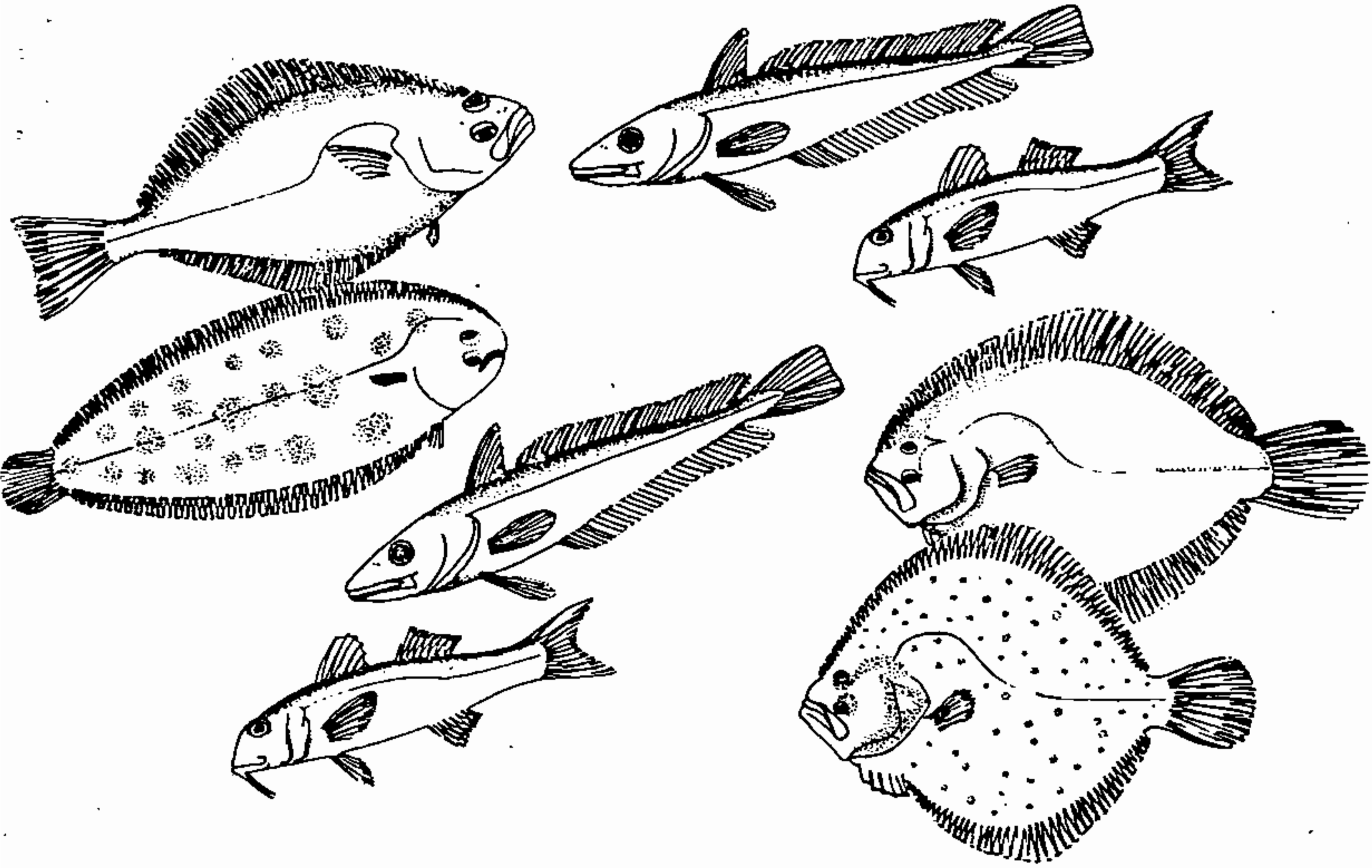
MINISTRY OF AGRICULTURE, FISHERIES AND FOOD

MARINE FISH FARMING



AN EXAMINATION OF THE FACTORS TO BE CONSIDERED IN THE CHOICE OF SPECIES

LABORATORY LEAFLET (NEW SERIES) No. 24

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CONTENTS

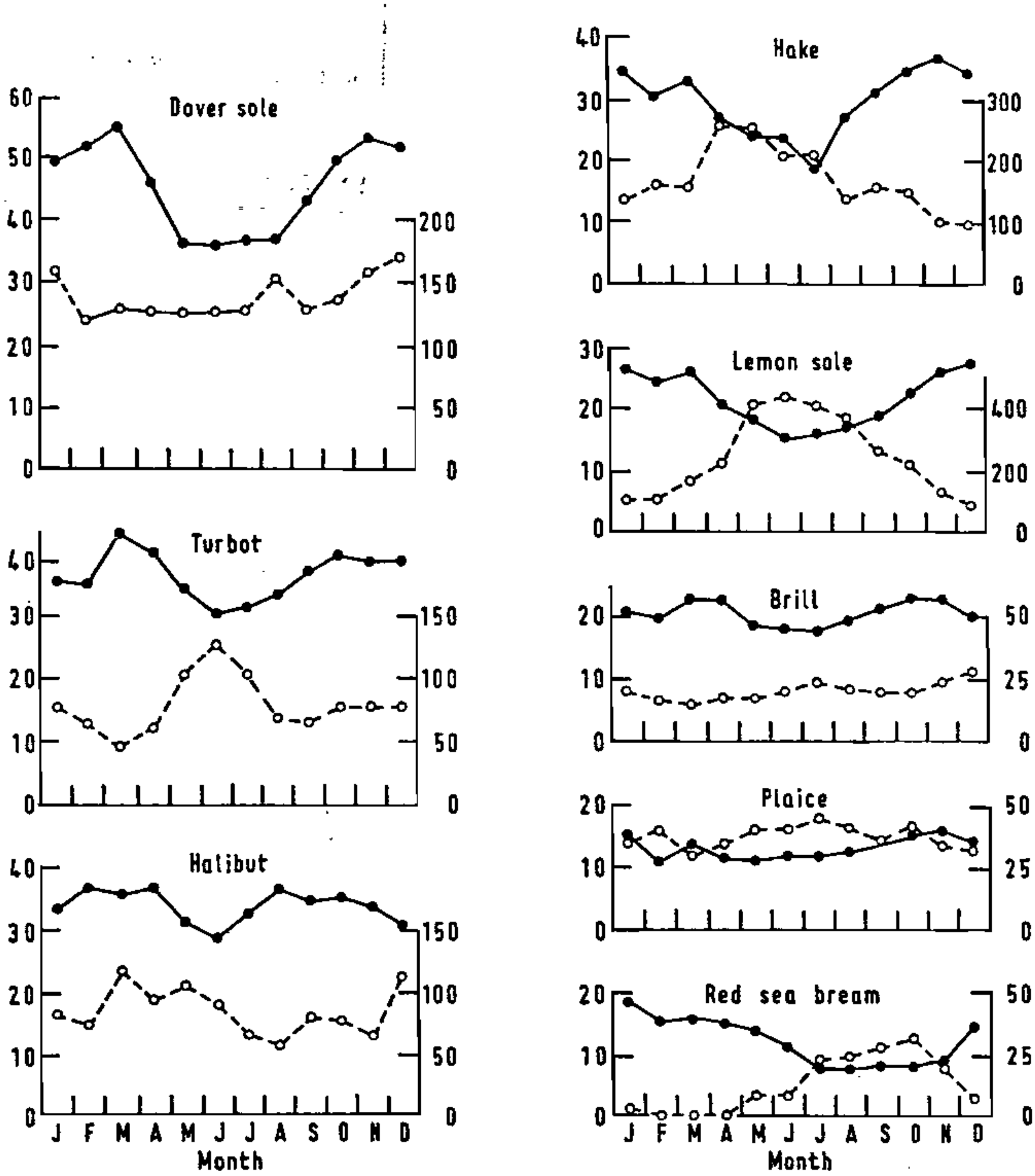

Figure 1 The monthly fluctuations in market price and landings of eight species of fish landed at ports in England and Wales. All figures are averages for the period 1967 to 1969.

●——● Value (in new pence per kg); shown on left-hand scale.

o---o Weight of fish (in metric tons); shown on right-hand scale.

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INTRODUCTION

Freshwater fish farming has been practised for centuries and today forms important expanding industries in many countries. In the developing countries fish farming supplies badly-needed protein; elsewhere, fish farming is helping to satisfy consumer demand for high-quality fishery products. Current estimates place the total annual world production from freshwater and brackish-water fish farms at around 3 million metric tons.

At present, only in Japan is marine fish farming (excluding shellfish) conducted on a commercial scale to any extent, mostly with the yellowtail (Seriola quinqueradiata). However, many countries have expended and are still expending considerable research effort in this field; for example, in the USA and Canada investigators are developing methods for the culture of Pacific and Atlantic salmon (Onchorynchus spp. and Salmo salar), common pompano (Trachinotus carolinus), and the "black cod" or sablefish (Anoploma fimbria). In Great Britain research effort has been concentrated on the marine flatfish, plaice (Pleuronectes platessa), Dover sole (Solea solea) and more recently turbot (Scophthalmus maximus) and lemon sole (Microstomus kitt). Experimental results have shown that these species can all be spawned under artificial conditions, and in the case of plaice and Dover sole large numbers of larvae have been hatched and the young fish reared and grown to marketable size. In view of these achievements it is now necessary to determine which species of fish, including those already worked on and others which have not yet been subject to scientific investigations, have the necessary attributes for commercial farming. The most important of these attributes are: (i) a high market price, (ii) a fast gain in weight on a cheap and readily available food, and (iii) ease of breeding and rearing of young in captivity. Bearing in mind these attributes and using other available data, this leaflet attempts to assess which species have most potential in the field of commercial fish farming and therefore merit further scientific investigation. The figures on costs and returns used in this leaflet relate to present knowledge and are likely to be different when marine fish farming becomes commercially practicable. The importance therefore of some of the tables is not so much in demonstrating levels of profitability but rather to highlight the most important factors which require further research and development to achieve commercial viability.

MARKET PRICE

The profitability of any fish farm will depend largely on the value of the product produced. For this reason the selection of suitable fish to farm has been based on the ten most valuable species of white fish caught around the British Isles. These are listed in Table 1 in order of value in new pence per kilogramme. The prices quoted are the mean annual first-sale prices, for the period 1969-70, of fish landed at ports in England and Wales. To demonstrate the best return which could be realized, the maximum market price attained by each species has also been included in Table 1.

Table 1 The ten most valuable species of marine fish caught in waters surrounding the British Isles

Species	Mean annual value per kg for the period 1969-70 (new pence, n.p.)	Maximum value per kg for the year 1970 (new pence)
Dover sole	58	88
Turbot	40	50
Halibut	38	51
Hake	33	42
Lemon sole	27	37
Brill	26	34
Red mullet	20	56
Grey mullet	20	25
Plaice	14	20
Red sea bream	14	23

There is a large seasonal fluctuation in the market price of fish landed at our ports. The mean monthly market prices of eight of the above species for the period 1967-69 are shown in Figure 1, together with the amount landed (grey and red mullet are omitted because of inconsistencies in the monthly data regarding landings of these two species). It is seen that price appears to be governed mainly by the amount of fish landed, although condition may also be a contributory factor. At some ports price also varies according to the size of the fish landed. This is demonstrated by the following table, which shows how the value of some species varied with size at Lowestoft during 1969:

Species	Category	Size range (cm)	Value per kg	
			shillings	new pence
Dover sole	Large	36-50 +	12.48	62.4
	Small	24-35	12.59	62.95
Turbot	Large	46-70 +	8.68	43.40
	Small	30-45	5.52	27.60
Plaice	Large	45-60 +	2.86	14.30
	Medium	35-44	3.19	15.95
	Small	25.34	2.39	11.95

The quantity of farm fish produced is not likely, initially, to be sufficient to influence prices on the market when sold in direct competition with the commercial catch. However, fish farmers may be able to benefit from the price fluctuations described above by marketing their product at a time when high prices prevail.

For example, the optimum periods for marketing the species shown in Figure 1 would be spring and autumn. The rest of this paper assumes that any fish sold from fish farms can be marketed at prices which are offered for wild-caught fish at present.

GROWTH RATE

Complementary to the desirability of a high market price is the need for rapid growth to marketable size, since this will minimize capital costs. Growth curves for the ten species listed in Table 1 have been obtained by fitting age/weight data to a theoretical growth equation; these curves are shown in Figure 2A and B for flatfish and roundfish respectively.

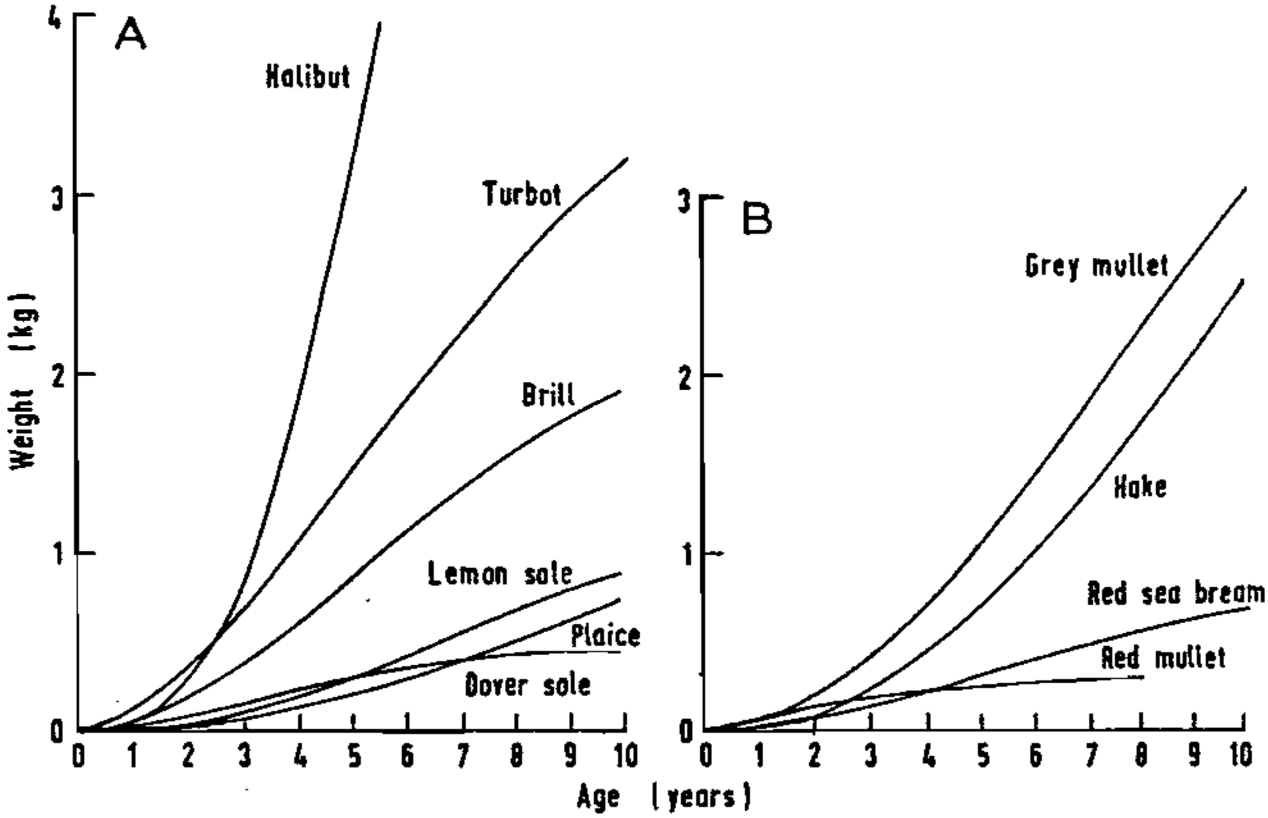

Figure 2 Growth curves for (A) flatfish and (B) roundfish.

For six of these ten species there is a minimum length below which they cannot legally be marketed. This is not so for halibut, red and grey mullet and red sea bream, and a minimum marketable size has been selected for these species on the basis of information collected from fish markets. It is present practice in freshwater farms to sell fish when they attain marketable size, or soon after. The length, weight, age and value at first marketable size of each of the ten species are shown in Table 2.

There are many factors to consider which may influence harvesting time. The market value of a fish increases as the fish grows and it is possible that it may be more profitable to crop, not at first marketable size, but at a later stage. The increase in value of each of the ten species of fish from age 2 to 6 years is shown in Table 3. In theory the most profitable age for marketing will be when

Table 2 The length, age, weight and value of each species of fish at first marketable size

Species	First marketable at			Value at first marketable size, per fish (new pence)
	Length (cm)	Age (years)	Weight (kg)	
Turbot	30	2.8	0.614	24.56
Halibut	32	2.0	0.271	10.30
Brill	30	2.9	0.373	9.70
Red mullet	25	3.9	0.220	4.40
Dover sole	24	2.7	0.124	7.19
Hake	30	2.8	0.197	6.50
Grey mullet	25	2.2	0.219	4.38
Lemon sole	25	3.7	0.180	4.86
Red sea bream	25	4.1	0.215	3.01
Plaice	25	4.0	0.139	1.95

Table 3 The value and weight of each of the ten species from ages 2 to 6 years inclusive

Species	2 years	3 years	4 years	5 years	6 years
(a) Value (new pence) per fish					
Dover sole	3.71	8.70	13.69	17.86	21.00
Turbot	14.72	27.72	42.92	58.88	74.68
Halibut	10.83	32.26	68.86	121.71	190.87
Hake	3.23	7.79	14.42	22.97	33.13
Lemon sole	1.30	3.08	5.56	8.56	11.85
Brill	4.99	10.11	16.25	22.75	29.22
Grey mullet	3.66	8.08	14.00	21.02	28.72
Red mullet	2.46	3.62	4.48	5.04	5.38
Plaice	0.52	1.12	1.97	3.07	4.34
Red sea bream	0.80	1.74	2.90	4.19	5.46
(b) Weight (kg) per fish					
Dover sole	0.064	0.150	0.236	0.308	0.362
Turbot	0.368	0.693	1.073	1.472	1.867
Halibut	0.285	0.849	1.812	3.203	5.023
Hake	0.098	0.236	0.437	0.696	1.004
Lemon sole	0.048	0.114	0.206	0.317	0.439
Brill	0.192	0.389	0.625	0.875	1.124
Grey mullet	0.183	0.404	0.700	1.051	1.436
Red mullet	0.123	0.181	0.224	0.252	0.269
Plaice	0.037	0.080	0.141	0.219	0.310
Red sea bream	0.057	0.124	0.207	0.299	0.390

the marginal costs equal the marginal returns, that is when the value of the last unit of increased output equals the value of the extra costs required to produce that last unit of output. This point will vary under different circumstances and will depend on the relation between the relative prices of inputs and outputs and various technical factors discussed below. These technical factors are: (i) the amount of food required to produce a unit of fish flesh (i.e. the food conversion ratio) increases with age (this is dealt with in more detail later), and (ii) if the fish are retained too long they will begin to mature and a proportion of the food fed will be wasted in producing eggs and milt. Fish kept beyond spawning will lose weight (particularly females, due to the release of eggs) and also quality. It is also worth mentioning at this point that there is a marked sexual difference in growth in many species of marine fish, females tending to attain greater weight at age than males. Yields may therefore be increased by farming female fish. The sexual difference in growth in turbot is shown in Figure 3.

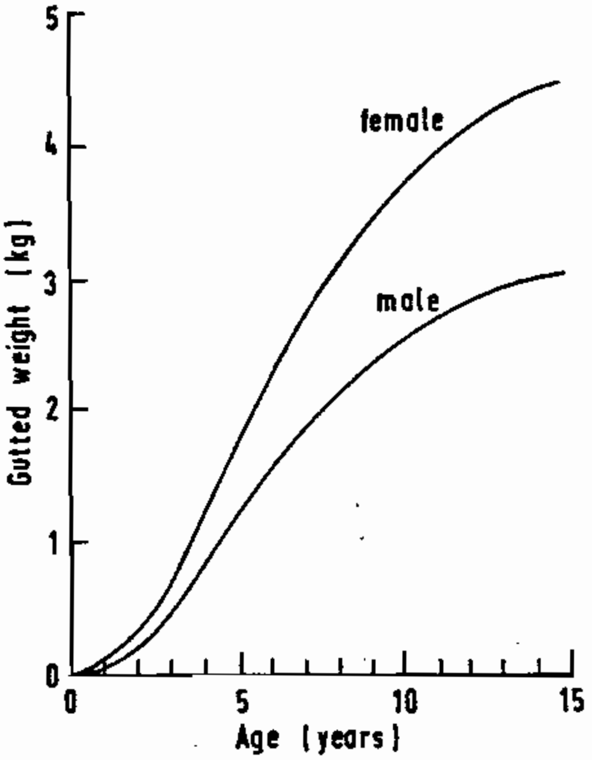

Figure 3 Sexual difference in growth in turbot.

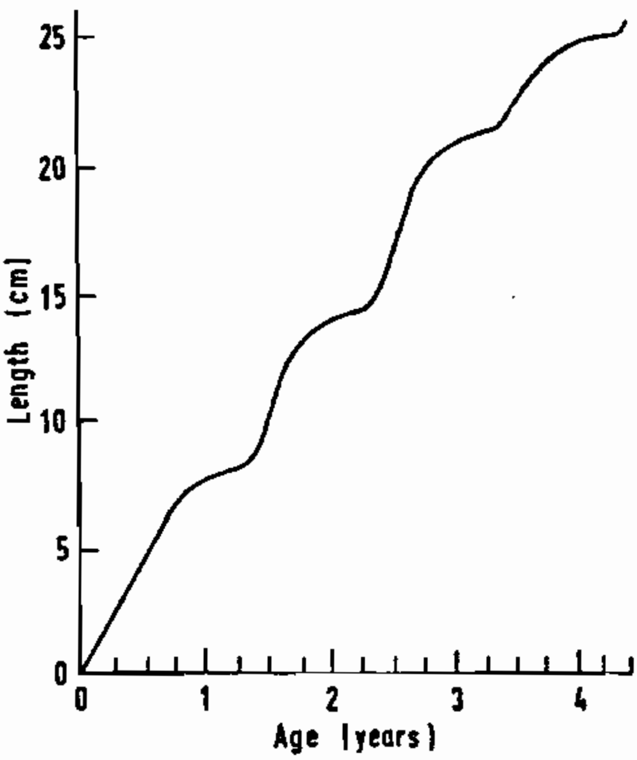

Figure 4 Seasonal growth of plaice (taken from Lamont 1967).

The growth curves drawn in Figure 2 represent the growth performance of the fish in natural exploited populations as determined from the mean weight of the fish caught in each age group. However, growth in the wild does not in fact follow such smooth curves because the growth rate varies seasonally, being fast in the spring and summer and ceasing almost completely during the autumn and winter; this results in step-like growth curves such as those shown for North Sea plaice in Figure 4. It is apparent that the fish grow for approximately only half the year, during the spring and summer, when the temperature is highest. If these summer temperatures could be maintained throughout the year the time taken for the fish to reach marketable size would be substantially reduced.

To achieve a high rate of production a fish farm in this country would need to increase the growth rate of the fish by raising the water temperature in its ponds, at least during the winter months. It is not known exactly what temperature increases the various species will withstand, but it is possible, for example, that turbot, Dover sole and brill may be kept at higher temperatures than halibut and plaice, which are usually found further north. The White Fish Authority has an experimental fish farm at Hunterston where fish are kept at temperatures above those in the natural environment all the year by utilizing the heated cooling water discharged from the nearby power station. The mean annual temperature in the ponds is around 18°C and preliminary results include growing Dover sole to marketable size in 1½ years and plaice in 2 years.

It has been determined by experiment and from studies on growth in the wild that in plaice, Dover sole and turbot growth ceases at water temperatures of approximately 6°C. In the south-west of England the coastal sea temperature rarely falls to 7°C during the winter months and consequently the mean annual temperature is higher than that of the North Sea; for example at Mousehole (Cornwall) the mean annual value during the period 1966-69 was 12.2°C. At this temperature turbot and Dover sole would reach marketable size in approximately 2 years and plaice in 3 years. The growing on of hatchery-reared fish in floating cages may well prove commercially feasible in coastal areas such as this. Cage culture is used extensively throughout the world for many species of freshwater fish, particularly carp. The abundant water flow through the cages enables high stocking densities to be maintained, with correspondingly high production per unit area. The continual removal of waste products and constant supply of aerated water also promotes rapid growth.

FEEDING AND FOOD CONVERSION INTO FISH FLESH

The type of food used, its cost and the conversion ratios achieved are important factors in determining the economic viability of farming a particular species of fish. The natural diets of the ten species of fish under discussion are shown in Table 4 and it is seen that they are all wholly carnivorous except for the grey mullet which also consumes algae. The cost of providing the natural live diets of these species is likely to be prohibitive to any commercial venture and so a cheap substitute has to be found. One cheap source of high-protein food is trash fish and fish offal. At first sale on the fish markets fish offal realizes 1.0p per kg, and the trash fish sandeels and sprats 0.95p and 1.7p per kg respectively. Trash fish is an acceptable food for the young and adult stages of turbot, Dover sole and plaice, and there is no reason to suppose that it will not be acceptable to other species.

As fish grow in size the amount of food required for the body's other functions exceeds the amount used for growth, and consequently the efficiency of food conversion decreases. Experiments in this country, on the plaice and Dover sole, and in Japan, on other species, have shown that conversion ratios change from approximately 4 units of food to 1 unit of fish at age 1 to 10.5:1 units at age 6. Taking the average conversion ratios for ages 2 to 6 years, Table 5 has been constructed to show the food cost of growing the ten species of fish to each age. This cost has also been expressed as a percentage of the fish's market value at each age. These calculations have been based on the present cost of fish offal and cheapest trash fish, which is 1.0p per kg. The validity of this exercise rests on the assumption that the conversion ratio is the same at each age for all the species. This may be a false assumption, but at present there are insufficient data available on species other than plaice and Dover sole to test this.

Table 4 The natural foods of the ten main commercial fish species

Species	Juveniles	Adults
Turbot	Polychaetes Crustaceans Molluscs	Fish
Halibut	Crustaceans Fish	Fish Crustaceans Cephalopods
Brill	Crustaceans	Fish Crustaceans
Red mullet	Crustaceans	Crustaceans Molluscs Polychaetes
Hake	Fish	Fish
Dover sole	Crustaceans Polychaetes	Polychaetes Molluscs
Grey mullet	-	Molluscs Crustaceans Algae
Lemon sole	Crustaceans Polychaetes	Crustaceans Polychaetes Molluscs
Red sea bream	Small crustaceans	Crustaceans Echinoderms Fish
Plaice	Crustaceans Polychaetes Molluscs	Molluscs Polychaetes

It can be seen from Table 5 that as the fish increase in size the food costs increase as a percentage of the fish's value. This decreasing food conversion ratio demonstrates the importance of choosing the correct age at which to market the fish. In Denmark some trout farmers use young herring and coalfish as food. They achieve conversion ratios of 6:1 and operate profitably, with food costs forming approximately 25 per cent of the market value of the fish.

Table 5 The cost of food with increasing age for ten species of fish

Age (years)	Average conversion ratio	Species									
		Dover sole	Turbot	Halibut	Hake	Lemon sole	Brill	Grey mullet	Red mullet	Plaice	Red sea bream
(a) Value of fish, in new pence per fish											
2		3.71	14.72	10.83	3.23	1.30	4.99	3.66	2.46	0.52	0.80
3		8.70	27.72	32.26	7.79	3.08	10.11	8.08	3.62	1.12	1.74
4		13.69	42.92	68.86	14.42	5.56	16.25	14.00	4.48	1.97	2.90
5		17.86	58.88	121.71	22.97	8.56	22.75	21.02	5.04	3.07	4.19
6		21.00	74.68	190.87	33.13	11.85	29.22	28.72	5.38	4.34	5.46
(b) Cumulative cost of food, in new pence per fish											
2	4.2:1	0.27	1.54	1.21	0.41	0.20	0.80	0.78	0.52	0.16	0.24
3	5.0:1	0.70	3.17	4.03	1.10	0.54	1.79	1.88	0.80	0.37	0.58
4	6.1:1	1.22	5.49	9.90	2.32	1.10	3.23	3.68	1.06	0.74	1.08
5	8.0:1	1.80	8.68	21.04	4.40	1.98	5.23	6.50	1.29	1.36	1.82
6	10.5:1	2.36	12.83	40.14	7.63	3.26	7.84	10.54	1.47	2.32	2.77
(c) Food cost as percentage of value of fish											
2		7.3	10.5	11.2	12.7	15.4	16.0	21.3	21.1	30.8	30.0
3		8.0	11.4	12.5	14.1	17.5	17.7	23.3	22.1	33.0	33.3
4		8.9	12.8	14.4	16.1	19.8	19.9	26.3	23.7	37.6	37.2
5		10.1	14.7	17.3	19.2	23.1	23.0	30.9	25.6	44.3	43.4
6		11.2	17.2	21.0	23.0	27.5	26.8	36.7	27.3	53.5	50.7

So far, only wet feeds have been discussed, and for commercial farming these have a number of disadvantages. For example, trash fish contains 70-80 per cent water, depending on fat content, and therefore conversion ratios are necessarily poor. Correspondingly, storage costs for trash fish and labour costs in feeding are also likely to be high. Most commercial freshwater farms use dry feeds in pelleted form; with these foods the conversion ratios are very satisfactory (of the order 1.25-1.5:1), storage costs are low, and so are labour costs because the food can be dispensed from automatic feeders. Of the species under discussion, grey mullet have been fed successfully on a dry artificial diet, and young turbot consume trout pellets quite readily. However, the cost of such pellets is very high compared with unprocessed trash fish. For example, 1 kg of trout pellets costs about 17.0p in Britain, against 1.0p per kg for fish offal or trash fish. Even with the better conversion ratios and decreased labour costs the use of dry feeds would appear to be uneconomic unless the initial costs can be reduced considerably. However, dry feed costs might be reduced if fish farming became practised on an appreciable commercial scale.

PROVISION OF STOCK

A necessary requisite for a domesticated farm fish is that it must be possible not only to rear it in captivity but also to bring it to maturity and successful spawning. This ensures a guaranteed supply of stock for the farm and also in the long term it may be possible to improve strains by selective breeding or genetic manipulation. Stocks of marine fish kept in captivity have spawned naturally; these include plaice, Dover sole, lemon sole and turbot. These species, with the exception of the Dover sole, can also be spawned artificially by stripping eggs from the female by hand. Some species will not produce ripe eggs in captivity unless induced to do so by injections of pituitary hormone - the grey mullet falls into this category. Marine fish have high fecundities and therefore it is not essential to have a large brood stock to supply the needs of a farm. The eggs are also buoyant and can be skimmed from the surface of the spawning ponds with a fine net. The fecundities of the ten species of fish listed in Table 1 are shown in Table 6, together with egg diameters, size of newly hatched larvae and extent of domestication.

Most marine fish larvae are very small and their initial feeding is one of the main problems of marine fish farming. Consistent success has so far been obtained only with live foods, the most important of which is the newly hatched larvae (or "nauplii") of Artemia salina. The eggs of this brine shrimp are produced commercially, and the cost of rearing a plaice to metamorphosis on the newly hatched nauplii is approximately one-fiftieth of a penny in material. Apart from plaice, of the other species listed in Table 6, Dover sole can be reared on Artemia nauplii, but other species such as brill, lemon sole and turbot need smaller cultured foods, for example rotifers, before they can be weaned on to Artemia. In the case of the grey mullet, first feeding is established on oyster larvae, moving on to rotifers and copepods, and finally Artemia. Ease of rearing marine fish larvae appears to be related to egg size, for a large egg means more yolk and a more vigorous larva. On this basis the halibut should prove an easy fish to rear, but there are obvious difficulties in maintaining a breeding stock of such very large fish.

Table 6 Fecundity, egg size, larvae size and extent of domestication of ten species of marine fish

Species	Number of eggs spawned per kg of fish	Mean diameter of egg (mm)	Length of newly hatched larva (mm)	Extent of domestication
Halibut	41 000	3.80	9.0 +	No data
Grey mullet	-	1.32	3.2	Artificial spawning induced with pituitary hormone. Limited success in rearing
Dover sole	728 000	1.30	3.1	Spawned naturally and reared to maturity
Hake	184 000	0.98	3.0	No data
Turbot	1 078 000	1.02	2.8	Spawned naturally and artificially. Limited success in rearing
Brill	465 000	1.30	3.8	Spawned artificially. Limited success in rearing
Lemon sole	563 000	1.30	3.8	Spawned naturally and artificially. Limited success in rearing
Red sea bream	-	1.20	-	No data
Red mullet	-	0.86	2.83	No data
Plaice	150 000	1.93	6.1	Spawned naturally and artificially. Reared to maturity

In addition to hatching and rearing farm stock on site, young fish for growing on may be caught on nursery grounds in the wild. This is the method employed in Japan in the commercial cultivation of yellowtails. Provision of stock by this method is only feasible for species whose young can be captured in large numbers at minimum cost. Only plaice, and possibly Dover sole and grey mullet, appear to satisfy these requirements.

PRODUCTION RATES

Another important factor likely to affect the commercial feasibility of fish farming is the number or weight of each species that can be produced per annum in terms of kg per m^2 or unit volume of water flow. Production rates for the flatfish have been estimated by calculating the bottom surface area of each species at marketable size and determining the number which could be contained in 1 square metre. This can be converted to kg per m^2 by multiplying by weight at marketable size. For comparative purposes the average production rate of roundfish has been taken as being equivalent to that achieved by Danish trout farmers, namely 15 kg per m^2. Using these figures Table 7 has been constructed, which shows the annual production and the gross return, per m^2, for each species, based on the market price at first sale for wild fish.

Table 7 Estimated annual production rates and gross returns for ten species of marine fish

Species	No. of fish per m^2	Total production (kg/m^2)	Age when marketable (years)	Production ($kg/year/m^2$)	Gross returns (new pence/ year/m^2)
Turbot	27.9	17.1	2.8	6.1	244.0
Halibut	36.8	10.0	2.0	5.0	189.0
Hake		15.0	2.8	5.4	176.9
Dover sole	64.5	8.0	2.7	3.0	171.7
Red mullet		15.0	3.9	3.8	77.0
Brill	28.0	10.4	2.9	3.6	93.6
Grey mullet		15.0	2.2	6.8	136.4
Plaice	49.5	6.9	4.0	1.7	24.1
Lemon sole	43.2	7.8	3.7	2.1	56.7
Red sea bream		15.0	4.1	3.7	51.2

The initial numbers of fish to be stocked per m^2 will be determined by the final size of fish required. The numbers of flatfish to be stocked per m^2 (assuming no mortality) to yield fish of marketable size are indicated in Table 7. It is worthy of note that the costs of stocking for turbot, which gives the highest production, are less than for other species. Also the validity of the estimates in Table 7 is strengthened by the fact that marketable plaice produced at the White Fish Authority fish farm at Hunterston have been grown at a density of 50 fish per square metre.

The annual production rates quoted in Table 7 are derived from the time taken for each species to grow to first market size in the wild. As mentioned previously, experiments have shown that under artificial conditions turbot, Dover sole and plaice can be grown to market size in less time than that shown in Table 7. The effect of decreasing the time taken for the fish to reach market size is to increase annual production rates (Table 8) and reduce labour, repair and capital costs per unit of output. It is therefore important for fish farms to grow their product to the most economic market size in as short a time as possible.

Table 8 The effect of reducing time taken to reach first market size on annual production rates. Market size reached in (a) 1 year, (b) 1.5 years, (c) 2 years, and (d) 2.5 years

Species	Annual production in kg/year/m^2			
	(a)	(b)	(c)	(d)
Turbot	17.1	11.4	8.5	6.8
Halibut	10.0	6.7	5.0	4.0
Hake	15.0	10.0	7.5	6.0
Dover sole	8.0	5.3	4.0	3.2
Red mullet	15.0	10.0	7.5	6.0
Brill	10.4	6.9	5.2	4.2
Grey mullet	15.0	10.0	7.5	6.0
Plaice	6.9	4.6	3.4	2.8
Lemon sole	7.8	5.2	3.9	3.1
Red sea bream	15.0	10.0	7.5	6.0

CONCLUSIONS

Any attempt at an assessment of the economic feasibility of marine fish farming must, at this time, be rather speculative, but it is useful to examine some of the likely production costs, since these figures give some guidance as to which species are most likely to give economic returns.

In the figures presented so far the only cost that has been dealt with is that of food. However, food costs form only a part of the cost of fish production; other major costs include depreciation of plant, labour, provision of farm stock, repairs, and management and clerical costs.

Labour costs have been based on figures quoted for Danish trout farms where the average production per man-year in profitable operations is 15 tons. At an average production rate of 15 kg/m^2 this is equivalent to 1 000 square metres of tank space. Taking an annual salary of £1 500 then labour costs would be around £1.50 per square metre. The cost of tanks is difficult to estimate, but tanks with a 20 year lifespan, inclusive of pumps and piping, would cost approximately £20 per square metre to install, giving an annual depreciation of £1.00 per square metre. Thus labour costs plus depreciation would be £2.50 per square metre per year. Provision of stock has been costed at £50-70 per

1 000 kg of final product. For comparison the cost of producing fingerling channel catfish is less than this, £12 per 1 000 kg of final product; however, the technical expertise and equipment needed for rearing marine fish is greater than that needed for freshwater species such as catfish, and this accounts for the higher cost. Food costs have been determined on the price of trash fish, 1p per kg, at an average conversion ratio of 5:1. Overheads, clerical expenses and repairs, for example, have been estimated as 10 per cent of the total production cost.

In Table 8 it was shown that annual production is dependent on the speed at which the fish may be grown to first market size. Production costs outlined above and theoretical net returns have been calculated on this basis. However, it is possible that - depending on prevailing prices and technical efficiency - it may be economic to sell some or all fish at greater size. Table 9 shows estimated production costs and net returns, per unit area, for fish grown to first market size in 1.0, 1.5 and 2.0 years. Table 10 shows the same costs and net returns expressed per unit weight.

Table 9 Balance between costs and returns and time taken to grow fish to first market size (per unit area)

Species	Final production (kg/m^2)	1.0 year			1.5 years			2.0 years		
		Total production cost (n.p./m^2) (a)	Gross return (n.p./m^2) (b)	Net return (n.p./m^2) (c)	(a)	(b)	(c)	(a)	(b)	(c)
Turbot	17.1	482	684	+202	619	684	+65	757	684	-73
Dover sole	8.0	372	464	+ 92	509	464	-45			
Hake	15.0	456	495	+ 39	594	495	-99			
Halibut	10.0	396	378	- 18						
Red mullet	15.0	456	300	-156						
Lemon sole	7.8	370	211	-159						
Grey mullet	15.0	456	300	-156						
Brill	10.4	400	271	-129						
Plaice	6.9	357	96	-261						
Red sea bream	15.0	456	210	-246						

Table 10 Balance between costs and returns and time to reach market size (per unit weight)

Species	Final production (kg/m^2)	1.0 year			1.5 years			2.0 years		
		Total production cost per kg (n.p.) (a)	Gross return per kg (n.p.) (b)	Net return per kg (n.p.) (c)	(a)	(b)	(c)	(a)	(b)	(c)
Turbot	17.1	28.2	40.0	+11.8	36.2	40.0	+3.8	44.3	40.0	-4.3
Dover sole	8.0	46.5	58.0	+11.5	63.6	58.0	-5.6			
Hake	15.0	30.4	33.0	+ 2.6	39.6	33.0	-6.6			
Halibut	10.0	39.6	38.0	- 1.6						
Red mullet	15.0	30.4	20.0	-10.4						
Lemon sole	7.8	47.4	27.0	-20.4						
Grey mullet	15.0	30.4	20.0	-10.4						
Brill	10.4	38.5	26.0	-12.5						
Plaice	6.9	51.7	14.0	-37.7						
Red sea bream	15.0	30.4	14.0	-16.4						

The importance of Tables 9 and 10 is not so much the figures quoted but the order in which the fish lie as regards profitability. It is seen that the species most likely to give economic returns are the high-priced ones - turbot, Dover sole, hake and halibut - and those most unlikely to give economic returns are red sea bream and plaice.

In conclusion, therefore, on the evidence presented in this leaflet, further research and development in the field of marine fish farming should be concentrated on those species of high market value. Further work into such technical problems as rates of growth, food conversion ratios and population densities will go some way to determining whether it is possible to farm these species in a way which gives adequate returns for capital invested. Until this is done it is not possible to assess with any reasonable degree of certainty whether these species will be suitable for farming under such strictly controlled conditions.

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