statutory advice to the Department of Communications, Marine and Natural Resources in relation to the granting of aquaculture licences. They also provide key inputs to the Molluscan Shellfish Safety Commmitee and FSAI. MI provides data and advice to the Management Cell which ensures a risk management approach to shellfish safety and participates in the Aquaculture Forum and a number of working groups with industry.

2 – **Research.** The Institute carries out research and supports RTDI (research, technology, development and innovation) activity in the Aquaculture sector projects under the Marine Research Measure of the National Development Plan. These research projects in the areas of cod, mussels, scallops, sealice and shellfish toxins are designed to support employment, provide for sound management decisions to guide the on-going sustainable development of the resource and thereby to underpin future innovation, growth and wealth creation in aquaculture.

MI collaborates with BIM and Taighde Mara in many areas of aquaculture including the planning of research programmes, quality schemes and the work of the Co-ordinated Local Aquaculture Management Systems (CLAMS) processes in selected bays nationwide.

Loughs Agency

www.loughs-agency.com

The Loughs Agency is an agency of the Foyle, Carlingford and Irish Lights Commission (FCILC), established under the 1998 Agreement between the Government of the United Kingdom and the Irish Government. The FCILC is legislated for by the North/South Co operation (Implementation Bodies) (Northern Ireland) Order 1999 and the British-Irish Agreement Acts 1999 and 2002. The FCILC's sponsoring Departments are the Department of Agriculture and Rural Development in the North and the Department of Communications, Marine and Natural Resources in the South.

The functions of the Loughs Agency are as follows:

- The promotion of development of Lough Foyle and Carlingford Lough for commercial and recreational purposes in respect of marine, fishery and aquaculture matters;
- The management, conservation, protection, improvement and development of the inland fisheries of the Foyle and Carlingford Areas;
- The development and licensing of aquaculture; and
- The development of marine tourism.