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Abstract.
In the early 1980s, catch rates of sea bass in the inshore fisheries around English and Welsh coasts were decreasing rapidly, and growth overfishing - allied to erratic recruitment - was threatening the sustainability of the stock and its fishery. A yield per recruit analysis, based on regional exploitation patterns, demonstrated that an increase in the age at first capture would improve long-term yields and boost recruitment to the spawning stock, with different levels of gain and loss in the existing regional fisheries. A public discussion paper was widely distributed, explaining the management objective, to increase the age at first capture from an average of 3 - 5 years, depending on region, to a minimum of 5 years (36-38 cm TL), its scientific rationale and means of achievement. Thirteen regional consultation meetings were held with stakeholders to judge the practicality and likely impact of introducing appropriate technical measures. We describe the introduction and effectiveness of a national MLS of 36 cm and complementary mesh size regulations for enmeshing nets (both later adopted at an EU level), and seasonal closures of 34 inshore nursery areas where bass <36 cm were considered to be particularly vulnerable to exploitation; the evaluation of this conservation package before and after its introduction; demonstrate that it has improved the exploitation pattern in the bass fisheries and provided biological and economic benefits; and discuss the acceptability of these technical measures by stake holders and their effectiveness.

Keywords: seabass; exploitation pattern, technical measures; success.
Background

In the south of England and Wales, juvenile bass of 3 -5 years of age are accessible during the greater part of the year to fishermen and anglers operating from the shore and close to the shore in small boats, where large catches can be obtained by a variety of fishing methods. It is partly because of this vulnerability, and the growing scarcity of other inshore fish resources and the high prices offered for bass, that the commercial bass fishery developed rapidly in the late 1970s and 1980s. A tagging study (Pawson et al., 1987), showed that, once bass mature, they adopt the habit of migrating between summer feeding grounds and offshore pre-spawning and spawning areas to the south and west (Figure 1). As a consequence, larger bass are less accessible to British inshore fishermen, though they became increasingly targeted by French mid-water pair-trawlers during winter and early spring through the 1980s.

Annual catches of bass in the UK commercial fishery had fallen from a peak of over 1000 t in 1983-84 to around 600 t in 1985-86 (Pickett, 1990). With an estimated first sale value at £3-4 million, bass was still the seventh most valuable finfish species in England and Wales, where it accounted for a high proportion of the earnings of many inshore fishermen. Around 400 full-time commercial fishermen using 270 boats were known to be directly involved in the bass fishery in 1986, and about 2500 other fishermen using more than 1800 boats took bass as a valuable by-catch. Some participants in the fishery had been strongly affected by the declining availability of bass. For example, in 1981 more than 150 commercial fishermen directed their efforts, in season, at bass around rocky headlands and reefs in South-west England, but by 1986 fewer than 20 people were involved in this fishery. CEMARE estimated that, in 1986/87, some 24,500 sea anglers fished regularly for bass in the UK (Dunn et al., 1989) and, because of its good eating qualities and high market value, most anglers retained some of their catch. Estimates of anglers' catches of bass showed them to be similar to the level recorded from the commercial fishery.

Biological sampling across the bass fishery in England and Wales showed that the exploitation pattern of bass had been shifting towards younger ages in the mid 1980s: the large 1976 year-class was maximally exploited at age 8; the 1979 year-class at age 5 and the 1981 and 1982 year-classes at ages 4 and 5 (Pawson and Pickett, 1988). Whilst regional exploitation patterns differed, a yield per recruit analysis against size and age at first recruitment to the fishery showed that a maximum yield for the UK bass fishery as a whole might be obtained if fish were first caught at 40 - 45 cm, providing fishing effort could be directed towards larger bass (Figure 2). Though there was no indication of an overall decline in the adult bass stock (which appeared still capable of producing above-average year classes), this analysis pointed strongly towards growth overfishing. However, most of the exploitation of juvenile bass was in the English Channel (VIIId and VIIe), where maximum yields would only be obtained with recruitment to the fishery at between 32 and 36 cm, owing to local fishing patterns and availability of different sizes of bass (Pawson and Pickett, 1988). Too high a recruitment size would deny fishing opportunities to those who have to rely solely on inshore waters for their livelihood.

These analyses supported Holden and Williams' (1974) conclusion that, to increase yield per recruit and enhance recruitment to the bass spawning stock around Britain by reducing fishing mortality on juveniles, it was necessary to raise the size at which bass first recruit to the fishery towards 38 cm. Quantitative approaches, such as catch quotas, were rejected; partly because there were insufficient assessment data on which to base recommendations for direct catch controls, and particularly in view of doubts about the efficacy of these types of control in such a fragmented multi-species fishery that employs mainly small, inshore boats. As a consequence, the priority was to find a means to direct the bass fishery away from juvenile fish, i.e. to improve the exploitation pattern.
In the mid-1980s, both national and European Community regulations for bass fishing prescribed only a minimum landing size (MLS) of 32 cm. Any additional measures would need to support a higher MLS, whilst being applicable to the wider interests of both commercial and recreational fishermen. With the intention of protecting juvenile bass, by making it illegal to land them, and by prohibiting the use of fishing methods that would catch or kill them in areas where they were most vulnerable, in July 1986 the UK Government proposed a package that combined a minimum landing size (MLS) of 36 cm, a complementary minimum mesh size (MMS) of 100 mm for enmeshing (gill) nets and the prohibition of fishing in designated nursery areas.

Consultation
To be effective, any management control must be acceptable to and respected by those on whom it falls, whether implemented through local, national or international legislation. In England and Wales, the regulations for managing the bass fishery would be enforced by the Ministry of Agriculture, Fisheries and Food (MAFF) Sea Fisheries Inspectorate, supported by local sea fishery committees (SFCs) and the regional water authorities, now the Environment Agency (EA). It was also hoped that, to foster self-policing of the regulations, an accord could be reached between commercial fishermen and recreational anglers over the proposed management package. To help this process, an explanation of the results of CEFAS’s investigation of the biology of the bass and its fishery and the scientific background to the management recommendations was published (Pawson and Pickett, 1987).

Extensive consultations were held in 1987 with all parties with interests in the bass fishery, both to clarify the need for measures to protect juvenile bass and to ensure that their implementation did not unduly disrupt important local fisheries for other species. During these consultations, we found that it helped if the exercise’s objective was made abundantly clear from the outset and had a credible scientific basis. It quickly became clear that introduction of controls that were too stringent would not be enforceable, and might actually militate against better management of the fishery, and that neither a code of practice nor voluntary agreements on fishing restrictions would be practicable because of the wide range of interests and the number of participants in the fishery.

Whilst agreement was reasonable quickly reached on MLS and mesh size controls (see below), a second consultative paper was issued in March 1989, describing the proposed nursery areas and emphasising that MAFF was prepared to consider variations and modifications to the extent of the areas, the length of closed seasons and the restrictions on fishing activities for species other than bass on the basis of evidence and informed comment.

The responses to MAFF’s proposals for managing the bass fishery came from the commercial fishermen, anglers and local regulatory bodies such as SFCs and the EA, and from a range of associated interests: tackle manufacturers, harbour authorities and local councils, and were taken into consideration when redrafting the proposals to achieve a more acceptable, and effective, package.

It should be emphasised that the UK’s strategy for managing its bass fishery gave no priority to either commercial or recreational use of the resource. This contrasts with that pursued in the Republic of Ireland (ICES, 2002), where it is implicitly recognised that bass angling is important to tourism and takes priority over any commercial fishery for bass. In Ireland, however, it was assumed that the respective national fisheries exploited a relatively separate part of the European bass stock, whereas the UK shared its stock with other nations’ vessels fishing both inside and outside its territorial waters. In particular, there was a need to ensure that mobile fleets, displaced
from other fisheries by stock declines or tight quota controls, did not begin to look to the bass resource as a free-for-all, until it too became severely depressed. Declaring the bass to be a protected species, with a high MLS and no commercial exploitation inside the UK 6 mile zone, would be a precarious stance from which to negotiate with the administrations of countries that have no management plans for their bass fisheries.

Management options
Minimum landing size (MLS)
Whilst an MLS pitched at the mean size at which female bass first mature to spawn (around 42 cm TL; Pawson and Pickett, 1996) would help to protect immature fish and preserve the stock's breeding potential, our aim was only to prevent too many small fish being caught, so that yields to the fishery were not further depressed by inadequate growth in the population as a whole. However, in the mid-1980's, a premium price was often obtained for plate-sized bass (now adequately supplied by farmed fish), and commercial fishermen along most of the south coast of England argued that a MLS higher than 32 cm would cut catches drastically in these inshore fisheries, in which small fish predominated. They also claimed that the eventual benefits would accrue chiefly to the French fleet fishing for larger bass offshore, which was constrained only by the EC MLS of 32 cm. Though there had been no decline locally in the number of small bass caught, this reflects a fishing pattern targeted chiefly at juvenile fish and there was no evidence of recruitment failure owing to excessive depletion of the spawning stock. At the other extreme, the true sport angler is not too interested in small bass nor in their market value and is prepared to accept a much higher MLS: they would welcome any measure which improved the chances of bass reaching a large size.

It was concluded that a national MLS of 36 cm would satisfy the management objective of reducing growth overfishing, whilst allowing some important small-boat fisheries to remain viable. UK commercial fishermen were concerned that raising the UK MLS for bass to 36 would discriminate against them because, under European Community law, national regulations could not then be applied to fishermen from other member states. However, such fishermen are not permitted to fish within UK coastal waters out to 6 miles, and bass under 40 cm are seldom encountered farther offshore. Nevertheless, the UK Government pressed (on the basis of CEFAS's analysis) for an increase in the EC MLS for bass from 32 to 36 cm, in order to strengthen the regulation by applying it across north-west Europe and increasing the legislation's powers. This was accomplished in December 1989 and implemented in 1990 under Council Regulation (EEC) No 3094/86 (as amended by Council Regulation (EEC) No. 4056/89), substantially reducing opposition from the UK industry to the management package as a whole.

Mesh size controls
Having settled on a target MLS of 36 cm, it was necessary to determine complementary mesh size controls that would help fishermen minimise the number of undersized fish they had to discard from their catch. It was clear that restrictions on mesh sizes in trawl nets were unlikely to be introduced specifically for bass fishing, in part because trawl mesh sizes tend to be influenced by the need to comply with international rather than national requirements, but also because inshore trawlers tend to tow their nets for short periods -- usually less than 1 hour -- and the relatively high recapture rate of bass caught by trawl for tagging suggests that any undersized bass can be released alive with a good chance of survival.

Catch data from gill nets used in the commercial fishery (accounting for about one-third of the commercial bass catch in the UK) showed that, with a stretched mesh size of 100 mm (measured knot to opposite knot), very few bass under 36 cm would be caught (Figure 3). It was proposed, therefore, that a minimum mesh size (MMS) of 100 mm be introducing for all enmeshing gears,
chiefly because it is not possible to identify a 'bass gill net fishery' amongst casual and part-time fishermen, with whom enforcement of any management measure (particularly specific ones such as an MLS) can be difficult.

Consultations revealed that there was little opposition and much support for the introduction of mesh size controls for enmeshing nets. However, it became apparent that there are several fisheries in which a 100 mm MMS could be a disadvantage, either because small but profitable fisheries would be less viable (e.g. sole, golden-grey mullet, red mullet and the 'small pelagics' - sprat, herring, mackerel and pilchard), or through an unintentional diversion of effort towards fish that are more susceptible to meshes of >100 mm (e.g. salmon). In particular, fishermen along the English Channel coast were concerned about drift and ring net fisheries for grey mullet, for which they required mesh sizes of 80-85 mm (some in potential bass nursery areas). This was dealt with by exempting these fisheries from mesh size controls, but otherwise implementing a banned range (65 - 89 mm) in enmeshing nets carried or used by registered fishing boats within British fishery limits, between 54.5° N (Cumbria) on the west coast and 53.5° N (north Lincolnshire) on the east coast. Net manufacturers and suppliers were given at least 2 years warning of these requirements. This approach was later adopted at a European level in developing the Commission's fixed net mesh size controls in Annex VI of Council Reg. 850/98, which specifies allowed mesh size ranges by target species, and includes a banned range of 70-90 mm.

Restrictions on fishing in nursery areas
Enforcing the MLS of 36 cm and complementary controls for mesh sizes in enmeshing nets would clearly be most important in areas where juvenile bass predominate in catches. These tend to be close inshore, where tagging exercises in the mid-1980s had shown exploitation rates to be as high as 50% each year. The key part of the package of management measures, therefore, was the proposal to restrict all fishing activities that are likely to take small bass in areas where the majority of fish in the local bass population were below the legal minimum landing size and vulnerable to exploitation. These came to be known as the bass nursery areas.

Juvenile bass are found in sheltered or enclosed inshore areas (i.e. estuaries, inlets, rias and harbours) for most of the year, though in winter they may be found in the open sea, where they are then much less vulnerable to fishing. With an MLS of 36 cm, the bass in need of protection are predominantly juvenile fish 3-5 years old (Pawson and Pickett, 1996). Prior to the period of climate warming which was most marked in the winters of 1988 - 1990 (Pawson, 1992), the susceptibility of 0-group bass to low temperatures in winter (Lancaster, 1992) meant that potential nursery habitats north of the Dee Estuary on the west coast and the Thames Estuary in the North Sea were unlikely to contain sufficient small bass in most years to merit protective measures in addition to the MLS and MMS controls. The main exceptions are where warm water was discharged from coastal power stations, such as at Heysham, in Morecambe Bay, Lancashire, and at Bradwell in the Thames Estuary.

The relative status of the prospective nursery areas shown in Figure 4 was assessed on the basis of (a) the probable proportional contribution of recruits to the adult bass stock as a whole, and (b) the significance of protecting juveniles there in terms of the benefits to local bass fisheries. In many cases, it was thought unnecessary to prohibit fishing in the whole nursery area and still be able to provide adequate protection to juvenile bass, and consideration was given to identifying specific locations in a nursery area and the time of year in which the bass there were particularly vulnerable.

Regulation (EC) No 850/98 for the conservation of fishery resources through technical measures for the protection of juveniles of marine organisms.
vulnerable to fishing, the ease of delineating that area, and the degree to which fishing restrictions could be enforced.

During preliminary consultations in 1987, the idea of prohibiting fishing for bass in nursery areas had largely been accepted by both sport and commercial interests, and considerable information on the various fisheries in the 34 areas, identified as having a priority for control above and beyond the 36 cm MLS and enmeshing net mesh size controls, had been obtained. Because it was difficult to determine exploitation rates on the local bass population in nursery areas, we were not able to analytically assess the potential benefits that this regulation would have for yields in the fishery. In deciding whether particular fisheries could be permitted to continue to operate in these nursery areas, we therefore attempted to judge the vulnerability to capture of undersized bass in those areas known to harbour them against the social and economic significance of local fisheries for bass and other species.

Commercial fishermen were especially concerned that closing areas to protect juvenile bass would not deny them access to fisheries for other species that were important for their livelihood. Similarly, a complete prohibition of angling, as initially proposed for some nursery areas, would severely affect angling activity for species other than bass. Whilst the national angling organisations also welcomed the principle of closing nursery areas to fishing, there was no doubt that a closure of entire nursery areas to all angling would not be acceptable politically. Consultation at the local level revealed the relative importance of these fisheries and their respective interactions with the bass fishery, and the participants' willingness to accept, or determination to oppose, the various aspects of the bass management proposals.

As a consequence of strong representations of this nature to the Minister, the final measure, though specifically aimed at protecting undersized bass where and when they were most vulnerable, was less restrictive than had been hoped (by managers). The regulation applied to any person fishing from a boat, whether registered or not, and prohibited fishing for bass in 34 separate designated nursery areas for all or part of the year. These areas, their extent and the seasonal duration of the prohibition, together with an explanation of the MLS and enmeshing net mesh size regulations, were set out in a freely available "glossy" (MAFF, 1990).

It was apparent that, despite the attendant limitations, nursery areas and the other measures would best be designated by a national order, rather than by SFC or NRA Bye-law, thus ensuring equality of treatment in all regions and an immediacy of implementation. The 36 cm MLS regulation, and mesh size controls on enmeshing nets, were made under sections 1 and 3 respectively of the Sea Fish (Conservation) Act 1967 (Great Britain-Parliament, 1989a and 1989b), and nursery areas were established under section 5 (Great Britain-Parliament, 1990). For the purposes of enforcement, it was made clear that SFC and NRA personnel could be appointed as British Sea Fishery Officers under section 7 of the Fisheries Act 1968 (Great Britain--Parliament, 1968).

**Impact and Evaluation**

Unlike almost any previous sea fisheries legislation in the UK, the bass regulations were expected to affect both commercial fishermen and anglers to a similar degree. The closure of nursery areas was the most radical part of the management package, and Pawson and Pickett (1987) pointed out that restrictions on fishing in nursery areas were attractive both in biological conservation terms and in making management of the fishery more even-handed, since MLS and mesh size restrictions have a much greater impact on commercial fishermen than they do on sport anglers.
Ironically, perhaps, it turned out to be the anglers who would face the greatest restrictions if nursery areas were closed to all fishing activity.

For commercial fishermen to comply with the regulations, the main changes would be an adjustment in gear and fishing grounds to avoid taking juvenile bass. Inshore fishermen are adaptable, and they show great flexibility in their fishing practices to counter fluctuations in the availability of fish resources. The impact would vary, depending on the extent to which fishermen had previously focused their effort on small bass and whether they habitually worked in those nursery areas for which restrictions on fishing were being proposed. By a fate of nature, three successive year classes (1984 - 86) of bass were relatively weak, and this had resulted in a dearth of fish between 32 and 36 cm in the late 1980s. By the time the regulations were introduced early in 1990, many bass fishermen had already become used to directing their effort at older, larger bass of the relatively strong 1982 and 1983 year-classes. Although it was inevitable that there would be a loss of earnings for some people in the short term, it was anticipated that this would be reversed within 1 to 2 years, as those bass benefiting from protection grew and recruited to the fishery. It was estimated that within 5 years of the regulations coming into full effect, the yield to the fishery should increase by up to 25% (Pawson and Pickett, 1987, 1988).

As part of the long-term management and monitoring of the UK bass fishery, it was agreed that a review of the effects of the management package introduced in 1990 would be carried out after 3-4 years (Pickett et al., 1995). This showed that the proportion of juvenile (<36 cm) bass in landings had decreased from 27% in 1987-89 to 4.6% in 1992. It was concluded that mesh size regulations had been largely effective in controlling the proportion of undersize bass landed, aided by additional controls applied by various Sea Fisheries Committees. Monitoring of fishing activity in bass nursery areas in 1992 showed a wide variation in the amount of bass fishing, but overall indicated a marked decline in activity. By 1993, average annual yields and yield-per-recruit had already shown measurable increases in Divisions IVc/VIIc (south-east), VIIe (south-west) and VIIa,f and g (west) regions (Table 1). However, these increases (average YPR up by 48%) were also attributable to increases in growth rate, related to a succession of warm summers and mild winters (Pawson, 1992).

The first international assessment of the European sea bass stocks was carried out by ICES in 2002 (ICES, 2002), using catch-at-age data by ICES division for the years 1985, 1990 and 1995. These produced estimates of exploitation pattern (age-related mortality) and mortality levels in the population as a whole. Figure 5 shows that the management objective, to move the exploitation pattern towards higher ages, had been achieved by 1995, when equilibrium VPAs showed peak exploitation at age 6 for fisheries in the North Sea (IVb,c) Channel (VIIc,d,e) and west coast (VIIa,f,g). That this was not unduly biased by the presence of the extremely abundant 1989 year class is demonstrated by exploitation patterns again showing a peak at age 6 in 2001 (ICES, 2003).

**Discussion**

We have shown that the technical measures introduced by the UK to better manage the bass fishery around England and Wales increased protection of juvenile bass and helped safeguard the stock prosecuted close inshore by small boats that target both adult and small bass. This package was associated with effort and exploitation patterns in the late 1980s, when it was argued that the exploitation pattern in the offshore fishery was already satisfactory, by virtue of the natural distribution of the fish which are principally adults in this fishery. Today, these measures may no longer adequately protect either the stock or the economic viability of the bass fishery, in view of the expansion of effort by offshore pair trawlers targeting the previously underexploited adult stock(s) during winter and early spring. To date, however, there is no evidence of a reduction in
recruitment, which has been good since the large year-class of 1989, with 2002 appearing to be of similar magnitude. Climate warming is certainly aiding this process and possibly masking any negative impacts of fishing on the spawning stock. Landings in the UK fishery have doubled since 1990, from a yearly average of 605t from 1985-90 to 1230 t from 1991-2001, showing that the predicted increase in yield has been maintained, albeit with the help of good recruitment. The number of vessels fishing for bass in England and Wales increased from a low of 1694 in 1991 to 2282 vessels in 1994, decreasing to 1711 vessels in 1998 and increased to a high of 2328 vessels in 2002, fluctuations which, in part, appear to be related to the abundance of incoming year-classes. The spread of the bass population northwards into the North Sea through the last decade has also resulted in more small bass being caught offshore, and there may be a need for additional controls allied to the technical measures applied to protect juveniles in the coastal zone.

The UK's strategy for bass conservation in the late 1980's did not include catch controls, because the bass fishery's mixture of coastal and offshore interests and the absence of international catch records presented a difficulty in carrying out analytical assessments or achieving national and international agreement on allocations and quotas. It is equally difficult to see how fishing effort could be regulated in the inshore fishery, which is conducted by a host of small commercial vessels and anglers, whose bass fishing activity simply could be controlled only by opening and closing the fishery nationally. Given the seasonal variations in the availability of bass around the coasts owing to migrations (Pawson et al., 1987), this approach would be extremely disruptive, particularly to the recreational fishery.

ICES (2002) has already noted that, at least in Divisions IVb,c and VIIa,d,e,f,g,h, bass stocks appear to be fished with an exploitation pattern that avoids growth overfishing and at a fishing mortality level which is sustainable, both combining to give a near maximum yield per recruit. Biologically, there may be some benefits from an increase in the size at recruitment, but any consideration of this should take into account the effects on inshore artisanal fisheries, implications for mesh size regulations and the potential for illegal landings to the strong market for small bass. ICES has advised that, given the uncertainties in the assessment, and the possible influences of an unfavourable change in environmental conditions on recruitment, effort in the bass fishery should not be allowed to increase. The Commission, on the basis of this advice, stated in December 2002 that "Member States will limit their fishing effort on sea bass to the levels of recent years and regularly report on catches to the Commission". We have yet to see this implemented.

**Table 1.** Yield per recruit estimates, based on equilibrium recruit numbers and patterns of $F$, derived from XSA, before (1985 - 89) and after (1990 - 93) the introduction of the UK bass management measures in 1990, in ICES Divisions IVc + VIIId; VIIe and VIIa,f& g. (From Pickett et al., 1995)

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<th>1985-89</th>
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<tr>
<td>South-east</td>
<td>590g</td>
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<tr>
<td>South-west</td>
<td>580g</td>
<td>850g</td>
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<td>West</td>
<td>660g</td>
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Figure 1. The life cycle of sea bass *Dicentrarchus labrax*. 
Figure 2. The relationship between yield-per recruit and age and size at recruitment, for regional exploitation patterns in ICES Divisions IVc, VIId, VIIe, VIIf&g, and all UK coastal waters, averaged over 1984-87.
Figure 3. Theoretical gill-net retention curves for bass in mesh sizes of 89 and 100 m (from Reis and Pawson, 1992), and weight (g) of bass at length.
Figure 4. The geographical distribution of the 34 bass nursery areas designated by MAFF in 1990.
Figure 5. Exploitation pattern (F-at-age) derived by an equilibrium VPA applied to international catch numbers at age of bass for 1995 in (a) ICES Divisions IVb, c and VIIId, (b) VIIe,h, and (c) VIIa,f and g, using 3 different estimates of terminal F.
REFERENCES


