Sperm, from as many males as possible, is added to the egg suspension until approximately 10 sperm per egg is seen when viewed under the microscope. After about 20 minutes the eggs are carefully washed in a 60μm sieve. Three 1ml samples are taken from the 10L concentrated egg suspension and all the eggs are counted to estimate the total number of eggs in the container. When all the eggs are washed and counted they are divided equally into clean 10L containers until a single layer of eggs is formed on the bottom of each container. They are topped up with U.V. cartridge-filtered water and are left undisturbed to await hatch-out. Two or three hours after fertilization a sample of eggs is taken from the bottom of the containers and fertilization rates are calculated, which are usually in excess of 90%.

Larval Rearing

At 17°C hatch-out usually occurs within 20 hours and larvae are seen swimming in the water column close to the surface. When most of the trochophores have hatched they are gently decanted into 300L PVC larval rearing tanks, containing U.V., cartridge-filtered seawater (to 1μm). The larval tanks are not aerated, and remain in the dark for the next 15-20 hours until they develop to the operculate stage. At this stage the larvae are siphoned onto 60μm sieves and washed carefully. The larval tanks are washed thoroughly with hot fresh water before being refilled with fresh seawater. The larvae are then decanted back into the tanks. This procedure is carried out daily until the larvae are ready for settlement.

Settlement

Settlement usually occurs on day 5 when the larvae are well developed and can be seen crawling, when viewed under the microscope. Ten to 12 days before larvae are ready to settle, the tanks are prepared. The settlement tank consists of a 2500L raceway made from PVC-coated white polyester fabric manufactured by Fastank Engineering commonly referred to as "Fastanks". Each tank contains 240 collector plates of square 40x40cm corrugated clear perspex. Diatoms are encouraged to grow on the plates by adding nutrients - sodium nitrate ($Na\ NO_3$), and sodium metasilicate ($Na_2\ SiO_3$) to the seawater on a daily basis. Seawater in the tank is changed daily and aeration is provided through 1/2" wavin piping at the base of the tank. To encourage rapid settlement the amino acid GABA is added to the tank just before the larvae are introduced. This chemical induces larvae to settle within 24-36 hours and has been used successfully with both species of abalone at the SRL.

One of the main problems encountered at settlement is that settlement is not uniform within the tank. Some plates receive a heavy settlement of larvae while others can receive very low numbers. Heavy settlement can lead to over-grazing at an early stage, usually within 6-8 weeks and unless the diatom coating is replenished, mortalities will occur. This problem is partly relieved by adding *Tetraselmis suecica* to the tanks but it is not always successful, as *Tetraselmis* is a free swimming algae and any coating achieved only lasts 2-3 days at most.

Nursery System

When the spat have reached a mean shell length of 4-5 mm, which takes about 3 1/2-4 months during the growing season, they are transferred to the nursery system where they are introduced to a macroalgal diet consisting mainly of *Palmaria palmata* and *Ulva*. The nursery consists of a 3m Fastank described earlier. The tank contains 24 columns made from 16' wavin. The bottom of the column is covered with 2mm mesh and water is pumped through each unit by an airlift pump made from 3/4" wavin piping. The tank receives a constant flow of fresh seawater. The advantage of this system is that it is easily maintained and the spat are in direct contact with the seaweed at an early stage. Spat remain in this system until they reach a shell length of 12-15mm at which stage they are ready for ongrowing at sea sites or in land-based systems.

At present there are two companies attempting to ongrow abalone on a commercial scale in Ireland using longline and bottom culture techniques tried and tested at the Shellfish Lab. Ongrowing trials with both species of abalone are also taking place in Inis Oirr, one of the Aran Islands, in a land-based system, and results are very encouraging to date.

Enhancing Digestion in Marine Snails and Echinoderms by Exposure to Specific Food Sources

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While searching for enzymes for seaweed cell wall degradation we noticed that although grazers are selective in their diets, shifts in feeding can be forced. In many cases the ability of an organism to consume a less-than-preferred food improved with time of exclusive exposure to the less-desirable food source. Data collected on an herbivorous marine amoeba in culture, and tank-maintained abalone, urchins, turban snails, and sea hares, indicated that specific enzymatic activities such as alginase, agarase, fucanase, carrageenase, and cellulase, were positively correlated with the exposure time (days) of the animal to that seaweed exclusively. On several occasions of such forced feeding, although the animals consumed the seaweed, the weight gain of the animals was minimal, or even negative (i.e. weight loss). The degradative state of seaweed pieces in the feces of these animals correlated well with changes in the animals' weight. Gut content and even feces of animals which were fed on preferred seaweeds, and repeatedly gained weight contained large numbers of protoplasts and generally disintegrated plant tissue, with a larger percentage of loose cuticles. Some of the offered seaweeds were not ingested. Of the less desired seaweeds, some of those that were torn while ingested passed through the intestine but were hardly degraded. This was true even in cases where specific enzymatic activities did increase during exposure to the specific food source.

Table I presents a summary of weight gain, seaweed tissue degradation state, and the presence or absence of protoplasts in *Aplysia* main stomach five days after feeding with various seaweeds. It was interesting to find that *Gelidium*, which was ingested but did not seem to be digested, maintained the weight of the animals over the three weeks of the feeding session. In comparison, *Macrocystis*, which was ingested actively, seemed mostly degraded in the stomach, and even released protoplasts, did not support growth and the animals lost weight on this diet. Crude enzyme extracts from the stomach juices of these animals when fed on *Ulva, Porphyra, Gigartina,* and *Macrocystis*, produced large numbers of healthy protoplasts when applied to tissues of the same fed seaweed.

Aplysia californica
(++=Consistent gain; +=some gain; 0=no gain; --=loss)

Seaweed fed	Weight gain	Tissue in feces	Protoplasts
Ulva	++	degraded	++
Porphyra	++	degraded	++
Gelidium	0	mostly not degraded	--
Gracilaria	+	some degradation	few
Gigartina	++	mostly degraded	++
Macrocystis	--	mostly degradation	++
Sargassum	--	not degraded	--

Table II presents similar data from the feeding of the large marine amoeba *Trichosphaerium I-7* (Polne-Fuller, 1987). Here the amoeba grew and divided best on *Macrocystis, Pophyra*, and *Gigartina*. Over time the amoebae did adapt to grow and divide nearly as well on *Sargassum* blades and vesicles, on *Gracilaria*, and even on the young tips of *Gelidium*. Feeding was always easier for the amoebae if the seaweeds were pre-boiled.

***Trichosphaerium* I-7**
(++=fast growth and cell divisions; +=survival; --=not eaten)

Seaweed fed	Growth & Division	Tissue in feces	Protoplasts
Ulva	+	partly degraded	+
Porphyra	++	degraded	++
Gelidium	0	not degraded	--
Gracilaria	+	some degradation	+
Gigartina	++	mostly degraded	++
Macrocystis	++	degraded	++
Sargassum	--	not degraded	--

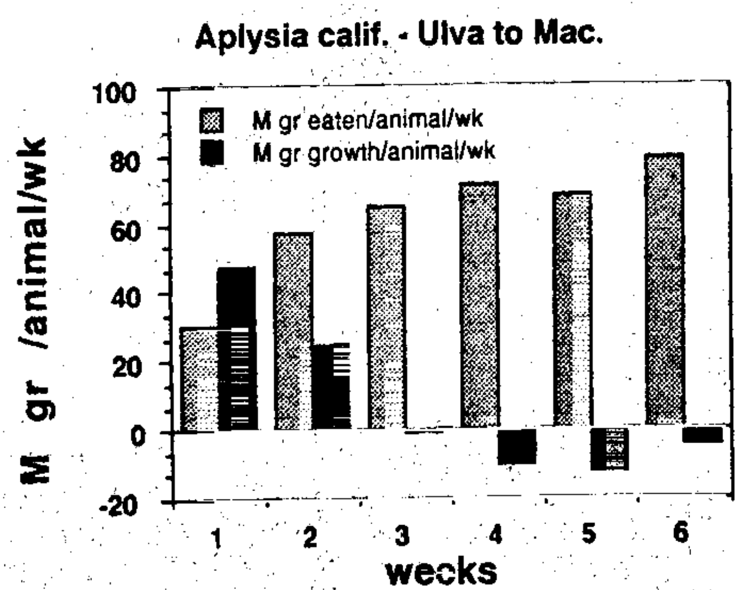

Figure 1 presents the intake of Macrocystis *by* Aplysia californica *and the weight changes of thses* Aplysia *during the 6 weeks of the experiment. Note the loss of weight during the 4-6 weeks in spite of the continuous ingestion of the seaweed. The* Aplysia *did die of starvation after about 10 weeks if diets were not changed.*

Reference:

Polne-Fuller, M. 1987. A multinucleated marine amoeba which digests seaweeds. *J. Protozool.* 34:159-65.

Abalone, Sea Urchins and Stocked Lobsters: An Income Supplement for Inshore Shellfish Fishermen.

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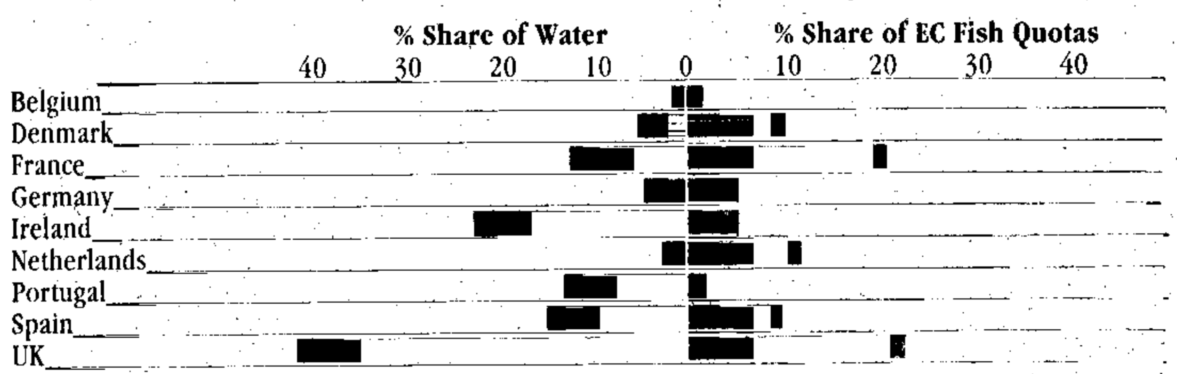
Abalone, sea urchins and lobsters are newcomers to the shellfish cultivation scene in Ireland. Mussels and oysters are the main species grown around the coast, while scallops and clams are also of some importance. The following figures give an idea of scale for the seafood sector in Ireland. The first-sale value of shellfish aquaculture in 1991 was Ir£6 million from a 27,700 tonne production. The value of salmonid production was significantly greater than this at Ir£33.5 million for 10,705 tonnes, (9,300 tonnes of farmed salmon and 1,405 tonnes of trout). The total exports of fish and fish products from the Republic of Ireland in 1991 was 175,000 tonnes, valued at Ir£175.2 million.

BIM (An Bord Iascaigh Mhara, the Irish Sea Fisheries Board) is the government-funded agency charged with the overall development of the Irish seafood sector. BIM was established under the Sea Fisheries Act, 1952, and was initially involved in developmental, as well as commercial activities. It was reorganised to have a purely developmental role in 1964. This was the time of President John F. Kennedy, and following a meeting with the Irish Taoiseach (Prime Minister) Lemass in 1963, a bilateral co-operative fisheries project was established. As a result, an American survey team from the Bureau of Fisheries, US Department of the Interior, visited Ireland and made a series of recommendations, which resulted in the new approach at BIM. The shellfish development programme, involving management and private farming of oyster, mussels and clams, commenced properly at this time. BIM has a track record of almost 30 years in this area. At present, aquaculture development is a high priority issue. A new Aquaculture and Planning Division was set up in 1989.

The latest plan for aquaculture development in Ireland, "Job Creation in the Aquaculture Sector: Programme for Development 1993-'97," is presently being launched in Dublin by the Minister for the Marine, Michael Woods.

The small percentage share of the European Communities' (EC) fish quotas allocated to Ireland versus our large share of marine waters can be seen in Fig 1. Against the background of serious constraints being put on the future

Member States EC Fish Quotas*



*Fish Quotas are shown in terms of cod equivalent (Tonnes)

Figure 1

development of sea fishing, with restrictions on fleet tonnage, by the EC's Common Fisheries Policy, aquaculture is one area with scope for expansion. This is particularly the case with shellfish cultivation, which has less environmental impact than finfish farming. The plan aspires to create 1,140 new jobs in aquaculture, with some 569 of these involving Ir£13 in investment created in the first two years. The Ir£46 million investment plan is to be funded by some Ir£26 million from the private sector, Ir£9million from national government and Ir£11 million from the EC. The bulk of this development is in the shellfish area and a focus on partnerships with coastal communities. Projected increase in aquaculture output is shown in volume terms, Fig 2 and in value terms, Fig. 3.

Figure 2

Projected Aquaculture Outout
1991-1997 Tonnes

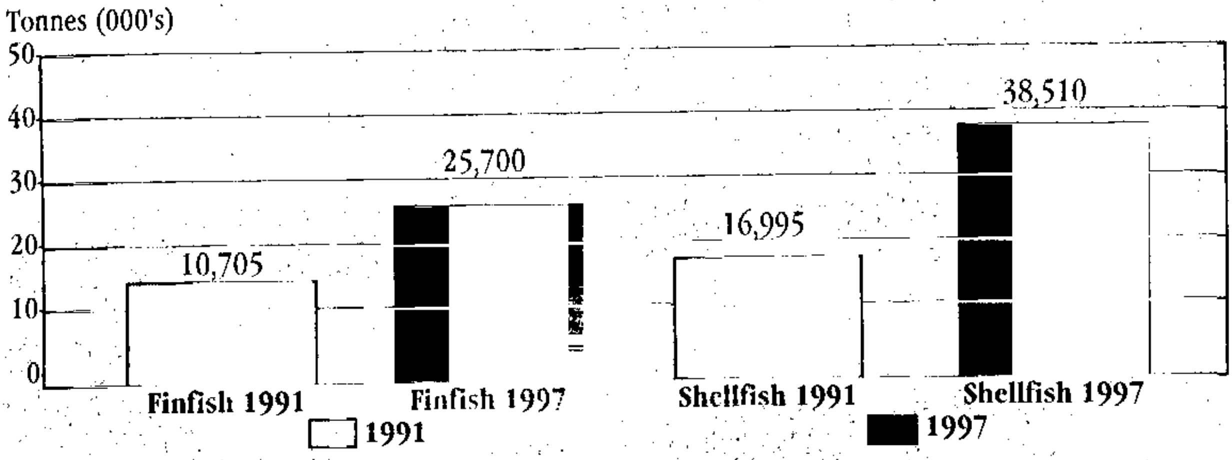
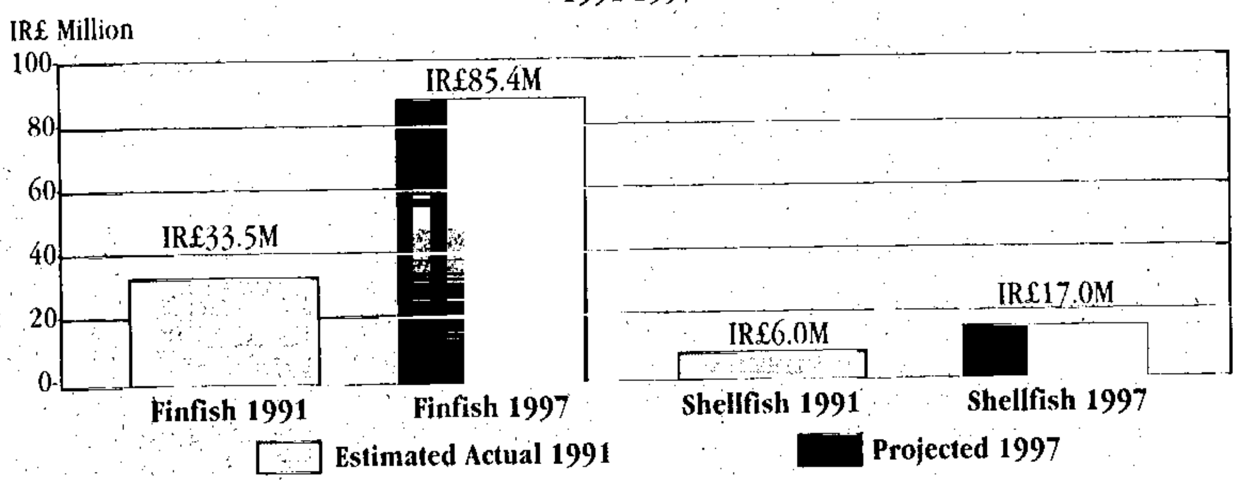


Figure 3

Projected Aquaculture Output
1991-1997



Novel Shellfish Species

A specific measure for the shellfish area over the next five years concerns abalone, lobster and sea urchin, which have not traditionally been cultivated here. Our aim at BIM is to work with fishing co-ops and individual inshore fishermen around the coast in bottom up development with regard to the ideas and approaches necessary to make these species viable alternatives to overfished species. Salmon fishing is in serious decline for various reasons, and the switch to cultivation and management of the above species can assist diversification away from salmon and other non-sustainable fishing activities.

It is hoped that this measure will play a part in providing employment in fishing communities and help to maintain them intact. The adoption of this activity, which can link well with the skills and hardware already available on the coast, should also serve to bridge a gap between fishing and aquaculture, overall. Intensive cultivation of mussels and oysters is a specialist activity often carried out by former "landlubbers" or newcomers to an area. The cultivation of these novel aquaculture species fits the definition of extensive aquaculture, and has more in common with traditional fisherman.

These novel species have the added advantage of being niche products that enjoy a very high market value in Europe. The demand is usually in excess of available supply. As the standard of living continues to rise, the projections are that this end of the seafood spectrum will have an even greater market appeal.

Recommendations of U.S. experts have been followed in regard to the strategic focus of fisheries development in Ireland over the past 30 years, and BIM is still open to adopting sound advice from our neighbours across the Atlantic. It is pleasing to acknowledge that in recent times the level of scientific back-up for the shellfish cultivation sector has increased enormously in Ireland vis a viz the early '60s, and I would like to pay tribute to our host institution, University College Galway, whose contribution has been paramount in this area.