

What is aquaculture?

Agriculture, the husbandry of crops and animals **on land**, is Ireland's largest industry and contributes very significantly to the domestic and export markets.

Aquaculture, the husbandry of animals and plants **in aquatic environments**, is also an important industry. Ireland has an abundance of aquatic environments suitable for aquaculture ranging from its extensive and varied coastline, to its abundant inland waterways.

Distinction between fishing and aquaculture

Many people do not realise that there is a difference between fishing and aquaculture, so it is important to distinguish between them. **Fishing** is the harvesting of already **existing populations** of fish and other aquatic animals. (Seaweed harvesting is a separate activity.) **Aquaculture** is the purposeful cultivation and subsequent harvesting of both freshwater and marine aquatic plants and animals. The cultivation of marine animals is by far the most important sector of aquaculture.

Components of Aquaculture

The variety of organisms cultivated is extensive (mussels, oysters, scallops, clams, trout and salmon) and production can be divided into two main areas.

Hatcheries and nurseries are scattered around the country producing a variety of juvenile organisms which are reared until they are big enough to be sold on. These immature organisms are grown on licensed aquaculture farms, they are also used in some cases to stock fish ponds and rivers (rainbow trout); to restock wild populations (sea urchins and brown trout). This is an integral part of **conservation**.



Production of mature species

A variety of **finfish** species are produced and the Atlantic salmon (*Salmo salar*) is by far the most important. Approximately 80% of aquaculture produced salmon is certified as organic and is thus a premium product with a total value of €90M. Rainbow trout, char, cod and perch are also being produced on a small but growing scale.

Shellfish are any aquatic invertebrates which have an **exoskeleton** and include various species of **molluscs** and **echinoderms**. The molluscs consist mainly of oysters and mussels but novel species are also grown. The two main oyster species cultivated: are the Pacific or *gigas* oyster (*Crassostrea gigas*) and the native or flat oyster (*Ostrea edulis*). **Mussels** (*Mytilus edulis*) are grown in two distinct ways: on the bottom and on ropes. Bottom grown mussels are the most common and 50% of all mussels grown are organic, and most are exported live to European countries.

Novel species include clams, scallops and abalone.

Echinoderms: The edible sea urchin (*Echinus esculentus*) is grown in hatcheries and is used to restock wild populations but their eggs are a high value gourmet food. **Rag worms** (*Nereis virens*), used as bait by fishermen, have also been grown in the past.

Seaweeds: A variety of seaweed species *Laminaria digitata* (Oarweed), *Alaria esculenta* (Dabberlocks) and *Saccharina latissima* (Sugar kelp) live in deep water below the low tide mark are now being cultivated. These species are being grown on long lines at sea. However experimental trials are taking place with *Palmaria palmata* (Dulse or Dillisk) and *Porphyra umbilicalis* (Purple laver) These species are considered a food delicacy and are much sought after in Europe.



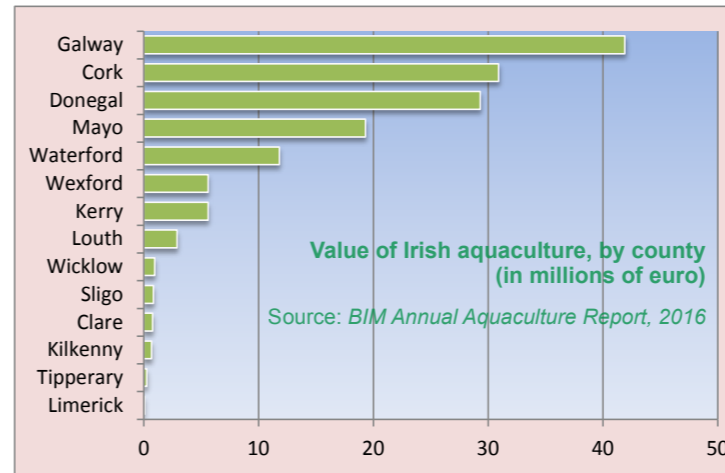
Environmental challenges

The marine ecosystem is fragile and irreversible changes are likely if the practices involved in aquaculture production are not environmentally sustainable. **Ecosystem based management systems** need to be developed and monitored in such a way as to maintain biodiversity and productivity as well as the chemical and physical properties of the ecosystem. Sites need to be selected appropriately to ensure minimum impact on wildlife such as loss of feeding areas and disturbance by increased human activity.

ECOPACT is an exciting new initiative developed by BIM in cooperation with the Irish Shellfish Association and the Irish Salmon Growers Association, designed to bring about the widespread adoption of Environmental Management Systems (EMS) into the Irish aquaculture industry. The adoption of a formal system of environmental management by an aquaculture company represents a powerful commitment to environmentally sustainable operations to a standard beyond compliance with the laws governing fish farming in Ireland. An **Environmental Management System** is a set of processes and practices that enable a business to increase its efficiency while reducing its environmental impact. It is an enlightened approach which benefits the community, the environment and the company concerned.

There are two types of containment systems; namely **open** and **closed**. Each has definite advantages but closed containment systems have far less impact on the environment. While recirculation is being successfully applied in some freshwater units in Ireland to grow salmon smolts and trout, for example, it is not commercially viable to grow mature salmon in recirculation or closed aquaculture systems at present.

Farmers need a clean environment for successful farming and it is in their interest to maintain a clean environment in the vicinity of the sea pens (Atlantic salmon) and longlines (mussels and seaweed). Correct siting of farms is crucial in the initial setting up of a fish farm. Careful consideration must be given to a whole variety of listed conditions including the location of the farm in relation to **Special Areas of Conservation** (SACs) and **Special Protection Areas** (SPAs). Other considerations include local tides, currents, bathymetry, visual impact, marine mammals, seabirds and other marine users.



Farming of any species of animals (cattle, sheep, pigs, poultry) where large numbers of animals are concentrated in a relatively small space carries the risk of disease incidence. To keep his animals as healthy as possible a fish farmer works closely with a fish vet. The sea louse is natural parasite of Atlantic salmon and sea trout. There are a number of highly effective treatments for sea lice, not least being the use of **cleaner fish**, wrasse and lumpfish which are being increasingly used on Norwegian, Scottish and Irish salmon farms.

In order to prevent the escape of farmed fish the pens must be able to withstand winter storms. Escaped animals can sometimes establish **feral** populations. For example small populations of the Pacific oyster, *Crassostrea gigas* are now established in several large estuaries such as Lough Swilly, Lough Foyle and the Shannon estuary.

In 2013 the contribution of aquaculture to the world total fish production was 43.1%, up from 42.1% in 2012. It was only 30.6% in 2003.

Carnivorous fish such as salmon need large amounts of fishmeal and oil as food. This food includes small oil-rich **pelagic** fish. Each kilogram of salmon requires about 1.3 kg of feed. However, many farmed species are herbivores. Globally, aquaculture uses about half a kilogram of wild whole fish to produce one kilogram of farmed seafood, and so aquaculture is a net producer of protein.

Interbreeding is also a potential problem which can lead to a reduction in **gene pool strength** if the escapees mate with wild populations. A long-term study in Co. Mayo found that 'hybrid' Atlantic salmon had much lower survival rates than pure wild fish.

Employment and economic contribution of aquaculture

Aquaculture production in Ireland in 2015 was worth €149 million (first point sale value). The sector employed 1,841 people on 280 production units.

There is great scope for expansion and it is expected that by 2020 there will be a significant increase in volume of aquaculture harvests. These increases are expected to come from both conventional aquaculture and a new deep sea salmon farming initiative. It is estimated that every seventy tonnes of extra production results in one new job. Over 80% of aquaculture occurs on the western seaboard so it is important in maintaining communities in these areas which are subject to emigration.

BIM is the Irish State agency responsible for developing the Irish seafood industry. It was established under the Sea Fisheries Act 1952.

BIM's mission is to grow a thriving Irish seafood industry; expand the raw material base, add value and develop efficient supply chains that together deliver on the Government's Food Harvest 2020 targets for seafood and create sustainable jobs

We help to develop the Irish seafood industry by providing:

- technical expertise
- business support
- funding
- training and
- by promoting responsible environmental practices.

The industry contributes about €700 million annually to national income and employs 11,000 people, mainly in coastal counties from Donegal to Louth.

The four main activities in the Irish seafood industry are covered by:

- Fishing – The top fishing ports in Ireland are Killybegs, Castletownbere, Dingle, Dunmore East and Kilmore Quay, but fishing vessels also land into numerous small ports around the coast.
- Fish farming - Aquaculture activity includes growing finfish, such as salmon and trout and shellfish farming, including the cultivation of mussels, oysters and scallops.
- Processing - Seafood companies produce high value products from salmon, whitefish, shellfish and pelagic fish species (e.g. herring, mackerel and horse mackerel) all of which generate substantial export earnings to the sector.
- Marketing - Irish seafood is sold at home (€340 million) and in international markets (Europe, Africa and the Far East) where exports are valued at €375 million.

BIM's clients are fishermen, fish farmers, processors and anyone involved in marketing Irish seafood. But BIM also works with students, educators, the media, seafood consumers and the general public to spread the word about the quality and potential of the Irish seafood industry.

BIM offers a range of training programmes for the Irish Fishing Industry. Training programmes include: marine engineering, radio, safety and aquaculture. The training programmes are accredited by the Department of Transport, Tourism & Sport & Quality and Qualifications Ireland. BIM has five training centres in Ireland and entry to BIM's training courses is directly to their colleges, as BIM is not part of the CAO system.

For further information visit: www.bim.ie

Find this and other lessons on www.sta.ie

Syllabus References

The main syllabus references for the lesson are:

Leaving Certificate Biology

- The syllabus should enable students, as future citizens, to discuss and make judgements on issues in biology and science that impact on their daily lives and on society. (p. 2, Introduction)
- The Scientific Method (p.7)
- The Characteristics of Life (p. 8)
- General Principles of Ecology (p. 11)
- Human Impact on an Ecosystem: Pollution; Conservation: Outline of any one practice from one of the following areas: agriculture, fisheries, or forestry. (p. 11); Study of an Ecosystem (p. 13)
- Nutrition (p. 9); Balanced diet (p. 34)

Science and Technology in Action is also widely used by **Transition Year** classes.

Learning Outcomes

On completion of this lesson, students should be able to:

- distinguish between fishing and aquaculture
- outline the role of hatcheries in the production of immature organisms for restocking
- distinguish between finfish and shellfish and the methods used to produce them
- outline the main challenges facing Irish aquaculture
- describe the economic importance of aquaculture to the Irish economy in terms of food, employment and income.

General Learning Points

These are additional relevant points which are used to extend knowledge and facilitate discussion.

- Wild species can be bred and reared successfully in captivity if the right conditions are provided.
- ECOPACT is designed to bring about the adoption of Environmental Management Systems in the Irish aquaculture industry.
- There are two types of containment systems; namely open and closed. Each has advantages.
- Although salmon farming is the largest aquaculture sector in Ireland, cultivation of oyster and mussel is also significant.
- Good management and careful environmental monitoring reduce the risk of permanent damage to the ecosystem.
- Processing of harvested species adds significantly to the economic value of aquaculture.
- The location of aquaculture can lead to increased economic prosperity in an area and provide social stability.

Student Activities

- Find out more about open and closed containment systems. Make a list of the advantages and disadvantages of each.
- Investigate the variety of species farmed in Ireland and the areas where they are farmed. In each case find out how much the culture of each species is worth to the Irish economy.
- Select a species that is farmed using aquaculture in Ireland and study its life cycle.
- Make a study of the countries where the various species are exported to and the quantities involved.
- Outline what is meant by 'ecologically based management'.
- Investigate the types of organisms that can survive in the anaerobic conditions of the sulfide producing mud.
- Make a poster showing the life cycle of one of the following: mussel, gigas oyster, sea urchin.
- Investigate how eggs of a named species used in aquaculture are collected and fertilised.
- Some fish farmed in Ireland are carnivores and some are herbivores. They all need to be fed large quantities of food. Investigate what food is fed to a particular species and how it is produced or obtained.

True/False Questions

- | | |
|---|-----|
| a) Fishing is a form of aquaculture. | T F |
| b) Aquaculture is worth over €100 million to the Irish economy each year. | T F |
| c) Closed containment systems do more damage to the environment than open systems. | T F |
| d) Parasites cause more problems in dense populations. | T F |
| e) Invasive species displace native species. | T F |
| f) The Pacific oyster can become an invasive species. | T F |
| g) Sea horses are cultivated in Ireland. | T F |
| h) Fish faeces are good for the sea bed and encourage plant growth. | T F |
| i) Epizootics are thought to decrease wild populations of salmon and trout. | T F |
| j) Interbreeding of escapes with wild populations increases the gene pool strength. | T F |
| k) Most Irish aquaculture occurs on the western seaboard. | T F |

Check your answers to these questions on www.sta.ie.

Examination Questions

Leaving Certificate Biology (HL) 2004, Q. 5

- (a) What is meant by pollution?

Give an example of a human activity that results in the pollution of air or water.

Suggest a means of counteracting this pollution.

- (b) Explain conservation in relation to wild plants and animals.

Suggest two reasons for conserving wild species.

State one conservation practice from agriculture or fisheries or forestry.

Leaving Certificate Biology (HL) 2011, Q. 10 (a)

- (i) Distinguish between contest competition and scramble competition by writing a sentence about each.
- (ii) Name a factor, other than competition, that controls wild populations.

Leaving Certificate Biology (HL) 2012, Q. 11 (b)

Organisms that are introduced into new environments outside their natural ranges are referred to as exotic species. In some cases these introductions have been deliberate and in other cases accidental e.g. when a species kept in captivity in a new country escapes and gives rise to a wild population.

Worldwide, the great majority of deliberate attempted introductions have been unsuccessful.

- (i) Suggest a reason for attempting to establish an exotic species in a new country.
- (ii) Suggest two reasons why the great majority of attempted introductions have been unsuccessful.
- (iii) Use your knowledge of the life cycle of flowering plants to suggest how an exotic plant may escape from captivity.
- (iv) Use the knowledge that you have gained in your studies of ecology to suggest how the introduction of an exotic species may impact negatively and positively on an existing community.
- (v) It has been stated that an exotic species has a good chance of becoming established in a new environment if there is a vacant niche. Explain the term niche in this context. Do you agree with the above statement? Explain your answer.

Leaving Certificate Biology (OL) 2007, Q. 10 (b)

Answer the following questions in relation to a marine food web:

Name a producer. What does the animal plankton feed on?

What feeds on the animal plankton? Why are periwinkles referred to as primary consumers?

Starting with a producer, complete a food chain with four trophic (feeding) levels, naming each organism involved.

Did You Know?

- The table (right) shows the aggregate value in 2015 of various aquaculture sectors for four counties: Clare, Cork, Donegal and Galway.
- Nationally the total value of Irish aquaculture in 2015 was €149M — and increase of €33M over the previous year. This increase was mainly in the salmon sector. Sea production has recovered from under 10,000 tonnes (worth €58m) in 2014 to over 13,000 tonnes (worth €90M) in 2015.

| | |
|------------------|-------------|
| Salmon | €75,723,585 |
| Gigas Oyster | €12,880,465 |
| Smolt/parr/ova | €6,686,158 |
| Rope Mussel | €5,297,857 |
| Native Oyster | €1,504,000 |
| Freshwater Trout | €341,910 |
| Scallop | €222,000 |
| Abalone | €150,000 |
| Hatchery Gigas | €45,000 |
| Seaweed | €35,000 |

Biographical Notes

Jan Feenstra 1959 –

Jan was born in the Netherlands (1959) and moved to Ireland with his parents in 1974 where he entered St. Columba's College, Dublin. During his final years at school, he decided that Third Level education was not for him and obtained an apprenticeship on a trout farm in 1978.

After a few years he realised that he would benefit from a third level degree. He enrolled at TCD where he obtained a first class degree in Zoology (1983) and graduated top of his class. He specialised in Limnology (freshwater snail biology). Within days of graduating he was offered a job with Marine Harvest, Donegal. He is now its Managing Director.

Marine Harvest is the largest seafood company in Ireland, employing 275 staff and specialising in organically reared salmon.

Jan believes that Ireland has huge potential as a seafood producer, but is stifled by outdated and cumbersome regulations. He says the industry needs bright young science graduates who are at ease in remote coastal communities.

Revise The Terms

Can you recall the meaning of the following terms? Revising terminology is a powerful aid to recall and retention.

agriculture, added value, alien, aquaculture, benthic, conservation, containment system, echinoderm, ecosystem based management system, epizootics, eutrophication, exoskeleton, feral, finfish, fishing, gene pool strength, genetically modified, hatchery, invasive, novel species, parasite, pelagic, seaweed, shellfish.

Check the Glossary of terms for this lesson on www.sta.ie