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REVIEW OF THE IRISH AQUACULTURE SECTOR

AND

RECOMMENDATIONS FOR ITS DEVELOPMENT

Robert O'Connor
Brendan J. Whelan
James A. Crutchfield
with
A. J. O'Sullivan

THE ECONOMIC & SOCIAL RESEARCH INSTITUTE

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GLOSSARY

Abbreviations

AVG – Aquatic Veterinary Group in University College Galway
BATNEEC – Best Available Technology Not Entailing Excessive Costs
BC – British Columbia Canada
BIM – Bord Iascaigh Mhara, The Irish Sea Fisheries Board
BOD – Biochemical Oxygen Demand
DDS – Disease Diagnostic Service, University College Galway
DED – District Electoral Division
DOM – Department of the Marine
DSP – Diarrhoetic Shellfish Poisoning
EIA – Environmental Impact Assessment
EIS – Environmental Impact Statement
EPA – Environmental Protection Agency
ERD – Enteric Redmouth Disease
ESF – European Social Fund
FCR – Feed Conversion Ratio
FAO – Food and Agricultural Organisation of the United Nations
HIDB – Highlands and Islands Development Board, Scotland
ICH – White Spot Disease
IDA – Industrial Development Authority, Ireland
IFREMER – French Marine Resources Research Organisation
IPN – Infectious Pancreatic Necrosis
ISA – Irish Shellfish Association
ISGA – Irish Salmon Growers' Association
ISPG – Irish Salmon Producers' Group (Marketing Organisation)
LA – Local Authority
MAFF – Ministry of Agriculture, Fisheries and Food, UK
NCEA – National Council for Education Awards
NDC – National Development Corporation
NOK – Norwegian Kroner
OECD – Organisation for Economic Co-operation and Development
PD – Pancreas Disease
PSP – Paralytic Shellfish Poisoning
RD – Rural District
RTC – Regional Technical College
SDS – Sudden Death Syndrome
SFADCO – Shannon Free Airport Development Corporation
SRL – Shellfish Research Laboratory, Carna, Co. Galway
STAG – Sea Trout Action Group

TBT	–	Triboutyltin - an anti-fouling agent, now banned
VHS	–	Viral Haemorrhagic Septicaemia

Terms

Anoxic	–	Oxygen deficient
Crustaceans	–	Shellfish such as crabs, lobsters, shrimps
Molluscs	–	Shellfish such as cockles, mussels, oysters, clams, scallops, etc.
EPI fauna	–	Other animals
Salmonids	–	All salmon and trout species of fish
Benthos	–	Flora and fauna found on the ocean bed
Plankton	–	Microscopic forms of organic life found at various depths in the sea, lakes, rivers, ponds, etc., Used as food for marine animals
Triploid Fish	–	Fish which do not breed
Fallowing	–	Leaving fish cages empty for a period
Algal Blooms	–	Poisonous blooms which grow in the sea and kill fish, e.g., Red Tide
Eutrophication	–	over-enrichment of the water column by organic material
Phyto-plankton	–	Microscopic plant organisms as distinct from microscopic animal organisms

GENERAL SUMMARY

Overview

Aquaculture (fish farming), as defined by the FAO, implies some form of human intervention into the rearing process of aquatic organisms to enhance production. This industry produces 14.5 per cent of the world's seafood supply, and forecasts predict this proportion will continue rising. At present, 85 per cent of world aquaculture production is concentrated in Asia.

Fish farming in Ireland is still in an early phase of development. Salmon, trout and shellfish production are the dominant sectors. Udaras na Gaeltachta has successfully developed the industry in the Gaeltacht regions. Bord Iascaigh Mhara (BIM) is responsible for development in the rest of the country. BIM is also the national medium for technical and technological transfer in aquaculture and for marketing.

The main sources of financial aid for the Industry are Udaras na Gaeltachta, BIM and the EC. The EC provides grants for the development of aquaculture projects of up to 40 per cent of capital costs provided there is a matching contribution from the state of at least 10 per cent.

Licence Requirements

Up until 1959, only oyster production was covered by Irish legislation. Under the Fisheries (Consolidation) Act 1959, legislation on shellfish farming was extended to cover mussels, cockles and periwinkles. In the granting of shellfish licences under this Act, the applications had to progress through a number of stages, including the holding of a public inquiry.

Provision was also made in Section 15 of the 1959 Act for the licensing of finfish culture. It was thought at the time that such culture would be on inland sites only, and the legislation was framed accordingly. The Minister was given wide powers under Section 15 to grant fish culture licences subject to such conditions as he thought fit. There was no provision for public hearings.

Methods of providing more public participation in the granting of finfish licences were incorporated in Section 54 of the Fisheries Act of 1980. In this section, provision was made for designating areas of the sea as being suitable for aquaculture. In the designation process, applications had to progress through a number of stages which could include public inquiries. Within the designated areas, licences to engage in aquaculture could be granted. It was hoped that this procedure would hasten the licensing process. One public hearing would cover a whole area and once the area was designated, individual licences could be granted within it without fuss.

Unfortunately things did not turn out as planned. Great difficulty arose in getting public approval for designation decisions. As a result, some applications had to be withdrawn and one order for Smerick Harbour in Kerry was overturned by the High Court. Because of the opposition mounted against the designation process, Ministers reverted to granting licences both for finfish and shellfish under Section 15 of the 1959 Act which was not repealed by the 1980 Act. However, this procedure has now been questioned by a High Court action and if the verdict goes against the Minister, the whole licensing procedure will have to be changed. In any case, it is believed that regardless of the outcome of this case, new licensing legislation will have to be introduced. The present system is almost unworkable.

The Salmon and Trout Farming Industries

Atlantic and Pacific are the two main groups of salmon in the world. Landings of wild Atlantic salmon are about 12,000 tonnes per annum, while those of Pacific salmon oscillate around 700,000 tonnes per annum. Up until recently, therefore, Atlantic salmon commanded a higher price than Pacific because of its scarcity. Chinook and Coho are two relatively rare species of Pacific salmon, which command similar prices to Atlantic. These three species all compete for the same markets.

Under an artificial rearing system, salmon are grown in fresh water hatcheries, and are then transferred after about two years to sea pens or cages. They are fed in the cages and sold off one or two years later, weighing from $1^1/_2$ to 5 kgs. Modern sea cages can withstand exposed sea conditions, hence development is no longer constrained to sheltered sites only. However, these offshore sites are more expensive to service, and security is more difficult.

Norway has the largest production of farmed Atlantic salmon, rearing 165,000 tonnes of the world supply of 244,000 tonnes in 1990. Scotland is next with 34,600 tonnes. Ireland's production in 1990 was 6,300 tonnes and 9,000 tonnes in 1991. Projections for 1995 show that Norwegian production will increase to 168,000 tonnes, while that for Scotland is expected to rise substantially to 47,000 tonnes. Irish production was expected to reach 15,000 tonnes by 1995 but more recent findings indicate that this projection may be somewhat optimistic. Pacific salmon farming has increased substantially in recent years also, from 2,000 tonnes in 1981 to 49,000 tonnes in 1990. Japan and Canada are the largest producers, with 20,000 and 12,000 tonnes respectively in 1990. Forecasts indicate that production of all farmed salmon (Atlantic and Pacific) will reach 375,000 tonnes in 1995. Such large increases in supply will cause severe marketing difficulties.

Trout may be produced in inland lakes or in the sea. The sea trout are farmed in the same way as salmon. Most of the production, however, takes place in fresh water. Trout production was widespread before salmon farming was established but its rate of expansion over the 1980s has been much slower than that of salmon. France (34,000 tonnes), Italy (29,600 tonnes) and Denmark (26,000 tonnes) are Europe's largest producers. Irish production is only about 1,000 tonnes. Growth rates for the industry are expected to rise in the future. Even though prices are lower, high disease levels in salmon farming will cause producers to switch production to trout.

The Salmon Market

Although the market for fresh and frozen salmon is now world wide, consumption is heavily concentrated in three areas, the European Community, North America and Japan. The European market shows a strong preference for fresh or chilled salmon, mostly farmed or wild Atlantics and for smoked salmon which is prepared from fresh Atlantics (farmed and wild) and from wild Pacific salmon. The European market also takes small quantities of frozen Pacific salmon from US and Canadian sources.

The US market is still dominated by wild Pacific salmon, though increasing amounts of farmed Atlantics are now being marketed in fresh or frozen form. In Japan, the main consumption is wild Pacific salmon; farmed salmon are a small but increasing part of the total supply.

Because of increased supplies, Atlantic salmon consumption has increased dramatically over the past decade. The greatest increase has occurred in France where per capita consumption went from 0.04 kg in 1980 to 0.83 kg in 1990. There have been substantial increases also in UK, Belgium/Luxembourg and Italy with smaller increases in Spain, Germany, Sweden and Ireland.

The overall demand for Atlantic salmon is forecast to rise from 170,000 tonnes in 1989 to 266,000 tonnes in 1992 and to 372,000 tonnes in 1995. Over this period it is expected that fresh/frozen consumption will increase by 80 per cent, smoked by 86 per cent and other products by 250 per cent.

Because of increased supplies, producer prices in current terms for Atlantic salmon declined by over 20 per cent between 1980 and 1989 but in real terms (prices deflated by consumer price index) the decline was 50 per cent. This decline has had a serious effect on the incomes of salmon farmers everywhere. Norway is blamed for overproduction and the EC has now introduced a regulation making Atlantic salmon imports to the EC subject to a minimum price. This price, however, is so low that it offers no protection to EC producers and Irish and Scottish farmers are lobbying for a more realistic price. Unless this is obtained, many producers will go bankrupt.

Landill Mills Associates, who have made a study of the salmon market for BIM say that over the coming years a relatively new high quality product such as salmon would be expected to create increased demand without price movement. If this happens, as is likely, demand can be expected to outstrip supply by 1992 and lead to prices rising again for some years, such as happened after a supply shortfall in 1987. On the basis of the 1987 experience, a supply shortfall projected for 1992 to 1995 should lead to an improvement in real prices of 2-5 per cent per annum in these years. Thereafter, prices are expected to decline in line with anticipated production costs. At this point prices are expected to be linked closely to cost of production plus a steady margin of 10-15 per cent. This is the type of price relationship which obtains in the mature broiler chicken industry.

Shellfish Farming

Shellfish culture contributes in a major way to economic development and employment in many of the remote areas around the coast. There are a total of 148 shellfish enterprises in the state employing about 1,000 people on a whole-time or part-time basis. The value of annual sales of farmed shellfish is about IR£5.6 million.

The principal farmed shellfish in Ireland are mussels and oysters, though in recent years clams, scallops and abalone are becoming important. Experiments are also being conducted on lobster ranching.

Mussels are grown by two general systems: (1) culture on the bottom; and (2) suspended culture. Bottom culture consists of dredging seed mussels, usually from offshore beds, and transferring the seed to shallow areas within the harbour where they grow to maturity. About 15,000 tonnes of bottom mussels were produced in 1990, valued at IR£1.8 million. In suspended culture the seed mussels are collected in settling areas and grown to market size in other areas suspended on long lines or from rafts. Some 3,400 tonnes of these mussels were produced in 1990, valued at IR£1.4 million. Suspended mussels are more costly to produce than bottom mussels but they contain more meat than the latter and thus fetch higher prices. There are good markets for all mussels at the present time.

Two species of oyster are grown in Ireland, the native flat oyster and the cupped Pacific oyster. The native oyster is a choice market item both in Ireland and on the Continent. Prices are high, mainly because of limited supplies. Production has been reduced in recent years due to high disease mortality. Bonamia disease has decimated stocks all over Europe and has already appeared in some areas in Ireland. Once it gets into a fishery it is impossible to eliminate. Production of flat oysters in Ireland in 1990 were 420 tonnes, valued at IR£1.7 million.

The Pacific oyster is much easier to grow under controlled conditions than the flat oyster and as yet is not subject to any major disease. Because of large supplies on the Continent, market conditions are difficult and require considerable effort. Irish production in 1990 was 360 tonnes, valued at IR£500,000.

Production of other shellfish species in Ireland is as yet rather small. Scallops and clams are the main species being tried out. These are currently making good prices in Europe. Some 15 clam projects were harvested for the 1990 market when output was about 70 tonnes, valued at IR£280,000. This output is expected to increase substantially over the coming years. Scallop and abalone production and lobster ranching are still in the experimental stage.

Survey of the Irish Aquaculture Industry

In a survey of all the fish farms in the state, carried out by the ESRI in 1991, it was found that the total value of all sales less purchases of mature fish in 1990 was IR£29.5 million. Salmon contributed IR£20.9 million, trout IR£1.8 million, shellfish IR£5.6 million and independent hatcheries IR£1.2 million. The value of structures, including cages, rafts, nets, boats, vehicles and buildings was estimated at IR£46.2 million. Of this, IR£36 million was on salmon and trout farms and IR£10.2 million on shellfish farms.

When the value of stock changes was added to sales, the total output of the aquaculture industry was IR£37.3 million. Deducting non-labour costs of IR£29.0 million from this gives a gross value added for the industry of IR£8.3 million. When paid labour of IR£8.7 million was taken from this, gross income was –IR£434,000. Depreciation was estimated at IR£5.7 million, so that trading and self-employment income from the industry in that year was –IR£6.1 million. Because of very low prices in 1990 and high mortality on some farms, the gross income from salmon farming was –IR£4.6 million. Trout farms, on the other hand, gave a gross income of IR£0.6 million while that from shellfish farms and hatcheries was IR£3.5 million.

Total employment in the industry in 1990 was 1,801 people, of which 772 were full-time and 1,029 were part-time workers. About 800 of these workers were in finfish farming and the remainder in shellfish operations. Total numbers employed represent about 1,000 person years. Using an input/output table, it was estimated that these 1,000 person years would generate a total of 2,260 person years in direct, indirect and induced employment.

Problems Encountered by Fish Farmers

Seventeen finfish farmers out of 25 interviewed and 85 shellfish farmers out of 123 interviewed had difficulties of one kind or another in obtaining licences. Because they did not have full licences, 23 finfish farmers and 16 shellfish producers had difficulties in getting insurance and/or finance. Most finfish farmers considered that market support services were adequate but only about one-fifth of shellfish farmers were of this view.

In regard to chemical substances, finfish and shellfish farmers tended to have different views. Some 60 per cent of finfish farmers considered the chemicals used by them to be dangerous only if applied incorrectly. On the other hand, 63 per cent of shellfish farmers thought that aquaculture chemicals were very dangerous and must be applied and handled with great care.

In regard to policy changes, streamlining the licensing system was the top priority for all fish farmers. More funding and more emphasis on marketing was suggested as an action by 50 per cent of shellfish and by about 40 per cent of finfish farmers. Other actions mentioned by respondents were

Better environmental monitoring and protection.

Easier access to finance.

More/better research information and improvement of image and quality control.

Environmental Problems

During the 1980s, some adverse environmental effects of intensive aquaculture were given wide publicity in Ireland. Finfish farming in particular was singled out for special attention.

Concern was mainly expressed on the following points:

(1) Organic pollution of sheltered marine inlets and entrophication of lakes.

(2) The toxic effects of chemicals used to prevent diseases and pests in caged fish.

(3) The potential danger to wild stock fish populations as a result of inter-breeding with fish which have escaped from farms and the effect on wild sea trout of sea lice from the salmon cages.

(4) The visual impact of floating cages, long lines, rafts and shore structures in areas of high scenic value.

In regard to organic pollution, choice of suitable sites for fish farms with good water exchange can reduce or eliminate this problem. An Environmental Impact Survey must now be submitted with all licence applications for 100 tonnes of finfish or over. This must include an investigation of water movement and eventual degradation of solid wastes. It should go a long way towards solving the organic waste problems.

The putting of chemicals into water is fraught with danger. The chemical under most discussion is Nuvan which is used in the control of sea lice on salmon. It is dangerous to fish farm workers unless handled with care and also it can kill some shellfish in the vicinity of cages.

There is no scientific evidence of environmental damage from Nuvan but prudence dictates that only the minimum amount should be used and that it be handled, stored and applied with care. A number of alternatives to Nuvan are being investigated and some interesting possibilities have been suggested, including the use of small fish called wrasse which eat the lice off the salmon.

There is little information available as to how reared salmon affect natural stocks, but techniques should be developed for producing triploid fish (which do not breed), and may be cultivated safely without fear of damage to wild species. Research must also be continued to discover the cause or causes of the sea trout collapse in the West of Ireland, which in some quarters is blamed on infestation by sea lice from salmon cages. Though this thesis has not been proved, every effort should be made to reduce sea lice infestation in cages, especially during smolt migration. Consideration should be given to such strategies as fallowing and cage movement.

The visual impact of floating cages, rafts, long lines, etc., can be very intrusive. These should be taken account of in the granting of licences. The licensing authority must ensure that fish farms are not located close to recognised bathing beaches, busy pleasure boating areas, boat shelters or navigation channels.

Conclusions and Recommendations

The opportunities for economic development in western coastal regions are limited. The only industries which have potential in these areas are tourism, capture fisheries and aquaculture. Unfortunately, tourism in

Ireland is very seasonal and there are long periods when there are very few visitors. It needs to be supplemented by other activities.

The capture fishery industry along the west coast is a most important income earner, but in view of EC policies to conserve stocks, the scope for increased landings is limited. Consequently, increased income and employment in these remote regions must come from aquaculture. The EC has classed Ireland as a sensitive region in this regard entitled to preferential rates of grant aid.

The following recommendations for the aquaculture industry are deemed to be appropriate:

(1) The present licensing system is unworkable. A system which will facilitate orderly development must be devised.

(2) Marine and coastal resource management policy should be formulated and administered by a group or agency representative of the coastal interests and established under the aegis of the Department of the Marine.

(3) Environmental mediation fora should be used regularly to resolve disputes between fish farmers and opposing interests. Adversarial and legislative approaches in which one side "wins" or "loses" are counterproductive.

Finfish

(4) The Irish Salmon Growers' Association should continue to lobby for a realistic minimum import price for Atlantic salmon.

(5) The salmon Quality Assurance Scheme must continue to be properly policed if it is to have the desired impact on price.

(6) The special BIM training courses in grading, hygiene and quality control should be continued and upgraded from time to time.

(7) Acceptable substitutes for some of the chemicals used in finfish farming must be found.

(8) Experiments should be continued to discover alternative techniques for elimination of sea lice on salmon.

(9) Research must be continued to discover the cause or causes of the sea trout collapse. As a precautionary measure every effort should be made to reduce sea lice numbers in salmon cages especially during smolt migration. Consideration should be given to such strategies as fallowing (leaving cages empty for a year) and cage movement.

(10) Techniques should be developed for producing triploid fish which may be cultivated safely without fear of damage to wild species.

(11) To reduce disease levels in warm summers, Irish salmon farmers should experiment with the lowering of stocking rates in the cages.

(12) Experiments should be carried out with finfish species like brown trout, turbot, Arctic char, ornamental fish and eels to see if they can be farmed economically.
(13) Discussions should take place with industries having hot water discharges in regard to the rearing of fish.

Shellfish

(14) Consideration should be given to moving from subsidies on fixed capital to the subsidisation of working capital. This could take the form of interest subsidies or deferred interest payments during the first three years of the shellfish growing cycle.
(15) Additional finance to the sector could take the form of an employment scheme whereby heretofore unemployed people could continue to draw their unemployment payments for three years while becoming established in the shellfish sector.
(16) A quality scheme for shellfish similar to that used for salmon is a necessity.
(17) An adequate network of regionally based onshore and foreshore holding facilities for shellfish is needed where product can be collected, graded and packed for market.
(18) The provision of a central onshore, cold store sea water tank facility for shellfish on the European mainland should be investigated.
(19) More attention must be paid to arranging regular supplies, on time deliveries, good grading and packing of shellfish for the market.
(20) Movement permits for shellfish should be introduced immediately to protect clear oyster areas from Bonamia disease.
(21) Co-operatives should be established in coastal areas and rules adopted for the ranching of lobsters.
(22) Experiments on the on-growing of scallops in Ireland should be continued.
(23) The development agencies should ensure that there is a satisfactory advisory service available to the shellfish industry.
(24) It is critical that all future shellfish development should comply with the recent EC Health and Hygiene Regulations.

Introduction

This study was commissioned by Bord Iascaigh Mhara (BIM) and Udaras na Gaeltachta with the following terms of reference.

Objective

To assess the social and economic contributions of aquaculture both nationally and in the coastal regions and to make recommendations for its future development.

Main Elements

1. (a) Review of State and EC Policy for the Development of Aquaculture.
   (b) Review trends in total investment and associated State and EC grants for sections of the industry at national and regional levels.
2. Review industry structure, i.e., size, number and regional locations of farms by major category with international comparison where possible.
3. Review trends in output, income and employment in the sector and of the economic activity generated elsewhere in the economy.
4. Review existing literature concerning environmental impact of fish farming in Ireland and internationally.
5. Review opportunities and constraints for the future development of the finfish and shellfish sectors as regards
   - market demand and strategies
   - industry competitiveness
   - aquatic resource - site suitability and
   - production capacity
   - technology
   - disease
   - compatibility of aquaculture with other
   - sectors or users
   - environmental, legal and social aspects
   - institutional framework
   - other opportunities/constraints.
6. Recommendations for the future development of the industry and the implications for State and EC support.

Chapter 1

AQUACULTURE – AN OVERVIEW

Aquaculture is the farming of aquatic organisms including finfish, crustaceans, molluscs and edible aquatic plants. As defined by the FAO (OECD, 1989a) aquaculture implies some form of human intervention in the rearing process to enhance production, such as regular stocking, feeding, protection from predators, etc. Fish farming also implies individual or corporate ownership of the stock being cultivated, as distinct from wild stocks which are a common property resource.

This definition is somewhat vague and gives rise to statistical problems of classification. Some aquacultural projects require the management of the fish in very controlled conditions, in which case there is no difficulty in recognising then as aquaculture. In other cases, as with bottom culture of shellfish and sea ranching of salmon, the husbandry is much less intensive and the intervention is minimal. In these cases arbitrary classifications have to be made. This should be kept in mind in interpreting some of the international and Irish statistics.

Fish farming or fish culture is an activity with a very long history, and may be considered as complementary to the hunting of wild-stock fish and the gathering of naturally-occurring shellfish populations. For high-value species, aquaculture is now more viable than harvesting the natural or wild populations, and possesses the following economic, environmental and social advantages:

(i) the supply of farmed fish or shellfish is generally less dependent on the weather and on the seasons;

(ii) the availability of fish for harvesting can be controlled and predicted within reasonable limits; aquaculture therefore has the potential to provide a more reliable supply to the markets;

(iii) fish farming is generally less hazardous than wild-stock fishing, especially far offshore;

(iv) aquaculture, in the context of an appropriate conservation policy, can reduce the pressure for further exploitation of certain wild-stock species;

(v) for some countries, aquaculture has the advantage of being located within territorial waters or on the national territory, making the country less dependent on obtaining a share of internationally disputed wild stocks.

FAO in its current annual Review of Aquaculture Statistics (1990) estimates that fish farming is now supplying about 14.5 per cent of the world's seafood supply (14.5 million tonnes out of a total world supply of 100 million tonnes). On the basis of these figures, and trends over the past decade, Fish Farming International (August, 1990) says that "before the end of the century, aquatic farming should be providing at least 20 per cent of the global fish harvest".

On a world scale, production of farmed fish is highly concentrated in certain regions. Almost 85 per cent of world production is in Asia. Europe comes next with 7.6 per cent. North America has 2.9 per cent and USSR 2.5 per cent with 1.5 per cent in Central and South America. Within these areas China is by far the largest producer with 6.7 million tonnes in 1988. Japan comes next on the list with 1.4 million tonnes. Other countries with relatively large production are Norway, Korea, Indonesia, India, Taiwan, USA, Spain, and France.

Cultivated Species

Finfish – Over 7 million tonnes of finfish were farmed in 1989 out of a total world finfish production of about 80 million tonnes. Of the farmed finfish, 4.6 million tonnes were carp, the main producers of this species being China, USSR and Indonesia. Of the other finfish produced, the main species were milkfish, tilapia, yellowtail, rainbow trout, catfish and salmon. USA is the main world producer of catfish in inland waters.

In many countries finfish are produced as an essential protein supplement often as an adjunct to agricultural activity. This is the case for carp and tilapia which in some Asian countries are cultivated in rice paddies. Such systems depend to a high degree on nature itself and require little human intervention.

Contrasting with these are those systems which require a good deal of human intervention and capital investment notably for salmon, eel, trout and yellowtail. Human involvement in the process can vary considerably. Salmon, for example, can be raised in intensive culture spanning the egg to the on-growing stage, while at the other end of the scale salmon aquaculture may take the form of sea ranching which involves only hatchery, release into the sea and harvesting. The relatively low return of salmon to place of release in the case of sea ranching must be set against the cost of investment for production sites for on-growing, feed and labour (OECD, *op. cit.*, p. 8). In the Irish case, sea ranching is impossible. Because of the high level of drift netting in the Atlantic Ocean, those releasing the smolts into river estuaries would get very few mature fish returning. Hence, if sea ranching is to be introduced here drift netting must be prohibited.

Crustaceans – A world total of 612,000 tonnes of crustaceans was farmed in 1989 out of a total world supply (farmed and wild) of about 4 million tonnes. Almost 80 per cent of the farmed production was in Asia and practically all of the remainder in North and South America. Within this group the most prominent species are prawns, shrimp and crawfish. Shrimp which grows quickly in tropical and semi-tropical waters is in great demand at the present time in Japan, Asia and Europe. Its production has attracted many investors, especially in recent years since it has been possible to master the hatchery techniques on a widespread basis. Shrimp or other crustacean farming does not appear to be a profitable enterprise in the cooler waters of Europe. The growing period in these waters is too long.

Molluscs – Over 3 million tonnes of molluscs were farmed in 1989 out of a total world production, farmed and wild, of about 7.5 million tonnes. Of the farmed molluscs 33 per cent were mussels, 30 per cent cupped oysters, 10 per cent scallops and the remainder mainly clams and cockles. About 70 per cent of mollusc production takes place in Asia, 20 per cent in Europe and 4 per cent in North America. Most of the production depends on the collection of natural spat in the sea and its transfer to a protected sea area where on-growing takes place, either on the sea bottom or suspended on lines trestles or floating structures. The main problem involved in mollusc production is water quality. The water must be free from toxic pollutants and it must contain sufficient nutrients to support growth of plankton.

Seaweeds – Some 3.6 million tonnes of edible seaweeds were produced in 1989. This production occurred mainly in East Asia with smaller quantities in West Asia and South America. A small amount of seaweeds are produced in the USSR but hardly any in the rest of Europe.

Aquaculture in the European Community

Finfish farming in the European Community is still largely dominated by salmonids with 213,000 tonnes produced in 1989 including 135,000 tonnes of trout and 48,400 tonnes of salmon. The next most popular finfish species carp (11,600 tonnes) and eels (4,400 tonnes) are reared in fresh water. A beginning has been made with the farming of species like bass, bream, mullet and turbot. The production of shellfish is very largely dominated by mussels which accounted for 454,000 tonnes in 1989 or about 75 per cent of the total mollusc production. The volume of crustaceans remains negligible, although some encouraging preliminary results have been obtained with the semi-extensive farming of penaeid shrimps. The value of aquaculture production in the EC in 1989 was 1.2 billion ECU or

17 per cent of the value of the wild fisheries in that year (7 billion ECU).

Farmed fish production in the EC in 1989 is given in Table 1.1.

Aquaculture in Ireland

In the last century there was considerable interest in the cultivation of salmon and oysters. According to Wilkins (1989) the world's first salmon hatchery was established in Co. Galway in 1854 and the first trials with on-growing Atlantic salmon took place in Dublin and Wicklow shortly afterwards. The successful development of Atlantic salmon farming occurred in Norway over 100 years later and the Norwegian techniques have now been adopted around the world, including Ireland, where salmon farming now accounts for over 70 per cent of the Irish aquaculture earnings.

Since the 1950s there has been some rainbow trout farming in fresh water in Ireland. In more recent times, trout smolts produced in fresh water have been grown to maturity in the sea. The rainbows grown in the sea are considered to have a better flavour than those grown in fresh water, and fetch higher prices.

Trials with cultivating oysters in coastal ponds took place at several locations along the south and west coasts in the 1800s. Bates (1991) says that failure to adopt techniques developed by the French in the nineteenth century meant that oyster cultivation in Ireland was unsuccessful. It is only in the recent past that lost ground has been made up in the shellfish area with the introduction of bottom growing of mussels in Wexford harbour based on a method developed by the Dutch. Using this method, mussel seed is collected along the east coast and brought in to the shallow nutrient-rich waters of Wexford harbour. Here they grow to market size in 12 to 18 months as opposed to being uprooted by winter storms and washed ashore from the open sea. This bottom growing technique has now been adopted in a number of other areas around the coast. A further development in mussel growing has been the introduction of long line techniques to grow what are known as suspended culture or rope mussels. The West Cork coast centred on Bantry is well developed in this regard.

Management of native oyster beds in the past had mainly involved restricting fishing effort. More recently, settlement of young oyster spat has been assisted by placing weathered mussel shells on the sea bed in suitable areas when the larvae are about to settle. The young oysters grow on the shells and after about a year can be transferred to other on-growing areas. The survival rate of these juveniles in nature is very low, but when kept in mesh containers out of predators' reach, survival increases considerably. Onshore tanks, known as spatting ponds, have been very effective in enhancing the productivity of parent oysters.

Table 1.1: *Farmed Fish Production in the European Community Member Countries in 1989**

Species	*Belgium/ Luxembourg*	*Denmark*	*United Kingdom*	*Nether-lands*	*Ireland*	*Germany*	*France*	*Italy*	*Spain*	*Portugal*	*Greece*	*Total*
Finfish							*Metric Tonnes*					
Trout	800	25,000	15,000	250	900	15,000	29,000	30,000	16,000	970	1,800	134,720
Salmon		5,500	30,000		5,514	500	5,500	500	900			48,414
Carp	600		100	100		6,100	3,800	800	9		100	11,609
Bass							200	1,073	31	5	590	1,899
Bream							80	768	241	19	500	1,608
Mullet								2,505	63	10	1,600	4,178
Turbot						1	100		270			371
Eel		250	40	500		50	400	1,982	52	590	500	4,364
Sole									8	4		12
Catfish	150			1,000								1,150
Tuna									254			254
Other	100						4,000		460			4,560
Total	1,650	30,750	45,140	1,850	6,414	21,651	43,080	37,628	18,288	1,598	5,090	213,139
Molluscs												
Mussels			9,210	90,000	12,300	19,000	45,000	85,000	193,000	325	230	454,065
Oysters			540	1,000	860	80	135,000	5,000	3,300	100		145,880
Others			190				560		4,100	7,000		11,850
Total			9,940	91,000	13,160	19,080	180,560	90,000	200,400	7,425	230	611,795
Crustaceans												
Shrimps							330		50			380
Crayfish			10									10
Total			10				330		50			390
All farmed fish	1,650	30,750	55,090	92,850	19,574	40,731	223,970	127,628	218,738	9,023	5,320	825,324

* Provisional figures. Figures for production of salmon in France and Germany do not agree with those in Table 2.4 being from different sources.

Source: CCE, 1990.

Faster growing Pacific oysters were introduced in the late 1970s. This species needs warm water in order to spawn and so does not generally reproduce in the wild here. Four specialised hatcheries now produce juveniles of these and other shellfish such as clams.

In the recent past, a number of non-traditional species have been added to the list of species grown in aquaculture. New farmed shellfish include clams (both native and foreign species), scallops and abalone or ormers. Clams are grown in the sand near low tide level; they are covered in light mesh to keep birds and other predators away.

Scallops have one of the best market profiles of all sea food. The growth of scallop cultivation in Japan is one of the biggest success stories of aquaculture. In Ireland, scallop seed is collected in a semi-enclosed inlet in Mulroy Bay, Co. Donegal. It is also produced by Red Bank Shellfish in its hatchery in Co. Clare. Experiments with the on-growing of both native and Japanese scallops are being conducted at a few centres around the coast.

Abalone, which must be fed on seaweed, are single-shell species with a high speciality value. Two species are currently being grown experimentally, one imported from the Channel Islands and a Japanese species. Both were introduced by the Shellfish Laboratory in Carna, Co. Galway. This laboratory has also devised means of growing sea-urchins, another valuable species, and experiments on commercial production are under way.

New finfish candidates for aquaculture in Ireland are also being cultured at present. These include turbot, brown trout and Arctic char.
Irish aquaculture production by species for the years 1980 and 1990 is given in Table 1.2.

Education and Training

The development of the industry has been greatly facilitated by extensive training programmes throughout the country. Courses are being carried out by BIM, by Cork and Galway universities and by a number of the Regional Technical Colleges. Udaras na Gaeltachta has a range of schemes for industrial and community training as well as the advice facility of its subsidiary company Taigde Mhara Teo. There is also a scholarship scheme for the funding and placing of third-level students within the Gaeltacht. Two training videos on salmon farming are also available.

Details of the various formal courses available are given in Appendix A.

Research and Advisory Service

Aquaculture research is carried out in the Fisheries Research Centre (FRC) in Abbotstown near Dublin, the Salmon Research Trust in Newport, Co. Mayo, the Shellfish Research Laboratory (SRL) in Carna, Co. Galway, and a number of the universities mainly in Galway, Cork, UCD and TCD. In addition, there are numerous smaller projects carried out every year in the RTCs. BIM carries out applied research and development and technology transfer work in the broad fish farming area. It also produces an advisory service to the sector. The "Aquaculture Explained" series of booklets produced by BIM deals with various aspects of finfish and shellfish farming practice.

Table 1.2: *Irish Aquaculture Production by Species 1980 and 1990*

	1980		*1990*	
	Tonnes	*IR£m*	*Tonnes*	*IR£m*
Farmed salmon	20	0.1	6,300	22.1
Sea farmed trout	160	0.3	320	0.9
Fresh water trout	420	0.6	710	1.8
Rope mussels	180	0.1	3,300	1.3
Bottom mussels	4,560	0.3	15,000	1.8
Native oysters	360	0.5	400	1.3
Pacific oysters	60	0.1	260	0.3
Clams, etc.	–	–	70	0.3
Total	5,760	2.0	26,360	29.8

Note: Some of the 1990 figures in this table differ from those in the tables in Chapter 6. They include production from farms which went out of production towards the end of 1990 and were thus not included in the ESRI Survey.

Source: BIM.

Veterinary support is provided by the Aquatic Veterinary Group (AVG) at the Disease Diagnostic Service (DDS) located in UCG. Similar services are provided in University College Cork. The Government has recently announced the setting up of a Marine Research Institute. Details of the structure of this Institute have not yet been announced but it is expected to include personnel from the FRC in the first instance (longer-term make up of the Institute has yet to be determined).

Advice on fish farming can be obtained from the Department of the Marine, BIM, Udaras na Gaeltachta, The Central Fisheries Board and the various research organisations mentioned above. The Irish Salmon Growers' Association (ISGA) may be able to help with initial queries on salmon and trout farming. Its publication *Good Farmers Good Neighbours* and its code of practice document contains information on fish husbandry, the environment and safety on the farm. The recently formed Irish Shellfish Association (ISA) may also be able to help. In addition, there are a number of private consultants who will undertake work for fish farmers on a fee-paying basis. Details of the various services available to fish farmers are contained in each Autumn edition of Aquaculture Ireland and in the 1990/91 Edition of the Irish Aquaculture Directory and Guide (see list of References).

Licensing

Licences from the Department of the Marine and/or from Local Authorities are required for the establishment of fish farming operations. The licensing system which is very complicated is described in Appendix B. Suffice to say here that it is difficult to obtain all the licences required. As a result it may often take years to get a farm established and it is becoming more difficult in recent years as campaigns against fish farms (particularly salmon and trout farms) are mounted by various groups.

In discussions with some of the interests involved, means of overcoming the difficulties have been suggested. In addition to changes in the existing legislation, the views expressed include alterations in the methods of drafting legislation and the issuing of licences. The latter ideas are discussed in Chapter 7, dealing with the Environment and Chapter 8, Conclusions and Recommendations.

Financial Assistance

There are three main sources of financial aid for fish farmers. BIM offers aid in all areas outside the Gaeltacht. Udaras na Gaeltachta offers aid in Irish speaking areas while aid from the EC goes to all areas.

BIM offers funding in four ways:-

(1) At the pilot development stage it can provide a grant of 50 per cent on eligible fixed asset expenditure up to a maximum grant of IR£20,000 for any one project. Qualifying expenditure comprises expenditure on new fixed assets or for improvement of assets intended for use on the farm. Eligible investors include individuals, partnerships, companies or co-operatives with the necessary expertise.

(2) In the commercial phase of development BIM may provide a capital subsidy of 10 per cent of eligible fixed asset expenditure and this in turn will qualify the project for a further EC grant of approximately 40 per cent. In cases where EC grants are not available due to shortage of funds BIM may increase its basic grant of 10 per cent to 30 per cent of qualifying expenditure. Qualifying expenditure for commercial projects and eligibility of investors are the same as for pilot projects.

(3) BIM may also provide loans to bridge part of the EC grants. These loans are limited to 20 per cent of eligible fixed asset expenditure.

(4) BIM also operates a Resource Development Grant scheme for aquaculture which provides assistance towards the cost of feasibility studies, and supports financially the commercial application of research and development findings for project areas likely to result in aquaculture operations. For feasibility studies, the upper limit for eligible expenditure is set at IR£30,000, with grant aid applicable at a rate of 50 per cent.

Udaras na Gaeltachta provides similar type aids to BIM in the Irish speaking areas, except that in these areas up to 65 per cent of the capital cost may be made available for aquaculture projects. Of these up to 40 per cent may be obtained from FEOGA and the balance from Udaras na Gaeltachta.

The value of capital grants from the state and the EC for finfish (salmon and trout) and shellfish farms for the years 1980 to 1989 is shown in Table 1.3 together with the sales of farmed finfish and shellfish in the same years. The table shows that over the period a total of IR£5.6 million in state grants was paid to finfish farms. EC grants over the same period for finfish farms amounted to IR£5.1 million, making total grants for finfish farms IR£10.7 million. Sales of farmed finfish over the same period were valued at IR£77.8 million. Relating sales of finfish for the period 1982-1989 to grant payments for the period 1980-1987, the sales/Irish grant ratio was 36.4/1 while the sales/total grant ratio was 16.7/1.

Table 1.3: *Capital Grants Paid by the State and the EC to Finfish and Shellfish Farms Together with Sales of These Fish 1980-1989*

	State Grants[a]		*EC Grants*		*Sales*	
Year	*Finfish*	*Shellfish*	*Finfish*	*Shellfish*	*Finfish*	*Shellfish*
			IR£000			
1980	64.2	80.7	45.1	17.3	1,057	570
1981	186.6	171.4	–	7.1	1,235	669
1982	211.0	165.0	461.7	9.5	1,516	835
1983	138.3	88.8	147.8	34.1	2,313	1,243
1984	124.9	251.8	674.3	56.2	3.109	2,223
1985	111.2	198.4	83.8	140.5	4,367	1,752
1986	433.0	159.6	459.9	45.5	5,710	1,918
1987	802.3	217.8	567.7	62.1	11,960	3,082
1988	1,742.5	360.6	1,915.0	204.1	21,680	3,395
1989	1,821.6	462.4	729.3	538.3	24,820	5,119
Total	5,635.6	2,156.5	5,084.6	1,114.7	77,767	20.806

[a] Paid by BIM and Udaras na Gaeltachta.

Note: Grants other than capital grants and other types of state involvement are not included.

Total state grants paid to shellfish farms over the 1980 to 1989 period amounted to IR£2.2 million. EC grants for shellfish over the same period were IR£1.1 million making total grants for shellfish farms IR£3.3 million. Farmed shellfish sales over the period amounted to IR£20.8 million. Again, allowing a 2-year lag between grant payment and sales, the shellfish sales/Irish grant ratio was 30.5/1, while the shellfish sales/total grant ratio was 19.2/1.

These sales/grant ratios compare favourably with those for manufacturing industry, i.e., 27/1 in 1987 (see O'Connor, 1990a).

In addition to the grants shown in Table 1.3, the National Development Corporation (NDC), recently merged with the IDA, has invested in a small number of projects ranging from hatcheries through on-growing to marketing. In certain circumstances (when no other agency is able to assist a project for whatever reason) County Development teams (which operate in western counties) may recommend a grant from the Western Development Fund administered by the Department of Finance.

Grants for the development of processing facilities (such as graders, packers, smokers, etc.) which add value to the fish produced on a farm are available from the EC and from a number of home organisations. In Gaeltacht areas the grants are given by Udaras na Gaeltachta. This assistance, including EC grants, can be up to 65 per cent of eligible capital costs. In the mid-western area (Clare, Limerick and North Tipperary) processing grants are available from SFADCO (Shannon Free Airport Development Co.). The amount of grant in this area, including that from the EC, can vary from 45 per cent to 60 per cent depending on location. In the remainder of the state, assistance is available from the IDA under the Small Industries Grant Scheme. Under this programme, including those from the EC, grants of up to 60 per cent are available to operations sited in the west of Ireland. In eastern counties the maximum grant is 40 per cent.

BIM operates a Small Business and Co-operative Development grant scheme. This can assist fish handling and shellfish purification facilities to a level of 30 per cent of capital expenditure incurred in a project up to the point of first sale.

Marketing

On the marketing side BIM is the umbrella organisation for the promotion of Irish sea food. In carrying out this and other marketing functions it co-operates closely with Udaras na Gaeltachta and with the industry. The strategy adopted involves a number of phases (BIM 1988).

The primary aims are to provide market research and information programmes, an upgrading of quality standards, and an expanded programme of seafood promotion both at home and abroad.

In this connection BIM has undertaken a number of market research and product development programmes to focus on market niches for added-value fish and farmed fish products. As part of this programme it has produced a series of market research reports and bulletins for the various finfish and shellfish species and the market prospects for each.

On the home market the aim is to build up and reinforce the image of fish as a nutritious health food. Specific measures to stimulate increased demand involve:

(a) advertising, publicity, promotion and education campaigns. "Focus on Fish Week" has been designed to raise the profile of seafood in the country;
(b) assistance in import substitution, including product testing and launching;
(c) sales promotion for new and unfamiliar species; and
(d) establishment of an improved distribution network through selective assistance under a BIM Development Grant Scheme.

EC Regulations

The European Community has a deficit in fish products and the aim of policy is to find new sources of supply, in particular, by increasing its fishing possibilities and by extending its activities in the aquaculture sector. Towards these ends a number of measures have been introduced to improve and adopt structures in this sector. These include financial aid and regulations relating to fish marketing and hygiene (EC 1986, EC 91/67, EC 91/492, EC 91/493).

The level of grant aid by the Community to Ireland for the development of aquaculture projects is 40 per cent of the capital costs provided there is an enabling contribution of 10-30 per cent by the state. Grants for protected marine areas and other such structures are 50 per cent from the Community and 10-35 per cent from the state. These rates shall be raised by 5 percentage points in the case of projects which are implemented within the framework of redevelopment schemes for sea fishermen who scrap operational fishing vessels.

There are already two EC directives passed in July 1991 relating to health conditions for production and placing on the market of (1) live bivalve molluscs and (2) fishery products which will affect the aquaculture industry significantly. A third directive adopted in January 1991 will regulate animal health conditions for aquaculture species and products. An important feature of the latter regulation is that imports of live fish, in particular ornamental fish, to the EC may be restricted. This means that more of these fish will have to be bred domestically in the EC. This should present an opportunity for Irish growers to share in a very large market. World trade in these fish is currently estimated at IR£5,000 million annually, of which 40 per cent is in the EC. A summary of the specific EC Directives is given in Appendix C.

Chapter 2

THE SALMON AND TROUT FARMING INDUSTRIES

Salmon

There are two main types of salmon in the world, the Atlantic salmon and the Pacific salmon grouping, consisting of six species, Chinook, Coho, Chum, Pink, Sockeye and Cherry. The life cycle of both is similar except for one important difference. Pacific salmon die after spawning. Most Atlantic salmon survive spawning and a small percentage may spawn several times. During the life cycle, eggs are hatched out in rivers and streams. The young fish feed in the fresh water for about 2 years and then migrate as smolts to the sea where they feed and grow to maturity. After 1 – 2 years in the sea the mature salmon return to the rivers in which they were born to spawn another generation of fish. The homing instinct in salmon is very strong and while there are some wanderers most return to their native river.

Landings of wild Atlantic salmon are much smaller than those of wild Pacific salmon. The total world catch of the former is only about 12,000 tonnes per annum while that of the latter varies between 600,000 and 800,000 tonnes. Consequently Atlantic salmon have always been something of a rarity sold in fresh form to an affluent minority of consumers. In contrast a high proportion of Pacific salmon is canned or frozen. The large runs are very seasonal and must be stored by these methods.

Two species of Pacific salmon – Chinook and Coho – are seldom canned. Like the Atlantic salmon, these high quality fish are consumed principally in smoked or fresh form. In 1989 the production of these two species (excluding those farmed) was about 41,000 tonnes compared with 785,000 tonnes of the other Pacific species – sockeye, pink, chum and cherry. The world wild Atlantic salmon catch in that year was about 12,000 tonnes. Figures for world wild salmon landings by species for the years 1980 to 1989 are given in Table 2.1.

Table 2.1: *Total Wild Salmon landings by Species 1980-1989*

Year	*Atlantic*	*Chinook*	*Coho*	*Chum*	*Pink*	*Sockeye*	*Cherry*	*Total*
				'000 tonnes				
1980	12.0	23.1	31.9	166.8	226.1	111.8	2.8	574.5
1981	11.8	22.4	28.8	184.8	259.9	132.5	3.3	643.5
1982	9.3	24.9	42.2	178.9	167.2	127.9	3.7	554.1
1983	11.3	16.8	29.8	155.7	210.8	162.3	3.0	589.7
1984	12.4	17.7	40.6	210.5	210.5	126.8	4.0	622.5
1985	10.1	17.5	41.0	267.6	301.1	150.8	3.9	792.0
1986	10.3	19.1	43.4	239.0	211.8	136.5	3.6	663.7
1987	11.9	17.2	25.5	217.1	218.1	131.2	3.4	624.4
1988	7.0	17.8	33.4	286.3	164.4	107.2	2.5	618.6
1989	12.0	15.0	26.3	243.6	363.1	163.2	2.8	826.0

Source: FAO Yearbook of Fishery Statistics. Catches and Landings, Various issues.

The Pen Rearing System

Salmon smolts are grown in fresh water hatcheries for 14 months to 2 years and are then transferred to larger containers in the marine environment, mainly floating sea pens, or cages, though there are examples of salmon being reared in closed off sea channels or in shore tanks where sea water is circulated by pumping. The fish are fed in the cages for one to two years and are then sold off weighing anything from $1^1/_2$ to 5 kg. The heavier fish usually fetch the highest prices but their cost of production also is higher.

Floating sea cages consist essentially of a net bag suspended from a floating framework anchored to the sea bottom by stay ropes and chains. In the early days of salmon farming it was necessary to have sheltered sites for the cages then available. This constrained development. It also led to pollution of the sea bed by fish droppings and waste food in areas where there was poor flushing of the sea water.

The on-site pollution problem has now been improved to a great extent by the invention of large cages which are capable of withstanding exposed sea conditions. One of these – the Bridgestone – a large rubberised cage of Japanese manufacture is capable of standing up to the roughest of sea conditions. These cages, each capable of holding up to 100 tonnes of mature fish, are now in common use in fish farming countries, with more in use in Ireland than anywhere outside Japan. They have greatly increased the number of sites which can be used for aquaculture. Another cage, the Dunlop Tempest Sea Pen, for which some of the metal walkways and supports are manufactured in Letterkenny by Bonner Engineering, is now competing with the Bridgestone for off-shore sites.

This version comes in small and large sizes. It has walkways around the circumference, a feature not possessed by the Bridgestone cages.

The servicing of the large cages, located a considerable distance from the shore, is however very expensive in that large service boats are required. Even then, many days may pass in winter before personnel can reach these pens. Security problems are also increased. Two Irish firms, Steel Forms in Oranmore, Co. Galway, and Wavemaster (previously known as Turmec) in Co. Meath, manufacture smaller steel cages which can be used in less exposed places. Wavemaster cages are now used in a number of countries; Greece is a recent large customer.

In the early years of salmon farming, smolt availability was a serious constraint on expansion. Smolts were in scarce supply and those available were often not very suitable. They reached sexual maturity and ceased growing at relatively early ages. This greatly reduced the value of the fish.

As a result of careful selective breeding, particularly by Norwegian scientists, the early maturing problem has now been largely overcome and strains are available which will grow quickly to any weight required. This is a plus for the salmon farmers but it is causing concern among environmentalists who fear that escaped farm fish will crossbreed with wild strains and produce progeny incapable of living in the wild. This issue is discussed in Chapter 7.

Disease

Disease was not originally a major problem in Atlantic salmon farming. Of late it has become a key concern. In the past most of the fatal diseases could be controlled by vaccines or medicines but in recent years newer diseases of uncertain aetiology are causing serious problems. One of these, Pancreas Disease (PD), is now one of the most important diseases in Scottish, Irish and Western USA fish farms. The pathology of the disease is variable. Affected fish may exhibit rapid recovery, slow recovery or no recovery. Deaths attributable to PD are normally low (less than 10 per cent), most fish returning to normal within three months (McVicar, 1987). However during this period there is a marked susceptibility to other diseases from which deaths occur.

It is now believed that conditions inducing stress on farmed salmon influence the development, course and severity of PD. A severe outbreak in Irish salmon farms in 1989 was thought to be caused by raised water temperatures during the warm summer weather. However, a reduction of the disease level in the equally warm summer of 1990 throws some doubt on this theory. Experiments are being carried out in various countries to determine the cause of the disease and its treatment. Until the results of these experiments are available fish farmers in susceptible areas are being advised to reduce stress on the fish by lowering stocking densities.

The Environment

The effect of salmon farming on the environment generally has now become an important concern in recent years, both in Europe and North America. In 1987 An Taisce – The National Trust for Ireland – while accepting the industry as an appropriate use of our natural resources – expressed concern on the following points (An Taisce, 1990: p. 64):-

(1) Organic pollution of sheltered marine inlets and eutrophication of lakes.
(2) The toxic effects of antifoulants and chemicals used to prevent diseases in caged fish.
(3) The potential danger to wild stock fish populations as a result of interbreeding with fish which have escaped from farms.
(4) The visual impact of floating cages, long lines, rafts and onshore structures, particularly in areas of high scenic value, and
(5) A loss of wilderness quality in certain remote areas.

In responding to these concerns, the industry has commissioned a considerable amount of research to find publicly acceptable solutions to the various problems. These environmental issues are addressed in some detail in Chapter 7.

Production of Farmed Fish

Fish farmers specialise in the production of three main species of salmon, Atlantic, Chinook and Coho. These fish compete for the same type of white tablecloth markets and the ordinary consumer would have difficulty in distinguishing one species from the other. Hence growth in the production of farmed Pacific salmon will affect the market for Atlantic salmon, particularly in the US.

Atlantic Salmon

Up to very recently Atlantic salmon have grown much better in cages than the Pacific species. The quantity of Atlantics farmed grew from 10,200 tonnes in 1981 to 244,000 tonnes in 1990 (see Table 2.2). Norway is far and away the greatest producer of farmed Atlantic salmon, the amount produced growing from about 9,000 tonnes in 1981 to 165,000 tonnes in 1990. Scotland, with 34,000 tonnes in 1990, is the second largest producer in the world, followed by the Faroes (12,000 tonnes), Ireland (6,300 tonnes), Canada (7,000 tonnes), USA (4,000 tonnes), Chile 5,000 tonnes, Australia (1,600 tonnes), Sweden (1,300 tonnes) with smaller amounts coming from Spain and France. The Icelandic industry which produced 6,000 tonnes in 1990 is now reported to be on the verge of collapse (*Eurofish Report*, July 4, 1991).

The outlook for 1995 is somewhat speculative but Landill Mills Associates (1990) expect that total production will reach 308,000 tonnes in that year. Norwegian production is not projected to increase very much. Scottish production is expected to grow to 47,000 tonnes and Irish to 15,000 tonnes. Production in thousands of tonnes from other countries in that year are, Canada 18,000, Iceland 16,000, Chile 12,500, Faroes 10,000, USA 9,000, Spain 5,700, Sweden 3,500 and Australia 2,000. In view of recent price trends, we have reservations about some of those projections. We think that both the Scottish and Irish figures are optimistic and there is serious doubt about the Icelandic and Canadian figures. The collapse in the Icelandic industry mentioned above will affect the projections from that country while controversy has arisen about the farming of Atlantic salmon in British Columbia. Production of this species may be suspended in that area.

Table 2.2: *Annual Production of Farmed Atlantic Salmon by Country, 1981 – 1990 with forecasts for 1995*

Country	*1981*	*1982*	*1983*	*1984*	*1985*	*1986*	*1987*	*1988*	*1989*	*1990 (est.)*	*1995 (Forecast)*
					'000 tonnes						
Norway	8.9	10.3	17.0	22.3	28.7	45.7	47.4	80.3	114.9	165.0	167.6
Scotland	1.0	2.1	2.5	3.9	6.9	10.3	12.9	18.0	28.6	34.0	47.3
Ireland	*	0.1	0.3	0.4	0.7	1.2	2.2	4.1	5.3	6.3	15.0
Faroes	0.1	0.1	0.2	0.7	1.3	1.9	2.5	4.0	7.5	12.0	10.3
Iceland	*	*	0.1	0.1	0.1	0.7	0.7	1.3	1.6	6.0	16.2
Sweden	0.1	0.1	0.1	*	0.1	0.1	0.1	0.2	0.4	1.3	3.5
Spain	–	–	–	–	0.1	0.1	0.1	0.3	0.5	1.0	5.7
France	–	–	–	–	–	–	–	0.2	0.4	0.6	1.7
Chile	–	–	–	–	–	–	*	0.2	1.6	5.0	12.5
Canada	*	0.1	0.2	0.1	0.5	0.8	1.0	1.6	5.3	7.0	17.6
US	–	–	–	–	0.5	1.0	2.5	1.7	2.4	4.0	8.8
Australia	–	–	–	–	–	–	–	0.5	1.5	1.6	2.0
Total	10.2	12.8	20.3	27.6	38.9	61.8	69.4	112.3	170.0	243.8	308.2

* Less than 50 tonnes.

Source: Landill Mills Associates (1990).

Pacific Salmon

Despite earlier setbacks the production of farmed Pacific salmon has increased considerably in recent years from about 2,000 tonnes in 1981 to an estimated 49,000 tonnes in 1990 (see Table 2.3). Japan, with 20,000 tonnes of Coho and Chinook in 1990, is the largest producer. Canada comes next on the list with 12,000 tonnes, followed by Chile with 10,000 tonnes and USA with 5,000 tonnes. New Zealand produced 2,000 tonnes of Chinook in 1990 and France 100 tonnes of Coho. The forecast for 1995 is 66,500 tonnes.

The data from Tables 2.2 and 2.3 are aggregated in Table 2.4. This table shows that total world production of farmed salmon increased from 12,200 tonnes in 1981 to 292,600 tonnes in 1990. The forecast for the year 1995 is 375,000 tonnes, of which 308,000 are Atlantics and 67,000 Pacifics. If we assume that the wild catch remains at its present level of about 700,000 tonnes then total salmon production will have gone from 656,000 tonnes in 1981 to 993,000 tonnes in 1990 and to 1,075,000 tonnes in 1995. By that year the farmed production will be about 54 per cent of the wild catch or 35 per cent of total salmon wild and farmed. The problems of marketing this large amount of salmon are discussed in Chapter 3.

Production of Farmed Salmon in Different Countries

Norway

Norway is the main producer of farmed Atlantic salmon. The sheltered Norwegian fjords which are heated by the gulf stream and have deep waters are ideal sites for aquaculture. Limited flushing is a restraint to intensive cultivation, however, particularly in the inner reaches of the fjiords.

Salmon farming began in Norway in the mid-1960s and by 1989 there were 790 farms in operation serviced by 642 smolt units and producing 115,000 tonnes of fish (Bjorndal, 1990). Prior to 1988 there was a limit of 8,000 cubic metres (cu.m.) on the amount of pen space a farmer could have. Since 1988 the limit has been raised to 12,000 cu.m. The limit on smolt production is 1,000,000 smolts per annum. The total work-force in the industry including those employed in smolt production is currently 6,900. Additional indirect employment is estimated at 3,100 people (*ibid.*, p. 12).

Table 2.3: *Annual Production of Farmed Pacific Salmon by Country and Species 1981–1990 with forecasts for 1995*

County	*Species*	*1981*	*1982*	*1983*	*1984*	*1985*	*1986*	*1987*	*1988*	*1989*	*1990 (est.)*	*1995 (Forecast)*
						'000 tonnes						
Japan	Coho/Chin	1.2	2.1	2.9	4.4	6.8	7.0	12.0	14.0	18.0	20.0	25.5
US	Coho	0.5	0.7	0.9	2.7	1.0	1.5	1.5	2.7	4.0	5.0	7.3
Canada	Coho/Chin	0.2	0.4	0.1	0.1	1.0	1.0	1.2	6.0	14.0	12.0	18.2
Chile	Coho	0.1	0.2	0.1	0.1	0.5	1.1	1.8	4.0	5.0	10.0	12.8
France	Coho	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
New Zealand	Chinook			*	*	0.3	0.6	1.0	1.5	1.5	2.0	2.6
Total	–	2.1	3.5	4.1	7.4	9.7	11.3	17.6	28.3	42.6	49.1	66.5

*Less than 50 tonnes

Table 2.4: *Annual Production of all Farmed Salmon by Country 1981 to 1990 with Forecasts for 1995*

Country	*1981*	*1982*	*1983*	*1984*	*1985*	*1986*	*1987*	*1988*	*1989*	*1990*	*1995 (Forecast)*
					'000 tonnes						
Norway	8.9	10.3	17.0	22.3	28.7	45.7	47.4	80.3	114.9	165.0	167.6
Scotland	1.0	2.1	2.5	3.9	6.9	10.3	12.9	18.0	28.6	34.0	47.3
Ireland	*	0.1	0.3	0.4	0.7	1.2	2.2	4.1	5.5	6.0	15.0
Faroes	0.1	0.1	0.2	0.7	1.3	1.9	2.5	4.0	7.5	12.0	10.3
Iceland	*	*	0.1	0.1	0.1	0.7	0.7	1.3	1.6	6.0	16.2
Sweden	0.1	0.1	0.1	*	0.1	0.1	0.1	0.2	0.4	1.3	3.5
Spain					0.1	0.1	0.1	0.3	0.5	1.0	5.7
France	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.3	0.5	0.7	1.8
Japan	1.2	2.1	2.9	4.4	6.8	7.0	12.0	14.0	18.0	20.0	25.5
Chile	0.1	0.2	0.1	0.1	0.5	1.1	1.8	4.2	6.6	15.0	25.3
Canada	0.2	0.5	0.2	0.1	1.5	1.8	2.2	7.6	19.3	19.0	35.8
US	0.5	0.7	0.9	2.7	1.5	2.5	4.0	4.4	5.1	9.0	16.1
Australia								0.5	1.5	1.6	2.0
New Zealand					0.3	0.6	1.0	1.5	1.5	2.0	2.6
Total	12.2	16.3	24.4	34.9	48.6	73.1	87.0	140.7	211.5	292.6	374.7

Norway's progress since the mid-1960s has been engineered through active government support. Financial assistance by the government is given in three ways; direct loans at subsidised interest rates, investment grants of up to 40 per cent of capital investment, depending on location, and loan guarantees. Total government assistance over the period 1961 to 1987 has been estimated at NOK 1,586 million (IR£154m). In addition, very heavy investment from the private sector is provided through normal borrowing from the banks and other financial institutions.

The Norwegian industry has been very profitable in the past. In most years, up to 1989, an 8,000cu.m. cage could produce a turnover of IR£500,000 and if well run could generate a profit of IR£65,000 per annum. The return from an average smolt hatchery was somewhat similar. This scenario did not go unnoticed by investors and large companies wishing to diversify. These large companies are not normally granted producers' licences but they can purchase existing farms and many have done so.

Because of restrictions on farm size the large producers with licences in excess of 8,000cu.m. (granted before restrictions were imposed) have become frustrated with Norwegian licensing conditions and have expanded overseas in Scotland, Ireland, Canada, Australia and Chile.

The Norwegian industry suffered a severe setback in 1989 when prices dropped by about 20 per cent on the previous year's level. At these prices, the average producer would have lost money. The average price, across the size grades, received by producers in 1989 was about NOK 30 per kg while production costs are estimated by Landill Mills Associates (1990) at NOK 31 per kg. These costs vary widely, however, from NOK 20 on the most efficient farms to NOK 60 on the least efficient.

On average, cost of production in Norway is much similar to that in Scotland and Ireland. However when the different cost items are compared it is found that Norway tends to have lower feed costs and higher smolt costs than Scottish or Irish farmers. The relatively high cost of smolts in Norway results from the fact that in that country smolts are purchased to a large extent from specialised producers who make a profit on the operation. Due to severe winters in Norway there are higher costs associated with smolt production there (more buildings, more heating, etc.). In Scotland and Ireland where there are much higher levels of integration most smolts are entered in the accounts at cost of production.

The low unit feed cost in Norway is due to the fact that very high energy (high fat) diets are used which give much better food conversion rates than those elsewhere. The corollary of this is that Norwegian salmon have become fatty as a result of the high fat diets and are becoming unpopular on the market, particularly for smoking. This could result eventually in a discount for Norwegian fish.

The problems within the Norwegian industry, implied by the wide range of production costs are serious. According to some reports, bank losses have been very large (NOK 0.6-0.7 billion in 1988/89) which is 10 per cent of the banks investment in the sector. Up to 70 per cent of the farms North of Trondheim are believed to be technically insolvent but are being allowed to continue trading because of the banks involuntary support, coupled with the desire to maintain employment. In fact the level of declared bankruptcies is very low (4 per cent) (*ibid.*, p. 27).

Norway is blamed for the 1989 price slump. It is claimed that the Norwegians overproduced in that year and flooded the market with cheap fish. The Scottish and Irish salmon growers' associations approached the European Commission in November 1989 and convinced the Directorate that an investigation into below cost selling by the Norwegians was warranted.

As a result, the Norwegian Fish Farmers Sales Organisation (which market all Norwegian farmed salmon) agreed to hold back 40,000 tonnes of salmon to relieve pressure on the market. This was financed by a loan of NOK 1.3 billion and a levy of NOK 5 per kilo on all fish sold. The result was an increase in prices on the French market in January of 1990 to something over cost of production levels (O'Connor, 1990). However from February onwards prices for small fish under 3 kg reverted to previous levels and have remained at about these levels since then.

A factor which could have an important bearing on the market situation is the imposition of protectionist measures by the US government and the recent proposal for similar measures by the EC Commission. The US government has now imposed taxes on Norwegian salmon imports; importers must pay a duty of 16.32 per cent on all fresh imports.

Alleged dumping of Norwegian salmon on the Community market was investigated by the EC Commission in 1990 and on the 15th March 1991 it issued a decision terminating the anti- dumping proceedings, concerning imports of Atlantic salmon originating in Norway, on the grounds that Community producers would be unable to replace Norwegian supplies, particularly those of large fish over 5 kg. (Official Journal of the EC, 15/3/91).

The UK and Ireland expressed reservations about this decision. That these reservations were warranted has now been proved correct. In late May 1991, an algae bloom was noticed approaching the Norwegian coast. In an effort to escape this invasion, large numbers of immature fish were harvested and thrown on EC markets, causing almost a free-fall in prices. It is reported that in June 1991, UK processors could buy Norwegian salmon at Stg.50p per lb.

As a result of this price fall further lobbying by the Irish and Scottish Salmon Growers' Association took place and on the 8th November 1991 the EC Commission laid down a Regulation making imports of Atlantic salmon (into the EC) subject to a minimum price. On top of this there must be paid a 2 per cent import levy and internal freight within the EC. The Regulation covered fresh and frozen fish up to 4 kg in weight and was due to apply for 90 days until the 29th February 1992. It has since been extended.

Within days of the enactment of this regulation, the minimum price of about £3,000 per tonne was revised downwards by 14 per cent on the grounds that a mistake had been made in converting the Norwegian kroner to the ECU. This reduction has made the minimum price of little value to EC producers but it does, of course, make salmon cheaper for consumers. The ISGA and the Scottish Salmon Growers' Association are continuing their campaign for a realistic reference price system or other appropriate remedies.

Scotland

Salmon farming began on the North West coast of Scotland and in the Islands in the 1970s. The east coast is too exposed for aquaculture. Because the Scottish coastline is not as well protected as the Norwegian fewer suitable sites could be used in the early years.

The limited number of sites have, however, been the subject of large scale development by big corporations most of whom have integrated smolt and on-growing production. In 1989, 176 companies were involved in the Scottish industry on 333 sites, 12 of which were land based. Almost 50 per cent of the production took place on 28 of the sites. Less than 600 tonnes (2% of total production) were produced on the land based sites.

The top ten salmon farmers are responsible for over 60 per cent of the production. The largest producer is the Unilever owned Marine Harvest Ltd., based in Edinburgh with 21 sea water sites. Its output in 1989 was 7,500 tonnes or 25 per cent of the Scottish total. Marine Harvest is fully integrated. It produces its own smolts. It processes packaged steaks, fillets and smoked fish and is also involved in the production of feed.

As Table 2.2 shows, output of the Scottish industry grew from 1,000 tonnes in 1981 to 34,000 tonnes in 1990. The numbers employed within smolt and on-growing production are 1,432 full-time and 405 part-time workers. When the part-time workers are converted to full-time, output per person year in 1989 was estimated at 17.5 tonnes. The corresponding figure for Norway is 16.7 tonnes and for Ireland about 15 tonnes.

According to a survey by North of Scotland Agricultural College in 1989 on a sample of 22 farms covering 60 per cent of Scottish production, average unit salmon production cost was Stg.£3.4 per kg with a range of Stg.£2.3 to Stg.£5.0. A comparison of these figures with those of Norway requires some care but when allowance is made for differences in the treatment of smolt costs in both countries Landill Mills Associates estimate that the average differential between Norway and Scotland is very small, of the order of 10-20p per kg (in Norway's favour). Irish production costs on 1989 given by Landill Mills were IR£3.2 per kg. which would suggest that Irish farms, on average, were profitable in that year despite the very adverse markets.

Up to mid-1988 the Highlands and Islands Development Board (HIDB) had given a total of Stg.£22 million in grants to Scottish salmon farmers. At present no grants are being awarded either for smolt production or for on-growing (a decision subject to periodic review). The EC scheme is now coming to an end after giving about Stg.£6 million for salmon farm development over the past 5 years. EC grants currently available are mostly for fish processing. A maximum EC contribution of 40 per cent of capital costs can be made provided the national government puts up 10 per cent.

Other sources of funds are the Agricultural Development Programme for the Scottish Isles of which Stg.£2 million is earmarked for fish farming. The HIDB also helps to get small salmon producers included in the government's loan guarantees scheme with a ceiling of Stg.£100,000 per loan. This is important in the current financial climate. Banks have recently foreclosed on a number of small producers who were unable to meet loan repayments.

Salmon farmers in Scotland believe that both statutory and voluntary bodies are becoming more anti-fish farming. The River Purification Boards play a more prominent role than heretofore in policing the environmental impact of salmon farms. It is becoming more difficult to obtain licences particularly for fresh water cages. A wide variety of "conservationist" bodies are now taking an interest in the industry. Most of these are concerned with organic pollution, genetic pollution, chemical usage and visual nuisance.

Ireland

The Irish industry is discussed in detail in Chapter 6 so only a brief outline is necessary here. At the present time there are 22 on-growing salmon farms in Ireland usin conventional cage culture and 10 independent smolt producers. Most of the on-growers are integrated back into smolt production. With fewer suitable inshore sites than Scotland the Irish industry has been a leader in pioneering the use of offshore cages. Some 50 Bridgestone cages are now in use around the Irish coast as well as a few of the smaller flexible Tempest Pens developed by Dunlops.

Ireland's production of farmed salmon increased from 10 tonnes in 1977 to 5,500 tonnes in 1989, 6,300 tonnes in 1990 and to about 9,000 tonnes in 1991. Production was expected to be higher than this in the latter year but outbreaks of pancreas disease (PD) in 1989 and 1990 and to a lesser extent in 1991, killed a large number of salmon. Some of the cages in Clew Bay which had very high mortality in 1989 are now stocked with rainbow trout. The latter are not affected by PD.

Work is continuing at the National Diagnostics Centre in UCG to find a cause and cure for PD. The research is funded by Bioresearch Ireland, the Irish Salmon Growers' Association (ISGA), a number of feed manufacturers and the EC. In addition, an epidemiological study into the disease, funded by the ISGA and BIM, is being launched in the West of

Ireland in conjunction with Queen's University of Belfast and the Veterinary Research Laboratory in Northern Ireland.

PD disease was not serious in 1991 but another disease, sudden death syndrome (SDS), caused high mortality on at least one farm. The cause of this disease, which affects the hearts of the fish, is unknown. It is thought to be associated with management since all farms in the same locality were not affected.

Another problem which affected a number of salmon farms in January 1991 was storm damage. Some 350,000 fish at various stages of development were lost in this near hurricane. Fish were washed out of some cages while other cages broke their moorings and were washed ashore. It seems that Bridgestone cages stood up best to the elements; Connemara was the worst affected area.

The high disease mortalities and depressed markets in 1989 and 1990 created very severe financial pressures for Irish producers. It will be shown in Chapter 6 that the sector as a whole incurred large losses in 1990. However, except for two fairly major casualties and one smaller one, the Irish industry seems to have weathered these problems well. Outputs and profits in 1991 are likely to be much improved but the continuing low level of prices poses a serious threat to the industry.

Marketing is of crucial importance in running a successful salmon farm, and many of the larger producers prefer to do their own marketing. Three of the largest Irish firms whose output in 1990 accounted for 55 per cent of all Irish salmon sold, carry out this function themselves. It would be impossible for the smaller firms to market their own produce individually and, as a result the Irish Salmon Producers' Group (ISPG) was set up.

The ISPG whose head office is in Kilkeirin in Connemara, acts as marketing agent for the fish farmers. It arranges for movement of fish from farms to packing stations where they are graded and shipped to market. Principal markets are France 60 per cent, Ireland 20 per cent, USA 10 per cent, Benelux 5 per cent and Spain/Germany 5 per cent. ISPG sells fresh salmon whole or gutted, fillets and pre-pack. Sales are mainly to fresh markets with some to smokers. It tries to sell directly to retailers on order rather than deliver to the residual Rungis fish market in France where prices can often be very low. It has been suggested to us that there may be an opportunity for joint ventures and link-ups with Continental firms of proven marketing ability. Our enquiries indicate that for salmon at any rate the present arrangements are considered to be satisfactory. For shellfish, on the other hand, such link-ups may be worthwhile. The shellfish marketing situation is discussed in detail in Chapter 5 below.

In addition to future price levels and disease outbreaks, the other main problems facing the Irish industry have arisen from concern about environmental issues.

The environmental issues raised in Ireland are the same as those listed above for Scotland, namely, organic pollution, chemical usage visual nuisance and possible effects on wild life such as genetic impairment of wild salmon stock. As a result of these concerns which were given particular prominence by the rod licence dispute in 1989 and 1990, it is becoming more and more difficult to get established in aquaculture. The industry is taking these issues very seriously and has commissioned a number of studies to determine environmental damage, if any, caused by specific practices and to find more environmentally friendly means of coping with the issues raised.

Faroe Islands

Efforts to develop salmon farming in the Faroe islands were tried unsuccessfully in the 1950s, 1960s and 1970s. A number of private farms became established in the early 1980s, and production grew from about 100 tonnes in 1981 to 7,500 tonnes in 1989 and an estimated 12,000 tonnes in 1990.

The import of smolts is not allowed in the Faroes and as a result the level of smolt production has been a constraint on growth. The fjords of the Faroes offer a limited number of well sheltered on-growing sites. A licence is required to operate a farm. Some 70 farms are in operation in the country with a total licensed capacity of 720,000 cu.m. Maximum size per farm is 15,000 cu.m. and foreign ownership is precluded.

Iceland

For many years Iceland has concentrated on ocean ranching of salmon. As a result it has developed a large smolt producing capacity. The results from the ranching operations were, however, disappointing and interest shifted to salmon aquaculture. The constraints on the latter are low water temperatures and lack of suitable sites. Due to shortage of sea sites the industry has concentrated on onshore units which are more expensive than sea cage operations. It is doubtful if these onshore farms can survive in a world where supplies are increasing and prices are declining. At a press conference in early June 1991, Agriculture Minister, Halldor Blondal, disclosed a report stating that the industry had no hope of survival in the near future. At the same time, the government has announced plans to grant an additional US$5 million in operating loans to three to four farms in order to avert absolute disappearance of the industry from the country and preserve knowledge gained so far (Eurofish Report, *op. cit.*).

Other European Countries

Elsewhere in Europe salmon farming has not developed to any great extent and the projections for future years are very modest. Some Coho salmon are grown to portion size on freshwater sites in France, Italy and Yugoslavia. Coho is used as a substitute for rainbow trout which suffers from VHS disease in certain areas. There is some Atlantic Salmon farming in Sweden but production in that country will always be high risk due to cold winters. A large land based Salmon farm in Spain lost all its fish in 1989 due to an algae bloom (Needham, 1990). Unless industrial pollution of the sea is controlled salmon farming cannot develop in continental Europe even where the climate is favourable.

Japan

Japan is the main producer of farmed Pacific salmon in the world. Most of the production is Coho. There is some Chinook while Atlantic and sockeye salmon are being reared on an experimental basis.

Government regulations require that salmon be reared by small operators rather than by large companies. As a result farms are typically less than 7,000 cu.m. capacity. Though not allowed to take part in on-growing operations the large companies control most of the production through arrangements with the growers. These companies take part in smolt production, feed and cage supplies and sales of fish.

Coho are put to sea in pens in October/November and are harvested the following May to July weighing about 2kg. The fish cannot be kept over the summer due to high water temperatures (Bjorndal, 1990, p. 17). Atlantic salmon because of its pale colour is not as popular in Japan as the redder fleshed Pacific salmon. The Japanese will, however, purchase Atlantic salmon if the price is right and the foreign trade statistics show that they imported 17,000 tonnes of Atlantics in 1990. Total production of all farmed salmon in Japan is expected to reach 26,000 tonnes by 1995.

Chile

Chile with more than 4,500 kilometres of coastline is one of the few countries in the world with fish landings of over 5 million tonnes per year.

The southern part of Chile where salmon are farmed has more than 2,000 kilometres of fjords, sheltered bays and inlets. This sparsely inhabited region, with practically no other industrial activity makes salmon and trout farming possible in an ideal unpolluted natural environment (Legarreta, 1990).

Because salmon are not native to Chile the waters were originally free from salmon pathogens. Consequently the industry has been relatively disease free so far except for some problems with algae blooms. This may change, but the available sea area is so large that producers can move to new sites. The biggest constraint on the industry is the absence of good roads in the southern part of the country.

Up to 1989 around 320 sites had been licensed to grow salmon. Of these 170 are already in production with sea water pens; 34 are in juvenile production and 7 are in ocean ranching. About two-thirds of the working farms are planned for 300 to 500 tonnes production per annum. Only 5 have plans for over 1,000 tonnes.

Salmon farming began in Chile in 1979 and by 1989 5,000 tonnes of Coho salmon were produced, together with 1,600 tonnes of Atlantics. The forecast for the year 1995 is 25,000 tonnes of which 13,000 will be Atlantic salmon and the remainder Pacific species mainly Coho with some Chinook and Cherry.

Because Chile is situated in the southern hemisphere its seasons are opposite to those of the northern hemisphere. This provides the Chileans with a major advantage in competing for US fresh salmon markets; the off-season for the North American wild fishery (November-May) coincides with the harvesting season in Chile. Hence, unlike European salmon, Chilean farmed salmon faces no competition from the wild fishery.

In the beginning, the main market for fresh Chilean salmon was in the USA. Today the largest portion of the market is frozen salmon to Japan. The fresh Chilean salmon are exported by air to the USA competing mainly with farmed European Atlantics when the wild salmon supply is finished. The air freight cost from Chile to New York is similar to that from Norway to New York. To break into and maintain the US market, rigid quality standards and controls have been introduced.

Canada

Salmon farming began in British Columbia (BC) in 1972 with the rearing of Pacific salmon species, particularly Chinook and Coho. It proved difficult, however, to raise these species in captivity and there were very high mortality rates in the early days. In 1984 there were only 10 active sites producing 107 tonnes of salmon. Since then disease problems seem to have been controlled. This is mainly due to lower stocking densities in the cages. Stocking densities are 7-8 kg per cu.m. in BC compared with 20-25 kg per cu.m. in Norway. In 1989 there were about 200 active sites producing 14,000 tonnes of Coho and Chinook and about 5,000 tonnes of Atlantics (Landill Mills, 1990). According to Bjorndal, (1990) these existing sites are capable of producing 70,000 tonnes but his forecast is for 50,000 tonnes by 2000.

The strict regulatory conditions on farm size in Norway have contributed to the expansion of salmon farming in BC. Norwegian businessmen unable to expand their production at home have turned to other countries for sites and it was estimated that at one stage Norwegian interests were represented in 50 per cent of all investment in the BC industry (Bjorndal and Schwindt, 1987). The level of Norwegian investment is now much lower than this, due to a large pull-out of funds in 1990 and 1991. The British Columbian and Norwegian salmon producers compete for the same US fresh salmon market. This market is expanding but with Chilean imports now coming on stream a big marketing effort is needed if prices are to be maintained. At the end of the day success for any foreign nation on the US market could rest on the relative values of currencies at any one time.

Salmon farming on the east coast of Canada is difficult because of the cold winters. Salmon smolts are killed at temperatures below 0°C and most of the sea areas along the Atlantic coast of Canada fall below this level in winter. Only in New Brunswick are there suitable sites and 44 farms are now operating in Charlotte County. These produced 7,000 tonnes of Atlantic salmon in 1990.

A number of salmon rearing experiments using land based systems are being carried out in the other maritime provinces to counter the limitations imposed by lethally cold waters. Land based salmon farms are however proving very expensive to run and most of those established to date are in financial difficulties (Needham, 1990). Experiments with Pacific salmon are ongoing in Ontario and Coho are now being raised in the great lakes. The latter are used mainly for sports angling.

USA

Salmon farming began in the north western states of the USA in the early 1960s when attempts were made to develop ranch-type fisheries for the valuable Chinook and Coho species. Fish hatchery schemes were initiated and smolt release programmes begun. Two systems were adopted, ocean ranching in Oregon and farming in pens or sea cages in Washington.

The second idea proved to be the more successful. Only a very small proportion of the smolts released into the ocean returned as mature fish. In the early years pen reared Coho salmon were raised to pan size (0.5 kg) for restaurant and supermarket sales and it was not until the early 1980s that the move to producing large salmon began. There have also been attempts to introduce Atlantic salmon and almost all farm operations started since 1987 have been designed for Atlantics.

Production figures for the USA in the early years are often questionable but it is estimated by Landill Mills Associates (1990) that 4,000 tonnes were produced along the west coast in 1989, mostly Coho, with some Chinook and Atlantics. In addition, 15 companies harvested 2,400 tonnes of Atlantic salmon off Northern Maine in the same year (Needham, 1990). The US is not likely to emerge as a major producer of farmed salmon unless Alaska comes on line as a supplier, which is unlikely. The strong capture fishing lobby in Alaska is against aquaculture and had salmon farming banned in that State in 1988. The Washington and Oregon coasts offer only a limited number of good sites and development is very often a source of environmental conflict in these states. Crutchfield (1989) says

> Puget Sound (the sea off Washington Coast) already is an intensively utilised land/water system. Water transportation, commercial and recreational fishermen, pleasure boaters, beachcombers and shore line residents all compete in varying degrees for use of these waters. Virtually all of the desirable pen rearing sites will put salmon farmers in direct conflict with some other users. Unlike other major sea-farming areas, e.g., the west coast of Norway, Scotland's North Coast and islands and southern Chile, there is no logical argument that salmon farming is needed in Puget Sound which is the most prosperous region in the state of Washington.

Similar arguments could be put forward for the Oregon coast. In any case, the unindented coast of this State is generally unsuited for cage culture.

The position in Alaska is different. Here there are large isolated areas highly suited to salmon farming and if the conflict with the commercial fishermen is resolved in favour of fish farming the US could become a major producer.

New Zealand

Most farmed salmon in New Zealand are produced by two companies in Big Glory Bay. Total production in 1990 was estimated at 2,000 tonnes of Chinook salmon. It is illegal to farm Coho in New Zealand. The fish are harvested after two years in the sea cages with harvesting taking place between October and March. Japan and the US are the principal export markets.

Australia

Australia has become a small but significant producer of Atlantic salmon with an output of 1,500 tonnes in 1989 by three main operators involving Norwegian and Japanese interests. According to Landill Mills

Associates (1990) the limits on the domestic market and the increasingly unpromising export markets are discouraging producers from expanding. Subsequent growth is therefore seen as being very limited.

Summary of Outlook

It is difficult to forecast growth rates in the coming years since projections depend very much on the operation of a number of constraints, i.e., the market, government regulations, the environmental lobby, disease problems and investment costs.

Though the industry is going through a very difficult time at the moment most of the experts we have consulted are of opinion that the industry will continue to grow over the coming decade but more slowly than in the 1980s. Needham (*op. cit.*, p. 9) is of opinion that in the long term the main growth areas will be British Columbia and Chile (and perhaps even Alaska if the authorities there change their minds about salmon farming). He says that after the present production surge there will be contraction in Norway, Scotland and Ireland with limited capacity to expand in Atlantic North America, the Faroes and Japan.

Both Trond Bjorndal and Landill Mills Associates, who are very familiar with the European scene, are not nearly so pessimistic. These authors consider that there is room for growth in the four main European countries, Norway, Scotland, Ireland and the Faroes. There are still many available sites in these countries and while cage densities may have to be reduced to cope with disease they think that the market will continue to expand and that improved management techniques will ease the environmental problems. Despite the current problems, the projections by Landill Mills Associates indicate a production of 308,000 tonnes of Atlantic Salmon and 67,000 tonnes of Pacific salmon by 1995.

Trout Farming

The principle of trout farming is to hold specially bred juvenile fish, fed on a formulated fish meal diet, in ponds or tanks containing fresh water until they are a suitable size for the market. Alternatively, young fish may be transferred to the sea where they are held in net cages exactly similar to those used to grow salmon. In this case the fish tend to grow to a larger size not unlike that of salmon. This makes them well suited to smoking.

Fresh water trout farming began in Ireland in 1958 with the opening of the Inland Fisheries Trust's fish farm at Roscrea, Co. Tipperary, to produce trout for river restocking and to act as a training facility. By 1970 there were five farms centred around Tipperary and Wicklow selling 83.5 tonnes of fish and by 1982 the figure had risen to 21 farms selling 560 tonnes. With the increasing popularity of salmon farming, many trout farmers turned to salmon smolt production and by 1990 there were only 13 trout farmers producing 710 tonnes of fresh water and 320 tonnes of sea water trout.

Since 1980 European trout output has been growing at a rate of about 7 per cent per annum, compared with 51 per cent per annum for farmed Atlantic salmon. In the US and Canada trout output seems to have become static (see Table 2.5).

The largest trout producers in Europe are France, Italy, Denmark, Finland, UK, Spain and West Germany. These countries produced over 87 per cent of total European output in 1989. The three largest producers in 1989 were France 34,000 tonnes, Italy 29,600 tonnes and Denmark 26,000 tonnes.

The slower production growth rate for trout than for salmon is explained by the fact that the product does not have the same image as salmon and consequently the price is lower. Also there is not much foreign trade in trout meat. Most is sold domestically with attempts being made by producers to balance supply and demand. Growth is therefore related to the prosperity of consumers and to the overall image of fish as a health food. Landill Mills Associates forecast that growth will continue at the same level as in the past.

Others we have talked to feel that growth in future may be faster than in the past. The large trout now being produced are becoming competitive with salmon particularly in the smoked form. Consequently as disease levels increase in some areas salmon farmers are likely to switch to trout. Though prices for the latter are lower than for salmon these are balanced somewhat by lower trout smolt prices and lower disease levels.

Within the trade the trout industry is divided into two groups; producers of small portion sized, 250 grm fish, and large 2-3 kg salmon trout. Production by these two groups in Europe from 1985 to 1989 is given at the bottom of Table 2.5. As can be seen, the great bulk of European production is portion sized trout. Output of this category grew by about 6 per cent per annum over the last 4 years. The large trout group which makes up 20 per cent of the total has grown a great deal faster (14% p.a.) and is expected to continue to grow at this rate. These trout can be produced in both fresh water and in the sea. In France the sea water is too warm in summer and the large trout are grown in fresh water using sterile fish. These fish can be grown to any size required and can be marketed at any time of the year (Chevassus and Faure 1989). Ordinary fish reach sexual maturity at an early age, cease growing and must be marketed at that time.

Table 2.5: *Annual Production of Farmed Trout in Different Countries 1980 – 1989 and forecasts for 1992 (Sea and Inland Production)*

Country	*1980*	*1981*	*1982*	*1983*	*1984*	*1985*	*1986*	*1987*	*1988*	*1989*	*1992 (Forecast)*
						'000 tonnes					
Austria	1.5	1.6	1.8	2.0	2.3	2.5	2.0	2.5	2.7	2.4	3.0
Belgium	0.0	0.0	0.0	0.0	0.0	0.7	0.6	0.6	0.4	0.7	1.0
UK	5.5	6.5	6.0	7.0	8.5	10.2	11.3	13.1	15.0	16.5	25.0
Denmark	17.5	18.0	20.8	23.5	23.9	24.3	24.7	23.0	26.5	26.0	26.0
Faroes	0.0	0.0	0.0	0.0	0.0	0.7	1.1	0.6	1.5	1.5	1.0
Finland	4.8	5.4	6.5	7.6	8.7	9.8	10.5	10.5	15.0	17.0	20.0
France	20.0	21.0	22.0	23.0	24.3	25.5	28.0	32.5	30.5	34.0	34.0
Iceland	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.4	1.0
Ireland	0.2	0.2	0.2	0.2	0.3	0.4	0.5	0.5	0.7	0.8	5.0
Italy	20.4	21.5	19.8	18.0	19.3	20.5	22.6	23.8	28.5	29.6	40.0
Norway	3.4	4.5	4.7	5.1	3.6	5.1	4.3	8.8	9.3	9.3	3.5
Spain	10.0	12.0	12.8	13.6	14.1	14.5	14.5	15.1	15.8	15.8	18.0
Sweden	0.0	0.0	0.8	1.6	2.3	3.1	3.1	4.3	5.5	5.5	7.0
Switzerland	1.5	1.5	1.4	1.3	1.1	1.0	1.0	1.3	1.5	1.5	2.0
West Germany	11.0	13.0	13.5	14.0	14.0	14.0	14.0	14.0	14.4	15.0	15.0
Total Europe	95.7	105.1	110.1	116.8	122.3	132.3	138.2	150.6	167.5	176.0	201.5
US	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0
Japan	17.5	18.1	18.8	19.4	20.0	13.8	15.0	15.0	15.0	15.0	15.0
Chile	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.9	2.5
Total	133.2	143.3	149.0	156.2	162.3	166.1	173.2	185.6	202.6	211.9	239.0
						European Production by Size					
Large trout	–	–	–	–	–	23.1	25.4	28.4	27.5	39.8	69.5
Portion Size	–	–	–	–	–	108.8	112.4	122.0	129.7	135.7	132.0

Source: Landill Mills Associates 1990.

The main producers of large trout at the present time are Finland (17,000 tonnes), Sweden (5,500 tonnes), Norway and Denmark (4,000 tonnes each). In these countries the large trout are produced in sea cages in the same way as salmon. Ireland produced 300 tonnes of large sea trout in 1989. The indications are for substantial growth in this sector in future years particularly if salmon disease levels increase. From an environmental point of view trout are preferable to salmon. They do not attract sea lice in the cages to the same extent.

Chapter 3

THE SALMON MARKET

Introduction

In preparing this chapter, we have drawn heavily on the 1990 Bord Iascaigh Mhara Report on the salmon farming industry prepared in conjunction with Landill Mills Associates (*op. cit.*, pp. 107 *et seq.*). This report is the most up-to-date and best researched document available. We wish to thank BIM for allowing us to draw on its contents.

Overview

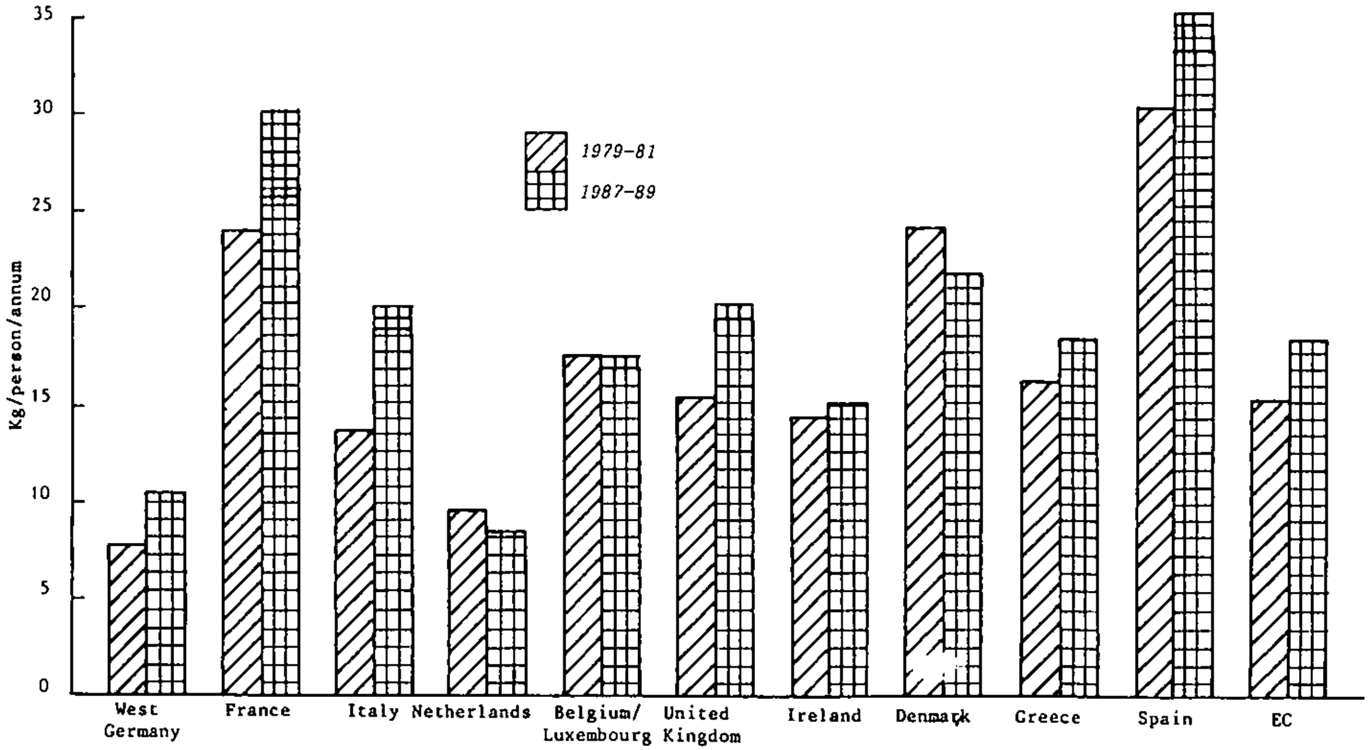
Although the market for fresh and frozen salmon is now world-wide, consumption is heavily concentrated in three markets, the European Community, North America, and Japan.

As indicated in the following analysis, however, these markets are significantly different in structure. The European market shows a strong preference for fresh chilled salmon, mostly farmed and wild Atlantics, and for smoked salmon, which is prepared from fresh Atlantics and from wild Pacific salmon. The "fresh" market also takes small quantities of frozen Chinook, Coho, and bright chum salmon from US and Canadian sources. Small amounts of pink salmon are used for prepared dishes.

The North American market is still dominated by wild Chinook and Coho, though increasing amounts of chum, sockeye, and even pink salmon are now being marketed in fresh and frozen form. Though American consumers prefer fresh salmon, there is far wider acceptance of frozen fish as a close substitute than in Europe. This reflects the distances of the major markets (Boston, New York, Chicago, and Los Angeles) from the production centres (Alaska, British Columbia, Washington, and Oregon), the short harvest season for wild Pacific salmon, and the much greater size and sophistication of the frozen food distribution system in North America.

The Japanese salmon market shows the same kind of segmentation, but – reflecting differences in Japanese consumption patterns – on different bases. At this point, we merely note that farmed salmon are a small but rapidly increasing part of the total supply in Japan, and that farmed Coho from local and Chilean sources are the preferred farmed product.

Figure 1: *Fish consumption in 11 EC Countries.*



Source: Laureti, E., 1991, Rome: FAO.

Fish Consumption

Fish consumption has increased in most EC countries over the past decade. Figure 1 shows that per capita consumption has risen fairly substantially in Italy, the UK, France and Spain, and to a lesser extent in West Germany, Ireland and Greece. Consumption has remained constant or declined in Belgium/Luxembourg, The Netherlands, and Denmark. Reliable figures are not available for Portugal.

Though fish consumption has been declining in some countries, Table 3.1 shows that Atlantic salmon consumption generally has been increasing. The figures in this table, which are derived from production and trade figures, must be taken with some caution because:

(a) the trade figures do not distinguish between Atlantic and Pacific salmon, and the type of fish has to be inferred from the original source of export.

(b) the trade figures are given in product weights, and errors can occur in converting these into round weights, and

(c) since reliable data are not available for inventories of frozen salmon, it was assumed, in preparing the figures, that consumption was equal to production plus imports less exports. This obviously was not true for Norway in 1989, and accordingly Norwegian consumption has not been included in Table 3.1.

Of the other countries listed in Table 3.1, Japan consumes very little Atlantic salmon at present, but if Pacific salmon were included, total salmon consumption would be over 1 kg per person in 1990.

Table 3.1: *Per capita Consumption of Atlantic Salmon in 12 Countries in 1980, 1985 and 1989 (Round Weight)*

Country	*1980*	*1985*	*1989*	*Country*	*1980*	*1985*	*1989*
		Kg				Kg	
France	0.04	0.15	0.83	Italy	0.01	0.04	0.15
USA	0.00	0.03	0.10	Netherlands	0.00	0.04	0.20
West Germany	0.06	0.12	0.28	Switzerland	0.00	0.16	0.24
UK	0.03	0.14	0.41	Sweden	0.23	0.36	1.00
Spain	0.00	0.31	0.25	Ireland	0.20	0.23	0.82
Belgium/Lux.	0.07	0.20	0.55	Japan	0.00	0.00	0.06
				Average	0.02	0.06	0.23

Source: Keogh (1990).

The general impression one gets from the literature is that the consumption base for salmon in most countries is very narrow. An Irish survey carried out by BIM in 1990 showed that only 29 per cent of those interviewed admitted to ever having eaten salmon and only 4 per cent were regular eaters (Keogh, 1990). Similar patterns have been reported for a number of other countries. Hence there would appear to be scope for broadening the salmon consumption base on a global basis – particularly during periods when prices are relatively low.

Salmon Products

There are five main types of salmon product:
(1) Fresh salmon.
(2) Frozen dressed salmon.
(3) Smoked salmon.
(4) Processed products – salmon based recipe meals.
(5) Canned salmon.
Each of these products is described briefly below.

Fresh Salmon

Most Atlantic salmon is now retailed in fresh chilled form. It is usually sold by the producers in the round (ungutted). Subsequently, it may be steaked or filleted at point of sale. However, the strong shift to supermarkets in retail fish sales has been accompanied by a more sophisticated pattern of presentation. Most supermarkets in the UK, France, Ireland, and the US display fresh salmon in a variety of cuts, and sizes.

Frozen Salmon

Salmon loses value on freezing; it may sell at a lower price and additional costs are incurred in freezing and storage. Hence, if supply to market can be regulated, it is more profitable not to freeze. Because most Atlantic salmon is farmed, market supplies can be tailored to demand, and with fast air freight and modern refrigeration techniques, it is possible to ship salmon long distances in the fresh state. On the other hand, a major proportion of the Pacific salmon, which comes in large runs over a short period, must be frozen, smoked, or canned.

The traditional consumer suspicion of frozen fish has broken down in several major markets. US and Japanese consumers, for example, have begun to accept *properly handled* frozen fish as equal or superior in quality to most fresh fish. In France, however, the prejudice still lingers, but the experience with white fish suggests that frozen farmed salmon will assume a larger role in the market, particularly if production continues to outrun demand. Three points regarding the freezing of salmon should be emphasised:

(1) The sooner it is frozen after killing the better the flavour;
(2) To obtain the best results it should be dipped in water immediately before freezing, and
(3) it should, if possible, be consumed within 6 months of being put in the freezer. After this time it tends to lose flavour.

Smoked Salmon

This product has traditionally been a high priced luxury delicacy. Recently it has become much more accessible as its price has declined in real terms. Smoked sides were traditionally bought whole and sliced at home. Now much of the product is sold pre-sliced in small vacuum packs of 100-200 grams.

Processed Products

A wide range of salmon products is now becoming available. These include cold salad delicatessen products, salmon sausages, recipe meals, and catering packs. The amount of salmon in these packs varies with the product. In general, they contain cheaper frozen Pacific pink salmon or lower grade Chinook and Atlantics.

Canned Salmon

Much of the harvest of Pacific salmon is canned, with pinks, sockeye, and chum the principal inputs. In recent years there has been a marked shift from canning to frozen processing, fuelled by Japanese and US demands for less seasonal supplies of "fresh" salmon. The split between freezing and canning varies sharply from year to year, depending on price expectations. Canned salmon competes more directly with other canned fish, such as sardines and tuna, than with fresh or smoked products.

Sport Fisheries

Sport fisheries based on wild salmon support important industries in Northern Europe and North America. These generate considerable income in the areas where the fisheries occur. It was thought at one time that farmed salmon could be used to supplement the wild stock in sport fisheries. This has not worked out very well in practice. When hooked farmed fish come meekly ashore without putting up a fight; the discerning fishermen are thus not very interested. The situation is, however, not entirely negative. Less discriminating fishermen seem to enjoy angling for farmed salmon, and a number of reservoirs in England are used for this purpose. In general, however, the trend toward selective breeding of farmed salmon produces characteristics that make them less and less desirable for recreational fishing. If the goal of artificial enhancement of salmon were to improve sport fishing, an entirely different type of hatchery/release programme would be followed.

The Market in the Different Countries

As production of farmed Atlantic salmon increased over the past decade, so also has the market. Table 3.1 shows that growth in consumption has not been uniform in the different consuming countries. In Italy, Spain, and France, average growth rates between 1987 and 1989 have been over 50 per cent per annum, while in Belgium, the UK, and West Germany growth has been less than 30 per cent. Countries with annual growth rates of 30-50 per cent include The Netherlands, the US, Ireland, and Sweden. Trade in fresh and frozen Atlantic salmon in EC countries in 1990 is shown in Table 3.2. Total imports in that year were 130,000 tonnes. These came mainly from Norway (93,000 tonnes), Faroe Islands (11,000 tonnes), UK (8,900 tonnes), Denmark (8,800) and Ireland (4,500 tonnes). Danish exports are all re-exports. Denmark produces few, or any, salmon. The largest importing country is France with imports of 56,700 tonnes in 1990. Denmark comes next with 22,500 tonnes, followed by Spain (15,200 tonnes), Germany (14,700 tonnes), Italy (6,200 tonnes) and UK (4,500 tonnes). Irish imports were only 435 tonnes, most of which came from Norway.

There were also imports into Europe in 1990 of considerable amounts of frozen Pacific salmon. In addition there was trade in smoked salmon and fresh chilled and frozen salmon fillets. It is not possible to distinguish the latter as between Atlantic and Pacific salmon from the foreign trade statistics.

Market trends in the more important salmon-consuming countries in 1989 are discussed below.

The French Market

France is the pre-eminent consumer of farmed salmon. It is also the major market for Irish salmon. Its physical proximity makes it the easiest continental market to access from Ireland. Finally, French consumers have historically regarded wild Irish salmon as a premium product, and that reputation has carried over to the farmed product. Major Irish marketers are firmly established with French marketing networks.

Table 3.2: *Trade in Fresh and Frozen Atlantic Salmon in EC Countries in 1990*

	Importing Countries											
Exporting Countries	*EC12*	*Bel/Lux*	*Denmark*	*Germany*	*Spain*	*France*	*Ireland*	*Italy*	*The Netherlands*	*Portugal*	*Greece*	*UK*
France	325	97	25	47	11	–	1	69	3	–	–	72
Belgium/Lux	175	–	–	9	–	146	–	–	17	1	–	2
Netherlands	477	121	17	140	16	111	–	70	–	–	–	2
Germany	130	3	59	–	–	9	–	–	59	–	–	–
United Kingdom	8,872	609	45	173	132	7,380	82	122	319	7	3	–
Ireland	4,498	61	–	141	607	3,308	–	10	58	–	–	313
Denmark	8,784	943	–	2,374	279	4,055	–	451	367	22	11	282
Iceland	1,756	37	134	6	87	1,469	–	2	1	1	–	19
Faroe Islands	11,103	391	4,447	746	1,748	2,962	15	338	61	–	–	395
Norway	92,987	4,078	17,085	11,024	12,236	37,276	337	5,171	2,378	19	–	3,383
Sweden	589	1	500	25	50	13	–	–	–	–	–	–
Greenland	180	–	180	–	–	–	–	–	–	–	–	–
Other	236	2	56	34	13	27	–	8	28	66	–	2
Total	130,112	6,343	22,548	14,719	15,179	56,756	435	6,241	3,291	115	14	4,470

Note: Imports from and exports to non-European countries excluded. Ireland's total exports of fresh and frozen Atlantic salmon in 1990 were 4,976 tonnes, of which 384 tonnes went to the USA and 104 tonnes to Japan.

Source: Irish data from Irish Trade Statistics; all other figures from *EUROSTAT.*

Salmon consumption in France more than doubled between 1985 and 1989, from 25,455 to 53,500 tonnes round weight. This growth was achieved by a large increase in the use of Atlantic salmon, consumption rising from 8,400 tonnes (round weight) in 1985 to 42,500 tonnes in 1989. This increase was accompanied by a decline in consumption of Pacific salmon over the period from 17,000 to 11,000 tonnes.

Source of French Supplies

Norway is the main provider of salmon to the French market, supplying about 55 per cent of imports in 1989 and 66 per cent in 1990. About 70 per cent of imports are in fresh form, 27 per cent are frozen fish and the remainder are smoked. Other important suppliers to the French market in 1989 were UK – 13.0 per cent, US – 11.7 per cent, Ireland – 5.8 per cent, and Canada – 4.5 per cent. US and Canadian supplies are all frozen Pacific salmon. Norway, the UK, and Denmark are the main sources of smoked salmon imports.

Disposal of Salmon on the French Market

In 1989, about 80 per cent of French salmon sales took place in retail stores of various kinds (fishmongers, delicatessens and chain stores), 15 per cent went to caterers, and 5 per cent was exported. Practically all the exports were smoked salmon.

Of the retail sales, about 47 per cent was smoked salmon, 40 per cent was fresh fish, prepared meals accounted for 6 per cent, and the balance was frozen Pacific salmon. Within the catering sector, three-quarters of sales were fresh Atlantic salmon and the remainder, smoked salmon of both Atlantic and Pacific origin. Of the smoked salmon, 27 per cent was sourced from fresh Atlantic salmon, and 20 per cent from expensive frozen pacific salmon (Coho and Chinook). Some 15 per cent was imported in smoked form.

Prices

Prices (CIF Boulogne) for large salmon increased erratically from Stg.£3.75/kg in 1981 to Stg.£5.22/kg in 1987. They dropped somewhat to Stg.£4.4/kg in 1988 and fell drastically to Stg.£3.4/kg in 1989. Prices for small fish in 1989 went as low as Stg.£2.7/kg which is less than average cost of production. As stated in Chapter 2, the Norwegian compensatory action re-established prices on a more stable basis in January 1991 and did so on a level more in keeping with production costs. However, prices declined again shortly afterwards and are still very depressed.

Prices obtaining in France in May 1990 make it clear that salmon is no longer a premium seafood like shrimps, scallops, or even high quality white fish. Indeed, species which at one time were not remotely comparable, such as portion trout and cod, are now in the same price bracket as salmon, with sole, turbot, and many of the shellfish much more expensive. Fresh Atlantic salmon prices are now fairly similar to those for the better meat cuts, but smoked salmon, both Atlantic and Pacific, is still a prime product.

Outlets for Salmon in France

Retail

Some 700 hyper- and supermarkets in France account for 60-70 per cent of salmon retail sales. These stores consequently have great power to develop a product, on the one hand, and to push down its retail price on the other. The harnessing of this power has been a crucial factor in the development of the fresh salmon market. In the mid-1980s, the chain stores saw the prospects for capitalising on salmon's rapidly reducing price to promote it as a prominent attraction. This policy succeeded, but there is considerable debate as to how much scope there is to continue further expansion in this way. Many traders feel that salmon is now overdone as a promotional item. Having established its position at current low prices, it will now have to take its place amongst the range of fresh fish on offer in the supermarkets. Others point out that large sections of the population seldom eat salmon and that there is scope for increasing sales among such people, particularly in view of the prospect of continuing increases in prices of quality white fish. Price elasticity of demand in the retail sector has yet to be fully tested.

Catering

There is no conflict of view about the scope for the catering sector in France. Salmon appears on nearly every quality restaurant menu and is no longer a special feature. If anything therefore alternative prestige items are the customer's choice. Hence growth of salmon consumption in the quality catering sector must be limited. On the other hand, where bulk catering is concerned, low cost frozen salmon will usually be sought on price grounds, and this in all likelihood will mean use of Pacific salmon.

Smoked Salmon

The smoked salmon trade also deals with a segmented market. The traditional demand for custom-sliced, high-quality smoked fish is giving way to a rapidly expanding market for pre-packed sliced product, sold mostly through chains rather than speciality fish stores and delicatessens.

The increasing availability of low cost Atlantic salmon has led to replacement of prime Pacific species (Chinook and Coho), the traditional French smoker's raw material. Pacific's share of the smoked market has dropped dramatically from 75 per cent in 1985 to 25 per cent by 1989, matched by a substantial drop of 60 per cent in the actual quantity of Pacific salmon smoked. Some traders think that this trend towards Atlantics for smoking will continue, though developments in late 1990 suggest some resurgence in demand for top quality Chinooks and Coho by smokers.

New Products

Sophisticated secondary products are now beginning to be developed. This sector, is, however, very small and is highly fragmented, with a host of different products based on cheap frozen Pacific species. Growth in the market is viewed as limited.

Forecasts for France

Traders currently hold conflicting views regarding the future growth of the French salmon market. There is concern about continued growth in world production of farmed fish, coupled with a feeling that the French market cannot continue to expand at the rate seen so far. It is believed that there will be two phases to sales growth over the next five years. The current oversupply and related low prices will prevail for the next one to two years. By then, slower growth in output should lead to a firming of prices. Projections for the different sectors are as follows:

It is estimated that consumption of fresh Atlantic salmon in retail and catering will increase from 26,000 tonnes in 1989 to 36,400 tonnes in 1992 and to 41,600 tonnes in 1995. Smoked Atlantic salmon is forecast to go from 16,500 tonnes (round weight) in 1989 to 25,900 tonnes in 1992 and to 31,400 tonnes in 1995. When these figures are aggregated, total consumption of Atlantic salmon in round weight terms is forecast to rise from 42,500 tonnes in 1989 to 62,300 tonnes in 1992 and 73,000 tonnes in 1995. Over this same period, consumption of Pacific salmon will remain more or less unchanged at 11,000 tonnes. A decline of 3,000 tonnes in the smoked product will be compensated for by a similar increase in salmon used in secondary products.

The UK Market

Although the UK is a significant producer of farmed salmon, it has also become a major market for salmon. Salmon consumption, other than canned, increased from 12,500 tonnes (round weight) in 1985 to 26,900 tonnes in 1989, an increase of over 114 per cent over the four years. Consumption in 1990 is estimated at 32,000 tonnes. In addition, canned salmon consumption in 1989 was about 34,000 tonnes (round weight), although this consumption has declined by about 16 per cent since 1985.

Despite increased home production of farmed Atlantics in the UK, total imports of salmon have not declined in recent years. In fact, they increased slightly between 1985 and 1989, from 7,200 to 7,900 tonnes (product weight). There has, however, been a change in the import mix over this period. Imports of Atlantic salmon have increased while those of Pacific salmon have declined. Hence, as in France, Atlantic salmon is tending to replace the Pacific species. The principal suppliers of imported Atlantic salmon to the UK are Norway, with smaller amounts coming from the Faroes, Ireland and Denmark.

In line with increased production, UK exports of salmon have increased substantially in recent years from 4,000 tonnes in 1986 to 11,000 tonnes in 1989 (round weight). Most of these exports go to France. About 80 per cent of the exports are fresh salmon, most of the balance being smoked. There is now a substantial smoked salmon industry in the UK based mainly on Atlantic salmon.

Disposal of Salmon on UK Market

Of the total consumption (other than canned) of 27,000 tonnes in 1989, 27.3 per cent was sold in fresh form through retail outlets, 11.7 per cent went to the catering trade, and 14.3 per cent was processed for the home market. Some 46.7 per cent (13,150 tonnes) went to smokers who produced 6,300 tonnes of smoked fish, of which 5,300 tonnes were sold on the home market and 1,000 tonnes were exported. In round weight terms, consumption of smoked salmon in the UK in 1989 was about 10,700 tonnes which is about the same as the amount of fresh salmon sold by the retail and catering trade. Smoking is certainly an important outlet for salmon in recent years.

Salmon Prices

The ex-farm price of round farmed salmon in the UK market reflects CIF prices in other European markets. Farm-gate prices for farmed salmon in May-June 1990 varied from Stg£2.60 per kg for 1-2 kg salmon to Stg£3.90 for 3-4 kg salmon. Wholesale prices at that time were Stg£3.10 to Stg£4.60 for fresh salmon, while retail prices in Sainsbury's supermarket were Stg£7.67/kg for whole Scottish salmon and Stg£10.95/kg for salmon steaks. Smoked salmon in the delicatessens was Stg£22/kg, while it was selling for Stg£30.75/kg in Marks and Spencers.

These prices were higher than those for cod steaks which were selling for Stg£7.24/kg or plaice fillets at Stg£5.70/kg. Sirloin steaks at Stg£16.50/kg were, however, much dearer than salmon steaks, while best pork chops at Stg£11.88/kg were around the same price as salmon steaks.

The above prices demonstrate a very significant difference between the UK market and those of most other European countries in regard to the very high retail mark up attributed to salmon. It seems that no attempt has been made to pass on the substantial farm-gate price reductions to the consumers of fresh salmon. Prices have come down in real terms, but in current terms, the retail margin has been maintained at a steady Stg£8/kg for most of the 1980s. According to Landill Mills, it is the retailers and the major chains, in particular, who are benefiting from the reduced ex-farm prices rather than the consumers.

Outlets for Salmon in the UK

Retail

On a more positive note, Britain's rapid shift from traditional shops to chain retail distribution of food products is reflected recently in higher overall fish and salmon sales. In the past, the limited availability and high prices of wild Atlantic salmon confined sales largely to catering establishments and a limited number of speciality fish shops, supplied directly or through central wholesale markets. More recently, the growth of multiple-unit retailing has shortened distribution channels for fish, and dramatically increased the availability of good-quality fresh and frozen fish. The chains provide a natural outlet for much of the sudden increase in total supplies of Atlantic salmon that followed the rapid growth of farming in Norway and Scotland.

These changes made it possible to dispose of the large increases in supply at relatively stable real prices until 1987, when the prospect of general oversupply became evident. The subsequent drop in prices brought salmon into the range of a variety of substitutes and demand exhibited an unexpected degree of elasticity.

As in France, the top end of the UK market – hotels, "white tablecloth" restaurants, and clubs – was the first segment attracted to farmed salmon, and the one most likely to benefit from quality control and year-round supply. While it is far from saturated, further growth is likely to be much slower than in the past.

There is still much room for expansion in the more price-conscious retail market. The likelihood of continued stability or decline in the supply of high-quality white fish, the expectation of stability of real prices for poultry (already at a floor level cost), and growth in per capita disposable incomes all suggest an improved competitive position for farmed Atlantics, fresh and smoked, in the UK. A recent paper indicates that less than 50 per cent of UK consumers are now users of salmon (O'Hara, 1990). If continuation of attractive prices, improvement in numbers of product forms, and the effective promotional programmes of the retail chains enable salmon producers to reach even half of that untapped market, growth prospects appear promising.

A word of caution is in order. The growth in salmon consumption in Britain occurred during a period of generally strong economic growth. The current prospect of a continuing recession could cut into the demand for salmon – particularly imports – for several years. As herring producers have discovered, it takes time and money to reclaim a lost segment of the seafood market.

Caterers

Catering absorbs significant quantities of salmon in the UK – 3,300 tonnes per annum of fresh salmon and further amounts of frozen processed and smoked fish. There are two principal catering sectors, the quality restaurants which are the traditional outlets for salmon and the mid-quality caterers, such as the chain restaurants, hotels and enterprising pubs. The mid-quality caterers now account for about 50 per cent of catered salmon sold. Up-market restaurants serve less than 15 per cent and the balance is absorbed by a variety of other catering outlets, such as travel and institutional caterers and canteens.

Caterers have benefited significantly from the fall in salmon prices. As a result, salmon has become an average-cost main course item in the mid-quality restaurants. There is thus scope for increasing sales in these outlets. Scope for expansion in the high-quality sector, on the other hand, is seen as very limited.

Smoked Products

The smoked salmon sector is very important in the UK, absorbing almost 50 per cent of net salmon supplies. As a high-quality, high-cost prestige product, smoked salmon is in the same position as fresh salmon when it comes to expanding its sale volume. Lowered raw material prices are not being passed on to the consumer on the grounds that lowering retail prices would downgrade the product, and lost margins would not be made up by increased sales.

In the smokers' view most growth in the market must come from the development of value-added smoked products, and product diversification is now under way. Instead of traditional smoked sides, smokers are offering a range of products in 8 oz. and 1 lb packs. The Shetland Smokehouse produces smoked salmon pate containing 75 per cent salmon, with cream cheese, lemon, and spices. A further development is the smoked salmon roulade – a smoked salmon slice rolled with a filling of cream cheese and dill presented in an attractive clear tray containing sufficient for a party starter for four persons. Smoked salmon is also being turned into sausages. Unlike France, the future for the smoked salmon market in the UK is widely seen as lying in broadening the product range, rather than in expanding sales of existing products through price reductions.

Forecasts for the UK

Landill Mills Associates project that consumption of fresh Atlantic salmon in the UK will increase from 11,000 tonnes in 1989 to 14,000 tonnes in 1992 and to 18,000 tonnes in 1995. Smoked Atlantic salmon consumption is projected to rise from 11,000 tonnes in 1989 to 16,800 tonnes in 1992 and to 22,400 tonnes (round weight) in 1995. Among secondary products, consumption of Atlantic salmon is projected to go from 2,000 tonnes in 1989 to 10,700 tonnes in 1992 and to 41,000 tonnes by 1995. The latter figure appears very high but the predominance of ready-prepared meals in the UK market suggests that this is a possible outcome. Aggregation of these figures shows total consumption of Atlantic salmon rising from 24,000 tonnes in 1989 to 41,500 tonnes in 1992 and to 81,400 tonnes in 1995. The corresponding change in Pacific salmon consumption is from 3,000 tonnes in 1989 to 2,100 tonnes in 1995.

The German Salmon Market

Germany imported 18,000 tonnes (round weight) of Atlantic salmon in 1989, of which about 5,000 tonnes were smoked product. This equates to consumption, as virtually no salmon are caught and there are very few re-exported. The corresponding consumption in 1985 was 7,400 tonnes. Salmon are imported into Germany in fresh or frozen form or as smoked fish. It is estimated, however, that 70 per cent of all unprocessed salmon imported is eventually smoked by German smokers. This means that as much as 80 per cent of all salmon retailed in Germany is in smoked form.

German salmon imports are dominated by Norway. Norwegian fresh or frozen fish are imported directly, while imported smoked products, most of which come from Denmark, are based mainly on Norwegian fish. In round weight terms, Norway supplies, both directly and indirectly, almost 90 per cent of German supplies. Irish exports to this market are very small – 141 tonnes in 1990.

Product Sectors

Fresh Salmon

Although prices have declined somewhat in the last few years and availability has increased, fresh salmon is still not a strong retail product. The fresh/smoked mix remains as it was five years ago at 20:80. This distinguishes the former West German market from the rest of Europe. The relatively low fresh fish consumption may be due to very high retail prices for fresh salmon in Germany, about 50 per cent higher than in France, IR£9.5 vs. IR£6.3/kg. Smoked salmon prices on the other hand, are not greatly out of line with those elsewhere.

According to Landill Mills Associates, some traders see scope for growth in the fresh retail sector if prices decline, but this view is by no means unanimous. A gloomier view expressed by some wholesalers is that fresh salmon has already lost its top-of-the-market image *vis-à-vis* other fish, and the market is likely to remain static in the near future. In 1989, a German made TV film about Scottish salmon farming presented the industry in a very unfavourable light from an environmental point of view. As a consequence, the current image of salmon in Germany leaves much to be desired.

We are somewhat sceptical of this pessimism. Changes in German demographic patterns with reunification, increasing "Europeanization" of consumer behaviour, the possibility of more active promotion of fresh fish, in general, and salmon, in particular, by chain retailers suggest to us that retail sales of fresh farmed salmon could rise substantially.

The catering sector continues to be an important outlet for fresh salmon. Virtually every traditional German restaurant has salmon on the menu. In addition, salmon in gutted or steak form is now almost universally available in the chain stores and fishmonger/food shops, even in working class areas. All supermarkets that have fish counters offer salmon, but not all of the smaller markets have fish counters. The strength of the restaurant interest in fresh salmon also indicates that the scope for expansion of retail sales may be understated.

Smoked Salmon

Smoked salmon is sold in virtually all supermarkets and chain stores. It is widely available in restaurants, offered in a wide range of forms. In German terms the product is relatively inexpensive. Smoked salmon steaks run from DM10-20 (IR£3.7-7.5) per portion in Hamburg restaurants.

Niches for Irish smoked products exist in Germany and, it is hoped, will expand. An Irish product, the "Shamrock Express", promoted with a high-quality image, has been very successful. Currently this promotion operates only in the Wiesbaden area, but there are plans to expand it into other regions.

Forecasts for Germany

As elsewhere in Europe, there is a wide diversity of opinion concerning the future growth of the German salmon market. Some feel that there is a finite market for smoked salmon, as there has proved to be for smoked eel. Others feel there is room for growth, although at a slower rate than over the last few years. It is believed that German unification will eventually lead to increased demand. As a luxury item which has been denied the majority of former East German consumers for many years, salmon is the sort of item that might be high on many future shopping lists. However, it will take some years before this comes about. Recent integration developments have actually weakened the market for the time being.

Having taken the views of a sample of traders, Landill Mills Associates estimate that the fresh salmon sector might grow by 15 per cent per annum (from a rather low base) and the smoked sector by 7.5 per cent per annum, up to 1992. After that, growth may be determined by events in the former East German market. It seems clear, however, that Scottish and Norwegian salmon producers will come under increasing pressure from the German Green lobby. The industry in Ireland might profit from this by stressing the more "free-range", open-water nature of Bridgestone cages.

Quantifying the forecasts, we estimate that fresh Atlantic salmon in retail and catering outlets will rise from 4,200 tonnes in 1989 to 5,600 tonnes in 1992 and to 6,900 tonnes in 1995. Smoked consumption will increase from 13,800 tonnes in 1989 to 17,100 tonnes in 1992 and to 19,900 tonnes in 1995. Aggregation of these figures gives 18,000 tonnes (round weight equivalent) in 1989, 22,700 tonnes in 1982 and 26,800 tonnes in 1995. Over the same period no change is expected in the consumption of Pacific salmon which will remain at about its present level of 1,000 tonnes per annum.

The United States Market

Atlantic salmon represents only about 16 per cent of total US salmon consumption, including canned, but the market is important to Atlantic salmon producers because of its overall size.

Demand for seafood in the USA is low, relative to that in Europe. Average annual per capita consumption is only about 7.23 kg compared with 30 kg in France and 20 kg in the UK. However, demand for seafood is rising faster than for other sources of protein. Fish consumption is positively correlated with income which, in turn, is probably related to health factors.

Domestic consumption of salmon in the US in 1989 was 143,700 tonnes (round weight), of which 74,300 tonnes were canned salmon and 69,400 tonnes fresh, frozen or smoked salmon. All of the canned salmon were of Pacific origin. Of the non-canned salmon, 46,000 tonnes were Pacific salmon and 23,500 tonnes (round weight) Atlantic salmon of which 20,500 tonnes were imported. Practically all of the latter were farmed fish.

Of the Atlantic salmon imported some 14,000 tonnes (round weight) came from Norway, 3,000 tonnes from Canada and 1,000 tonnes from the UK. The remaining amounts came from Chile, The Faroes, Iceland and Ireland. Imports from Ireland were about 400 tonnes. If Pacific salmon are included, Norway in 1989 had about 45 per cent of the US fresh and frozen market for farmed fish, and Canada has 40 per cent. The growth in imports of Atlantic salmon has not been even. Rapid growth up to 1986 became stalled in 1987 due to high CIF prices and resumed again only in 1989 when prices dropped significantly. US importers are very price conscious, and as a result the salmon trade is very vulnerable to price rises caused by exchange rate fluctuations and other factors.

The ability of exporters to reduce prices is, however, a mixed blessing. In 1989, wholesale prices of Norwegian salmon in the US fell below $6.5/kg. This undermined Chinook prices, and an anti-dumping campaign was instituted against Norway by the US International Trade Commission. The Commission has now concluded that the US industry has been damaged as a result of Norwegian sales at less than fair value, and as stated in Chapter 2, a duty of 16.32 per cent across the board has been imposed against all fresh Norwegian salmon imports. This duty is going to make it very difficult for the Norwegians to compete against other European, Chilean and North American salmon farmers in future years.

Apart from the levies, distance from the US market is also going to cause difficulties for the Norwegians, and indeed for all European salmon farmers, now that Atlantic salmon is being produced in North America and Chile. Freight costs to Los Angeles are only about US$0.37/kg by land from British Columbia in Canada, compared with US$1.68/kg by air from Chile and US$2.75/kg from Norway.

Charges to New York are about the same from Norway and Chile (US$2.11/kg) but these are much higher than those from British Columbia to New York, which are only about US$0.84/kg. The combined effect of these cost factors has produced an odd "two-tiered" price structure for farmed Atlantic salmon in the US, based on perceived quality and cost difference. For several months in late 1990 and January 1991, Norwegian Atlantics sold for almost US$1.00/kg above Canadian, Chilean, and US farmed Atlantics but as Chilean and North American production increased, this differential (and the anti-dumping penalties) has forced Norway out of the US market. As a result, it would appear that a worthwhile niche for very high-quality Irish fresh and smoked fish could be established, particularly in the Northeast and mid-Atlantic regions.

Outlets for Salmon in the USA Market

Structure

Of the 69,000 tonnes of non-canned fish consumed in the US in 1989, some 35,000 tonnes were consumed fresh, 19,000 tonnes were frozen fish, and 15,000 tonnes (round weight) were smoked fish. Sixty per cent of the fresh fish is used by the catering industry mainly in the quality restaurants, while the remaining 40 per cent is sold retail. As in Europe, the once-dominant position of speciality fish shops is rapidly giving way to the modern, well-equipped and price-conscious chain retailers. Kazilionis (1990) points out that 41 per cent of US supermarkets now have separate seafood departments and that 53 per cent expect to have them shortly.

The US market has strong seasonal and regional characteristics. The two major areas of consumption are the New England/mid-Atlantic area and the Pacific west coast. In the East, consumption is strongly influenced by the European ethnic origins of the inhabitants and their salmon consuming traditions, especially among the Jewish Community. The proximity and availability of supply from Boston and New York are also factors; most European imports come through these cities.

On the West Coast, Atlantic salmon has to compete with the wild Pacific product which, of course, has a traditional following. Since the latter is seasonal in its supply, only available fresh from April to November, most Atlantic salmon is sold in the winter months. This is also true, to a lesser extent, on the East Coast, as well. Atlantic salmon does not have a great following in its own right except in the top-class restaurants. The fact that it is available fresh out of the Pacific season has enabled it to break into the market. Even in Seattle, Washington, the hub of the Pacific salmon marketing network, Atlantic salmon is regularly available in restaurants and hotels.

Prices

Although retail salmon prices vary considerably between different cities ($16-26/kg), reflecting transport and other costs, prices for fresh Atlantic and Pacific salmon within the same store are usually not very different. There is a slight premium of 6-7 per cent for Irish salmon in some eastern stores, but traders believe that this is unlikely to be maintained. Salmon is now regarded as a commodity fish, and US processors and distributors believe that 99 per cent of consumers cannot distinguish between salmon of different origins. This is not true in all regions, however; the important West Coast market clearly separates wild and farmed fish.

Typical charges for Atlantic salmon along the distribution chain in 1989 were as follows:

Fresh Round 3-4 kg.	*FOB* (Europe)	*Airfreight N.Y.* ($2.1/kg)	*Port Handling* (4%)	*Importer* (5%)	*Wholesaler* (8%)	*Distributor* (5%)	*Retailer* (60%)
US$/kg.	6.0	8.1	8.3	8.8	9.5	10.0	16.0

Market Sectors

Retail

Surprisingly large regions in the US, particularly the Midwest and mid-South, consume little or no fresh or frozen salmon. This situation is likely to change as the large supermarket chains continue to expand their share of the retail market. They can and will supply salmon, wild or farmed, on a year-round basis, drawing on European, North American, and Chilean sources. And equally important, they are now offering a much better range of seafood items and are promoting them actively because of their recognised value as "traffic generators". The sheer size of the US market means that even a small penetration of the virtually untouched market segments would add significantly to world demand.

Catering

The majority of Atlantic salmon is currently consumed in the catering sector mainly in the medium- to high-priced restaurants (the "white tablecloth" market). The top category restaurants maintain a strong preference for fresh fish, and this usually overrides the choice of species. They are prepared to substitute frozen for fresh salmon only out of season and then only from suppliers who specialise in high-quality frozen Chinooks and Coho. In this market segment the main competitors for Atlantic salmon are wild Coho and Chinook when in season (summer and autumn) and other premium-priced seafoods (swordfish, halibut, lobster, crab etc.) at other times of the year.

Atlantic salmon is not necessarily the premium salmon species in the US. A 1987 market research audit covering various types of restaurants suggested that farmed Chinook was favoured over Atlantic salmon in expensive restaurants in winter when wild fresh Pacific salmon was not available. However, this preference was reversed in favour of Norwegian salmon in the less expensive restaurants.

Smoked Salmon

The total size of the US smoked salmon market is small – about 7,500 tonnes per annum. Over 90 per cent of this product is produced by US domestic smokers from Pacific salmon species. The balance comes from imports. Very little Atlantic salmon is smoked in the US.

The major US market for smoked salmon is the Jewish Community. Smokers interviewed by Landill Mills Associates felt that smoked salmon had a very bright future in the US in view of its up-market associations. They reported their own businesses were growing fast. Growth in this area, however, is more likely to increase the demand for Pacific than for Atlantic salmon. The average retail price for smoked salmon is about US$18/kg.

Forecasts for the US

The underlying trend for the US salmon market must be one of growth both in the medium and long term. This view is based on the health awareness among US consumers, their rising disposable incomes, and the continuing shortages of competing white fish. What matters, however, is the share that European farmed Atlantic salmon can gain in this market. The rising output of "locally" farmed Atlantic and Pacific salmon in mainly, New Brunswick and British Columbia, will provide highly competitive alternative supplies of fresh and frozen salmon, while Chilean exports will similarly undercut European supplies in price, particularly on the West Coast.

Landill Mills Associates estimate that future consumption of Atlantic salmon will grow at 25 per cent per annum for the retail trade and at 10 per cent for catering, from 21,500 tonnes in 1989 to a combined total of 33,600 tonnes per annum by 1992, and 39,600 tonnes by 1995. Of the latter demand, it is estimated that 12,500 tonnes will be supplied by Chile and 22,000 tonnes by US and Canadian producers, leaving only 5,100 tonnes to come from Europe, compared with about 17,000 tonnes in 1989. Looking further ahead, it would appear that relatively low-cost producers in the Western hemisphere will supply much of the extra demand, and the eventual displacement of European supplies would seem likely.

This rather unpromising outlook for European suppliers does not mean that opportunities do not exist for Irish salmon. There are niches in some of the Irish-named chain stores (e.g., Houlihans) which could be exploited and promotion of Irish smoked salmon in the New England market, where sympathy for things Irish is strong, would seem to be the best bet.

The Spanish Market

Spain with a total per capita fish consumption of about 37 kg per annum continues to be one of the most important seafood markets in the world. The Spaniards have traditionally been large consumers of white fish (hake and cod) and until recently were never big consumers of salmon, which is still regarded as a luxury item.

The Spanish salmon market has grown rapidly throughout the 1980s, particularly over the last five years, when consumption rose from 1,500 tonnes (round weight) in 1985 to 9,700 tonnes in 1989 and 11,000 tonnes in 1990. Norway is the main supplier of salmon to Spain, with smaller amounts from the Faroe Islands, Ireland, Denmark, Scotland and other European producers. Imports of frozen Pacific salmon are only about 700 tonnes per annum.

In common with other European markets, the Spanish salmon market has seen continuous price declines and increasingly intensive competition between foreign producers since 1986. In March 1990, the wholesale price of Norwegian salmon delivered to Barcelona was IR£3.9/kg. By the time these fish reach the retail markets, prices are some 50 per cent higher – around IR£5.6/kg. Salmon steaks are retailed at prices 45 per cent higher than this (IR£8.2/kg).

Norwegian imports still dominate the market, but Scottish and Irish salmon are beginning to be perceived as having a slight quality advantage. However, prices continue to remain of primary importance to Spanish buyers.

Although Madrid and Barcelona remain the most important salmon markets, there is a continuing shift towards the holiday areas of the south-west. This has given the Spanish market a new regional and seasonal dimension, as the large wholesalers are attracted to the tourist-led demand for fresh and smoked salmon products in both the retail and the catering trades.

Product Sectors

Fresh and Frozen Salmon

Fresh, farmed salmon is now readily available in most suburban fish shops. It also is offered in fresh and smoked form in the top-class chain stores. There seems to be a widespread consensus among traders however that there is little scope for salmon substituting for white fish. Changing relative prices may change this, however. Turbot and hake are now more expensive than salmon at all levels in the distribution chain, and world shortages of white fish indicate increasing price disparities favouring salmon. Whole gutted hake sells at IR£7.6/kg in the shops, compared with IR£5.5/kg for whole salmon.

Smoked Salmon

There has been a significant increase in smoked salmon consumption in recent years, from 560 tonnes in 1986 to 2,000 tonnes in 1989. This is highlighted by an increase in the number of operating smokers, from 11 in 1986 to 25 at the present time. Smoked salmon remains, however, a relatively expensive food in Spanish terms (around IR£16.5/kg). The market potential is correspondingly restricted.

Catering

Figures are not available for the quantity of salmon used in catering, but traders interviewed by Landill Mills Associates were far less optimistic about future continuing growth than they were for the retail sector. Indeed, zero growth in the use of salmon for catering is seen as likely.

Forecasts for Spain

Opinion is varied with regard to growth beyond 1991. There is broad agreement that the retail sector presents more prospects for growth than the catering sector, but many traders feel that there is a finite limit to the market for traditional salmon products. Landill Mills Associates suggest an average growth of 23 per cent per annum up to 1992, dropping to 13 per cent per annum thereafter. If these growth rates are attained, consumption will rise from 9,700 tonnes in 1989 to 17,800 tonnes in 1992 and 25,900 tonnes by 1995. All the growth is expected in fresh retail sales and smoking.

In spite of the Norwegian domination of the Spanish market and the predicted slowdown in the rate of growth, there are still opportunities for fresh Irish salmon and salmon products in Spain. The opportunities for smoked Irish salmon are limited, however, since the salmon smoking industry in Spain is well established. A low-fat salmon requirement by Spanish smokers may provide a competitive advantage for Ireland. Another option would be to establish an Irish-owned smoking operation in Spain. This option has already been taken up by a Norwegian producer and a Danish processor.

The Italian Market

The Italians are not traditional consumers of salmon. Until the mid-1980s imports of salmon could be measured in hundreds of tonnes; it is only recently that significant imports have developed. As in Spain, salmon is regarded as a luxury food and "green" issues surrounding its production are largely irrelevant.

Total consumption of salmon in Italy in 1989 was 10,700 tonnes (round weight) compared with 5,500 tonnes in 1985. In 1989, over 80 per cent of consumption was Atlantic salmon. The corresponding proportion in 1985 was 38 per cent (2,100 tonnes). All of the Italian salmon is imported. Most of the fresh and frozen imports come from Norway, while the smoked salmon imports come from France, UK, Denmark, and a number of other European countries. A high proportion of the fresh and frozen imports is smoked in Italy, where over 60 per cent of consumption is in smoked form.

Prices

Average wholesalers' mark-ups are about 25 per cent on the import price, while a further 30-50 per cent is added by the retailers. Prices of salmon, particularly smoked salmon, vary considerably between different outlets, even in the same city. Some of this variation is due to product differences. There appears to be a marked and substantial premium for Atlantic salmon which is gradually ousting Pacific salmon from the market. Average prices for fresh Atlantic salmon in IR£/kg are: CIF – 4.24, wholesale – 5.0, and retail – 9.7. Retail prices for smoked salmon vary enormously in different markets, from IR£27 per kg. in Milan supermarkets to IR£50 per kg. for off-the-side cuts in a fish shop in Morliegno.

Product Sectors

Fresh and frozen salmon are readily available in fish shops, delicatessens, and supermarkets throughout the north of Italy. They are generally only available in the larger centres in the southern part of the country. Fresh salmon generally has a high-class quality image, but there seems to be a lack of information about how salmon should be cooked. There is thus considerable scope for promotion in this area. Non-smoked salmon is a new product to the great majority of Italian housewives.

Smoked salmon is consumed almost exclusively in the urban areas of Northern Italy. Most smoked salmon is sold carved off the side by grocers or delicatessens. Its position in the Italian market is therefore akin to salami or other cooked meats typical of the delicatessens. Because salmon is sold in this way, brand identification is lost.

The catering sector in Italy is not as important as in Spain and Germany. Not all restaurants offer it on the menu. It can, however, be found in a number of sandwich bars and takeaways available as cooked products, such as salmon mayonnaise.

Forecasts for Italy

There is considerable room for growth in the Italian salmon market, since Italy has not yet been subjected to high pressure selling from Norway or elsewhere. Traders anticipate a steady sustained growth of 10 per cent per annum over the next four years. Faster growth might result if the relatively untapped southern market were to be penetrated.

Landill Mills Associates predict that fresh Atlantic salmon consumption in retail and catering outlets will rise from 4,000 tonnes in 1989 to 6,100 tonnes in 1992 and to 7,600 tonnes in 1995. Smoked Atlantic salmon is expected to rise from 4,700 tonnes in 1989 to 5,700 tonnes in 1992 and to 7,000 tonnes (round weight) in 1995. An aggregation of these figures gives 8,700 tonnes in 1989, 11,800 tonnes in 1992, and 14,500 tonnes in 1995. Over the same period, no change is expected in the consumption of Pacific salmon which is predicted to remain at 2,000 tonnes per annum.

Irish Opportunities on Italian Market

It is believed that the most productive approach for Irish producers would be to concentrate on building a brand image coupled with a high-quality profile, rather than competing on price alone. An enthusiastic local agent would be essential for such market development. There is also scope for improving intelligence about the Italian market generally; several traders felt that present suppliers were not sufficiently aware of the seasonal and other special demands of the market.

However, in the short term, it will undoubtedly be Irish smoked salmon that presents most scope. There are a number of Irish smokers who can produce a product that is markedly superior to that produced by Italian smokers. Some specialised and focused research by Irish smokers in the North of Italy might be appropriate, followed by trial shipments if the results confirm the scope of the opportunity. Price reductions are considered by the trade to be counter productive. They merely lead to a change in clientele (down-market) with no net sales increases in the short run, but may be essential over a longer period to reach the growing chain store markets.

Other Markets

The markets described above account for about 75 per cent of the trade in Atlantic salmon. The remainder of the trade takes place in a number of smaller "secondary" markets. These markets can be categorised under four headings:

(1) Northern European countries (minor markets)

(2) Japan

(3) Southern European countries (minor markets)

(4) Emerging South East Asian countries.

Other parts of the world are already preoccupied with obtaining stable foods and are unlikely to have either the incomes or the inclination to purchase a luxury item like salmon even at current low prices. This group includes countries in East Europe, which are unlikely to be able to purchase salmon in the near term.

Northern Europe (Minor Market)

This is by far the largest block market at the present time, taking about 26,000 tonnes in 1989. The countries included are Belgium/Luxembourg, Denmark, Finland, Iceland, Ireland, Holland, Norway, Sweden and the Faroes. Including as it does some of the main producing countries, per capita consumption in the block is relatively high – 0.5 kg per annum. Growth in consumption in these countries is estimated by Landill Mills Associates at about 12 per cent per annum up to 1992 and at 6 per cent per annum thereafter up to 1995. On the basis of this growth rate, forecast consumption is estimated at 37,000 tonnes in 1992 and at 44,000 tonnes in 1995 (Table 3.2). Belgium, where Irish suppliers are already established, is perhaps the most attractive target.

Southern Europe (Minor Markets)

The countries included in this block are Portugal, Greece, Switzerland, Austria and Yugoslavia. Although consumption of salmon in these countries is very low at the present time (around 2,500 tonnes per annum), future consumption is expected to reflect market developments in Spain and Italy. It is already appearing on menus in tourist centres, and from these it is expected to spread out to the more affluent sections of the population. The projection is for a ceiling consumption of 0.5 kg per head, compared with 1.0 kg in Northern Europe. This should lead to a purchase of 22,500 tonnes by 1995, compared to 10,200 tonnes in 1992 and 2,500 tonnes in 1989. The countries involved are assumed to achieve the economic growth necessary to support this level of consumption. This may be optimistic for Yugoslavia in view of that country's current political problems.

Japan

Per capita consumption of salmon in Japan is the highest in the world. It is however, a very specialised market. Red sockeye is the preferred species. Domestically produced chum (wild and ranched) and farmed Coho supply most of the demand not filled by the large imports of frozen sockeye from North America and Coho from North America and Chile. Salmon roe is also a very important by-product, accounting for almost 25 per cent of the value of US and Canadian salmon exports to Japan.

The Japanese will purchase Atlantic salmon if the price is right but because of freight costs, fresh Atlantic salmon is expensive relative to the home-produced product. Frozen Atlantics could be shipped more cheaply, but the frozen product loses its identity and becomes a competitor for part of the frozen Pacific market, with a comparative disadvantage because of its pale colour. Landill Mills Associates forecast that present consumption of 11,000 tonnes per annum of Atlantic salmon should grow to 22,500 tonnes by 1995. It is possible that Japan might become a more important factor in world demand if persistent surpluses could be pulled from the European market for sale in Japan in frozen form. The Japanese consumer is long accustomed to products processed from frozen fish, and Japanese marketers have a strong track record in carving out niches for new seafoods (e.g., sablefish and yellowfin sole). Diversion of 20,000-40,000 tonnes of farmed Atlantics to Japan would have considerable impact on prices in other world markets. It is important to note that even in a decade of slowly declining per capita seafood consumption in Japan, purchases of salmon have doubled, and the value of those purchases has increased fourfold. This, together with the gyrations in North American sockeye harvests and prices, has stimulated interest in farmed Atlantics among major Japanese traders.

Emerging South East Asia

With rapid industrialisation and income growth in this region, it is expected that Atlantic salmon could be introduced as an up-market food. Because very little salmon is consumed in these countries at present, there is little information on which to base a forecast. However, net demand could rise to 5,000-6,000 tonnes per annum by 1995, and this figure has been included in the "other markets" category of Table 3.3 which brings together the forecasts for all the different countries and areas.

Overall Demand Forecast

Table 3.4 shows that overall demand for Atlantic salmon is forecast to rise from 170,000 tonnes in 1989 to 265,000 in 1992 and to 371,000 tonnes by 1995. The annual growth rate between 1985 and 1989 was about 45 per cent. Between 1989 and 1992, when current oversupply problems are being resolved, the growth rate is estimated at 16 per cent per annum, while demand in the 1992-1995 period, when a readjusted industry comes to terms with the market, is put at 12 per cent per annum. There will thus be a considerable slowing down in demand in future years, compared with the heady years of 1988 and 1989.

The Atlantic salmon market is also examined by category of product in Table 3.4 which shows that at the present time fresh/frozen salmon is the dominant product, accounting for 46 per cent of the market, with smoked salmon accounting for 31 per cent and secondary products for only about 1 per cent. By 1995, fresh salmon will still be the dominant product, but its market share will have dropped to 39 per cent, while that of secondary products will have increased to 11 per cent.

Table 3.3: *Growth in Demand for Atlantic Salmon 1985-1995 (000 tonnes round weight)*

Country of Origin	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995
	Historic Data					Forecasts					
France	8.4	15.2	18.3	28.1	42.5	48.6	55.1	62.3	65.8	69.3	73.0
UK	6.8	8.2	9.3	13.7	24.0	28.1	33.6	41.5	47.1	60.3	81.4
Germany	7.4	9.8	11.9	14.9	18.0	19.5	21.0	22.7	24.0	25.4	26.8
USA	6.8	7.7	10.3	12.5	21.5	24.9	28.9	33.6	35.5	37.5	39.6
Spain	1.5	2.6	3.8	6.1	9.7	11.8	14.4	17.8	20.1	22.8	25.9
Italy	2.1	3.0	4.7	8.1	8.7	9.6	10.7	11.8	12.7	13.6	14.5
Northern Europe	8.9	12.1	10.5	18.6	26.3	29.5	33.0	37.0	39.2	41.6	44.1
Southern Europe	0.0	0.0	0.0	1.0	2.5	4.0	6.4	10.2	13.3	17.3	22.5
Japan	0.5	1.1	2.3	4.8	7.5	9.0	10.8	13.0	15.6	18.7	22.5
Other Markets	0.0	1.5	0.0	4.4	9.7	11.1	12.8	15.0	16.4	18.4	21.0
Total	42.4	61.2	71.1	112.2	170.4	196.0	226.9	265.1	289.7	324.9	371.3
Annual growth rate %	–	44.3	16.2	57.6	56.1	15.8	15.7	16.7	9.4	12.0	14.1

Source: Landill Mills Associates, 1990.

Table 3.4: *Growth in Demand for Atlantic Salmon by Major Product Category 1989-1995*

Product	1989	1992	1995	1989	1992	1995
	Tonnes (Round weight)			Per cent		
Fresh/Frozen	77.9	115.9	146.3	45.8	43.7	39.4
Smoked	52.0	76.2	96.4	30.5	28.7	26.0
Secondary Products	2.0	10.7	41.0	1.2	4.0	11.0
Other (including disaggregated)	38.5	62.3	87.6	22.6	23.5	23.6
Total	170.4	265.1	371.3	100.0	100.0	100.0

Source: Landill Mills Associates 1990.

Supply/Demand Balance and Future Salmon Prices

The global supply and demand forecasts which have been made independently of each other are brought together in Table 3.5 to see how they compare. The table shows that in 1990, supply exceeded demand by 47,500 tonnes (24 per cent). This meant salmon had to be frozen and put into storage, thereby increasing supplies in 1991. However, without any carry-over from 1990, planned output of fresh farmed Atlantic salmon in 1991 exceeded estimated demand by 44,000 tonnes or by 19 per cent. This put heavy downward pressure on prices and has led to many bankruptcies.

After this shake-out, it is expected that supply/demand will once again come into line in 1992, and for the following three years the projected demand will exceed supply, resulting, it is expected, in increased prices. It should be emphasised that production plans in all major supplying nations are in a state of flux. For example, the forecasts in Table 3.5 assume that planned cutbacks in Norway and Scotland will occur in 1991-1992. However, this may not be politically acceptable. Also, an industry source in British Columbia estimates that a full 50 per cent of the 19,000 tonnes expected by 1992 will be Atlantics, a sharp rise from the present 15 per cent. Chile is also anticipating both large increases in supply and a continued shift to Atlantics (*Seafood Trend Newsletter*, September 17, 1990). A slightly more pessimistic forecast might therefore indicate that prices will remain pinned to costs of production of more efficient producers for several years.

It should also be noted that bankruptcies, which were numerous in Norway, Scotland, and Canada in 1989, reduced the number of units by only a small amount. Most operations were simply recapitalized at a lower level or bought out by larger firms. The durability of salmon farms in the face of low prices is further enhanced by continued technical progress in feeds, feeding regimes, cages, and disease control.

Table 3.5: *Demand/Supply Balance for Atlantic Salmon 1989-1995*

		1989	*1990*	*1991*	*1992*	*1993*	*1994*	*1995*
Supply estimate	(000 tonnes)	170.4	243.5	271.6	254.0	257.0	281.0	308.0
Demand estimate	,,	170.4	196.0	227.3	266.0	290.6	325.7	372.0
Supply less demand	,,	–	47.5	44.3	(12.0)	(33.6)	(44.7)	(64.0)
Per cent over supply	%	–	24.2	19.5	(4.5)	(11.7)	(13.7)	(17.2)

Source: Landill Mills Associates 1990.

Price Analysis

Table 3.6 summarises some prices for Atlantic salmon during the 1980s. Norwegian and French prices have been chosen for this exercise since these two countries dominate the supply and demand sides of the market and to a great extent determine Atlantic salmon prices throughout the world.

Table 3.6 shows that salmon prices, in both current and real terms, have fallen throughout the 1980s. The decline however, has not been regular. A sharp drop in 1981 was followed by a fairly steady rise up to 1985 as the market began to expand. Prices dropped sharply again in 1986, when Norwegian producers, fearful of disease, unloaded large quantities of young fish on the market. There was a recovery in 1987 due to a shortage of young fish at the beginning of the year. However, the long-term downward trend reappeared in 1988 as stocks built up again. A severe drop occurred in 1989, when producer prices fell by about 23 per cent below the previous year's level and many of the less efficient went bankrupt.

Wholesale prices have also fallen throughout the decade. In current terms, Boulogne CIF prices fell by 15 per cent between 1980 and 1989 and by a massive 31 per cent since 1985. Real wholesale prices (current prices deflated by the UK retail price index) fell by 50 per cent over the decade and by 43 per cent since 1985.

It is believed that Irish producers were not as hard hit pricewise as the Norwegians in 1989. Having less fish to dispose of, it was possible for Irish marketers to sell much of their stocks on regular orders to wholesalers at prices higher than those ruling on residual markets like that in Boulogne (S. Garvey, ISPG personal communication). In contrast, over-borrowed Norwegian producers, strapped for cash, were forced to sell large quantities of small fish on the Boulogne market, causing prices to plummet.

Table 3.6: *Atlantic Salmon Prices 1980-1989 (UK£/kg Round Weight 2-4 kg)*

	1980	*1981*	*1982*	*1983*	*1984*	*1985*	*1986*	*1987*	*1988*	*1989*
Norwegian Producer Price	3.58	2.33	3.03	2.81	3.31	3.52	3.36	3.82	3.64	2.80
Boulogne CIF Price	3.75	3.56	3.83	3.71	4.02	4.63	4.02	4.24	3.83	3.18
Boulogne Real Price*	3.75	3.18	3.15	2.92	3.01	3.27	2.75	3.69	2.44	1.88
Index of Real Prices 1980 = 100	100	84.8	84.0	77.9	80.3	87.2	73.3	98.4	65.1	50.1

* Current price deflated by UK retail price index for all items to base 1980 = 100.

Sources: O'Connor and Whelan, (1987), and Landill Mills Associates, (1990).

Relationship Between Fish Size and Price

In the early days of salmon farming there was a substantial difference between the prices of large and small salmon, the large fish fetching up to 40 per cent more per kilo than the small ones. Since then there has been a reduction in the differential. An abundance of small salmon reaching the market in 1989 and 1990 reversed the trend, but the present differential is not expected to be maintained in the future; the price of small fish will rise again when the market picks up. Nevertheless, the larger fish will always command a higher price/kg than the smaller ones because they are more expensive to produce and are in strong demand for smoking.

In Ireland the main demand is for large salmon over 3kg, and Irish producers are not always able to supply such fish on a regular basis to hotels, restaurants and supermarkets. Consequently, about one-sixth of the Irish consumption of about 3,000 tonnes per annum is imported.

Price Forecasts

In forecasting prices for any commodity, we usually start by predicting supplies in future years and then considering how these supplies will affect prices. In doing this, two methods may be employed. The one is to make estimates about future prices based on past experience, traders' opinions, and any other information available. The other is to use more rigorous statistical methods if sufficient data are available.

Using the first method, we would expect that in future years salmon prices will settle down at a little over average cost of production. This prediction is based on the view that production will go on increasing as indicated in Table 3.5 and that the increased supplies will continue to exert downward pressure on prices. As a result, there is little possibility of a permanent increase in real prices. If prices do increase in a particular year due to a temporary shortfall in supplies, production is likely to increase in the following years, again putting pressure on prices. On the other hand, prices cannot stay for very long at below average cost of production levels. If they did, the industry would be wiped out.

The above reasoning is rather crude, and researchers would always prefer to use more scientific methods, if possible. One such method is to prepare a demand curve equation based on historic relationships in the industry and then derive future prices by applying this equation to predicted future supplies.

Because there tends to be a two-way relationship between supply and price (supply influencing price and price, in turn, influencing future supplies), the demand curve has usually to be based on a simultaneous equation regression model. To calculate such an equation with any degree of accuracy, however, requires a long series of data from the industry and relatively stable technology. Because salmon farming is a new industry, such a long-time series is not available, and for that reason a simultaneous equation model cannot be used.

We are forced to use a single equation model in which price is regressed on supply. There are identification problems involved in using such a model unless we can assume that the relationship between supply and price is not circular, i.e., that supply in a particular year is independent of the price ruling in that year. We would argue that this assumption is valid for the Atlantic salmon industry because of the length of the planning-production cycle.

The supply reaching the market this year is dependent on the number of smolts put in the cages one or two years previously, and that, in turn was largely influenced by the fish farmers' guesses as to the prices they would get for the grown fish at time of sale one or two years later. Supply at any one time is, therefore, not determined by the price ruling in the market at that time, although this price will, of course, affect future supply decisions.

What we have, then, seems to be a shifting supply curve, i.e., a different supply curve for each year crossing a demand curve which is shifting outward over time, but at a slower rate. The data would indicate that we have something which looks like a normal demand curve where declining prices are causing more salmon to be consumed.

Using the data in Table 3.7 for prices and production, Landill Mills Associates calculated the following regression equation which fits the data better than any other formulation:

$$Y = 6.504 - 0.235\sqrt{X} : R^2 = 0.864$$

where Y = Price and X = Supply of fish/quantity demanded

R^2 is the coefficient of determination.

When this equation is applied to the projected series of supply estimates in Table 3.5, some interesting points emerge. For example, at the 170,000 tonne supply level (as in 1989), elasticity of demand is 2.2, i.e., a 10 per cent fall in price gives a 22 per cent increase in demand. At the 272,000 level of supply (as in 1991), the elasticity is 1.7, while at a low level of, say, 80,000 tonnes the elasticity is 3.9.

A second interesting feature which emerges is that the equation can be used to make cautious short-term price forecasts for 1990 and 1991. If the estimated world production of 243,000 tonnes of Atlantic salmon were put on the fresh market in 1990, the average price would fall to Stg£2,841/tonne. Because, however, 40,000 tonnes of Norwegian salmon were frozen down and withdrawn from the market in that year, the expected fresh sales were 203,000 tonnes, and the average CIF price (based on the model) needed to clear this quantity of salmon from the market was Stg£3,000/tonne.

Table 3.7: *World Round Weight Production of Atlantic Salmon and Average Wholesale Real Prices* 1980-1989*

Year	*Production (000) tonnes*	*Price Stg£/kg*	*Year*	*Production (000) tonnes*	*Price Stg£/kg*
1980	4.8	6.423	1985	38.9	5.544
1981	10.2	5.460	1986	61.8	4.657
1982	12.8	5.350	1987	69.4	4.797
1983	20.3	5.029	1988	112.3	4.125
1984	27.6	5.231	1989	170.0	3.177

* CIF price Boulogne deflated by the UK retail price index to base 1989 = 100.

In 1991, 272,000 tonnes were projected to come on the fresh market. The model suggests an average price for this amount of Stg£2,628/tonne in constant 1989 terms. Since this price would give many farmers returns of less than cost of production, there would have to be a cutback in production in future years until prices rose again to more profitable levels.

The Long-run Outlook

This model is not suitable for making long-run projections. The supply estimate of 308,000 tonnes in 1995 would lead to a CIF price of Stg£2,353/tonne, which is below the cost of production of the most efficient producers. This cannot happen. Once the price drops below average cost of production, supplies will begin to be cut back. Therefore, if the level of production forecast in Table 3.5 is to be attained, prices in 1995 and previous years will have to be much higher than predicted by this model.

For the longer term, then, a different approach has to be adopted. Landill Mills Associates say that over the coming years, a relatively new high quality product, such as salmon, would be expected to create increased demand without price movement (the demand curve would shift to the right). This has probably happened to some extent in the past and is likely to happen to a greater extent in future because of health considerations and scarcity of wild fish. If this happens, as is likely, demand can be expected to outstrip supply by 1992, as indicated in Table 3.5, and lead to prices rising again for some years, such as happened after the supply shortfall in 1987. On the basis of the 1987 experience, the supply shortfall projected for 1992 to 1995 should lead to an improvement in real prices of 2-5 per cent per annum in these years. Thereafter prices are expected to decline in line with anticipated production costs. At this point prices may also decline as a result of shorter distribution channels and tighter marketing margins which will follow consolidation of both producers and marketers into larger units with more vertical integration. At this point, prices are expected to be linked closely to cost of production, plus a steady margin of 10-15 per cent of turnover. This is the type of price relationship which obtains in the mature broiler chicken industry. Salmon prices are likely to follow the same trend.

Using this type of model, Landill Mills Associates estimate tentative real prices for the years 1990 to 2000 in Table 3.8.

These forecasts, if attained, will lead to a drastic shake-out among producers over the coming years. The inefficient will be wiped out and only the very efficient will survive, as has happened in the pig and broiler chicken industries over the past 20 years. These sectors are now characterised by large units where margins are exceptionally tight and efficiency is the key to survival. The salmon farming industry is likely to follow the same path.

Table 3.8: Forecast of Salmon Prices in the 1990s
(Irish £ per tonne in Real Terms for 2-4 kg Fish – CIF Boulogne Price, Base Year 1990)

Year	*Price IR£/tonne*	*Annual Change %*	*Year*	*Price IR£/tonne*	*Annual Change %*
1988	4,538	-	1994	3,333	4
1989	3,685	–23	1995	3,409	5
1990	3,300	–12	1996	3,210	–9
1991	3,050	–8	1997	2,941	–9
1992	3,111	2	1998	2,882	–2
1993	3,204	3	1999	2,825	–2
			2000	2,768	–2

Source: Landill Mills Associates 1990.

Concluding Remarks

Despite the above rather gloomy forecasts it must be stressed that there are many optimistic signs in the market also. We are not in full agreement with the view expressed by several market analysts that lower prices for fresh Atlantics, and the expansion of sales by supermarkets will reduce demand among consumers who buy salmon as a "prestige" item. A more logical argument is that longer term growth in production will keep salmon at the lower end of the quality seafood group in price; and that the resulting penetration of markets which now take little fresh salmon (e.g., Germany, Italy, Spain, the US Midwest), plus continued growth in established markets, will lead to more optimistic sales' prospects. Farmed salmon is still far from the staple meal item that its quality and relative price warrant in the future.

Another factor favourable to long run market prospects for farmed salmon is the likelihood of gradual strengthening of prices for high quality whitefish. The total catch of gadoid and other comparable whitefish has been remarkably stable for decades. However, examination of the composition of the catch shows a pronounced decline in the best quality items, and an offsetting increase in lower grade substitutes.

World landings of Atlantic cod, the mainstay of the European and North American whitefish trade, have declined persistently, and there is no indication that this trend will be reversed despite revolutionary changes in fishery management. Strong stocks of Pacific cod have provided only a small offset, and these are also expected to decline over the next few years. The gap has been filled by lower valued hake, Alaska pollock, hoki, etc., but at much lower prices than those paid for quality cod (e.g., Norwegian, Icelandic, and Northeast Pacific factory trawler fish).

If, as Landill Mills Associates predict, farmed salmon will be selling at prices which make them competitive with quality whitefish in both restaurants and supermarkets, the outlook for absorption of significantly higher volumes is improved. A growing shortfall of cod may also stimulate the small but growing market for prepared frozen salmon products.

Chapter 4

SHELLFISH FARMING

Shellfish farming operations tend to be small-scale enterprises usually carried on by local people, many of whom have other occupations. The majority of the labour is the promoter's own and the employment combines well with inshore fishing or small farm activity. The main drawback is the lack of proper harbour facilities. There is need to upgrade these, and more particularly, purification and handling facilities to meet EC requirement from 1993.

Because of declining populations in maritime areas and with good markets available for shellfish on the continent, government agencies are now devoting considerable effort towards developing this industry further. The aim is to attract young people into the business, if possible. In addition to its income and employment-creating capacity, it has the great advantage that it is seen as being environmentally friendly.

Shellfish culture contributes in a major way to economic development and employment in many of the remote areas round the coast which otherwise lack significant resources and which are characterised by high rates of unemployment and underemployment. There are a total of about 152 shellfish enterprises in the State. Cork, Kerry, Mayo, Galway and Donegal have the largest numbers, with smaller numbers in Louth, Wexford, Waterford, Clare and Sligo. At the end of 1990 there were about 1,000 persons directly employed on shellfish farming, of whom 225 were full-time. There were probably as many more employed in shellfish processing and ancillary industries with additional numbers employed in the dredging and processing of wild shellfish. The total value of all shellfish sales in 1989, as published by the Department of the Marine (see Fishery Statistics, 1989) was IR£19.2 million of which IR£4.9 million came from sales of molluscs (most of which were cultivated in some way).

As stated in Chapter 1, grants of up to IR£20,000 of the capital expenditure on pilot scale projects are available from BIM or Udaras na Gaeltachta while grants for larger scale commercial projects are available through these agencies and the EC (FEOGA) Grant Scheme. To date a number of large and small scale shellfish projects are being assisted through these schemes. In addition BIM and Udaras provide assistance with market development and support in the technical and experimental aspects of the industry.

Licensing

Long delays in obtaining the necessary permissions to start a shellfish project are a cause of much irritation among prospective shellfish farmers. In the past many ventures had to proceed with provisional approval from the Department of the Marine pending the issue of full aquaculture and other licences. The Department says there will be no more such informal permissions; that regulations in the shellfish sector are now a priority and it is expected that all operations in the "limbo" situation will be licensed shortly.

Environmental Aspects

To date, shellfish farming has not been generally affected by the environmental issues which have been of such concern in relation to finfish farmers. To some extent this is due to the fact that water quality is not affected by the shellfish beds or structures and chemicals are not used in disease or pest control. In the long term, the visual effects of trestles and rafts could become a problem. If site availability were to become a limiting factor, conflicts could arise with other users of the coastline. For example, in Donegal, complaints have been made about the perceived visual effect of shellfish farms and one project ran into severe difficulties and had to relocate. Similar problems have not, however, occurred in the south-west where there is a more highly developed tourist sector. It should be mentioned that along the west French coast, tourism and shellfish growing coexist peacefully. The latter is the longer established of the two and it provides full-time employment, as opposed to the seasonal jobs from tourism. Tourists are interested in the aquaculture activity; it links the location with the activity of the local people and the seafood dishes which are special to the region.

Types of Shellfish

The main farmed shellfish are the molluscs because they grow relatively quickly. Crustaceans are more mobile, are slower growing and are thus difficult to farm profitably in temperate climates. In Ireland the principal farmed shellfish are mussels and oysters though in recent years clams, scallops, and abalone are becoming important.

Mussels

The largest farmed mussel fisheries in European countries are in Spain, the Netherlands, Italy and France. In 1989 Spain produced 194,000 tonnes;

The Netherlands, 107,000; Italy, 101,000, and France, 59,000 tonnes. Irish production in that year was 12,300 tonnes (FAO, 1991).

Mussels are grown by two general systems in Ireland -

(1) Bottom culture and

(2) Suspended, or rope culture where the mussels are suspended from ropes, long lines or rafts.

Bottom Culture

Bottom culture consists of dredging seed mussels usually from offshore beds and transferring the seed to shallow beds where it grows into mature mussels in $1^1/_2$ years. Meat yield is usually 15-25 per cent of total weight.

This system has now been well developed in Wexford Harbour, and to a lesser extent in Cromane and other areas. There are nine former Dutch-based dredgers in Wexford which collect seed mussels along the south-east coast, re-lay them in the shelter of the harbour and harvest them when they are fully grown. The local processing company, Lett and Company, is Ireland's largest shellfish processor and the largest producer of frozen mussels in Europe. This firm operates three of the nine dredgers. Bottom mussels from other areas in Ireland are also purchased by Letts for processing. Some 5,000 tonnes of mussels were processed here in 1989 into various products such as frozen mussel meat, mussels in half shell, mussel soup and prepared mussel dishes. The firm packs under the label Tuskar Rock Seafood.

With in excess of 100 staff, Lett's processing operation is a significant employer in Wexford. The nine dredgers and numerous smaller boats also provide significant employment. To maintain output and employment on a year-round basis Letts purchase and process other shellfish as well as mussels. In 1989 these included whelks (100 tonnes), and Dublin Bay prawns (600 tonnes). The mussels are harvested and processed from September to March while the whelks and prawns are processed during the summer months.

A number of other areas around the coast are producing bottom mussels or are being developed for production. At Cromane in Kerry, mussels are transplanted from slow growing areas in Castlemaine Harbour. Efforts are currently being made to locate seed beds in other areas of the Kerry coast. Lack of reliable sources of seed remain a problem. Youghal Harbour periodically produces mussels but stock at present is very low. In 1990, using underwater photography, BIM attempted to locate seed for restocking in the coastal area near Youghal but without success. Transplanting trials on the northern side of Carlingford Lough have not been successful either. There are prospects, however, for developing the potential of Lough Swilly, Lough Foyle and Waterford harbour for bottom mussel culture.

Suspended Culture

In suspended culture mussel seed is collected either directly from the water on spat ropes or collectors or is scraped from the rocks during spring or early summer. The mussel seed is fed into mesh stockings which are suspended in the water in the on-growing areas from long lines. Purpose built rafts were formerly used but their use is diminishing. The young mussels are later thinned out to speed growth and give larger shells. They usually reach harvest size within 9 to 18 months of being put out. The advantage of suspended culture is that thin shelled, sand-free mussels with a meat yield of over 30 per cent can be produced. These fetch about IR£450 per tonne compared with a price of IR£90 per tonne for bottom mussels. The disadvantage of the system is the large capital costs. For efficient production a major investment is required in boats, winches, grading equipment and purification facilities. Very often mussel farmers cannot afford these facilities and are thus hampered in their operations. Usually the best results are obtained through co-operative effort by a number of producers who purchase jointly the larger equipment. An example of one such group is the Bantry Fish Farming Co-operative Society.

Shellfish farming in Bantry and Glengariff started in the early 1980s, shortly after the oil terminal disaster at nearby Whiddy Island. The recently unemployed oil workers set about making a living in shellfish farming. Longlines were used in the inner Bantry Bay area which was designated as suitable for aquaculture by the Department of the Marine. Longlines proved more cost effective than rafts and also gave more uniform growth.

At present the mussel farms are clustered around the east end of Whiddy Island and also in Glengariff Harbour. These waters are well protected from the elements and are not in danger of being polluted. The number of sites, however, is limited. Trials in the outer bay are encouraging and in future it may be possible to locate farms in this area clear of navigation routes.

The major harvesting season runs from September through January. Algae blooms with associated toxins of the type causing Diarrhetic Shellfish Poisoning (DSP)* tend to be troublesome in July and August. Hence, mussels are not harvested in these months, nor until testing by the Department of the Marine shows that the mussels have got rid of the toxin and are safe to eat. Off season the producers go to other jobs, such as farming, fishing, boat repairing, spat collecting, etc. It should be noted that the algal blooms tend to be more of a problem in the south-west than

* DSP can cause consumers short-term illness, but should not be confused with Paralytic Shellfish Poisoning (PSP) which is a serious public health risk in some shellfish producing countries.

elsewhere in Ireland. Employment in the Bantry operation is estimated at 3 full-time, 21 part-time and 60 seasonal workers. A local factory which processes the mussels employs 45 people during the season.

Total production in 1989 and 1990 was about 2,000 tonnes, valued at IR£840,000. This is practically all direct income to the area. Imported raw materials are minimal.

Required investment depends on whether or not the person involved already has a boat. A minimum viable operation would be nine lines producing about 42 tonnes per annum plus a boat, engine and licence fee (IR£150 per annum) for a total of IR£40,000 to IR£45,000. About 50 per cent of this cost is available from grants on capital items. Thus for an own investment of IR£22,000, the annual sales would be between IR£25,000 to IR£40,000. The work involved is hard but it can be fitted in with other part-time employment. The biggest problem for beginners is the length of time they have to wait until the first crop is ready for sale. However as compared with other shellfish the lead time from sowing of spat to harvest is short: 12 to 18 months in the south-west as compared with 2-3 years for oysters and clams. Other areas producing suspended mussels are Kenmare (300 tonnes) Killary Harbour (500 tonnes) Clew Bay (500 tonnes) and Donegal (300 tonnes).

Total cultivated mussel production in Ireland in the years 1980 to 1990, which is given in Table 4.1, shows that suspended culture mussels have grown at a rate of about 35 per cent per annum over the period (though from a very low base). Production in 1990 was 3,380 tonnes valued at about IR£1.4 million. Percentage growth in the production of bottom cultured mussels has been much slower than that for suspended mussels, about 12 per cent per annum, with a substantial reduction in output in 1989 due to lack of suitable spat.

The farming of mussels relies entirely on the collection of wild spat. While there have been no major failures in supply for the Wexford growers or the rope mussel growers along the west coast, sourcing of seed mussels is a problem for Cromane and Youghal where mussel spawning and settlement are climate-dependent and prone to variation from year to year. The 1989 situation is a case in point. As the farmers' success in collecting seed depends on timing, there is need for a local monitoring service in each bay which will indicate the optimum seed-collecting periods.

Oysters

Two species of oyster are produced in Ireland – the native flat oyster and the Pacific cupped oyster. Oysters have to date been high-priced food items consumed mainly in restaurants. Mostly they are eaten uncooked in Europe and Japan but elsewhere in the world they tend to be cooked. The consumption pattern for native oysters is very seasonal, stretching from September to April in most markets, with peaks at Christmas and Easter.

Table 4.1: *Production of Cultivated Mussels in Ireland 1980 to 1990*

Year	*Suspended Culture*		*On Bottom*		*Total*	
	Tonnes	*IR£ 000*	*Tonnes*	*IR£ 000*	*Tonnes*	*IR£ 000*
1980	175	70	4,557	400	4,732	470
1981	200	84	4,658	410	4,858	494
1982	300	124	5,280	466	5,580	590
1983	584	263	5,600	659	6,184	922
1984	1,077	506	12,640	1,351	13,717	1,857
1985	1,636	695	8,722	545	10,358	1,240
1986	1,043	437	9,572	754	10,615	1,191
1987	1,500	675	13,393	1,188	14,893	1,863
1988	1,600	720	11,048	1,253	12,648	1,928
1989	2,850	1,000	9,500	1,200	12,350	2,200
1990	3,380	1,352	15,000	1,800	18,380	3,152

Source: Bord Iascaigh Mhara and Department of Marine."

Native Oysters

The native flat oyster – *Ostrea edulis* – is a choice market item both in Ireland and on the Continent. Prices are high, mainly because of limited supplies. Production has been reduced in recent years due to high disease mortality. Bonamia disease resulting from infestation of oysters by the protozoan Bonamia ostrea has decimated stocks all over the Continent and the UK. Dutch stocks were almost wiped out in 1991.

As a result of this disease, along with pollution and over-fishing, European output has dropped from over 100,000 tonnes in the early 1950s to about 12,000 tonnes in 1989 – 6,000 tonnes in the Atlantic Ocean and the Northern Seas and 6,000 tonnes in the Mediterranean Sea. Spanish production of flat oysters in 1989 was about 3,000 tonnes, output by France was around 2,000 tonnes, Dutch output was 1,000 tonnes, while UK production was given at 170 tonnes* (FAO, 1991). Irish output has not been

* Export figures would indicate that UK production is greater than this, probably 500 tonnes.

affected to the same extent as that in other countries and has increased somewhat in recent years to about 400 tonnes per annum. Bonamia has been detected in parts of Cork Harbour, inner Galway Bay and Clew Bay.

Native oysters spawn naturally in Irish waters in summers where sea temperature exceeds 16°C for a number of weeks. This seed is a vital element in the development of the Oyster fisheries of Tralee Bay, Clew Bay, the bays of the Connemara region, Clarinbridge and Foyle. Natural production, however, varies from year to year due to weather conditions and other causes. To overcome this variation, attempts are now being made to produce seed in onshore spatting ponds and in intensive hatcheries. The spatting pond idea (adapted from work done by the UK Ministry of Agriculture, Fisheries and Food (MAFF) in Wales during the 1940s) has worked well for Pacific oysters but not so well for the native species.

Producers must therefore rely as far as possible on natural production. For that reason the naturally productive areas mentioned above must be protected by the State. Classification as shellfish-producing waters under an EC Shellfish Waters Directive is recommended as a first step. By installing collecting systems in these areas, it should be possible to obtain spat for re-seeding other potentially productive areas around the coast, and possibly even develop an export market for seed. For example, if the Tralee Bay oyster fishery expands as expected, it is estimated that it could produce sufficient seed for all the deficient areas around the Irish coast.

Cash flow remains a problem in oyster farming (as well as in all shellfish cultivation). Despite this, flat oyster production has grown considerably in recent years, from 13 tonnes in 1980 to 430 tonnes in 1990. The Tralee bed, the first of the oyster fisheries where serious development work started a number of years ago, continues to expand production. A pilot scheme in the Maherees off the Kerry coast sponsored by BIM in co-operation with Tralee Oyster Fishing Society Ltd. is aimed at developing the industry to a much more intensive level through the introduction of cultivation techniques.

In the Maherees project the oyster seed is collected in the sea on mussel shells and laid out in suitable on-growing areas on the sea bed using a five year rotation (one-fifth of the area being planted each year). At the end of this period annual production from this operation is expected to be 450 tonnes.

Another large scale stocking programme is being carried out by an innovative company at New Quay, Burren, Co. Clare: Red Bank Shellfish. A new hatchery for various shellfish species has now been completed and $2^1/_2$ million native oysters have been planted out in the bay which is owned in fee simple by the Company. The aim is to produce 100 tonnes per annum together with a similar amount of clams and scallops.

Other areas where flat oyster production is being developed and monitored are Kilkerrin Bay in Connemara, Blacksod Bay, Clew Bay and Lough Foyle. Comharcumann Sliogeisc in Kilkerrin is active in developing efficient low-cost seeding of the beds.

Production Problems for Oysters

In the production of flat oysters, capital investment is moderately high but because capital grants of up to 50 per cent are available, capital rationing is not a serious problem. More serious is the long production period. Since oysters grow slowly, reaching market size in four to five years, beginning producers have to wait a long time before they get any income. This means that oyster cultivation can be no more than a part-time operation, in the early years, suitable for people with alternative occupations who can wait until saleable produce is available. After that it can be a profitable industry for full-time producers.

One means by which beginners could overcome the cash flow problem is by selling immature oysters, after 1 to $1^1/_2$ years, to established growers who can afford to finish them off. This would shorten the production period for both groups. Indeed the time has now come when this practice can be exploited to a greater extent than in the past. It has recently been discovered that disease free oysters can spend up to a year in infected waters before symptoms of the Bonamia disease appear. This fact enables French and Dutch producers to import immature oysters from disease-free areas and grow them to maturity in their own infested waters. Irish producers in disease free areas can benefit from this practice provided they can keep their waters free of disease.

This, of course, is a major problem. Already, Bonamia disease has appeared in a number of areas around the coast and there is a danger that it will spread to all areas. Very strict precautions must be taken to ensure that oysters from infected beds are not allowed into disease free areas. In theory a permit must be obtained from the Department of the Marine before oysters can be moved from one sea area to another. In practice, illegal movements are difficult to control but additional resources to monitor movement on the ground would assist matters.

But even if staff were available, there are loopholes in the law which make it almost impossible to enforce. A recent Court decision in Kinvara stated that the Fishery Officer must prove that he saw the shellfish being re-laid before he can get a conviction. Legislation in this area is currently being reviewed to tighten up shellfish disease control.

Pacific Oysters (Cupped Oysters)

The Pacific oyster, *Crassostrea gigas*, is not perceived to have the quality of the native oyster but it is much easier to grow under controlled conditions, reaching market size in about two growing seasons. The species is not subject to Bonamia disease and does well in Ireland. It does not, generally, reproduce naturally here because of low summer temperatures in Irish bays. While this requires the use of hatchery seed, it eliminates the threat of displacement of the native species by the lower priced Pacific oysters.

France is the largest producer of cupped oysters in Europe, producing 130,000 tonnes in 1989. UK production of gigas and other cupped species in that year, as given by FAO, was about 600 tonnes. Production in The Netherlands was 580 tonnes (FAO, 1991).

The output of gigas oysters in Ireland rose from 60 tonnes in 1980 to 160 tonnes in 1988 and to 361 tonnes in 1990. About half the 1990 production came from Carlingford Lough where oyster growing has been in operation for a decade. The seed for the Carlingford operation is obtained mainly from hatcheries in England and Guernsey and is grown to market size in net bags on trestles along the foreshore of the Lough. Production at the present time is about 150 tonnes but it is hoped eventually to produce 400 tonnes per annum.

A recent report on the Carlingford industry carried out by the French fishery research organisation, IFREMER (Grizel, H. and D. Bailly, 1990) says that the working conditions on the foreshore makes it almost impossible for the growers to handle more oysters than at present. The workshops on the land need to be upgraded. In this situation the producers cannot envisage any form of marketing other than bulk sales of hand graded oysters. Considering the difficulties of marketing oysters in this way it is crucial that on land infrastructure facilities be improved quickly in line with the EC Directive on bivalve molluscs, to be implemented by 1993 (see Appendix C).

The report also says that the current onshore facilities are, in most cases, not the best for good growth and for maintaining the ground in good condition. It needs to be modified progressively in accordance with rules laid down in the report. The capital costs for all the required modifications are, however, very high. For a co-operative or other operation producing 130 tonnes per annum for direct sales to wholesalers and retailers' total capital costs would be IR£260,000, or IR£2,000 per tonne. Even though half this sum would be available in grant aid from BIM and the EC, the balance to be provided by the producers is still substantial and may be outside the reach of many local people.

A number of other areas are now growing Pacific oysters. Donegal has seen 15 new entrants over the last few years. Dungarvan is also developing into a large oyster growing area. It has a purification facility provided by Udaras na Gaeltachta operating on a co-operative basis. Having the advantage of slightly warmer water, the south coast generally can produce market size oysters in less than two years.

At the present time most of the Pacific Oyster seed purchased in Ireland is imported but Irish hatcheries are now capable of supplying total home seed requirements. However, the foreign hatcheries have recently given extended credit terms and entered into buy-back trade arrangements. This makes it difficult for local seed producers to compete.

What is needed most in Ireland at the moment are more nurseries. Nursery operations are a very specialised interface between hatcheries and growers, taking 2mm seed to a minimum of 8mm when it is ready for on-growing. Traditionally, nursery production has been operated as an offshoot of the hatcheries but there is need for a regional spread of nurseries to supply local demand, particularly by small growers. The present demand in Ireland is for 25 million nursed seed per annum and the expected growth in production will raise this requirement.

Figures for production (quantities and value) of cultured oysters in Ireland for the years 1980 to 1990 are given in Table 4.2.

Table 4.2: *Production of Cultivated Oysters in Ireland 1980-1990*

Year	*Native*		*Pacific*		*Total*	
	Quantity	*Value*	*Quantity*	*Value*	*Quantity*	*Value*
	Tonnes	*IR£'000*	*Tonnes*	*IR£'000*	*Tonnes*	*IR£'000*
1980	13	36	60	59	73	95
1981	41	117	58	58	99	175
1982	58	166	49	49	107	215
1983	60	171	35	35	95	206
1984	67	195	110	111	177	306
1985	116	336	101	101	217	437
1986	175	525	113	117	288	642
1987	296	1,036	104	123	400	1,159
1988	320	1,120	160	192	480	1,312
1989	388	1,358	300	360	688	1,718
1990	420	1,660	361	509	781	2,169

Scallops

Scallops, a very valuable shellfish species, are currently in short supply throughout Europe. Total European production of the common scallop in 1989 was 16,000 tonnes. The main producers were France, 6,500 tonnes; Scotland, 4,200 tonnes; England and Wales, 3,100 tonnes; Isle of Man, 1,230 tonnes; Northern Ireland, 220 tonnes and Republic of Ireland, 227 tonnes (FAO, 1989).

Hatchery production of scallop juveniles in the past was difficult and costly, but this drawback has now been surmounted by Red Bank Shellfish, using adapted French technology. The most efficient method of production is by the collection of naturally occurring spat in areas where it exists in reasonable quantities. Until it was almost wiped out a few years ago, the level of spatfall in Mulroy Bay in Donegal was large enough to support a substantial industry. Fortunately, the spat levels in this bay have recovered again due to good summers, a BIM stocking programme and fishing restrictions introduced by the Department of the Marine. Some 2½ million juvenile scallops were produced in the area in 1990.

Work is continuing to develop economic methods for bottom culture of scallops, with Comhar Cumann Sliogeisc in Kilkerrin and Letts of Wexford active in this area in 1991. BIM is conducting suspended growing trials in the Bantry, Valentia, Dunmanus and Roaring Water Bay areas. Provisional results are very promising.

Letts have also introduced the seed of Japanese scallops on an experimental basis into quarantine at Carne, Co. Wexford where trials to compare their growth rates with those of native scallops are being conducted. It is believed that the Japanese scallops will grow much faster than the native species and they are held to be of equally good quality. The results of the trials are not yet available.

Clams

The two clam species of commercial importance in Ireland at the present time are:-

(a) the native clam – *Tapes decussata* and
(b) the Manila clam – *Rudi tapes semi-decussata*

The Native Clam

Production of native clams in Ireland has never been significant and even has declined in recent years. The principal areas where inter-tidal native clams were harvested in the past were on the West and North West coasts. Most of the wild populations in these areas appear to have arisen due to large-scale sporadic settlements giving rise to populations of single year clams with no further settlement. Thus, the populations are very susceptible to over fishing and recover very slowly. New stocks of a related species also exist but have not been exploited commercially.

The Manila Clam

In recent years there has been increasing interest in the cultivation of Manila clams in Irish coastal waters. Production involves two stages. Seed is purchased from hatcheries and held in a nursing system for about one year in mesh covered trays or on trestles. The preferred nursing area is a sheltered shore line with access to the trays or trestles at low tide. At the beginning of the second year the small clams are planted out in sheltered areas on the sea floor where they grow to maturity in a further year.

High prices for Manila clams (IR£6 per kg.) in the late 1980s attracted investment in clam aquaculture, and a number of projects were initiated all round the coast from Donegal to Louth. The price has now dropped to around IR£4 per kg., but the operation is still profitable at this price. To date one project has harvested and marketed 35 tonnes and hopes to sell 50 tonnes in 1991. Fifteen other projects harvested stock for the 1990 market. Output in that year is estimated at 60 tonnes valued at IR£240,000. Production estimates for 1991 are 210 tonnes and 390 tonnes for 1992. Most growers produce between 1 and 7 tonnes each. Currently, 4 projects have production targets for more than 50 tonnes each. In addition, there are three hatcheries and a further two hatcheries are in the planning stage. Clam seed is now being exported on a small scale.

In order to get some idea of the cash flow problems involved in artificial clam production a cash flow budget for a 50 tonne per annum operation is given in Table 4.3. This budget is derived from a model prepared by C. McPadden of BIM based on the following assumptions:

(1) The growth period from nursery to market size is $2^1/_2$ years. Hence cash flow is not generated until the beginning of the third year.
(2) Survival between seed and harvest is 60 per cent.
(3) Capital equipment is replaced every 5 years.
(4) The average price is IR£4,000 per tonne.
(5) Grant aid is 50 per cent of capital costs.
(6) All capital requirements are borrowed at a rate of 17 per cent per annum.

On the basis of these assumptions Table 4.3 shows that the operation will have generated a debt of IR£143,000 at the end of year 2 before the first harvest is sold in year 3. The third year harvest is not sufficient to clear all of the debt and it is not until the fourth year that returns are positive. In the fifth year, gross profit is about IR£120,000 per annum, and it remains at about this level in subsequent years.

These returns should be acceptable to the investors and particularly in border areas like Sligo, Donegal and Louth, where grants may be provided by the Ireland Fund. For those producing smaller quantities much of the capital costs could be saved by having the operations done on contract and for part-time operators labour income would be available from another occupation. After five years the internal rate of return (IRR) on the investment in Table 4.3 is 45 per cent. If, however, prices were to fall to IR£3,500 per tonne the IRR would drop to 32.9 per cent, and if the fall were to IR£3,000 per tonne the IRR after five years would be 16.5 per cent. The price level is therefore crucial to the whole operation. Considering the risks involved a price of less than IR£3,000 per tonne would appear uneconomic for all except well established growers.

But even at IR£4,000 per tonne small producers with no other source of income would have difficulty in getting established unless they could sell off some small clams to other growers at the end of a year. At present integrated growers (those who produce their own seed) sell off some of their nursery stock while retaining the rest for on-growing. Others avoid the nursery stage by buying in half grown clams. Intending growers should investigate these methods of reducing cash flow difficulties. Getting in some cash at an early stage would reduce interest charges and help greatly in getting established.

Table 4.3: Cash Flow Budget for 50 tonnes per annum, Clam Project

	Year					
Item	*1*	*2*	*3*	*4*	*5*	*6*
$^1/_2$ capital cost (1)	19,230	3,030	15,600	100	100	19,230
Operating costs (2)	50,624	58,058	80,840	79,420	79,420	78,200
Total above	69,854	61,088	96,440	79,520	79,520	97,430
Interest @ 17% p.a.	–	11,875	24,280	9,550	–	–
Total debt	69,854	72,963	120,720	89,070	79,520	97,430
Income from Sales	–	–	200,000	200,000	200,000	200,000
Gross Profit	–	–	+79,280	110,930	+120,480	102,570
Cumulative profit	(69,854)	(142,817)	(63,537)	47,393	+167,873	+270,443

(1) Includes tractor, dingy trailer, forklift and harvester

(2) Includes salaries (IR£24,000 p.a.), part-time wages (IR£1,000 p.a.), seed (IR£16,000 p.a.), Social Security (IR£3,000 p.a.), Insurance (IR£2,074 p.a.), fuel (IR£1,000 p.a.) and Marketing costs (variable).

Strains of Manila clam are now being produced in Ireland which resemble closely both the shape and colour of native clams. When these come to market they should fetch much higher prices than the present Manila strains.

Other species

Research is currently underway on the viability of a number of other species such as abalone, sea urchins, periwinkles, lobsters and freshwater crayfish. Of these species only abalone has yet been grown to market size in Ireland. According to Mercer (1991), abalone is one of the most expensive seafoods in the world and is showing a steady upward trend in the face of decreasing catches.

At present there are two companies involved in growing abalone, one in Clew Bay and the other in Ballyvaughan. Smaller trials are being conducted in Dingle, Tralee Bay and Carlingford Lough. These trials strongly indicate that abalone cultivation could become an important component of Community aquaculture within 3-4 years.

Currently, the fledgling abalone industry in Ireland is dependent on imported spat from one hatchery in Guernsey. This is the only steady source of supply in Europe and as demand exceeds supply spat prices are very expensive. In 1991 the Shellfish Research Laboratory in Carna supplied significant quantities of abalone seed for large-scale trials and there are plans for at least two commercial hatcheries in the near future.

Research into sea urchins is not as far advanced as with abalone, and techniques are still being developed for large scale "seed" production and on-growing. There has been successful small scale seed production at SRL in Carna for the last three seasons and efforts are now being developed to produce pilot scale commercial quantities. In the SRL on-growing is being undertaken in cages and tanks and the feasibility of polyculture with abalone is being evaluated.

Lobsters

Lobsters are very high priced shellfish but, because of their long growing period, artificial rearing in enclosed structures is not an economic proposition. Techniques are now available for producing juvenile lobsters and the possibility of releasing these into the sea to enhance wild stocks is being examined. Projects of this kind – lobster ranching – would have to be carried out on a co-operative basis. Groups of local people would have to agree to share the costs and the returns in the same way as oyster and mussel co-operatives. An operation of this kind, if it can be made to work, opens up exciting possibilities for coastal communities.

Comments

Though there has been a strong growth in shellfish farming over the past decade, it has been from a very low base and total production is still low by European standards. The main difficulty in achieving large scale production is related to cash flow. To alleviate this difficulty, the Irish Shellfish Association (ISA) in its Development Plan (ISA, 1990), suggests making a change in the method of giving grant-aid. It says:

> The particular nature of shellfish farming dictates a high working capital requirement. Stocks and labour are the major cost items which must be borne over a lengthy cycle time. Financing of working capital is therefore a major problem. The position enjoyed by French competition provides a model where State subsidies are used to support low interest loans repayable from sales revenue. Appropriate options for additional forms of State support in Ireland include interest subsidies, loan guarantees and employment grants. Such schemes would be more effective primers of growth in so far as they would assist the more committed elements in the industry.

Even if the total amount available for State payments to the shellfish sector is fixed, there would seem to be merit in moving from the present emphasis on the exclusive subsidisation of fixed capital to subsidising working capital, at least to some extent. This could take the form of interest subsidies or deferred interest payments during the first three years of the growing cycle. Farmers planting trees now receive acreage payments for the first 15 years of the plantation in addition to substantial capital grants. Shellfish farmers have a good case for similar treatment over a three-year period.

Some sources of additional finance to the sector should also be considered. For instance, the employment grant scheme may have particular merit. A number of young people on Unemployment Assistance might be persuaded to take up shellfish farming on their own or in a co-operative if the unemployment payments they receive were transferable to an employment grant in this enterprise.

This question was raised by the Department of the Marine with the EC Commission in Autumn 1991 in the context of preparing the new Multi Annual Guidance Programme for Aquaculture. The Commission acknowledged that financing of working capital is a problem for the shellfish industry throughout the Community and is having the matter examined. We understand that the Department of the Marine is examining the ISA suggestion in consultation with BIM and Udaras na Gaeltachta.

Education, Training and Research

The ISA says there is a solid base of expertise in the industry concentrated within the biological and production areas. However, further growth of the industry requires a major input of engineering and business management, including marketing and finance. These disciplines are not adequately covered by existing courses, which need to be considerably updated and re-orientated.

The ISA also says that knowledge of the shellfish industry overseas is also lacking in the Irish industry. There is need for exchange programmes which would allow overseas experts to work in Ireland and Irish personnel to work and train abroad. We are in agreement with these suggestions. The views of IFREMER on the Carlingford oyster industry (discussed above) give some idea of the usefulness of overseas expertise in the development of projects. In addition, part-time training courses to meet the needs of the smaller self-employed growers are also needed. These might be organised by BIM on the lines of its port-training courses for regular fishermen, or the part-time course operated by BIM in south Galway in Winter 1990/91 which culminated in a visit to see French oyster production. The ISA have also made an interesting series of suggestions in relation to research and technology. We recommend that these be examined by the appropriate agencies. It is hoped that the Marine Institute, when it comes into operation, will look carefully at these suggestions.

Other Policy Issues

The ISA has made the following recommendations, with which we concur:

(a) The immediate implementation of the Department of the Marine registration system to enable the authorities to monitor and control the movement of seed into and within Ireland.

(b) Rapid updating of legislation to control the spread of shellfish diseases.

(c) The introduction of a new efficient licensing system in consultation with the industry. In particular, a means of licensing groups of producers is needed, such as the re-introduction of oyster or other shellfish fishery orders which were extinguished under the 1980 Fishery Act.

Chapter 5

THE MARKET FOR SHELLFISH

Mollusc consumption in the EC countries is shown in Table 5.1. France is the highest consuming country in the EC, using 360,000 tonnes in 1987/89. Spain is next on the list, with 285,000 tonnes. Italy is next, with 179,000 tonnes, and the UK is fourth, with 56,000 tonnes. Ireland, with 2,300 tonnes is the smallest consumer. Spain has the highest *per capita* consumption at 7.3 kg per person. France comes next, with 6.4 kg. Consumption in Greece is only 0.3 kg per person, while that in Ireland is 0.7 kg.

Table 5.1 also shows that even though *per capita* mollusc consumption is growing strongly in most EC countries, it declined substantially in The Netherlands, Denmark and Greece between 1979/81 and 1987/89. The overall EC growth rate between these years was 36 per cent.

The market for the different species is discussed below.

Table 5.1: *Consumption of Molluscs in EC Countries in 1987/1989*

Country	*tonnes*	*Kg/hd*	*Change in Kg/hd 1979/81 to 1987/89*
	000	*No.*	*%*
Spain	285.3	7.3	+58.8
France	359.9	6.4	+18.9
Italy	179.3	3.1	+67.4
United Kingdom	56.0	1.0	+42.4
The Netherlands	38.7	2.6	–16.9
West Germany	42.5	0.7	+57.2
Denmark	4.7	0.9	–54.1
Bel/Lux	36.0	3.5	–1.0
Portugal	14.0	1.4	+67.4
Greece	3.1	0.3	–52.7
Ireland	2.3	0.7	+50.7
Total	1,021.7	3.1	+36.1

Source: Laureti, E. (1991).

Mussels

Spain is Europe's biggest mussel consumer, using over 200,000 tonnes per annum. The market is supplied mainly by domestic production of raft cultured mussels. There are also some exports to France and Italy (see Tables 5.2 and 5.3). Ireland did not normally export mussels to Spain in the past but a market for Irish mussels in that country is now beginning to develop (see Table 5.2).

France

France consumes about 100,000 tonnes of mussels per annum, over half of which are supplied by home producers. Imports come mainly from Holland and Spain, with fairly substantial amounts also from the UK and Ireland. France is Ireland's largest mussel market, taking 5,720 tonnes of fresh, chilled and frozen mussels in 1989, valued at IR£1.9 million f.o.b. or IR£527 per tonne. These figures must, however, be taken with some caution. The quantity is given in product weight and includes mussels in shell as well as mussel meat. Obviously, cargoes of mussels in shell will have a high weight and a relatively low value, and vice versa for the mussel meat. It should be noted that shellfish meat when exported is usually in frozen form whereas whole shellfish are fresh or chilled.

Irish mussels on the French market have a good reputation, and demand for them is relatively strong. Demand is mainly affected by home supplies and by imports from Spain, Holland, Denmark and the UK. The biggest problems are the difficulties of arranging on-time deliveries and high transport costs. Emphasis should, therefore, be placed on supplying more frozen products which do not need to be delivered as required and on obtaining holding facilities on the Continent from which fresh mussels can be supplied at short notice. Imports of frozen mussels from Ireland in 1989 were 741 tonnes valued at IR£1.01 million.

UK

In spite of its long coastline, the UK mussel industry is relatively small. Present landings are around 7,000 tonnes per annum of bottom mussels. Suspended culture system trials have had little commercial success. The main problems facing all English growers are lack of reliable sources of seed and low first sale prices, while in Scotland the colder waters are a handicap. Despite its relatively low production, however, UK exports 5,000-6,000 tonnes of mussels each year mainly to France where prices are much higher than on the home market.

The UK, because of its location, is an important market for Irish mussels. Prior to 1984, Irish producers supplied one-quarter to one-third of UK consumption. These Irish supplies consisted mainly of fresh bottom mussels. Since 1984, Ireland has increased its market share substantially due to the penetration of the market by Lett and Co. with a wide range of frozen and marinated mussel products. These products are sold through wholesalers in the larger cities. A second reason for the increased proportion of imports from Ireland is the successful marketing of recipe mussel dishes made from rope-cultured mussels from the South-West of Ireland.

These products are sold in a number of chain stores across Britain, particularly in Marks and Spencers (M & S). Irish recipe dishes are particularly in demand by M & S which insists that the mussels are cultivated off the ground to avoid barnacle encrustations and sand infiltration.

Two firms are involved in processing Irish suspended culture mussels, producing a range of ready-prepared dishes such as: Moules Mariniere (mussels in white wine stock with onions), Moules Bonne Femme (mussels in a cream and white sauce with mushrooms) and Moules au Gratin (mussels in a garlic bread crumb).

Despite the success of the processed product, the supply of suspended culture mussel dishes has now overtaken demand by the market. It is believed that this is a temporary situation and that demand will outpace supply in the long term. The market for in-shell mussels is holding up well. One thing is clear, however, the processed market demands very high standards in product quality, packaging and presentation. To maintain and increase their market position, Irish suppliers will have to make improvements in these areas but it has to be said that rope grown mussels at IR£450 per tonne are becoming very expensive for processing.

In addition to the processed products, Irish in-shell mussels have a good reputation in Britain. The main demand is for bottom mussels. Rope-cultured mussels are considered to be too expensive for the traditional fresh market. The bottom mussels are packed in 15 kg bags and delivered by truck to the wholesale markets in Manchester, Birmingham and London on Mondays and Tuesdays each week. BIM believes that the market share for these mussels can be increased as they are perceived to be of superior quality to their competitors.

Total Irish exports to the UK in 1989 were 1,300 tonnes product weight valued at IR£2.6 million or IR£2,000 per tonne f.o.b. Obviously, a high proportion of these exports was frozen mussel meat, considering that the producer price for bottom in-shell mussels is less than IR£100 per tonne and that suspended culture mussels sell for about IR£450 per tonne.

Table 5.2: *Trade in Fresh and Chilled Mussels in EC Countries in 1989*

Exporting countries	*Importing countries*										
	EC12	*Luxembourg*	*Belgium/ Denmark*	*West Germany*	*Spain*	*France*	*Ireland*	*Italy*	*The Netherlands*	*Portugal*	*United Kingdom*
						Tonnes					
France	905	10	6	322	455			38	67		7
Belgium/Luxembourg	142			2		117			23		
The Netherlands	46,452	29,121	29	453	311	16,537					1
West Germany	11,662	48	2,134			2		594	8,884		
Italy	67			1	66						
United Kingdom	5,749	2		1	28	4,953	450		315		
Ireland	5,546	67		6	87	4,981					405
Denmark	8,297	440		6,730		25			1,077		25
Greece	9							9			
Spain	24,816			833		10,887		13,096			
Total EC	103,645	29,688	2,169	8,348	947	37,502	450	13,737	10,366		438
Yugoslavia	842							842			
Turkey	566							526		40	
Albania	501							501			
Other	78			36		42					
Total	105,632	29,688	2,169	8,384	947	37,544	450	15,606	10,366	40	438
						IR£'000					
France	767	10	7	356	338			28	16		12
Belgium/Luxembourg	151			2		131			18		
The Netherlands	29,190	22,421	28	355	180	6,205					1
West Germany	1,513	21	85			1		218	1,188		
Italy	35			2	33						
Uniteed Kingdom	1,275	1		1	23	1,098	51		101		
Ireland	1,804	25		5	66	1,173					535
Denmark	1,001	138		666		11			151		35
Greece	24							24			
Spain	13,426			537		5,591		7,298			
Total EC	49,186	22,616	120	1,924	640	14,210	51	7,568	1,474		583
Yugoslavia	648							648			
Turkey	436							405		31	
Albania	386							386			
Other	60			27		33					
Total	50,716	22,616	120	1,951	640	14,243	51	9,007	1,474	31	583

Source: Eurostat

Table 5.3: *Trade in Frozen Mussels in EC Countries in 1989*

Exporting Countries	*Importing Countries*											
	EC12	*Luxem-bourg*	*Belgium/ Denmark*	*West Germany*	*Greece*	*Spain*	*France*	*Ireland*	*Italy*	*The Nether-lands*	*Portugal*	*United Kingdom*
						Tonnes						
France	120	3		72	19	3		12	1	8		2
Belgium/Luxembourg	13									13		
Netherlands	1,030	9	30	130	38	4	804	2			7	6
West Germany	21	11								7	3	
Italy	11			1	10							
United Kingdom	84	1				11	27	38		7		
Ireland	1,676	6		9			741			8		912
Denmark	382	62		4		2	230	1	8	44		31
Spain	163			77			5		4		77	
Total EC	3,500	92	30	293	67	20	1,807	53	13	87	87	951
Turkey	282			22		21	181		35	2	18	3
Other	613			23		353	77		3	5	2	150
Total	4,395	92	30	338	67	394	2,065	53	51	94	107	1,104
							IR£'000					
France	190	7		102	38	6		18	3	11		5
Belgium/Luxembourg	14									14		
Netherlands	1,471	10	77	129	85	5	1,143	3			11	8
West Germany	21	6								9	5	1
Italy	19			1	18							
United Kingdom	95	1				23	14	42		15		
Ireland	3,105	11		16			1,018			6		2,054
Denmark	437	66		6		1	256	2	12	49		45
Spain	216			74			11		18		113	
Total EC	5,568	101	77	328	141	35	2,442	65	33	104	129	2,113
Turkey	340			28		34	188		59	3	25	3
Other	1,146			72		543	110		2	45	3	371
Total	7,054	101	77	428	141	612	2,740	65	94	152	157	2,487

Source: Eurostat

The Netherlands

The Netherlands is Europe's third largest mussel consuming country with an annual consumption of about 80,000 tonnes. It is also an important exporter, sending about 30,000 tonnes per annum to Belgium and 20,000 tonnes to France.

Domestic production of mussels is variable, fluctuating around 90,000 tonnes per annum throughout the 1980s. In 1980/81 production was only 70,000 tonnes whereas it was 116,000 tonnes in 1982/83. Production in 1989 is given by FAO at 107,000 tonnes. For environmental reasons the Dutch government restricts the expansion of farmed mussels, forcing traders to look to Denmark and West Germany for additional supplies. In 1989 imports from Denmark were about 1,100 tonnes, and those from Germany 8,900 tonnes. Imports from the latter country are very variable because of variation in German production. Small amounts are also imported from Ireland to make up for shortfalls in supply from other sources. Irish exports to Holland were 1,570 tonnes in 1985 and only 8 tonnes in 1989 due to the fact that fresh imports are restricted on a technical measure (the detection of a species of plankton which may be associated with PSP in Cork Harbour).

The potential for exporting Irish mussels to Holland depends on the quality of the Irish product and on the existing supply situation. According to BIM (O'Sullivan, 1987) traders expressed an interest in Irish mussels if they were over 6 cm in length with a meat content in excess of 20 per cent. There is always a demand for these mussels for re-export to Belgium and it is anticipated that some Dutch firms may take an active interest in securing sources of supply in Ireland. Given the expected decline in mussel production in Denmark and uncertainties about production in Germany, Dutch processors may turn to Ireland for supplies.

The Belgian Market

The Belgians have been major consumers of mussels which are considered a staple in the Belgian diet. Over most of the 1980s, consumption of fresh mussels has hovered around 30,000 tonnes per annum or 3 kg per head. This is a high level of consumption and compares with 2.6 kg/hd in Holland. Sources in the trade are of the opinion that Belgian consumption is likely to increase in future years (Fitzsimons, 1988).

All mussels consumed in Belgium come from imports, with Holland supplying the vast bulk of the market. Only small amounts come from Denmark and France. The demands of the market are quite exacting in terms of size of mussel, quality, meat content, grading and presentation.

Restaurants and fishmongers insist that mussels must be scrubbed and free of sand and grit.

Although the Belgian market for mussels is generally considered a traditional one, interested mainly in the fresh product, the quality and range of frozen products in the supermarkets suggest that a significant proportion of the population is now demanding prepared products for the obvious reason of convenience and storage.

West Germany

It is estimated that home consumption of mussels in West Germany is about 35,000 tonnes per annum in recent years (O'Sullivan, 1987). Mussel landings fluctuate significantly from year to year depending on the severity of the winters. Total landings were as low as 3,500 tonnes in 1957 and as high as 59,000 tonnes in 1984. There is a mixture of both farmed and wild mussel fishing in Germany. The former, which is all bottom production, makes up about 25 per cent of the total.

Imports fluctuate in relation to home production, being around 10,000 tonnes per annum in recent years, compared with 8,000 tonnes in the early 1980s. Denmark is the main supplier, with smaller amounts coming from Spain, Holland, and France. Ireland exported 15 tonnes of mussels to Germany in 1989 valued at IR£21,000.

Despite the high imports a significant proportion of Germany's mussel supply is exported to Holland, Denmark and Italy. These exports are in fresh and/or prepared form. The level of exports is very variable depending on production. Exports in 1989 were 11,700 tonnes valued at IR£1,513 million or IR£130 per tonne.

The potential for Irish exports of fresh mussels to Germany is limited. Traders have a preference for German mussels over those from other sources. Fresh Irish mussels are generally unknown in the trade. The main possibility for Irish mussels is likely to be in cases of stock shortages or perhaps in the January to March period when the quality of German mussels declines, i.e., meat content falls below 20 per cent.

The frozen mussel trade is a growing one in Germany but O'Sullivan (ibid.) reports that reaction in the trade to the potential for Irish frozen mussel products was not encouraging. It was felt that there was little room for new brands on the market given the dampening effects on consumption from adverse publicity arising from poison scares. Several thousand tins of Spanish mussels had to be withdrawn from the market in 1987 after the discovery of the poison, saxatoxin, in some tins. The market has, however, recovered since then and potential may exist for Irish producers in the co-packing area especially among frozen fish suppliers who do not have mussels in their product range. At the end of the day it boils down to a question of marketing but in the short term there may be easier markets to penetrate.

Denmark

Landings of mussels in Denmark are estimated at over 90,000 tonnes per annum. Danish mussels are almost all wild grown. There is little mussel culture in the country. This situation may change as there are now strong fears within the industry that supplies from the wild beds cannot be maintained at present levels. Over-fishing of existing stocks is the main threat to future supplies.

Although Denmark is not a major consumer of mussels, the country is a significant processor and exporter of the product. To balance fluctuations in domestic supplies, cheap German mussels at about IR£99 per tonne are imported for processing. Imports average about 2,000-3,000 tonnes per annum.

It is estimated that over 90 per cent of Danish production is destined for export. The main markets for fresh chilled and frozen mussels are West Germany and Holland, with smaller amounts going to Belgium and France. About 8,300 tonnes were exported in this form in 1989. Exports of prepared mussels go mainly to France – 230 tonnes in 1989 – with smaller amounts going to The Netherlands, UK, and Belgium.

The hope for Irish producers is that present Danish production levels of wild mussels cannot be maintained, thus making more room for farmed mussels on the French, Dutch, Belgian and German markets. If the Danes are forced to produce farmed mussels their prices will have to increase and their present competitive edge will be reduced.

Summary and Conclusions for Mussels

The main markets for Irish mussels are France and the UK, with smaller amounts going to Spain, Holland, Belgium and West Germany. It is very difficult to get comparable figures for mussel imports and exports since the trade statistics do not distinguish between shelled and whole mussels. Generally speaking, fresh and chilled mussels are in shell while frozen and prepared mussels are shelled.

The bulk of Irish mussels going to the UK are frozen mussels and prepared recipe meals. The former are based on bottom mussels while the latter are produced from suspended mussels. There is also a growing market in the UK for fresh bottom mussels. Suspended mussels are expensive for traditional markets in Britain but they are sold by some of the better quality supermarket chains.

The bulk of Irish mussels going to the French market at the present time are fresh suspended culture mussels. In previous years large quantities of bottom mussels were exported there from Cromane. There does not seem to be too much difficulty in selling the available supplies on the French market. The problems are the high transport costs and the difficulties of maintaining on-time deliveries. The delivery question could be overcome by acquiring holding areas on the Continent. The best way to reduce transport costs would be by selling more shelled or processed mussels.

There are improved prospects for selling high class rope mussels on the Dutch market for re-export to Belgium. It will, however, be difficult to break directly into the Belgian market with any substantial quantities. The German market is problematic and will be difficult to penetrate. On the whole the market for mussels is buoyant. European consumption is increasing, and at the present time, Irish marketers seem to be able to sell their total production at reasonable prices. To increase market share, however, Irish producers must meet exacting standards in product quality, presentation, grading, packing and service.

Oysters

The flat oyster *(edulis)* continues to set the market standard in traditional oyster consuming countries, the retail price being about three times that of the Pacific oyster (gigas). Edulis is now in short supply in all markets where it has traditionally been consumed and it commands a premium price as a result. This clearly offers opportunities for Irish producers if they can keep Bonamia disease in check. Since the disease has already appeared in Ireland (although relatively confined) the future prospects for flat oysters are uncertain.

The principal export markets for Irish flat oysters are France, Netherlands, and Germany. The UK is the main market for gigas oysters. Oysters are usually packed for market in baskets of 100, 50, 25, and 12 pieces. The smaller sizes are for direct sale to the consumer. The larger sizes go mainly to outlets which have wet fish counters where oysters are sold individually. Generally, the bigger distributors prefer deliveries of small quantities, two or three times per week and the suppliers who can make such deliveries have a major competitive advantage. Because of our peripheral location, frequent deliveries are very costly, particularly to the Continent. Exporters could reduce these costs by obtaining relaying facilities in Europe or by piggy-backing oysters on other fresh food trucks. Because of disease regulations, it is almost impossible to obtain relaying facilities in Europe. Hence it would appear that the piggy-back idea is the one which must be exploited.

The market for oysters in the main consuming countries is discussed below.

France

France is by far Europe's biggest consumer of oysters, consuming between 100,000 and 120,000 tonnes per annum. These include about 2,500 tonnes of edulis oysters. A high percentage of French households eat oysters on a regular basis. The season lasts from September to April with two-thirds of consumption taking place during the Christmas holiday period.

France is also a large exporter of oysters (see Table 5.4). In 1989, 4,600 tonnes were exported. The main importing countries from France were Italy (3,400 tonnes), Spain (458 tonnes), West Germany (377 tonnes) and Belgium/Luxembourg (368 tonnes). Exports to the UK in that year were only 29 tonnes. French exports are mainly gigas oysters. Nearly all the production of edulis oysters is consumed on the home market.

Flat oysters are imported to supplement home supplies. These imports which amount to between 500 and 800 tonnes per annum come mainly from Holland, the UK and Ireland. The amounts from these countries vary considerably from year to year depending on their production. Irish exports to France were 262 tonnes in 1983 but they declined to 62 tonnes in 1986 and increased again to 245 tonnes in 1989. On average UK exports to France are about 240 tonnes, and Dutch about 140 tonnes per annum.

Dutch flat oysters have a high reputation on the French market and command a premium price. The service provided by the Dutch is very well organised and reliable. Transport by truck takes only 5 hours and there are deliveries every evening to the Rungis market in Paris. Consistent supplies are maintained throughout the season even if this means re-exporting Irish or UK oysters. Grading is also very consistent.

It is against these high standards that Irish exporters must measure themselves. Mostly they are in a difficult situation. Being a long distance from the market, transport costs are very high. There are also problems in keeping up regular supplies from relatively small stocks. If a supplier's own stocks run out, buyers expect him to find stocks elsewhere, as the Dutch suppliers do.

In the 1990/91 season, flat oysters were very scarce in France. As a result, French buyers came to Ireland and bought directly from Irish merchants. The average f.o.b. export price in that season was about IR£4,250 per tonne. This pattern of purchasing, of course, applies only with scarce products and must not be expected to continue indefinitely. Due to good settlement in French waters in 1989, production is expected to be about 6,000 tonnes in 1991, three times the average annual production since 1984. As a result, Irish prices in the 1991/92 season are expected to be down on the previous year.

There is over-production of gigas oysters in France, making penetration of the market by Irish oysters very difficult. However, Irish exports are now going to that market, though at rather low prices (IR£700/tonne). A joint operation with a firm in France for export of Irish gigas to the Italian market is also a possibility. Consumption of oysters is increasing rapidly in Italy and it would be useful to gain a toehold in this market. Prices there are rather low at present but they can be expected to increase as the market develops. The problem is to obtain permission to relay Irish oysters in French waters. This problem must be tackled and overcome.

The Netherlands

As stated in Chapter 4, Holland produces about 1,300 tonnes of flat oysters per annum. Gigas oysters are also produced but in smaller quantities. In recent years the latter have been increasing while flat oysters are decreasing. Production of gigas in 1989 is estimated at 500 tonnes. Most of the oysters produced in Holland are destined for export. Home consumption accounts for only about 100 tonnes per annum. Belgium is the largest export market, taking an average of about 1,200 tonnes per annum. As stated above, France takes an average of about 140 tonnes and Germany somewhat less. There are also exports to Spain (167 tonnes in 1989).

Despite their marketing successes, the Dutch have problems on the supply side. As a result of Bonamia disease, edulis oysters are currently cultivated only in Lake Gravilingen in the Zeeland area. Other producing areas have been closed down in an effort to get the disease under control. High mortalities occurred in Lake Gravilingen in 1991 due to Bonamia, and there is very poor production of edulis as a result.

To maintain market supplies the Dutch usually have to import oysters. The level of imports varies from year to year depending on home production. On occasions dredging of Lake Gravilingen is interrupted when temperatures fall below freezing point. In such years imports may be as high as 500 tonnes. More normally, imports are 160 tonnes or less per annum, mainly from the UK and Ireland. Irish exports in 1989 were only 11 tonnes valued at IR£37,000 but in some years up to 40 tonnes have been taken by Dutch importers.

Because of an expected decline in edulis oyster production in the coming years, it is expected that Holland will try to increase its exports of gigas oysters to maintain income levels (Fitzsimons, 1987). This in turn may create a demand for gigas imports and Ireland should be ready to meet this demand if it comes about.

Table 5.4: *Trade in Oysters* in EC Countries in 1989*

Exporting Countries	*Importing Countries*										
	EC12	*Luxem-bourg*	*Belgium/ Denmark*	*West Germany*	*Spain*	*France*	*Ireland*	*Italy*	*The Nether-lands*	*Portugal*	*United Kingdom*
						Tonnes					
France	4,625	368	22	377	458			3,365	4	2	29
Belgium/Luxembourg	27					9			18		
The Netherlands	1,701	1,187	27	138	167	153			1		28
West Germany	1		1								
Italy	860				852	8					
United Kingdom	549	36	2	15	112	345	37*		2		
Ireland	634	2	3	57		245			11		316
Greece	1,052				986			66			
Portugal	11				11						
Spain	43					29		1		13	
Total EC	9,503	1,593	55	587	2,586	789	37	3,432	36	15	373
Turkey	1,977				1,513			463	1		
Japan	110			4							106
Other	144	2		11	77	12		22	16		4
Total	11,734	1,595	55	602	4,176	801	37	3,917	53	15	483
						IR£'000					
France	7,201	821	43	878	1,087			4,276	16	2	78
Belgium/Luxembourg	74					56			18		
The Netherlands	5,928	3,777	61	431	959	621				1	78
West Germany	2		2								
Italy	744				736	8					
United Kingdom	2,017	191	4	36	362	1,201	216+		7		
Ireland	1,939	11	7	153		980			37		751
Greece	1,929				1,820			109			
Portugal	9				9						
Spain	99					92		2		5	
Total EC	19,942	4,800	117	1,498	4,973	2,958	216	4,387	78	8	907
Turkey	1,349				1,063			285	1		
Japan	366			16							350
Other	419	7		70	188	84		18	44		8
Total	22,076	4,807	117	1,584	6,224	3,042	216	4,690	123	8	1,265

* Includes native and Pacific oysters.

+ Most of the Irish imports are transhipments from Northern Ireland through the Republic to France. The remainder are imports of Pacific Oyster seed.

Source: Eurostat

Germany

Although German consumption of oysters has increased rapidly in recent years to about 600 tonnes per annum, home production is still very small at only about 20 tonnes per annum. Over-fishing has led to a gradual decline in stocks and despite several attempts to increase production, output continues to remain at a very low level. The main obstacle to the long-term development of oyster culture in Germany is the difficulty of over-wintering. Low water temperatures result in high oyster mortality.

France and Holland are the main exporters of oysters to Germany. In 1989 imports from these countries were 377 and 138 tonnes, respectively. Imports from the UK in that year were 15 tonnes and from Ireland 57 tonnes. Over 90 per cent of French exports to Germany are gigas oysters. In contrast, edulis oysters are the dominant type exported from Holland, though gigas are now assuming a growing role in Dutch exports.

It is possible to identify three broad methods of distributing oysters in Germany. The first consists of weekly or twice weekly deliveries of fresh fish and other fresh food products from France. Typically, the importing companies send their own trucks to the Rungis market in Paris.

The second category relates to direct deliveries by Dutch exporters. The latter operate an efficient oyster delivery service between Holland and Germany, whereby Dutch merchants deliver two or three times per week to German fish wholesalers. The Dutch service is similar to a domestic source in that the wholesaler can purchase small quantities at a time – 40-60 kgs. The Dutch have a reputation for efficiency and reliability in this field.

The third distribution line is importation through independent transport companies, i.e., air transport. Oyster exports from Ireland fall into this category. The service is fast but expensive. For a number of German merchants this method of importing is relatively inconvenient. The importer has to pick up the oysters at the airport, compared with delivery to the door by the Dutch. A second difficulty is the requirement with air delivery of a minimum consignment of 100 kg. For a number of German wholesalers this volume is too high, 50-60 kgs being a more appropriate quantity.

Wholesale prices for edulis oysters are about 60p each compared with 30p for gigas; as a result gigas are gradually taking over the market. Nevertheless, edulis remains an important up-market segment.

Ireland has a number of problems in increasing its market share for oysters in Germany.

(1) Its greater distance from the market means a cost disadvantage *vis-à-vis* Dutch and French suppliers. Irish exports are usually delivered by air whereas French and Dutch oysters go by road. The transport cost is a particular disadvantage for gigas because of their lower unit price.

(2) To the extent that Irish oysters are known within the trade in Germany, they enjoy a good reputation, comparable in quality with Dutch Imperials and English Colchesters. Many importers, however, have never handled the Irish product and so in general it is less well known than French, Dutch or English. Among a number of importers who have handled Irish oysters their favourable image is counterbalanced by a poor image of Irish exporters. Importers complain about poor packing, inadequate sorting and irregular supplies (Fitzsimons, ibid., p. 28).

In contrast, the Dutch exporters have a good reputation within the German trade. They have the added advantage of proximity to the market so that orders which are received one day are delivered to the importer on the following day and deliveries are made several times a week.

Suggested Approach by Irish Exporters to German Market

(a) The main potential for Irish exports in Germany is with edulis. The limited general availability of the product and the expected shortfall in Dutch production provides definite opportunities for Irish exporters provided they are able to offer a reliable delivery service.

(b) The main areas for oyster consumption in Germany are the prosperous urban centres: Munich, Frankfurt, Hamburg, Stuttgart, Berlin and the Rhine region, including Cologne and Bonn. Oyster exporters should concentrate on these areas.

(c) The regular delivery of Irish oysters by truck to selected German centres could help exports by lowering transport costs and by supplying a regular dependable service. Exporters should investigate the possibilities of share loading with other Irish food exporters. It is only in the context of a good road delivery service that gigas exporters, in particular, have a potential in the German market.

Belgium

The Belgians are major consumers of oysters, eating in the region of 1 kg per person per annum. Supplies come exclusively from imports which average about 1,600 tonnes per annum. In recent years the composition of oyster consumption has changed. Shortfalls in the supply of edulis from Holland and France are compensated for by increased imports of gigas which retail for one-third of the price of edulis.

In 1989, total imports were 1,593 tonnes, of which 368 tonnes came from France, 1,187 tonnes from Holland, 36 tonnes from the UK and 2 tonnes from Ireland. In the previous year imports from Ireland were 15 tonnes. Irish supplies are practically all edulis oysters. The average CIF import price for these oysters was IR£5,692 per tonne in 1988 and IR£5,000 per tonne in 1989.

It is not surprising that Holland is the dominant supplier of oysters to the Belgian market. The town of Yerseke, in the major producing area of Holland, is just across the border and within three hours' travelling from Brussels. Some large Belgian traders interviewed recently by BIM personnel stated that they would be unwilling to change from Dutch to Irish sources of supply. They had been doing business with the same suppliers for years and when shortages occurred the Dutch would supplement the shortfall with imports from other countries. They could not depend on other suppliers to do this essential business.

The manager of one of the large supermarkets in Belgium (which accounts for 12.5 per cent of all shellfish sales in the country) stated that he would deal with Irish sellers. He stipulated, however, that any supplier would have to drop off supplies at his warehouses in Antwerp and Brussels before 5 p.m. on Tuesdays and Thursdays of each week. Quantities required would be 500-600 kg per delivery at each warehouse. These are pretty stringent conditions and might be difficult for an Irish supplier to meet.

However, one major distributor, based outside Brussels, informed the BIM interviewer that his company would be interested in obtaining Irish flat oysters and would also take gigas if the prices were equivalent to those for the French product.

The market for oysters in Belgium is approximately 60 per cent catering and 40 per cent retail. A number of distributors supply the catering sector. The most exclusive hotels and restaurants tend to deal with one broker who specialises in supplying small quantities of high priced products. Some of these brokers would be prepared to collect oysters at the airport and deliver them to their clients provided the quality was good and exactly to specification.

There are no opportunities for supplying oysters in bulk for relaying in Belgium. The main interest among distributors is for oysters packed in baskets of 25, 50 or 100 oysters. The trade requires that the baskets have a label which gives details of the origin of the oysters, the name and address of the exporter, the standard of the product and date of packing. The latter is obligatory.

In November 1990, wholesale prices for medium sized gigas (80-100g) packed in baskets of 100 pieces were BF 700 (IR£12.96). This is equivalent to IR£1,296 per tonne or 13p per oyster. Some quotations were, however, as low as IR£1,000 and as high as IR£1,800 per tonne. Because of present scarcities, wholesale prices for good flat oysters are over IR£5,000 per tonne.

Recommendations for the Belgian Market

To gain initial acceptance to the Belgian Market with gigas oysters it will be necessary to do business with an important distributor who can be convinced that the Irish product is of good quality, properly graded and available on a continuous basis. Promotions with such a distributor will be necessary to popularise the product.

Given the expense of air freighting oysters, it is unlikely that exporters would attempt to enter the Belgian market with gigas using this method of transport. To supply the market it will be necessary to make an arrangement with some other food exporter who is serving the Belgian market regularly by truck.

The UK

Despite determined efforts by the Ministry of Agriculture, the UK oyster industry has suffered from all the diseases that have been present on the Continent. Initially growers of Portuguese oysters (*Crassostrea angulata*) saw their stocks dwindling as the supply of seed declined due to disease abroad. Later edulis oysters throughout the southern half of Britain became infected with Bonamia disease.

On the positive side, new beds of edulis were found in the Solent which have proved to be an excellent source of oysters. Also, the Loch Fyne fishery in Scotland has been considerably improved while other west coast sea lochs of Scotland show potential for producing limited quantities of edulis free of disease.

Gigas production continues to expand both in the traditional oyster growing areas of south England and also in new areas. There are now a substantial number of growers in Britain but the quantities produced are not exactly known. It is estimated that a total of about 1,000 tonnes of all oysters are produced, of which perhaps 50 per cent are edulis oysters.

Total exports in 1989 were 549 tonnes, of which 126 tonnes were live oysters weighing less than 40 grammes each (seed oysters). These went mainly to Spain, France and Ireland. Of the 423 tonnes of edible oysters exported, 315 tonnes went to France and the remainder to Belgium, Spain and West Germany. Most of these exports are believed to be edulis oysters.

Imports by the UK in 1989 were 483 tonnes of edible oysters, of which 316 tonnes came from Ireland, 106 tonnes from Japan, 29 tonnes from France and 28 tonnes from Holland. Most of the imports were gigas oysters and gigas oyster meats.

The UK Market

The reduction in supplies has drastically reduced the consumption of oysters in the UK from that of former years. However, it is now believed that the pendulum is swinging back again. An increasing number of restaurants and hotels are offering both edulis and gigas on the menus. The demand for gigas is increasing for the following reasons:-

(a) They are available all year round.
(b) They are not very expensive.
(c) They add a touch of affordable luxury to a menu.

The size of the UK market was estimated at 550 tonnes in 1989 and 700 tonnes in 1990. In 1989 Irish exports represented 67 per cent of total imports and 54 per cent of the total market. A recent report on the Irish Pacific Oyster industry by BIM (BIM, 1991) says that it will be difficult to maintain this share of the market in future years unless demand expands significantly because:

- Local producers are increasing their output from 200 tonnes in 1987 to 500/600 tonnes in 1991.
- The current recession is worse than expected and must reduce expenditure even at the top end of the market,
  and
- Although Ireland's share is over 50 per cent of the market, there is a low awareness of Irish oysters among UK distributors since the oysters are mainly supplied by one company based outside the Republic (Cuan Sea Fisheries).

The primary and most attractive markets in the UK are restaurants and hotels. Secondary markets include oyster bars, seaside resorts and food processors. Unfortunately the multiple market is not interested in oysters at present. This is disappointing. These stores represent 40 per cent of total shellfish sales in the UK.

UK Market Structure

Substantial changes have taken place in the pattern of marketing oysters in the UK over the past half century. Many of the oysters sold today do not pass through the traditional wholesale markets. The small growers supply hotels, restaurants and fishmongers in their own localities with their requirements virtually on demand. In adopting this pattern of selling, the extra costs involved in distributing directly from producer to consumer are offset by the exclusion of intermediaries.

Examples of door-to-door sellers are Cuan Sea Fisheries in Northern Ireland, who deliver gigas anywhere in the UK within 24 hours of the time of ordering. Lough Fyne oysters in Scotland also operate a door-to-door service by van courier. The oysters are dispatched within a delivery time of up to 36 hours. In general, these types of delivery costs can be as high as 11p per oyster.

Cuan Sea Fisheries had been the main buyer of Irish gigas for some time. In 1990, due to a prolonged Court action (which was successful for Cuan) the number of oysters which it bought was greatly reduced. As a result, Irish producers, particularly those in Carlingford, had great difficulty in disposing of their stocks. In the absence of Cuan, the UK market was strongly penetrated by the French and Dutch, and Cuan, who are back in the market again have experienced difficulty in regaining lost ground.

The pattern of consumption within the UK is different from that in other countries. Many of the older generation are reluctant to eat raw oysters. To cater for those people, Cuan Sea Fisheries have developed a wide range of prepared oyster products. These products include frozen oysters whole in the half shell and in several recipes including au gratin (stuffed oysters in garlic butter) and breaded oysters. An important advantage of the frozen oyster is that it opens itself automatically on defrosting, which is significant, considering that the difficulty in opening oysters can be a major constraint on sales. The other recipe products are more attractive in catering establishments where busy chefs do not have the time to open and prepare the oysters.

Prices

On the Billingsgate market in February 1991, buying-in prices for gigas were 18p each while selling prices ranged from 27-32p each. For fishmongers, buying-in price was 32p and selling price was 40-45p each. *Fishing News* of the 15 February 1991 reported fishmongers selling edulis oysters at 65-88p each, depending on grade.

The pricing policy of hotels and restaurants in the UK creates a serious problem for the expansion of oyster sales. Oysters are bought in by these establishments at 30p each and sold to the customers at IR£1.00 each or more. At these prices it becomes impossible to expand demand; few people can afford to pay such high prices.

To overcome this difficulty, new and varied forms of product must be developed to attract fresh customers and overcome the problems people have with eating raw oysters. There is a growing market for frozen oyster meats. The economics of these markets need close attention but they do appear to be the best way of expanding the market for the growing supplies of gigas oysters.

Summary and Conclusions for Oysters

Because of the disease problem and the consequent reduction in supplies, there is little difficulty in disposing of all the edulis oysters Ireland can produce at good prices. The main market for these is in France with smaller amounts going to Holland, Germany and Belgium.

There was a problem, however, with the marketing of gigas oysters in 1990 and the early part of 1991. The industry had difficulty in disposing, at economic prices, of the increased production which had occurred. Once Cuan Fisheries ceased purchasing, there was no good alternative buyer for Irish producers. Atlantic Shellfish, a Cork company, took up some of the slack but at reduced prices.

Over the latter part of 1991, the market improved and substantial quantities of gigas are now moving each week to the French market. However, there is urgent need to address the long-term needs of an industry which is increasing production at a rapid rate. A recent report by IFREMER on the Carlingford Lough industry (*op. cit.*) states that in the long run the best hope for success lies in exploiting the UK market. The demand on this market is for large oysters 90-100 grams packed in 24 to 50 piece waterproof wooden boxes. The main demand comes from the catering establishments in sea resorts or large cities. Prices generally show a tendency to increase. Also, a direct action by suppliers to develop a recognised brand name would be rewarded by a premium. For example, Irish "rock" oysters are sold in London restaurants at a higher price than other oysters.

As regards competition on the UK market, IFREMER said that French producers are not in a position to supply large quantities of the type of oysters required by the UK market. However, if this market is not satisfied and prices continue to rise, some French producers may fill the gap. Dutch producers are already doing this. But, for environmental reasons, the development of further oyster farming in Holland is limited.

The major issue facing Irish gigas oyster producers is the need for a marketing structure and the development of a marketing strategy for the industry. One possibility is the establishment of an umbrella company which would be responsible for sales and marketing of all producers. When in place this company could arrange for the production of new products where appropriate. It might be active in exploring the possibilities for joint ventures with Continental firms of proven marketing ability.

An Irish oyster company would, however, face considerable difficulty in maintaining uniformity of quality to its customers with products sourced from different production regions. Hence, handling and purification facilities must be developed on a regional basis. Under the recent EC Directive on Health Conditions for Bivalve Molluscs, grants are available from BIM and the EC towards the cost of providing the necessary facilities.

BIM, in conjunction with the marketing organisation, should draw up an indicative sales and marketing plan. When this plan is in place the creation of a brand image for Irish oysters should be considered. This Bord should incorporate a quality label and should define standards in respect of area of origin, purification, appearance, colour, shape and all criteria likely to affect perception of product quality.

In 1991, BIM, in conjunction with producers, organised promotions in England featuring oysters in restaurant and retail outlets. In these promotions, special attention was paid to the large supermarkets. This is a volume market requiring the ultimate in service and distributive organisation. There is great potential here for Pacific oysters. It has been mainly through misconception and lack of knowledge of the supply capability that the multiples have not stocked oysters to date. Given that these molluscs are sold in supermarkets in other countries, the responsibility rests with the oyster industry to make it happen in the UK.

Nor should the home market be neglected. Industry experts believe this market to be approximately 100 tonnes per annum and that it could be increased. Wholesalers say that their main outlets are pubs and restaurants. In interviews with Quaestus Ltd. who undertook the 1991 market research report for BIM (1991), some publicans felt that if oysters were processed they might be more popular. Overall, they feel that the market is untapped but it needs to resolve some of the negative factors associated with oysters such as difficulty of opening and high prices. They recommended more promotion and a customer education programme.

Quaestus make the following recommendations for the home market:-

- Stalls should be set up in centres which attract target audiences, e.g., Powerscourt, St. Stephen's Green Centre, Merrion Centre, etc. Recipes and fliers should be supplied.
- During the summer a beverage company should be asked to sponsor an oyster road show where a vehicle would attend the major events and sell oysters.
- Specific TV programmes should be identified where different oyster preparations can be displayed.
- Special offers should be done with restaurants, hotels and pubs.

Given these promotions, it should be possible to expand the home market for the product.

Scallops

Scallop prices continue to increase and the demand cannot be satisfied by traditional scallop dredging. In 1989 the f.o.b. export price for mature scallops was over IR£7,000 per tonne. In that year Ireland exported 154 tonnes of wild scallops to France for a value of IR£1.134 million f.o.b. (IR£7,364/tonne). Smaller amounts of 10 tonnes went to Belgium and 4 tonnes each to Germany and Britain. The export of scallops in that year to the Netherlands was 159 tonnes. Wild scallop exports in 1990 were: 129 tonnes to France, 369 tonnes to the Netherlands and 23 tonnes to Spain. In view of the high prices, there does not appear to be any problem with the marketing of scallops over the next few years. In the long run, of course, when production increases, problems will inevitably arise. That, however, should not deter would-be producers. Those first into production with a saleable commodity make large profits while the commodity is scarce. The late arrivals run into all the difficulties, with falling prices, as production expands in response to the earlier higher prices.

Clams

In the past, France was the main market for the small amounts of Irish clams produced. However, France is a net exporter of clams, both native and manila. The internal market is over-supplied by local production. The balance of supplies, including imports, is exported to Spain.

Although France exports about 50 per cent of its production, French importers are prepared to trade in Irish clams at a price 13-14 per cent lower than that paid to local French producers. Opportunities also exist for the regular supply of small quantities (100-300 kg) to the Rungis wholesale market at a price of about 15 per cent more than that paid by importers. French import prices for Manila Clams *(T. Rudi semi-decussata)* from Ireland in 1989 were IR£4.50 per kg. Wholesale prices in the Rungis market for large French Manilas at the same time were about IR£6.00 per kg.

Spain is now the main market for Irish clams. This country is the largest importer of clams in Europe. The overall market volume for all clams is estimated at 25,000 tonnes (McFadden, *op. cit.*, p.i). Portugal, France, Italy and North Africa supply approximately 6,000 tonnes of Native Clams *(T. decussata)*, with another 4,000 tonnes produced locally. Prices for these clams have remained high, in the region of IR£8–9 per kg. c.i.f. These prices are expected to remain at this level as there are no indications of any major increase in supplies of this species either from home producers or from imports.

Italy is now the largest exporter of *T. Rudi semi-decussata* to Spain (circa 7,000 tonnes per annum). These exports come from wild populations in the Goro area. Spain also imports another species of clam *(Venus gallina)* from Italy. Imports of this species in 1989 were 15,000 tonnes. This is a rather small low-priced clam which is in short supply at present. As a result, the shortfall is being replaced by *T. Rudi semi-decussata.* There is thus a good demand for Irish produced Manila clams on the Spanish market at the present time. Because the Irish clams have white coloured meat, they fetch a higher price than other imports which have yellowish coloured meats.

Prices for Clams

Prior to 1988, imports of *T. Rudi semi-decussata* to the Spanish market were small and predominantly from France. At first the market did not readily distinguish between the manila and the native clam, particularly at the larger sizes, and as a result there were very good prices for the former in 1988. Production of *T. semi-decussata* from wild populations in Italy commenced in 1988 and in 1989 large volumes (6,000-8,000) tonnes were harvested. Much of this production was exported to Spain and resulted in over-supply and a consequent drop in prices.

Spanish import prices for Irish *T. decussata* in 1989 were IR£8-9 per kg. The prices paid for *T. Rudi semi-decussata* were much lower than this. Medium sized Italian clams of this species in 1989 had a CIF import price of IR£3.75 per kg., whereas larger French ones were listed at around IR£5 per kg. Wholesale prices for these French clams in Barcelona in February 1990 were quoted by McFadden (op. cit., p. 26) at IR£5.26 per kg. In 1991 the wholesale price for Irish produced Manila clams on the Spanish market is about IR£5.5 per kg. This allows for an ex-farm price of IR£4.5 per kg. and a transport cost of 30p per kg. The prices depend very much on the size of the clams. Though there is a good demand for all sizes, the very large clams (under 30 pieces per kg) are much more highly priced than the smaller sizes (60-80 pieces per kg). Prices for small items are similar to those obtained for good quality *V. gallina* which are currently selling in the wholesale market at IR£3.00-3.80 per kg. The best prices for all clams are obtained in the weeks leading up to Christmas and Irish producers should have their harvests ready for this time.

Prior to 1991, Irish exports to Spain of all live molluscs, including clams, had to be purified in depuration stations in Spain. The Spanish authorities have recently accepted the Irish Department of the Marine sanitation programme regulations. This means that shellfish from approved areas can now enter without prerequisite Spanish purification.

Abalone

No clear picture of the market for abalone has emerged yet, mainly because only small quantities of the farmed product are available to date. Limited supplies of wild abalone (ormers) reach the Paris market from Brittany and fetch in the region of IR£5.50 per kg. These ormers are about

120 mm long. Farmed abalones would be only 70 mm (it takes too many years to reach 120 mm) and at this rate the Paris price would be equivalent to IR£3.30 per kg. Considering that it takes 4 years to reach 70 mm and that they have to be fed on seaweed throughout this period, the economics of production at the above prices seem doubtful. The opposite view is held by Dr John Mercer of the SRL in Carna who states that European and world markets are very undersupplied but it would be necessary to get regular supplies to these outlets if the industry is to prosper. Hence, some form of co-operative marketing organisation is desirable (Mercer, *op. cit.*, p. 8).

In the case of sea urchins, European and world markets are undersupplied. There are good existing markets in France where according to Mercer, per kg. prices vary from IR£25 to IR£35. As with abalone, proper marketing structures need to be in place from an early stage.

Conclusions for all Shellfish

UK and European markets will be the main targets of Irish shellfish marketing efforts. Unfortunately, Irish producers have many competitive and cost disadvantages in servicing these markets. In addition to the locational disadvantages, the Irish industry is characterised by a fragmented production structure and a lack of co-ordination by producers in marketing. The organisation of regional producer groups is imperative in order to overcome the constraints inherent in this situation. Such groups should be able to mount an effective marketing effort.

The BIM shellfish promotion effort must also be expanded. This will become essential as quantities expand and continuity of supply can be guaranteed.

The potential of the home market must not, however, be overlooked. With a general increase in living standards, the purchasing power of the Irish market is increasing. Other positive factors are the growing influence of Europe on tastes and fashions and the increasing interest in seafood as a health product. These factors should be translated into increased demand for shellfish through an intensified marketing effort.

Now that there are large numbers of Continental visitors coming to Ireland every year, an attempt should be made to develop seafood markets in our coastal towns as is done in Brittany, in France. Fish farms should be advertised as tourist attractions, with fish and shellfish offered for sale to the visitors.

The main elements required to establish a sound marketing process are:-

1. Accurate forecasting of production schedules.

2. An adequate network of regionally based onshore or foreshore holding facilities where product can be collected, graded and packed for shipment. These facilities should provide purification and processing where necessary. The critical marketing functions of supply management and quality control should be carried out at these stations. A prototype initiative of this kind is already established in Dungarvan.
3. An effective information network which communicates up-to-date information from the market place to the producers, and
4. A central onshore coldstore/seawater tank facility located on the European mainland should be investigated. This facility would package product for shipment to direct order.

These facilities may appear expensive in view of the present small scale of the Irish shellfish industry. However, the EC Regulations on Fish Health and Marketing, as described in Appendix C mean that such facilities must be provided. EC grants will be available for any capital structures required.

In addition to the provision of these facilities, Irish producers must meet exacting standards in product quality, presentation, grading, packing and service. Unfortunately, these are areas where Irish traders have a reputation for unprofessionalism. Irregular supplies, incomplete deliveries, late deliveries, bad grading and poor packing (resulting in mortalities) appear to be the near universal experience of buyers who have dealt with Irish seafood importers in the past (Bennett, 1990). These difficulties must be overcome.

Chapter 6

SURVEY OF AQUACULTURE INDUSTRY

Introduction

In order to compile a detailed picture of the aquaculture industry, a survey of all known aquaculture enterprises was designed and carried out in early 1991. The objectives of this inquiry were to obtain detailed information on the size and nature of the fish farm, its sources of funding, levels of stocks and sales, estimates of the value of capital employed, how the fish were sold, the extent of processing, levels of operating costs and labour force. The survey also collected a variety of information on the technical and environmental aspects of the enterprises such as fish diseases, usage of drugs and chemicals, etc. Fish farmers' experiences with and attitudes towards licensing, government policy and other related issues were also assessed. A copy of the questionnaire used is given in Appendix F. It should be noted that in the year to which the survey refers (1990) and the previous year (1989) the salmon industry encountered numerous problems in relation to disease, low prices and adverse publicity affecting investment. The survey results strongly reflect these problems. Information on the industry collected in a 1987 survey of Gaeltacht farms (O'Connor and Whelan, 1988) gave a much more optimistic outlook. Salmon prices were high and the industry was very profitable.

Because of the relatively small number of enterprises in the industry, it was decided to attempt a complete enumeration rather than selecting a sample. A list was compiled from BIM and Udaras na Gaeltachta sources of all known enterprises involved in finfish and shellfish production and in the operation of finfish hatcheries.* This list comprised 259 names, and interviewers were sent to all of these.** The interviewers found that 39 of these had gone out of business and 21 were subsidiaries of other enterprises.

* There are 4 shellfish hatcheries in the state, two of these refused to give information and the other two had no sales in 1990.

** After the survey was completed, it was drawn to our attention that the coverage of the list was not complete in respect of the Freshwater Trout section. This deficiency was remedied by adjusting the weights to reflect the correct total number of enterprises. For this reason, the estimates for the Freshwater Trout section presented here supplant those published in Whelan and O'Connor (1991).

The outcomes of the interviewing were as follows:

	Shellfish	*Trout*	*Salmon*	*Salmon*[(a)] *Hatcheries*	*Shellfish Hatcheries*	*Total*
Initial Population	191	13	34	16	5	259
Gone out of business	33	–	4	2	–	39
Listed farm found to be a subsidiary of another listed enterprise	10	–	6	4	1	21
Total Operating Enterprises	148	13	24	10	4	199
Refused or never available for interview	25	5	7	–	2	39
Interviewed	123	8	17	10	2	160
Response Rate	*83%*	*62%*	*71%*	*100%*	*50%*	*80%*

(a) Includes two farms originally destined for salmon production which have been turned over entirely to sea-reared rainbow trout in 1990.

Thus, the population of enterprises to which our data refer comprises 199 farms or hatcheries and interviews were obtained with 80 per cent of these.

In preparing this chapter all the quantitative data on output, investment, costs, labour force, etc., have been weighted to give estimates for the total population. Opinion data is presented in unweighted form. The weights in question were derived on the basis of estimated 1990 production which was available for all the farms in the population.

Salmon and Trout Farms

Production, Capacity and Investment

The Survey results relate to 24 marine and 13 freshwater farms. Most of the marine farms produced only salmon, some produced both salmon and rainbow trout and two were devoted exclusively to trout production. All of the trout farms were land-based units producing freshwater fish. The majority of farms produced their own smolts and on these farms the smolt production is included as part of the enterprise. Throughout the rest of this chapter, the term "salmon farm" covers all marine farms producing finfish (i.e., salmon and/or rainbow trout).

Table 6.1 shows that 13 of the salmon farms and 9 of the trout farms commenced operations on or before 1986 while 11 salmon farms and 4 trout farms came into existence after that date. Annual sales of salmon and trout between 1985 and 1990, on the farms currently in production in the

State, are given in Table 6.2. Total sales of salmon on these farms rose from 666 tonnes in 1985 valued at IR£2.9 million to 5,987 tonnes in 1990 valued at IR£20.4 million. Trout sales rose from 458 tonnes valued at IR£0.9 million in 1985 to 1,035 tonnes in 1990 valued at IR£2.8 million. The figures for salmon production in this table differ somewhat from figures given by BIM; they do not include production or sales by firms which have recently gone out of production and are thus not included in the survey.

Of the salmon farms in operation in 1991, 15 produced less than 250 tonnes each in 1990, 5 produced between 250 and 500 tonnes while a further 4 had production of over 500 tonnes per farm.

Table 6.1: *Date of Commencement of Salmon and Trout Production*

Type of Farm	*1982 or before*	*1983-1986*	*1987-1990*
		No. of Farms	
Salmon Farms	6	7	11
Trout Farms	9	0	4
Total	15	7	15

Table 6.2: *Annual Sales of Farmed Salmon and Trout 1985-1990 on Farms in Operation in 1991*

	Quantity (tonnes)			*Value (IR£m.)*		
Year	*Salmon*	*Trout**	*Total*	*Salmon*	*Trout*	*Total*
1985	666	458	1,124	2.9	0.9	3.9
1986	1,179	524	1,703	4.9	1.1	6.0
1987	1,705	584	2,289	7.5	1.3	8.8
1988	3,290	773	4,063	14.9	2.0	16.9
1989	5,196	910	6,106	20.6	2.3	22.9
1990	5,987	1,035	7,022	20.4	2.8	23.2

* Includes fresh and sea water reared rainbow trout.

Note: The figures in this table differ somewhat from those given by BIM: they do not include figures for production or sales by farms which have recently gone out of production.

The number and capacity of the salmon and sea reared rainbow trout cages are given in Table 6.3. There were a total of 893 cages with a capacity of 1,388,000 cubic metres. Of these, 335 were Wavemasters, 136 Polar Circle, 58 Steelform, 54 Bridgestone, and 14 Kames. The remaining 296 cages were not specified. It should be noted that these figures include harvesting and holding cages which would not normally be included in estimating tonnage from cubic capacity.

The current value of structures and other fixed assets is estimated at IR£36.0 million, of which IR£34.4 million is in salmon farming and IR£1.6 million in the trout sector. Cages, anchors and moorings account for IR£9.7 million, nets for IR£2.1 million, boats for IR£3.7 million and transport vehicles for IR£1.2 million. The value of stores and other buildings is put at IR£10.0 million and other equipment at IR£9.3 million (see Table 6.4).

Table 6.3: *Number and Capacity of Salmon and Sea Trout Cages*

Make of Cage	*Number of cages*	*'000 Cubic metres*
Wavemaster	335	455.3
Steelform	58	76.3
Polar Circle	136	175.3
Kames	14	34.7
Bridgestone	54	381.2
Other and not specified	296	265.1
Total	893	1,387.9

Note: Harvesting and holding cages included.

Table 6.4: *Current Value of Structures and Other Fixed Capital on Salmon and Trout Farms*

Item	*Salmon Farms**	*Trout Farms IR£ million*	*Total*
Cages, anchors and moorings	9.1	0.6*	9.7
Nets	2.1	0.0	2.1
Boats	3.7	0.0	3.7
Transport Vehicles	1.0	0.2	1.2
Stores	0.8	0.1	0.9
Other Buildings	8.8	0.3	9.1
Other	8.9	0.4	9.3
Total	34.4	1.6	36.0

* Includes marine farms producing sea-reared rainbow trout.

The investment funds obtained from different sources are shown in Table 6.5. Total investment is IR£80.6 million, of which IR£28.5 million is bank and other borrowing and IR£20.4 million is own funds. The latter is mainly investment by other industries in aquaculture. Share capital is IR£11.5 million, IR£6.1 million is EC grants and IR£5.4 million is BIM, Udaras na Gaeltachta and other government grants. Average investment per farm is IR£3.5 million for salmon farms and IR£0.4 million for trout farms.

Of the salmon sales in 1990, 71 per cent were fish under 3 kg in weight, with 29 per cent being 3 kgs weight or greater. On average the small fish were sold for IR£3.29 per kg while the larger ones fetched IR£3.53 per kg.

Table 6.5: *Sources of Investment, in Salmon and Trout Farms*

Sources of Funds	*Salmon Farms*	*Trout Farms*	*Total*
		IR£ million	
BIM	1.6	0.2	1.8
Udaras na Gaeltachta	3.1	0.0	3.1
Other Government	0.5	0.0	0.5
EC	5.8	0.4	6.1
Share Capital	9.7	1.8	11.5
Own Funds*	19.6	0.8	20.4
Bank and Other Borrowing	27.8	0.6	28.5
Other	8.7	0.1	8.8
Total Investment	76.8	3.9	80.6
Average Investment per Farm	3.5	0.4	2.4

* Own funds are mainly intra-group transfers of funds within large companies.

The destination of salmon and trout sales in 1990 is shown in Table 6.6. Of the salmon sales, 222 tonnes (3.7 per cent) were sold directly to the Irish retail trade, while 1,104 tonnes (18.4 per cent) were sent directly abroad by the producers. The remaining 4,661 tonnes (77.9 per cent) were sold to Irish wholesalers or marketing groups. Some of the latter fish were sold on the home market either for fresh consumption or for smoking, while the remainder were exported mainly in fresh or chilled form. About 200 tonnes were exported in frozen form. There were some 400 tonnes of smoked salmon imports also.

Of the 324 tonnes of sea-reared rainbow trout marketed, 50 per cent was sold to Irish wholesalers or marketing groups and the remainder exported directly by producers. An estimated 710 tonnes of freshwater trout were sold. Of these 223 tonnes (31.5 per cent) were sold to the Irish retail trade and the remaining 487 tonnes (68.5 per cent) were sold to Irish wholesalers or marketing groups. The total value of all trout and salmon sales was IR£23.2 million.

The quantity of stocks of fish at the end of 1989 and 1990 and the value of the change in stocks between the two periods are given in Table 6.7. This table shows that stocks increased by 2,200 tonnes between the beginning and end of 1990. Of this increase salmon accounted for 1,900 tonnes and trout for 300 tonnes. By applying the average of beginning and end year prices to the change in quantities, the value of the change in stocks was estimated at IR£5.85 million. Of this sum, IR£5.43 million is attributed to salmon and IR£0.42 million to trout stocks.

Table 6.6: *Destination of Farmed Salmon and Trout Sales in 1990**

Destination of Sales	*Salmon*		*Sea trout*		*Freshwater trout*		*Total*	
	Tonnes	*IR£m.*	*Tonnes*	*IR£m.*	*Tonnes*	*IR£m.*	*Tonnes*	*IR£m*
To Irish retail trade	222	0.8	0	0	223	0.5	445	1.4
To Irish wholesalers, marketing group etc.	4661	15.9	162	0.5	487	1.1	5310	17.7
Sent abroad directly	1104	3.6	162	0.5	0	0	1266	4.1
Total	5987	20.4	324	1.0	710	1.6	7021	23.2

Table 6.7: *Quantity of Stocks at end of 1989 and 1990 and Value of Stock Changes*

	Quantity			
Type of Farm	*End 1989*	*End 1990*	*Change 1989-1990*	*Value of change**
		'000 tonnes		*IR£m.*
Salmon Farms				
Salmon	5.5	7.4	1.9	5.43
Sea Reared Trout	0.3	0.5	0.2	0.26
Trout Farms				
Fresh Water Trout	0.3	0.4	0.1	0.16
Total	6.1	8.3	2.2	5.85

* Stocks valued at average of beginning and end year prices.

Labour Force Employed

The labour force employed in salmon and trout farming in 1990 and the number of person years worked are given in Table 6.8. The total number of persons employed on all the farms was 802, of which 511 were full-time and 291 were part-time workers. Of the full-time workers, 478 were paid employees and 33 were unpaid family workers who share in the profits of the projects. Of the total workers, 741 were on salmon farms and 61 on trout farms. Total person years worked on all the farms was 548. Of these, 496 were on salmon farms and 52 on trout farms.

Table 6.8: *Labour Force Employed in Salmon and Trout Farming in 1990 and Number of Person/Years Worked*

	Salmon Farms			*Trout Farms*			*Total*		
	F.T.	*P.T.*	*Total*	*F.T*	*P.T.*	*Total*	*F.T.*	*P.T.*	*Total*
					No. of Workers				
Paid Workers	445	277	722	33	12	45	478	289	767
Unpaid Workers	19	–	19	14	2	16	33	2	35
Total	464	277	741	47	14	61	511	291	802
					Person/Years Worked				
Paid Workers	445	32	477	33	4	37	478	36	514
Unpaid Workers	19	–	19	14	1	15	33	1	34
Total	464	32	496	47	5	52	505	37	548

Note: F.T. = Full-time; P.T. = Part-time."

The educational and technical qualifications of the labour force on the farms from which returns were obtained are given in Table 6.9. Of the owners or chief executives, 44 per cent had third level education, 44 per cent had second level and 12 per cent had only primary level education. In addition, 48 per cent had attended fish farming courses. Among the other full-time staff, 15 per cent had third level education, 57 per cent had second level, while 28 per cent had primary level only. Some 23 per cent of other full-time workers attended fish farming courses.

Of the part-time workers, 2 per cent had third level education, 67 per cent had second level, while 31 per cent had primary level only.

Table 6.9: *Educational and Technical Qualifications of the Labour Force Employed in Salmon and Trout Farming*

	Salmon Farmers			Trout Farmers			Total		
Type of Education	*Owner*	*Other staff FT*	*Other staff PT*	*Owner*	*Other staff FT*	*Other staff PT*	*Owner*	*Other staff FT*	*Other staff PT*
					Per cent				
Primary only	1	27	31	20	40	27	12	28	31
Primary + Second level	49	58	68	40	49	64	44	57	67
Third level	49	15	2	40	11	9	44	15	2
Total	100	100	100	100	100	100	100	100	100
Fish Farming Courses									
Short (under 6 months)	24	14	–	60	9	–	37	13	–
Long (over 6 months)	12	10	–	10	11	–	11	10	–
Total	36	24	–	70	20	–	48	23	–

Problems Encountered by Salmon and Trout Farmers

A list of the problems encountered by salmon and trout farmers is given in Table 6.10. Ten out of the 17 salmon farmers who completed questionnaires mentioned fish diseases as being a problem, while 9 mentioned attacks by birds and seals. Acquiring a site was also mentioned as a difficulty by 9 respondents while 7 mentioned early maturity/grilsing. The physical conditions of sites, e.g., heavy wave action was mentioned as a difficulty by five respondents.

Among the trout farmers, attacks or predation by birds or wild animals was mentioned as a problem by six respondents. Three people mentioned arranging ice supplies as a difficulty. Two respondents mentioned the following difficulties:

- Finding outlets for fish produced
- Early maturing or grilsing and
- Physical conditions of the site, e.g., heavy wave action.

Other problems mentioned by 4 salmon farmers were:-

- Obtaining goodwill of local community,
- Biological conditions of the site e.g., plankton blooms,
- Obtaining the water quality samples and sea bed data required by the Department of the Marine,
- Competition for space with other users or conflicts with other activities e.g., angling or wild stock fishing and

* Finding outlets for fish produced.

Table 6.10: *Problems Encountered by Salmon and Trout Farmers*

	Salmon Farms	Trout Farms	Total
	Number of farmers		
Finding outlets for the fish produced	4	2	6
Arranging transport	1	–	1
Arranging storage	1	–	1
Arranging ice supplies	1	3	4
Getting supplies of juveniles	1	1	2
Fish diseases	10	1	11
Obtaining goodwill of local community	4	1	5
Getting technical or other advice	1	–	1
Early maturing/"grilsing"	7	2	9
Acquiring a site	9	1	10
Physical conditions of site, e.g., heavy wave action	5	2	7
Biological conditions of site, e.g., plankton blooms	4	1	5
Obtaining the water quality and sea bed data required by the Department of the Marine	4	–	4
Competition for space with other users, or conflict with other activities, e.g., angling or wild-stock fishing	4	–	4
Attacks or predation by sea birds, seals, etc.	9	6	15
Other problems	7	2	9

Financial Results on Salmon and Trout Farms

Financial results on the salmon and trout farms are given in Table 6.11. Overall substantial losses were incurred on many of the salmon farms whereas trout production was profitable.

In assessing the profitability of the farms, it is necessary to take account of the cost of replacing the capital employed by including an allowance for depreciation. In arriving at an appropriate depreciation rate, account was taken of the expected lifetime of the asset. Thus, short-lived items such as nets were depreciated at a higher rate than long-lasting assets such as buildings. Depreciation was calculated on the basis of the *full cost* of the assets without making any allowance for grants or subsidies received by the farm. The depreciation figures shown refer, therefore, to provision for the cost of replacing the capital on the assumption that no further grants are payable for this. This means that the depreciation as shown is the true cost to society of using the capital in aquaculture. The actual cost to the individual farmer will be lower to the extent that grants or subsidies will be paid to him on replacement capital in the future. Similarly, the cost to the Irish economy will be lower if EC grants and subsidies specific to the fish farming section are payable on replacement investment.

Table 6.11: *Financial Results on Salmon and Trout Farms in 1990*

	Salmon	*Trout*	*Total*
		IR£000	
Sales	21,347	1,910	23,257
Purchase of mature fish	(452)	(79)	(531)
Sales less purchases	20,895	1,831	22,726
Stock changes	5,430	158	5,588
Gross Output	26,325	1,989	28,314
Expenses			
Smolts + other juveniles	3,133	80	3,213
Feed	11,162	612	11,774
Insurance	2,254	17	2,271
Interest	1,354	25	1,379
Disease Treatment/Diagnostics	978	16	995
Packaging and marketing	1,903	54	1,957
Transport	1,423	69	1,492
Energy	914	33	947
Other	1,115	163	1,278
Non-Labour Costs	24,237	1,069	25,306
Gross Value Added	2,088	920	3,008
Paid labour costs	(6,700)	(349)	(7,049)
Gross Income	(4,612)	571	(4,041)
Depreciation	(4,237)	(115)	(4,352)
Self-employment + trading income	(8,849)	456	(8,393)

Sales of salmon and sea-reared rainbows (less purchases of mature fish) were IR£20.9 million. The value of marine salmonid stocks increased by IR£5.4 million between the beginning and end of the year so that the value of gross output was IR£26.3 million. Total expenses other than paid labour and depreciation were IR£24.2 million, giving a gross value added to the industry of IR£2.1 million. When labour costs were deducted from this amount gross income was negative at –IR£4.6 million and when depreciation of IR£4.2 million calculated on a "full cost" basis as described above was added to this the total loss on the operation was IR£8.8 million. Even if account were taken of grants and subsidies (which would have the effect of reducing the depreciation charge by about 50 per cent to IR£2m), Irish salmon farms would still have recorded an overall loss.

The value of output on the freshwater trout farms was IR£2.0 million. Costs other than depreciation and labour were IR£1.1 million giving a gross value added of IR£0.9 million. When depreciation and labour costs of IR£0.46 million were deducted from this, income from self-employment was IR£0.46 million, or 23 per cent of gross output.

A number of the marine farms suffered storm damage during 1990. We enquired about receipts from insurance claims and found that about IR£800,000 was received in compensation in relation to their claims. If this receipt is included in the income estimates, it would reduce the negative self-employment and trading income figures on these farms to IR£8m.

Individual cost items for salmon and trout as a proportion of total costs are shown in Table 6.12. Feed at 32 per cent of total costs is the largest item of expenditure on salmon farms. Paid labour at 19.0 per cent is also a big item. Purchases of smolts and other juveniles account for 8.9 per cent. Insurance accounted for 6.4 per cent of costs, packaging and marketing for 5.4 per cent, transport for 4.0 per cent and interest for 3.8 per cent.

Table 6.12: *Individual Expenses as Percentage of Total Expenses on Salmon and Trout Farms*

	Salmon	*Trout*
	Per cent	
Smolts and other Juveniles	8.9	5.2
Feed	31.7	39.9
Insurance	6.4	1.1
Paid Labour	19.0	22.8
Interest	3.8	1.6
Disease Treatment/Diagnostics	2.8	1.0
Packaging/Marketing	5.4	3.5
Transport (own + hired)	4.0	4.5
Energy	2.6	2.2
Depreciation	12.0	7.5
Other	3.2	10.6
Total	100.0	100.0

On the trout farms, feed accounted for 39.9 per cent of costs, labour for 22.8 per cent, purchases of juvenile fish for 5.2 per cent, transport for 4.5 per cent, packing and marketing for 3.5 per cent and depreciation for 7.5 per cent.

Reasons for Poor Results on the Salmon Farms

The results on marine farms producing salmon were particularly poor and we attempted to discover the reason for this by looking at the income and expenses on the individual farms. It was interesting to note that, of the 15 farms in the sample producing salmon, 4 made sizeable profits. Seven broke even or had small losses. Four farms were mainly responsible for the losses. Unit production costs (cost per kg. output) and other features on these three groups of farms are given in Table 6.13 where they are compared with similar figures for Scottish farms in 1989. It should be noted that

(a) the Scottish data, being from a different year, are not strictly comparable with the Irish but they give a reasonable picture of events.

(b) The Scottish fish are valued at average price delivered to Boulogne. The Irish salmon are valued at the prices farmers received. Some of these are in-cage prices; others are prices received on export markets where the farmers themselves did the marketing. In both cases, the cost of delivery to export markets are included in the expenses.

(c) A separate heading for transport expenses is not included in the Scottish results. This cost is included in other items, possibly in packaging and marketing and in administrative overheads (i.e., own transport).

(d) All the profitable Irish farms were small family units accounting for only about 10 per cent of total output. The break-even farms were a mixture of small and large farms accounting for 52 per cent of output. The loss-making farms were all large units which accounted for 38 per cent of output.

Comparison of Fish Losses and Cost Items

Fish Losses: These are an important determinant of unit costs. Large losses are associated with reduced output and hence higher costs per unit output. On the Irish farms fish losses as a percentage of smolts put in were 10.9 per cent on the profitable farms, 14.0 per cent on the break-even farms and 38 per cent on the loss-making farms. These compared with 7.2 per cent on the Scottish farms.

Costs: Smolt costs per kg. of output are highest on the profit-making farms and lowest on the loss-making farms. The former purchased all their smolts whereas the latter were all integrated farms producing their own smolts which were entered in the accounts at cost of production.

The loss-making farms had higher feed costs than the others. Some of these costs were due to consumption by the smolts but there was probably some waste of feed as well.

Table 6.13: *Unit Production Costs and Other Features on Different Groups of Irish and Scottish Salmon Farms*

	Irish Farms 1990				*Scottish Farms 1989**
	Profitable Farms	*Break-even Farms*	*Loss making Farms*	*All Firms (Weighted)*	
No. of Farms	4	7	4	22	22
Per cent output in group	10.3	52.4	37.3	100	60
Fish Losses as percentage of smolts put in	10.9	14.0	38.0	22.8	7.2
Cost Items	*Production Cost IR£/kg*				
Smolts	0.73	0.50	0.32	0.40	0.82
Feed	1.03	1.20	1.64	1.34	1.14
Paid Labour	0.32	0.55	1.38	0.83	0.57
Disease Treatment	0.05	0.06	0.24	0.12	+
Insurance	0.16	0.20	0.44	0.28	0.12
Packaging & Marketing	0.19	0.15	0.38	0.24	0.22
Transport	0.11	0.18	0.19	0.18	–
Energy	0.00	0.02	0.29	0.12	+
Admin./Overheads	–	–	–	–	0.29
Interest	0.14	0.22	0.09	0.17	0.13
Depreciation	0.21	0.36	0.79	0.52	0.29
Other	0.09	0.12	0.18	0.14	0.14+
Total Cost	3.03	3.56	5.94	4.34	3.72
Price received for Sales	3.45	3.52	3.27	3.41	3.70

* Scottish results based on a survey of 22 representative farms covering 60 per cent of the Industry carried out by North of Scotland Agricultural College and quoted in Landill Mills Associates Report (*op. cit.*, Table 3.2.10)

\+ Scottish "Other", includes disease treatment and energy.

Paid labour per unit of output was much higher on the loss-making farms than on the others. It was over four times as great as on the profit-making farms. This result must, however, be taken with some caution. The profitable farms, being all small family units, had unpaid family labour which is not included as a cost in the calculations. If this labour were valued at the same rate as the paid labour, it would increase average cost per kilogram on these farms by about 14 pence. This still leaves these farms in a profitable situation.

In a paper presented at an aquaculture conference in Furbo, Co. Galway, in October 1990, Tony Fox of Fanad Fisheries said that salmon farmers should aim to keep labour costs at 10 per cent of total costs. It is interesting to note, therefore, that on the profitable salmon farms paid labour was 10.6 per cent while on the loss-making farms it was 23 per cent of total costs. On the break-even farms the ratio was 15.4 per cent compared with a ratio of 15.3 per cent for the Scottish farms.

All of the other expense items, except interest, were higher on the loss-making farms than on the others. Interest payments were lower because most of the loss-making farms were financed through share capital. On the break-even farms insurance is higher and packaging and marketing lower in Ireland than in Scotland. Of the other items which can be compared, both interest and depreciation are higher on the Irish break-even farms than on the Scottish.

The conclusion to be drawn from these comparisons is that the Irish break-even farms are relatively efficient by Scottish standards. The loss-making Irish farms have very high costs per unit output, particularly labour and depreciation. As stated above, these high costs are associated, among other things, with large fish losses either from disease or escapes.

All the farms reported disease problems of some kind, the main disease being Pancreas disease (11 reports), Vibrio (6 reports), Furnuculosis (2 reports) and other diseases (7 reports). In all, over 1 million salmon were lost due to disease and escapes. This represents a total loss rate of 22.8 per cent, which is very high. A normal rate is about 18 per cent (Fox, *op. cit.*).

The disease problems seem to be associated with the warm weather in the summer of 1990. Reports received for 1991, when the weather was much cooler, indicate much reduced mortality rates everywhere. As is stated in Chapter 2 above, it now seems clear that output in 1991, at 9,000 tonnes, was substantially above that in 1990. While data or costs for 1991 are not available, this increase in output has undoubtedly improved the profitability of the sector.

Proposed Investment in Fixed Capital and Future Sales on Salmon Farms

Despite the poor financial returns in 1990, salmon farmers in particular were optimistic about the future, giving the figures in Table 6.14 for proposed investment and sales in the years 1991 to 1995. Salmon farmers propose to invest IR£13.8 million in fixed capital over these five years. The proposed investment by trout farmers is IR£1.1 million. In regard to production, salmon sales were predicted to rise substantially to 10,600 tonnes in 1991 and to continue rising to 13,000 tonnes by 1995. Sea rainbow trout production is expected to decline somewhat from 750 tonnes in 1991 to 700 tonnes in 1995 but it should be remembered that the 1991 projection is almost double the actual 1990 sales. Earlier projections (750 tonnes) made by BIM for 1990 were not attained in that year. This was mainly due to problems experienced in the more inshore sites. Recently, there has been renewed interest and investment in more offshore trout sites and production is expected to increase accordingly. Freshwater trout are projected to increase from 949 to 1,118 tonnes over the period.

Table 6.14: *Proposed Investment in Fixed Capital and Sales on Salmon and Trout Farms 1991-1995*

	1991	*1992*	*1993*	*1994*	*1995*	*Total 1991-1995*
				IR£m		
Investment in Fixed Capital						
Salmon Farms	3.2	3.5	2.5	2.3	2.3	13.8
Trout Farms	0.3	0.3	0.3	0.1	0.1	1.1
Total	3.5	3.8	2.8	2.4	2.4	14.9
Sales		*Tonnes*				
Salmon Farms						
Salmon	10,639	11,173	11,670	12,447	13,085	-
Sea Reared Trout	750	700	700	700	700	-
Trout Farms						
Freshwater Trout	949	1,015	1,076	1,117	1,118	-
Total	12,338	12,888	13,446	14,264	14,903	-

The salmon farmers' projections both for investment and sales are somewhat optimistic. In the short term the sales projections may be realised. Because there appears to be a good deal of spare capacity in the industry at present, some increase in salmon output could take place without further fixed capital investment and judging from the stocks in the sea at the end of 1990 a substantial increase was planned for 1991 when about 9,000 tonnes were produced. In the medium term the industry may be constrained by lack of capital unless overall profitability shows an improvement over the 1990 situation. It seems to us that fish losses, either from disease or escapes, are the crucial factors and these must be addressed. As pointed out in Chapter 7, one method for reducing the likelihood of disease outbreaks is to reduce stocking rates in the cages, particularly during warm periods.

Independent Hatcheries

As indicated above, most of the salmon and trout farms in the state produce their own juveniles; similarly with the shellfish farms. The costs of these hatcheries are included in the financial results for the salmon, trout and shellfish farms. In addition, there are ten independent finfish and four independent shellfish hatcheries in the state. Some data are available for all the independent finfish hatcheries but nothing usable was obtained from those for shellfish. Two refused to co-operate while the data obtained from the other two were very incomplete. Thus, the figures presented in this section relate to the ten finfish hatcheries.

Of these hatcheries, three commenced operations prior to 1982, 4 started up between 1983 and 1986 and the remaining three between 1987 and 1989. Annual sales rose from IR£321,000 in 1985 to IR£1.17 million in 1990. The current value of structures and other fixed capital items is estimated at IR£1.6 million, of which ponds and tanks account for IR£593,000. Stores and other buildings are valued at IR£850,000 while cages and nets are priced at IR£112,000. Total investment is estimated at IR£3.7 million.

There are 30 full-time and a further 30 part-time paid workers employed. In addition, there are 6 full-time and three part-time unpaid workers employed, making for a total of 69.

All of the owners had at least second level education while three had third level. Of the other workers, 6 had primary level, 40 had second level and 17 had third level education. Twelve workers had attended fish farming courses.

Finding outlets for the juveniles produced was mentioned as a problem by 7 of the respondents. This was a very serious problem on a number of the hatcheries in 1990 when it became impossible to dispose of stock even at very low prices. Another problem mentioned by 6 respondents was attacks or predation by birds. Diseases were mentioned as a problem on 4 hatcheries.

The financial results (see Table 6.31) are summarised as follows:-

Sales account for IR£1.166 million and when stock increases of

IR£536,000 are added to this, gross output comes to IR£1,702 million. Non-labour costs are estimated at IR£1.220 million giving a gross value added of IR£482,000. Deducting paid labour expenses of IR£416,000 from this gives a gross income of IR£66,000 but when depreciation of IR£81,000 is taken from this income for self-employment and other trading, income is negative at IR£15,000.

A mixed response was obtained to questions on the future prospects for the industry. Five hatcheries said that the outlook was very poor. There was no market for smolts at the present time. One of these said it would have to close down on a temporary basis until the market improved. The other 5 were much more optimistic. They felt that the market for mature fish and hence for smolts would improve and they would be ready to supply juveniles when this happened.

Shellfish Farms

Structure of the Shellfish Sector

There are a total of 148 shellfish enterprises in the State. Table 6.15 shows that 97 of these operate at one site, 26 at two sites, 14 at three sites and 7 at four or more sites. There are 54 rope mussel enterprises, 4 bottom mussel producers, 62 Pacific oyster producers, 7 native oyster producers and 21 other shellfish producers. The four bottom mussel producers are Co-ops or similar organisations and cover a number of individual producers, similarly with the seven native oyster producers. The bottom mussel and native oyster enterprises included in this survey are ones in which there was some *human* intervention in the rearing process. What were deemed wild shell fisheries, though they had substantial output, are excluded.

Table 6.15: *Number of Sites or Locations of Shellfish Farms*

Number of sites	*Rope Mussels*	*Bottom Mussels*	*Pacific Oysters*	*Native Oysters*	*Other*	*Total*
			Estimated No. of farms			
One	42	–	37	5	13	97
Two	6	–	13	2	5	26
Three	2	2	8	–	2	14
Four or More	4	2	–	–	1	7
Not stated	–	–	4	–	–	4
Total	54	4	62	7	21	148

Table 6.16 shows that 21 groups commenced operating prior to 1982, 35 started up between 1983 and 1986 while 92 were initiated between 1987 and 1990. Among the latest arrivals are 30 of the 54 rope mussel producers, 2 of the 4 bottom mussel enterprises, 42 out of 62 Pacific oyster growers and 18 of the other shellfish growers. The latter are mainly clam producers.

Table 6.16: *Date of Commencement of Shellfish Production*

Main Species Farmed	*1982 or Before*	*1983-86*	*1987-1990*	*Total*
		No. of Farms		
Rope Mussels	7	17	30	54
Bottom Mussels	2	-	2	4
Pacific Oysters	7	13	42	62
Native Oysters	5	2	-	7
Other	-	3	18	21
All Shellfish Farms	21	35	92	148

The current values of structures and other fixed capital in the shellfish industry are shown in Table 6.17. The total value is estimated at IR£10.2 million of which IR£2.3 million is invested in trestles and long lines, IR£4.6 million in boats, IR£870,000 in stores and other buildings and IR£0.6 million in transport vehicles. The remaining IR£1.7 million is invested in rafts, nets and miscellaneous.

The largest investment of IR£2.9 million is in fixed capital for rope mussels. Capital devoted to bottom mussel production was valued at IR£2.7 million while the value of Pacific oyster structures and equipment is put at IR£2.5 million. Native oyster structures are valued at IR£0.4 million and structures for the other shellfish are estimated at IR£1.7 million.

Sources of investment in shellfish aquaculture are shown in Table 6.18. Total investment is estimated at IR£17.5 million of which IR£8.8 million came from own funds and share capital, IR£3.6 million was obtained from BIM, Udaras na Gaeltachta and other Government sources in the form of grants, loans, etc. IR£2.5 million came from EC sources, IR£2.2 million from bank and other borrowings and the remaining IR£0.3 million from other sources.

Table 6.17: *Current Value of Structures and Other Fixed Capital on Shellfish Farms*

Item	*Rope Mussels*	*Bottom Mussels*	*Pacific Oysters*	*Native Oysters*	*Other*	*Total*
			IR£'000			
Rafts	126	0	131	0	2	259
Trestles/ Long lines	839	1	1,019	133	349	2,341
Nets	29	1	155	41	25	251
Anchors and moorings	81	0	14	0	19	114
Boats	1,149	2,351	95	52	923	4,570
Transport vehicles	123	110	193	40	132	598
Stores	23	55	76	10	12	176
Other buildings	0	71	368	111	143	693
Miscellaneous	488	143	487	0	109	1,227
Total	2,858	2,732	2,538	387	1,714	10,229

Table 6.18: *Sources of Investment, Government Loans, etc., for Shellfish Farms*

Item	*Rope Mussels*	*Bottom Mussels*	*Pacific Oysters*	*Native Oysters*	*Other*	*Total*
				IR£'000		
BIM	643	59	604	788	347	2,441
Udaras na Gaeltachta	58	197	248	421	83	1,007
Other government	14	21	38	95	19	187
EC	463	183	1,212	521	161	2,540
Bank and other borrowing	578	612	689	98	209	2,186
Own funds and share capital (equity)	1,200	2,000	1,736	1,061	2,830	8,827
Other	36	0	51	139	49	275
Total investment	2,992	3,722	4,578	3,123	3,698	17,463
Average investment per farm	55	768	74	446	176	118

The value of annual shellfish sales in the years 1985 to 1990 is shown in Tables 6.19. Total sales rose from IR£1.8 million in 1985 to IR£5.6 million in 1990. Among the different species, rope mussel sales rose from IR£0.7 million to IR£1.3 million, bottom mussels went from IR£0.5 million to IR£1.8 million; the value of Pacific oyster sales rose from IR£101,000 to IR£518,000 while native oysters rose from IR£336,000 to IR£1.7 million. In valuing sales the shellfish are valued at prices received by producers before any processing took place other than freezing, depuration or packaging.

The destination of sales in 1990 is shown in Table 6.20. Of the total shellfish sales, 53.2 per cent were prepared by the producers and sold abroad, 36.0 per cent were sent abroad directly in the fresh form, 9.0 per cent were sold fresh to Irish wholesalers or marketing groups, and 1.8 per cent were sold fresh to the Irish retail trade.

Table 6.19: *Annual Sales of Farmed Shellfish 1985-1990*

Item	*Rope Mussels*	*Bottom Mussels*	*Pacific Oysters*	*Native Oysters*	*Other*	*Total*
			IR£'000			
1985	695	545	101	336	75	1,752
1986	437	754	117	525	85	1,918
1987	670	1,180	123	1,036	60	3,069
1988	720	1,253	192	1,120	155	3,440
1989	1,000	1,200	60	1,358	201	4,119
1990	1,331	1,800	518	1,660	288	5,597

Table 6.20: *Destination of Farmed Shellfish Sales in 1990*

Destination of sales	*Rope Mussels*	*Bottom Mussels*	*Pacific Oysters*	*Native Oysters*	*Other*	*Total*	*Total %*
			Tonnes				
Fresh to Irish retail trade	216	–	92	18	17	343	1.8
Fresh to Irish wholesales or marketing groups	1,425	27	78	118	13	1,661	8.6
Sent abroad fresh	1,464	5,007	193	238	32	6,934	36.0
Prepared and sold in Ireland	60	–	7	–	–	67	0.3
Prepared and sold abroad	195	9,966	13	46	10	10,230	53.2
Total	3,360	15,000	384	420	72	19,235	100

Looking at the different species of shellfish we notice that most of the rope mussels were sent abroad directly in the fresh form or were sold to Irish wholesalers or marketing groups. Most of the bottom mussels were prepared and sold abroad while about 5,000 tonnes were exported fresh. As stated above, however, these mussels were valued at the price fishermen received for them and not at the price of the processed products. Processing costs and labour employed in anything but minimal processing are excluded in this study.

Of the Pacific oysters 92 tonnes were sold fresh to the Irish retail trade, 193 tonnes were sent abroad in fresh form, while 78 tonnes were sold fresh to Irish marketing groups. Only 20 tonnes were sold by producers in a prepared form. Most of the native oysters were sold fresh either to Irish wholesalers or were sent abroad directly. Some 46 tonnes were prepared by producers and sold abroad. Preparation in this case was mainly packing and freezing.

The value of stocks at the end of 1989 and 1990 is shown in Table 6.21. Total stocks at the end of 1989 were valued at IR£3.8 million and at the end of 1990 the value was IR£5.5 million giving an increase in value of IR£1.7 million. Over the period the value of rope mussel stocks increased slightly (by IR£38,000) as did the value of bottom mussels stocks (up by IR£39,000). Pacific oyster stocks increased by IR£715,000, native oysters by IR£269,000 and other shellfish stocks by IR£643,000. The increase in Pacific oyster stocks is related to the market situation. A number of producers sold very few or no oysters in 1990 so that stocks built up over the year. The increase in the other stocks were mainly Clams from new operations which were not fully ready for sale in 1990.

Table 6.21: *Value of Farmed Shellfish Stocks 1989 and 1990*

Species	*End 1989*	*End 1990*	*Change in Stocks 1989-90*
		IR£'000	
Rope Mussels	843	881	+ 38
Bottom Mussels	161	200	+ 39
Pacific Oysters	1,390	2,105	+715
Native Oysters	946	1,115	+269
Other	592	1,235	+643
All Shellfish Farms	3,832	5,536	+1,703

Note: It was not possible to calculate changes in the quantities of stocks because of variation in the units used by the respondents to report their stocks (tonnes, number of fish bags, boxes, etc.). The change in the money value of stocks was used instead.

The labour force employed in shellfish farming is shown in Table 6.22. There were a total of 930 people employed of which 524 were paid workers, 241 were unpaid family workers and 165 were fishermen supplying Co-operatives or other companies with farmed bottom mussels and native oysters. Of the total work-force, 225 were full-time and 705 were part-time. Some 75 full-time workers and 221 part-time workers were employed in rope mussel production. Bottom mussels had 16 full-time and 121 part-time workers employed. In Pacific oyster production, there were 76 full-time and 169 part-time workers and in native oysters, 13 full-time and 132 part-time people were employed. Other shellfish had 45 full-time and 62 part-time workers.

Total person years worked for all farms was 417. Of these 109 were in rope mussels, 70 in bottom mussels, 110 in Pacific oysters, 67 in native oysters and 61 in other shellfish production.

Table 6.22: *Labour Force Employed in Shellfish Farming*

	Rope Mussels		*Bottom Mussels*		*Pacific Oysters*		*Native Oysters*		*Other*		*Total*		
	FT	*PT*	*FT*	*PT*	*FT*	*PT*	*FT*	*PT*	*FT*	*PT*	*FT*	*PT*	*Total*
						No.							
Paid Workers	33	181	12	13	27	118	13	65	30	32	115	409	524
Unpaid Family	42	40	4	3	49	51	–	7	15	30	110	131	241
Other Unpaid	–	–	–	105	–	–	–	60	–	–	–	165	165
Total	75	221	16	121	76	169	13	132	45	62	225	705	930
						Person/Years Worked							
Paid Workers	33	14	12	1	27	26	13	20	30	7	115	68	183
Unpaid Family	42	20	4	1	49	8	–	4	15	9	110	42	152
Other Unpaid	–	–	–	52	–	–	–	30	–	–	–	82	82
Total	75	34	16	54	76	34	13	54	45	16	225	192	417

The educational and technical qualifications of those employed in shellfish farming (other than the fishermen who supplied bottom mussels and oysters) are given in Table 6.23. Of the total workers, 21 per cent had third level education, 60 per cent had second level and 18 per cent had primary level only. Some 16 per cent attended fish farming courses. About 40 per cent of owners and full-time employees had third level education and around 20 per cent of these had attended fish farming courses.

Table 6.23: *Educational and Technical Qualifications of Persons Employed in Shellfish Farms*

Type of Education	*Owner*	*Employees*		*Total*
		Full-time	*Part-time*	
		Per cent		
Primary only	12.1	14.8	22.0	18.4
Primary and second level	46.8	46.1	70.2	60.4
Third level	41.0	39.1	7.8	21.2
Total	100.0	100.0	100.0	100.0
Fish Farming Courses				
Short (under 6 months)	14.4	4.3	6.6	8.2
Long (over 6 months)	9.8	15.7	5.4	8.2
Total	24.2	20.0	12.0	16.4

Table 6.24 shows the problems encountered by shellfish farmers. Finding outlets for the fish produced was a problem for 73 producers. Of these 25 were rope mussel producers and 43 were Pacific oyster growers. The physical condition of the site was a problem for 50 farmers. Of these, 29 were rope mussel producers and 12 were Pacific oyster farmers. Thirty five people complained about the biological conditions of their sites (Plankton blooms). These were mainly rope mussel producers. Twenty-four people complained about attacks of birds and other predators. Most of these were pacific oyster producers. Twenty two people had difficulties in acquiring a site, 21 had problems with getting supplies of juveniles, 19 complained about difficulties in getting technical and other advice, 16 mentioned obtaining the goodwill of the community as a problem and 12 complained about arranging transport. In all, the rope mussel and Pacific oyster groups had most problems. Bottom mussel producers had few complaints.

Table 6.24: *Problems Encountered by Shellfish Farmers*

Problems Encountered	*Main Species Farmed*					*Total*
	Rope mussels	*Bottom Mussels*	*Pacific Mysters*	*Native Oysters*	*Other*	
	No. of Farmers Reporting this Problem					
Finding outlets for the fish produced	25	0	43	0	5	73
Arranging transport	7	0	4	0	1	12
Arranging storage	3	0	2	1	0	6
Arranging ice supplies	0	0	1	1	0	2
Getting supplies of juveniles	5	0	11	2	3	21
Fish diseases	5	0	4	0	0	9
Obtaining goodwill of local community	5	1	8	1	1	16
Getting technical or other advice	7	1	5	1	5	19
Acquiring a site	9	1	9	1	2	22
Physical conditions of site, e.g., heavy wave action	29	1	12	2	6	50
Biological conditions of site, e.g., plankton blooms	29	0	5	0	1	35
Obtaining the water quality and sea bed data required by the Department of the Marine	3	1	4	0	0	8
Competition for space with other users, or conflict with other activities, e.g., angling or wild-stock fishing	5	1	3	1	0	10
Attacks of predation by sea birds or seals	3	0	13	1	7	24
Other problems	18	2	7	0	7	34

Financial Results on Shellfish Farms

Financial results on the shellfish farms are given in Table 6.25. As in the case of salmon farms, depreciation was calculated on a "full cost" basis, without making any allowance for grants paid. To the extent that grants or subsidies are payable on replacement investment, this will overstate the cost as perceived by the individual farmers. For the industry as a whole sales were IR£5.6 million; stock increases were IR£1.7 million so that gross output was IR£7.3 million. Non-labour costs were IR£2.5 million and when these were deducted from gross output, gross value added was IR£4.8 million. Deducting paid labour and depreciation from this amount gives income from self-employment of IR£2.3 million which is 31 per cent of gross output. Shellfish farming employs a good deal of unpaid family labour. The value of this at the same average rate as paid employees is estimated at IR£1.63m and when this is deducted from income from self-employment, profit from the industry comes to IR£660,000 which is 9 per cent of gross output.

Table 6.25: *Financial Results on the Shellfish Farms*

	Main Shellfish Species Farmed					
	Rope Mussels	*Bottom Mussels*	*Pacific Oysters*	*Native Oysters*	*Other*	*Total*
			IR£'000			
Sales*	1,419	1,800	759	1,457	162	5,597
Stock Changes*	79	39	744	28	813	1,703
Gross Output	1,498	1,839	1,503	1,485	975	7,300
Expenses						
Spat + other juveniles	14	0	411	37	143	605
Transport	121	287	85	14	54	561
Interest	85	55	74	67	235	516
Insurance	22	34	26	7	36	125
Packaging, marketing	30	20	87	3	31	171
Energy	12	59	16	2	22	111
Postage, telephone, legal	48	53	75	13	46	235
Other non-labour	51	40	30	17	14	152
Total non-labour costs	383	548	804	160	581	2,476
Gross value added	1,115	1,291	699	1,325	394	4,824
Paid Labour costs	(251)	(125)	(283)	(106)	(518)	(1,283)
Gross income	864	1,166	416	1,219	–124	3,541
Depreciation	(377)	(284)	(362)	(51)	(205)	(1,279)
Self employment + trading income	487	882	54	1,168	–329	2,262

* This table classifies the data by the main shellfish species farmed. Thus, to the extent that some farms produce more than one species, the figures differ from those shown in Tables 6.19 and 6.21.

The most profitable enterprises were bottom mussels and native oysters. Rope mussels showed a lower return. Returns from Pacific oysters and other species such as clams and scallops were less favourable.

Rope Mussels

Sales are IR£1.4m and stocks increased by IR£79,000 so that gross output is IR£1.5 million. Non-labour costs are IR£383,000 and when these are deducted from gross output, gross value added is IR£1.1m. Deducting paid labour costs of IR£251,000 from this gives a gross income of IR£864,000 and when depreciation is taken into account income from self-employment and other trading income is estimated at IR£487,000.

Bottom Mussels

Gross output is IR£1.8 million. Deducting non-labour costs of IR£548,000 from this gives a gross value added of IR£1.3m. Paid labour is IR£125,000 and when this is deducted from value added, gross income is IR£1.2m. Deducting depreciation of IR£284,000 from this gives a figure of IR£0.9m for income from self employment and other trading income.

Pacific Oysters Farms

Sales on farms whose main product is Pacific Oysters amounted to IR£759,000. When stock increases of IR£744,000 are added to this, gross output is IR£1.5 million. Deducting non-labour costs of IR£804,000 from gross output gives a gross value added of IR£699,000. Paid labour costs are IR£283,000 and when these are deducted from value added, gross income is IR£416,000. However depreciation at IR£362,000 reduces income from self employment to IR£54,000.

Native Oyster Farms

Gross output of farms specialising in native oysters is IR£1.5 million. Deducting non-labour expenses of IR£160,000 from this gives a gross value added of IR£1.3 million. Taking paid labour costs of IR£106,000 from this gives a gross income of IR£1.2 million and with depreciation only IR£51,000, income from self employment is IR£1.2 million.

Other Shellfish

Gross output which includes an increase in stocks of IR£813,000 is IR£975,000. Taking non-labour costs of IR£581,000 from this gives a gross value added of IR£394,000. Paid labour is valued at IR£518,000 so that gross income is negative at –IR£124,000 leaving nothing to remunerate family labour and depreciation.

Individual Costs as a Proportion of Total Costs

Individual costs as a proportion of total costs are given in Table 6.26. For rope mussels the largest single item is depreciation which accounts for 37 per cent of total costs. This indicates relatively high capital investment in this operation. Paid labour at 24.8 per cent is the next highest item of expenditure. We must be careful, however, in interpreting labour costs since, as shown in Table 6.22, there is a good deal of unpaid labour in all the shellfish groups. Hence, low labour costs in any group probably indicate a high amount of unpaid labour and vice versa. Other fairly high rope mussel cost items are transport (12 per cent) and interest (8.4 per cent).

For bottom mussels the highest items of expenditure are transport (30.0 per cent) and depreciation at 29.7 per cent. Paid labour accounts for about 13 per cent of costs. It should be borne in mind when interpreting the costs for bottom mussel enterprises that some of them are run in conjunction with substantial processing operations. In the survey, it proved difficult to separate the costs of farming operation from those of the processing activity. Thus, the costs shown for these farms may be somewhat understated.

Table 6.26: *Individual Expenses as a Percentage of Total Expense on Shellfish Farms*

	Rope Mussels	*Bottom Mussels*	*Pacific Oysters*	*Native Oysters*	*Other*	*Total*
			Per cent			
Spat + other juveniles	1.4	0.0	28.4	11.7	11.0	12.0
Transport	12.0	30.0	5.9	4.4	4.1	11.1
Interest	8.4	5.7	5.1	21.1	18.0	10.2
Insurance	2.2	3.6	1.8	2.2	2.8	2.5
Packaging and marketing	3.0	2.1	6.0	0.9	2.4	3.4
Energy	1.2	6.2	1.1	0.6	1.7	2.2
Postage, telephone, legal fees etc.	4.7	5.5	5.2	4.1	3.5	4.7
Other Non Labour	5.0	4.2	2.1	5.4	1.1	3.0
Paid Labour	24.8	13.1	19.5	33.4	39.7	25.5
Depreciation	37.3	29.7	25.0	16.1	15.7	25.4
Total	100	100	100	100	100	100

In the case of Pacific oysters, the cost of spat and juveniles at 28.4 per cent is the highest single item followed closely by depreciation (25.0 per cent) and paid labour (19.5 per cent). High fixed capital and juvenile costs are a problem with this enterprise.

With farms whose main product is native oysters the highest item of cost is paid labour (33.4 per cent) followed by interest (21 per cent) and depreciation (16.1 per cent). Spat and juveniles account for 11.7 per cent, postage, legal fees, etc., for 4 per cent and transport for 4.4 per cent.

For the other shellfish, paid labour is 39.7 per cent of total costs, interest, 18.0 per cent, depreciation, 15.7 per cent and spat and juveniles, 11.0 per cent.

Efficiency of Shellfish Farms

In order to examine the efficiency with which some of the shellfish enterprises were managed, we divided producers into three categories.

(a) Those making losses.

(b) Those where income from self-employment or profit was under IR£10,000 and

(c) Those where income from self-employment or profit was over IR£10,000.

Tables 6.27 and 6.28 show the costs per IR£1 of Gross Output on farms whose main products were Rope Mussels and Pacific Oysters respectively. There were too few producers of Bottom Mussels or Native Oysters to warrant producing similar tables for these enterprises.

Table 6.27 shows that the 44 rope mussel farms in our survey were approximately evenly spread across the three income categories. Those earning more than IR£10,000 were, on average, about four times larger (in terms of Gross Output) than the other farms. The loss-making farms contrast sharply with the others in that their paid labour and capital expenses tend to be much higher than those of the others. It would appear that farms run on a very "commercial" basis with high quantities of paid labour and high investment and borrowing are significantly less efficient than the more tightly run "family" enterprises with low inputs of paid labour and low borrowings.

If depreciation were calculated taking grants and subsidies into account, average costs per IR£ of Gross Output would fall by about 12p. On this basis, three of the 13 loss-making farms would become marginally profitable.

Table 6.27: *Average Expenses per IR£ of Gross Output on Rope Mussel Farms Classified by Income Level of the Farm*

	Loss-Making	*Income <IR£10,000*	*Income >IR£10,000*	*All Farms (Weighted)*
No. of Farms (No.)	13	14	17	54
Percent of Output in Group (%)	12.3	14.5	73.2	100.0
Expenses per IR£ Output				
Spat and other Juveniles	0.07	0.00	0.00	0.01
Paid Labour	0.60	0.22	0.10	0.17
Transport	0.27	0.08	0.05	0.08
Insurance	0.08	0.01	0.01	0.01
Packaging & Marketing	0.09	0.01	0.01	0.02
Postage, Telephone & Legal and Accounting Fees	0.08	0.04	0.02	0.03
Other	0.21	0.02	0.02	0.04
Total Current Expenses	1.40	0.38	0.21	0.36
Interest	0.27	0.01	0.03	0.06
Depreciation	0.94	0.20	0.17	0.25
Total Capital Expenses	1.21	0.21	0.20	0.31
Total Cost per IR£ Output	2.61	0.59	0.41	0.67

Table 6.28 presents similar data for farms whose main product was Pacific Oysters. It should be noted that a number of these produced significant quantities of other shellfish such as Native Oysters and Rope Mussels. From examining the questionnaires, it appears to us that these subsidiary enterprises were, at least in 1990, more profitable than the Pacific Oyster production and in a number of farms constituted the difference between making a profit and making a loss.

The poor profitability of the main Pacific Oyster enterprise in 1990 is evident. Of the 55 farms returning questionnaires, almost half had made a loss. The high income farms tended to be about 3 times the size of the other two categories in terms of Gross Output. On the loss-making farms the cost of spat, paid labour and capital expenses are particularly high. The crucial effect of depreciation costs is evident from these data: the biggest contrast between farms making a loss and those making small positive profits is in the depreciation charge (54p. per IR£ Gross Output on loss-making farms compared with 17p. per IR£ on farms making positive incomes under IR£10,000 per year). If depreciation is calculated taking grants and subsidies into account, average costs per IR£ of Gross Output would fall by 12p. This has the effect of making 4 of the 26 loss-making farms profitable. It should be borne in mind that the high costs per IR£ Gross Output in the loss-making farms are likely to be attributable to low levels of output, relative to the planned scale of the operation. Low output may be due to disease, poor marketing or an early stage of development where costs have been incurred but produce is not yet ready for market.

Table 6.28: *Average Expenses per IR£ Output on Pacific Oyster Farms Classified by Income Levels of the Farms*

	Loss-Making	*Income <IR£10,000*	*Income >IR£10,000*	*All Farms (Weighted)*
No. of Farms (N)	26	18	11	62
Per cent of Output in Group (%)	39.0	21.5	39.4	100.0
Expenses per IR£ Output				
Spat and other Juveniles	0.50	0.20	0.11	0.27
Paid Labour	0.33	0.15	0.08	0.19
Transport	0.08	0.08	0.02	0.06
Insurance	0.04	0.01	0.00	0.02
Packaging & Marketing	0.13	0.02	0.01	0.06
Postage, Telephone, Legal & Accounting Fees	0.08	0.05	0.02	0.05
Other	0.06	0.02	0.01	0.03
Total Current Expenses	1.22	0.53	0.25	0.68
Interest	0.10	0.04	0.02	0.05
Depreciation	0.54	0.17	0.04	0.24
Total Capital Expenses	0.64	0.21	0.06	0.29
Total Cost per IR£ Output	1.86	0.74	0.31	0.97

Projected Output of All Shellfish

The farmers interviewed projected that sales of rope mussels would increase from 3,360 tonnes in 1990 to 6,000 tonnes in 1995. Pacific oysters were predicted to go from 384 tonnes in 1990 to 1,600 tonnes in 1993 and remain at that level up to 1995. Bottom mussels are projected to increase from 15,000 tonnes in 1990 to about 17,700 tonnes in 1995. Native oyster production was projected to go from 420 tonnes in 1990 to 1,300 tonnes in 1995 if Bonamia disease can be kept at bay. Clams and scallops are expected to increase from 60 tonnes in 1990 to 880 tonnes in 1995. These projections are, however, highly dependent on markets being available.

Also, they relate to farmers already in the industry; future output will be greater if there are substantial new entrants to the industry.

Summary of the More Important Results for All Fish Farms

To obtain a comprehensive picture of the aquaculture industry, some of the more important data are brought together and summarised in this section. Table 6.29 gives the quantity and value of the sales of the different finfish and shellfish disposed of in 1990. Total quantity of all sales were 26,287 tonnes valued at IR£28.9 million. In addition juveniles to the value of IR£1.2 million were sold by independent hatcheries so that the total value of sales was IR£30.1 million. (The value of these juveniles is deducted as a cost in calculating the income arising in the industry.) The prices given in the last column of Table 6.29 are not entirely farm gate prices. They include some marketing and packaging costs where fish farmers did their own marketing. The current value of structures and other fixed capital items used in the industry is given in Table 6.30. The total value of these items is IR£47.9 million. This compares with a total investment in the industry of about IR£102 million.

Table 6.29: *Finfish and Shellfish Sales in 1990*

	Quantity Tonnes	*Value IR£000*	*Price IR£/tonne*
Salmon	5,987	20,400	3,407
Sea Trout	325	1,010	3,108
Fresh Water Trout	710	1,910	2,690
Rope Mussels	3,360	1,331	396
Bottom Mussels	15,000	1,800	120
Pacific Oysters	384	518	1,349
Native Oysters	420	1,660	3,952
Other Shellfish	72	288	4,000
Total	26,258	28,917	-

The financial results and the labour force employed in the industry are given in Table 6.31. This table shows that when the increase in stocks is added to sales the gross output of the industry is IR£37.3 million. Deducting non-labour costs of IR£29.0 million from this gives a gross value added of IR£8.3 million. When paid labour costs of IR£8.7 million are taken from this, gross income for the industry is a negative at IR£(434,000). Deduction of depreciation increases the negative figure to IR£(6.1) million for Trading and Self-Employment Income.

Table 6.30: *Current Value of Structures and Other Fixed Capital in Irish Aquaculture*

	Finfish	*Shellfish*	*Independent Hatcheries*	*Total*
			IR£ million	
Ponds, Cages, Rafts, Trestles, Lines, Nets, Anchor Moorings	11.8	3.0	0.6	15.4
Boats	3.7	4.6	-	8.3
Transport vehicles	1.2	0.6	0.1	1.9
Buildings	10.0	0.9	0.8	11.7
Other	9.3	1.2	0.1	10.6
Total	36.0	10.2	1.6	47.9

Total employment in the industry is 1,801 people of which 772 are full-time and 1,029 are part-time workers. These numbers represent about 1,000 person years' employment.* Using a 23-sector input-output model Professor E. W. Henry of the ESRI has calculated that each person year of direct employment in aquaculture would generate 1.26 further person year's work in indirect and induced employment. Hence the total employment generated by aquaculture in 1990 (direct plus indirect plus induced) is estimated at 2,260 person years.

Other Problems and Opinions of Fish Farmers

Tables showing the problems encountered by fish farmers, other than independent hatcheries are given in Appendix E. We refer briefly to the content of these tables below.

* For the purposes of our survey, a "person year" was taken to be 240 days of full-time work.

Table 6.31: *Financial Results and Labour Force Data for Salmon, Trout, Shellfish and Independent Hatcheries*

	Type of Farm				
	Salmon	*Trout*	*Shellfish*	*Independent Hatcheries*	*Total*
			IR£000		
Sales less purchases of mature fish	20,895	1,831	5,597	1,166	29,489
Stock changes	5,430	158	1,703	536	7,827
Gross Output	26,325	1,989	7,300	1,702	37,316
Non-Labour Costs	24,237	1,069	2,476	1,220	29,002
Gross Value Added	2,088	920	4,824	482	8,314
Paid Labour	6,700	349	1,283	416	8,748
Gross Income	(4,612)	571	3,541	66	(434)
Depreciation	4,237	115	1,279	81	5,712
Trading and Self Employment Income	(8,849)	456	2,262	(15)	(6,146)
			No.		
Paid Labour					
Full-time	445	33	115	30	623
Part-time	277	12	409	30	728
Unpaid Labour					
Full-time	19	14	110	6	149
Part-time	–	2	296	3	301
Total	741	61	930	69	1,801
Person Years Worked					
Paid Workers	477	37	183	39	736
Unpaid workers	19	15	234	6	274
Total	496	52	417	45	1,010

Licensing Problems

Problems relating to licensing are presented in Tables E1 and E2. Table E1 shows that 17 finfish farmers out of 25 interviewed and 85 shellfish farmers out of 123 interviewed had difficulties of one kind or another in obtaining licences under the 1980 and 1959 Acts. Nine finfish and 35 shellfish farmers said they had difficulties in getting foreshore licences. A few others said they had problems with planning permission, effluent discharge and other types of licences. It should be emphasised that these numbers are not additive. Because two or more licences are nearly always required the same person could have difficulty in obtaining more than one licence.

Since they did not have full licences under the 1980 or 1959 Acts at time of application, 23 finfish farmers and 16 shellfish producers said they had difficulties in getting insurance and/or finance. Similar difficulties were encountered by a number of the same farmers because they did not have foreshore or other licences (see Table D2).

Adequacy of Services

Questioned regarding the adequacy of various services (Table E3) 70-80 per cent of salmon and shellfish farmers considered training services adequate. A lower percentage of trout farmers were of this view, (56 per cent). Advisory services were also considered to be adequate by over 67 per cent of all fish farmers. Only 37 per cent of all respondents considered that the legal position re ownership of stock and common property rights were satisfactory. The shellfish farmers were particularly dissatisfied in this regard.

Sixty seven per cent of trout and 43 per cent of salmon farmers considered that market support services were adequate but only about 22 per cent of shellfish farmers were of this view. Quality control was considered adequate by 74 per cent of all respondents. This varied from 86 per cent of salmon farmers to 56 per cent of trout farmers and 75 per cent of shellfish producers.

Some 56 per cent of trout farmers considered that government policy towards aquaculture was adequate but this view was only held by 36 per cent of shellfish and 29 per cent of salmon farmers. Private consultancy and technical services available got a very high rating by all three groups of respondents (74 per cent) with state technical services getting a lower rating particularly among salmon farmers. Only 43 per cent of the latter were satisfied with these services compared with 89 per cent of trout and 61 per cent of shellfish farmers.

Licensing arrangements got a very low rating by all three groups of producers. Only 26 per cent were satisfied with them. In particular salmon farmers were very dissatisfied, just one respondent saying they were adequate. Some 46 per cent of respondents were satisfied with research and development service and there was little variation in this percentage among the different groups.

Toxicity of Chemicals

Views regarding the toxicity of chemicals are given in Table E4. As might be expected finfish and shellfish farmers tended to have different views on this topic. Some 60 per cent of finfish farmers considered the chemicals used by them to be dangerous only if applied incorrectly. On the other hand as few as 29 per cent of shellfish farmers were of this view. Sixty three per cent of shellfish farmers agreed that the aquaculture chemicals are very dangerous and must be applied and handled with great care whereas only about 30 per cent of finfish farmers thought that this was so.

Answers to the question "How likely are chemicals and drugs to cause damage to the environment?" are given in Table E5. Thirty-nine per cent of shellfish farmers said they were likely or very likely to cause damage even where water circulation was adequate. Only 8 per cent of finfish farmers considered that damage was likely in those circumstances; 92 per cent said damage was unlikely.

Some 85 per cent of finfish farmers said that chemicals were *unlikely* to cause damage to shellfish even if the latter were in close proximity to finfish cages. Only 19 per cent of shellfish farmers were of this view; 81 per cent considered that damage to shellfish was likely or very likely in these circumstances. Some 46 per cent of finfish farmers agreed that damage to shellfish was likely or very likely if the chemicals were not applied correctly whereas 95 per cent of shellfish farmers were of this view.

Table E6 gives the reaction of fish farmers to the question "How prone are certain species of wild fish to damage by the drugs and chemicals used in fish farming"? All of the finfish farmers said that wild finfish were not prone to damage whereas only 23 per cent of shellfish farmers agreed with this; 56 per cent of shellfish farmers thought that wild finfish were somewhat prone and 21 per cent said they were very prone to damage by these chemicals.

About 69 per cent of finfish farmers said that wild shellfish stocks were not prone to damage by aquaculture chemicals but only 9 per cent of shellfish farmers were of that opinion; 38 per cent of the latter thought that wild shellfish were very prone and 53 per cent considered they were somewhat prone to damage. Similar reactions from the two groups were obtained in replies to questions on damage by chemicals to farmed shellfish and other marine organisms.

Asked if they had seen environmental damage which they believed was caused by finfish farms in their area, 81-89 per cent of all respondents said they had not seen such damage; 11 per cent of trout and shellfish farmers and 19 per cent of salmon farmers said they had seen damage (see Table E7).

Opinions as to Policy Changes Required

The opinions of fish farmers as to the action or policy changes which would improve or develop aquaculture are given in Table E8. Streamlining of the licensing system was the top priority for salmon farmers, 56 per cent of whom suggested this action; 45 per cent of shellfish and 33 per cent of trout farmers were in favour of this action also.

More emphasis and more funding for marketing was suggested as an action by 50 per cent of shellfish farmers, 44 per cent of trout farmers and 38 per cent of salmon producers. Other actions mentioned by the respondents were:-

	Per cent
Better environmental monitoring and protection	18
Easier access to finance	28
More/better research information and advice	27
Improve image, quality control	12

Chapter 7

*AQUACULTURE AND THE ENVIRONMENT**

Introduction

This chapter is concerned with the ecological and resource management issues involved in aquaculture development. Before dealing with these issues, it is necessary to say that it would be surprising if fish farming activities did not have the potential to affect the environment and our uses of it. Not all such effects are, however, detrimental; some may be innocuous or imperceptible and others beneficial.

Beneficial environmental effects of an aquaculture operation may include:

(i) addition of small amounts of organic matter to a nutrient-limited environment, leading to a potential increase in natural productivity, e.g., a local improvement in oyster growth in Connemara has been associated with the presence of fish cages;

(ii) greater public awareness of the value of coastal and aquatic resources;

(iii) increased pressure on dischargers of waste (especially effluents containing toxins or pathogenic bacteria) to reduce or eliminate their discharges;

(iv) more widespread understanding among coastal communities and environmental organisations of the interactions between different uses of the shoreline and coastal waters,which may lead to strategies for better management of these resources; and

(v) positive interactions between aquaculture and tourism.

The main adverse effects which are considered in detail in the sections that follow are:

(i) local damage to environmental quality as a result of pollution by:

  (a) organic matter and nutrients affecting water quality and plankton growth;

  (b) the impact of uneaten fishfood and other debris on the seabed;

  (c) the disposal of solid wastes on land.

(ii) the potential damage caused by antibiotics and other treatments used in finfish farms

* This chapter was prepared by Mr A. J. O'Sullivan.

(iii) potential threats to other marine and freshwater wildlife, including:
   (a) genetic, pathogenic and behavioural interactions between fish which have escaped from farms and native species;
   (b) interactions between aquaculture operations and fish predators including seals and sea birds;
   (c) effects on sand eel stocks and on sea birds which feed on sand eels and other small fish;
   (d) possible links between salmonid farming and the widespread reduction in sea trout numbers on the west coast.

(iv) visual impacts of aquaculture operations including nuisances such as industrial or night-time noise, litter, debris, lights and vehicular traffic;

(v) competition for scarce water space or shoreline lands on lake shores or sea coasts or for facilities or infrastructure.

Addition of Organic Matter and Nutrients to Water

Before considering the effects of organic matter and nutrients, however, it is necessary to outline the types of waste produced and to provide some estimates of the quantities of these substances discharged by fish farms.

Fish-farm wastes are composed of two major fractions: solid wastes which consist of uneaten food, faeces, fish scales, mucous and other detritus; and soluble wastes which include dissolved phosphorus and nitrogen compounds. The subdivision is not rigid - soluble material can be leached from solid waste, while the soluble wastes can be taken up and assimilated by plankton or algae in the tanks, and may re-enter the water as particulates.

The most important components of these wastes are organic matter, which will eventually be broken down by bacteria; nitrogen which is a major nutrient required by algae and phosphorus which is also essential for the growth of algae. Other substances in waste include dissolved calcium, magnesium, sodium, potassium, waste vitamins, trace elements and chemicals. Estimates of the quantities of these organic wastes produced by fish farms are given in Appendix D.

I Impacts of Aquaculture on the Water Column

Unfortunately, there is very little coherent information on the impact of these fish farming wastes on the marine water column (Institute of Aquaculture, 1989). Surveys of sea farm sites around the coast of Ireland (Stewart, 1984; Gowen, 1990) revealed localised increases in ammonia concentrations close to cage sites, but no detectable effects on nitrate or nitrite levels.

The study by Gowen (1990) of data from cage-based salmon farm sites on the coast of Ireland concluded that, with two exceptions, the farms had not caused any changes in water quality parameters or in phytoplankton biomass. The exceptions mentioned are Kilkieran Bay where a localised elevation of ammonia levels was noted in the vicinity of a fish farm, and part of Mulroy Bay where summer levels of nitrate appear to have increased. The increase in nitrate was not accompanied by any change in chlorophyll concentration, thus it was concluded that the phytoplankton in the water had not been affected.

Nevertheless, Gowen (1990) does point out that the potential for cage-based finfish farming to cause eutrophication does exist in slowly-flushed semi-enclosed embayments or straits. The Institute of Aquaculture (1989) also notes that the effect of marine fish farming on phytoplankton is critical for both farmed and wild fish populations, particularly if enhancement of phytoplankton productivity results in the formation of toxic blooms. In such an event, however, the farmed stock would most likely be the first to suffer, as happened in an Irish sea lough (Doyle, *et al.*, 1984) and in Puget Sound (Rensel, *et al.*, 1989). In the latter area, phytoplankton blooms were involved in the mortality of at least 250,000 Atlantic and Pacific salmon of all ages in 1987, with monetary losses of over $0.5 million.

It is also relevant to note that suspended culture of shellfish (e.g., mussel rafts and long lines) will affect the cycling of nutrients in coastal ecosystems. An energy budget for mussel long lines calculated by Rosenberg and Loo (1983) suggests that 80 per cent of the energy ingested as food is assimilated and 20 per cent is discharged as faeces; of the 80 per cent assimilated, 46 per cent of the total is used in respiration and 34 per cent goes into the production of the mussel meat and shell. Estimates by Rodhouse *et al.* (1985) and Larsson (1985) suggest that for each tonne of mussels *(Mytilus edulis)* produced, approximately 0.5 Kg of phosphorus, 6.6 Kg of nitrogen, and 32.5 Kg of carbon are removed from the aquatic ecosystem.

The high filtering rates of shellfish also result in large volumes of water being filtered, particularly where the shellfish are cultured on a large scale. Under such circumstances, the concentration of phytoplankton can decrease, and the growth of the shellfish will become slower. There are no data on the ability of mussels to reduce phytoplankton abundance in Irish harvesting areas such as Bantry Bay, but it is well known among mussels growers that the inner ropes hanging from a raft can be much less productive than those on the perimeter.

Shellfish also excrete phosphorus and nitrogen, and a study of mussel long lines in Sweden showed an increase in the concentration of ammoniacal nitrogen and inorganic phosphorus in water passing through the farm at low current velocities and in warm weather.

II Impacts of Aquaculture on Sediments and Benthos

The primary efffect of the continuous rain of organic matter (mainly uneaten food and faeces) falling to the sea or lake bed from fish cages is to enrich with carbon the bottom sediments. In most cases this is restricted to the immediate vicinity of the fish cage sites where the impacts can range from undetectable in well-flushed locations to severe in very sheltered fjord-like environments. The data from Irish fish cage sites examined by Gowen (1990) showed that these effects of organic waste deposition were restricted to the immediate vicinity of the fish farms, and that the level of organic enrichment was generally less than that in Norway or Scotland.

Impacts of Finfish Cages on Benthic Communities

This settlement of organic matter and the subsequent enrichment of the sediments also affects bottom-living animals and plants at virtually all fish farm sites. Under extreme conditions a lifeless zone, devoid of macrobenthic organisms but dominated by bacteria, develops beneath the cages. Around this may be a fringe or transition zone dominated by a few pollution-tolerant opportunistic species. Biological productivity may be high here, but the number of species is generally small. Under severe conditions of organic deposition, only bacteria can tolerate the lack of oxygen and these survive by decomposing the organic matter and releasing gases such as methane and hydrogen sulphide (out-gassing).

The benthic data from Irish fish cage sites studied by Gowen (1990) showed a situation similar to but less affected than similar sites in Norway and Scotland. Furthermore, some degree of recovery was noted where fish farming had ceased.

Impacts of Suspended Shellfish Culture

Organic matter also falls to the bottom of the seabed under shellfish farms, but the quantities are much less since the shellfish are not fed by the aquaculturist but depend on plankton as the principal constituent of their diet. The deposition of live mussels, shell materials and other debris can provide sites for attachment of many small marine animals including sponges and worms. In general, the effects of organic wastes from shellfish farms are similar to those of salmon farms, but the impacts are less severe and are more likely to be localised to the immediate vicinity of the farm.

Recovery of Benthic Communities After Cessation of Fish Farming

Communities of benthic animals will return to normal background conditions after the source of the organic enrichment has been removed. The rate of return to normal is very site-specific, and between two and ten years may be required for a complete recovery, even though the actual wastes deposited may disappear within four or six months.

III Production and Disposal of Solid Wastes on Land

In addition to the organic matter described in the section above, fish farming activities produce a number of other wastes, some of which can be obnoxious or difficult to dispose of. These include:

(i) dead or diseased fish;
(ii) occasional discarded chemical containers and out-of-date chemicals;
(iii) offal from fish processing;
(iv) general litter such as discarded ropes, netting, floats and other objects;
(v) sludge from settling ponds, separators or biofilters on land-based fish farms.

The disposal of dead or diseased fish initially gave rise to widespread public concern as fish farming developed rapidly. Such fish are now buried in lime pits in local authority or private landfill sites, and few problems have been recorded. In any event, the quantity of fish requiring disposal is not large compared with the quantity of municipal wastes.

According to information supplied by fish farmers in Ireland, they had disposed of 1.1 million salmon and 311,000 trout in 1990 (ESRI survey, reported in Chapter 6). The most common methods of disposal were to local authority or private landfill sites; only one farm reported sending dead or diseased fish to a protein recovery plant.

The disposal of fish offal from packaging and processing plants is not a problem as most of the fish wastes are accepted by the fish-meal industry. The conversion of fish offal to a form of silage or to a soil enricher is also possible using recently-developed equipment.

Discarded containers which had held Nuvan (a treatment used against sea lice) have been found very occasionally on landfill sites, and on piers or slipways from which fish farms were serviced. Public concern was aroused, but the problem is a very minor one compared with the much greater quantities of hazardous material containers used (and discarded) by those engaged in intensive agriculture.

In a number of areas, particularly Killary Harbour and to a lesser extent Bantry Bay, the mussel farming industry has been associated with abandoned or damaged rafts, longlines and other equipment being left on the shore where they constitute a form of litter which is visually intrusive. Abandoned or damaged rafts may be a danger to navigation and a hazard to other rafts or longlines close by. Overall, the amount of litter, however, is much less than that produced by agriculture or discarded in the countryside by householders. Plastic litter on beaches, abandoned cars, fertiliser bags and silage wrapping are more widespread, visually intrusive and difficult to collect.

Sludge produced by land-based fish farms may be transferred to septic tanks for biological digestion, thickened before disposal to landfill, or spread on agricultural land. Landspreading is a suitable option, taking advantage of the nitrogen and phosphorus present in the sludge, but it may not always be available as a result of:

(i) the difficulty of finding a sufficient acreage for spreading; and
(ii) constraints on sludge spreading in winter months and during wet weather.

IV Mortality Control Measures and Their Effects

The Principal Mortality Control Measures

The use of antibiotics, disinfectants and other substances to control mortalities, diseases and parasites in fish farms, hatcheries and fish culture units is widespread and general. Many aquatic diseases are very difficult to treat and usually result in destruction of fish stocks and the need for extensive disinfection of the culture facilities. In other cases, however, prophylactic chemicals are used to eliminate diseases which have entered the culture unit. Disinfectants are also used as precautionary measures to prevent the spread of disease or parasites.

Therapeutic agents are administered to caged or tank-held fish in two ways: by incorporation into the fish feed (enteric treatment) or by a dip or bath treatment (topical application). Both of these treatment methods will potentially have some consequences for the environment - the substance which is mixed with the diet can dissociate itself from the food or be excreted, and the contents of the bath or dip are normally flushed to waste in the area around the farm when treatment has been completed.

The main groups of organisms causing disease in farmed fish may be classified as:

(i) ecto-parasites and fungi affecting the fish externally, e.g., sea lice;
(ii) endo-parasites affecting the fish internally;
(iii) bacteria;
(iv) viruses;
(v) planktonic organisms producing toxic substances or causing levels of dissolved oxygen to fall significantly during hours of darkness.

These organisms also affect wild populations in which they contribute to natural mortality, serving to eliminate weaker or injured individuals. In the case of farmed finfish and shellfish, however, the more intensive conditions increase the probability of disease outbreaks as a result of the following factors:

(i) stress caused by high stocking densities;
(ii) rapid spreading of the disease facilitated by close proximity of the fish to each other;
(iii) the presence of environmental stresses such as low oxygen levels or high ammonia levels, which may predispose the fish to attack by parasites; and
(iv) the build-up of a reservoir of disease organisms in the water surrounding the fish or on the sea-bed.

The principal diseases and parasites affecting farmed fish in Ireland are listed in Table 7.1. Pancreas disease, sea lice and vibrio are the diseases and parasites most commonly encountered on Irish finfish farms (ESRI survey, Chapter 6). Along with other diseases, such as furunculosis, Costia, gill fever and fin rot they are treated using one or more of the antibiotics, vaccines or disinfectants listed in Table 7.2.

On salmon farms, Nuvan (dichlorvos) was the most commonly used treatment, being applied on an average of 14 times per year. Oxytetracycline and Metasol were used during 1990 on seven salmon farms. Formaldehyde, Chloramine T and Malachite Green were the treatments most frequently used during 1990 on trout farms. Malachite Green, formaldehyde and Chloramine T were also used frequently in hatcheries.

Attitudes to Mortality Control Measures

Because of the problems which some anti-parasite and anti-fungal substances have caused in the past, especially to nearby shellfish farms, there has been growing concern among fish farmers and members of the public about their use and subsequent release to coastal waters. Fish farmers are well aware of the toxic nature of these substances, but the degree of concern differed between finfish and shellfish growers who responded to the ESRI questionnaire. Some 63 per cent of the shellfish farmers considered that the chemicals used in aquaculture are very dangerous, and should be handled and applied with great care, whereas only 30 per cent of the finfish farmers shared this opinion.

Table 7.1 : *The Principal Types and Causes of Mortalities in Farmed Fish in Ireland*

Type of Disease or Mortality	*Causative Organism*	*Disease or Condition*
Non-infectious	Gyrodinium aureolum	Red tide
	Not known	Nephrocalcinosis
Infectious viral	IPN virus	Infectious Pancreatic Necrosis
Infectious bacterial	Aeromonas salmonicida	Furunculosis
	Vibrio anguillarum	Vibriosis
	Myxobacteria spp	Myxobacterial disease
Parasitic diseases	Trichodina, Costia (protozoans)	Gill infections
	Caligus elongatus and L. salmonis	Sea lice
Fungal diseases	Saprolegnia sp	Saprolegnia
Not known	Pancreas disease	

Source: McArdle, 1987

Table 7.2: *Substances used to Control Diseases and Parasites on Sea and Freshwater Fish Farm Sites in Ireland*

Chemical	*Used Against*	*FW/SW*	*Method*
Formaldehyde	ectoparasites	FW/SW	DA
Malachite Green	ectoparasites and fungi	FW/SW	DFS B
Nuvan (dichlorvos)	salmon lice	SW	B
Ivermectin	salmon lice	SW	B
Salt	ectoparasites	FW	DB
Oxytetracycline	bacteria	FW/SW	T
Oxolinic acid	bacteria	FW/SW	T
Chloramine T	bacteria	FW	A

Where : B = Bath, A = Addition to system, F = Flush, D = Dip, I = Injection, S = Spray, T = Treated food, FW = Freshwater, SW = Seawater.

Around 85 per cent of finfish farmers considered that the chemicals used are unlikely to cause damage to shellfish, even if the latter are in close proximity to the finfish cages. On the other hand, 81 per cent of shellfish farmers felt that damage to shellfish was likely or very likely in such situations. At the same time, 85 per cent of finfish farmers and 88 per cent of shellfish farmers reported that they had not seen any environmental damage which they could attribute to finfish farming in their areas.

If it was possible to rear fish without using such chemical treatments, this would be a significant advance leading to reduced operational costs (the chemicals are expensive) and less potential for conflict between the rearing of finfish and shellfish in confined areas.

A number of cage-based salmon farms in relatively exposed locations claim that they have been able to rear fish to marketable size without using any antibiotics. Reduced stocking rates, careful husbandry and sites with good water exchange appear to have been the principal factors permitting this welcome development.

Nevertheless, it is not possible to visualise how a finfish or shellfish hatchery could remain free of disease if no treatments are used. Even if the tanks are self-cleaning, and all the water used comes from a clean supply, the activities of birds, the need to bring in eggs or fry, containers and visitors could introduce disease organisms.

Drugs Used to Control Sea Lice

Of the substances listed in Table 7.2, the one which has attracted the most attention is Nuvan 500 EC, a contact and fumigant insecticide used widely to control pests in animal and poultry houses. It is extensively used in agriculture and is an organophosphate whose active ingredient is Dichlorvos, which acts by inhibiting the activity of the enzyme cholinesterase in the nervous system. In water, Dichlorvos has a half life of between 20 and 80 hours (depending on temperature and pH). Its principal use in the fish farming industry is to treat sea lice *(Lepeophtheirus salmonis* and *Caligus elongatus)* in salmonids. These are parasites which can cause severe damage to fish, frequently resulting in secondary infections and death.

Nuvan is one of the most effective treatments against sea lice available at the present time, the others being:

(i) Ivermectin, a fungal-derived insecticide widely used in agriculture;
(ii) Pyrethrum, a naturally occurring insecticide;
(iii) the use of wrasse (a small fish which removes the lice from the salmon and eats them) which is at present being researched; and
(iv) vaccination (effective but not fully developed).

The principal dangers and disadvantages of Nuvan are:

(i) effects on the health of the operators using it, particularly if the proper protective clothing is not worn;
(ii) the difficulty of maintaining the correct concentration of Nuvan for up to one hour in large cages;
(iii) mortality of the fish stocks if the maximum concentration is exceeded as a result of operator error or miscalculation;
(iv) the stress caused to the fish either as a result of badly administered Nuvan treatment or miscalculation;
(v) the difficulty of ensuring that all lice can be removed from a fish farm given that the Nuvan treatment can be carried out on only one cage at a time and the sea lice can travel from cage to cage;
(vi) the presence of residues in the fish for up to 12 days after treatment (Boxaspen and Holm, 1991);
(vii) the toxicity of Nuvan to economically important species of shellfish (Institute of Aquaculture; 1989, Duggan; 1990); and
(viii) public perception that Nuvan has significantly damaged the environment.

In Scotland, there have been several reported cases of fish being overdosed and of mortalities during Nuvan use, but it is likely that the latter were due to the lack of oxygenation during treatment. It is known that not all fish farmers use a canvas curtain or skirt and carefully calculated quantities, resulting in considerable uncertainty about the amount of Nuvan released to the environment. This has led the Highland River Purification Board to require fish farmers to notify the Board at least 48 hours in advance of any intention to use Nuvan, thus giving the Board the option of observing the treatment and taking water samples.

In Norway, the presence of dichlorvos and trichlorfon residues in fish have led to a regulation prohibiting the marketing of Norway salmon until three weeks after treatment, by which time the fish may have become re-infected with sea lice (Boxaspen and Holm, 1991).

For these reasons the salmon farming industry in Ireland is anxious to replace Nuvan as soon as possible with some other treatment. Research is currently being carried out at University College Galway, University College Cork, Trinity College Dublin, in Stirling University and in Norway on the alternative treatments listed above.

According to Duggan (1990), Jackson (1990) and Buchanan (1990) no clear evidence has been reported of environmental damage from the use of Nuvan but, because of its extreme toxicity to crustaceans at very low levels (some species are sensitive to levels as low as one part in 10 billion, i.e., one-thousandth of the concentration in which the caged fish are treated), stringent precautions should be taken in regard to application storage and amounts used.

Ivermectin

Ivermectin was suggested as early as 1985 as a possible replacement for Nuvan (Smith, 1990), and has been found to have the following advantages:

(a) its toxicity to humans is low (for example, it is used internally to treat night-blindness caused by a parasite in Africa);
(b) it is very poorly soluble in water (around 7 parts per billion);
(c) it photodegrades fairly rapidly in surface waters (half life of less than 12 hours);
(d) it is excreted by the fish mainly in particulate form and will end up in the seabed sediment;
(e) it binds strongly to organic carbon and ceases to be bio-available or bio-active;
(f) the main degradation products are much less toxic than the drug itself; and
(g) it can be administered orally, i.e., in the fish feed, thus reducing the quantity of the drug required for treatment.

Research at University College Galway has shown Ivermectin to be effective in controlling lice when administered orally and it has not caused any toxic effects on fish when applied at the recommended dose. However, its ecological effects, impact on other marine life forms, breakdown products and retention time in the fish have yet to be determined.

Ivermectin is widely used in agriculture to treat internal and external parasites of cattle, horses and sheep, and is available under the trade name of Ivomec. It has not yet been licensed for use in aquaculture, but is reported to be widely used on salmon farms in Ireland (*Irish Times,* 22 December 1990). In September 1991, the ISGA requested its members to discontinue using Ivermectin until it had become licensed for use in salmon farming.

Merck, Sharp and Dohme Ltd., manufacturers of the drug, state that they have not initiated or sponsored any studies to investigate the potential of Ivermectin to treat sea-lice infestations of salmon, but that they have asked a Swedish research group (EWOS) to examine the ecological and safety issues. The results of the research are expected in 1992.

Pyrethrum

Pyrethrum, which has served as an effective insecticide for many years, is a naturally occurring substance which breaks down rapidly in the environment. In fish farm application it needs to be dissolved in a layer of oil which then remains on the surface of the water. In order to be deloused fish have to jump through the oil layer and the effectivness of the treatment is a function of the amount of active Pyrethrum together with the degree of jumping activity of the fish. It has proved to be very effective also against sea lice (Boxaspen and Holm, 1991) and may eventually become commercially viable.

Pyrethrum has a long history of use as an insecticide, and its effects on warm-blooded animals (including man) are well documented. No negative effects on humans have been recorded, and doses of up to 20g have been taken internally as an inhibitor against internal parasites.

Wrasse

Wrasse are small species of rock-fish which feed by browsing on a diet of crustacea and molluscs, and have been used commercially to control sea lice in Norway, Scotland and Ireland. Studies using wrasse began in Norway in 1987 and they were put into commercial salmon cages in 1988 where they successfully kept down the number of sea lice. The results are promising but there are still a number of questions unanswered about the biology of wrasse and their environmental requirements.

Research currently underway in Norway and at Trinity College Dublin is aimed at examining the viability of wrasse to control sea lice, and BIM have been assisting the aquaculture industry to develop improved methods for catching and holding wrasse in captivity.

Other Techniques for Sea Lice Control

Ideally, a range of alternative anti-parasitic and other treatment methods should be available to fish farmers, but it will be some time before any real alternatives to Nuvan will become available. In the meantime, all suitable precautions to prevent infestations of sea lice should be implemented and biological research efforts intensified in an effort to improve and implement ecologically acceptable control strategies, including for example:

(i) reduction of lice numbers in salmon farms by good husbandry and low stocking densities;

(ii) breaking the life cycle of the parasite by leaving the salmon cages empty for several months after harvesting the adult fish and before introducing smolts (e.g., from January/February to April/May) if this can be arranged without prohibitive cost; and

(iii) letting some sites lie fallow for a year or more, bearing in mind the implications of this for licensing and regulatory procedures.

The Impact of Anti-Bacterial and Anti-Fungal Agents

In addition to the anti-parasitic measures discussed above, fish farms use significant quantities of anti-fungal and anti-bacterial agents. These include oxytetracycline, oxolinic acid, flumequine, and furazolidine (see Table 7.2), all of which are provided in fish feed and reach the sea bed through the deposition of uneaten food or faeces. Metasul, which is not classed as an antibiotic, but is one of a group of drugs known as potentiated sulphonamides, is also used on fish farms as an anti-bacterial agent.

Recent work in Norway (Kupka Hansen *et al.*, 1991) has shown that oxytetracycline and oxolinic acid are not degraded in the sediment underneath fish cages, and can be detected for up to 7 months after application. Their presence in the sediment causes a dramatic initial reduction in the total number of bacteria present, followed by an elevated number of drug-resistant bacteria which could be detected for at least 11 weeks after treatment. Bacterial activity in the sediment appeared to be strongly inhibited by these antibiotics, but returned to control levels within 10 weeks.

In Scotland, Inglis *et al* (1990) reported high frequencies of antibiotic resistance in the micro-organism *Aeromonas salmonicida* (infections of which produce the disease furunculosis) and a number of disease outbreaks have been caused by pathogens resistant to all licenced antibiotics. The situation is serious, especially if, as suggested by Smith (1991), the rate of bacterial resistance to existing drugs develops faster than the rate at which new drugs become available.

From an environmental point of view, the anti-bacterial treatments mentioned do not appear to have had any significant effect on macrofauna outside the limits of the cages.

V: Anti-Fouling Materials

Unless the netting used in fish farm cages is kept clear of marine growth, the flow of water decreases and environmental conditions within the cage become undesirable. In the mid 1980s cage nets were anti-fouled using tributyltin (TBT) which is extremely toxic to marine life and caused problems in a number of semi-enclosed areas. In Mulroy Bay (Co. Donegal) and Ballynakill Harbour (Co. Galway) commercial shellfish stocks may have been affected. Scallop settlement almost disappeared in Mulroy Bay, though in this case overfishing and an aged stock may have equally contributed; while in Ballynakill Harbour one major oyster grower had to suspend operations for four years.

TBT is now banned from use in the industry and has largely been replaced by copper based anti-foulants. Copper is also particularly toxic to crustacean shellfish but there are no reports yet of any significant mortalities from this cause in the vicinity of finfish farms. It is understood that a non-toxic and equally effective anti-fouling wax is now available.

In most farms, nets are taken to the vicinity of the shore base to be cleaned, usually with high pressure water jets which can dislodge encrusted material. A number of farms have net washing drums, and it is understood that chemicals are not generally used in either of these cleaning processes.

VI: Colouring Agents

A number of carotenoid pigments, principally Canthaxanthin and Astaxanthin, are used in sea cage based salmon farms to give the necessary pink colour to the flesh of the product. Without these materials being incorporated in the feed, the farmed salmon flesh would be white in colour. These substances are nature identical and are non-toxic.

Canthaxanthin is widely used as a colouring agent in tomato juice, soft drinks, ice cream and confectionery. It is found naturally in blue/green algae (Cyanophyceae), Chanterelle fungi, crustacea and fish species. The predominant carotenoid pigment in wild Atlantic salmon and rainbow trout is astaxanthin which, in fish farming, has certain advantages over canthaxanthin. It is a natural pigment and it is absorbed and deposited in the flesh more efficiently than canthaxanthin. However, it is less stable in pelleted feeds and is more expensive. EC Feed Additive Legislation (70/524/EEC), which is currently being reviewed, permits the use of canthaxanthin in feeds for salmon and trout over six months old, up to a maximum level of 80mg/kg, and astaxanthin up to 100mg/kg.

Concern has been expressed about the possible carcinogenic properties of canthaxanthin, and its use is banned in the United States.

VII: Genetic, Pathogenic and Behavioural Interactions Between Escaped Fish and Native Species

The growth in salmon farming has led to an increased proportion of farmed fish surviving in the wild as a result of fish escaping from smolt rearing units or sea cages. As a consequence, there is growing concern in Ireland, Norway and Scotland about the effects of reared escaped fish on natural stocks of Atlantic salmon and on other species such as sea trout.

Fish that escape from a fish farm at smolt stage in fresh water will return with high precision to that particular fresh-water system when they become mature. If smolts escape from an estuary the proportion of those not returning or straying will increase. When smolts or young salmon escape from a marine sea cage, the mature adults tend to return to the same area and if not caught will enter rivers in that area to spawn.

The capacity of these escaped fish to survive in nature is still unknown. In a number of countries, however, it has been observed that wild smolts survive better than reared smolts of comparable size. In Norway, the proportion of reared salmon (ranched and farm escapees) has increased from about 10 per cent in 1986 to about 20 per cent in 1988 in commercial fisheries in Norgewian home waters. In some localities up to 30 per cent reared fish have been observed, and a possible cause for this might be a comparative advantage which the reared fish possessed over wild fish which had become stressed by acidic conditions in the rivers and by heavy fishing pressure.

In Ireland, substantial numbers of farmed fish (10-15% of the rod catch) were taken in specific river fisheries during the 1988 fishing season, but the proportion fell significantly in the 1989 fishing season (Browne, 1990a and 1990b). The number of fish farm escapees reported by respondents to the ESRI survey (Chapter 6) amounted to 39,000 fish during 1990. In January 1991, a very large number of fish escaped from cages as a consequence of a severe storm.

Populations of fish farm escapees and native fish may interact with each other through:

(i) behavioural or ecological interactions;
(ii) spread of diseases between wild and farmed fish;
(iii) interbreeding (exchange of genetic material).

Behavioural Interactions between Wild and Farmed Salmon

Some of the behaviour patterns shown by farmed fish which have escaped or been released to the wild are mentioned above. The principal behaviour differences between farmed and wild stock fish are (Browne, 1990b; NASCO, 1990):

(i) farmed fish show much greater "straying rates" than wild stock fish, especially if they have escaped from a sea cage site, and they will enter rivers on an uncertain basis;
(ii) fish-farm escapees are more likely to congregate in the lower reaches of rivers;
(iii) farmed fish are likely to enter rivers later than the wild fish, and may spend less time in the rivers;

(iv) the delayed spawning behaviour of farmed fish gives rise to the likelihood of their overcutting and damaging the redds made by wild stock fish, and physically displacing the wild stock eggs; and

(v) farmed salmon may have less reproductive success than the wild stock fish.

Despite the large numbers of escaped salmon now found in Norwegian and Icelandic rivers, and to a lesser extent in Scotland and Ireland, there is no evidence of adverse behavioural interactions. Farmed fish have been observed spawning together, and spawning with wild stock fish. The effects of the presence of farmed fish on the quality of rod angling are discussed below.

Spread of Diseases between Wild and Farmed Fish

Fish in cages are vulnerable to diseases and parasites due to the high density of fish present and the stressful environment. Problems may arise when fish are moved from one isolated geographic locality to another, where there is a risk of importing parasites and diseases to which the local fish are not adapted.

An example of this is the recent outbreak of the parasitic fluke *Gyrodactylus salaris* in wild salmon in Norway (McArdle, 1991). This parasite attacks salmon parr and causes heavy mortality; the estimated loss of salmon in Norway in 1984 to this parasite was 250-500 tonnes. The parasite was probably imported from the Baltic and spread to some 32 salmon rivers by fish from infected hatcheries (Egidius, *et al.*, 1988; Hansen, 1990).

In general, however, wild fish pose a much greater disease threat to farmed fish than vice versa, and it is recognised by fish pathologists that wild fish carrying pathogens (but not necessarily showing signs of disease) are a major cause of disease outbreaks on fish farms (McArdle, 1991). The transfer is not simply one-way however; any increase in pathogen numbers (as may occur in a fish farm epizootic) may increase the risk of infection to wild fish (Institute of Aquaculture, 1989).

Genetic Interactions between Wild and Farmed Salmon

It is now widely accepted that most species of fish are subdivided into completely or partially isolated stocks which are genetically separate from each other; for example, Thorpe and Mitchell (1981) identified 74 genetically distinct salmon stocks in Britain and Ireland. Although the broodstock used in salmon hatcheries may have been derived from several wild stocks, the selection process (which aims to produce fish which perform well under culture conditions rather than in the wild) has resulted in:

(i) a reduction in the genetic diversity of farmed salmonid stocks;
(ii) farmed fish stocks becoming increasingly less fit for survival in the wild; and
(iii) increasing genetic divergence between wild and cultured salmonids.

There is no reason why farmed fish should not interbreed with wild stock, and both wild and farmed fish have been observed spawning together. These factors have led to increasing concern being expressed about the long-term genetic effects of fish farm escapees on wild stocks. Because some of the genetic differences between stocks are adaptive, escaped fish may introduce non-adapted genes into a population if they successfully reproduce. The genetic differences between salmon stocks may therefore become reduced as a result of the continuous impact of a significant number of non-adapted fish; this is likely to affect the fitness of wild populations, resulting in a decreased production of smolts or poorer survival back to the river of those fish which have successfully migrated to the sea. In the latter case, since the capacity of our rivers to produce wild-stock smolts is finite, the number of returning adult fish would become reduced (Browne, 1990b), with consequent implications for rod angling and wild fisheries.

It is important to note, however, that the problem is a very complex one and that there is still a lack of data on genetic interactions between escapees from fish farms and wild salmon stocks. Research underway in Norway, Scotland and Ireland (at University College Cork) should lead to a greater understanding of the issue, but will require around two years to complete.

VIII: Interactions Between Aquacultrure and Predator Species

Wild birds and mammals which are natural predators of fish and shellfish become quickly attracted to fish farms as a potential source of food. The species attracted include heron, cormorant, shag, eider, long-tailed duck, red-breasted merganser, oyster-catchers, divers (red-throated, black-throated and great northern), slavonian grebe, guillemots, gulls, terns, gannets, common seal, grey seal, otter and mink.

In Ireland, only some of these species are present in sufficient numbers to cause problems at fishfarms (Whilde, 1990), but we know very little about the status of their populations or the extent to which they interact with the fish-farming industry.

Surveys of Scottish finfish farms have produced long lists of bird species which farmers claim are causing problems (Ross, 1988), of which herons, cormorants and shags are the principal fish eating predators. On shellfish farms the commonest and often the only avian predator is the eider duck which is much less common in Ireland, being resident only on the northern coast and an irregular visitor elsewhere (Ruttledge, 1980).

The types of damage claimed by fish farmers against predatory birds and mammals include:

(i) consumption of fish and shellfish stocks;

(ii) damage to fish, either killing them or injuring them so that they become less marketable or more prone to diseases or parasites;

(iii) spreading of fish diseases or parasites; and

(iv) the presence of fish-eating birds or mammals close to the cages can disrupt the normal swimming and foraging behaviour of the fish, inducing stress and leading to increased vulnerability to disease, disruption of feeding and reduction of growth.

The scale of damage caused by these predators varies according to factors such as site selection and cage design. Methods used to reduce damage by predators include protection of the cages with netting (predator nets), deterrents by visual or acoustic scaring and destruction by shooting, trapping, poisoning and drowning. In Scotland over 80 per cent of fish farms surveyed by the Marine Conservation Society in 1987 claimed to suffer damage by seals, 50 per cent from herons, cormorants and shags; 20 per cent from mink, and 10 per cent from otters.

In addition, all marine farms, especially large scale salmon farms are undoubtedly sites of potential disturbance to wildlife. Most finfish farms and onshore servicing bases are centres of almost constant activity, with transport between offshore cages and the base usually being operated by powerful and relatively noisy boats. However, there has been little study of the specific effects of mariculture-related disturbance on bird or seal populations (Institute of Aquaculture, 1989).

The environmental impacts of predator control on local populations has not yet been assessed, but is likely to be considerable in some locations. Predator populations do not remain static, and there are indications that the numbers of seals and herons may be increasing on the west coast of Ireland.

A more accurate analysis of impact requires further knowledge of the scale of anti-predator activities and detailed figures on the status and distribution of predator species. Too often problems are not foreseen when a fish farm is proposed in a particular site (despite the requirement for an environmental impact study), proper preventative measures are not taken, and unnecessarily destructive measures may then be used in an attempt to reduce the damage to caged fish.

IX: Potential Effects of Aquaculture on Sand-Eel Stocks and Sea-Birds

The increasing demand in Europe for sand-eels and other small fish in order to provide fishmeal (which is extensively used in the food pellets fed to caged finfish) may be having serious detrimental effects on sea-bird species. Arctic terns, kittiwakes, puffins, great skuas and red-throated divers have declined in population on the islands around Scotland and in Shetland. Ornithologists believe that the cause of these deaths is starvation as a result of persistent industrial over-fishing of the sand-eel which is the staple diet of these sea-birds. Salmonid farming, like other forms of intensive livestock rearing, relies on high protein feeds of which dried fishmeal is a principal component. In Britain, for example, the production of 28,000 tonnes of farmed salmon in 1989 required approximately 35,000 tonnes of feed, derived from a catch weight of about 130,000 tonnes of fish. It has been argued that the process of catching, drying, pelleting and transporting feed produced from sea-caught fish to salmon farms in remote locations is costly and inefficient in terms of energy use (Scottish Wildlife and Countryside Link, 1990).

North Sea stocks of industrial fish (sandeels, capelin, Norway pout and sprat) are under great pressure from over-exploitation. As a consequence, fishfeed producers are obtaining greater quantities of raw material from South Atlantic and Pacific sources of industrial fishmeal, leading to increasing pressure on stocks of similar industrial fish in locations where the catch may not be adequately regulated.

It has been argued that salmonid farming contributes to the overfishing of other fish species, adding to the overall problem of global resource depletion. On the other hand, the use of fishmeal in feeds for fishfarms is only a small proportion of world exploitation of "industrial" fish stocks.

In Ireland, fishmeal is produced primarily from the waste materials generated by fish processing plants (heads, tails, viscera); sand-eels are not used. However, fish feeds incorporating wastes or offal have a much lower food conversion ratio and their use leads to greater production of organic material and nutrients at fish cage sites. As a consequence, they are being replaced where possible by "dry" low-impact feeds. One such fish feed of this type is produced in Ireland from 100 per cent herrings, compounded with high quality fish oil, vitamins, minerals and haemoglobin.

X Visual Impacts of Aquaculture Operations

The visual impact of fish farming activities in the landscape depends to a great extent on the nature and scale of the operation and on the sensitivity of the location. The interaction between the landscape, the fish farm and the viewpoint of the observer is complex, and the brief analysis which follows is necessarily a simplification. It is important to note that no survey of the visual impact of fish farming structures has been carried out in Ireland, in contrast to Scotland (Cobham Resource Consultants, 1987; Scottish Wildlife and Countryside Link, 1988).

Floating Cages

Floating cage units, particularly if the cages are large or grouped together, or are close to the shore, are very noticeable. Their appearance may be made worse by brightly coloured predator nets, huts, feed hoppers, feed storage sheds and other structures which raise their profile. Their visual impact is particularly undesirable in areas of high scenic quality, or when seen from an elevated viewpoint. The visual impact of cages is minimised when they are sited in relatively large water bodies (open sea areas or large inland lakes), well away from roads and other public viewpoints, preferably against a backdrop of land. Cages in smaller fresh-water lakes are generally more serious in their impact.

On the Irish coast, there are only a few coastal sites where cages are visually intrusive; in most locations they are at a sufficient distance from public viewpoints. At sea, moored structures can be an accepted part of the view, and the general feeling towards well-designed and appropriately located individual fish cages is positive (Bord Failte, 1991). The small number of cages in Irish fresh-water lakes is not particularly intrusive, and is unlikely to increase because of a government decision to refuse further licences to cage-based units in inland waters.

Shore Bases

Shore bases which service floating cages are unattractive if they feature buildings and other structures which are inappropriate to the locality or site by reason of their large scale, use of non-local materials or designs, or the lack of adequate screening. Untidy sites, with litter, debris or abandoned equipment, add to the problems. However, it is possible to design such shore bases in an appropriate vernacular style, using local materials and colours, and to locate and screen them so that visual intrusion is minimised.

Shore bases associated with the larger salmon farms in Ireland appear to be generally well-designed, appropriately coloured with respect to the landscape, and relatively remote from public viewpoints. They are regulated by the local authorities under the Planning Acts and their impacts are controlled by conditions attached to the grant of planning permission. At a number of locations, however, shore bases have expanded their storage capacity by using refrigerated containers which are visually unsuitable.

Land-Based Farms

Onshore or land-based fish farms, including hatcheries, can be well hidden from view, with the exception of large-scale operations in relatively open landscapes. In such cases, the impact is made worse if the tanks are sited above ground in a geometric pattern, if they are brightly coloured, or if the site is visible from an elevated viewpoint. Careful site selection, good site layout, thoughtful choice of materials and colours, and selective use of ground contouring and screening by trees or shrubs, can achieve minimal visual impact.

Rafts and Long-Lines

Mussel rafts and long-lines can be very conspicuous, particularly if the rafts are numerous, moored in lines or rows, or support sheds and grading equipment on deck. Long-lines can be visually intrusive in scenic areas, especially if the barrels or floats are brightly coloured, of assorted sizes, or lie at different angles. In some bays on the Irish coast, e.g., in parts of Kenmare Bay, mussel long-lines are highly visible and from some viewpoints give the appearance of being very closely spaced.

Intertidal Shellfish Layings

Intertidal shellfish, such as oysters on trestles or clams on the ground, are virtually invisible and cause no visual impact. At worst, the trestles will be visible as lines of dark coloured objects low on the foreshore, perhaps for a couple of days each month around the times of low water spring tides. When growing oysters or clams, care should be taken to ensure that damaged or derelict trestles or other equipment should not be abandoned on the shore, particularly above high water mark.

General Concerns about Visual Impact

Comparison between the National Coastline Study (1972) maps showing landscapes of consistently high scenic quality and the maps showing areas designated for aquaculture reveals significant similarities between the two (Sargeant, 1990). There is a high coincidence of coastal areas designated for aquaculture (or proposed for designation) with scenic and highly scenic areas. These are also prime tourist areas where the wilderness quality of the landscape is an important component of the tourism product.

The loss of wilderness character in areas of undeveloped landscape is a complex and undefinable issue which goes much further than considerations of visual impact (Scottish Wildlife and Countryside Link, 1988). The concept of wilderness is central to the internationally recognised value of such landscapes, the enjoyment and appreciation of which is affected by intrusions such as disturbance of wildlife, introduction of technological noise (e.g. motor boats, radios, road traffic), litter accumulation, or unpleasant associations in the public mind (e.g., concern about chemicals believed to be harmful).

Fish farming is only a minor component of the totality of changes which are perceived to be diminishing the quality of Irish coastal and lake-shore landscapes, and should therefore not be seen out of context.

XI: Competition for Water Space, Land and Infrastructure

Competition for water space between aquaculture and other activities in both coastal and inland locations will depend on:

(i) the type and scale of the aquaculture operation;

(ii) the management practices and attitudes of the fish farm operators; and

(iii) the extent and variety of other activities and beneficial uses of the same or nearby areas.

Four out of the 17 salmon farmers who completed questionnaires in the ERSI survey (Chapter 6) reported problems of competition for space with other users, or conflicts with other water-based activities. Competition is most likely to occur where there is extensive commercial or recreational fishing, or where other water sports such as sailing or water skiing are popular activities. The main concerns frequently expressed by other users are:

(i) loss of areas formerly available for water sports;

(ii) loss of formerly available fishing areas, and damage to fishing gear by fouling or entanglement with fish farm structures or mooring lines;

(iii) potential obstructions to navigation caused by fish farms, particularly at night or at times of poor visibility by unlit cages, rafts or long lines;

(iv) loss of traditional yacht or fishing vessel anchorages, some of which may provide essential shelter needed for protection from storms;

(v) obstructions caused by sea-bed debris from fish farms; and

(vi) limitations on public access to water or to the shore.

In Scotland and Norway, most of these problems have been caused by fish cages, rafts or long-lines moored in inlets of the sea or in sheltered bays. It is estimated that 15 – 20 per cent of the best anchorages on the West coast of Scotland may not now be used by cruising boats because of fish farm installations. Cages are seldom lit, and are moved from time to time to avoid undue build-up of detritus. Litter on the seabed is also a potential hazard, reducing the anchor-holding quality of the bottom, with the result that yachtsmen and fishermen are wary of anchoring near fish farm sites where a dragging anchor could lead to collision with a fish cage, causing damage for which the boat owner could be liable (Scottish Wildlife and Countryside Link, 1988).

On-shore farms in Scotland have also prevented access to the water or have required coastal pathways to be diverted so as to allow the farm to operate efficiently.

In Ireland, the number of coastal fish cages is much smaller than in Norway or Scotland, and is exceeded by the number of rafts and long-lines used for suspended culture of shellfish. Furthermore, most of the current and potential sites for sea-bed or intertidal culture of shellfish, and for on-shore finfish farms, have not (as far as is known) been used for any significant recreational activity, especially by tourists. The principal exceptions include some parts of Kenmare Bay (e.g., in Kilmacillogue Harbour) and a site for proposed sea cages near Ballyvaughan, Co. Clare.

If sailing and other water sports become more widespread around the Irish coast, perhaps as a result of the construction of marinas, care will have to be taken to ensure that sub-tidal and intertidal shellfish layings are sufficiently well marked and the areas shown on charts so as to minimise the possibility of yachts inadvertently anchoring on them.

Potential conflicts with commercial fishing have generally been avoided in Ireland through the use of public inquiries preceding the designation of areas for aquaculture under Section 54 of the 1980 Fisheries Act. In a number of locations however, fishermen have objected strongly to the making of a Designation Order (see, for example, Appendix B). The social and legal issues embedded in these conflicts are discussed more fully below.

XII: The Sea Trout Problem

A factor which contributed to public concern about fish farming in Ireland has been the widespread discussion of a possible link between the expansion of intensive salmon rearing and the very sudden and catastrophic decline in sea trout numbers along the West coast, particularly in 1989 and 1990. The issue received extensive media coverage (for example: Ahlstrom, 1990; Joyce, 1990; Marchington, 1991; Murphy, 1991;

O'Sullivan, K., 1991; Siggins, 1991; Tierney, 1991), a significant proportion of the headlines indicating fish farming as the cause of the decline.

The problem appeared initially in the Galway/South Mayo region when, following two years of declining catches (1986 and 1987), thin seatrout were first noticed in and around Killary Harbour in 1988. While these fish formed only a small percentage of the 1988 catch, the overall catch returns for most fisheries in North Connemara showed a marked decline compared with 1987, itself a bad year. Catches from other areas in 1988 were reasonable, but the problem became more widespread in 1989 when seatrout disappeared almost completely from fisheries between Newport in County Mayo and Galway Bay; on some fisheries up to half of the trout caught were thin and had an unhealthy appearance.

Climatic conditions were very unsuitable for sea trout in 1990 and sea trout runs in the affected region of Connemara/South Mayo were again drastically below normal levels. Runs (especially of finnock) improved in 1991 when weather conditions were much more normal.

The problem appeared to occur after smolts entered the sea, having migrated out of fresh water. In the sea, the fish seemed to stop feeding; they became thin, pale-fleshed and infested with juvenile sea lice, and many returned prematurely to fresh water.

In response to the urgent need for an investigation and resolution of the problem, the Sea Trout Action Group (STAG) was formed in late 1988. STAG is an alliance of fishery interests, scientists and state bodies concerned with the welfare of the sea trout. One of its first actions was to devise and obtain funding for a programme of scientific investigation to determine the cause of the collapse. The programme was undertaken during 1990, under the co-ordination of the Salmon Research Agency of Ireland (SRAI), and with the involvement of scientists from University College Galway, Trinity College Dublin, the National Diagnostics Centre, the Fisheries Research Centre of the Department of the Marine and staff of the Central and Western Regional Fisheries Boards.

Theories advanced for the cause of the collapse, and investigated by the STAG/SRAI research programme, covered a wide range of possible causes and included:

(i) predation by seals or cormorants, especially in the vicinity of fish farms;

(ii) increased commercial exploitation of sea trout;

(iii) damage to the marine food chain on which sea trout depend, either through:

  (a) heavy commercial exploitation of sand-eels;

  (b) the effects of Nuvan on small crustacea;

(c) a decline in the number of elvers arriving in West Coast estuaries; or

(d) climatic factors or changes in currents;

(iv) increased incidence of disease, either from natural causes or spread from fish farms;

(v) afforestation, especially by conifers, causing acidification of streams and rivers;

(vi) recent changes in climate or in localised weather patterns;

(vii) behavioural changes associated with some abnormal or yet unidentified source of stress, or some abnormal consequence of stress; and

(viii) an increase in the number of sea lice in the vicinity of salmon farms which may provide a reservoir for this parasite.

The possible role played by coastal salmon farms, and the potential causal links between salmon farming and the decline in sea trout were thoroughly examined in the STAG/SRAI programme.

The research programme included a netting survey of five marine sites along the West coast beginning in mid-March 1990. Sea-trout smolts caught in the sea showed no problem until early May, when along with some of the kelts they returned to the river mouths as thin non-feeding fish covered in sea lice. Netting in the vicinity of sea cages did not result in the capture of any sea trout or smolts. No evidence of disease was found, and affected fish merely showed all of the usual symptoms of starvation, together with intense sea lice infestation.

In December 1990 the SRAI presented to STAG a report on its investigations (SRAI, 1990) in the form of scientific papers. On the basis of the SRAI report, STAG compiled its own report which included the following working hypothesis on the likely causes of the sea trout decline (STAG, 1991):

(i) in all probability the major factor was a sea lice population explosion derived from coastal salmon farms;

(ii) underlying physiological factors causing stress to the fish, such as exceptionally warm temperatures and unusual rainfall patterns, may have also contributed to the collapse;

(iii) disease is unlikely to have been a factor;

(iv) environmental factors in fresh water, such as pollution or acidification, while they may be contributing to a long-term decline of sea trout, are unlikely to be the principal causes of the 1989/90 collapse.

The Sea Trout Action Group report also made some 22 recommendations, of which the following related to environmental and aquaculture issues:

(i) emergency steps should be taken to eliminate sea lice problems at existing salmon farms;
(ii) existing farms located in or near the estuaries of affected wild stock fisheries which fail to eliminate their lice problems should be relocated by the regulatory authorities;
(iii) independent assessments of the incidence of sea lice, including the presence of juvenile lice, in salmon cages should be made on a regular basis;
(iv) no further licences or tonnage increases should be granted for salmon farm sites in locations where they might impact wild stock fisheries;
(v) production levels in aquaculture units should be checked regularly and should comply strictly with the licences issued;
(vi) every assistance should be given to the development of more effective methods of lice control; and
(vii) an effective plan to protect the sensitive catchments of the region from further planting of conifer forestry should be drawn up as a matter of urgency.

The working hypothesis was initially criticised by An Taisce (Colleran and O'Sullivan, 1990), and more recently by the Irish Salmon Growers' Association (ISGA, 1992).

An Taisce welcomed the publication and endorsed the recommendations of the STAG report (mentioning in particular the seven listed above), but considered that it did not conclusively prove that sea lice infestation was the primary cause of the collapse of sea trout stocks. In its comments, An Taisce made the following points:
(i) the correlation between the location of salmon farms, the increase in sea lice numbers, and the observed sea lice infestation of returning sea trout cannot be ignored;
(ii) more effective methods of sea lice control on fish farms are needed urgently, and the use of Nuvan should be eliminated;
(iii) the study did not rule out the alternative hypothesis that sea lice are a secondary, rather than a primary, cause of the collapse, and that the observed infestation of returning sea trout resulted from the natural tendency of predators or parasites to attack weakened or stressed fish;
(iv) Ireland is at the geographical limit of the sea trout range, and the unusual climatic conditions of the previous two years cannot be ruled out as potentially significant factors;
(v) changes in land use such as afforestation, overgrazing by increased sheep numbers, and other factors affecting riverine chemistry may be affecting the condition of the sea trout at the time of going to sea,

causing stress and possible adverse changes in their behaviour and feeding patterns in the marine environment; and

(vi) the admitted gaps in our knowledge of the sea trout's biology, and the absence of valid baseline data, should be addressed as a matter of priority.

The Irish Salmon Growers' Association (ISGA, 1992) drew attention to differences between the conclusions of the STAG report and those of the SRAI report, and suggested that sea lice infestation was more likely to be a secondary symptom in the collapse of the mid-western tout stocks, with environmental factors as the primary cause. In support of this, the ISGA quotes the Fish Pathologists Working Group of the International Council for the Exploration of the Sea (ICES) which reviewed the STAG report during 1991 and concluded that "the hypothesis that in all probability sea lice derived from fish farms are a major factor in the collapse of sea trout stocks in the West of Ireland is not justified in the light of available scientific evidence".

The ISGA also makes the points that:

(i) it is the general experience of salmon farmers that sick fish attract sea lice;

(ii) sea trout appeared to be unaffected in Mulroy Bay in spite of the presence of a large number of salmon farms;

(iii) there have been serious declines in sea trout in river systems which do not empty into bays containing fish farms;

(iv) despite intensive searching, biologists had failed to find lice larvae in the vicinity of fish farms in 1991;

(v) there are references in the literature to heavy infestations of sea lice on wild salmon and sea trout long before salmon farming was in existence;

(vi) there is evidence from Europe that coniferous forests can have a seriously detrimental effect on salmonid stocks by increasing acidification to toxic levels, and that the ability of smolts to adapt to fresh water has been shown to be adversely affected by acidic conditions; and

(vii) in many western catchments, acidity was found to be nearing or to have reached dangerous levels.

The Minister of the Marine set up a working group of scientists to examine the problem of the sea trout collapse and this reported in December 1991. Among the Working Group's conclusions were:

- the stock collapse and its related phenomena in the West of Ireland was not the same as the decreases in rod catch recorded in the UK fisheries with the possible exception of the North West of Scotland

- the sea trout stock collapse cannot be attributed either individually or collectively to environmental changes. These include field drainage, stream drainage, agricultural intensification, afforestation and increased use of fertilizer
- The estimates of daily larval production of sea lice are not a good predictor of sea lice infestation in sea trout. On a broad geographic scale there was, however, a broad correspondence between total larval production estimates and the level of infestation of sea trout
- No bacteria, virus, parasite or disease which could account for the collapse had been identified.

In February 1992, STAG produced its third report (STAG 1992). This reviewed the further work that had been done by the SRAI and other scientists. The report maintained the former working hypothesis and concluded that "the weight of the available evidence indicates that the increase in the number of lice emanating from salmon farms was a major contributory factor in the sea trout collapse". It then made a series of recommendations broadly along the lines of its first report outlined above. Neither this conclusion nor the Third STAG Report as a whole was accepted by the ISGA representative on STAG who referred in his reservation to the ISGA's document discussed above (ISGA, 1992).

The extent of the catastrophic decline in sea trout stocks, and the failure to conclusively disprove the allegations that fish farms have played some role in it, represents a problem which the industry must take very seriously. Without necessarily accepting that aquaculture is the main cause of the sea trout problem, every effort must be made to control sea lice numbers, especially during smolt migration. Consideration should also be given to such strategies as fallowing, cage movement and reduction in stock densities on a precautionary basis. It is also vital that the current research efforts be encouraged so as to obtain more information on the sea trout, especially its life history, food supplies, physiology, behaviour and relationships with parasites and predators in the freshwater and marine environments.

XIII: Interactions Between Aquaculture and Tourism

While noting the potential conflicts mentioned already which may arise between aquaculture and tourism or recreation, it is equally true that opportunities exist for positive interaction or benefits between the two sets of activities. These opportunities are derived in part from features shared by tourism and aquaculture (O'Sullivan, 1991a):

(i) both require a high quality physical and biological environment, and both attempt to utilise rather than exploit the environment on which they depend;

(ii) the resources of tourism and aquaculture are renewable resources, subject to good management of their enterprises;

(iii) if the carrying capacity of the environment is overstretched in either case, e.g., by excessive numbers or scale of finfish farms in enclosed bays or by too many tourist-related developments on the coast,they can damage the environment which provides the foundation for their existence;

(iv) both can confer substantial benefits on rural communities, especially through the provision of employment which could not be sustained by other means;

(v) both activities recognise pollution as a common problem, though differing in extent; and

(vi) both are essentially export industries, and benefit the country's balance of payments.

Positive Interactions between Aquaculture and Tourism

Beneficial or positive interactions between the two sectors mentioned during discussions with individuals involved in tourism and aquaculture include:

(i) tourists provide an additional market for fresh or processed farmed fish and shellfish, purchased either directly from growers, or via shops or restaurants;

(ii) a reliable supply of locally-produced finfish and shellfish allows the growth of high quality fish or seafood restaurants which can themselves be an attraction to tourists;

(iii) fish farms may also become tourist attractions, especially if provided with visitor facilities and appropriately marketed (see below);

(iv) fish escaped or released from farms may contribute to the stock available to rod anglers; and

(v) the presence of aquaculture operations can help to put increased pressure on existing or potential dischargers of waste to coastal waters or lakes to reduce or eliminate their discharges;

(vi) aquaculture and tourism need, and can together help to maintain, an attractive image of clean water and a clean environment; and

(vii) aquaculture may, in some areas, provide a good reason to improve water quality standards which can then serve as a further attraction for visitors.

The provision of special facilities for visitors to aquaculture sites, for many years a feature of some inland trout farms, has recently been extended to sea cage-based salmon farms. Most commercial trout farms in Britain, and some in Ireland, include a range of visitor facilities such as an anglers' lake, beginners' fish pond, farm viewing, picnicking areas, and the sale of products such as fresh trout, smoked trout and freezer packs (An Taisce, 1987). Marine-based salmon farms have not until very recently been in a position to develop similar visitor attractions, but in 1991 two west coast farms began to offer "visitor experiences" which included:

(i) a modern visitors' centre with information on the salmon farming operation;
(ii) boat trips to the sea-based cages (lifejackets and oilskins provided);
(iii) tours of the on-shore facilities;
(iv) an optional sea food meal; and
(v) the opportunity to purchase fresh or smoked salmon.

These salmon farm tours have been very successful (one operator reported over 1000 visitors in 6 weeks during the summer of 1991), and they enable people with any level of interest in the industry to see and experience working conditions, e.g., on sea cages, to gain an appreciation of the skills and technology involved, and perhaps to become less fearful of the reported adverse environmental effects.

Negative Interactions between Aquaculture and Tourism

Negative interactions, or undesirable impacts, some of which have been referred to earlier in this chapter, also occur in both directions as would be expected. Fish farms may adversely affect tourism as a consequence of:

(i) some visitors perceiving long-lines and cages to be visually intrusive, especially in areas with a high landscape value or wilderness quality.
(ii) the perception that buildings on or near the shoreline, security fencing, lights, and the presence of litter and abandoned equipment detract from the scenic and other qualities of an area;
(iii) competition for water space in sheltered inlets between aquaculture ventures and people engaged in sailing or cruising; for example, a number of formerly empty and remote anchorages on the south-west coast, enjoyed by a few cruising yachtsmen, are now considered to be "cluttered" with long-lines and cages;
(iv) the continuing (though perhaps necessary) use of chemicals such as biocides and antibiotics on fish farms creating an association in peoples' minds, as a result of which fish farms may be perceived negatively;
(v) similar negative perceptions among rod anglers and people interested in wildlife, arising from beliefs that:

(a) fish farms can damage wild-stock fish through interbreeding with escaped fish, or through spread of disease or parasites; and/or

(b) fish farmers trap, scare or shoot sea-birds and seals; and

(vi) escaped fish in rivers, while contributing to the catch of some rod anglers are regarded as a nuisance by experienced anglers (Browne, 1990a and 1990b).

While some of these negative interactions between aquaculture and tourism have a physical basis, e.g., competition for water space, most of them are the result of perceptions or beliefs which colour peoples' attitudes towards what they see in the environment (O'Sullivan, 1991a). Education and the provision of honest, accurate and open information on the effects of aquaculture are therefore of the upmost importance.

XIV Adequacy of the Existing Environmental Controls

The licensing procedure is the main vehicle for ensuring that adequate controls are available to protect the environment. These are discussed in detail in Appendix B. Most criticism is levelled at the designation order procedure of the 1980 Fisheries Act.

The principal difficulties which began to emerge with the operation of the Designation Order procedure could be described as:

(i) the choice of the term "designation" gave rise to considerable apprehension among other users of the area to be designated – it suggested giving priority to aquaculture, and possibly restricting other alternative uses or making life more difficult for holders of existing "rights";

(ii) the extensive areas chosen by the Department for designation added to this local apprehension, and served to heighten public concern about the proposed Designation Order;

(iii) the Designation Orders and licences were incorrectly perceived as privatising a common resource;

(iv) individuals and organisations with an interest in environmental conservation perceived the Designation Orders and the growth of aquaculture as a threat to the environment;

(v) some traditional fishermen perceived aquaculture as endangering their economic interests, and therefore opposed its development;

(vi) fishermen and other local inhabitants discovered "traditional rights" which they claimed to have enjoyed over many years, and which they stated would be lost if the area in which these rights existed was designated for aquaculture; and

(viii) the 1980 Act draws no distinction between finfish and shellfish aquaculture, and the Designation Orders are not specifically made for any type of aquaculture; as a consequence, designation was resisted by some local communities which might have welcomed an order allowing shellfish cultivation, but prohibiting finfish farming.

The last point is particularly relevant as there is a general perception among coastal residents, fishermen and environmentalists that shellfish farming is more environmentally benign and therefore more acceptable.

Licensing Difficulties

Under the 1980 Fisheries Act, aquaculture licences may be issued by the Department of the Marine only in an area covered by a Designation Order. This procedure, though intended to speed up the issuing of licences, had the opposite and unintended effect of slowing the process down. The difficulties with the Designation Order procedure have led to a situation where many aquaculture ventures are operating on temporary licences, or are unlicensed.

When the proposed Environmental Protection Agency is established, any licences issued by the Department of the Marine will be subject to the approval of the Agency (under the EPA Bill as presently conceived) for the purposes of environmental protection.

The EC Environmental Impact Assessment Directive and Regulations Implementing It in Ireland

Environmental Impact Assessment (EIA) is relatively new to Ireland, even though the procedure has been in existence for some 20 years. An early requirement for Environmental Impact Studies is contained in Section 39(a) of The Local Government (Planning and Development) Act 1976, and in Article 28 of the Local Government (Planning and Development) Regulations 1977. Under these regulations, public projects were excluded, yet such activities (particularly arterial drainage of rivers, road construction and sewerage schemes), had some of the most extensive and significant effects on the environment.

On 1 February 1990, the EC Directive 85/337 on the Assessment of the Impact of Certain Public and Private Projects on the Environment, more commonly known as the Environmental Impact Assessment Directive, was transposed into Irish law by two sets of regulations:

(i) the European Communities (Environmental Impact Assessment) Regulations 1989 (S.I.349 of 1989); and
(ii) the Local Government (Planning and Development) Regulations 1990 (S.I.25 of 1990).

These regulations incorporate EC Directive 85/337 into planning control procedures, and reference is made to fish farming in S.I.349 of

1989, Article 24, First Schedule, Part II, Section I, pages 116-117, where the size threshold above which an EIS is required is given as:

> Seawater salmonid breeding installations with an output which would exceed 100 tonnes per annum; all salmonid breeding installations consisting of cage rearing in lakes; all salmonid breeding installations upstream of drinking water intakes; other freshwater salmonid breeding installations which would exceed 1 million smolts and with less than 1 cubic metre per second per 1 million smolts low flow diluting water.

This threshold limit is one of the most strict in Europe; for example, in Scotland proposed seawater salmonid farming units require an EIS if:

(i) the total cage area is over 6,000 square metres, with a 2 km radius, and the project will be located in certain sea lochs of the west coast and Western Isles; or

(ii) the total cage area is over 12,000 square metres, within a 2 km radius, and the project will be located in any other area.

The EIS must be submitted to the Department of the Marine which, in the case of applications for marine salmonid farms, has specifically requested information additional to that required under the above regulations. The Department's additional data requirements are given in Appendix B.

The legislation has resulted in some four EISs of salmonid farms (listed in Table 7.3) being submitted to the Department between July 1988 and December 1990, a surprisingly small number in relation to the total number of marine farms currently in operation. This is because most of the existing salmon farms were in operation before the implementation of the EIA Directive in Ireland.

Table 7.3: *Environmental Impact Studies of Marine Fish Farms Submitted between July 1988 and December 1990*

County	*Location*	*Developer*	*Date*
Cork	Deenish Island	Salmara and IRD Waterville	Dec 1989
Cork	Inishfarnard	Kealincha Salmon Ltd	Dec 1989
Galway	Ballynakill Bay	Tully Mountain Salmon Farm	Mar 1990
Clare	Ballyvaughan Bay	Vestobrook Ltd	May 1989

Before examining the effectiveness of the environmental control exercised under the EIA procedure, and its impact on the industry, it is necessary to consider briefly the definition and purpose of Environmental Impact Assessment (EIA).

EIA may be defined as a systematic integrated evaluation of both positive and negative impacts of projects, programmes or policies on the natural environment, on beneficial uses of the environment, on man-made structures, amenities and facilities, and on the socio-cultural environment (O'Sullivan, 1989). The aim of the approach is to identify and predict any impacts of consequence, to interpret and communicate information about the impacts, and to provide an input to the decision-making and planning processes.

Its value lies not only in the facts gathered but also in the structured way in which these facts and predictions must be analysed and communicated to local people and to the planning authority. Its application has frequently saved time and money for the developer who is made aware of potential problems at an early stage, and can therefore avoid expensive project modifications later.

Significant weaknesses in the EIA procedure as a whole, some of which have been the subject of formal complaints to the European Commission, include:

(i) the Directive is entirely project based and does not address the environmental problems caused by programmes or by the cumulative impacts of separate but closely linked projects;

(ii) not enough emphasis is given in the Directive or in the Irish Regulations to the consideration of alternatives;

(iii) neither the Directive nor the Irish Regulations make any provision for scoping;

(iv) the government failed to transpose fully into Irish law Article 3 of the EC Directive; and

(v) the exemption formulae entitling certain Ministers to dispense with the requirement of an environmental impact assessment are not framed with sufficient precision.

From the industry point of view, the controls exercised under the Environmental Impact Assessment Directive and Regulations are stringent, and require the preparation and submission of lengthy and costly documents. It could be argued that these requirements, though necessary to ensure an adequate level of environmental protection, make it more difficult for the smaller operator to secure a licence.

Environmental Monitoring

The environmental monitoring of marine finfish farm sites required by the Department of the Marine appears to be quite comprehensive.

Despite these requirements, however, it is clear from the report by Gowen (1990) that adequate environmental data were available from only some fish farm sites, and that certain benthic data could not be compared. He suggests that more than a single set of samples should be collected annually, and that control or reference measurements should be made at stations which have the same characteristics as the fish farm site, but which are a sufficient distance from the farm to avoid possible influence. Gowen also recommends that the scale of the monitoring should be related to the predicted impact, and suggests that only a low level of monitoring is required in areas which have a good water exchange and/or where the sea bed is well scoured.

Gowen's findings suggest that the Department's monitoring requirements, though reasonably adequate, could be more finely tuned to the needs of environmental protection. In our view, the data should also be made available for public inspection, especially by environmental and fishermen's organisations with an interest in the environment.

Aquaculture Industry Code of Practice

In 1989 the Irish Salmon Growers' Association issued a voluntary Code of Practice entitled "Good Farmers – Good Neighbours". It contains a wide range of recommendations aimed at reducing the intrusive effects of fish farming, and at integrating fish farms into the environment and the local communities. The recommendations cover topics such as:

(i) site selection;
(ii) scale of development;
(iii) reducing visual impact;
(iv) keeping fish healthy and disease free;
(v) safety of staff and visitors; vi) prevention of pollution;
(vii) reduction of noise and traffic;
(viii) predator control; and
(ix) precautions when using Nuvan and Malachite Green.

The Code of Practice is a welcome step towards ensuring that salmon farmers become more conscious of the potential environmental problems which they can cause. Given the constraints under which the industry operates the code is well formulated, and should be widely adopted. It needs however to be followed up by a wider scheme covering all aquaculture operations, preferably drawn up in consultation with a Coastal Resources Management Agency or Advisory Council (see below).

XV Aquaculture and Local Communities – The Social Dimension

The initial welcome given to aquaculture by coastal communities along the west coast of Ireland became tempered during the late 1980s by a growing concern about pollution and other potential adverse effects (An Taisce, 1987; Bord Failte, 1991), and by demands for greater control over its development at a local level. Public perception of aquaculture has swung from a general acceptance to a much more critical response.

Conflicts appeared in locations such as Killary Harbour and Mulroy Bay, where evidence given at public enquiries during 1986 suggested that recreational activities were suffering as a consequence of mariculture development. The High Court case in December 1988 (O'Hanlon, 1988), in which a number of fishermen from the Dingle Peninsula succeeded in overturning a mariculture Designation Order for part of Smerwick Harbour, demonstrated the attitude of a traditional fishing community to a development perceived as an imposition, and as leading to the possible loss of an area for fishing and navigation.

These changes in attitude followed a pattern very similar to that on the west coast of Canada and the United States where the rapid growth and government promotion of the aquaculture industry led many people to believe that an uncontrolled "gold rush" mentality had taken over the development of the new industry (Black, 1991). In British Columbia, some 400 applications for salmon farm licences in areas previously dominated by vacation and retirement communities resulted in a vociferous reaction to the advent of the industry. In response, the provincial government in 1986 placed a temporary moratorium on the development of new salmon farms and commissioned an inquiry which made recommendations for a more balanced and sensitive resource allocation process.

In Scotland, where public consultation procedures on aquaculture licensing are not as well developed, similar conflicts have occurred; and the impacts of mariculture on the environment, on landscape and on recreation have been the subject of several studies and consultants' reports (Scottish Wildlife and Countryside Link, 1988).

Identifying the key reasons for the changing attitudes to aquaculture in Ireland is not easy, but it is suggested that many of the problems encountered have their origins in:

(i) the nature of the relatively remote coastal areas which have provided the best sites for aquaculture operations;

(ii) the history of marginalisation of the communities living in these areas, with a population structure damaged by heavy emigration, leaving a residue of a sense of powerlessness towards outside agencies (Byrne, 1991);

(iii) the strategy of locating technically advanced and highly capitalised enterprises in communities with no skills for dealing with the potentials, limitations or challenges of this type of economic development; and

(iv) no local public participation in the initial strategy for aquaculture development, and therefore no mutually agreed goals for social development.

It may be argued also that one of the principal aims of the government agencies which have encouraged and supported the development of aquaculture, namely the creation of jobs, requires a more detailed approach. Increasing the number of jobs available is not sufficient; a sensitive approach needs a more detailed understanding of the winners and losers in each case. For example, it has not been demonstrated that aquaculture development will help to sustain the livelihoods of people dependent on inshore fisheries, or even that the impact of aquaculture will be neutral towards inshore fishing. On the contrary, groups of local fishermen on the west coast either resisted aquaculture developments or ignored them out of an apprehension that fish farming would eventually destroy their livelihoods.

In order to achieve sustained prosperity from the development of a natural resource of the type used by aquaculture there must be:

(i) successful integration of economic goals with social and environmental priorities at all levels;

(ii) these goals to be agreed by consensus at local and national levels;

(iii) an explicit policy favouring the development of a type of aquaculture and a structure for the industry which merges with and supports the patterns of land use, lifestyles and occupations of local communities.

That policy will not be easy to formulate, but should be attempted because it could function as a major factor in drawing up a strategy for avoiding the type of problem which has led to recent confrontations between fish farmers and those opposing the industry. It should include measures such as:

(i) preferential consultation with local interests on any fish farm proposal;

(ii) positive discrimination in favour of local interests when allocating resources such as site leases, grants, etc.

Certain types of fish farming enterprise present ideal opportunities for strengthening some threatened but cherished elements of the way of life in west coast communities, while at the same time providing some extra wealth and comfort. That way of life may appear frugal, but it is reasonably well adapted to its environment and has until very recently maintained a balanced land use. It may be characterised as small-scale, labour-oriented and comprising a variety of part-time occupations.

Large commercial operations fit less easily into that type of socio-environmental structure than do smaller owner-operated enterprises. The Scottish Wildlife and Countryside Link (1988), while acknowledging the valuable role played by multi-national companies in sponsoring and spearheading the development of the industry, argued strongly against allowing the aquaculture industry to become dominated by them because of the resulting adverse ecological and social implications.

Both Udaras na Gaeltacha and the Highlands and Islands Development Board have had a policy of maintaining a balance between large and small companies, but giving preference to small operators in their allocation of grants. However, this may not be a sufficient means of guaranteeing an appropriate balance to serve ecological and social needs, especially since:

(i) the allocation of licences is made on a "first come, first served" basis, with no preference for small operators;
(ii) the detailed but very necessary environmental information required by the Department of the Marine has made it more difficult and costly for the small operator to complete his licence application quickly;
(iii) a rapid and widespread uptake of sites by the most ambitious companies has led to the almost complete depletion of sites suitable for local enterprises; and
(iv) information about the extent of existing licences and leases (and therefore about unleased and/or unlicenced areas) is not readily available to the local community.

Views very similar to those expressed by the Scottish Wildlife and Countryside Link (1988) were expressed at Connemara Sea Week in October 1990 at a plenary session attended by people working in the industry and by people strongly opposed to it. Following a day of workshops and a plenary session at which the techniques of environmental mediation (see below) were applied, consensus was achieved on a wide range of points including:

(i) there should be a more effective role for local communities in determining the future planning of their areas and resources, and they should be able to make informal decisions about coastal resources;
(ii) a comprehensive plan for shellfish farming, finfish farming and fishing should be drawn up by an independent team of experts under the direction of a local body representative of all local communities,

industries, wildstock fishing including drift netting, tourism, Udaras na Gaeltacha and the County Development teams;

(iii) land-based fishfarming and salmon ranching should be explored for their potential; and there should be free access to full information about fish farm licences and permissions.

As a consequence of a number of ongoing factors, including an economic downturn in the industry itself, the confrontation between groups opposing and favouring finfish farming in Connemara has virtually come to a halt. In 1991 a voluntary organisation, Cairde na Mara, was established by a group which broadly supported the aquaculture industry but who were critical of some aspects of its development. A survey carried out on behalf of Cairde na Mara in April/May 1991 which polled a random group of households in the Kilkieran district of County Galway revealed strong but qualified support for fishfarming in the area (Garvey and Bennett, 1991). The results of the survey showed that:

(i) over 90 per cent of the respondents believe that fishfarming has a positive effect on the community;

(ii) two-thirds of the respondents believe there should be more rapid development of fishfarming;

(iii) over 70 per cent of the respondents believe that fishfarming has had a positive effect on increasing employment, reducing emigration, improving social life and the standard of living in the community;

(iv) some 60 per cent of respondents believe that fishfarming has had neither a positive nor a negative effect on the Irish language, shellfishing or the environment;

(v) between 20 per cent and 40 per cent of respondents believe that fishfarming detrimentally affects the conditions of the roads (39%), the environment (31%) and shellfishing (21%); however over 40 per cent of these respondents still favour the further development of the industry;

(vi) approximately 30 per cent of respondents have some member of their household working in fishfarming;

(vii) some 45 per cent of respondents believe there is inadequate information available on what is happening in the industry.

The survey was carried out on 20 per cent of the population of Skannive electoral division in which the unemployment level is 30 per cent, and from which 30 per cent of children have emigrated. It is the belief of Cairde na Mara that aquaculture is probably the only means of creating sustainable employment in this area.

XVI Opportunities and Methods for Reduction of Environmental Conflicts

Technical and Operational Changes

Technical and operational changes which could reduce environmental conflicts and adverse impacts of aquaculture include:

(i) abandonment of certain fishfarm sites where the water exchange is insufficient to prevent the build-up of organic materials and other longterm contaminants;

(ii) greater utilisation of the principles of letting certain sites lie fallow until the benthic fauna and flora have recovered from organic enrichment and to prevent the build-up of parasites and other disease organisms;

(iii) maintaining lower stock densities in cages so as to reduce the incidence of disease, stress and mortalities.

Technological Advances and New Developments

*Technological advances and new developments which are helping, or may help, to eliminate adverse environmental impacts of aquaculture include:

(i) improved, low impact, feed formulations;

(ii) more effective feeding systems;

(iii) use of a device to collect uneaten food and faeces from underneath salmon cages.

(iv) improved disease control and treatment; v) the use of sterile salmon; vi) the use of onshore pumped water supply systems;

(vii) the developmentof cages and long-lines suitable for more exposed sites;

(viii) the attainment of commercial viability for salmon ranching.

Low Impact Feeds and Feeding Systems: As indicated in the early part of this chapter, fish feeds have been considerably improved in recent years. These feeds can give better food conversion ratios, and their correct use can lead to a reduction in waste loads at the cage site and less road traffic between feed plant and fishfarm. A slow-floating feed, which is introduced at the bottom of the fish cage by a novel method, has been developed in Norway, and is claimed to significantly reduce feed conversion ratios and feed losses. In addition, computerised feeding systems can deliver the correct amounts of feed more accurately at the appropriate times.

The environmental disadvantages of these improvements are that the low-impact feeds are generally manufactured from sand-eel, herring, or other fish which could be more efficiently used directly as a source for protein in the human diet.

Preventing the Deposition of Organic Matter Beneath Fish Cages: Several attempts have been made to collect solids below salmon and trout cage-based farms. In Poland, large filter- funnel shaped collectors positioned below the cage bottom removed 45 per cent of solid wastes, but only 15 - 20 per cent of nitrogen and phosphorus loadings (Institute of Aquaculture, 1988). A more recent device, the "Refa Lift-up Feed Collector" developed in Norway, claims to prevent left-over feed and medication from reaching the environment around the cage. It is made of a fine mesh netting which surrounds the cage and hangs beneath it.

Improved Disease Control and Treatment: References to a number of improvements in disease control and treatment were made above; they include:

- low density stocking;
- leaving the cages empty for a period of around three months after harvesting;
- using less toxic materials such as Pyrethrum;
- developing and getting approval for vaccines;
- using wrasse to remove sea lice

The Production of Sterile Salmon: The use of triploid or sterile salmon, which are currently being bred on an experimental bases, could lead to reduced competitive interaction with wild stocks, and to a decrease in the probability of adverse genetic interactions between wild and farmed fish.

Shore Based Fish Farms

Shore based fish farms can achieve greater control over water quality and mortality, and well-designed onshore farms include settling basins and separators to remove sludge and organic matter from the treated effluent.

In siting onshore farms supplied by pumped water, care must be taken to ensure that liquid effluents (spent water in which the fish have been reared) are dispersed through properly sited outfalls, and that there is adequate control over the chemicals used. Good husbandry and site cleanliness should also be insisted upon. Both of these requirements, and any conditions relating to lights, noise, vehicular traffic, litter and disposal of sludges or other solid wastes, can be dealt with by appropriate conditions attached to the planning permission (Planning Acts), to the trade effluent discharge licence (Water Pollution Act, 1977), and to the aquaculture licence (Fisheries Act, 1980).

Exposed Location Cages and Longlines: The development of cages and longlines capable of withstanding much more exposed sea conditions, including very large wave heights, is now well under way. However, there may be a limit to the degree of exposure possible, as was made clear by the short lifespan of the very large fish farm moored inside Inisheer.

Salmon Ranching: Salmon ranching has the advantage that the fish do not require to be fed in captivity during their growth to marketable adults; the smolts are released to sea and return eventually to the cage site where they were reared. No inputs of artifical feed or fertiliser are required.

It is inevitable that some ranched fish will escape before release, and that others will return to adjoining rivers where they may contribute to rod anglers catches. In order for salmon ranching to become economically viable, drift-netting at sea would have to cease or be severely curtailed.

Integrated Coastal Resources Management

As pointed out above, the existing system of licensing and designation under the Fisheries Act 1980 contains an imbalance in favour of aquaculture expansion. There is nothing intrinsically wrong with this, and it is not surprising in view of the Act having been drawn up and administered initially by the Department of Fisheries. In order to create a better balance, however, it is necessary that decisions about the exploitation or development of coastal resources should be made in a context where all possible choices may be weighed and assessed. Such an assessment would need to take into account the sum total of economic and social benefits and costs arising from each of the choices.

Clearly such a framework for choice cannot be the responsibility of a government department whose prime objective is the development of one particular resource, as in the case of the former Department of Fisheries. Even the Department of the Marine, with its wider responsibility (including that for fresh-water and inland fisheries !) is inhibited from taking a sufficiently broad view. Instead, it is preferable that such a framework for decision-making should be administered by a group or agency representative of all coastal interests, established under the Department of the Marine.

This agency should be given the task of producing a draft policy for discussion and provided with access to the necessary expert advice. With the support of a small secretariat, it could function as a policy-initiating body along lines similar to the Office of Coastal Zone Management in the United States. An Taisce (1987) and Earthwatch (O'Brien, 1989) recommended the establishment of a Coastal Resources Advisory Council, a suggestion which was welcomed by Bord Failte (1991).

Such a move would be in line with the growing international perception that marine and coastal resource management policy should be formulated and implemented by a single government agency. For example, in 1986 the National Assembly and Senate of France passed a law on the management, preservation and development of coastal zones, establishing general principles and bringing within a single legislative instrument all rights and activities relating to the coast and coastal waters (Loi no 86 – 2 du janvier 1986, J.O. du 4 janvier).

In the meantime, some progress in the avoidance and resolution of conflicts could be achieved by the Aquaculture Advisory Committee of the Department of the Marine which, it is understood, has unfortunately not met for some time. To be effective, this committee (or its equivalent) should have available to it reasonably detailed evaluations of the different coastal resources and activities in areas where designation orders or mariculture licenses are proposed, and these evaluation reports should be made available for public comment and discussion. This would also provide an opportunity for state and local government agencies, and for voluntary and vocational organisations to comment. Thus in the event of any subsequent local enquiry concerning planning issues the details of all coastal resources including tourism and recreation as well as mariculture or fisheries would be available for consideration.

Continuing technical and other developments, especially in relation to mariculture, will require further evolution of any administrative system. The conflicts and problems arise primarily because the questions change but the organisations cannot adequately respond.

In the case of aquaculture, fisheries and tourism, government and its agencies have failed to anticipate the emergence of the wider environmental and resources management issues. We must therefore, as a priority, re-evaluate policies in these areas. "Top-down" policies will only repeat the mistakes of the past; instead we need to develop an integrated coastal resources management policy along the following lines:

(i) by involving people at local level, including co-operatives, residents, farmers, fishermen, etc;

(ii) by listening and providing feedback and communication;

(iii) by including a careful examination of objectives, options and the environmental and social implications of alternative decisions;

(iv) by providing adequate information and education.

An Taisce in 1987 and again in 1989 (Oliver and Colleran, 1990) emphasised the need for such an integrated coastal resources policy. It should embrace conservation, management and appropriate sustainable development of coastal resources. In order to develop such a policy the following steps could usefully be taken:

(i) define what is meant by "coastal zone" and/or "coastal resources";
(ii) secure agreement on objectives;
(iii) initiate the process by producing a small number of position papers or drafts on specific activities, e.g., on tourism, aquaculture, fisheries, etc.
(iv) re-examine each of these drafts at local level, amending them where necessary so that they can be seen to take into account specific problems and concerns, involving local communities;
(v) commission Environmental Impact Assessments of the current tourism and aquaculture development programmes (programmatic EISs) or Environmental Audits of the industries;
(vi) on the basis of these reports, encourage a series of public discussions on the future of the coastline;
(vii) allow for the emergence of a policy which reflects the uncertain nature of our knowledge and our inability to predict future outcomes with accuracy; thus the policy should contain a series of options appropriate to differing local areas and their aspirations.

Coastal Zone or Coastal Resources

The coastal zone is usually defined as:

> The band of dry land and adjacent water space (including water and sea bed) in which terrestial ecosystems and land use directly affect ocean space ecosystems, and vice versa. Functionally it is the broad interface between land and water where biological production, consumption and exchange processes occur at high rates of intensity.

The coastal zone is a band of variable width which borders the continents, islands and inland seas — it is very hard to define its landward and seaward boundaries; the landward boundary is necessarily vague: the oceans may affect climate far inland from the sea, and ocean salt penetrates estuaries to a considerable extent. The seaward boundary may appear easier to define scientifically but it has been the cause of extensive political argument and disagreement. Generally coastal waters can be identified at least to the edge of the continental shelf, but the influence of major rivers may extend many miles beyond this boundary.

Because of these problems, the term coastal resources is preferred:

these are resources which, for their existence, sustainability, accessability or exploitation, are critically dependent at any stage or time upon the dynamic interface between land and water which we call the coast.

Coastal resources therefore include sea-birds which spend most of their lives at sea but return to sea-cliffs to nest, wild-stock fish caught on the edge of the continental shelf but dependent on shallow inshore waters for their nursery grounds, and coastal agriculture which benefits from the mild and moist climate caused by the proximity of the ocean.

Effects of Policy Weaknesses

If coherent policies for aquaculture and for the management of our terrestrial, aquatic and coastal resources are absent, and if the methods for avoiding or mediating conflicts are weak or lacking, then development and resource utilisation will continue in a manner characterised by:

(i) a marked variation in receptivity among different communities and authorities towards proposals for new or expanded aquaculture and tourism ventures;

(ii) lack of general consensus about future direction of aquaculture and tourism development and its social role;

(iii) local conflicts which will become politically charged and lead to significant delays and costs in getting new developments licenced and operational;

(iv) difficult community relations and a negative image for these industries; and

(v) an uncertain investment climate.

Public Participation and Freedom of Environmental Information

As noted earlier, there have been calls for greater access to environmental monitoring data in both Ireland and Scotland. Clearly, as long as the data are unavailable and there are suspicions that damage is being caused to the marine environment by fish farming, then local communities will fight planning applications for the granting of licences in their areas. It would be far better therefore to ensure that monitoring data are made available freely and that local communities are encouraged to examine and understand them.

In any event, the EC Directive on freedom of environmental information will make it mandatory for member states to provide information of this nature to the public on request.

Environmental Mediation

Mediation has a long history, particularly in the United States where it has not been confined to industrial relations or family disputes (Collins, 1991). In the 1960s the US Department of Justice operated a mediation service for civil rights disputes, and in the 1970s mediation became a major tool of public policy makers, especially in the area of environmental policy. Environmental mediation is now an established process in many States, where it has helped resolve a number of difficult coastal resources management conflicts.

The process of mediation involves the intervention into a dispute of an acceptable, impartial and neutral third party who has no decision-making authority, but who will procedurally assist the parties to voluntarily reach an acceptable settlement of the issues in dispute (Collins, 1991).

Environmental mediation aims to produce an outcome or result that is generally accepted as good; the primary goals are:

(i) to satisfy the interests of everyone involved;
(ii) to select an efficient solution, i.e., an option which ensures that all possible joint gains have been secured;
(iii) to result in commitments which can be implemented (all parties should be encouraged to make only those promises which they can keep);
(iv) to ensure the legitimacy of the conflict resolution process or mediation in the eyes of all those affected by the outcome;
(v) to ensure that the outcome deals wisely with uncertainty and recognises our lack of knowledge of natural systems; this is especially important in dealing with issues which hinge on the interpretation of scientific, particularly ecological, data or observations;
(vi) to ensure that the outcome is reached reasonably quickly; and
(vii) to result in improved relationships, so that the participants are left in a better position to deal with their differences in the future.

Before embarking on environmental mediation, the following issues should be clarified, the necessary information obtained, and ground rules established:

(i) the participants or actors in the conflict process must be identified at a very early stage: local people, neighbours, potential employees, local municipal government, central government, state agencies, non-government organisations concerned with fisheries or with the environment, actual or potential fish farm operators, the local business community, etc;
(ii) the aspirations, perceptions and legitimate fears of each group must be identified, recognised and accepted;

(iii) the impacts of the proposed or on-going aquaculture venture must be clearly identified, along with the inter-actions (positive and negative) between it and other existing or future uses of land and/or water;

(iv) general agreement must be sought and obtained that multiple use is the best strategy for the local area, that the problem cannot be resolved in an "either/or" way, but that an integrated approach yields better gains in the long term; and

(v) a set of clearly stated and agreed objectives must be produced.

Environmental mediation has been used on only one occasion in Ireland – during Connemara Sea Week in October 1990 when, with the aid of an independent mediator from outside the local area, salmon farm owners and workers came together with fish farm opponents to reach agreement on a number of fundamental issues. (O'Sullivan 1991b)

Traditional methods of resolving coastal resource management disputes, such as public hearings, court cases, licensing or zonation arrangements, are generally unsatisfactory or much less satisfactory. They are based on contention between parties or rely on an adversarial and legislative approach in which one side "wins" and the other "loses". In such situations, the losing group (if its feelings are strongly held) will shift the conflict to another arena, or may seek revenge in an unrelated situation (Susskind and McCreary, 1985).

Non-adjudicatory approaches such as policy dialogues and mediation can be more effective; they emphasise consensus-building, are based on face-to-face discussions between contending or competing interest groups, and include altered but important roles for planners/ecologists as negotiators and mediators.

In mediation-based or non-adjudicatory approaches to resource allocation and conflict resolution, policies and attitudes are important; decisions based on economics alone will rarely achieve their objectives or be viable/sustainable in the long term.

Finally, conflicts are less likely to appear when genuine efforts are made to seek out and develop positive interactions between resource based activities. The promotion of positive interactions between apparently competing resources is not new.

Well known examples include the use of nutrient-rich domestic sewage to enhance the production of food by aquaculture or to raise the level of productivity in existing ecosystems. In temperate or cold climates, waste heat from power plants has been used to control spawning and increase growth rates of fish and shellfish or to warm beaches for bathing.

It may appear unfortunate that the aquaculture industry seems to have been singled out for criticism on environmental grounds. But this should now be considered an opportunity by the industry to demonstrate clearly its commitment to the environment. Positive steps which might be taken include:

(i) acceptance by the industry of the principle of sustainable development;
(ii) acceptance of the precautionary principle;
(iii) acceptance of strict environmental goals;
(iv) rigorous implementation by the industry of its own codes of practice;
(v) use of the best available and low impact technology (not BATNEEC, which is merely the best available technology not entailing excessive costs).

In addition, work already under way to emphasise positive interactions between fish-farming and other activities should be expanded or continued. Such programmes and projects include:

(i) continuing promotion of marine environmental awareness, particularly in schools but also among local residents and visitors;
(ii) open days on fish-farms, with conducted tours of finfish culture units, leading to "aquaculture tourism";
(iii) the development of direct links between seafood restaurants and fish-farms (the positive interactions here already exist, they merely need to be made more visible); and
(iv) continuing promotion of the health benefits of cultivated seafood.

Some of these approaches are already being taken or can be taken by the industry; others will need the involvement of government. Here we must face the fact that the lack of a coherent government policy on natural resources (and especially the lack of a policy which takes into account the social and environmental implications of developing these resources) appears to have been a significant contributory factor in allowing conflict situations to develop. In order to redress this, a primary task of government must be to develop and implement policies based on a comprehensive and integrated approach to the management of coastal resources. Communities living in coastal areas must be given a central role in the formulation and implementation of appropriate policies particular to each region.

Chapter 8

CONCLUSIONS AND RECOMMENDATIONS

The Need for Economic Development

Ireland is among the poorest of the EC member states with a per capita GDP of only 64.5 per cent of the Community average. This is even less than the Spanish figure of 73.6 per cent. But within Ireland there are also marked income differences in the different regions. Unpublished calculations by Dr M. Ross of the ESRI for the year 1984 shows that per capita personal income in the Western region (Mayo and Galway) was only 87 per cent of the National average while in the Sligo/Donegal region the figure was as low as 83 per cent. These income figures include transfer payments (old age pensions, unemployment benefit and assistance, children's allowance, etc.) which account for over one-fifth of the personal incomes. If these were not taken into account per capita, GDP in these counties would be less than 80 per cent of the corresponding state figure.

As a reaction to the low incomes and unemployment, there has been substantial emigration from the country over the past decade. No figures are available for regional out-migration but the indications from media reports are that it is very high.

Figures for dependency ratios, unemployment and population densities in some coastal rural districts, in Ireland as a whole, and in the EC in 1986 are given in Table 8.1. For the EC the dependency ratio (total population less those at work as a fraction of those at work) is 1.34. For Ireland the ratio is 2.24, while for the rural district of Dunfanaghy in Donegal it is 3.97. The dependency ratios in the Clare RDs shown are around the same level as for the state as a whole but this we think is related in some way to the emigration rates. The unemployment rates in these areas are relatively low because many of those out of work have left. In regard to unemployment the rate in the EC in 1986 is estimated at 11.3 per cent. This includes people seeking their first job. For Ireland the figure is 17.9 per cent but for Glenties in Donegal it is over 39 per cent and for Dunfanaghy 29 per cent. Other RDs with high rates of unemployment are Ballina 34.8 per cent, Clifden 27.5 per cent, and Cahirciveen 23.8 per cent.

Table 8.1: *Dependency Ratios, Unemployment Ratios and Population Densities in Some Coastal Rural Districts, in Ireland and in the EC in 1986*

County	*Rural District*	*Dependency Ratio* [1]	*Unemployment %* [2]	*Persons per sq. km.*
Clare	Ballyvaughan	2.239	15.3	8
	Ennistymon	2.01	12.4	23
	Kilrush	2.192	15.1	21
Cork	Bantry	2.472	18.5	19
	Castletownbere	2.776	18.4	14
Kerry	Cahirciveen	2.816	23.8	11
	Dingle	2.504	17.2	17
Galway	Clifden	2.88	27.4	11
Leitrim	Kinlough	2.274	18.6	18
Mayo	Ballina	2.562	34.8	13
	Belmullet	3.891	21.7	12
	Westport	2.926	20.9	17
Sligo	Dromore West	2.354	15.8	14
Donegal	Dunfanaghy	3.966	28.9	19
	Glenties	3.315	39.3	23
Ireland		2.24	17.9	50
EC (12)		1.34	11.3	143

Notes: (1) Total population less those at work as a fraction of those at work.
(2) Includes first time job seekers.

In regard to population densities the EC has 143 people per square kilometre, Ireland as a whole has 50 while there is 15 or less in Ballyvaughan (8), Cahirciveen and Clifden (11), Belmullet (12), Ballina (13) Dromore West and Castletownbere (14). Admittedly most of these RDs are mountainous, rocky or boggy regions but nevertheless the population densities are very low - much less than they were in 1971. Hence unless some kind of economic activity can be introduced entire populations will move out of some of the remoter regions as has happened with many of the coastal islands.

Opportunities for Economic Development in Coastal Regions

The opportunities for economic development in western coastal regions are limited. Manufacturing industry has developed in the larger urban areas along the coast - Galway, Sligo, Limerick, Shannon, Tralee, etc., but it is difficult to get industries to locate in the smaller towns and rural areas. Though dependence on agriculture is high in these regions, farm incomes are low and the decline in the CAP may make matters worse; already a high percentage is getting the farmers' dole. The three indigenous industries which have potential in these areas are tourism, capture fisheries and aquaculture.

Tourism

Tourism is an important industry in coastal regions. Angling on the western lakes and rivers is a considerable source of revenue to the areas. Other holidaying is also of great value. Unfortunately tourism in Ireland is very seasonal and there are long periods when there are very few visitors. Hence some other forms of economic activity are a necessary supplement. Indeed pluri-annual activities (holding a number of jobs on a part-time basis) is a characteristic feature of rural populations.

Capture Fisheries

Though the sea fishing industry in Ireland accounts for less than 1 per cent of the work-force it generates up to 10 per cent of the employment in those counties where the fishing industry is concentrated. In Donegal, for example, fishing accounts directly for 8.5 per cent of the labour force, and if indirect and induced employment within the county are added fishing accounts for up to 17 per cent of total employment in Donegal (see Drudy and Phelan, 1982).

Regarding income from sea fisheries, the latest report on portal landings by the Department of the Marine (1989) shows that as many as 16 ports situated mainly on the west and south west coasts had landings in excess of IR£1 million each in 1989. The total landings at all ports in 1989 were valued at about IR£78 million. This sum gives an indication of the flow of income to the coastal regions with incomes to workers in the fish processing industry providing further sources of income. Indeed in some of the major fishing port areas, (Killybegs, Rossaveal, Dingle and Castletownbere) fishing generates almost all the economic activity in the towns and hinterlands.

Though wild fish landings have increased steadily over the years the scope for increased landings is limited. There is at present a considerable imbalance between the capacity of the EC fishing fleet and the available resources. In December 1990 the Council of Ministers adopted a series of measures aimed at accelerating the rate of reduction of the capacity of the fishing fleet. In the Irish case the fleet capacity must be reduced by 3 per cent of its 1984 gross registered tonnage (GRT) and must not show any increases in this level over the period 1987-1991. Hence the GRT of new vessels entering the fleet must be balanced by the withdrawal of older vessels to an equivalent GRT.

It is possible that the productivity of the fleet will increase in future years but the scope for such productivity is limited also, particularly in regard to the high priced white fish species. Indeed the increasing pressure on white fish stocks in Community waters and the consequent reduction in Total Allowable Catches (TACs) and quotas have already led to a growing shortfall of EC supplies.

A further problem is related to Spain's entry to the EC. According to the Act of Accession, Spain will not be allowed to fish inside the 50 mile Irish zone for a ten year period commencing 1 January 1986. The regulation states however that there will be orderly opening of the Irish zone to Spanish vessels from 1 January 1996. This will reduce the stocks available to the Irish fishermen further.

In these circumstances the prospects for increasing the income and current employment in the Irish capture fishery depend on the outcome of negotiations in relation to the EC Common Fisheries Policy (CFP). It is envisaged that as far as Ireland is concerned, these negotiations will have some success but they are unlikely to counteract the decline in agriculture as a result of the proposed CAP revisions.

Aquaculture

In the prevailing circumstances aquaculture seems to have the greatest potential for creating income and employment in coastal areas but to do this it will have to be expanded to its optimum potential. In addition, certain capture fishermen, e.g., lobster, whose incomes are restricted due to limited availability of supply should be offered assistance in developing resources through aquaculture techniques.

Because the EC has a deficit in its fish products, it is supporting aquaculture in various ways in order to find new sources of supply. Currently, Community funding for aquaculture comes from funds separate from those for capture fisheries. It is recommended that these funds be integrated with the structural funds so that aquaculture can benefit fully from the doubling of the latter. Increasingly, however, the funds should be employed to promote more effective integration of fishing and fish farming. It is interesting to note in this connection that fishermen made redundant by the revised CFP are being offered preferential grants to get started in fish farming. Such grants, as well as grants to other persons, should take the form of retraining grants, interest subsidies on working capital and special grants for the cultivation of new species which have potential for successful cultivation. Areas in the aquaculture sector that require attention both from the Irish government and the EC are listed below.

The Licensing Problem

A major problem facing the aquaculture industry is the licensing system. This must be tackled and an acceptable regime devised if the industry is to prosper. As shown in Appendix B, the present system is unworkable, as is evidenced by the number of cases referred to the Courts. Investment will not take place if there is a danger that licences can be cancelled at any time because of court orders. A licensing system which will facilitate orderly development must be devised. It would seem that the most workable alternative to the present system will be the introduction of the system already in use in Northern Ireland where each project is licensed on its own merits rather than as part of a designation area strategy.

When the proposed Environmental Protection Agency is established by law, licences issued by the Department of the Marine will be subject to the approval of this agency for the purposes of environmental protection. This is likely to make it more difficult to obtain licences in future years, but it is hoped that it will diffuse many of the conflicts which have arisen between fish farmers and environmentalists.

The Environment

In assessing the environmental implications of aquaculture development we must recognise that it is not a homogenous industry. It is a group of activities sharing a common pool of knowledge about the culture of marine and freshwater organisms placed together for administrative and conceptual convenience but differing greatly in their impact on the natural environment and on coastal communities. It is clear that finfish farming in sea cages has a much greater social and environmental impact than, for example, the inter-tidal culture of Pacific oysters and clams. Yet both activities share common needs such as clean water and an image that enables growers to sell on foreign markets at a premium price. Hence any study of the environmental impact of aquaculture must recognise both the differences and similar needs of the variety of aquaculture ventures which are currently available or which may become available in the future.

It would be surprising if fish farming activities did not have the potential to affect the environment and our uses of it. Not all such effects, however, are detrimental. Some may be innocuous or imperceptible and others beneficial but in most cases finfish or shellfish farming may exert all three types of effects. Generally speaking the detrimental effects tend to be localised and are reversible but nevertheless, the objective must be to minimise them through sound policies and practices.

Among these might be mentioned the siting of marine finfish farms in good water flushing areas, away from estuaries or the mouths of good angling rivers or where they might interfere with navigation or shelter for ships. In particular, more research is needed on the possible connection between aquaculture and the sea trout collapse. Without necessarily accepting that aquaculture is one of the causes of the problem, every effort should be made to control sea lice numbers, especially during smolt migration. Consideration should be given to such strategies as fallowing and cage movement on a precautionary basis.

Suggestions for other problems are:

(a) to minimise the loss of uneaten food by paying particular attention to stock numbers and feed requirements;

(b) to develop techniques and equipment to collect solids from below salmon and trout cages, and

(c) to develop techniques for the production of triploid finfish which may be cultivated safely without fear of damage to wild species.

Integrated Coastal Resource Management

In the case of aquaculture, tourism and fisheries, government and its agencies have failed to anticipate the emergence of the wider environmental and resource management issues. We must, therefore, as a priority re-evaluate policies in these areas.

There is a growing international perception that marine and coastal resource management policy should not be formulated by a government department whose prime objective is the development of one particular resource - fisheries. Even the Department of the Marine is inhibited from taking a sufficiently broad view. It is preferable that such a framework for decision-making should be administered by a group or agency representative of all coastal interests established under the Department of the Marine. The agency should be given the task of producing a draft policy for discussion and provided with access to the necessary expert advice.

To be effective this committee should have available to it reasonably detailed evaluations of the different coastal resources and activities in areas where designation orders or aquaculture licences are proposed. This forum would provide an opportunity for state and local government agencies and for voluntary and vocational organisations to comment. Thus, in the event of any subsequent local enquiry concerning planning issues, the details of all local resources would be available for consideration.

Environmental Mediation

Traditional methods of resolving coastal resource management disputes such as public hearings, Court cases, licensing or zonation arrangements are generally unsatisfactory. They are based on contention between parties or rely on an adversarial and legislative approach in which one side "wins" and the other "loses". In such situations the losing group (if its feelings are strongly held) will shift the conflict to another arena or may seek revenge in an unrelated situation.

Non-adjudicatory approaches such as policy dialogues and mediation can be much more effective and satisfactory; they emphasise consensus building and are based on face-to-face discussions between contending or competing interest groups. The process of mediation involves the intervention into a dispute of an acceptable and impartial third party who has no decision-making authority but who will assist the parties to voluntarily reach an acceptable settlement of issues in dispute.

Environmental mediation has been used on only one occasion in Ireland - during Connemara Sea Week in October 1990 when with the aid of an independent mediator from outside the local area, salmon farm owners and workers came together with fish farm opponents to reach agreement on a number of fundamental issues. Fora of this kind should continue to be organised in future years with government backing. It seems to be the only way of resolving conflicts in this very sensitive area.

Salmon Farming

Salmon farming is going through a difficult time everywhere. Low prices due to oversupply has made life very difficult for producers. Diseases and pests of all kinds are also a problem. The low prices will wipe out the inefficient producers and those on unfavourable sites. As a consequence, prices will rise again in response to reduced supplies. As stated in Chapter 3, prices are expected to settle down at something over the average cost of production and those who cannot produce at this level will go out of business.

Many of the current problems in the industry have been created by the rapid growth in production in Norway. The market could probably cope with the recent growth if sales were on a regular basis but at any hint of impending disease Norwegian supplies are dumped on the EC market causing prices to plummet. The placing of quotas on imports from Norway should be an obvious solution to the problem but now that a special relationship has been agreed between the EC and EFTA it has become impossible to impose quotas of any kind.

As a result of lobbying by the Irish and Scottish salmon producer organisations, the Norwegians agreed to impose voluntary control on production and marketing. This worked for a short time but eventually the discipline could not be maintained and the Irish and Scottish producers were again forced to make representations to the EC about the situation. As a result of these representations, imports of Atlantic salmon into the EC were made subject to a minimum price. However, this price is so low that it offers no protection to the industry. EC producers are continuing their efforts to obtain a realistic reference price for imports and if this is not obtained the industry will continue to be in serious difficulties.

Irish producers have problems not encountered by the Norwegians or the Scottish farmers. The number of good sheltered sites is limited and producers are forced to go further offshore into rough seas where service of the cages and security is more difficult.

This disadvantage could, however, be mitigated to some extent by using it as a selling point. Production of fish in clear offshore unpolluted waters could be used as an advertisement to command a higher price for Irish than for Norwegian or Scottish fish in "green" areas like Germany and elsewhere. More and more people are becoming concerned about the source and quality of the food they consume and Irish producers should be prepared to cater for these concerns. The "organic" food idea is now a reality.

Disease is another serious problem for Irish producers, particularly in warm summers. This, of course, is a world-wide problem and research in the area is intense. Irish farmers will eventually benefit from the results of this research but in the meantime they should experiment with reduced stocking of the cages, a technique which has reduced disease levels considerably on Pacific salmon farms in Canada.

The Quality Assurance Scheme

Another factor which can help to increase the marketability of Irish farmed salmon is the Quality Assurance Scheme recently introduced by BIM in conjunction with the Irish Salmon Growers Association. The purpose of the scheme is to guarantee salmon of a specified and consistent standard to the customer. This is achieved by ensuring that farms and packing stations conform to agreed codes of practice and that salmon is graded according to strict standards.

The codes of practice which take account of the latest national and EC regulations cover everything likely to have a bearing on product quality from the time of stocking of smolts to the delivery of packed salmon to the point of first sale.

The scheme is policed by the Irish Quality Association, an independent body which carries out strict audits before membership is granted. Thereafter, farming and packing operations are regularly inspected by the Association's auditors to ensure that standards are being upheld.

The Quality Assurance Committee maintains control by its right to eject members from the scheme if they repeatedly fail to meet the standards. Special BIM training courses in grading, hygiene and quality assurance are being provided on an ongoing basis for staff on farms and packing stations, thus attempting to ensure the highest levels of quality awareness and practice. These courses should be continued and updated from time to time.

Approved members of the Quality Assurance Scheme are allowed to use the scheme's "quality labels" on their boxes and quality gill tags on their fish, thus offering the customer an easily recognised sign of guaranteed quality. It should be mentioned that quality measures of this type have been introduced by every major country producing farmed salmon and trout.

Trout

To date rainbow trout is the species cultivated both in fresh water and in the sea. They are more disease resistant than salmon and are not as subject to sea lice in the cages. The survey results in Chapter 6 showed that trout farming was a profitable enterprise in 1990 and the general feeling is that it will remain so on properly managed farms.

Demand for farmed trout is increasing in supermarkets and restaurants. Research results indicate that oily fish like trout are good for the heart (Burr, *et al.*, 1989) and as a result the health factor is becoming more and more obvious in the market place. It is now believed that the market for trout can be expanded and a sizeable industry built up. When it is considered that Europe produces and consumes 176,000 tonnes of farmed trout annually (see Table 2.5) there seems no good reason why Ireland could not increase its market share considerably.

BIM is supporting trials involved with the farming of brown trout in the sea. These are the same species as wild sea trout and their quality is perceived to be superior to sea-grown rainbow trout. They should command a premium price in the market place. It may also be possible to use such sea-reared brown trout to counteract the decline in sea trout numbers. Experiments along these lines are being carried out by the Salmon Research Agency (SRA) and Salmara (the ESB aquaculture section). However, the implications of such a strategy for remaining wild stocks are complex and would need to be carefully researched and considered, as would the acceptability of these reared fish to anglers. We recommend that the relevant research be continued.

Other Finfish Species

With the decline in salmon prices and the increase in prices of other fish due to scarcities, experiments are being carried out everywhere to determine if other species can be farmed economically. The species listed below offer the best prospects at present.

Turbot

This is a very high priced white fish. During the last 15 years research institutes and commercial organisations in Europe have devoted considerable resources to the development of techniques for rearing it. There is still a lack of basic knowledge on the ecology, nutritional physiology, and feeding behaviour, but despite this, turbot is still considered to be one of the most promising species for marine aquaculture in Europe (Paulsen, H., 1989).

In 1986 there were about 10 commercial plants in Europe but they produced less than 1,000 tonnes. The optimum temperature for cultivating turbot is 17°C; at lower temperatures they grow more slowly and in Northern Europe high growth rates can only be obtained through heating the sea water. For this purpose cooling water from power plants is often used.

Experimental work by UCC, BIM and Udaras na Gaeltachta on turbot production is underway in Bantry Bay, while similar work by Udaras, through its subsidiary Taighde Mara Teo., is being carried out in Cape Clear. Results to date are promising from a technical point of view but the economics of growing them in such cold waters have yet to be determined. Industries sited on the coast which have suitable warm water discharges might use this source of heat to on-grow turbot.

Arctic Char (Salvelinus alrinus)

Arctic char is a common inhabitant of many northern latitude lakes. Native populations of arctic char are found in Lough Conn and other Irish north-west lakes. The fish enjoys a very high reputation on continental markets and it is believed that it can be farmed successfully here (Chevassus and Faure, 1989).

Ornamental Fish

Ornamentals include species such as angel fish, gold fish (carp family), tilapia, catfish and guppies. As stated in Chapter 1, EC trade in these fish is about IR£2,500 million annually. As the EC is banning imports of ornamental fish after 1993 an opportunity exists for breeding them domestically. A few people in Ireland are already growing some of these fish successfully on a small scale in glasshouses. We recommend that experiments be put in train immediately to determine if they can be grown economically in our climate and the type of structures and capital required for the operation. There is a ready market to be filled.

Eels

These are very valuable fish commanding a ready market in the up market restaurants and retail outlets throughout Europe. The largest eel fishery in Ireland is in Lough Neagh. There is also a good eel fishery on the Shannon controlled by the ESB. From 1970 onwards the landings of eels in Europe have declined from 15,000 tonnes a year in the late 1960s to 9,000 tonnes per annum at present. Over-fishing, environmental changes, water pollution and diminishing recruitment of elvers are believed to be responsible. This dramatic decline in production has not been compensated for by a larger aquaculture production even though demand for eels remains high.

Many attempts at culturing eels have failed. Experiments were not conclusive or eel producing companies were not self-supporting. The reasons for the slow advance are various. Belpaire (1990) says that much has to do with the nature of the eel biology itself which is very complex and not yet fully understood. There have been a few successful experiments but mostly there have been failures. Although considered a strong fish, eels in dense husbandry conditions are very susceptible to bacterial and parasitic diseases.

Recent research work in Denmark and elsewhere indicates that the technology of growing eels in confined spaces is being mastered, and there are hopes that in a few years a successful system of culture will emerge. A number of trials are now under way in Ireland. Licences have been issued for the collection of elvers (young eels) in Donegal and in rivers in Galway and Mayo, while an on-growing re-circulation system has been established in 1990 in Co. Wexford with technical and financial support from BIM. We recommend that these trials be continued. The ranching of eels in inland lakes using elvers collected in the western rivers would appear to be the best way forward at present (see Nielsen, L., 1989).

Shellfish

As stated in Chapter 4, cash flow difficulties are a serious problem in shellfish farming. Producers in the start-up phase have to wait two to three years before any cash becomes available from sales.

Grant aid is available from the Irish government agencies and from the EC for shellfish production but these grants are mainly for fixed capital structures. No grants are available for working capital and those for the purchase or collection of seed stocks are limited to a specified percentage of the overall fixed capital costs of the project. These drawbacks must be rectified by changing the nature of the financial aid to cover working capital requirements. Suggestions in this regard and on production generally, discussed in Chapter 4 are:

(1) The provision of interest subsidies, loan guarantees employment grants and payment of something like the "farmers dole" to beginning shellfish farmers.
(2) The monitoring of natural oyster and mussel spatfall.
(3) Settlement trials for oyster and mussel spat to determine ways and means of controlling seed supplies.
(4) The provision of specialised nursery facilities so that juveniles can be made available at lower costs and enable seed to be grown to a stage in 3 months which at present takes the industry a year to reach. This would have several beneficial effects, one of which would be to reduce the cash flow time by 30 per cent.
(5) The introduction of a new movement order currently being drafted to control movement of stocks and minimise the risk of disease spreading.

Many of these suggestions could best be implemented by the appointment of regional biologists co-ordinated from a central office. These could carry out the necessary monitoring and trials required and make suggestions, based on their experiences, for new initiatives in the industry.

Shellfish marketing problems are discussed in detail in Chapter 5. A number of issues arise in the marketing process such as fragmented production and sales to intermediaries resulting in erratic product quality and low prices. Another important issue relates to health and hygiene. Many consumers are worried about food poisoning from shellfish and want assurances that all products offered for sale are safe to eat. For that reason a quality label similar to that used on salmon is required. A scheme to accomplish this is currently under way for the rope mussel industry.

Ireland has gone some distance already towards standardising shellfish quality. A sanitation programme introduced in 1985 classifies areas into three grades as follows:

Approved Areas: Shellfish from these areas may be sold without any treatment.

Conditional Areas: Products from these have to be purified, heat treated or processed before they can be sold.

Restricted Areas: Before sale shellfish from these areas have to be cooked in a retort at very high temperatures.

These areas are examined every two weeks by officers of the Department of the Marine, and water samples taken. Very strict conditions in regard to production, purification, transportation and relayering of mussels are laid down in the EC Bivalve Mollusc Regulations, described in Appendix C. This Directive, which comes into force on 1 January 1993, should go a long way towards ensuring good quality and reassuring the public on the safety of mollusc consumption.

Other issues requiring attention are:

(1) Accurate forecasting of production schedules.
(2) An effective information network which communicates up-to-date information from the market place to the producers.
(3) A central onshore cold store sea water tank facility located on the European mainland.
(4) More attention paid to arranging regular supplies, on time deliveries, good grading and packing. Irish traders have a poor reputation for professionalism in these areas.

Developments Within the Shellfish Industry

Mussels: The survey results presented in Chapter 6 showed that sales of rope mussels were projected to go from 3,360 tonnes in 1990 to 6,000 tonnes in 1995. In addition, BIM and Udaras expect a number of new farms to come on stream, so that by 1995 production could reach 7,000 tonnes or more. It is believed that markets at relatively good prices will be available for this amount.

Sales of bottom mussels are projected to increase from 15,000 to 18,000 tonnes over the five-year period and we think that this is also possible if seed mussel stocks can be located that are of a suitable size for transplanting.

Pacific Oysters: Despite the poor market in 1990 the outlook for Pacific oysters is good. The Carlingford producers are again selling into the UK market and in addition loads are now going each week to France. There are also sales to Germany and Spain. The French market, where prices are rather low, is being used mainly to dispose of unsold produce from the 1990 and 1991 harvest. When these surpluses are reduced the concentration will be on the UK and Belgian market where prices are much better. There are good prospects that the 1995 projection of 1,600 tonnes, given in Chapter 6, will be reached and sold at reasonable prices. BIM has mounted an intensive publicity and sales programme in England for Pacific oysters and this programme should be extended to the home market.

Native Oysters: A question mark hangs over the production of native oysters. Bonamia disease has now been detected at a number of sites around the coast but has not yet affected the commercial beds, apart from Cork Harbour. It is feared, however, that it will eventually strike in all areas. In order to protect the clean areas as long as possible, movement under permit should be closely monitored by the Department of the Marine.

Scallops: Of all the shellfish, scallops seem to have the greatest potential. Prices vary depending on quality and size but some recent consignments to France have fetched up to IR£7,000 per tonne. Mulroy Bay is now being built up as a national spat-collecting area and there are substantial sales of young scallops out of this area to Irish growers. Trials are also under way in a number of areas on the on-growing of scallops and the indications are that growth rates are very good. The trials with Japanese scallops being carried out by Letts and Company, Wexford are not yet complete.

Clams: The Manila clam market is now well established in Spain and it is expected that about 400 tonnes will be available for sale in 1992. Through selection, the colour of the manila clam is being changed, and very soon it will resemble in appearance the high-priced native clam. When that happens prices for the Manilas are expected to increase. Up to the present Irish clams have had to be sold to purification stations in Spain at reduced prices. Now that Spain has agreed to accept new EC regulations, a wider choice of markets in that country will be available, leading to better prices.

Lobsters: Lobsters are one of the most valuable shellfish species available, but because of their long growing period artificial rearing in enclosed structures is not an economic proposition. Irish fishermen sell about 300 tonnes of wild lobsters every year at an average price in recent years of about IR£8,000 per tonne. The Irish lobsters are harvested in summer whereas the main demand is in winter and spring (Christmas and Easter) when prices of up to IR£20,000 per tonne are paid on continental markets. To obtain these high prices long-term storage facilities would have to be available. The technology for this storage is well established and it is a matter for private enterprise to adopt it with appropriate national and EC support.

As mentioned in Chapter 2, techniques are now available for producing juvenile lobsters. If these were reared artificially for one year and then released into the sea, lobster stocks would be greatly enhanced and market supplies of wild lobsters increased substantially. Co-operatives to operate lobster ranching schemes based on this idea should be organised by the Development Authorities in coastal areas.

Abalone: This is a high priced shellfish which appears to have a good market on the continent. It is being produced by a few people in the west and south-west seas. We recommend that the experiments be continued to test its economic feasibility.

Sea Weeds: World production of sea weeds for human consumption is about 3.2 million tonnes (FAO, 1990). Practically all of these sea weeds are harvested in Asia. In Ireland some seaweed is harvested in Kerry and Galway. "Kerry Gro" made from algae is a well known plant food. We think that the sea weed industry could be developed further and we suggest that experiments be conducted by the universities to enlarge the range of products which can be made from sea weeds and to test the economics of the operations.

Summary of Recommendations

Aquaculture Generally

(1) EC grants for aquaculture should be integrated with the structural funds so that the industry can benefit from the doubling of the latter.

(2) A licensing system which will facilitate orderly development must be devised. The present system is unworkable.

(3) Marine and coastal resource management policy should be formulated and administered by a group or agency representative of all coastal interests and established under the Department of the Marine.

(4) Environmental mediation fora should be used regularly to resolve disputes between fish farmers and opposing interests. Adversarial and legislative approaches, in which one side "wins" or loses, are counterproductive.

Finfish

(5) The Irish Salmon Growers' Association should continue to lobby for a realistic minimum import price for Atlantic salmon.

(6) The fact that Irish salmon are produced in clear offshore unpolluted waters should be used as a selling point on foreign markets.

(7) The Salmon Quality Assurance Scheme must continue to be properly policed if it is to have the desired impact on price.

(8) The establishment of an Irish-owned salmon smoking establishment in Spain should be investigated by BIM.

(9) The special BIM training courses in grading, hygiene and quality control should be continued and updated from time to time.

(10) There are genuine doubts with regard to certain aspects of finfish cultivation and these must be examined and dealt with in an objective manner.

- (a) Acceptable substitutes for some of the chemicals used must be found.
- (b) Experiments should be continued to discover alternative techniques for the elimination of sea lice on salmon.
- (c) Sea and shore structures should be as unobtrusive as possible.
- (d) Dead fish must be disposed of in proper land fills or through other means such as ensiling and reduction.
- (e) Techniques should be developed for producing triploid fish which may be cultivated safely without fear of damage to wild species.
- (f) Research must be continued to discover the cause or causes of the sea trout collapse. As a precautionary measure, every effort should be made to reduce sea lice numbers, especially during smolt migration. Consideration should be given to such strategies as fallowing and cage movement.

(11) To reduce disease levels in warm summers, Irish salmon farmers should experiment with the lowering of stocking rates in the cages.

(12) Experiments should be continued to test the feasibility of rearing brown trout in the sea to re-stock depleted sea trout fisheries.

(13) Trials should be carried out with other finfish species to determine if they can be economically farmed. These include:- turbot, Arctic char, ornamental fish and eels.

(14) Discussions should take place with industries having hot water discharges in regard to the raising of fish.

Shellfish

(15) Consideration should be given to moving from subsidies on fixed capital to the subsidisation of working capital. These could take the form of interest subsidies or deferred interest payments during the first three years of the growing cycle.

(16) Additional finance to the sector could take the form of an employment grant scheme whereby hitherto unemployed people could continue to draw their unemployment payments for three years while becoming established in the shellfish sector.

(17) There is need for accurate forecasting of shellfish production schedules, both at home and abroad, for marketing purposes.

(18) Naturally producing oyster seed areas around the coast should be protected by the State, under an EC Shellfish Directive.

(19) An adequate network of regionally based onshore or foreshore holding facilities is needed where product can be collected, graded and packed for shipment. These facilities should provide for purification and processing where necessary.

(20) An effective information network, which communicates up-to-date information from the market place to producers, should be maintained.

(21) The provision of a central onshore, cold store sea water tank facility on the European mainland should be investigated.

(22) Attention must be paid to arranging regular supplies, on time deliveries, as well as good grading and packing of shellfish in formulating the new shellfish quality scheme.

(23) There is need for co-operation between mussel and native oyster farmers in different regions in regard to the provision of spat.

(24) The introduction of the new movement order for shellfish should be expedited to protect clear native oyster areas from bonamia disease. Vigilance by people in these areas is essential if the industry is to survive.

(25) Trials on the on-growing of scallops in Ireland should be continued.

(26) Co-operatives in coastal areas should be encouraged to undertake lobster ranching.

(27) The development agencies should ensure that there is a satisfactory advisory service available to the shellfish sector.

(28) Experiments should be conducted in the universities in association with the industry to enlarge the number of products which can be made from seaweed and to test the economics of the operations.

(29) As much aquaculture equipment as possible should be supplied from native sources. Currently, most equipment is imported from

the Continent and the transport involved increases costs significantly.

(30) More mechanisation is required at all stages of production and harvesting in order to increase the efficiency of the industry.

(31) It is critical that all future shellfish development should comply with the recent EC Health and Hygiene Regulations.

REFERENCES

ACKERFORS, H., and M. ENELL, 1990. *Discharge of Nutrient from Swedish Fish Farming to Adjacent Sea Areas,* Ambio: pp. 19, 28-35.

AHLSTROM. D., 1990. "Blaming the Climate for Decline in Sea Trout Numbers", *The Irish Times,* 6 November.

ALABASTER, J. S., 1982. "Survey of Fish-farm Effluents in Some EIFAC countries", in J. S. Alabaster (ed.), Report of the EIFAC Workshop on Fish-farm Effluents, Denmark: Silkeborg, 26-28 May 1981, EIFAC Technical Paper 41.

ALLISON, J. P., 1990. "The Effects of Forestry on the Water Chemistry and Ecology of Poorly Buffered Streams in Connemara", M.Sc. Thesis, Environmental Sciences, Trinity College, Dublin.

ALLOTT, N. A., W. R. P. MILLS, J. R. W. DICK, A. M. EACRETT, M. T. BRENNAN, S. CLANDILLON, W. E. A. PHILLIPS, M. CRITCHLEY and T. E. MULLINS, 1991. "Acidification of Surface Waters in Connemara and South Mayo". Dublin: Trinity College, Environmental Sciences Unit, Natural Resources Development Centre, Department of Geology, Department of Statistics, DuQuesne Ltd. and Environmental Resources Analysis Ltd., 61 pp.

ANON, 1988. *Marine Fishfarming in Scotland: A Discussion paper,* published by the Scottish Wildlife and Countryside Link, Perth, Scotland, March, 70 pp.

AN TAISCE, 1987. *Aquaculture, Amenity and Conservation – A Response by An Taisce to the Environmental Issues and Conflicts Raised by the Development of the Marine and Fresh-water Aquaculture Industry,* Dublin: An Taisce, 17 pp.

AN TAISCE, 1990. *Interactions Between Aquaculture and the Environment.* Edited by Patricia Oliver and Emer Colleran, Papers from a weekend conference in Connemara, Coast Hotel, Furbo, Galway, April.

AQUACULTURE IRELAND, Autumn 1990. Ireland's Fish-farming Journal, Dublin: Irish Farm Centre Bluebell.

- ASHE, DECLAN, "Flat Oysters".
- OTTWAY, MAOILIOSA, "Pacific Oysters".
- WALL, BRIAN, "Mussels, Bottom Culture".
- FITZSIMONS, MAJELLA, "Mussels, Rope Cultured".
- HENSEY, JOHN, "Abalone".
- SLATER, JOHN, "Scallops".

ARAKAWA, K. Y., Y. KUSUKI and M. KAMIGAKI, 1971. "Studies on Biodeposition in Oyster Beds – 1) Economic Density for Oyster Culture", *Venus* 30(3), pp. 113-128.

ARNETT, J., 1987. "Flow Patterns in Tanks", Unpublished M.Sc. thesis, University of Stirling.

BAKKE, H., 1990. "Organic and Inorganic Inputs and Controls in the Marine Environment – the Norwegian Experience", in *Interactions Between Aquaculture and the Environment*, Papers from a weekend conference on Aquaculture and the Environment, organised by An Taisce and the Institute of Biology of Ireland, Furbo, Co. Galway, 15-16 April 1989; edited by Patricia Oliver and Emer Colleran, Dublin: An Taisce, pp. 3-8.

BATES, D., 1991. "Food from Ireland's Waters", *Irish Food Science and Technology Yearbook*, October.

BELPAIRE, CLAUDE, 1990. "Eel Culture in Europe, Past and Present State", *Aquaculture Europe, Journal of the European Aquaculture Society*, Vol. 15, Part 2, Predene, Belgium.

BENNETT, JOHN P., 1990. *A Study of the Intensive Shellfish Culture Industry in Ireland*, MBA Dissertation, Department of Marketing, Faculty of Commerce, University College Galway, September.

BJORNDAL, TROND, 1990. *The Economics of Salmon Aquaculture*, Oxford: Blackwell.

BJORNDAL, TROND and R. SCHWINDT, 1987. "Norwegian Direct Investment in the British Columbian Salmon Aquaculture Industry". A Case Study. Discussion Paper No. 1/1987, Institute of Fisheries Economics, Norwegian School of Economics and Business Administration, Bergin.

BLACK, E. A., 1991. "Coastal Resource Inventories: A Strategy for Aquaculture Development", Paper presented at the International Conference Aquaculture Europe'91, Dublin, 10-12 June, Bredene, Belgium, European Aquaculture Society.

BORD FAILTE, 1991. "The Tourism Industry and Aquaculture Report," Dublin: Bord Failte Eireann, 37 pp.

AN BORD IASCAIGH MHARA, 1986. *The Atlantic Salmon Farming Industry: Performance and Future Potential*, Dublin: BIM, October.

AN BORD IASCAIGH MHARA, 1987. "The Production and Market Situation for Oysters in France".

AN BORD IASCAIGH MHARA, 1988. *Charting a New Course... Development Strategy for the Seafish Industry 1988/'91*, Dublin: BIM, 26 pp.

AN BORD IASCAIGH MHARA, 1991. "*A Strategy for the Development of the Irish Pacific Oyster Industry*, Dublin: BIM, Market Research Series, May.

BOXASPEN, K. and HOLM J. C., 1991. "Effects on environment, fish and farmer of new biocides used against sea lice compared to Nuvan". Paper presented at the International Conference Aquaculture Europe '91, Dublin, 10-12 June, Bredene, Belgium, European Aquaculture Society.

BOWDEN, C., 1981. *Coastal Aquaculture Law and Policy,* Boulder, Colorado: Westview Press.

BROWNE, J., 1990a. "Effect of Fish Farm Escapees on Wild Stocks", in *Interactions Between Aquaculture and the Environment,* Papers from a weekend Conference on Aquaculture and the Environment organised by An Taisce and the Institute of Biology of Ireland, Furbo, Co. Galway, 15-16 April 1989, edited by Patricia Oliver and Emer Colleran, Dublin: An Taisce, pp. 53-55.

BROWNE, J., 1990b. "Effect of Fish Farm Escapees on Wild Stocks", in fish Farming – the Other Side. Proceedings of a Conference organised by Sherkin Island Marine Station, County Cork, 31 March, Sherkin Island Marine Station pp 12-16.

BUCHANAN, J. S., 1990. "The Use of Chemicals in Farming Atlantic Salmon – the Industry Viewpoint", in *Interactions Between Aquaculture and the Environment,* Papers from a weekend Conference on Aquaculture and the Environment organised by An Taisce and the Institute of Biology of Ireland, Furbo, Co. Galway, 15-16 April 1989; edited by Patricia Oliver and Emer Colleran, Dublin: An Taisce, pp. 33-39.

BURR, M. L., *et al.*, 1989. "Effects of Changes in Fat Fish and Fibre Intakes on Death and Myocardial Reinfarctions – Diet and Reinfarction Trials", MRC Epidemiology Unit Cardiff and West Wales Hospital, Carmarthew, *Lancet,* 30 September.

BYRNE, A., 1991. *North-west Connemara: A Baseline Study of Poverty,* Published by the North and West Connemara Rural Project Ltd., Letterfrack, Co. Galway.

CASSIDY, C., 1989. "Fish Farms – Is The Price of Jobs Too High?", *The Sunday Press,* 27 August, p. 11.

CHEVASSUS, BERNARD and ANDRE FAURE, 1989. "Technical Developments in the Culture of Salmonids in France" in *Aquaculture, A Review of Recent Experience,* Paris: OECD, October.

COBHAM RESOURCE CONSULTANTS AND FISHERIES DEVELOPMENT LTD., 1987. An Environmental Assessment of Fish Farms, Final Report to the Countryside Commission for Scotland, the Crown Estate Commissioners, Highlands and Islands Development Board, and The Scottish Salmon Growers' Association, 100 pp.

COLLERAN, E., 1990. Preface to *Interaction Between Aquaculture and the Environment*, Papers from weekend Conference on Aquaculture and the Environment organised by An Taisce and the Institute of Biology of Ireland, Furbo, Co. Galway, 15-16 April 1989, edited by P. Oliver and E. Colleran, Dublin: An Taisce, pp 23-26.

COLLERAN, E., and A. J. O'SULLIVAN, 1990. Comments by An Taisce on the STAG Report, An Taisce, Press Release, 11 February, 4 pp.

COLLINS, T., 1991. "Conflict Resolution as an Environmental Management Strategy", Paper presented to the Conference on Environment and Development in Ireland, University College Dublin, 11 December.

CORDUFF, M., 1991. *Development Strategy for Intensive Shellfish Cultivation*, Udaras na Gaeltachta, Draft Discussion Document.

CROSS, T. F., 1991. "Genetic Interaction of Wild and Reared Fish: A Review," Paper delivered to Aquaculture Europe Conference, Dublin: June 10-12.

CROSS, T. F., G. M. BURNELL, M. C. CROSS, T. C. MORGAN, and M. F. MULCAHY, 1988. "Salmonid Fish Culture in Ireland: Biological and Commercial Considerations", Proceedings of a Joint Meeting of the Hydrobiology Sub-Committee, Royal Irish Academy and the Irish Marine Sciences Association, held at the Department of Zoology, University College Cork, September 1987.

CRUTCHFIELD, J. A., 1989. "Economic Aspects of Salmon Aquaculture", *The North West Environmental Journal*, Vol. 5 pps. 37-55, University of Washington Seattle.

DAIL COMMITTEE ON PUBLIC EXPENDITURE, 1986. "A Report on State Support and Services to the Fishing Industry". Available from the Government Publications Sales Office, Dublin.

DEPARTMENT OF THE MARINE, 1966. *Sea and Inland Fisheries*, Report, Dublin.

DEPARTMENT OF THE MARINE, 1990. *Sea Fisheries Statistics*, 1989, Dublin.

DIXON, I., 1986. "Fish Farm Surveys in Shetland", August 1986. Summary of Survey Results, Vol. 1. A report to NCC, Shetland Islands Council and the Shetland Fish Farmers' Association, Oil Pollution Research Unit, Field Studies Council, Orielton Field Centre, Pembroke, Dyfed.

DOYLE, J., M. PARKER, T. DUNNE, D. BAIRD and J. McARDLE, 1984. "The Impact of Plankton Blooms on Mariculture in Ireland", ICES Special Meeting on the Causes, Dynamics and Effects of Exceptional Marine Blooms and Related Events, Copenhagen, 4-5 October.

DRUDY, P. J. and C. PHELAN, 1982. *The Role of Sea Fishing in the Donegal Region*, Dublin: An Bord Iascaigh Mhara.

DUGGAN, C. B., 1990. "Chemical Usage in Aquaculture", in *Interactions Between Aquaculture and the Environment*, papers from weekend Conference on Aquaculture and the Environment organised by An Taisce and the Institute of Biology of Ireland, Furbo, Co. Galway, 15-16 April 1989, edited by P. Oliver and E. Colleran, Dublin: An Taisce, pp. 23-26.

EARLL, R. C., G. JAMES, C. LUMB and R. PAGETT, 1984. A Report on the Effects of Fish Farming on the Marine Ecology of the Western Isles, A Report to the Nature Conservancy Council, Contract MF3/11/9, Marine Biological Consultants Ltd.

EC, 1986. Council Regulation No. 4028/86. On Community Measures to Improve and Adopt Structures in the Fisheries and Aquaculture Sector, Official Journal of the European Communities No. L 37617, 31/12/86.

EC, 1991(a). Council Directive (EC/91/67) concerning the Animal Health Conditions Governing the Placing on the Market of Aquaculture Animals and Products, Brussels: January.

EC, 1991(b). Council Directive (EC/91/492) Laying Down the Health Conditions for the Production of Fishery Products, Brussels: July.

EC, 1991(c). Council Directive EC/91/493 Laying Down the Conditions for the Production and Placing on the Market of Live Bivalve Molluscs, Brussels: July.

EGIDIUS, E., L. P. HANSEN, B. JONSSON and G. NAEVDAL, 1988. "Mutual Impact of Wild and Cultured Atlantic Salmon in Norway". International Council for the Exploration of the Sea, Mini-symposium on Case Histories of Effects of Introductions and Transfers on Marine Ecosystems.

ENELL, M. and J. LOF, 1983. "Changes in Sediment Phosphorus, Iron and Manganese Dynamics Caused by Cage Fish Farming Impact", in *11th Nordic Symposium on Sediments*, 10-13 March, Finse, Norway, in T. R. Gulbrandsen and Steinar Sanni, (eds.) Norsk Limnologforrning, pp. 80-89.

ERVIK, A., P. JOHANNESSEN and J. AVRE, 1985. Environmental Effects of Marine Norwegian Fish Farms, ICES, Session W.

FAO, 1990. Annual Review of Aquaculture Statistics, FIDI/C 815, Revision 2, Rome.

FAO YEARBOOK OF FISHERY STATISTICS. *Catches and Landings*, Various Issues, Rome.

FAO, 1991. *Aquaculture Production 1986-1989*, Fisheries Circular No. 815, Revision 3, Rome: FAO, Fisheries Department.

FITZSIMONS, M., 1987. "The Production and Marketing Situation for Mussels and Oysters in the UK", Dublin: BIM.

FITZSIMONS, M., 1988. "The Market Situation for Oysters and Mussels in Belgium", Dublin: BIM.

FORSTER, J. R. M., J. P. HARMAN and G. A. SMART, 1977. "Water Economy – Its Effect on Trout Farm Production", *Fish Farming International*, 4(1), pp. 10-13.

FOX, T., 1990. "Improving Farm Efficiency, Cost of Production in Ireland," Paper read to Bradan 90, Furbo, Co. Galway, 13 October.

GALSKJOT, J., 1991. *Managing Fish Farms to Meet Pollution Control Regulations,* Denmark: Langebaek, Aquaculture Management and Development Advisory Services, 24 pp.

GARVEY, S. and BENNETT, J. 1991. "Aquaculture and Rural Development in the West of Ireland", Paper presented at the International Conference Aquaculture Europe '91, Dublin, 10-12 June. Bredene, Belgium, European Aquaculture Society.

GEE, A. S., and J. H. STONER, 1989. "A Review of the Causes and Effects of Acidification of Surface Waters in Wales and Potential Mitigation Techniques", *Arch. Environ. Contam. Toxicol.*, Vol. 18, pp. 121-130.

GLUDE, J., 1979. "An Evaluation of Coastal Aquaculture in Ireland with Recommendations for an Aquaculture Development Strategy", Unpublished report prepared for Bord Iascaigh Mhara, Dublin.

GOWEN, R. J., 1990. "An Assessment of the Impact of Fish Farming on the Water Column and Sediment Ecosystem of Irish Coastal Waters" (including a Review of Current Monitoring Programmes) – A Report prepared for the Department of the Marine, Dublin: Department of the Marine, 75 pp.

GOWEN, R. J. and N. B. BRADBURY, 1984. "The Potential Effects of Salmon Farming on the Marine Environment", Unpublished report, Department of Biological Science, University of Stirling.

GOWEN, R. J., and N. B. BRADBURY, 1987. "The Ecological Impact of Salmonid Farming in Coastal Waters: A Review", *Oceanography and Marine Biology Annual Review,* 25, pp. 563-575.

GOWEN, R. J., J. R. BROWN and D. S. MacLUSKEY, 1988. *Investigations Into Benthic Enrichment, Hypernutrification and Entroplication Associated with Mariculture in Scottish Coastal Waters (1984-88),* Department of Biological Science, The University of Stirling, ISBN 0-901636-80-0.

GRIZEL, HENRY and DENIS BAILLY, 1990. *Multidisciplinary Assessment of Oyster Culture in Carlingford Lough,* Report from Consultancy for BIM and Carlingford Lough Aquaculture Association, Paris: IFREMER, July.

HANSEN, L. P., 1990. "Behaviour of Escaped Farmed Atlantic Salmon and the Impact on Wild Salmon", in *Interactions Between Aquaculture and the Environment,* papers from a weekend Conference on Aquaculture and the Environment organised by An Taisce and the Institute of Biology of Ireland, Furbo, Co. Galway, 15-16 April 1989, edited by P. Oliver and E. Colleran, Dublin: An Taisce, pp. 50-52.

HANSEN, L. P., 1989. "The Co-existence of Wild, Ranched and Farmed Atlantic Salmon: A Challenge to Salmon Management", in *Salmonid Fish Culture in Ireland – Biological and Commercial Considerations,* Proceedings of a Conference held at University College Cork, Ireland, in September 1987.

HERRIOTT, N., 1989. "Report to An Bord Iascaigh Mhara on the viability of pump ashore fish farms in Scotland", Letterfrack, EMA/Mariculture Systems, 34 pp.

HERRIOTT, N., 1990. "Fin-fish Farming and Shellfish – Are they Compatible?", in *Interactions Between Aquaculture and the Environment,* Papers from a weekend Conference on Aquaculture and the Environment organised by An Taisce and the Institute of Biology of Ireland, Furbo, Co. Galway, 15-16 April 1989, edited by Patricia Oliver and Emer Colleran, Dublin: An Taisce, pp. 47-49.

HERRIOTT, N., 1991. "Report to An Bord Iascaigh Mhara on a visit to the Prince Edward Island Shellfish Industry", Canada, May, Letterfrack: EMA/Mariculture Systems.

HESTHAGEN, T., and L. P. HANSEN, 1991. "Estimates of the Annual Loss of Atlantic Salmon, *Salmo salar,* in Norway due to acidification", *Aquaculture and Fisheries Management,* Vol. 22, pp. 85-91.

INGLIS, V., G. N. FRERICHS, S. D. MILLAR and R. H. RICHARDS, 1990. "Antibiotic Resistance Patterns of *Aeromonas salmonicida* Isolated in Scotland", Abstracts of Meeting on Bacterial Diseases of Fish, p. 53, Stirling: Institute of Aquaculture.

INSTITUTE OF AQUACULTURE, 1989. "Fishfarming and the Safeguard of the Natural Marine Environment of Scotland" – A report prepared for the Nature Conservancy Council, Edinburgh: NCC, June 1990, pp. 136.

INSTITUTE OF AQUACULTURE, INSTITUTE OF FRESHWATER ECOLOGY and INSTITUTE OF TERRESTRIAL ECOLOGY, 1990. "Fish Farming and the Scottish Freshwater Environment" – A report prepared for the Nature Conservancy Council, Edinburgh: NCC, June, pp. 285.

IRELAND, JOHN DE COURCY, 1981. *Ireland's Sea Fisheries: A History,* Dublin: The Glendale Press, 184 pp.

IRISH SALMON GROWERS' ASSOCIATION LTD., 1990. *Good Farmers, Good Neighbours – A Code of Practice for Fish Farmers in Ireland,* Dublin: ISGA.

IRISH SALMON GROWERS' ASSOCIATION LTD., 1992. *Preliminary Review of Sea Trout Problems and Research to December 1991,* Dublin: ISGA, 24 pp.

IRISH AQUACULTURE DIRECTORY AND GUIDE 1990/91, published by La Tene Maps Ltd., Pharmacy House, Sandyford, Dublin 18.

IRISH SHELLFISH ASSOCIATION, 1991. *A Development Plan for the Shellfish Aquaculure Industry in Ireland,* Sliogeisc, Co. Galway, November.

JACKSON, D., 1990. "Nuvan Toxicity in the Marine Environment", Paper presented to Irish Society of Toxicology, Athlone, 23 March.

JOYCE, C., 1990. "Fish Farms Blamed as the Sea Trout Vanish", *Business and Finance,* August 16, p. 10.

KAZILIONIS, S. H., 1990. *Salmon in Supermarkets. The United States Perspective,* Paper read to Salmon 90, Norway: Trondheim, May.

KEARY, BRIAN, 1991. *Aquaculture Legislation in Ireland. An Examination and Critique of Section 54 of the Fisheries Act 1980,* Department of Languages and Applied Social Sciences, College of Humanities, University of Limerick.

KEOGH, PAT, 1990. *Global Trends in Production and Markets for Farmed Salmon,* Paper read to 5th Annual Conference and Trade Exhibition Irish Salmon Growers' Association, Connemara, Coast Hotel, Furbo, Galway, October.

KUPKA HANSEN, P., B. T. LUNESTAD and O. B. SAMUELSEN, 1991. Environmental Effects of Antibiotics/chemotherapeutics from Aquaculture, Paper presented at the International Conference Aquaculture Europe '91, Dublin, 10-12 June, Bredene, Belgium, European Aquaculture Society.

LANDILL MILLS ASSOCIATES, 1990. "International Production and Market Situation for Farmed Atlantic Salmon", Consultancy Report BIM, Dun Laoghaire, Dublin, April.

LARSSON, A. M., 1984. *Hydrographical and Chemical Observations in a Coastal Area with Mussel Farming,* Sweden: University of Gothenberg, Department of Oceanography, Report No. 46, 29 pp.

LARSSON, A. M., 1985. "Blue Mussel Sea Farming – Effects on Water Quality", Vatten, 41, pp. 218-224.

LAURETI, E., 1991. *Fish and Fishery Products, World Apparent Consumption Statistics based on Food Balance Sheets,* 1961-1989, Fishery Information Data and Statistics Service, Rome: FAO.

LEGARRETA, P., 1990. "Salmon and Trout from Chile", Paper read to the World Salmon Marketing Conference, Salmon 90, Norway: Trondheim, May.

LIAO, P. B., and R. D. MAYO, 1972. "Salmonid Hatchery Water Re-Use Systems", *Aquaculture,* 1, pp. 317-335.

MAITLAND, P. S., 1989. *The Genetic Impact of Farmed Atlantic Salmon on Wild Populations,* Edinburgh: Nature Conservancy Council, 35 pp.

MATHIESEN, A. M., 1989. "Fish Health Control Systems in Iceland", in *Salmonid Fish Culture in Ireland – Biological and Commercial Considerations,* Proceedings of a Conference held at University College Cork, Ireland, September 1987, pp. 98-104.

MARCHINGTON, J., 1991. "Sea Trout Scare", *Shooting Times and Country Magazine,* June 13-1-19

McARDLE, J., 1989. "Disease Problems of Aquaculture in Ireland: Their Prevention and Treatment", in *Salmonid Fish Culture in Ireland – Biological and Commercial Considerations,* proceedings of a Conference held at University College Cork, Ireland, in September 1987, pp. 20-39.

McARDLE, J., 1991. "Disease in Wild and Farmed Fish and Their Interaction", Paper presented at a workshop organised by the Irish Salmon Growers' Association and Bord Failte Eireann, University College Galway, 5 February.

McPADDEN, C., 1990. *The European Market for Clams and the Potential for Irish Clam Aquaculture,* BIM, Crofton Road, Dun Laoghaire, June.

McVICAR, A. H., 1987. "Pancreas Disease of Farmed Atlantic Salmon. *Salmo Salar* in Scotland: Epidemiology and Early Pathology", in *Aquaculture, A Review of Recent Experience,* Paris: OECD, 1989, p. 73.

MERCER, J. P., 1991. New Possibilities for Community-based Aquaculture, Shellfish Laboratory, Carna, Co. Galway, Lecture to Community Groups, April.

MILLS, C. P. R., and D. J. PIGGINS, 1989. "The Contribution of Ranched Salmon to a Recreational Fishery", in *Salmonid Fish Culture in Ireland – Biological and Commercial Considerations,* Proceedings of a Conference held at University College Cork, Ireland, September 1987, pp. 77-86.

MORGAN, M., 1991. "Decline of the Sewin", *Salmon and Trout Magazine,* February, p. 19.

MULLER-FUEGA, A., J. PETIT and J. J. SABAUT, 1978. "The Importance of Temperature and Wet Weight on the Oxygen Demand of Rainbow Trout *(Salmo gairdneri)* in Fresh Water", *Aquaculture,* 14, pp. 355-363.

MURPHY, M., 1991. "STAG Stuck in a Rut", *Sherkin Comment,* Issue No. 7, pp. 8-9, Sherkin Island Marine Station.

NASCO, 1990. Report of the Norwegian Meeting on Impacts of Aquaculture on Wild Stocks, 23-26 April, Edinburgh, North Atlantic Salmon Conservation Organization, Paper CNL(90)28, 9 pp.

NATURE CONSERVANCY COUNCIL, 1989a. "Fishfarming and the Safeguard of the Natural Environment of Scotland", Edinburgh: NCC, 136 pp.

NATURE CONSERVANCY COUNCIL, 1989b. "The Genetic Impact of Farmed Atlantic Salmon on Wild Populations" – Based on a Report Prepared for the NCC by Dr P. S. Maitland, Fish Conservation Centre, Stirling. Edinburgh: NCC, 35 pp.

NATIONAL BOARD FOR SCIENCE AND TECHNOLOGY, 1982. *Science and Technology for Aquaculture Development,* Dublin: NBST.

NATIONAL COASTLINE STUDY, 1972. Dublin: an Foras Forbartha (3 vols).

NEEDHAM, T., 1990. "The Production Scene – Atlantic Salmon", Paper read to The World Salmon Marketing Conference, Salmon 90, Norway: Trondheim, May.

NIELSEN, LARS, 1989. "Ranching of Eels in Danish Seawater and Freshwater", *Aquaculture, A Review of Recent Experience,* Paris: OECD, October.

NORMAN, M., 1990. "Fin-fish Farming and Shellfish – Are They Compatible?", in *Interactions Between Aquaculture and the Environment,* Papers from a Weekend Conference on Aquaculture and the Environment organised by An Taisce and the Institute of Biology of Ireland, Furbo, Co. Galway, 15-16 April 1989; edited by Patricia Oliver and Emer Colleran, Dublin: An Taisce, pp. 47-49.

NORWEGIAN FISH FARMERS ASSOCIATION, 1990. *The Norwegian Fish Farming Industry in Harmony with the Environment,* Trondheim/Tromso, January, 18 pp.

O'BRIEN, D. P., 1989. "Salmonid Farming in Ireland: Environmental and Legislative Problems Assessed", Earthwatch Special Report No. 4, Earthwatch, Bantry, Co. Cork, 24 pp.

O'CONNOR, R., 1990a. *The Irish Sea Fishing Industry,* Dublin: The Economic and Social Research Institute, Policy Research Series, Paper No. 11, 61 pp.

O'CONNOR, R., 1990b. Country Reports, Ireland, Salmon Market Newsletter, International Institute of Fisheries, Economics and Trade, Oregon State University, Corvallis, March.

O'CONNOR, R., 1990c. "The Irish Sea Fishing Industry", *The Irish Banking Review,* Spring, pp. 11-20.

O'CONNOR, R., J. A. CRUTCHFIELD, B. J. WHELAN and K. E. MELLON, 1980. *Development of the Irish Sea Fishing Industry and Its Regional Implications,* Dublin: The Economic and Social Research Institute, Paper No. 100, 383 pp.

O'CONNOR, R., and J. DEVEREUX, 1982. "Aquaculture; Its Prospects for the 1980s", The Economic and Social Research Institute, Memo. No. 150, April.

O'CONNOR, R and B. J. WHELAN, 1988. "Aquaculture in the Gaeltacht – Its Economic and Social Impact", A Report prepared by The Economic and Social Research Institute for Udaras na Gaeltachta, April, 130 pp.

OECD, 1989. Aquaculture, Developing a New Industry, Paris.

O'HANLON, R. J., 1988. High Court Judgement delivered, 21 December 1988. In the matter of the Fisheries Acts 1959 to 1980 and in the Matter of an Order made pursuant to the Fisheries Act 1980, Section 54, and in the Matter of an Appeal against the Making of the said Order; between Laurence Courtney and others, (appellants) and the Minister for the Marine (Respondent).

O'HARA, FRANK, 1990. *European Supermarket View – Salmon,* Paper read to Salmon 90, Norway: Trondheim, May.

OLIVER, P. and E. COLLERAN, 1990. *Interactions Between Aquaculture and the Environment,* Proceedings of a Conference on Aquaculture and the Environment, organised by An Taisce and the Institute of Biology of Ireland, Furbo, Co. Galway, 15-16 April 1989, Dublin: An Taisce, 75 pp.

O'SULLIVAN, A. J., 1984. *Mussel Bound – the Proceedings of An International Shellfish Seminar,* Bantry, 6-7 March, Dublin: Environmental Management Services.

O'SULLIVAN, A. J., 1985. "A Report to the Dail Committee on Public Expenditure on State Support and Services to the Fishing Industry", Dublin: Environmental Management Services, November 1985.

O'SULLIVAN, A. J., 1987. "Surrounded by Opportunity", *Technology Ireland,* Vol. 19, No. 5, September 1987, pp. 55-57.

O'SULLIVAN, A. J., 1989. "Environmental Impact Assessment – Planning a Better Environment?" *Local Authority News,* Winter 1989/90, pp 4-7. Dublin: Institute of Public Administration.

O'SULLIVAN, A. J., 1990a. "Aquaculture and the Management of Our Aquatic Resources: The Need for Integrated Policies and Planning", in *Interactions Between Aquaculture and the Environment,* Papers from a Weekend Conference on Aquaculture and the Environment organised by An Taisce and the Institute of Biology of Ireland, Furbo, Co. Galway, 15-16 April 1989, edited by Patricia Oliver and Emer Colleran, Dublin: An Taisce.

O'SULLIVAN, A. J., 1990b. "Salmon Farming – An Environmental View", Paper presented at Irish Salmon Growers' Association Ltd. Annual Conference, Furbo, Co. Galway, 12-13 October, p. 8.

O'SULLIVAN, A. J., 1991a. "Coastal Community Resource Management: A Framework for Analysis and Conflict Resolution". Paper presented at a workshop organised by the Irish Salmon Growers' Association and Bord Failte Eireann, University College Galway, 5 February.

O'SULLIVAN, A. J., 1991b. "Aquaculture and User Conflicts". Paper presented at the International Conference Aquaculture Europe '91, Dublin, 10-12 June, Bredene, Belgium, European Aquaculture Society.

O'SULLIVAN, G., 1987. "The Production and Market Situation for Mussels in the Netherlands, Denmark and West Germany".

O'SULLIVAN, G., 1987. "The Production and Marketing Situation for Oysters in the Netherlands and West Germany".

O'SULLIVAN, K., 1991. "Row flares over blaming of sea trout decimation on farm lice", *Connacht Tribune*, 8 February.

O'SULLIVAN, R. D., 1989. *Intensive Fin Fish Farming in Ireland – A Cause for Concern*, Published by the Author, 76 pages.

OWENS, S., 1982. "The Response of the Legal System to Technological Innovation in Aquaculture: A Comparative Study of Mariculture Legislation in California, Florida and Maine", *Coastal Zone Management Journal*, Vol. 4, No. 3, pps. 269-297. Quoted in Keary, op. cit., p. 39.

PARAMETRIX INC., 1990. Final Programmatic Environmental Impact Statement: Fish Culture in Floating Net Pens. Prepared for Washington State Department of Fisheries, Olympia, WA, USA. Published by Washington Department of Fisheries, January, 161 pp.

PARTRIDGE, K., N. HERRIOTT and V. ROANTREE, 1982. "Survey of Mariculture Activities and Potential around the Irish Coast". National Board for Science and Technology: *Aquaculture Technical Bulletin*, No. 7, 1982.

PAULSEN, H., 1989. "Current Status of Turbot Culture in Aquaculture: a Review of Recent Experiences", Paris: OECD.

PEARSON, T. H., and R. J. GOWEN, 1990. "The Impact of Caged Fish Farming on the Marine Environment – the Scottish Experience", in *Interactions between Aquaculture and the Environment*. Papers from a weekend Conference on Aquaculture and the Environment organised by An Taisce and the Institute of Biology of Ireland, Furbo, Co. Galway, 15-16 April 1989, edited by Patricia Oliver and Emer Colleran, Dublin: An Taisce, pp. 9-13.

PEASE, B. C., 1977. "The effect of organic enrichment from a salmon mariculture facility on the water quality and benthic community of Henderson Inlet, Washington". Ph.D. Dissertation, Seattle: University of Washington.

PENCZAK, T., W. GALICKA, M. MOLINSKI, E. KUSTO and M. ZALEWSKI, 1982. "The Enrichment of a Mesotrophic Lake by Carbon, Phosporus and Nitrogen from the Cage Aquaculture of Rainbow Trout *Salmo gairdneri*", *Journal of Applied Ecology*, 16, pp. 371-393.

PHILLIPS, M. J., 1985. "The Environmental Impact of Cage Culture on Scottish Freshwater Lochs". Final Report to the Highlands and Islands Development Board. Institute of Aquaculture, University of Stirling.

PHILLIPS,M. J., 1990. "Organic and Inorganic Inputs in Freshwater Environments", in *Interactions between Aquaculture and the Environment*. Papers from a Weekend Conference on Aquaculture and the Environment organised by An Taisce and the Institute of Biology of Ireland, Furbo, Co. Galway, 15-16 April 1989, edited by Patricia Oliver and Emer Colleran, Dublin: An Taisce, pp. 14-18.

REITE, O. B., and M. STAURNES, 1987. "Acidified Water: Effects on Physiological Mechanisms in the Gills of Salmonids". Paper presented at the Mid-term Review Conference, Surface Water Acidification Programme, Norway: Bergen. 22-26 June.

RENSEL, J. E., R. A. HORNER and J. R. POSTEL, 1989. "Effects of Phytoplankton Blooms on Salmon Aquaculture in Puget Sound, Washingon: Initial Research", *The Northwest Environment Journal*, 5, pp. 53-69.

REYNOLDS, S. L., 1983. "The Ecological Impact of Marine Fish Farming on Primary Production in a Scottish Sea Loch", unpublished B.Sc. thesis, University of Stirling.

RODHOUSE, P. G., C. M. RODEN, M. P. HENSEY and T. H. RYAN, 1985. "Production of Mussels, *Mytilus edulis*, in Suspended Culture, and Estimates of Carbon and Nitrogen Flow, Killary Harbour, Ireland", *Journal of the Marine Biological Association of the UK.*, 65, pp. 55-68.

ROSENBERG, R., and L. O. LOO, 1983. "Energy Flow in a *Mytilus edulis* Culture in Western Sweden", *Aquaculture*, 35, pp. 151-161.

ROSENTHAL, H., 1985. "Recent Observations on Environmental Effects of Large-scale Net Cage Culture in Japanese Coastal Waters", ICES, C.M. 1985/F:34.

ROSENTHAL, H., D. WESTON, R. GOWEN, and E. BLACK, 1987. Report of the ad hoc Study Group on "Environmental Impact of Mariculture", ICES Statutory Meeting, C.M. 1987/F:2, Mariculture Committee, Ref: Marine Environmental Quality Committee.

ROSS, A., 1988. Controlling nature's predators on fish farms, *Marine Conservation Society*.

ROSS, A., 1990. "UK Usage of Pesticides – Controls and Lessons to be Learned", in *Interactions Between Aquaculture and the Environment.* Papers from a Weekend Conference on Aquaculture and the Environment organised by An Taisce and the Institute of Biology of Ireland, Furbo, Co. Galway, 15-16 April 1989, edited by Patricia Oliver and Emer Colleran, Dublin: An Taisce, pp. 40-43.

ROSS, A., and P. V. HORSMAN, 1988. *The Use of Nuvan 500 EC in the Salmon Farming Industry,* Published by the Marine Conservation Society, Ross-on-Wye, Herts., England.

RUDDY, M., and T. VARLEY, 1989. "Sea Farming and Local Development in North Connemara", University College Galway, Centre for Community Development Studies, Social Sciences Research Centre, Occasional Paper, 35 pp.

RUTTLEDGE, R. F., 1980. *A List of the Birds of Ireland,* Dublin: Stationery Office, 146 pp.

SALMON REVIEW GROUP, 1987. *Report of the Salmon Review Group: Framework for the Development of Ireland's Salmon Fishery,* Dublin: Government Publications Sales Office, 103 pp.

SARGEANT, K., 1990. "Tourism and Aquaculture", in *Interactions between Aquaculture and the Environment.* Papers from a Weekend Conference on Aquaculture and the Environment organised by An Taisce and the Institute of Biology of Ireland, Furbo, Co. Galway, 15-16 April 1989, edited by Patricia Oliver and Emer Colleran, Dublin: An Taisce, pp. 60-63.

SCOTTISH WILDLIFE AND COUNTRYSIDE LINK, 1988. "Marine Fishfarming in Scotland" – A Discussion Paper, Perth: Scottish Wildlife and Countryside Link, 70 pp.

SCOTTISH WILDLIFE AND COUNTRYSIDE LINK, 1990. "Marine Fishfarming in Scotland" – A Review, Perth: Scottish Wildlife and Countryside Link, 27 pp.

SEA FOOD TRENDS, Newsletter, 21 January 1991, p. 213.

SECTORAL CONSULTATIVE COMMITTEE, 1984. "The Development of the Fishing Industry": A Report to the Sectoral Development Committee. Available from the Government Publications Sales Office.

SECTORAL DEVELOPMENT COMMITTEE, 1984. "Report and Recommendations on the Sea-fishing and Aquaculture Industry", SDC Report No. 3. Available from the Government Publications Sales Office.

SERRA, J. ALMEIDA, 1991. Foreword to "Aquaculture in the European Community", Directorate General for Fisheries, Commission of the European Communities, Brussels.

SHAW, SUSAN, 1990. "The Drive to Complete the European Internal Market – The Impact for Salmon", Salmon 90 Conference, Norway: Trondheim, May.

SIGGINS, L., 1989. "Battle Over Troubled Waters", *The Irish Times,* 3 June, Weekend Supplement, p. 1.

SIGGINS, L., 1991. "Report Likely to Blame Fish Farming for Trout Crisis", *The Irish Times,* 26 January; "Dispute Over Causes of the Decline of Sea Trout", *The Irish Times,* 5 February; "Report urges radical curbs on salmon farming", *The Irish Times,* 5 February.

SMITH, P., 1990. "Disease Control in Fish Farming", in *Interactions between Aquaculture and the Environment,* Papers from a Week-end Conference on Aquaculture and the Environment organised by An Taisce and the Institute of Biology of Ireland, Furbo, Co. Galway, 15-16 April 1989; edited by Patricia Oliver and Emer Colleran; Dublin, An Taisce, pp 27-32.

SMITH, P., 1991. "Antibiotics and alternatives". Abstract of paper presented at the International Conference Aquaculture Europe '91, Dublin, 10-12 June 1991, Bredene, Belgium, European Aquaculture Society.

SOLBE, J. F. de L. G., 1982. "Fish Farm Effluents: A United Kingdom Survey", EIFAC Technical Paper 41, pp. 29-56.

SRAI, 1990. "Declining Sea Trout Stocks in the Galway/South Mayo Region – A Scientific Appraisal", Salmon Research Trust of Ireland, unpublished report.

STAG, 1991. "Report of an investigation into the 1989/90 collapse of sea trout stocks in Galway and South Mayo". Galway, the Sea Trout Action Group, January 1991, 24 pp.

STAG, 1992. "Sea Trout News", No. 3 (1991 Report). Galway: The Sea Trout Action Group, February, 24 pp.

STEWART, K. I., 1984. "A Study on the Environmental Impact of Fish Cage Culture in an Enclosed Sea Loch", M.Sc. thesis, University of Stirling.

SUMARI, O., 1982. "A Report on Fish Farm Effluents in Finland, EIFAC. Technical Paper 41, pp. 21-27.

SUSSKIND, L., and McCREARY, S., 1985. "Techniques for Resolving Coastal Resource Management Disputes Through Negotiation", *Journal of the American Planning Association,* Summer 1985, pp. 365-374.

THORPE, J. E., and Mitchell, K. A., 1981. "Stocks of Atlantic salmon *Salmo salar* in Britain and Ireland – Discreteness and Current Management." *Canadian Journal of Fisheries and Aquatic Sciences.* Vol. 38, No. 12 pp. 1576-1590.

TIERNEY, C., 1991. "Future of West Coast Sea Trout in Jeopardy Warns New Report", *Connacht Tribune,* 8 February, p. 24.

TSUTSUMI, H., and T. KIKUCHI, 1983. Publ. Arnakusa Marine Biology Laboratory, Kyushi University, 7, pp. 17-40.

UKAWRG, 1988. *United Kingdom Acid Waters Review Group: Second Report to the Department of the Environment,* London: HMSO.

WARRER-HANSEN, I., 1982. "Evaluation of Matter Discharged from Trout Farming in Denmark", in J. S. Alabaster (ed.), Report of the EIFAC Workshop on Fish Farm Effluents, Denmark: Silkeborg, 26-28 May, EIFAC Technical Paper 41, pp. 57-63.

WARRER-HANSEN, I., 1990. "Production and Control of Wastes in Freshwater Fish Farming". in *Interactions between Aquaculture and the Environment.* Papers from a Week-end Conference on Aquaculture and the Environment organised by An Taisce and the Institute of Biology of Ireland, Furbo, Co. Galway, 15-16 April 1989; edited by Patricia Oliver and Emer Colleran, Dublin; An Taisce, pp 19-22.

WARRER-HANSEN, I., 1991. "Contribution to the Working Group on the Environmental Impact of Freshwater Aquaculture", manuscript, unpublished.

WESTERN REGIONAL FISHERIES BOARD, 1990. "The Acidification of Connemara Fisheries and Implications for Afforestation", Galway: WRFB, Earl's Island.

WESTON, D. P., 1986. "The Environmental Effects of Floating Mariculture in Puget Sound". Prepared by the University of Washingon, School of Oceanography, for the Washington State Departments of Fisheries and Ecology, 148 pp.

WESTON, D. P., and R. J. GOWEN, 1988. "Assessment and Prediction of the Effects of Salmon Net Pen Culture on the Benthic Environment". Unpublished report to Washington Department of Fisheries, Washington: Olympia.

WHELAN, B. J. and R. O'CONNOR (1991). "The Profitability of Salmon Farming in Ireland in 1990". Paper to the Irish Salmon Growers' Association Conference, Clifden, November 1991.

WHILDE, T., 1990. "Sharing the Environment with the Original Inhabitants – Some Thoughts on Aquaculture and Wildlife", in *Interactions between Aquaculture and the Environment.* Papers from a Weekend Conference on Aquaculture and the Environment organised by An Taisce and the Institute of Biology of Ireland, Furbo, Co. Galway, 15-16 April 1989, edited by Patricia Oliver and Emer Colleran, Dublin: An Taisce, pp.56-59.

WILDESMITH, B. H., 1982. *Aquaculture: The Legal Framework,* Toronto: Edmond Montgomery Ltd.

WILKINS, N. P., 1989. *Ponds, Passes and Parcs: Aquaculture in Victorian Ireland,* Dublin: Glendale Press.

APPENDIX A

AQUACULTURE, EDUCATION AND TRAINING COURSES

BIM offers a practical 25-week course in fish farming, leading to a BIM Certificate. The course is given in Greencastle, Co. Donegal. Fees and maintenance are paid by BIM. Most of those who have successfully completed the course to date are employed in fish farming. BIM also offers special short courses in various aspects of aquaculture in its headquarters in Dun Laoghaire.

Tralee and Letterkenny Regional Technical Colleges offer one year courses leading to the certificate in Aquaculture Technology. Students (intake of 25-30 per annum per college) under 25 years old are supported by European Social Fund (ESF) Grants. Successful graduates can go into employment or go on to further studies for NCEA awards.

UCG offers a variety of postgraduate courses based at its aquaculture facilities in the Shellfish Research Laboratory in Carna, Co. Galway.

Thesis: Ph.D. and M.Sc. duration of approximately 3 years and 2.5 years respectively. Entry requirement: at least a second class honours degree.

Courses: Higher Diploma in Applied Science (Aquaculture). Entry: B.Sc., general duration 12 months. M.Sc. (Aquaculture). Entry requirement: B.Sc. Honours. Duration 20 months.

Galway RTC offers two relevant courses. The first is a two-year certificate course in aquaculture. Students under 25 years of age on this course are eligible for an ESF grant for fees and maintenance. Successful graduates of the two Year Certificate Course can continue on to a one year diploma in Applied Aquatic Science. This course can also be taken by students with a B.Sc. general degree.

Two post graduate courses in aquaculture are offered by UCC. These are a one year diploma in Applied Science (Aquaculture) and an 18 months M.Sc. in Aquaculture. Students on these courses have fees paid by the ESF.

A special short course in salmon handling and packing funded by BIM is offered, on occasions, by Sligo RTC. This course is designed for people employed or wishing to be employed in the handling and marketing of fish. Details of the entry requirements for all these courses are given in the 1990/91 Irish Aquaculture Directory and Guide (see List of References).

APPENDIX B

LICENCE REQUIREMENTS FOR AQUACULTURE

The Department of the Marine (DOM) is the sole regulatory authority for *Marine* fish farming. For land-based, or fresh water fish farming the regulatory responsibility is shared between the relevant local authority and the Department of the Marine.

Sea Sites

A marine fish farm is required to be licensed by the DOM under two mechanisms:

(i) A foreshore licence under the Foreshore Act 1933, which gives permission to use and occupy a particular area of the State foreshore (which for the purpose of the Act extends to the limit of the territorial sea – 12 miles).

(ii) An aquaculture or a fish culture licence issued under the terms of the Fisheries Acts: these licences regulate fish husbandry on the site leased under the Foreshore Act.

Aquaculture licences are issued under Section 54 of the Fisheries Act 1980. This Act introduced the concept of designation of coastal areas for aquaculture by Ministerial Order. Aquaculture licences may be issued within the designated areas. Fish Culture licences may be issued in respect of areas other than those designated under Section 54. The latter are issued under the Fisheries (Consolidated) Act 1959. Both aquaculture and fish culture licences provide, as indicated above, for the regulation of fish husbandry.

Various levels of public notification apply in relation to the proceedings of applications.

- In relation to designation, a public enquiry has usually to be held.
- In relation to all individual applications for licences, notification is required under the provisions of the Foreshore Act 1933. Subsection 2(8) of this Act says that whenever an application is made to the Minister for a lease under this section, the Minister may, if he thinks fit, hold a public enquiry in regard to the making of such lease.
- In relation to salmon farms with production in excess of 100 tonnes per annum, the provisions of the EC Environmental Impact Assessment Directive apply (see later).

For the purposes of licensing aquaculture projects the Foreshore Act and the Fisheries Acts are operated as a single unit by the Minister for the Marine. The Foreshore Licence in effect assigns the use of a block of the sea to the licensee and gives him/her property rights to any structures erected in the specified area and to the fish therein.

Land-based Sites

In relation to land-based fish farming sites, local authorities are responsible in the normal way under the Planning and Water Pollution Acts. This means that planning permission and an effluent discharge licence are required. The Department of the Marine licenses fish husbandry at these sites using the mechanism of a fish culture licence granted under the 1959 Act. To the extent that a land-based site uses pumped sea water or discharges into the sea, a licence under the Foreshore Act will also be necessary to allow the laying of pipes across the State foreshore. It should be mentioned in this connection that there is now a ministerial decision not to licence smolt production in inland lakes. In addition, in the case of smolt production, an Environmental Impact Statement (EIS) is required under specific circumstances.

Thus, for land-based sites four or five licences or permits may be required:

(1) Planning permission from Local Authority (LA).
(2) Effluent discharge licence from LA.
(3) A fish culture licence from the DOM.
(4) A Foreshore Licence from the DOM.
(5) Possibly an Environmental Impact Statement (EIS).

Persons wishing to apply for any of the above licences should apply for further details to the Department of the Marine. The process is very involved and the exact specifications must be complied with before the application will be considered. To understand the difficulties it is necessary to know something about the Acts under which licences are granted. These are discussed below together with an evaluation of their content.

The Fisheries (Consolidation) Act 1959

Section 15 of this Act deals with Fish Culture licences. In the past these were generally interpreted to cover finfish since shellfish are dealt with by specific proposals in other sections. Sections 245 to 255 deal with oyster bed licences. Sections 256 to 269 deal with oyster fishery orders while Sections 281 to 282 extend the provisions of the oyster bed licences and orders to the cultivation of mussels and other molluscs. Nowadays some shellfish farms operate under fish culture licences (see below).

Fish Culture Licence

Subsection 15(1) says that the Minister may, as he thinks fit by licence (in this section referred to as fish culture licence), authorise, subject to such conditions as he thinks fit and specifies in the licence, a named person to carry on at a specified place such operations in relation to the culture of fish of a specified kind as may be specified by the licence. Section 15 has four other short subsections. These specify the conditions under which the Minister may amend or revoke a licence.

It is clear from the wording that Subsection 15(1) confers great powers on the Minister. There are no provisions for a local inquiry, nor for objections to be heard or taken into account. The wide powers granted to the Minister can be understood in the context of the time. In 1959 finfish aquaculture was a fresh water operation conducted mainly on private property and not in the sea where there are common property rights. Applications for finfish licences would generally specify that the structures to be erected would be on private property. Ownership of the stocks, trespass and other such matters would therefore be covered by ordinary property law and there was no need to take cognizance of these matters in the Act. However, as finfish farming developed in the 1970s licences for marine sites were granted under this Act in conjunction with the 1933 Foreshore Act. The conditions for granting a Foreshore Licence gave the public an opportunity to make representations about the siting of the fish cages and about the possible infringements of their rights to fish or carry out other activities in the area.

Oyster Bed Licences and Orders

Because these licences were to be granted for sea sites recognition had to be taken of the common property rights involved. In accordance with these rights the Act specified that, where an application was made to the Minister for an oyster bed licence or order a public inquiry had to be held, at which representation from interested parties would be heard. The Minister could make no decision on the application until he had considered the report of this inquiry. If a licence was granted notices of it had to be published in a local newspaper and any person aggrieved could appeal against it in the high court within a period of 28 days from date of publication. The decision of the High Court on the appeal was final (Section 11.1(d)).

Provision was made in the Act to protect the personal property rights of the licensees and grantees. The Act states that if a licence or order is granted, any person wilfully trespassing on such a fishery or taking away any oysters, shall be guilty of an offence and shall be liable to a fine on summary conviction.

The Act also states that oyster bed licences are transferrable to the licensees' heirs, executors and assignees but may be revoked by the Minister if he is not satisfied that the shellfish grounds are being properly cultivated. The Act does not state that Oyster Fishery Orders (which were granted to corporate bodies) are transferable, but it does state that they may be revoked if the Minister deems it appropriate.

The Fisheries Act 1980

The primary purpose of this Act was to establish the Fisheries Boards and to define their powers and functions. It also provided for a number of other fishing matters including a long section on aquaculture. In this section, an attempt was made to simplify the licensing procedure. Under the 1959 Act, separate applications had to be made for each foreshore/fish culture licence, oyster bed licence or oyster bed order and this nearly always involved public hearings for each application – a most time-consuming process. The 1980 Act introduced the concept of designation under which an area of the sea may be designated as an area in which aquaculture may take place (subject to licence) at a single hearing. Once the area was designated, aquaculture licences could be granted within it without further public hearings.

Aquaculture is dealt with in Section 54 of the 1980 Act which has 18 subsections. A summary of the more relevant of these subsections is given below.

Subsection (1) states that it shall be unlawful for any person to engage in aquaculture without

(1) a fish culture licence,
(2) an oyster bed licence,
(3) a licence granted by the Minister under this Section, or
(4) an oyster fishery order.

Subsection (2) says that the Minister may designate an area within which it will be lawful to engage in aquaculture in accordance with a licence granted by the Minister.

Subsection (3) says that whenever the Minister intends to make an order under this section he shall publish in at least one daily newspaper published in the State, the nature of the intended order and saying that representations and objections may be made in writing within three weeks. It states also that copies of the plan of the intended area and other documents relating thereto will be made available for inspection at a named local place.

Subsection (4) states that having regard to the representations made the Minister may hold a public inquiry where people are entitled to appear and be heard either in person or through legal representatives.

Having held the inquiry and received a report, the Minister under Subsection (5) may designate the area in the form originally proposed or modified as, in the circumstances of the case, he considers appropriate.

Any person who is aggrieved by the making of this order may within a period of 28 days of publication of the order appeal to the High Court against the order and the decision of the High Court shall be final (Subsection (7)).

Once an area has been designated the Minister under subsection 9(a) may grant aquaculture licences within it subject to such conditions as he thinks fit. The Minister may specify on an aquaculture licence the boundaries or limits of the place or waters in relation to where the licence is granted.

Subsection 10(c) says that an aquaculture licence shall not be construed as taking away or abridging any right on to or over any portion of the sea shore, which right is enjoyed by any person under any local or special act, charter, etc. Subsection 10(h) says that the Minister may not after the commencement of this section either grant an oyster bed (1959 Act) licence or make an oyster fishery (1959 Act) order. Shellfish, like finfish, would require an Aquaculture Licence.

Under Subsection (15), a person who before the passing of the 1980 Act was engaged in aquaculture may apply to the Minister for a licence and the Minister shall, if he is satisfied that the person was lawfully so engaged, authorise the person to carry on at the place in which the aquaculture was heretofore carried on subject to such conditions as the Minister considers appropriate. The Act does not state that the person granted an aquaculture licence under this subsection need be carrying on aquaculture within a designated area.

The final Subsection (17) states that if a person by trespass or fishing interferes with anything done pursuant to the aquaculture licence, notwithstanding the existence of any public right to fish, the person so interfering shall be guilty of an offence and, shall be liable to fine on summary conviction.

Environmental Impact Statement (EIS) Requirements for Marine Salmonid Farms

The EC's Environmental Directive (EC 85/337) was passed into Irish law by way of the European Communities (Environmental Impact Assessment) Regulation 1989 (S.I. 349/1989). S.I.s 40 and 41/1990 gave effect to this in fisheries law and S.I. 220/1990 refers to the foreshore aspects of an EIS. Earlier Ministerial Regulations were found in the Courts to be binding only in the public domain. An Environmental Impact Statement must be submitted to the Department of the Marine with applications for marine salmonid farms where proposed yearly output exceeds 100 tonnes.

1. The description of the physical characteristics of the project should include the location, number and type of cages, as well as details of moorings and any other floating structures proposed. Associated land based facilities (including facilities for disposal of dead fish) should be described. Transport requirements (land and sea) to and from the site should be detailed and related to existing infrastructural facilities such as roads and piers. Requirements, if any, for additional infrastructural facilities should be specified.
2. The description of the production processes should include quantity of fish to be harvested annually. Quantity and type of food to be used should also be specified.
3. The estimate of type and quantity of expected residues and emissions should include details of fish farm effluent characteristics. All chemicals and antibiotics intended for use in stock treatments should also be listed.
4. The description of those aspects of the environment likely to be significantly affected by the project should include the following:
   (i) Sediment Study including type, depth and redox potential;
   (ii) A baseline Survey of Water Characteristics:

   Physical: temperature
   salinity profiles
   water transparency – secchi disc

   Chemical: Oxygen tension
   Ph
   Ammonia (total)
   Nitrate
   Total N
   Total P
   Silicate

   Biological: Phytoplankton
   Chlorophyll
   Zooplankton
   Benthic fauna

   (N.B. Selection of control sites/monitoring stations is extremely important in order to follow natural fluctuations, seasonal cycles, etc.)

   (iii) Details of shellfish beds and fisheries in the area;

(iv) Commercial activity in the area (sea and environs);
(v) Recreational activities (including water sports, boating; angling; bathing);
(vi) Salmon and sea trout rivers in the area (including distance in kilometres from proposed fish farm).

5. The likely significant effects of the project on all other beneficial users of the sea and environs (including scenic aspects) should be detailed.
6. The description of the likely effects of the project on the environment resulting from the emission of pollutants and elimination of waste should give details of the potential effects of the fish farm effluents and chemicals on the water body as a whole; the sea bed; and other fish/shellfish life in the area. This section should therefore include the conclusions derived from a *Depth Survey* and a *Hydrodynamic Investigation,* both of which should be included as appendices.

The *Hydrodynamic Investigation* should specifically address the following:
(1) the movement and eventual degradation of solid waste from the farm;
(2) the effect of the fish farm effluent on the chemistry of the water body as a whole (this will involve an estimation of the turnover time of the water in the bay);
(3) the time and concentration of chemicals used on the fish farms in the vicinity of shellfish beds.

Sufficient field measurements must be undertaken to enable these assessments to be made.

In *open sea sites* with no sensitive areas (e.g., shellfish beds) nearby, only (1) above need be considered. This will involve, at the very least, current measurements of speed and direction at three depths over a complete tidal cycle.

In other sites, additional field measurements will be necessary to enable the required hydrodynamic investigation to be carried out. The Department should be advised *in advance* of the proposed parameters to be measured.

7. The description of the measures envisaged to avoid, reduce or remedy adverse effects of the fish farm should include the following:
   (i) Consideration of ability of cages to withstand wave conditions likely to occur at the site. *A Wave Climate Analysis* will be required to determine this and should be included as an appendix;
   (ii) Details of measures envisaged to prevent escapes;
   (iii) Details of anti-predator measures;
   (iv) Details of navigational lighting and marking of cages;
   (v) Details of proposed arrangements for bleeding of harvested fish.

Where an application for a licence and an EIS has been submitted in accordance with these regulations, the applicant shall publish in one or more newspapers, circulating in the vicinity of the location of the proposed aquaculture, a notice to the effect that he has applied for an aquaculture licence, indicating the location and nature of the proposed aquaculture, and naming a place where a copy of the EIS may be inspected free of charge, or may be purchased by any interested person. The applicant shall also state that submissions or observations may be made to the Minister during a prescribed period in relation to the effects on the environment of the proposed culture. In granting the licence or otherwise the Minister shall have regard to any submissions or observations made to him in connection with this application.

Evaluation of the Legislation

In drafting the 1980 Act the legislators were trying to hold the balance evenly between the fish farmers and the people who had traditional rights to the sea. As things turned out the pendulum has swung very much in favour of the latter. Prior to the introduction of the 1980 Act it was relatively easy to get a licence for aquaculture; since then it has become more and more difficult to obtain licences for both finfish and shellfish.

The Irish Shellfish Association (ISA) in its development plan (ISA 1990) says:-

> In the range of problems confronting the industry the licensing of shellfish cultivation has always loomed largest. The licensing regime operated under the Fisheries (Consolidation) Act 1959 was cumbersome. The new legislation – the Fisheries Act 1980 has exacerbated the situation and proven to be inoperable in most cases.
>
> As a result only 4 per cent of shellfish farms have complete licences. Apart from the unacceptability of this situation from a legal point of view, it creates difficulties for producers in obtaining loan finance and in dealing with possible local conflicts. The ISA recognises that individual shellfish farms operate within a complex web of legal instruments granted under a succession of legislation. A new system is necessary where licences may be granted expeditiously while taking the fullest account of the legitimate interest of other water users. This new system must cover all rights granted under existing legislation. It must also protect the existing growers who wish to expand, and bona fide new entrants to the industry

The same thing could be said for finfish licences but even to a greater extent. The anti-rod licence campaign has directed its attention specifically against finfish farming as a means of obtaining its objective and the shellfish people have been inadvertently sucked into the turmoil. Seldom has the conflict between industrial development and local interests been so marked.

In explaining this conflict, Brian Keary of Limerick University (Keary, 1991) says that this resource (the sea) has unknown potential and its privatisation will have unpredictable consequences. He then goes on to quote from Bowden (1981) who, referring to the USA, says that "the development of aquaculture would enrich a new class of entrepreneurs through the gratuitous grant of common resources without ensuring a fair return to the public. It would mean abandoning our last opportunity to distribute the benefits of natural resources development over a wide spectrum of society and would force thousands of commercial fishermen out of business". This is a rather strong statement. It is difficult to contemplate aquaculture forcing *thousands* of fishermen out of business. Nevertheless, the idea has some merit. In the context in which the statement is made, Bowden is trying to explain the reaction of some local US populations to the development of aquaculture.

In addition to the unknown potential, there are also dangers to the environment of introducing new species into the system and the polluting effects of the aquaculture itself. Land based industry and local authorities may also fear the development. Their polluting activities will be curtailed by the requirements of aquaculture such as water quality. They can no longer use the sea as a cheap sewer.

How to overcome these difficulties is the question. Various people say that something should be done but few if any have put forward tangible suggestions. A noted authority on the subject, B. H. Wildesmith (Wildesmith, 1982) suggests that what is required is "a solid and single legal framework which considers all the issues involved". This in our view is not a very helpful statement either. The whole subject is so complicated that it is impossible to deal with in a simple manner. The issue is basically one of competing and often irreconcilable claims on the same land/water systems.

The Finfish Licensing Legislation of the 1959 Act was relatively simple. The Minister could grant a finfish licence under Section 15 subject to his own conditions and those of the 1933 Foreshore Act which were not very onerous. The 1980 legislation was enacted, among other things, to simplify the procedures but in doing so it provided a stronger role for local objectors. According to Keary (*op. cit.*, p. 28) there are two concepts in the 1980 Act which are legally innovative and which impinge to a lesser or greater extent on the licensing problem. The first of these is the concept of *aquaculture* and the second is that of *designation.*

As stated in Chapter 1, the FAO definition of aquaculture implies some form of human intervention in the rearing process. In some cases, the intervention requires very controlled management while in other cases, as with bottom cultured shellfish or sea ranching the intervention is minimal. The question is should a licence be required where there is only minimum intervention? To that question we would answer yes. If a private individual intervenes in any way he does so with the intention of gaining a reward through the sale of increased or enhanced product. He must therefore be given some control over the product. That implies a licence or a permit of some kind:-

(a) to allow him intervene in the first place, and
(b) to protect him from trespass and dissipation of stocks.

In regard to designation, it is our opinion that this requirement is a serious impediment to the licensing procedure although it was introduced in an attempt to hasten the process. Unfortunately, things did not work out as planned. The term designation in the popular mind was interpreted as giving priority to finfish farming and constraining alternative uses of the area, fishing, navigation, boating, etc. According to Keary (ibid.) this perception mobilised opposition to fish farming and led to great difficulty in achieving public approval for designation decisions. As a result, some applications have had to be withdrawn and one order was overturned by the High Court when in December 1988 a group of Kerry fishermen challenged the designation of Smerick Harbour as an area suitable for aquaculture. Unfortunately, this decision was a victory for nobody. It meant that neither finfish nor shellfish farming can now be licensed under the 1980 Act in this area, though it is believed that there would be no objection to the latter. The objection was basically against the siting of salmon cages.

The Re-introduction of the 1959 Act

Arising from the opposition mounted against the designation process, and the consequent difficulties of granting licences, Ministers are now granting both finfish and shellfish licences under the 1959 Act on the grounds that:- (a) Section 15 of this Act was not repealed and (b) as stated in Section 1(3) of the 1980 Act, the 1959 and 1980 Acts shall be construed together as one. Since 1980 it is reported (*Irish Skipper*, 1 May 1990) that over 60 finfish culture licences have been granted under the 1959 Act. One of these licences granted in Ballyvaughan Bay, Co. Clare, gave rise to a High Court action in April 1990. In this action it was claimed that the Minister had abused his powers in granting the Licence under this Act. Mr Justice Johnson reserved judgement on the claim and judgement has not yet been given.

In another case in Kerry a judicial review was granted in March 1990 against the licensing of two projects at Deenish Island and Inishfarnard. This application has now been withdrawn pending judgement on the Ballyvaughan claim, which is being viewed as a test case. It will be interesting to see how this case goes. The judgement will have far reaching effects for finfish aquaculture in Ireland.

If the judgement goes in favour of the Minister we suspect that future Ministers will revert to the 1959 Act in combination with the Foreshore Act in all licensing cases. This course will be forced upon them since the 1980 Act is almost unworkable in non-designated areas. Also, considering that an EIS must now be lodged with all applications for salmonid licences in excess of 100 tonnes, the public will thus be given some protection against the larger ventures. As stated above the EIS must be made available to the public and representations on it considered by the Minister.

The Minister must, however, take great care in considering these representations to ensure that decisions will not be set aside in the courts by judicial review. The Smerick Harbour case should be a lesson for future reference (O'Hanlon, 1988). In this case, the Minister's officials were unable to rebut strong evidence brought by the plaintiffs on current movements, mainly because they had not carried out any tests themselves.

If the Ballyvaughan judgement goes against the Minister he will have to go back to the "drawing board". Section 54 of the 1980 Act will have to be amended to make it more workable or else some other licensing mechanism within the existing legislation will have to be found.

In any amendment of the 1980 Act the designated area requirement will have to be dropped. Indeed, it is now believed that the advent of the EIS system has effectively sidelined the designation process. Because of the EIS requirement each application for a 100 tonne salmonid farm must go through a detailed process of public examination whether it is for a site within or outside a designated area. The designation process is therefore no longer a means of expediting the granting of licences – if it ever was such.

If alternative licensing systems within the existing legislation are to be used subsection 54(1) of the 1980 Act may have to be repealed. This subsection says that:

> It shall not be lawful for any person to engage in aquaculture save under and in accordance with a fish culture licence, an oyster bed licence, a licence granted by the Minister under this section or an oyster fishery order.

If these licences were not required the Irish Shellfish Association says that the Minister could grant *temporary licences or permits* for shellfish farming under section 14 of the 1959 Act as amended by Section 4 of the Fisheries (Amendment) Act 1962.

Section 14 of the 1959 Act says that the Minister may whenever and so often as he thinks fit by permit in writing and subject to such conditions as he may specify in the permit authorise any named person to do at any season of the year all or any of the following things:-

(a) to catch or attempt to catch and to have in his possession any specified kind of fish for the purpose of artificial propagation, transplantation, the stocking, restocking or improvement of any fishery or for any scientific purpose and for the purpose of so catching to have in his possession, erect and use any fishing engine of a specified kind,

(b) to buy or sell ova and fry or any specified kind of fish for the purpose of stocking or restocking or any scientific purpose.

Section 4 of the Fisheries (Amendment) Act 1962 states:-

The following section is hereby substituted for Section 14 of the Principal Act:

(1) Subject to subsection (2) of this section nothing in this act or in any instrument made thereunder shall prohibit anything done by the Minister or a person previously authorised in writing by the Minister on his behalf for the purpose of the artificial propagation of fish, for some scientific purpose or for the improvement or development of any fishery.

(2) Nothing shall be done pursuant to subsection (1) of this section in relation to a several fishery without the consent of the owner thereof.

(3) A person authorised by the Minister under this section to do anything shall be furnished by the Minister with a certificate of authorisation and when doing anything pursuant to the authorisation shall, if requested by any person affected, produce the certificate to the person.

The shellfish association (on the basis of legal advice) says that Section 14 of the 1959 Act appears to obviate the necessity of a Foreshore Licence. As the licence would be temporary, the status quo of the Minister, the general public and the shellfish farms, would all be maintained and protected during an evaluation period. Furthermore, with such a licence the shellfish farmer would be able to get the necessary financial backup required for proper evaluation.

The Minister would be entitled to make such regulations as he thought fit pursuant to Section 9 of the 1959 Act which empowers the Minister to make such bye-laws which are in his opinion expedient for the more effectual government, management, protection and improvement of the Fisheries of the State.

Finally, with a temporary licence or permit, local people could judge for themselves the advantages or disadvantages of a shellfish site and operation and hence any objection or fears they might have could be evaluated fairly. .

On the assumption that the evaluation of the site went according to plan, the Shellfish Association would envisage that the Minister would grant a full fish culture licence for shellfish purposes in the terms of Section 15 of the 1959 Act incorporating any necessary foreshore licence.

We recommend that the above suggestions be carefully examined by the Minister for the Marine to see if they are feasible. If so the Minister might consider granting temporary finfish licences using this mechanism also. Such temporary licences are urgently needed at the present time to enable the shifting of cages from one area of the sea to another. The sea bed under cages may become fouled up after some years, and for disease prevention and cleaning of the bottom it becomes essential to move cages about so as to let grounds recover. This is called fallowing, which is now thought to be an essential element in finfish farming and which is not possible under present licensing procedures.

One rather revolutionary suggestion (given that subsection 15(1) of the 1980 Act is repealed) would be to grant both shellfish and finfish licences under the 1933 Foreshore Act. Section 2 of this Act (cited above) allows the Minister to lease part of the foreshore to a person while Section 3 permits the granting of a licence to any person in respect of any foreshore.... to use or occupy such foreshore for any purpose. Surely any purpose must embrace aquaculture. The idea deserves consideration.

A final suggestion put forward to us by the Irish Shellfish Association is to bring back the concept of the 1959 Act Oyster Fishery Orders for both shellfish and finfish licensing. (These were abolished under the 1980 Fisheries Act). The Association says that the best means of regulating an area as a public fishery is through such orders granted under Sections 256-270 of the 1959 Act.

Regardless, however, of what new system is introduced, it will not be easy to obtain licences for aquaculture of any kind in future years. The campaign against aquaculture (particularly against finfish farming) is so strong that objections are likely to be mounted against every application and legal reviews demanded where licences are granted. In these circumstances the mediation process outlined in Chapter 7 must be employed to diffuse conflicts and reach solutions in an amicable manner.

APPENDIX C

EC REGULATIONS

Community measures to improve and adapt structures in the fisheries and aquaculture sector are outlined in Council Regulation (EC) No. 4028/86 of December 18 1986. It says that structural measures must as far as possible be implemented within the framework of multi-annual programmes (put forward by the Government of each member state and approved by the Commission) which ensure that community measures are compatible with national measures and with the objectives and instruments of regional policy.

Article 2 of the Regulation states that the Multiannual Guidance Programme must set out the objectives and the means necessary to develop technically viable and profitable facilities for the farming of fish, crustaceans and molluscs. The programme must include the following information on aquaculture:-

(1) Importance of aquaculture in the national economy and in the various regional economies concerned.
(2) Initial situation of aquaculture by type of farming, region and species produced.
(3) Estimated potential aquaculture production in the regions concerned.
(4) Impact on the aquaculture industry of the present situation and foreseeable trends in the market for fish and aquaculture products.
(5) Description of the strengths and weaknesses of the aquaculture industry, requirements covered by the programmes.
(6) Investment needs during the period covered by the programme to obtain objections pursued.
(7) Prospects and investments envisaged for the establishment or development of protected marine areas.
(8) Measures planned for the protection of the environment.

Article 5(1) states that member states shall send to the commission each year before 1 April a summary report on the state of progress of their programmes.

The EC Directive on Environment Impact Assessment (EC 85/337) has recently been implemented into Irish law. Very strict national provisions have been introduced with regard to aquaculture, and most finfish proposals in sea and in fresh water now require an EIS in Ireland, unlike the case in most EC countries.

EC Financial Aids for Aquaculture

The EC criteria specify that:

(1) Projects must relate to (a) physical investments in the construction, equipment, modernisation or extension of installations for the farming of fish, crustaceans or molluscs, or (b) measures to protect or make fuller use of coastal marine areas by the installation, not deeper than the 50 metre isobath, of fixed or moveable obstructions for the delimitation of the protected areas and for the protection or development of fishing resources.

(2) Community aid may be granted to public, semi-public or private projects.

(3) Projects must relate to investments exceeding 50,000 ECU (IR£39,000 approximately).

(4) Projects must be for purely commercial purposes and be implemented by natural or legal persons possessing sufficient occupational competence.

(5) Projects must offer a satisfactory assurance of yielding a profit in due course.

(6) Shellfish farming projects must be implemented at locations where water quality is maintained in accordance with national and community guidelines.

(7) All projects must comply with the EC's Directive on Environmental Impact.

The level of grant aid by the Community to Ireland for the development of aquaculture projects is 40 per cent of the capital costs provided there is an enabling contribution of 10-30 per cent by the State. Grants for protected marine areas and other such structures are 50 per cent from the Community and 10 to 35 per cent from the State. These rates shall be raised by 5 percentage points in the case of projects which are implemented within the framework of redevelopment schemes for sea fishermen who scrap operational fishing vessels.

The number of investment projects submitted to the Commission from all EC countries grew from 49 in 1983 to 373 in 1988 and to 395 in 1989. The number of these applications which received funding rose from 32 (receiving 6.6 million ECU) in 1983 to 266 (receiving 40.0 million ECU) in 1988. Community grants are subject to funds being available within the budget. The result of this is that in 1989 only 177 applications could be funded for a sum of 32.4 million ECU. Irish receipts for aquaculture grew from 1.2 million ECU in 1983 to 4.3 million in 1988 but declined to 2.6 million in 1989. The best proposals usually receive whatever funds are available hence the importance of making a good presentation when applying for a grant. Information on the considerations to be taken into account and on the method of making proposals is available from BIM, Udaras na Gaeltachta and the Department of the Marine.

Specific EC Regulations and Directives Relating to Fish Health and Marketing

There are two new Directives passed in July 1991 relating to health conditions for production and placing on the market of (1) live bivalve molluscs (EC/91/493) and (2) fishery products (EC/91/492) which will affect the aquaculture industry significantly. A third Directive (EC/91/67), adopted in January 1991, will regulate animal health conditions for aquaculture species and products. These Directives, which are summarised below, are to be implemented in member states by January 1993, but derogations may be allowed.

Council Directive Laying Down the Health Conditions for the Production and Placing on the Market of Live Bivalve Molluscs (EC/91/493)

1. The Regulation says that live bivalve molluscs obtained from harvesting areas which do not permit of safe consumption may be rendered safe by submitting them to a purification process or by re-laying in clear water over a relatively long period. It is, therefore, necessary to define production areas from which molluscs may be gathered for direct human consumption or from which they have to be purified or re-layed. The boundaries of such areas must be fixed by the competent authority in the member state.
2. The means of transporting live molluscs to prevent them from contamination and breaking of shells are specified in the Regulation. The transport must permit adequate drainage and cleaning and must be equipped to ensure the best survival conditions for the molluscs. For each batch of molluscs transported, the gatherer must complete a registration document giving his identity, signature and date of harvesting.
3. Stringent conditions for re-laying molluscs are laid down. These include density levels in the water, minimum time of re-laying, depending on contamination levels, and minimum water temperature for each species.

4. The competent authority will draw up a list of approved purification and despatch centres. The purification centres are subject to stringent conditions of construction and operation. General procedures for staff are laid down in regard to personal hygiene and on the way the molluscs are handled. Regular inspection will be carried out by the competent authority to ensure that the procedures are properly carried out.
5. Requirements for despatch centres are:
   (a) that they must not cause any contamination to the product, and
   (b) operators must keep records of microbiological tests from approved production and relaying areas, and dates and quantities delivered to the centres and despatched therefrom.
6. Methods of transporting live molluscs intended for human consumption are laid down. Each consignment must contain a health mark attached.
7. Provisions applied to imports from third countries shall be at least equivalent to those governing the production and placing on the market of Community products.

Council Directive (EC/91/492) Laying Down the Health Conditions for the Production and the Placing on the Market of Fishery Products

This Directive says that:-

(1) Fishery products and the products of aquaculture can only be handled in approved establishments which will be regularly inspected by national authorities and where required by representatives of the EC.

(2) Stringent requirements for equipment and premises are laid down. These cover materials, building and cleaning facilities. Supplies of clean water are required as well as adequate lights and ventilation. The regulation also covers factory vessels and vehicles and depots used for the distribution of fish.

(3) General procedures for staff are laid down relating to clothes and washroom facilities.

(4) Fresh products should be stored under ice. Heading and gutting, filleting and slicing must be carried out hygienically. If for fresh sales fish must be chilled quickly after preparation.

(5) Frozen products must reach a core temperature of –18°C or lower. They must be stored in rooms with a temperature sensor, and records of temperature must be kept for inspection.

(6) For processed products records must be kept and made available for inspection on processing methods and storage life.

(7) Arrangements for checking and monitoring must be made by the competent authorities. Such arrangements will include:
(a) Checks on fishing vessels during stay in port.
(b) Checks on conditions of landing and first sale made.
(c) Inspections at regular intervals on establishments to check if the regulations are being followed.
(8) The conditions for import of fish from third countries are specified. There is a general provision that these imports should not qualify for more favourable treatment than those applied in the community.

Council Directive (EC/91/67) Concerning the Animal Health Conditions Governing the Placing on the Market of Aquaculture Animals and Products

The main provisions of this Directive are:
(1) For the most serious Class I and II diseases, including Infectious Hematopoietic Necrosis (IHN), Viral Haemorrhagic Septicaemia (VHS) and Bonamia Ostreae, approved zones are to be created which have been certified free of these diseases. Fish from non-approved zones cannot be moved into these zones unless slaughtered and gutted prior to dispatch.
(2) For other (class III) diseases, including such diseases as Infectious Pancreatic Necrosis (IPN), Furunculosis and Enteric Redmouth Disease (ERD), the regulations are not entirely clear but it seems that voluntary or compulsory control plans for these diseases will be introduced.
(3) A list of approved third countries or part of countries from which imports are allowed will also be drawn up. There may, however, be restriction to certain species from these approved areas.
(4) Aquaculture animals and products shall be accompanied by a certificate from the exporting third country attesting that they meet the requirements of this Directive. Inspections shall be carried out on the spot by veterinary experts to verify whether the provisions of this Directive are being met.

According to Shaw (1990), the short-term impact of the changes in animal health may well be relatively modest. Requirements for imports of live fish from third countries are little changed in the proposed legislation from these currently operated for many member states. They may, however mean restrictions on imports of ornamental fish which would mean that more of these would have to be bred domestically.

APPENDIX D

ENVIRONMENTAL EFFECTS: TECHNICAL ASPECTS

Introduction

This Appendix presents a review of the more technical issues and data relating to the effects of aquaculture on the environment. It begins with a review of the published literature on the quantities of organic waste produced by fish farms. It goes on to review the existing information on the impacts of aquaculture on sediments and benthos.

The Quantities of Organic Waste Produced by Fish Farms

Waste Loads

There is a considerable body of information on the amount of organic waste produced by finfish farms, but the data show considerable variability, probably as a result of different farming techniques, sampling procedures, and analyses (Institute of Aquaculture, 1989). Nevertheless, there is relatively good agreement between the data obtained from studies of fish cages, particularly for nitrogen production.

Based on analyses of the carbon, nitrogen and phosphorus concentrations of the diet and the fish, the waste loads given in Table D.1 were calculated by Phillips (1985). The figures are in kilograms per tonne of fish produced and indicate the range of loadings based on feed conversion ratios of 1.5:1 and 2.0:1 (see below).

Table D.1: *Estimates of the Production of Carbon, Nitrogen and Phosphorus from Fish Farms (in kg per Tonne of Fish Produced), from Phillips (1985)*

Element	*Input with feed*	*Waste Load*	*Percentage waste*
Carbon	592.2 – 789.6	437.8 – 635.2	73.9 – 80.4
Nitrogen	107.2 – 143.0	80.0 – 115.8	74.6 – 81.0
Phosphorus	25.2 – 33.6	20.4 – 28.8	81.0 – 85.7

Source: Phillips, 1985.

These approximate loadings based on theoretical calculations agree reasonably well with actual measurements beneath freshwater salmon cages and in land-based salmonid farms (Table D.2).

Table D.2: *Solid or Particulate Wastes Produced by Fish Farms (in kg per Tonne of Fish Produced)*

Species and system	*Kg dry weight of solids per tonne of fish produced*	*Reference*
Rainbow trout (freshwater)	650	Sumari (1982)
Survey of freshwater fish farms	1350	Solbe (1982)
Rainbow trout in f.w. ponds/tanks (dry feed)	550	Warrer-Hansen (1982)
Rainbow trout in f.w. cages (dry feed)	289	Phillips (1985)
Salmon cages, sea	700	Weston (1986)
Salmon cages, sea (theoretical calculation)	820	Institute of Aquaculture (1989)
Rainbow trout in f.w. ponds/tanks (dry feed)	100-150	Warrer-Hansen (1991)

Source: Adapted from Institute of Aquaculture, 1989.

The mid-range data are in reasonable agreement, but those at the upper and lower extremes may require some explanation. It is now known that Solbe (1982), in his survey of trout farms, excluded rod-caught fish sold to recreational fishermen, thus overcalculating the production of wastes by underestimating the amount of fish which generated the wastes (Warrer-Hansen, personal communication). The estimate by the Institute of Aquaculture (1989) was based on 20 per cent feed loss and 30 per cent faecal wastage (70 per cent digestibility). If feed loss could be reduced to 5 per cent and feed conversion ratio improved to 1.5:1, the production of waste could be reduced by some 40 per cent to around 500 kg per tonne.

The most recent figures by Warrer-Hansen (1991) are based on calculations by Galskjot (1991) which take into account the very recent improvements in fish feed (Table D.3).

The tendency has been to reduce the protein and phosphorus content of pelletized feeds, and to increase the fat/oil and energy content and the digestibility. Within the most recent 5-6 years, research on dry or pelletized feeds used for salmonid production in Europe has resulted in:

(i) higher digestibility of the food;
(ii) an improved feed conversion ratio;

(iii) lower waste volumes; and
(iv) significant reductions in the amounts of nitrogen and phosphorus added to the environment.

Table D.3: *Changes in the Composition of Fish Feeds from 1950 to 1990*

Years	*Protein* %	*Oil* %	*Carbohydrates* %	*Phosphorus* %
1950–59	35	5	30	2.5
1960–69	40	7	23	2.0
1970–79	53	11	12	1.5
1980–86	50	20	10	1.1
1987–	42	24	19	0.9

Source: Gaeskjot, 1991

These new feeds also have the advantage, from an environmental point of view, of being much more expensive than the older types; this provides a significant incentive to use the feed efficiently and not to waste it by overfeeding. Even a minor amount of overfeeding can lead to a significant increase in the costs per kilo of fish produced and to a reduction in fish farm earnings. However, they have the disadvantage of being manufactured from sand-eel or herring, with consequential effects on the stocks of these fish (see Chapter 7).

The feed conversion ratio (FCR) is a major factor influencing waste production (see Table D.1 above), and the surveys of Scottish trout farms in the early and mid 1980s revealed that the FCR varied between 1.5:1 and 2.0:1. An FCR of 1:1 is now possible using the new "ecologically sensitive" feeds in freshwater farms, but is unlikely to be achieved in cage-based sea farms because of the greater difficulties in monitoring feeding behaviour and feed losses (Institute of Aquaculture, 1989).

In Denmark, legislation which will come into force on 1 October 1992 requires fish feed for sea farms to have a minimum digestibility of 70 per cent, a maximum feed conversion ratio of 1.6:1, and maximum dry matter concentrations of nitrogen and phosphorus of 8 per cent and 1.0 per cent, respectively. The recent Danish legislation affecting freshwater fish farms, which came into force on 1 January 1992, requires the feed to have the same maximum dry matter concentrations of nitrogen and phosphorus as in feeds for sea farms, together with the more stringent requirements for a minimum digestibility of 78 per cent, and a maximum feed conversion ratio of 1.0:1.

Biochemical Oxygen Demand

The consumption of dissolved oxygen by fish, and by bacteria during decomposition of fish farming wastes may reduce ambient oxygen concentrations (Institute of Aquaculture, 1989). The amount of oxygen consumed is very variable, and depends on fish size, activity, age, physiological state, feeding and environmental conditions such as temperature. An average figure for oxygen consumption by rainbow trout appears to be around 300 mg per kg of fish per hour (Liao and Mayo, 1972, Forster, *et al.*, 1977; and Muller-Fuega, *et al.*, 1978). A lower estimate of 67-78 mg/kg fish/hour is given by Arnett (1987) for the oxygen consumption of Atlantic marine salmon in tanks.

According to Solbe (1982), the production of one tonne of fish requires 600 kg of oxygen, together with a biochemical oxygen demand (BOD) caused by the breakdown of organic matter produced by the farm, calculated as 285 kg per tonne of fish produced. Warrer-Hansen (1982) gives a slightly higher estimate of 350 kg per tonne based on the feeding of trash fish (wet feed) to rainbow trout; using dry feed his estimate for the BOD load decreases to 250 kg per tonne (Warrer-Hansen, personal communication).

Nitrogenous Wastes

Nitrogenous wastes are very soluble, are excreted primarily in the urine or through the gills, and the amounts depend on the protein content of the food and its digestibility. Gowen and Bradbury (1987) calculate that 68 to 86 per cent of the consumed nitrogen is released to the water as ammonium and urea, i.e., 32kg of ammonium per tonne of food fed. Estimates of nitrogenous wastes produced per tonne of fish grown are shown in Table D.4 (freshwater farms) and Table D.5 (marine farms).

Phosphorus in Fish-farm Wastes

Phosphorus is generally concentrated within the particulate fraction of the wastes, and its discharge may have detrimental effects in fresh water where its very low concentrations inhibit the growth of algae, i.e., it acts as a limiting nutrient. Nevertheless, there appears to be no data on waste phosphorus production in marine fish farms; the data in Table D.6 are taken from freshwater operations.

Organic Wastes from Shellfish Farming

Solids from suspended shellfish culture operations include faeces, pseudofaeces, shells and other debris discarded or dislodged from the rafts or longlines. Estimates from Japanese oyster farms suggest that a typical oyster raft containing 420,000 oysters produces approximately 16 tonnes dry weight of faeces and pseudofaeces (Arakawa, *et al.*, 1971).

Estimates of solid waste production by mussels vary considerably and are difficult to interpret (Institute of Aquaculture, 1989), and in any event they may be of little relevance because a significant proportion of shellfish solid wastes are intercepted and consumed by epifauna living on the farm.

Table D.4: *Production of Nitrogenous Wastes by Freshwater Salmonid Farms (kg per Tonne of Fish produced)*

Species and system	*Kg per tonne of fish produced per annum*		*Reference*
	NH4–N	*total–N*	
Salmonids (European survey)	37-180	-	Alabaster (1982)
Survey of freshwater fish farms	55.5	67.5	Solbe (1982)
Rainbow trout (ponds/tanks dry feed)	45	83	Warrer-Hansen (1982)
Rainbow trout (f.w. cages dry feed)	63.9	104	Phillips (1985)
Rainbow trout (cages, Poland, wet feed)	-	97	Penczak *et al.* (1982)
Rainbow trout (cages, Sweden, dry feed)	-	87	Enell and Lof (1983)
Rainbow trout (dry feed)	-	25 – 45	Warrer-Hansen (1991)

Source: Adapted from Institute of Aquaculture 1989.

Table D.5: *Production of Nitrogenous Wastes by Marine Salmonid Farms (Kg per Tonne of Fish produced)*

Species	*Kg per tonne of fish produced per annum*		*Reference*
	NH4–N	*total–N*	
Salmo salar	-	80 (diss.) 43 (particulate)	Gowen and Bradbury (1985)
Salmo salar	47.9	-	Phillips (unpublished)

Source: Adapted from Institute of Aquaculture 1989.

Table D.6: *Production of Phosphorus Wastes by Freshwater Salmonid Farms (Kg per Tonne of Fish produced)*

Species and system	*Kg per tonne of fish produced per annum*		*Reference*
	PO4–P	*total–P*	
Salmonids (European survey)	-	22 – 110	Alabaster (1982)
Survey of freshwater fish farms	-	15.7	Solbe (1982)
Rainbow trout (ponds/tanks dry feed)	-	11.0	Warrer-Hansen (1982)
Rainbow trout (f.w. cages dry feed)	8.3	27.0	Phillips (1985)
Rainbow trout (cages, Poland, wet feed)	-	23	Penczak *et al.* (1982)
Rainbow trout (cages, Sweden, dry feed)	1.9	13.5	Enell and Loff (1983)
Rainbow trout (dry feed)	-	3 – 5	Warrer-Hansen (1991)

Source: Adapted from Institute of Aquaculture 1989.

Impacts of Aquaculture on Sediments and the Benthos

A proportion of the organic wastes released from fish farms will be consumed by zooplankton or small fish, but most will fall to the bed of the sea or lake to accumulate as organic matter.

These solids are richer in carbon, nitrogen and phosphorus than natural sediments and, unless swept rapidly away by currents, they will change the physico-chemical nature of the sediments below and adjacent to the operation. This "organic enrichment" will also affect the benthic organisms inhabiting these sediments (Institute of Aquaculture, 1989).

Measuring the amount of organic carbon, or the degree of enrichment in sediments, has to be done with care, and the results interpreted with caution. Most sediments contain a significant amount of inorganic carbon, e.g., in dead shells or other calcareous materials, and if this is included in the total carbon analysis the result would be misleading, giving a false indication of the level of enrichment. At established fish farm sites however, it is likely that total carbon is predominantly organic carbon.

Physico-Chemical Impacts of Finfish and Shellfish Culture on Sediments

The continuous rain of organic matter is the most significant effect; as a result, oxygen consumption of sediments underneath fish cages may be several orders of magnitude higher than at unaffected sites. The sediments will become anoxic if this additional oxygen demand exceeds oxygen supply, at which point there may be severe consequences for benthic organisms and the fish-farming operation.

The severity of such effects below marine salmonid cages ranges from undetectable in well-flushed locations (Dixon, 1986) to severe (Gowen and Bradbury, 1987). In extreme cases of high organic input and low current velocities, deoxygenation may extend to the water column overlying the sediment (Tsutsumi and Kikuchi, 1983). In the absence of oxygen, hydrogen sulphide, ammonia and methane are generated within the sediments, and may be released to the water column (outgassing). In such anoxic sediments, the "redox potential" (a measurement of the balance between oxidation and reduction) becomes negative.

The data from Irish fish cage sites examined by Gowen (1990) showed that the effects of organic waste deposition were restricted to the immediate vicinity of the fish farms, and the level of organic enrichment was generally less than that which had been observed at many sites in Norway and Scotland. His results are summarised in Table D.7.

TABLE D.7: *Summary of the Benthic Physico-Chemical Data Used by Gowen (1990) in Assessing the Extent of Organic Enrichment of a Number of Coastal Salmon Cage Sites (carbon content based on total carbon analyses*

Location of site(s)	*Redox potential*	*Outgassing undercages*	*Total sedimentary carbon*	*Organic enrich ment*
Kilkieran Bay	Positive	Yes	9 – 10 %	Slight
Bertraghboy Bay	Positive	Yes	9 – 10 %	Slight
Mulroy Bay	Negative	Yes	10 – 35 %	High degree
Leanagh Pool	Not recorded	Yes	Not recorded	Not assessed
Lettermullen	Not recorded	Only on disturbance	Not recorded	Moderate level

Note: Carbon content based on total carbon analyses.
Source: Gowen, 1990, Annex 4.

Gowen concluded that in Kilkieran and Bertraghboy Bays there was little accumulation of organic wastes, in Leanagh Pool and Lettermullen there were moderate levels of organic enrichment, but nearly all of the sites in Mulroy Bay were highly enriched. Only in Lettermullen and some of the Mulroy Bay sites did the zone of enrichment extend further than 10 metres from the cages. One location, Lettercallow, for which only limited data were available, was in a late stage of organic enrichment when surveyed in 1988. Continued use of this site for cage culture could have resulted in extensive oxygen depletion, and the survey recommended cessation of mariculture.

Gowen's examination of the available data show that, with a few exceptions, cage culture of salmonids in Irish coastal waters has not caused widespread or marked changes in the physical or chemical nature of the sediments at the fish farm sites.

Impacts of Finfish Cages on Benthic Communities

The settlement of organic matter and the subsequent organic enrichment has been found to affect bottom-living animals and plants at virtually all fish farm sites studied in Europe and the United States (Gowen and Bradbury, 1987; Earll, *et al.*, 1984; Weston and Gowen, 1988; Rosenthal, *et al.*, 1987; Parametrix Inc., 1990; and Gowen, 1990).

High inputs of organic matter directly below fish cages can result in an azoic or lifeless zone devoid of macrobenthic organisms, but dominated by bacteria. If present, this zone may be surrounded by a transition region dominated by a few tolerant opportunistic species; occasionally there may be an outer fringe zone where the organic matter supports increased biological productivity and beyond which there is a gradual return to background conditions.

Azoic zones are not found under all fish cage sites, and studies in Scotland and Norway have shown a wide variety of conditions (Dixon, 1986; Ervik, *et al.*, 1985). Earll, *et al.* (1984) found black sediments under most fish farms surveyed in Scotland, and this zone was usually surrounded by a "halo" of dense mats of the sulphate-reducing filamentous bacteria Beggiatoa. Sludge deposition under some of the oldest fish farms in Norway has unquestionably led to environmental and aesthetic degradation of some bays and inlets along the Norwegian coast (Norwegian Fish Farmers Association, 1990).

The benthic data from Irish fish cage sites in Kilkieran and Bertraghboy Bays examined by Gowen (1990) showed species numbers and diversity indices similar to three Scottish sites, two of which were considered to be highly enriched (Loch Ardbhair and Loch Spelve), and one moderately enriched by organic matter (Loch Carron). At these sites, the number of animal species recorded beneath the cages ranged from 0 to 12, while at a distance of 50 metres from the cages the number of species ranged from 11 to 58. On average, the number of species was reduced to about 12 per cent of the total found 30 to 50 metres from the farm.

Macrofauna data from Mulroy Bay did not allow any comparison with the Scottish sites, or with other Irish sites, to be made, but showed that the benthic community was dominated in some locations by the opportunistic polychaete worm Capitella capitata which is tolerant of high organic loads. Yet, it appears that Mulroy Bay continues to support good shellfish stocks, and the fish farm operator is reporting very heavy mussel settlement on the nets and structure of the cages.

Gowen (1990) concludes that the changes in the sea-bed ecosystem which have taken place beneath and in the vicinity of fish farms in Irish coastal waters are similar to those which have been associated with fish farms in other countries. At most Irish locations the changes are less severe, however, and some degree of recovery appeared to be indicated where fish farming had ceased.

Impact of Suspended Shellfish Culture on Benthic Communities

In general, the effects of shellfish farms are similar to those of salmon cages; benthic communities are shifted towards those more typical of organic enrichment, but the impacts are less severe and are more likely to be localised to the immediate vicinity of the farm. No data appear to have been collected from shellfish farming sites in Ireland, but it is likely that the effects would be similar to those found in other countries.

Recovery of Benthic Communities after Cessation of Fish Farming

Benthic communities will return to normal background conditions after the source of organic enrichment has been removed, and thus the effects of aquaculture can be regarded as reversible. The rate of return to normal is very site-specific, and between 2 and 10 years may be required for complete recovery, even though the actual wastes deposited may disappear within 4 to 6 months (Institute of Aquaculture, 1989).

Gowen (1990) noted that the second survey at the Lettermullen site (carried out 6 months after the first) indicated a considerable improvement following cessation of farming.

APPENDIX E

TABLES SHOWING OTHER PROBLEMS AND OPINIONS OF FISH FARMERS

Table E1: *Number of Fish Farmers Having Problems With Licence etc.*

Type of Licence/Permission	*Delay in Issuing*		*Other Problem*		*Total*	
	Finfish	*Shellfish*	*Finfish*	*Shellfish*	*Finfish*	*Shellfish*
Aquaculture Licence under 1980 Act	10	46	2	27	12	73
Fish Culture Licence under 1959 Act	3	7	2	5	5	12
Licence under Foreshore Acts	8	20		13	9	35
Planning Permission from Local Authority	2	0	2	1	4	1
Effluent Discharge Licence from Local Authority	1	0	2	1	3	1
Other Type of Licence or Permission	1	1	0	2	1	3

Table E2: *Number of Fish Farmers Who Had Difficulties in Getting Insurance and/or Finance Because They Did Not Have an Appropriate Licence*

Type of Licence	*Salmon Farmers*	*Trout Farmers*	*Shellfish Farmers*	*Total*
Aquaculture Licence under 1980 Act	15	2	11	28
Fixed Culture Licence under 1959 Act	5	1	5	17
Licence under Foreshore Acts	12	–	2	14
Planning Permission from Local Authority	4	1	5	10
Effluent Discharge Licence from Local Authority	1	2	–	3
Other Type of Licence or Permission	1	–	–	1

Table E3: *Number and Percentage of Fish Farmers Who Considered Provision in Various Areas to be Adequate*

	Salmon Farmers		*Trout Farmers*		*Shellfish Farmers*		*Total*	
Area	*No.*	*%*	*No.*	*%*	*No.*	*%*	*No.*	*%*
Training	10	71.4	5	55.6	93	80.2	108	77.7
Advisory Services	9	64.3	7	77.8	77	66.4	93	66.9
Legal position re ownership of stocks and common property rights	7	50.0	4	44.4	40	34.5	51	36.7
Marketing Support Services	6	42.9	6	66.7	25	21.6	37	26.6
Quality Control	12	85.7	5	55.6	87	75.0	104	74.0
Govt. Policy towards Aquaculture	4	28.6	5	55.6	42	36.2	51	36.7
Private Consultancy + Technical	14	100.0	8	88.9	81	69.8	103	74.1
State Technical Services	6	42.9	8	88.9	71	61.2	85	61.1
Licensing Arrangements	1	7.1	5	55.6	30	25.9	36	25.9
Research and Development	6	42.9	3	33.3	55	47.4	64	46.0

Table E4: *Numbers of Fish Farmers Holding Various Views About How Dangerous or Toxic are the Chemicals Used in Fish Farming*

Area	*Salmon Farmers*		*Trout Farmers*		*Shellfish Farmers*	
	No.	*%*	*No.*	*%*	*No.*	*%*
Are the Chemicals Dangerous or Toxic?						
1) Not at all	3	20	–	0	3	3
2) Rarely, or under unusual circumstances	–	0	–	0	6	5
3) Only if Handled or Applied incorrectly	8	53	6	67	33	29
4) Yes, they are very dangerous and must be applied and handled with great care	4	27	3	33	71	63

Table E5: *Reaction of Fish Farmers to the Likelihood of Environmental Damage from Chemicals or Drugs in Certain Specified Circumstances*

"How Likely are These Chemicals and Drugs to Cause Damage?"	*Finfish Farmers*			*Shellfish Farmers*		
	Very Likely	*Likely*	*Not Likely*	*Very Likely*	*Likely*	*Not Likely*
			Per cent			
Where water circulation is adequate	4	4	92	16	23	61
Where shellfish are in close proximity to cages	5	10	85	42	39	19
If chemicals are handled or applied incorrectly	23	23	55	68	27	6

Table E6: *Reaction of Fish Farmers to the Question of How Prone Certain Species are to Damage by Drugs and Chemicals Used in Finfish Farming*

How Prone to Damage by Drugs and Chemicals are:	*Finfish Farmers*			*Shellfish Farmers*		
	Very Prone	*Somewhat Prone*	*Not Prone*	*Very Prone*	*Somewhat Prone*	*Not Prone*
Wild Finfish Stocks	–	–	100	21	56	23
Wild Shellfish Stocks	5	26	69	38	53	9
Farmed Shellfish	–	26	74	44	45	10
Plankton, Microscopic Organisms	5	30	65	43	49	8
Other Marine Organisms	5	21	74	29	45	25

Table E7: *Number of Fish Farmers who Reported Environmental Damage That They Believe Was Caused by Finfish Farming in Their Area*

Area	*Salmon Farmers*		*Trout Farmers*		*Shellfish Farmers*	
	No.	*%*	*No.*	*%*	*No.*	*%*
Have seen such damage	3	19	1	11	13	11
Have not seen such damage	13	81	8	89	108	89
Total	16	100	9	100	122	100

Table E8: *Opinions of Fish Farmers as to Action or Policy Changes Which Would Improve or Develop Aquaculture*

Suggested Action	*Salmon Farmers*	*Trout Farmers*	*Shellfish Farmers*	*Total*
		Per cent		
Licensing system streamlined/improved	56	33	45	45
Designation System Improved/Streamlined	31	11	5	8
More Emphasis on/More Funding for Marketing	38	44	50	48
Better Environmental Monitoring/Protection	13	11	50	18
More/Better Processing Facilities	0	0	6	5
Improve Other Facilities (Testing, Piers, etc.)	0	11	15	13
Easier Access to Finance	25	0	30	28
Improve Image, Quality Control	25	11	11	12
Better Control of Diseases	0	0	2	2
More/Better Research Information, Advice	19	44	27	27
Dumping/Under Cost Selling by Competitors	13	11	0	2
Guaranteed Prices/Price Control	0	11	7	6
Other	19	33	24	24

APPENDIX F*

The Economic and Social Research Institute

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REVIEW OF AQUACULTURE SECTOR

Questionnaire for Producers of Fin-Fish (Salmon & Trout)

Resp. No. [| | |]

(Does not apply to salmon and trout hatcheries even if owned by respondent. Complete a separate questionnaire for such hatcheries)

1. Name and address of Fish Farm: ____________________

____

____

Location of farm: In Gaeltacht ... 1 Elsewhere in Ireland ...2

2. Type of fish reared: (code all that apply)

Salmon 1
Rainbow Trout in Sea 2
Rainbow Trout in Fresh Water........3

3.(a) What system of farming do you use: (code all that apply)

Cage(s) 1
Ponds/Raceways......2
Other (specify).... 3

____

(b) How many separate sites or locations do you have? ________

(c) If you operate cages: state make, number and capacity

Make of Cage	*Number*	*Total Capacity (Cubic Metres)*
Wavemaster	____	____
Steelform	____	____
Polar circle	____	____
Kames	____	____
Bridgestone	____	____
Farm ocean	____	____
Other (specify) ____	____	____
Total	____	____

* Slightly different versions of this questionnaire were used for shellfish farms and hatcheries. Copies of these may be obtained from the authors.

2

4. Given your present system and equipment, what is the maximum amount of fish that your farm could hold?

Could hold ________ tonnes

5. When did you begin production? 19______

6. How much investment (i.e., grants, loans, etc.) in total did you receive from each of the following sources since then?

	£'000
BIM	________
Udaras na Gaeltachta	________
Other Government Sources (specify) ________________	________
EC (FEOGA)	________
Share capital (equity investment)	________
Bank and other borrowings	________
Own funds	________
Other (specify) ________________	________
Total investment to date in the fish farm	________

7. What have been your annual sales of (i) salmon and (ii) Trout in each of the last six years (or since you started up if this is later)? (Please give the quantity in tonnes and the value.)

Species		*Year*					
		1985	*1986*	*1987*	*1988*	*1989*	*1990*
1. Salmon	Quantity (tonnes)						
	Value (£'000)						
2. Trout	Quantity (tonnes)						
	Value (£'000)						

3

8. What quantity and value of each species were you holding as stock (a) at the end of 1989 and (b) at end of 1990

Species	*End 1989*		*End 1990*	
	Tonnes	*Value £'000*	*Tonnes*	*Value £'000*
(1) Salmon				
(2) Trout				

9. How much do you propose to invest this year and in each of the next five years in (a) working capital and (b) fixed capital (i.e. buildings, equipment etc.)?

	Proposed Investment in:		
	(a) Working Capital	*(b) Fixed Capital*	*(c) Total(=a+b)*
		(£000)	
1991	______	______	______
1992	______	______	______
1993	______	______	______
1994	______	______	______
1995	______	______	______
1996	______	______	______

10. What proportion of this investment do you expect to come from the following sources?

BIM	______%
Udaras na Gaeltachta	______%
Other Government agencies (specify) ______________	______%
EC FEOGA	______%
Share capital (equity investment)	______%
Bank and other borrowings	______%
Own funds	______%
Other (specify)	______%
(Total should add to 100 per cent)	100 %

4

11. What is your expected sales of (a) salmon and (b) trout this year and for each of the next five years (tonnes)?

Species	*1991*	*1992*	*1993*	*1994*	*1995*	*1996*
1. Salmon	____	____	____	____	____	____
2. Trout	____	____	____	____	____	____

12. Total current value of all structures and other capital equipment:

Item	*Number*	*Total Current Value of These £'000*	*Location of supplier*	
			In Ireland	*Abroad*
a. Salmon cages	____	______	1	2
b. Trout cages	____	______	1	2
c. Nets	____	______	1	2
d. Anchors/moorings	____	______	1	2
e. Boats	____	______	1	2
f. Transport (vehicles, etc.)	____	______	1	2
g. Stores	____	______	1	2
h. Other buildings	____	______	1	2
i. Other (specify) ______________	____	______	1	2

5

13. (a) How did you dispose of your output in 1990? (Number of tonnes of each species sold to each of the following.)

	SALMON		TROUT	
	Tonnes	*Value (£)*	*Tonnes*	*Value (£)*
Fresh, to Irish retail trade	______	______	______	______
Fresh, to Irish wholesalers, marketing group etc.	______	______	______	______
Fresh, sent abroad directly by you (State country:____________________)	______	______	______	______
Smoked by you (give original "round" weight) & sold in Ireland	______	______	______	______
Smoked by you (give original "round" weight) & sold abroad (State country:______________)	______	______	______	______
Otherwise prepared or packed by you and sold in Ireland (give original "round" weight)	______	______	______	______
Otherwise prepared or packed by you and sold abroad (give original "round" weight) (State country: ________________)	______	______	______	______
Sales of live mature or part grown fish (not smolts) to other Irish producers	______	______	______	______
Total (should agree with 1990 figures in Q.7)	______	______	______	______

13 (b) (If salmon producer) What proportion of your 1990 output was sold as (i) under 3Kg. and (ii) over 3 Kg. fish ? (Two percentages must add to 100%.)

(C) What was the average price per lb. you received for each category in 1990?

		Price/lb
Fish under 3 Kg.	________%	£________
Fish 3 Kg. or more	________%	£________
	100 %	

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13 (d) What is the average size of your fish when you sell them?

_____________Kg.

(e) On average, how long would it take from the time you put smolts in the cages until they reach 3 Kg.?

_____________ Months

(f) During 1990, what percentage mortality did you have?

_____________ %

14 (a) Please indicate whether or not you have the facilities to carry out each of the following processes.

(b) What percentage of your output of (a) salmon and (b) trout undergoes each of the processes?

Process	*Do you have facilities for this?* Yes	No	*Percentage of Total 1990 Output which underwent this process* Salmon	Trout
Gutting	1	2	_______%	______%
Grading	1	2	_______%	______%
Packing	1	2	_______%	______%
Filletting	1	2	_______%	______%
Freezing	1	2	_______%	______%
Chilling	1	2	_______%	______%
Smoking	1	2	_______%	______%
Any other processing facility? (Specify:_____________)	1	2	_______%	______%

?

15. Current (non-staff) operating costs in 1990 and source of supply:

	Quantity (state unit)	Cost (£)	Percentage purchased In Ireland	Percentage purchased Imported directly
Smolts (if purchased)*	______	______	______%	______%
Other juveniles	______	______	______%	______%
Purchase of mature/semi-mature fish from other producers	______	______	______%	______%
Feed	______	______	______%	______%
Energy (ESB, Gas, etc.)	______	______	______%	______%
Fees for veterinary services	______	______	______%	______%
Fees for water monitoring baseline or other environmental studies	______	______	______%	______%
Drugs, medicines, etc.	______	______	______%	______%
Cost of hired transport	______	______	______%	______
Current running costs of own transport (amount chargeable to fish farm)	______	______	______%	______%
Packaging	______	______	______%	______%
Ice	______	______	______%	______%
Marketing Costs	______	______	______%	______%
Licence fees	______	______	______%	______%
Insurance	______	______	______%	______%
Local Authority Payments/ Rates etc.	______	______	______%	______%
Postage/telephone	______	______	______%	______%
Accountancy & legal fees	______	______	______%	______%
Interest charges	______	______	______%	______%
Other costs (specify) ____________________	______	______	______%	______%

* Include purchased smolts only here. If respondent has a salmon or trout hatchery complete a separate questionnaire for it.

8

16. Does the owner himself/herself work in the fish-farm and/or processing plant?

Yes ... 1 No ... 2

(If Yes) How many person/days did he/she work in 1990 in (a) the fish farm and (b) the processing plant (if any owned)?

(a) In the fish farm ________ days

(b) In the Processing Plant ________ days

17 (a) How many other persons do some paid work on the fish farm? How many person/days in total did they work in 1990? (Take full-time whole year = 240 person/days. Include members of owner's family if they are paid a regular wage or salary.)

	Number full-time	*Number part-time*	*Total person/days*
Managers (not the owner)	____	____	____
Technical staff	____	____	____
Clerical staff	____	____	____
Operatives	____	____	____
Total	____	____	____

(b) (If respondent has packing or processing plant) How many other persons do some paid work in the processing plant? How many persons/days in total did they work in 1990 (Take full-time, while year = 240 person/days.) Include members of the owner's family if they are paid a regular wage or salary.)

	Number full-time	*Number part-time*	*Total person/days*
Managers (not the owner)	____	____	____
Technical staff	____	____	____
Clerical staff	____	____	____
Operatives	____	____	____
Total	____	____	____

9

(c) Approximately how much was the total wage bill for these employees in 1990?
Fish farm £ __________ Packing/Processing Plant £______

(d) Do members of the owner's family work on the fish-farm or in the processing plant without being paid a regular wage or salary?

Yes ... 1 No ... 2

In total, how many person/days are worked by such family members?

Fish farm __________ person/days

Packing/Processing Plant __________ person/days

(e) Thinking now of (i) the owner, (ii) the full-time employees and (iii) the part-time staff, how many of them have completed second-level and how many third-level education?

	Owner	*Full-time staff*	*Part-time staff*
Primary only	____	____	____
Primary and second-level only	____	____	____
Third-level education	____	____	____
Total (should agree with Q.17(a))		____	____

(f) And how many of them have done:

(i) a short (under 6 months) course in fish farming	____	____	____
(ii) a long (6 months +) course in fish farming	____	____	____

10

18 (a) Have you had problems in any of the following areas? If yes, please describe them briefly.

Problem	*Had this problem* Yes	No	*Description of difficulties and solution (if found)*
1. Finding outlets for the fish you produce	1	2	
2. Arranging transport	1	2	
3. Arranging storage	1	2	
4. Arranging ice supplies	1	2	
5. Getting supplies of juveniles	1	2	
6. Fish diseases	1	2	
7. Obtaining goodwill of local community	1	2	
8. Getting technical or other advice	1	2	
9. Early maturing/"grilsing"	1	2	
10. Acquiring a site	1	2	
11. Physical conditions of site, e.g., heavy wave action	1	2	
12. Biological conditions of site, e.g., plankton blooms	1	2	
13. Obtaining the water quality and sea bed data required by the Department of Marine	1	2	
14. Competition for space with other users, or conflict with other activities, e.g., angling or wild-stock fishing	1	2	
15. Attacks or predation by sea birds or seals	1	2	
16. Any other problems (specify)	1	2	

11

(b) In the case of each of the following licences, could you say whether you (a) a full licence of this type (b) a temporary or draft licence of this type (c) have had a licence approved but not yet issued (d) have an application under consideration by the issuing authority (e) have not applied for such a licence? Code one number on each line.

	Have Full Licence	*Have Temp./ Draft Licence*	*Licence approved but not issued*	*Licence application being considered*	*Have Not Applied*
a. Aquaculture Licence under the 1980 Act (Dept of Marine)	1	2	3	4	5
b. Fish Culture Licence under the 1959 Act (Dept of Marine)	1	2	3	4	5
c. Licence under Foreshore Acts (Dept. of Communications)	1	2	3	4	5
d. Planning permission from the Local Authority	1	2	3	4	5
e. Effluent Discharge Licence from Local Authority	1	2	3	4	5
f. Other type of Licence or Permission	1	2	3	4	5

(Specify:________________________________)

(c) Have you had any difficulties in obtaining these licences?

Yes......1 No.......2

If Yes, please state which type of licence you had problems with, and briefly describe the difficulties.

Type of Licence Involved (Code a - f as above)	*Nature of Problem*
________	________________________
________	________________________
________	________________________
________	________________________
________	________________________

(d) Have you had difficulties getting (a) insurance or (b) finance because you did not have one or other of the above licences?

Yes ... 1 No ... 2

If yes, please state which licence and what difficulties you had:

____

____

12

19. Which organisations helped in setting up or running your fish-farm? What type of help did they give?

Organisation	*Type of Help Given (Circle all that apply on each line)* Grant	Credit	Training	Advice
BIM	1	2	3	4
Udaras na Gaeltachta	1	2	3	4
IDA	1	2	3	4
University	1	2	3	4
Regional Technical College	1	2	3	4
Eolas (NBST)	1	2	3	4
Local Banks	1	2	3	4
Other Lenders	1	2	3	4
Department of Marine	1	2	3	4
Other (specify)				
______________________	1	2	3	4

20. Could you say whether you think current provision in the following areas is adequate or inadequate, and if inadequate how could it be improved?

Areas	*Adequate*	*Inadequate*	*State how they could be improved*
Training	1	2	______________
Advisory services	1	2	______________
Legal position regarding ownership of sea and common property rights	1	2	______________
Marketing Support Services	1	2	______________
Quality control	1	2	______________
Government policy towards aquaculture	1	2	______________
Private consultancy and technical services	1	2	______________

Q20 (contd.)

State technical Services	1	2	________
Licensing arrangements	1	2	________
Research & Development	1	2	________

21. Did your stocks suffer from any diseases or pests in 1990? (Include sea lice, algal blooms, "red tide", pancreas disease etc. if appropriate. List the most serious disease or pest first. Also list the chemical(s) used to control each disease or pest)

Yes ... 1 No ... 2

	Name of disease or pest	*Name of chemical or drug used*
1	(a) ________	(b) ________
2	(a) ________	(b) ________
3	(a) ________	(b) ________
4	(a) ________	(b) ________

22. State quantity of different drugs used to control diseases and pests during 1990, and the number of occasions on which each was applied?

	Name of drug used	*Total Quantity Applied in 1990 (litres)*	*Number of occasions on which applied in 1990*
1	________	________	________
2	________	________	________
3	________	________	________
4	________	________	________

14

24. (a) Have you ever received any complaints or encountered any opposition to your fish farm or the way in which it is run?

Yes ... 1 No ... 2

(b) What type of complaint was made? (Code all that apply)

1. Alleged damage by chemicals used on farm 1
2. Alleged damaged by organic pollution from farm ... 2
3. Appearance/visual impact of farm 3
4. Interference with navigation by farm 4
5. Other problem 5
   (specify) ______________________________
   ____

(c) Who made these complaints? (Code all that apply)

Wild-stock fishermen (fin-fish) 1
Wild-stock fishermen (shellfish) 2
Other fin-fish farmer 3
Shellfish farmer 4
Local Authority Environmental Officers 5
Environmental Organisation 6
Water sports enthusiasts, e.g., skiers, yachtsmen, anglers, etc. 7
Other persons 8
(specify) ______________________________
____

(d) How did you try to deal with these problems? ______________________________
____
____

25. Have you had any problems of pilferage or vandalism of your cages, or other equipment and property?

Yes ... 1 No ... 2

If Yes describe the damage ______________________________
____
____
____

26. Is the harbour pier or jetty which you use to service your fish farm private or public property?

Private ... 1 Public ... 2

Have you received any complaints about your use of public piers for servicing your fish farm?

Yes ... 1 No ... 2

Describe complaints ______________________

____

27. Do you think that the chemicals or drugs used by fin-fish farmers are dangerous or toxic?

Not at all 1

Rarely, or under unusual conditions 2

Only if handled or applied incorrectly .. 3

Yes, they are very dangerous and should be applied and handled with great care 4

28. (a) Do you think that these chemicals or drugs can ever damage the environment?

Yes ... 1 No ... 2

(b) (If No) How can you be sure that no damage is caused by the chemicals or drugs salmon farmers use?

Have seen no damage 1
Have heard of no damage 2
Have received no complaints 3
Other (specify) ....
______________________ 4

GO TO Q.30

29. Do you think that these chemicals cause serious, long-term damage to the environment?

Always 1
Sometimes 2
Rarely 3
Never 4

30. How likely are these chemicals and drugs to cause serious, long-term damage to the environment in cases ...

	Very likely	*Likely*	*Not likely*
Where water circulation is adequate?	1	2	3
Where shellfish are in close proximity to the cages?	1	2	3
If the chemicals are handled or applied incorrectly?	1	2	3

31. How prone to damage by the chemicals and drugs used in salmon farming are:

	Very prone	Somewhat prone	Not prone
Wild fish stocks	1	2	3
Other farmed fin-fish	1	2	3
Wild stock shellfish	1	2	3
Farmed shellfish	1	2	3
Plankton, microscopic organisms	1	2	3
Other marine organisms (specify)	1	2	3

____

____

32.(a) Have you seen any environmental damage which you believe was caused by fin-fish farming in your area?

Yes ... 1 No ... 2

(b) Describe the damage you saw: ____________________________

____

____

(c) How extensive was this damage?

Slight, only a few organisms affected, none killed ... 1
Medium, death of a few organisms in a small area 2
Extensive, many fish/shellfish killed or affected over a wide area 3

(d) Distance between the salmon cages and the site of the damage:

________________ Metres

33. Do you believe that the accumulation or build-up of organic matter (droppings, uneaten food) on the sea bed below or near salmon cages can be a cause of environmental change?

Yes ... 1 No ... 2 Don't know ... 3

34 If yes to Q.33
(i) what type of changes do you believe *can* be caused, by the build up of organic matter
(ii) what type of changes *have actually occurred* in salmon farms in your area?
(Code all that apply in each column.)

	Can occur	*Has occurred*
Decrease in the variety of marine life on the sea bed	1	1
Increase in the variety of marine life on the sea bed	2	2
Formation of a black "sulphide" layer in the sea bed sediment	3	3
Formation of anoxic conditions and generation of hydrogen sulphide gas	4	4
Enrichment (eutrophication) of the water column by nutrients	5	5
Encouragement of plankton growth	6	6
Other (specify)	7	7

35. Is there an accumulation or build-up of organic matter (droppings, uneaten food) on the sea bed below or near your cages?

Yes ... 1 No ... 2 Don't know ... 3

36. (a) What quantity of dead or diseased fish did you need to get rid of in 1990?

Number of Fish______________

(b) How did you dispose of these unwanted fish?

To a local authority landfill 1
To a private landfill site 2
By dumping at sea 3
To a protein recovery plant 4
Other (specify) 5

____

____

37. Did any fish escape from your fish farm in 1990?

Yes ... 1 No ... 2

(i) How many fish would you say escaped ______________

(ii) Have you any idea what became of the escaped fish? Would you say that the bulk of these fish:

Died or were killed in the sea 1
Swam up some river to spawn 2
Other (specify) ....
____ 3

Have no idea.............................. 4

38. (a) Do you believe that cage-based fin-fish farms tend to attract wildlife, especially seals and sea birds?

Yes ... 1 No ... 2 Don't know ... 3

(b) Have you suffered losses from wildlife attacks?

Yes ... 1 No ... 2 Don't know ... 3

(c) If yes, describe the damage done to cages or stocks

____

____

____

(d) What precautions or measures do you take to prevent such attacks?

____

____

____

(e) To what extent have these been successful?

____

____

____

39. Do you have a salmon, trout or other hatchery?

Yes ... 1 No ... 2

Located in the Gaeltacht	1
Located elsewhere in Ireland	2

Complete a separate questionnaire for Hatchery Owners

40 List very briefly 3 actions or policy changes which you believe would lead to a significant improvement in or development of the Irish Aquaculture Industry :

1. ______________________________

____

____

2. ______________________________

____

____

3. ______________________________

____

____

41. This questionnaire was completed by: Date: ______________

Name: ______________________________

Position: ______________________________

Address: ______________________________

____

____

Telephone number: ______________________

Fax number: ______________________

Thank you very much for completing the questionnaire; you may be assured that your replies will be treated in confidence and that the responses of individual fish farm or hatchery owners or operators will not be quoted in our report without your permission.

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