The identification and separation of wild-caught and cultivated sea bass (*Dicentrarchus labrax*)

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MAFF

Fisheries Research Technical Report No.103

Directorate of Fisheries Research, Lowestoft, 1996

MINISTRY OF AGRICULTURE, FISHERIES AND FOOD
DIRECTORATE OF FISHERIES RESEARCH

FISHERIES RESEARCH TECHNICAL REPORT
Number 103

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1996

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Fish. Res. Tech. Rep., MAFF Direct. Fish. Res., Lowestoft, (103): 12pp.

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1. INTRODUCTION

The growing numbers of farmed bass imported into the UK have created problems for the fisheries enforcement agencies as these fish are not subject to the minimum size regulations in force for wild-caught bass in UK waters. Until recently it was impossible to test the claim that undersize bass landed in the UK were farmed and not wild. Following investigations carried out at the Ministry of Agriculture, Fisheries and Food (MAFF) Directorate of Fisheries Research (DFR), Lowestoft, a procedure has been developed for differentiating between the two types of bass with near 100% accuracy. It is based upon obvious differences in the pattern of ring deposition on the scales of farmed and wild bass as a result of their differing growth rates, and incorporates aspects of the physical appearance and presentation of the fish which can also provide evidence of farmed or wild origin.

2. BACKGROUND

Over the last decade the commercial fishery for bass in England and Wales has consistently been in the top ten species by first sale value of the landings, and in 1994 a conservative estimate of the value of the bass landed of £18 million (DFR figures) placed it third in the list. The bass fishery is not subject to any quota or licensing restrictions and is an important source of income for commercial fishermen, especially those involved in the small boat mixed fisheries in the English Channel. Bass is also a highly prized quarry for sea-anglers.

The main commercial fishery for bass has mostly been prosecuted by vessels less than 10 m operating in inshore waters. The majority of the landings have therefore been of small, mostly immature fish (less than 45 cm) which tend to stay in these inshore areas before reaching maturity and adopting an offshore migratory lifestyle, as described by Pawson, Kelley and Pickett (1987). There was a high demand from the market for these small bass. However, this had implications for the health of the bass stocks generally and in 1986 the UK minimum landing size (MLS), as measured from the tip of the snout to the end of the closed tail fin, was raised from 26 to 32 cm. The MLS applied to the landing of **all** bass caught, whether by commercial fishermen or anglers. The MLS was further increased in 1990 to 36 cm, and supportive EC legislation (Council Regulation (EEC) No. 3094/86 as amended by Council Regulation (EEC) No. 4056/89) extended this to any *D. labrax* landed from EC sea areas 2 and 3, covering waters from north of the Shetlands to the Straits of Gibraltar. In the same year other bass conservation measures (mesh size controls on gill-nets and restriction of bass fishing in 34 inshore nursery areas) were introduced unilaterally by the UK.

Under the 1990 legislation it is illegal for any wild bass less than 36 cm total length, caught in EC sea areas 2 and 3, to be ***retained or transhipped aboard a vessel, landed, stored, sold, displayed, or offered for sale.*** These provisions apply to ***merchants, retailers, commercial fishermen and recreational anglers.***

In the UK the introduction of the package of bass conservation measures in 1990 theoretically cut off the supply of small 'plate-sized' bass. But there was still strong market demand for these fish, both in the UK and on the continent. Being a high value and highly regarded species, the bass is a prime candidate for farming operations and the industry developed rapidly, mainly along the Mediterranean coasts. From less than 500 tonnes in the mid-1980s, production of farmed bass increased dramatically to around 25,000 tonnes in 1994, and is expected to be more than 40,000 tonnes in 1995 (Fish Farming International, June 1995). By far the largest proportion of farmed bass originates in Greece. The other major producers are Turkey, Egypt, Italy, France and Malta with smaller quantities being produced by Spain, Portugal, Cyprus, Tunisia, Morocco and Croatia. At present there are no commercial bass farming operations in the UK, the nearest source being Gravelines on the French Normandy coast where bass are reared using the hot water discharge from two PWR power stations. Concomitant with this rapid rise in production there has been a large increase in imports of farmed bass into the UK, and the wholesale price of imported bass has fallen from a peak of around £14/kg in the late 1980s to around £5/kg in 1994.

The reduction in price of imported farmed bass had a knock-on effect on the first-sale value of wild-caught bass landed in the UK. However, because of the extremely good recruitment to the stocks since 1990, the fall in price has been offset by the abundance of bass in the sea, and earnings from bass fishing have been maintained or even increased. The abundance of bass has attracted more participants into the fishery, many of whom are not full-time commercial fishermen, and there has been an increase in fishing effort in real terms over the last few years. Unfortunately, the bass is a slow growing species in UK waters, and the fish do not normally attain a legal size until their fourth or even fifth year. Thus a large proportion of the bass available to the fishermen are below the legal MLS. MAFF sampling showed that 10% of the recorded landings of bass in 1993 were below the MLS, but information from around the coast suggests that large quantities of undersize bass are landed illegally.

There is no MLS for farmed bass, and wild-caught bass from the Mediterranean is subject only to a 25 cm MLS if caught in French waters, or 23 cm elsewhere. There is no compunction upon importers of bass to provide proof of its origin. Consequently it is possible for undersized wild-caught bass to be passed off as farmed bass.

However, based upon the known growth patterns of both wild and farmed bass, and a knowledge of the practices of the bass farming industry, scientists at the MAFF Directorate of Fisheries Research at the Fisheries Laboratory in Lowestoft have devised a procedure which can be used to distinguish between farmed and wild-caught bass. This procedure entails no great scientific expertise, and it is envisaged that after initial training, it can be readily used by enforcement agencies in the field to establish whether or not there is a *prima facie* case to be answered under the current bass MLS legislation.

3. THE PROCEDURE

3.1 Physical inspection of the fish

There are no obvious morphological differences in the physical appearance of farmed and wild fish. However, farmed fish are usually culled in a way that does not spoil the appearance of the fish in order to maintain the quality of the product. Wild-caught fish will often show marks or damage caused by capture, such as net marks around the body if caught by any of the various gill net methods, hook marks or trawl damage (Figure 1). In addition, farmed fish are imported fresh, packed in ice, usually in polystyrene boxes. Obviously it is in the best interests of the importers to maintain the fish in this fresh, iced state and to leave the bass in their insulated containers for as long as possible. Wild caught fish, if intercepted early enough in the distribution chain, would probably not be packed as described, but would be held in open fish boxes with flaked ice strewn over them.

3.2 Size distribution of the fish

Any landing of wild bass is likely to contain a range of sizes, and even if this includes undersize fish, much larger bass will often be present in the catch. The observed size range can vary, depending upon the method of capture and area fished, but the length distribution obtained from a sample of bass can give an indication of its origin. Farmed fish are graded according to size at source, the usual categories being 250-350 g, 350-450 g and 450 g or greater. These would approximate to lengths in the ranges 28-31 cm, 31-36 cm and above 36 cm for the larger weight categories. We are only concerned with undersized bass, and any batch of fish claimed to be of farmed origin would therefore normally be expected to cover only a very narrow size range, as indicated by the first two size categories and would be unlikely to be part of a size range which included many larger fish, if any. It is useful therefore to measure a random sample from a batch or landing of bass containing suspected undersize wild fish (or all of the batch if it is small) in order to obtain the length distribution. A sample of farmed bass would be expected to have a far more homogeneous size distribution compared with wild bass.

As bass are normally offered for sale in a fresh, iced state, shrinkage due to freezing should not present a problem when measuring the fish. Trials have shown that even when bass are frozen for up to three months there is no significant difference between the length of the fish when measured fresh and after thawing.

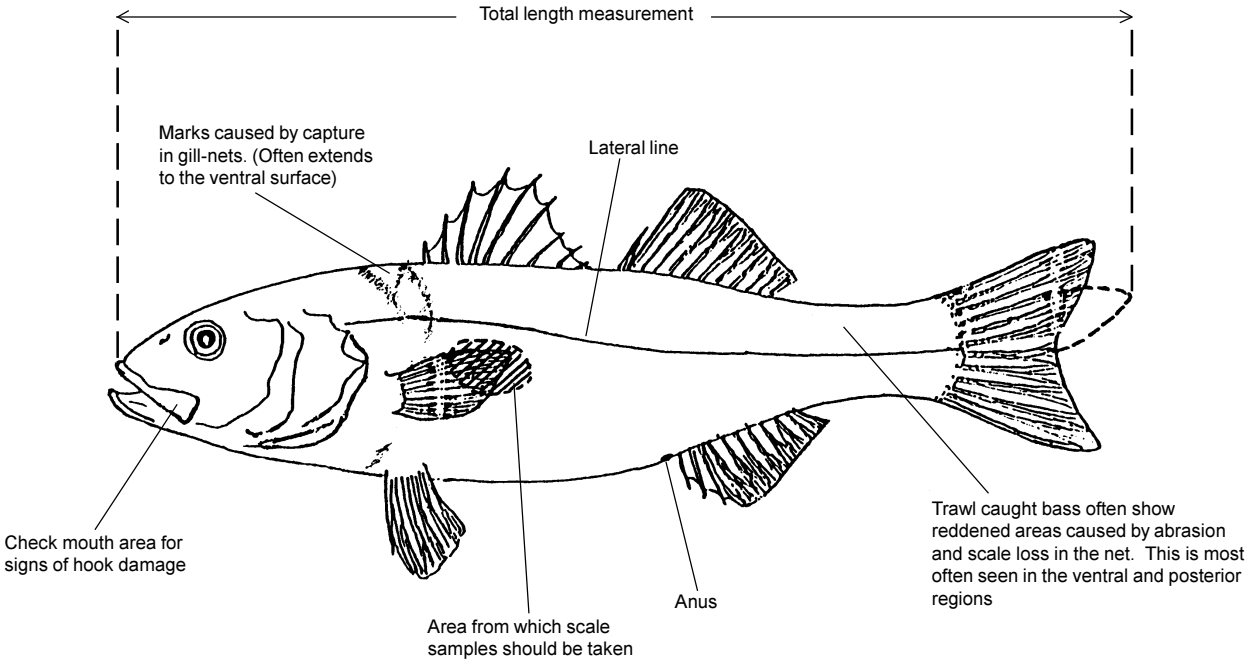


Figure 1. Physical inspection of bass. External features to note when separating wild and farmed fish

3.3 Gut contents

Bass are usually landed whole, ungutted, even if they are farmed. It is normal practice for farmed fish to be starved for a period before culling in order to empty their guts of any food residues. This improves the shelf-life of the fish. Even if there are food residues in the guts of farmed fish they can often be identified as such because they are normally fed either dry pellets or reconstituted fish-meal in pelleted form. Wild fish however can be expected to contain a wide range of natural food in their guts, such as lug and rag worms, crabs, shrimp, fish or even slipper limpets. The presence of any of these is almost proof in itself that the fish are from wild stock. Absence of food in the gut does not however prove that the bass are farmed.

It is not normally possible to inspect the stomach contents of bass at the merchants' premises or at the point of landing of the catch, but it is often possible to decide whether or not the stomachs do contain food just by the appearance of the fish: e.g. the belly of the fish is swollen. Wild bass which have been feeding may have food actually protruding from the mouth which has been regurgitated upon capture. It is also possible to inspect the food remains in the hind gut by gently squeezing the belly of the fish down towards the anus and expelling the residues. The appearance of the residues from artificial and wild foods can be quite different, those from artificial pelleted food being pale and granular, homogeneous in nature, and rather like wet sawdust in appearance. Those from wild foods are usually darker, heterogeneous in appearance and may contain hard, undigested material such as fish otoliths or crustacean and molluscan remains. In some fish farming operations frozen 'trash' fish (most commonly anchovy, capelin or sand-eels) is fed to the stock. The best indication of diet is obtained from detailed analysis of the actual stomach contents of the bass which could only be undertaken through dissection. If the bass are undersize, and other indications are that they are wild fish, then the confiscation of the fish for more detailed analysis elsewhere may be warranted.

3.4 Growth rates and scale patterns

Wild bass in UK waters are slow growing and do not normally attain the MLS of 36 cm until at least their fourth year, whereas in the warmer waters of the Mediterranean area wild bass achieve this size after about two and a half years, (Figure 2). In captivity, the growth rate is enhanced still further by regular feeding, and probably also by the relatively stable environmental conditions in which the fish are held. Hence the time required to produce the size of bass which would be marketable at 30-35 cm is reduced to around 18-24 months. If it took much longer than this the farming of bass would become uneconomical. The growth rate of any bass can be estimated by considering its length and age. It is a relatively simple process to take a sample of bass and produce an age/length distribution which will indicate whether or not the fish are wild. In practice though, this is not necessary.

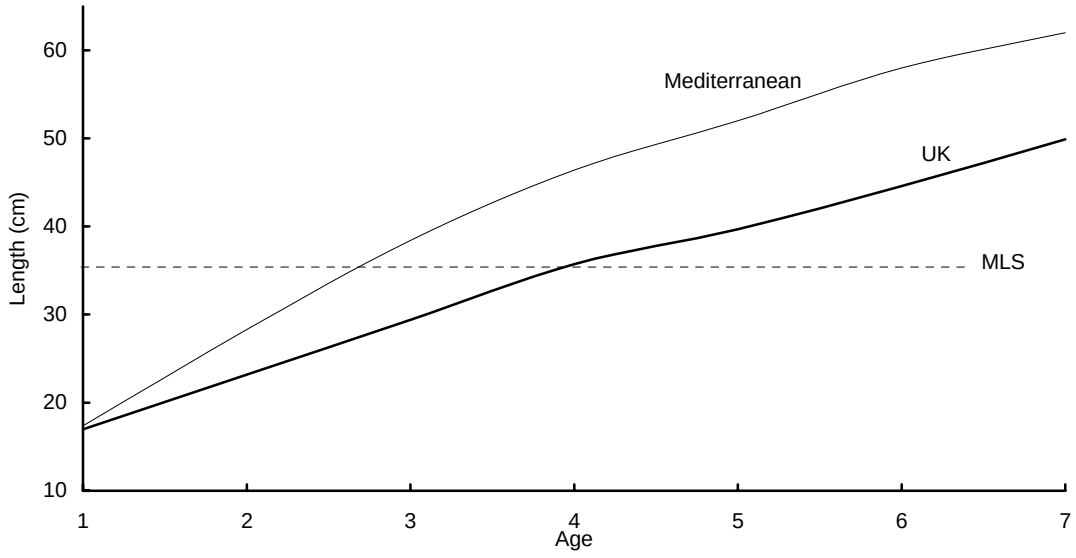


Figure 2. Mean length at age of wild bass from UK and Mediterranean waters

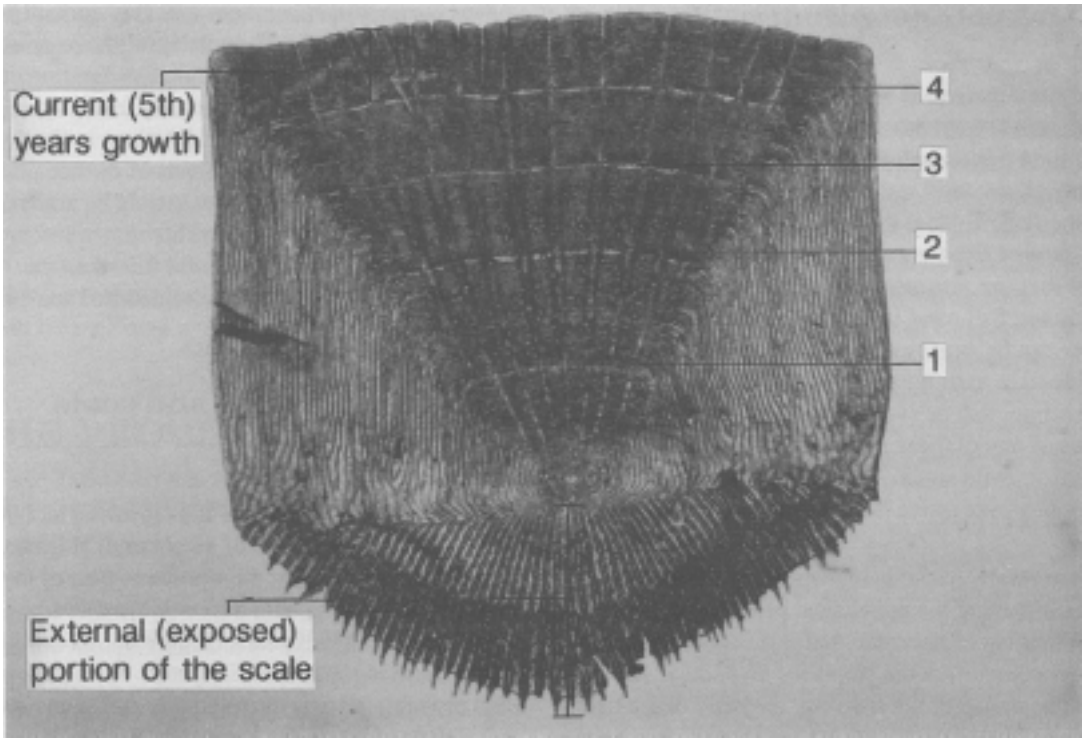


Figure 3. Photo-illustration of a scale from a 34 cm, 5 year old, wild bass from UK waters. The numbers refer to the annuli laid down on the scale at the end of each years growth

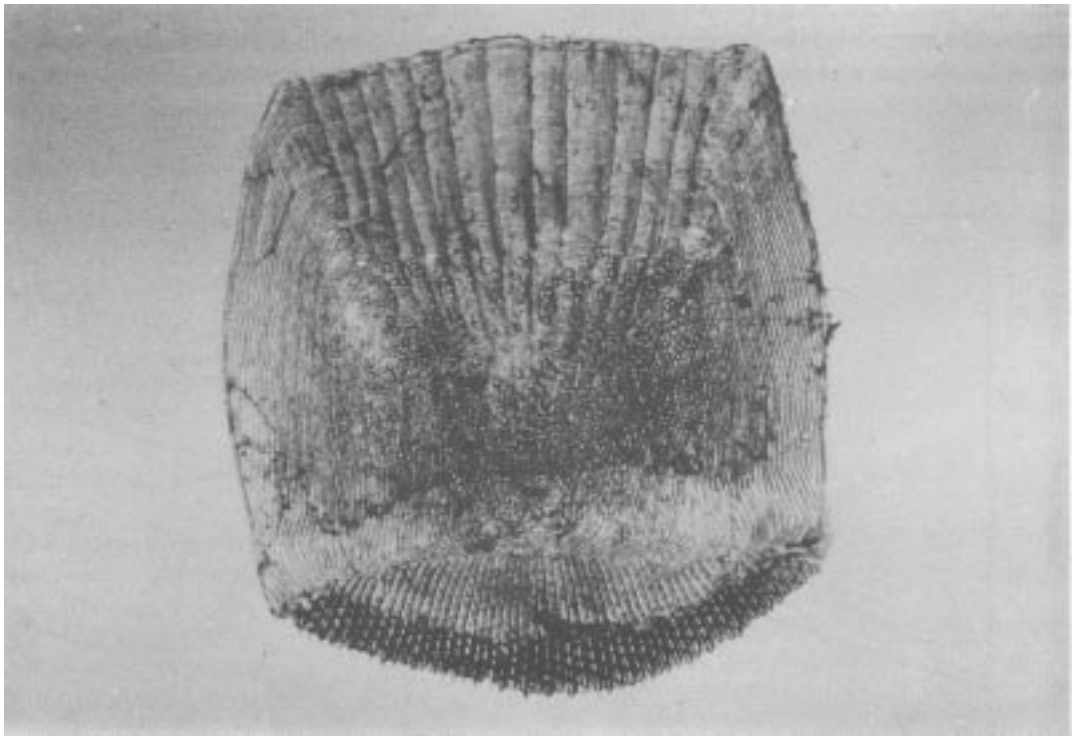


Figure 4. Photo-illustration of a scale from a 34 cm farmed bass. Note the lack of differentiation in the scale structure compared with that from the wild bass in Figure 3, and in particular the absence of any obvious annuli

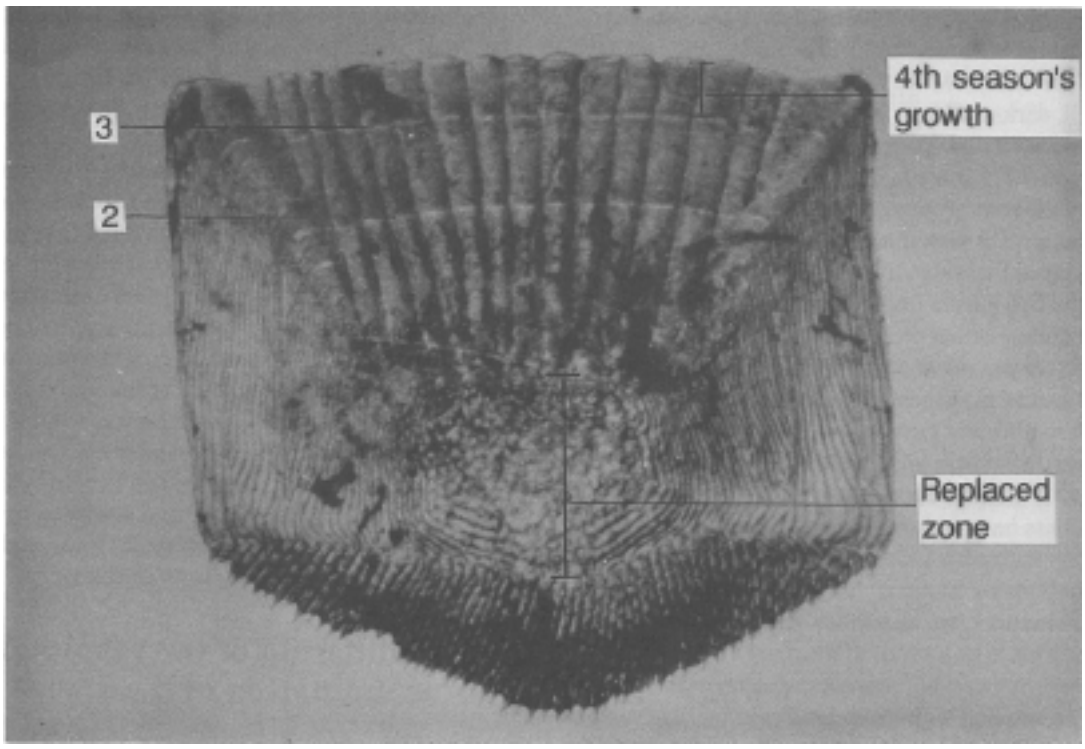


Figure 5. ***A replaced scale from a 29 cm wild bass caught in UK waters in the spring of 1994. Note the evenly granular appearance of the 'replaced zone' of the scale. In this example annuli are present outside of the replaced zone (labelled 2 and 3). Unreplaced scales from the same fish show that this fish was 4 years old. The scale would therefore have been lost and replaced sometime before the spring of 1992***

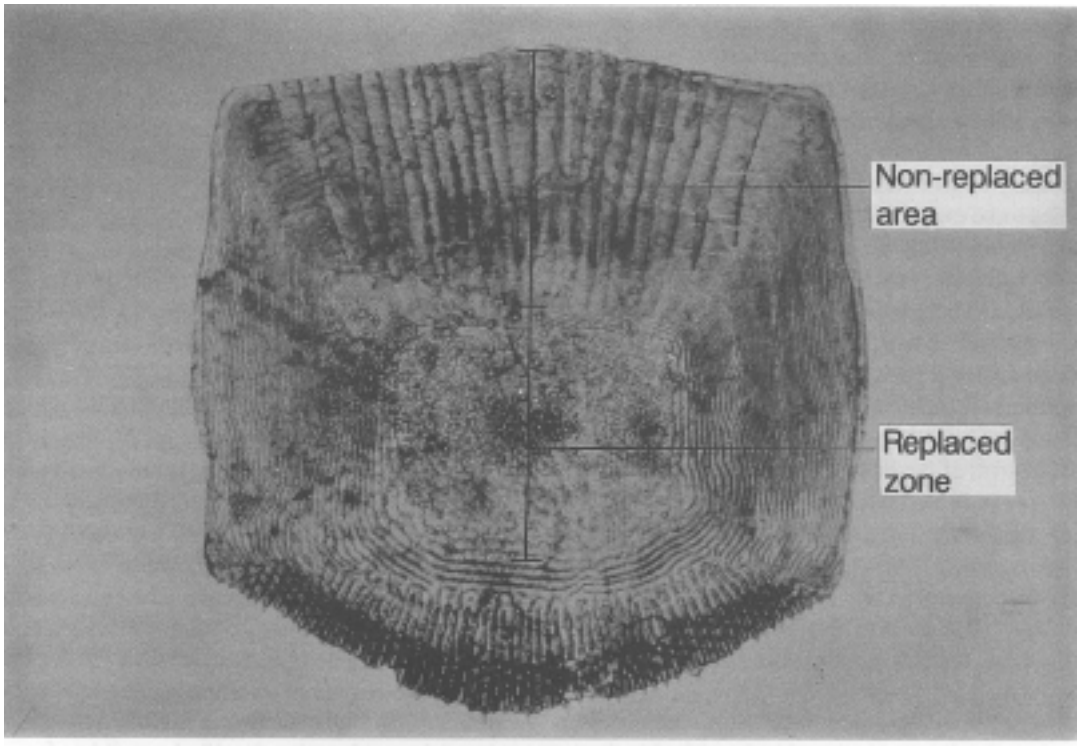


Figure 6. ***A replaced scale from a farmed bass. Note again the evenly granular appearance of the 'replaced zone' which, however, is still readily distinguishable from the non-replaced area, despite the lack of annuli typical of a farmed bass scale. Only if the whole scale has been replaced within the current year of growth is it impossible to distinguish between a farmed and wild scale. However, by sampling and examining several scales from each fish, the chances of them all being of that type are very small***

Bass are aged by counting the annual rings (annuli) on their scales. If scales from wild-caught bass from UK waters are examined they show a characteristic pattern of small, dark-marking rings (circuli) interspersed with much more obvious pale rings which are the annuli. Both types of ring are laid down incrementally on the scale as the bass grows, and are a function of the seasonal growth pattern of the fish. The annuli, in particular, are laid down in the spring or early summer when the fish moves from a quiescent, over-winter period during which there is little or no growth, to a far more active period when feeding, and hence growth, recommences in earnest. Because wild and farmed fish have very different growth rates, fish of the same size but from different origins will have very different patterns of annulus deposition on their scales. Wild-caught bass have a slower growth rate and show more annuli on their scales than do farmed fish. In addition, the annuli on the scales of farmed fish, as well as being fewer in number, are also much less well defined or even absent. This is as a result of the more constant environmental conditions under which the fish are reared, combined with a regular food supply, serving to remove or at least ameliorate the effects of seasonality on the growth pattern of the fish. As mentioned above, annulus deposition on bass scales is a function of the seasonal variation in the fishes growth pattern. These differences are illustrated in Figures 3 and 4. With practice, it is possible to recognise these differences in the field by using a small hand lens to examine cleaned scales removed from the bass. A magnification between ×10 and ×15 is suitable. The characteristic patterns of ring deposition on the scales of both farmed and wild bass are unaffected by freezing or storage in ice.

It is necessary to take care in selecting and handling the bass scales to be examined, especially if they are to be used as evidence in any ensuing prosecution. When bass larvae first hatch from their planktonic eggs they do not possess scales. These appear later on the fish, but not simultaneously all over it, and the scales will differ in shape from different parts of the fishes' body. The first scales to form are those in an area behind the fishes' head and around the lateral line. Figure 1 shows the optimum area for removal of scales samples in bass. Scales taken from the area indicated will not only be amongst the oldest on the fish (and so contain the most complete history of its growth) but are also the largest and the most regularly shaped, and so will be the easiest to interpret in terms of age. They are also less likely to have been lost and replaced by the fish at some time during its life.

The phenomenon of scale replacement is common and occurs when the fish has lost scales through abrasion or attack by a predator for example. The fish is able to completely replace the scale within a year of its loss. However, the replacement scale will have lost the previous annulus structure shown on an original scale from the same fish. Fortunately these replacement scales from wild fish are still distinguishable from those of farmed fish (Figures 5 and 6) even though they cannot be aged. Nevertheless, it is advisable when taking scale samples from bass to take at least ten from each fish to ensure that at least one original specimen is obtained.

The scales removed should be cleaned (by washing in warm water if possible) and stored in paper envelopes on which all available information relating to the fish should be written. The minimum information required is the length of the fish, source and date of sampling. Although it is preferable to clean the scales at the time of removal, this can be done later. The scales are best exhibited by sandwiching three or four good examples from each fish between two glass microscope slides, held together with sellotape and uniquely labelled. When mounted in this way they can be readily examined using a low power microscope and also photographed if necessary, for comparison with scales from wild caught and farmed bass of known provenance.

3.5 Validation of the results from examination of the scales

In order to test the accuracy of the scale reading method for identifying the origin of bass, blind trials were organised for the two scientists studying bass at the Lowestoft laboratory. They were provided with a randomised sample of scales removed from 103 farmed and 172 wild fish in the length range 17-41 cm. The wild fish samples included bass from a variety of locations around the English and Welsh coasts, caught at different times of the year since 1985 (to allow for any possible changes in natural growth rate over the past decade). The only information provided was the sample number and length of each fish. The participants were asked to decide whether each fish was farmed or wild, and also to identify any which, in their opinion, gave inconclusive results as to the fishes' origin.

The results were analysed by scoring the percentage of fish correctly assigned by each person as farmed or wild, excluding any fish of doubtful origin. This was done because if the samples had been from an actual landing of suspect undersize bass, then no opinion as to the origin of a particular fish would be offered where there was any ambiguity in interpreting the scales.

The results of the trials are shown in Table 1. There were slight differences between the two sets of results, but a degree of accuracy of over 99% was achieved. With an error rate of little more than 1% for individual scales, the chance of a complete sample of bass being misclassified by scale typing is extremely small. Only a few fish could not be classified as wild or farmed. In practice, because of identifiable patterns of growth on scales taken from wild bass from the same area or year class, classification rates are likely to be even higher if the bass are from a single landing or consignment, rather than from a wide variety of unknown dates and sources as was the case in the blind trial.

Table 1. ***Success rates achieved in correctly assigning wild or farmed status to a randomised sample of bass scales. The percentages correct are derived from the number in the sample (103 farmed, 172 wild) minus the number of unclassified fish. These are shown in the final column and as a percentage of the whole sample***

		Correct	Unclassified
Person 1	Wild	98.8%	0
	Farmed	98.9%	9 (8.7%)
Person 2	Wild	100.0%	2 (1.2%)
	Farmed	99.0%	0
Combined average	Wild	99.4%	1 (1.6%)
	Farmed	99.0%	5 (4.4%)

4. SUMMARY

Using the techniques described in Sections 3.1 to 3.3 above it is possible to decide in the field whether or not there is a *prima facie* case for believing that undersize bass have been taken from the wild in UK waters. When supported by evidence obtained using bass scales (Section 3.4) this is considered to offer sufficient proof. The procedures to be followed when examining a sample are summarised below and in the flow chart (Appendix 1):

1. Measure (and if possible weigh) each bass in the landing (total length to the nearest mm below as measured from the tip of the snout with the mouth closed, to the tip of the closed tail; weight to the nearest 5 g) and obtain the total weight of the catch. If possible measure all the fish, including those of legal size, to obtain a length distribution of the catch. If sub-sampling is necessary always record the weight of the sample measured as well as that of the total catch.

2. Ask to see any documentary proof of the origins of the bass and obtain copies if possible.

3. Inspect the fish for marks or damage caused by capture. Describe any found.

4. Try to ascertain whether or not the bass have been feeding, and if so record any identifiable food items.

5. Take scale samples, from all the bass if possible, but if not in the following order of priority.

   (i) All fish.

   (ii) All undersize fish plus a stratified sample of the legal size fish.

   (iii) From a sub-sample of the catch, take scales from all the undersize fish plus a stratified sample of the legal size fish.

   (iv) From a sub-sample of the catch take a stratified sample (2 fish per cm) throughout the length range.

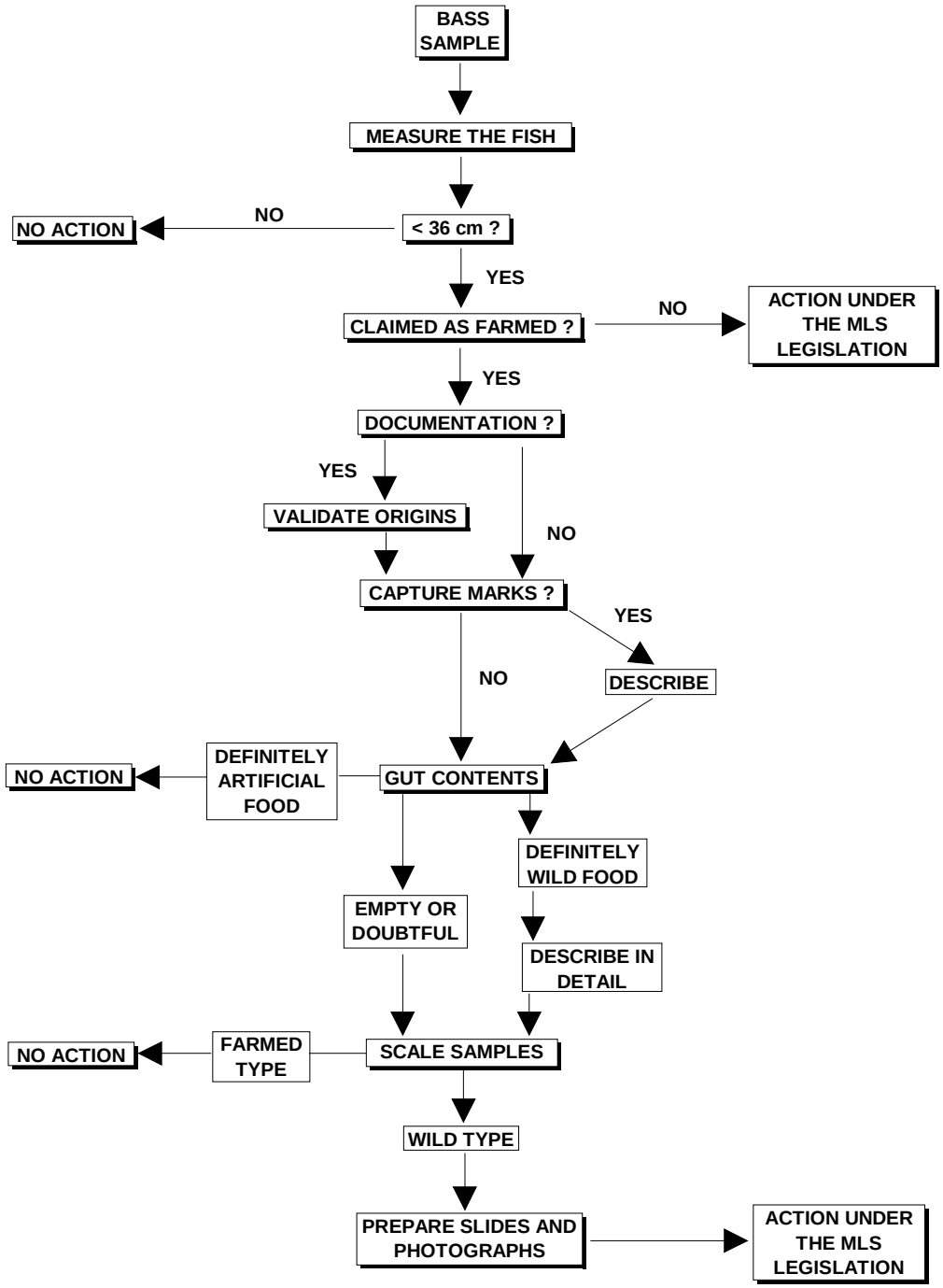
   Ensure that all the individual scale samples from the bass are fully labelled with a unique number for each fish, its length, weight (if done), and the date sampled.

6. Clean and mount the scales on microscope slides. Examine for evidence of wild growth patterns and photograph a representative scale from each slide using transparency film, for future use as exhibits if required.

5. REFERENCES

PAWSON, M. G., KELLEY, D. F. AND PICKETT, G. D., 1987. The distribution and migrations of bass, *Dicentrarchus labrax* L., in waters around England and Wales as shown by tagging. J. mar. biol. Ass. U.K., ***67***: 183-217.

Appendix 1. Flow chart showing the procedures to follow when sampling bass



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ISSN 0308 - 5589