Evaluation of Deep Water Fish Species

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Interest in sourcing high quality non-quota fish species continues to increase as fish quotas tighten and traditional whitefish stocks decline. Quality aspects of one such species, silver smelt *(Argentinus silus)*, were examined in an article in *Farm and Food*, October-December 1991. This work has now been extended using spot samples of a further six deep water, non-quota species caught in the Atlantic off the north west coast of Ireland. The tests, which will continue on an annual basis, are a co-operative effort between staff at The Fisheries Research Centre and The National Food Centre.

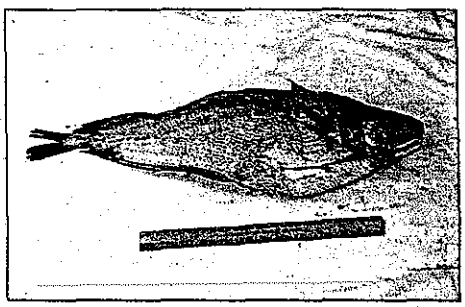
The six species evaluated were Bairds smoothead *(Alepocephalus bairdii)*, blue ling, *(Molva dypterygia)*, black scabbard *(Aphanopus carbo)*, rabbitfish *(Chimaera monstrosa)*, roundnose grenadier *(Coryphaenoides rupestris)* and greater forkbeard *(Phycis blennoides)*. Details of catching, procurement and fish characteristics are reported from The Fisheries Research Centre, while tests for proximate analysis, water holding capacity, gel strength, and colour were carried out at The National Food Centre using samples which were blast frozen at sea.

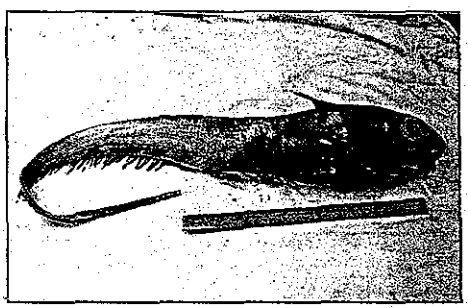
Background and procurement

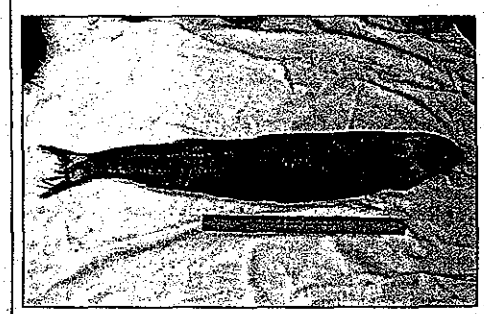
The Fisheries Research Centre is responsible for monitoring the status of marine fish stocks around the Irish coast. Scientific data are compiled annually and are then combined with other international data to assess the various fish stocks. This information is used by the EU in the annual negotiations on total allowable catch and on quotas for the traditional fish stocks (e.g. cod, whiting, haddock, mackerel). In recent years, against a background of traditional whitefish stock decline, there has been a growing interest in the exploitation of the deep water fisheries resources off the west coasts of Ireland and Scotland. This new fishery may help divert fishing effort, particularly by the larger vessels, away from the traditional stocks and so ease pressure on their exploitation. France has established a commercial deep water fishery within the last five years while Icelandic, Faeroes and Norwegian vessels are also developing deep water fisheries in the northern waters of the Atlantic.

In order to exploit a sustainable and renewable fish resource, it is essential to have information on the biology of the species, so that any effective management measures which are introduced will have a scientific basis. Very little is known about the biology of these deep water fish and because the species are long lived (up to 70 years) there are concerns that they may be vulnerable to overfishing. The Fisheries Research Centre has been involved in several projects on the biology of the deep water silver smelt and in 1993, using funding provided by the EU STRIDE programme, commenced a deep water research programme aimed at establishing the age, growth, reproductive and dietary characteristics of potentially commercial species.

In order to secure adequate samples, two sampling surveys were carried out in the deep waters (400-1,200 m) of the continental slope, off the west coasts of Ireland and Scotland. The surveys were carried out on board the Killybegs trawler the 'FV Mary M', one of the most modern trawlers in the Irish fleet and a vessel with the required nets and winch capacity to fish at depths in excess of 1,000 m. The surveys were carried out over a two-week period in April and a two-week period in September 1993. A selection of fillets from various deep water species were taken in the September survey and were blast frozen at sea for testing at The National Food Centre. This centre carries out research, development, service and training activities for the Irish food industry and has a significant programme on fish quality and fish products.







The non-quota fish species greater forkbeard, grenadier and smoothead may have potential for the manufacture of a wide range of fish products.

Ireland is in a unique position to exploit this deep water resource, but in order to establish a viable fishery, several avenues need to be explored and investigated. One is the establishment of stable markets for these deep water species; an essential prerequisite for this is the evaluation of the quality and properties of the fish flesh.

Characteristics of the fish

Most present day commercial fishing in the eastern Atlantic is conducted in water less than 300 m deep, on the continental shelf. The main fish targeted are the traditional species such as cod, haddock, whiting, hake, monk, megrim, plaice, sole, herring and mackerel. Deep water fisheries are those areas of the sea above or beyond the continental slope, generally at depths in excess of 400 m. The deep water fish species were previously thought to live in a relatively constant dark environment but recent work has shown that there are considerable seasonal changes in the deep water environment.

The roundnose grenadier have a tapering body shape, from a large head and trunk to a whip-like tail. They range in distribution from Newfoundland, Greenland, Iceland and Norway to the Bay of Biscay. This species is most abundant in the depth range 400-1,500 m and feeds on large crustaceans, squid and finfish; they spawn in spring and autumn. Specimens have been aged at up to sixty years old (compared with eight years for Irish sea cod) and they are thought to reach sexual maturity at twelve years of age (three years for Irish sea cod). Blue ling occur in deep water, usually 350 to 500 m, and are rarely longer than 130 cm. They feed on crustaceans and finfish, and spawn in spring. They are distributed from Iceland, Norway and the Bay of Biscay to the Mediterranean. Greater forkbeards are widely distributed, from Iceland and Norway to the Mediterranean. They occur in the depth range 150-700 m, spawn in early summer and feed on crustaceans and fish. They rarely exceed 68 cm. Black scabbard have an extremely elongated and compressed body form and are fast-moving, active, predatory fish which may reach 130 cm. They range in distribution from eastern Greenland, Iceland and Norway to Madeira and to western North Africa. They feed on crustaceans and fish and are thought to spawn throughout the year. Like the ray and shark species, rabbitfish are cartilaginous and have a body form greatly tapering from a large head and trunk to a whip-like tail. They are common in the depth range 300-500 m and are regarded as sluggish fish, feeding mainly on bottom-living invertebrates. They lay egg capsules in spring and summer and are distributed northwards from the Mediterranean to Iceland and Norway. Bairds smootheads form dense spawning shoals and occur in the depth range 650-1,700 m. They feed on crustaceans, crabs, tunicates and fish. They range southwards from Greenland and Iceland to the Bay of Biscay.

Proximate analysis

The results (Table 1) show that Bairds smoothead had a very high water content and consequently a low protein content. Black scabbard had the lowest moisture level but the highest fat content. Rabbitfish and greater forkbeard both had protein contents in excess of 20%. All the samples, with the exception of black scabbard had low to very low fat contents. Overall composition compared favourably with silver smelt and cod, with the exception of Bairds smoothead.

Water binding

The ability of fish tissue to bind and hold water is of major significance in the production of fish products, and tests were carried out on pieces of fish fillet or on mince and also on fish gels.

The data for fillets were obtained by thawing (at room temperature) weighed fish pieces and centrifuging at 500 g for 10 minutes. The extent of water loss as expressed by this procedure was determined, with highest values indicating the poorest water-binding properties. Comparisons were also made with other fish species (Table 2). In an extension to these tests the ability of thawed fish mince (100 g) to hold added water (200 g) was tested under similar centrifugation conditions (Table 3). This was achieved by blending the fish with the water to give a thick puree; a weighed aliquot of this was then subjected to centrifugation.

TABLE 2: Water loss from thawed fish pieces

Species	Water loss (%)	Rank order
Smoothead	74.9	6th
Blue ling	36.7	3rd
Black scabbard	35.8	2nd
Rabbitfish	34.1	1st
Grenadier	43.5	4th
Forkbeards	46.0	5th
Silver smelt	36.1	–
Cod	24.6	–
Pollock	19.0	–
Ling	19.8	–

TABLE 1: Proximate analysis for fillets of non-quota deep water fish species

Species	% Water	Protein	Fat
Smoothead	90.8 (6th)[1]	6.4 (6th)[1]	1.8
Blue ling	81.0 (4th)	19.4 (3rd)	0.1
Black scabbard	74.1 (1st)	18.7 (4th)	7.0
Rabbitfish	80.3 (2nd)	20.1 (2nd)	0.3
Grenadier	83.6 (5th)	16.8 (5th)	0.3
Forkbeards	80.6 (3rd)	20.3 (1st)	0.1
Silver smelt	78.8	17.5	2.1
Cod ('Control')	83.9	15.6	0.6

[1]Rank order

The data for water loss (Table 2) show that all samples compared unfavourably with cod, pollock, or ling. The sample of Bairds smoothead had a particularly large water loss which is to be expected based on its moisture content. With the exception of Bairds smoothead the data for the other five deep water species were relatively similar to those for silver smelt, i.e., all of them seem to be adversely affected by freezing. This suggests that more attention should be focused on freezing methods for these species and also on the use of cryoprotectants.

TABLE 3: Weight of added[1] water held by 100 g of fish mince (thawed) after centrifugation at 500 g for 10 min.

Species	Added water (g) held by 100 g of fish mince	Rank order
Smoothead	−37.1	6th
Blue ling	53.2	3rd
Black scabbard	54.0	2nd
Rabbitfish	67.0	1st
Grenadier	43.6	4th
Forkbeards	17.6	5th
Silver smelt	28.0	–

[1]200 g of water was blended with 100 g of mince.

The data in Table 3 show the ab[illegible] of 100 g of the different fish minces to hold 200 g of added water (i.e., blended with mince). The rank order of the data for the six species in Tables 2 and 3 are identical, with rabbitfish best and Bairds smoothead least good. The latter mince did not hold any of the added water and in fact lost some of its own water on centrifugation. These data have obvious implications in the preparation of products and analogues from these fish species, i.e., good water-binding is a major priority.

Evaluation of fish gels

Gels were made by mixing fish mince (thawed) with salt and added water (used only for added water gels) in a food blender for 3 minutes at full speed. The mixture was transferred to sausage casings and cooked for 40 min at 90°C. This produced cylinders of gel 25 cm long and 4 cm in diameter. These were stored at 1-2°C and were allowed equilibrate to ambient and were cut into cylinders 20 mm long. The cylinders were compressed by 8 mm (i.e., 40%) using a shear press (ram speed 4.38 mm/sec) and were immediately subjected to recompression to measure elasticity. The cylinders were then puncture-tested using a flat end probe of 12 mm diameter which was fitted to the shear press. The probe was allowed penetrate into the gel until a maximum reading was reached. All force values were measured in Newtons (N). The colour of the gel cylinders was recorded on a Hunter colour meter fitted with a 2.5 cm specimen port.

The results for full strength gels (Table 4) indicated that forkbeards produced the strongest gel and Bairds smoothead the weakest, both in terms of compression and penetration. Rabbitfish produced the most elastic gel based on % retention values (i.e., recompression value ÷ compression value x 100). The results for gels with added water (Table 5) indicate that the black scabbard gel was strongest, the Bairds smoothead gel the weakest, and the rabbitfish gel the most elastic. The rank order for the gels with added water was slightly different to that for the full strength gels.

Gel colour data (Table 6) indicated that none of the six species was as white as silver smelt but both Bairds smoothead and grenadier were whiter than cod. Both forkbeards and black scabbard were off-white which could limit their use for fish products and analogues.

Relative quality

Relative quality was established from the laboratory tests on the six species by adding the rank orders for moisture, protein (Table 1), water loss (Table 2), water retention (Table 3), compression data (Tables 4 and 5)

TABLE 4: Compression (N), recompression (N) and penetrometer (N) values for full strength (i.e. no added water) fish gels

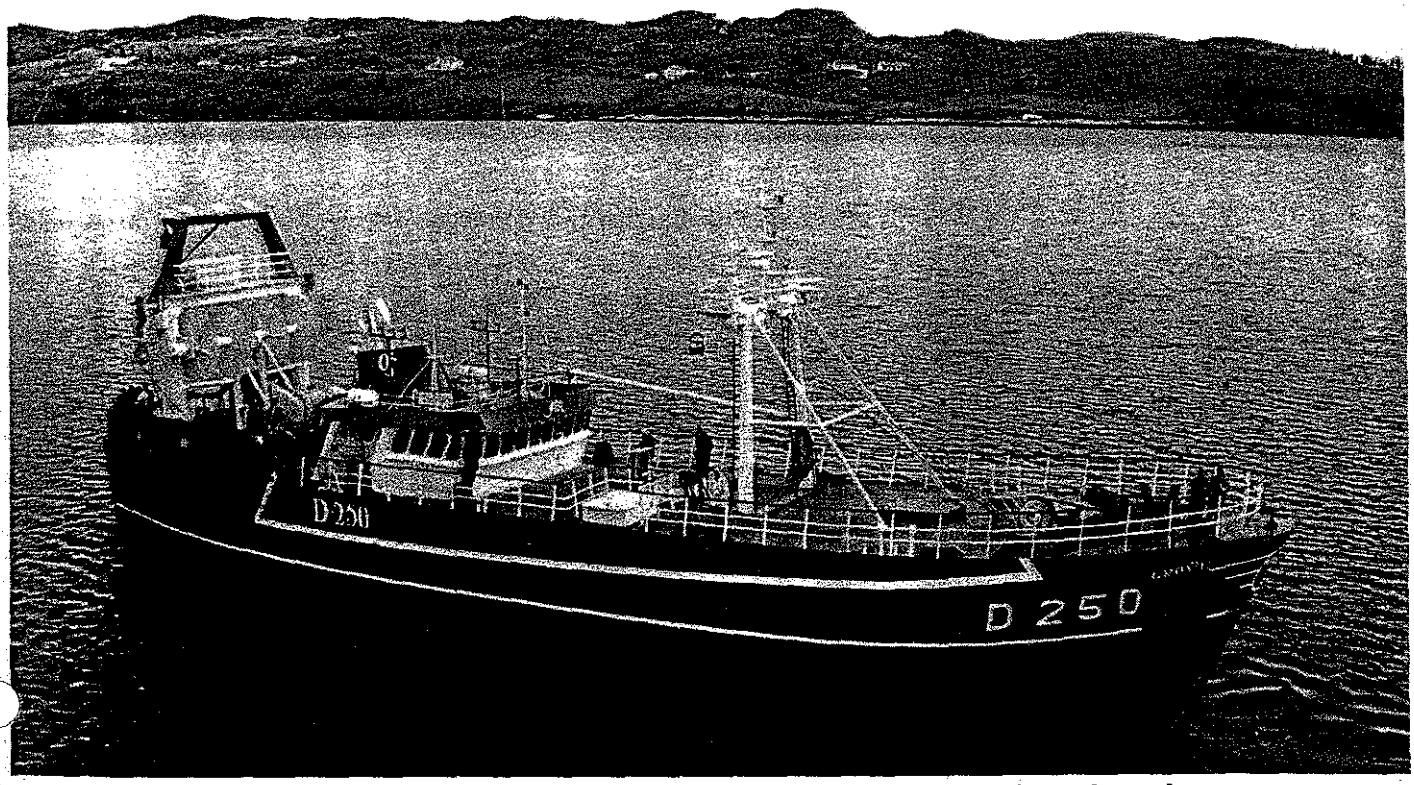
Species	Compression	Recompression	% Retention[1]	Penetrometer
Smoothead	32.2 (6th)[2]	23.6	73.3 (5th)[2]	6.7 (6th)[2]
Blue ling	109.8 (2nd)	86.4	78.7 (3rd)	19.0 (4th)
Black scabbard	86.3 (5th)	60.1	69.6 (6th)	13.4 (5th)
Rabbitfish	91.0 (4th)	82.4	90.5 (1st)	20.5 (3rd)
Grenadier	103.1 (3rd)	79.4	77.0 (4th)	21.1 (2nd)
Forkbeards	120.8 (1st)	97.8	81.0 (2nd)	29.1 (1st)
Silver smelt	92.5	–	–	24.1

[1]An index of elasticity; [2]Rank order.

TABLE 5: Compression (N) and recompression (N) values for fish gels with added water (2 parts mince + 1 part water)

Species	Compression	Recompression	% Retention[1]
Smoothead	10.1 (6th)[2]	7.4	73.3 (4th)[2]
Blue ling	37.2 (2nd)	27.2	73.1 (5th)
Black scabbard	42.4 (1st)	25.9	61.1 (6th)
Rabbitfish	29.8 (4th)	26.7	89.6 (1st)
Grenadier	23.5 (5th)	18.1	77.0 (3rd)
Forkbeards	34.7 (3rd)	29.2	84.1 (2nd)
Silver smelt	23.1		

[1]An index of elasticity; [2]Rank order.



Development of new fishing grounds will require a management plan to protect and sustain stocks.

and gel colour (Table 6), with the lowest rank sum indicating the best species and the highest sum the least good. On this basis the rank order was rabbitfish (22), forkbeards (29), blue ling (33), black scabbard (37), grenadier (37) and Bairds smoothead (52).

TABLE 6: Colour (white/yellow ratio) of full strength gels

Species	Hunter (L/b ratio)	Rank order
Smoothead	9.6	1st
Blue ling	6.8	4th
Black scabbard	5.9	5th
Rabbitfish	7.4	3rd
Grenadier	8.8	2nd
Forkbeards	5.2	6th
Silver smelt	11.2	–
Cod	8.6	–
Pollock	7.0	–
Ling	7.9	–

In terms of commercial abundance, The Fisheries Research Centre sampling surveys indicate that grenadier and black scabbard show potential for deep water trawling operations in the waters off the Donegal coast but the development of any fishery will be contingent on the emergence of a viable demand for the species. Rabbitfish was also caught in commercial quantities in the same area, but at present there is little interest in fishing this species because of low prices and low market demand. Greater forkbeards and blue ling are less abundant but could be an important by-catch (off the Donegal coast) due to the ready French market for these species. Bairds smoothead, while abundant at certain times of the year, are regarded as a nuisance catch as there is, at present, little market interest in the species.

Conclusions

- There is potential for developing an Irish deep water fishery off the west coasts of Ireland and Scotland but there is also a need to identify new fishing grounds, to experiment with new gear types and to establish a management plan that will protect and sustain the stocks.
- The 1993 sampling survey programme carried out by The Fisheries Research Centre has identified several potentially commercial species, and fishing areas, off the Donegal coast. The development of suitable markets and the evaluation of the food quality of these species is of paramount importance for the success of the fishery.
- The relative quality (best to least good) of the six deep water species examined, based on the laboratory tests, was rabbitfish, forkbeards, blue ling, black scabbard, grenadier and Bairds smoothead.
- The results for the six deep water species are based on spot samples and more extensive sampling will be necessary before definite conclusions can be drawn on the commercial potential of the species for the manufacture of fish products.
- It is envisaged that further deep water surveys will be carried out in 1994 and samples from these surveys and from any commercial landings of deep water species will be tested and will include an evaluation of the benefits of cryoprotectants.

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