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OBSERVATIONS ON THE STATUS OF BASS *Dicentrarchus labrax* STOCKS IN IRELAND IN THE LATE 1990s

by

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Plate A photograph recording a large landing of bass by anglers from the half-decker M.F.V. Splaugh Queen. The photograph, on a postcard, is believed to date from the mid-1960s.

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ABSTRACT

Investigative work was undertaken in 1996 to ascertain the strength of sea bass stocks following the introduction of a range of conservation measures which effectively extinguished the legitimate commercial fishery for the species. Information was sought from two sources: estimation of the age composition of the samples and the growth of bass by examining scales from exploited fish. An estimate of the density of juvenile pre-recruit bass was made from a seine net survey undertaken in various estuaries along the south coast.

Scales sent in by anglers and obtained through the regional boards from illegally netted fish indicate that a high proportion of bass landed between 1996 and 1998 belonged to the 1989-year class, which had been reported to be exceptionally large in Britain. Back-calculations of length-at-age from the scales of these and seine-netted bass suggested that growth improved in the later 1980s in response to higher sea temperatures but has since declined.

Work on an index of juvenile abundance began with 59 seine net hauls made in August 1996 and 1997. On these the areas most likely to support bass were characterised; 0-group bass were encountered more frequently than any other age group. Sites most likely to support bass were mud flats overlaid with shallow and still water which had a salinity range of 17 to 22‰ and bass were associated with certain species of estuarine fish and crustaceans; bass were negatively associated with other species occupying the deeper and more sandy parts of estuaries. Sampling stations for 0-group bass have been selected in Youghal Harbour and Wexford Harbour. Further exploratory work is required to extend the list of stations.

It was concluded that there has been a temporary increase in the numbers of sea bass, as has been reported by fishermen in Ireland, as a result of more favourable temperatures in the late 1980s. Growing conditions appeared to have deteriorated in the later 1990s and the summer growth of 0-group bass was the weakest in 1999 over the 4 years investigated. A time series of 0-group abundance is too brief to permit any conclusions to be reached. However, it can be stated that the recorded densities of juvenile bass between 1996 and 1999 were sparser than would be expected in south east Ireland in view of the supposed heavy winter concentrations of the species in the Celtic Sea.

INTRODUCTION

Sea bass, *Dicentrarchus labrax*, is widely regarded as the most important sea angling species in Ireland; sea angling generally was valued at £25 m to the economy by the Central Fisheries Board in 1996. Beyond this there seems to have been no analysis of the species' worth although recent investigations in Britain suggest that our stocks may be of greater value than hitherto estimated. Pickett *et al.* (1995) reported bass having a first sale value of £7.9 m in Britain in 1993 (the whole-

sale value in that year was estimated at £9.9 m). In 1992, the recreational fishery for bass there was reckoned to have 361,000 participants who spent £18.3m on their activities. Pickett (1990) estimated that bass landings averaged 637 t annually between 1985 and 1988; while this is small compared with, say cod or plaice (landings 36,414 and 21,611 t, respectively, in 1988), the high value of bass placed it among the top ten of annual first sale values in England and Wales. Pickett's data were obtained by a specially designed survey to elicit details of bass landings from the operators of small inshore vessels. Such vessels are not covered by the Communities' logbook scheme and they dispose of most of their landings through outlets other than the main auction halls, which are sampled by the Sea Fisheries Inspectorate.

Sea bass is a sub-tropical species at the northern limits of its range in the British Isles. It is more common along the southern coasts of these islands and forms winter aggregations in the Celtic Sea from which it disperses around the coast of Britain and Ireland as the water warms in spring and summer. Bass stocks are maintained by variable recruitments which also appear to be temperature related and probably regulated: a succession of good recruitments and improved growth contributing to a build-up of stocks to bring about a cyclical abundance.

Some of the earliest research on bass in Irish waters (Kennedy and Fitzmaurice, 1972) recognized the occurrence of good and poor growing years. A decline in stocks in the 1970s prompted the introduction of a number of conservation measures. Bye-law No. 577 of 1975 introduced a size limit of 14 inches (35. 6 cm) fork length, a close time for fishing bass by net or weir and a restriction in the taking of bass by net in certain waters. S.I. No 128 – Bass (Conservation of Stocks) Order, 1990 – forbade fishing from a boat for bass or the use of nets in their capture or to have the fish on board an Irish fishing vessel. Bass might not be trans-shipped from a sea fishing boat. The size limit was increased to 40 cm. In 1991, a Bass (Conservation of Stocks) Amendment Order (S.I. No. 189 of 1991) enabled officers of the Regional Fisheries Boards to enforce the provisions of S.I. 128 of 1990. A Bass (Restriction on Sale) Order (S.I. No. 191 of 1991) prohibited the sale or offer for sale of bass; this S.I. would be renewed annually. The Bass Fishing Conservation Bye-law (No. 673 of 1991) prohibited taking or having in possession more than two bass in any 24-hour period. It also specified a close season for bass angling between 15 May 1992 and 15 June 1992.

The cumulative effect of these regulations has been to extinguish the legitimate commercial fishery for bass. Bass however, is an extremely valuable product so it is unlikely that trade in the species would have been ended by these measures. Indeed, anecdotal accounts support the belief that there is a thriving clandestine market for bass. A consequence of recent developments has been the non-appearance of bass captured by the commercial fishery sector while reports from anglers (relayed through the Central Fisheries Board) suggest that the stocks have recovered somewhat.

The closure of the commercial fishery for bass has also shut down a source of statistical information from which the status of the stocks might be assessed, even if the quality of such data would not have been very accurate. Currently, the only record of catches that might serve to indicate the abundance of the fish has been provided by anglers (Fig. 1). The Cork Angling Club noted the numbers of bass taken by their members in the course of competitions between 1963 and 1997. Such figures have to be interpreted with caution: anglers tend to target species which they reckon are available to catch, hence the heavier landings in Fig. 1 are likely to result from greater fishing effort than the low catches which appear later in the series. The figures are however, thought to give an approximate indication of what has happened to bass stocks over the last four decades of

the century. A slight resurgence in abundance in the late 1900s will be the subject of the investigations described in this paper.

Over recent years, fishing activity in inshore waters has generally become more intense (Fahy, 1992, Fahy *et al.*, 1995; Fahy and Gleeson, 1996; Fahy, in prep.) and there has always been an interest in reopening the commercial fishery for bass. Anglers are anxious that bass should be regarded administratively as primarily an anglers' fish. There are also other questions to be considered. During its early years bass is an inshore species. As it matures it moves off-shore when it is potentially available for exploitation by various nations, notably the French who trawl bass in the Western English Channel. There is resentment that fish that originated in Irish waters should be available to other nationalities, but not to the commercial fishermen in their country of provenance, although there are no data which confirm that such exploitation is taking place. There is currently a desire by the Department responsible for fisheries to ascertain whether and how effective their conservation regulations have been and there is a belief that the perceived increase in abundance of bass in recent years derives from current management. These concerns prompted the investigations described here.

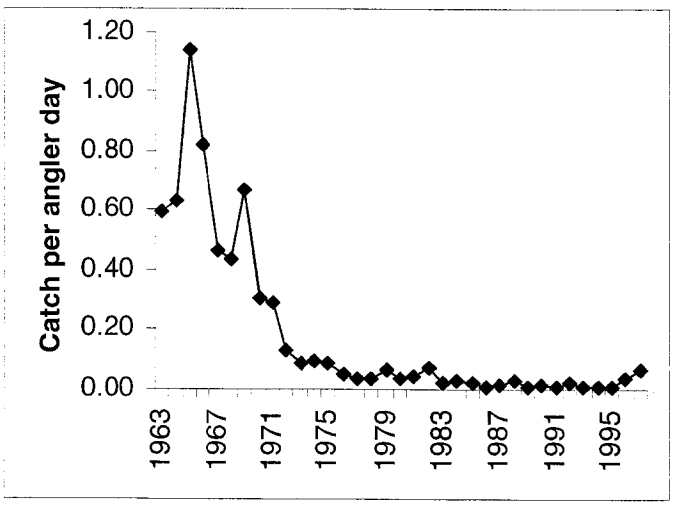

Figure 1. Bass catch per angler day in competitions organised by the Cork Angling Club from 1963 to 1997 as recorded by Tom Cunningham in a mimeo document entitled "Coastal Fish Conservation".

BIOLOGICAL INVESTIGATIONS

Two initiatives were devised to provide information on bass stocks:

1. The collection of scales and life data from angler-caught bass and illegally captured (and seized) bass from which the following would be sought:
   a. the age composition of the samples and
   b. an indication of growth in earlier years, by back-calculating length-at-age.

Both were intended to facilitate comparison of Irish sea bass with recent assessments of British stocks.

2. A repeatable survey of juvenile bass to evaluate the relative strength of annual recruitments. Back-calculated lengths-at-age would also be provided by specimens captured in the course of this survey.

MATERIALS AND METHODS

1. Age composition and growth of juvenile and adult bass

Scales and measurements were requested from anglers and from the Regional Fisheries Boards along the eastern, southern and south-western coasts. The results were very disappointing; 309 sets of scales, accompanied by details of length and weight, were obtained up to the end of 1999. They were provided by anglers and by the protection officers of the Regional Fisheries Boards who seized illegally net-caught bass. The scales of nine adolescent bass captured by beach seine in 1996 were included in the back-calculation of length-at-age as were 36 1-group bass taken in 1997.

2. Establishing an index of juvenile bass abundance

Beach seine surveys of estuaries along the south coast were undertaken in August of each of the years 1996–1999 inclusive. These were essentially exploratory, although sufficient sites were fished with consistent results during the second year to establish the basis for a repeatable evaluation of the abundance of 0-group bass. Surveys of this kind develop over a period of years and it is anticipated that further exploratory work on this one would accompany re-visits to sites that are already yielding usable data.

Kelley (cited in Pickett and Pawson, 1994), used a beach seine to sample juvenile bass of ages 0 and 1 years. The method has the merit of being repeatable and of providing quantitative and comparable results. Although the locations frequented by larger bass are well known to anglers, relatively little was known of juveniles in Ireland; Bracken and Kennedy (1967) recorded small numbers of specimens aged 0–2 years from the east coast but there has been no quantitative investigation of their biology and distribution before now.

British and Irish bass concentrate in the Celtic Sea during the winter months and disperse closer inshore around the coasts as temperatures rise in spring and summer (Holden and Williams, 1974). They would appear to be more abundant around the southern shoreline; they spawn close to river estuaries. When they were captured in earlier years, juvenile bass were located in estuarine pills and creeks around the southern coastline.

The first task was to locate adequate numbers of young bass and to devise a technique for fishing them repeatedly and consistently. River estuaries known to be frequented by larger bass were an obvious place to begin. In August 1996, four were selected on the south coast – Courtmacsherry, Youghal, Dungarvan and Wexford – based on information provided by the Central and Regional Fisheries Boards and by local anglers. Fishing effort was concentrated on the full tide. No bass were located in Courtmacsherry Bay or in Dungarvan Harbour; some larger fish (2–4 years) were netted at Youghal and there was some success in fishing parts of Wexford Harbour, one haul taking more than 232 0-group bass.

In August 1997, the fishing technique was altered radically: this time fishing effort was concentrated in the 2 hours of the lowest water, around the turning of the ebb tide. Courtmacsherry was

not fished in 1997 because its physical and faunal characteristics observed in 1996 suggested that it was an unproductive habitat for survey purposes. Youghal Harbour yielded some 0-group bass in 1997 and Dungarvan Harbour was fished again because its physical characteristics and fauna were those associated with the occurrence of these fish; only one was taken, however. Two days were spent in Wexford Harbour in 1997 and the number of locations at which 0-group bass were present increased; 1-group bass were also sampled at Wexford. One day was spent fishing the Back Strand at Tramore without success.

The survey in August of 1998 again concentrated largely on Wexford Harbour; in addition a site for netting 1+ bass on the Tourig River at the north end of Youghal Harbour was successfully fished on the turning tide. A pill north of the Harbour, at Wood Point on the River Blackwater, proved amenable to stop-netting and 0-group bass were captured there in some numbers.

In 1999, Wexford Harbour was again productive and repeated fishings were undertaken at St. Mary's Point. The South Slob site was abandoned because it was not considered possible to fish it in a standardised way. Rainfall was heavy in August 1999 and neither the Tourig River nor the Wood Point site yielded bass. Repeated fishings at Duncormick, a new location on the coast, did not provide bass either.

In the first 2 years of this work, therefore, three locations at which repeated fishings are feasible have been identified: one in Wexford Harbour at St Mary's Point; one in Youghal Harbour, on the Tourig River; and another at Wood Point, these latter two being weather dependent. While it is desirable to extend this list of fishing locations, it is feasible to commence an abundance index on results already obtained. The locations of beach seining hauls in 1996 and 1997, on which the characteristics of bass-producing waters have been established, are presented in Appendix 1; all sites are marked on the Appendix Figure.

Quantitative aspects of the fishing method

A seine net which had previously been used by Fisheries Development Ltd. in the Cross Border Herring Study (Anonymous, 1979) was used to collect samples. The net could be set from a small boat or inflatable, although in very shallow water (<10 cm) it was dragged out from the beach by hand. The net had a head rope length of 33 m. The outermost panels (5.5 m on either side) had a mesh size of 2.54 cm. Inside each was a panel of similar length of 1.42 cm mesh while the centre panel of the net was made up of a 0.95 cm mesh. The bag had a mesh size of 0.51 cm. The depth of the seine increased from 1.83 m at the wings to 3 m at the centre. The warps on either side were 30 m long.

The net was set so that the current kept the bag open. When the current was insufficiently strong to do so (and 0-group bass were located in still waters on almost every occasion), the boat used to set the net accompanied it during the haul, a member of the crew holding the cod end so that the net remained open. Following a pause of 5 min the net was drawn steadily and evenly onto the beach. The usual duration of a draw was approximately 12 min.

As set, the extended net is shown in plan in Fig. 2.

The volume of water sieved through the net was roughly calculated using the formula:

$$[0.5(\pi r^2 \times D)] + [0.5(L \times 2r \times D)]$$

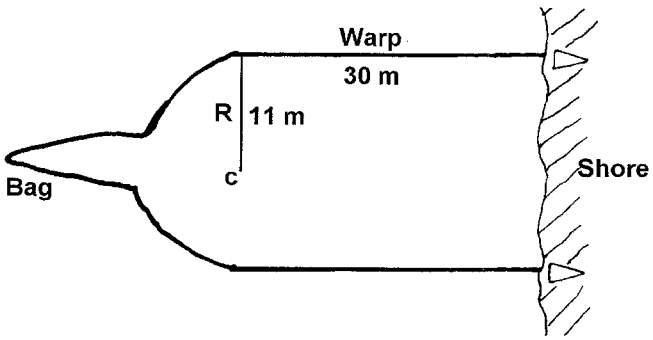

Figure 2. The seine net used in juvenile surveys, extended as set, shown in plan. Terms explained in text.

where **r** is the radius of the net assuming a semi-circular shape, **L** is the length of the warp and **D** is the depth at the centre of the circle (**c**) with a maximum value of 2.5 m.

The surface area of water enclosed by the net was calculated as:

$$[0.5(\pi r^2)] + [L \times 2r]$$

which gave a calculated surface area of 800 m^2 in still water. Values of less than this indicate that the net was set in restricted circumstances where, for instance, the warps could not be fully extended.

The speed of the current was estimated by timing the drift of a floating object over a measured distance. The following categories of current speed were identified:

Dead water, where the net hung limp and there was no sign of drift.

Slow current, when a current speed of less than 1 m/min was recorded.

Moderate current, where current speed exceeded 1 m but not 2 m/min.

Fast current, when speeds of greater than 2 m/min were observed.

These currents, operating over the time required to draw the net (approximately 7 min), would have resulted in an increased volume through the net of 25% for slow current, 50% for moderate and 75% for fast currents. The relationship of the four current speeds to depth at point **c** in the net (Fig. 2) is shown in Fig. 3.

A greater extension of the time of fishing further increased the volume of water sieved. The time and location of each haul were noted, as were the substratum, depth of water fished, and whether the current was fast, moderate, slow or non-existent. From this information the volume of water passing through the net was later estimated. In 1998 and 1999, water samples were taken back to the laboratory for determination of salinity. All animal life taken in a haul was recorded (though not all at species level) and its abundance was estimated in numeric terms. In the two years 1996 and 1997, 59 sites were fished. In 1998 18 were fished and 17 in 1999, but these were largely a repeat of fishings in the two previous years.

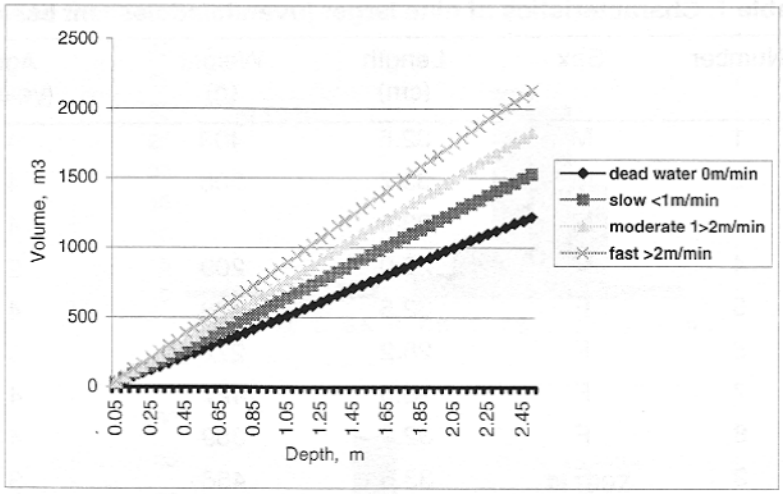

Figure 3. The relationship between depth at point **c** (see Fig. 2) and volume of water sieved at four current velocities.

RESULTS

Categorisation of sampled bass

Bass sampled in the two years belonged to two age/developmental categories as defined by Pickett and Pawson (1994):

Juveniles (fish of less than 32 cm) in which the gonads are immature and which might be further divided into fry and fingerlings according to the terminology of Roblin and Bruslé (1984) who defined the former as less than 6 cm and the latter as 6–12 cm in length and

Adolescent bass of between 32 and 42 cm in which size group males have maturing gonads during the winter and spring months, though not females.

Nine juvenile/adolescent bass were netted in the pills draining into Youghal Harbour at high tide in 1996. These fish belonged to age groups 2+ to 4+, the majority being 4+ (Table 1); back-calculations of their lengths at age are shown in Table 2 with those of the other aged fish.

Scales from a sub-sample of juvenile bass, all captured in Wexford Harbour, were examined in 1996 and all were 0-group. Length frequencies are given in Fig. 4 and average total length 7.5 cm (s.d. = 0.820; number sampled 110).

In 1997, a sample of 1-group bass was taken off the South Slob in Wexford Harbour. These fish ranged between 14.4 and 19.5 cm and they averaged 17.34 cm (s.d. 1.350; n = 36). Back-calculating length at the end of the first year provided an average of 7.8 cm (s.d. = 1.500), indicating that 96% of the year's growth in 0-group bass had taken place when sampling occurred in August 1996.

The provenance of 0-group bass sampled in 1997 was more diverse (Appendix 1) but their lengths were fairly similar everywhere. Maximum efforts were made when handling these fish to take a

Table 1. Characteristics of nine larger juvenile/adolescent bass

Number	Sex	Length (cm)	Weight (g)	Age (years)
1	M	32.6	403	4
2	M	33.7	506	4
3	M	33.2		4
4	M	26.0	209	2
5	F	32.5	438	4
6	F	28.2	272	3
7	F	33.5	427	4
8	F	32.0	389	4
9	F	33.5	456	3

small number only for laboratory purposes. In 1997, 25 0-group bass were taken for measurement and examination of stomach contents. Their total lengths averaged 5.1 cm (s.d. 0.820) and their length frequency distribution was quite distinct from that of similar fish taken at approximately the same time the previous year (Fig. 4); in 1997 growth would appear to have been poorer by 2 cm.

In 1998 and 1999, 0-group bass were measured in August. Their average length was 5.95 cm (s.d. = 0.996). The following year 63 0-group bass were examined, their average length being 4.65 cm (s.d. 1.105), a growth increment 38% poorer than in 1996 and the weakest growth of 0-group bass in the four years of sampling.

1. Age class composition of the exploited fish

Scales and life data from bass were obtained from anglers and from officers of the Regional Fisheries Boards who seized illegally net-caught fish. These materials may reach the laboratory some time after captures take place and the database is maintained and gradually updated as information comes to hand. The information on age/class composition of bass stocks has been estimated from 43 fish caught in 1996, 134 in 1997 and 101 in 1998; to date fewer than 40 fish caught in 1999 have reached the office.

The fish ranged in age from 2+ to 18+ years, the largest age group being the 1989 year class which accounted for almost 60% of the age sample in 1996 and declined to 36% in 1997 and 30% in 1998. Angler-caught bass are selected, undersized fish being returned to the water; indeed many of the samples in question had been liberated after scales had been removed. Anglers target larger bass and tend to fish in places known to be frequented by these. Nonetheless, allowing that some selection took place and that the sample was small, the dominance of 1989 bass was noteworthy (Fig. 5). This observation has also been made on bass stocks generally in the U.K. where it had been said that the 1984–1986 year classes were poor but that year class strength improved from 1987, while the 1989 year class was exceptionally large (Pickett *et al.*, 1995).

The length-at-age of these and all other bass encountered in this survey, based on an examination of scales sent in during 1996 and 1997 and including some survey caught material in 1996, are listed in Table 2.

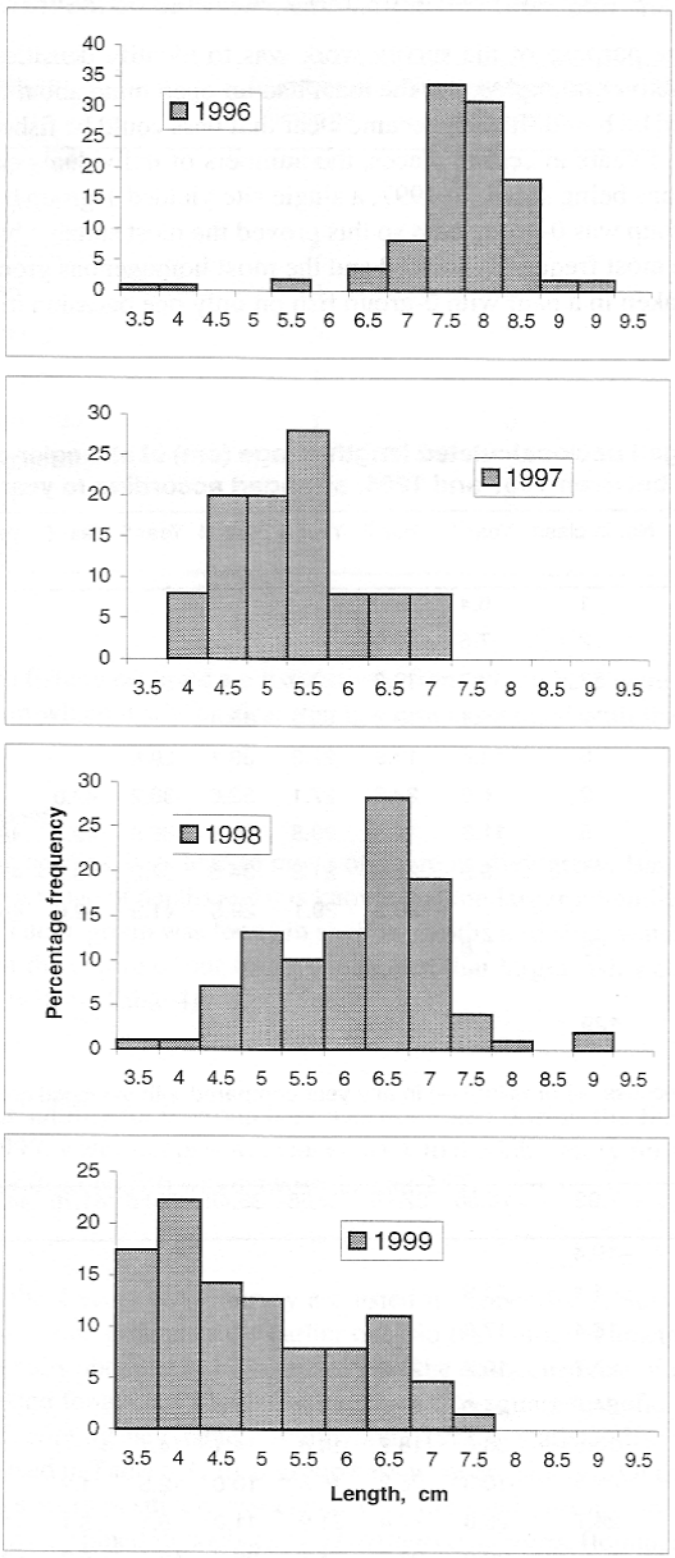

Figure 4. Percentage length frequencies of 0-group bass: sampled in August of each of the 4 years in which surveys took place.

2. *The survey of 0-group bass: characterisation of sites supporting juvenile bass populations*

At the outset, the purpose of the survey work was to identify densities of juvenile bass which might be quantitatively sampled, but the team had an open mind about the age group on which a time series would be based. It soon became clear that bass could be fished as 0-group or as mixed age groups of 2–5 years in certain places, the numbers of individual year classes contributing to these mixed groups being small. In 1997, a single site yielded 1-group bass. The most commonly occurring age group was 0-group bass so this proved the most suitable basis for an index of abundance, being the most frequently located and the most homogenous group. A single specimen of older bass was taken in a haul with 0-group fish on only one occasion in 1996.

Table 2. Averaged back-calculated length-at-age (cm) of all angler-captured and seine net captured bass between 1987 and 1995, arranged according to year class

Year	No. in class	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9
1987	1	6.4								
1988	2	7.6	18.0							
1989	52	9.2	19.0	27.9						
1990	19	10.1	19.2	28.0	35.4					
1991	5	14.6	19.9	27.3	33.1	39.5				
1992	9	6.9	22.3	27.1	32.6	38.2	43.0			
1993	5	11.3	14.3	28.8	32.8	36.8	42.3	46.5		
1994	1	9.9	20.2	21.3	34.6	37.2	40.7	45.2	49.4	
1995			20.3	29.1	29.5	41.3	42.6	45.4	48.8	52.8
1996	35	7.8								
Total	129									

Relative growth success (+) or failure (–) in any year compared with averaged growth (Table 7), shown below

Averaged length	7.92	16.08	22.96	28.38	33.48	37.66	41.78	44.30	47.86	Growth success of year
1987	–19.4									–19.4
1988	–4.4	11.9								3.8
1989	16.4	17.9	21.4							18.6
1990	27.7	19.2	21.9	24.8						23.4
1991	84.7	24.0	19.0	16.8	17.9					32.5
1992	–13.5	38.5	18.2	14.8	14.1	14.1				14.4
1993	42.3	–10.8	25.3	15.5	10.0	12.5	11.2			15.1
1994	24.7	25.8	–7.4	21.9	11.0	8.1	8.1	11.4		13.0
1995		26.0	26.7	4.1	23.4	13.1	8.7	10.2	10.4	15.3
1996	–1.5									–1.5

Table 3. Characterisation of 59 sites seine-netted in 1996 and 1997 according to substratum

Substratum	Number of fishings	Number with bass >0-group	Number with bass 0-group
Stones/gravel	4	0	0
Rocks/sand	1	0	0
Gravel/sand	5	0	0
Sand	8	0	1
Sand/mud	9	0	1
Muddy sand	1	1	1
Rocks and mud	1	0	0
Mussel shells/mud	4	2	1
Mud	26	3	6
Total	59		

Substratum

The substrata on which fishing occurred are listed, those from which bass were captured being indicated in Table 3, from which it will be clear that bass are associated with the finer grades, particularly with mud.

Depth and current speed

In common with many species, bass tend to move offshore as they grow. Bass of greater than 1 year old were found in a range of depths and it is known that the larger juveniles and adult fish are angled in deep water. The 0–group was found in shallow depths and slow water currents; the netting results obtained in the course of our surveys indicated that larger fish were less strongly associated with shallow waters (Table 4).

Salinities

The preferred range of salinity for 0–group bass was not noted during the first two years of the survey. In 1998 and 1999, water samples were taken back to the laboratory for analysis (Table 5). The preferred range for 0-group fish was between 17 and 21‰.

Associated fauna

Taxa recorded during the 4 years of the survey are listed in Appendix 2. Surveys in subsequent years covered much the same ground as the earlier ones so the faunal characteristics of the sites are established from results obtained in 1996 and 1997. The co-occurrence of pairs of taxa listed in Appendix 2 were tested for affinity or repulsion using a Chi-square test after the data had been arranged in a 2 × 2 contingency table (Southwood, 1966); statistically significant results ($P < 0.05$) are summarised in Table 6. Only 0-group bass were considered. Of the commonly sampled taxa, 0-group bass were positively associated with the sand shrimp *Crangon*, grey mullet *Crenimugil labrosus*, three-spined stickleback *Gasterosteus aculeatus*, flounder *Platichtys flesus*, and juvenile black sole *Solea solea*. 0-group bass were negatively associated with sand eels Ammodytidae, sand smelt *Atherina presbyter* and estuarine goby *Pomatoschistus minutus*, all of which occurred on a more sandy substratum. The negative association between 0-group bass and

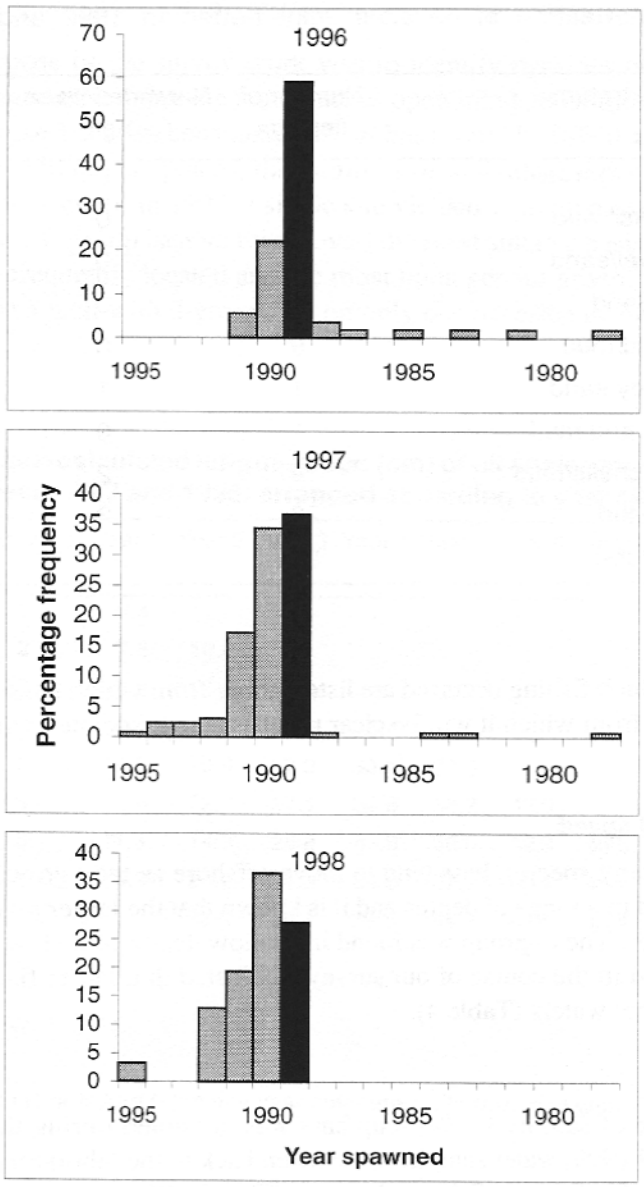

Figure 5. The year class composition of bass (captured by anglers who submitted scales and of illegally netted bass seized by officers of the Regional Fisheries Boards) in 3 recent years. The 1989–year class is shown in black.

shore crab *Carcinus maenus* is noteworthy given the importance of this species as a food item for larger juvenile and adult bass. 0-group bass however, were taken on only one occasion in association with a single specimen of an older age class. Clupeids (mainly sprat *Sprattus sprattus*) and scad *Trachurus trachurus* probably frequented deeper water than 0-group bass.

Other faunal associations

In August 1997, the stomach contents of 27 0-group bass were examined. All contained food that consisted of small crustaceans. A selection of these was sent to Dr. Mark Holmes in the Natural

Table 4. The surface area fished and the volume of water sieved through the seine net and the number of fishings in which 0-group and older bass were captured

	Area fished (m^2)	No. of fishings	Number with bass >0-group	Number with bass 0-group
No current	600	1		
	700	0		
	800	33	4	5
Slow current	900	0		
	1000	10		4
Moderate current	1100	0		
	1200	4	1	
Fast current	1300	0		
	1400	10		
	1500	0		
	1600	0		
	1700	0		
	1800	0		
	1900	0		
	2000	0		
	2100	0		
	2200	0		
	2300	0		
	2400	1	1	1
	Totals	59		10

Table 5. The occurrence of 0-group bass at different salinities as recorded in seine samples taken in 1998 and 1999

Range of salinity parts per thousand	Number of observations	Number of occurrences of 0-group bass	Number of occurrences/Number of possibilities
0–5	1		
6–10	3	1	0.33
11–15	1		
16–20	10	5	0.50
21–25	4	3	0.75
26–30	0		
>30	8	1	0.13

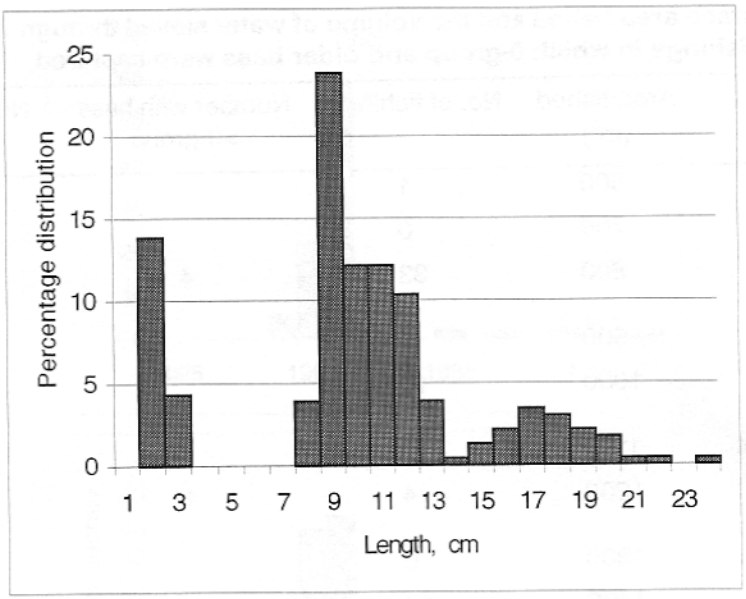

Figure 6. Length frequency of grey mullet captured with bass in 1996 (n = 231).

Table 6. Inter-specific associations among the more common taxa sampled in 59 seine net draws in 1996 and 1997

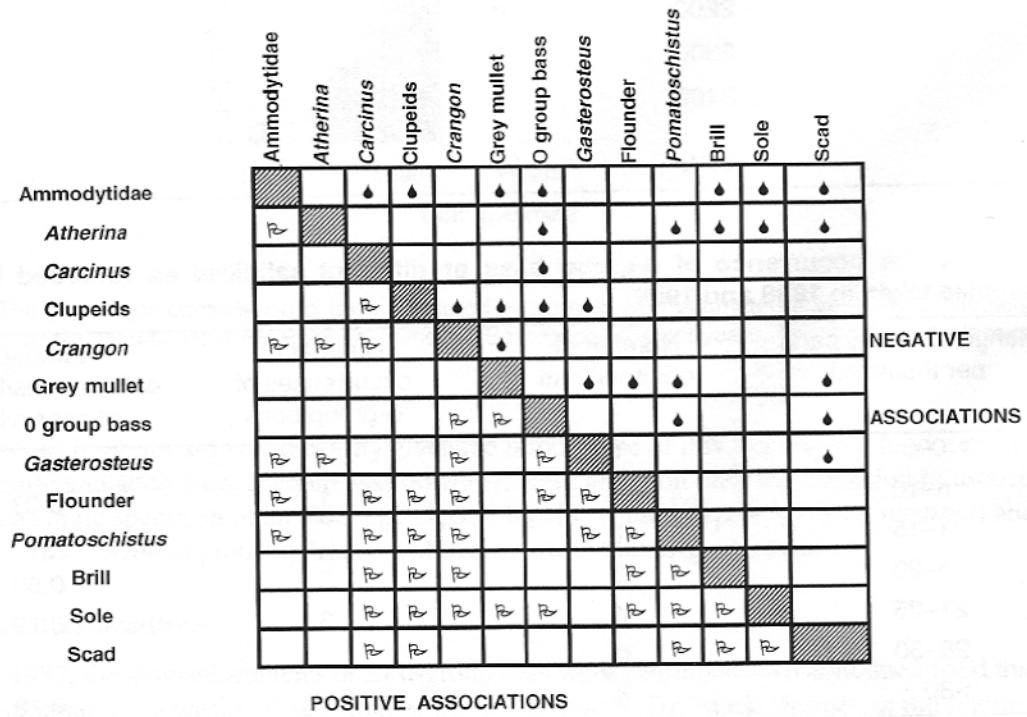

Table 8. A growth curve for Irish bass during the first 9 years of life derived be averaging back-calculated length at age obtained by Fahy (1981) and by Kennedy and Fitzmaurice (1972)

At end of year	Wexford bass[a]	Group A[b]	Group B[b]	Group C[b]	Group D[b]	Averages
1	7.5	7.6	8.6	6.6	9.3	7.9
2	15.6	16.3	16.7	14.6	17.2	16.1
3	23.4	22.7	22.8	21.4	24.5	23.0
4	29.3	28.6	26.9	27.4	29.7	28.4
5	34.3	34.1	31.0	32.8	35.2	33.5
6	38.0	38.7	35.1	37.0	39.5	37.7
7	41.2	43.7	38.7	40.9	44.4	41.8
8	40.0	47.2	41.9	44.2	48.2	44.3
9	47.7	49.8	43.9	46.7	51.2	47.9

[a]From Fahy (1981).
[b]From Kennedy and Fitzmaurice (1972)

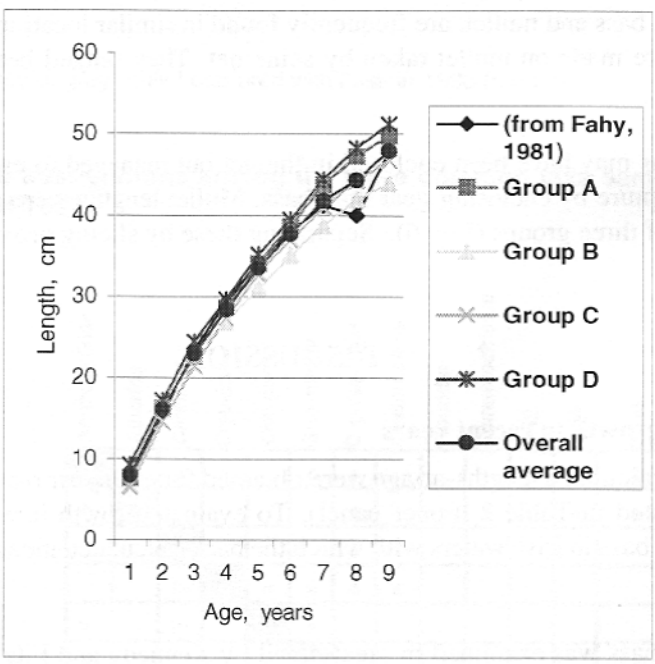

Figure 7. Mean lengths-at-age of various categories of bass in Irish waters, drawn from Table 7.

each year from 1987 until 1995. These readings suggest that the growth index was initially poor, improved to reach a peak in 1991, after which it declined.

An explanation for changing bass growth rates over the past decade

Bass is at the northern fringe of its range around these islands. Temperature is frequently cited as highly influential in its biology and distribution. Holden and Williams (1974) proposed that sea

temperatures were effective in regulating growth of bass. Devauchelle (1984) suggested that gonad maturation and spawning were influenced by temperature; Kelley (1988) believed that exceptionally cold weather was detrimental to bass during their first sea winter. Pawson (1992) demonstrated correlations between the relative abundance of juvenile bass (expressed as survey mean c.p.u.e.) in the English Channel and the temperature deviation expressed as °C from an 11-year monthly mean for the period beginning in 1980. In his paper, Pawson showed that the seasonal inshore waters of the English Channel had undergone a cycle of warming, cooling and warming again during this decade.

The critical seasonal temperature periods identified by Pawson in the annual biological cycle of bass are November to the following March when the gonads develop, March to May when spawning occurs, and May to November when growth takes place. Temperature data collected at Malin Head and expressed as degree days are evaluated over similar periods for the 1980s (Fig. 8) using the mean established over a 10-year period (1980–1989) and extending the means to 1994; their overall pattern is similar to that in the English Channel with a period of cooling in the mid-1980s and relatively high temperatures at the end of the decade; these favourable conditions persisted into the 1990s. Thus, temperature conditions on the Irish coast, so critical to the performance of bass stocks, would appear to have followed similar trends to those in Britain where they were associated with an improvement in bass stocks.

Figure 9 provides a comparison of the relative growth success with the relative deviation of the May–November growing period. Both show an increase from 1987. In 1991, the autumn growing period declined and from the following year the growth index did likewise, although not so dramatically. The explanation for this is the fact that bass, which have in earlier years achieved a length-at-age advantage, are likely to maintain this for a time even if the ambient temperature deteriorates.

The abundance of 0-group bass

Numbers of 0-group bass per m^2 in the 4 years of the survey and per m^3 in 1996 and 1997 are summarised in Table 9. The numbers are only given for sites which yielded 0-group bass (non-occurrences are not taken into account) because the presence of bass had to be confirmed before their numbers might be estimated; very few sites supported bass. Thus, these estimates of abundance will tend to over-estimate the fish. Allowing for that, the numbers of bass recorded in the course of these surveys are very low, ranging from 0.006 to 0.155 fish per m^2 in 1997 and 1996, respectively. In his index of abundance of 0-group bass, Kelley expressed his results in terms of area rather than volume (Pickett and Pawson, 1994), for which reason the volumetric calculations were abandoned in 1998 and 1999. The densities he recorded were also considerably greater than those observed on the south coast of Ireland in 1996 and 1997. At this stage of the development of an index of bass abundance no firm conclusions should be drawn other than to remark that, in likely habitats in a part of the country close to the supposed high marine densities of bass in the Celtic Sea, the species is represented by very sparse numbers of juveniles.

On the other hand, the widespread belief among Irish inshore commercial and sport fishermen that bass have returned – albeit temporarily – in some strength after a series of poor recruitments in the 1980s would appear to be factually based. The circumstances which prevail in Irish waters, notably the temperature regimen of recent years, display similar trends to that in the English Channel where bass have been monitored in some detail. Temperature is a significant regulator of the bi-

Table 9. The densities of juvenile bass (0-group) recorded from 1996 to 1999 inclusive

Number 0-group	No./m² fished	No./m² fished	Average density		
			m²	m³	
15					
232					
			Mean 0.155	1.074	
			S.D. 0.192	1.216	In 1996
			S.D./Mean 1.240	1.132	
1	0.001	0.001			
2	0.001	0.001			
3	0.002	0.002			
3	0.002	0.001			
1	0.001	0.001			
25	0.031	0.030			
1	0.001	0.001			
6	0.008	0.010			
			Mean 0.006	0.006	
			S.D. 0.010	0.010	In 1997
			S.D./Mean 1.752	1.698	
1	0.015				
155	0.194				
1	0.017				
1	0.008				
62	0.010				
			Mean 0.049		
			S.D. 0.081		In 1998
			S.D./Mean 1.663		
1	0.001				
11	0.014				
22	0.028				
13	0.016				
17	0.021				
29	0.036				
11	0.014				
11	0.014				
12	0.015				
			Mean 0.018		
			S.D. 0.010		In 1999
			S.D./Mean 0.560		

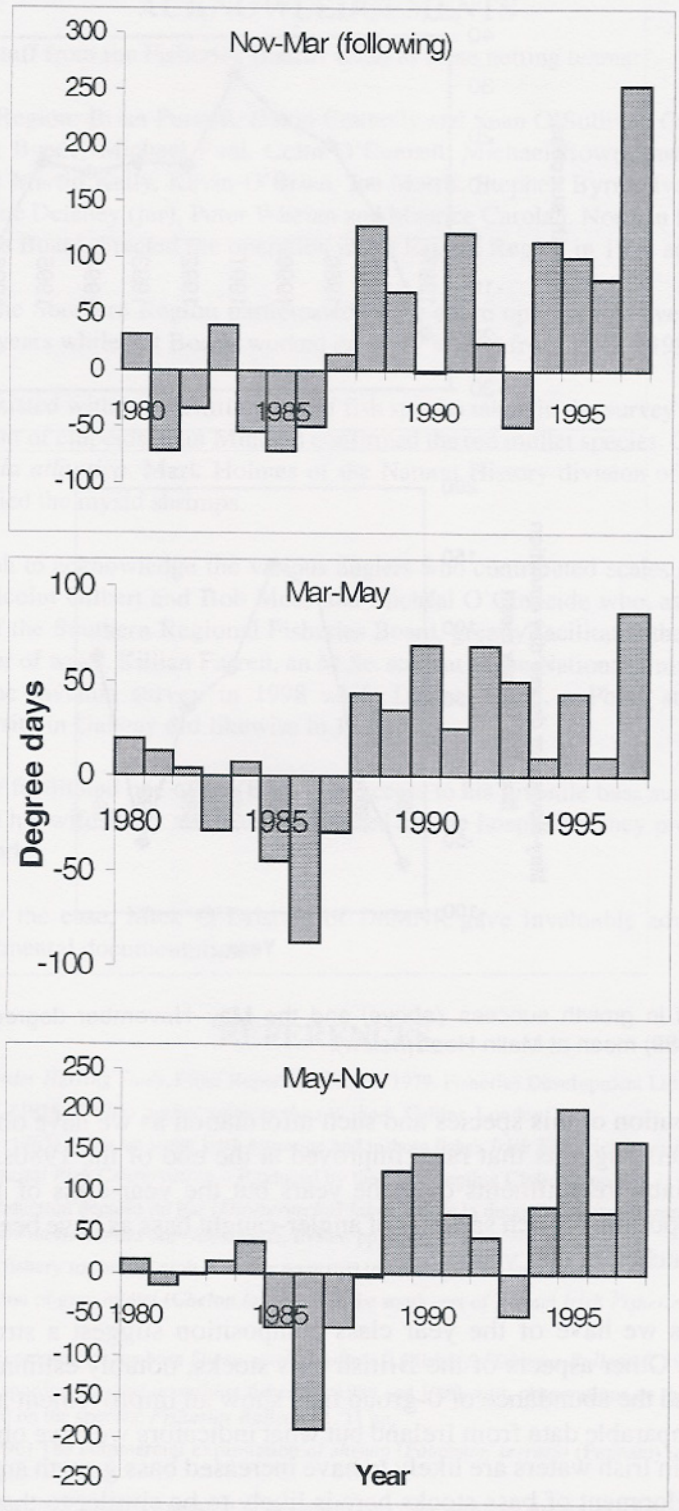

Figure 8. Deviation from the 1980–1989 mean of sea temperatures at Malin Head for three periods of the year which have been identified as influential in the reproductive and growth biology of bass. Temperature data were supplied by the Meteorological Service.

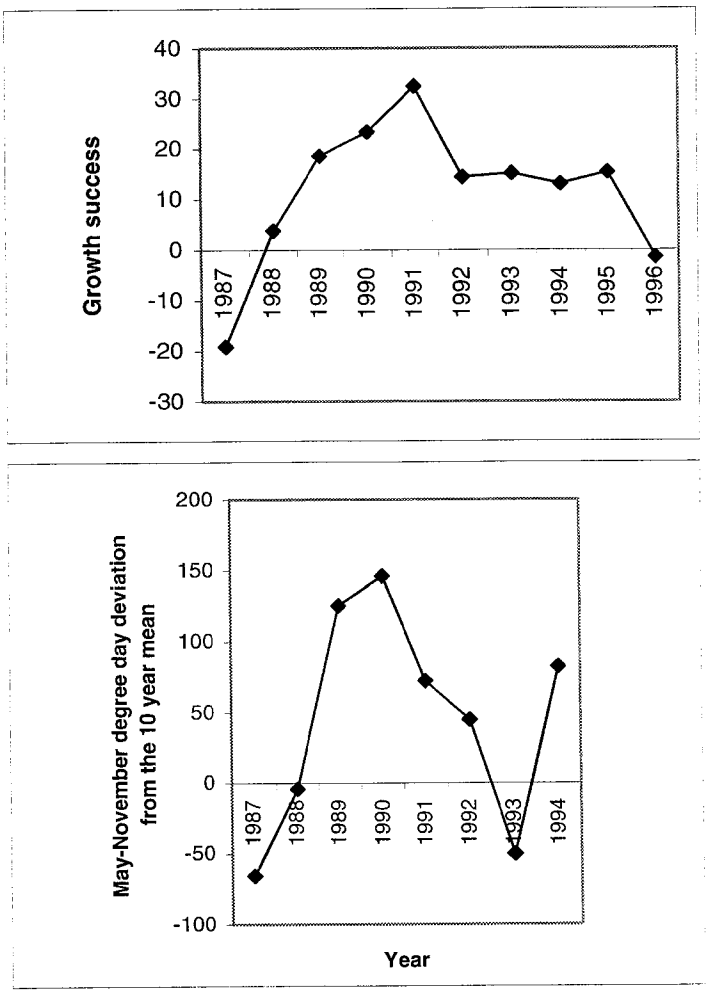

Figure 9. Trends in growth success *(above)* and the May–November degree day deviation from the 10-year (1980–1989) mean at Malin Head*(below)*.

ology and distribution of this species and such information as we have obtained on the growth of bass in Irish waters suggests that rates improved at the end of the 1980s. British stocks of bass have shown variable recruitments over the years but the year-class of 1989 was exceptionally large; a large proportion of such samples of angler-caught bass as have been examined in this work consist of fish hatched in that year.

What indications we have of the year class composition suggest a strong recruitment of fish hatched in 1989. Other aspects of the British bass stocks, notably estimated stock and spawning stock biomass and the abundance of 0-group fish, show an improvement at the turn of the decade. There are no comparable data from Ireland but what indicators we have obtained suggest that conditions obtained in Irish waters are likely to have increased bass growth around the turn of the decade and the development of bass stocks here is likely to be similar to that of British stocks. The work reported here, however, indicates that the improved growth and likely recruitment of bass in Irish waters around the turn of the decade was a temporary phenomenon which has been replaced by slower growth rates and, given the low density of juvenile bass sampled by seine net, probably smaller recruitments and, in 1999 at least, very poor summer growth of 0-group fish.

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John Flynn of the Southern Region participated in the entire operation at every site fished during the four years while Pat Boede worked on every station from 1997 – 1999.

Liz Barnwall assisted with the identification of fish species taken in the survey and provided a detailed account of clupeids. Dan Minchin confirmed the red mullet species. Colm Lorden identified *Sepiola atlantica*. Mark Holmes of the Natural History division of the National Museum identified the mysid shrimps.

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Appendix 1. Details of 59 seine net hauls in August 1996 and August 1997

Haul	Location	Site	Time of fishing	Time before/after low water	Substratum	Area fished (m^2)	Volume fished (m^3)	*Crenimugil labrosus*; grey mullet >0-group	*Crenimugil labrax*; bass >0-group	*Dicentrarchus labrax*; bass >0-group	*Dicentrarchus labrax*; bass 0-group
1996											
1	Courtmacsherry	Site 1	13.30	3.15	sand/gravel	1400	1750				
2	Courtmacsherry	Site 2	15.30	5.15	sand/gravel	1400	1750	65			
3	Courtmacsherry	Site 3	16.00	5.45	sand/gravel	1400	1750				
4	Courtmacsherry	Site 4	16.15	6.00	sand/gravel	1400	1750				
5	Courtmacsherry	Site 5	17.00	-5.15	sand/gravel	1400	1750				
6	Youghal 1	Site 6	13.15	2.00	sand	1400	1225				
7	Youghal 2	Site 7	13.45	2.30	gravel	1400	2100				
8	Youghal 3	Site 8	16.00	4.45	mud	800	830		35		
9	Youghal 3	Site 9	16.30	5.15	mud	800	830		20		
10	Youghal 3	Site 10	17.30	-5.45	mud	800	830		18		
11	Dungarvan	Site 11	12.00	-0.15	mud	800	600				
12	Dungarvan	Site 12	13.30	1.15	mud	800	600				
13	Dungarvan	Site 13	14.15	2.00	mud	800	600	40	54		
14	Dungarvan	Site 14	15.00	2.45	mud	800	600				
15	Youghal	Site 15 – the Pill	17.15	5.00	mud	800	700		1		
16	Youghal	Site 16 – the Pill	17.30	5.15	mud	800	700	40			
17	Youghal	Site 17 – the Pill	17.45	5.30	mud	800	600	10	7		
18	Youghal	Site 18 – the Pill	18.15	6.00	mud	800	600	30	3	1	
19	Youghal	Site 19 – the Pill	18.30	-5.50	mud	800	600	20	15	7	
20	Youghal	Site 20 – the Pill	18.45	-5.30	mud	800	600	10	17	1	
21	Wexford	Site 21 – Wexford Harbour 3	14.45	0.15	mud	800	120	23	23		232
22	Wexford	Site 22 – Wexford Harbour 3	15.30	1.00	mud	800	70				15
23	Wexford	Site 23 – Wexford Harbour 4	16.45	2.15	sand/mud	800	400				
24	Wexford	Site 24 – Wexford Harbour 4	17.15	2.45	sand/mud	800	200				
25	Wexford	Site 25 – Wexford Harbour 4	17.30	3.00	sand/mud	800	500		142		
26	Wexford	Site 26 – Wexford Harbour 4	18.20	3.50	sand/mud	800	500				
27	Wexford	Site 27 – Wexford Harbour 1	19.00	4.30	gravel/stones/sand	1400	1278		7		
28	Wexford	Site 28 – Wexford Harbour 2	19.30	5.00	gravel/stones	800	730	2			
1997											
1	Upper Wexford Hbr	Mary's Point	11.30	-2.30	mud	800	146	155			3
2	Upper Wexford Hbr	u/s Mary's Point	12.05	-1.55	mud	800	195	4			1
3	Upper Wexford Hbr	opp Mary's Point	13.00	-1.00	mud	1000	91				2
4	Upper Wexford Hbr	d/s haul 3	15.00	1.00	mud	1000	183				
5	Upper Wexford Hbr	North Shore	15.50	1.50	sandy mud	1000	183		20		3
6	Upper Wexford Hbr	East of haul 5	16.30	2.30	sand, rocks	600	500	1			
7	Youghal	The Pill	11.10	-2.20	mud	800	146				
8	Youghal	The Pill, beside 7	12.00	-1.30	mud	1000	183				

Appendix 1 *contd.*

Haul	Location	Site	Time of fishing	Time before/after low water	Substratum	Area fished (m^2)	Volume fished (m^3)	*Crenimugil labrosus*; grey mullet >0-group	*Crenimugil labrax*; bass >0-group	*Dicentrarchus labrax*; bass >0-group	*Dicentrarchus labrax*; bass 0-group
9	Youghal	Across the Pill	13.00	-0.30	mud	1000	244				1
10	Youghal	Across second Pill	13.30	0.00	muddy sand	2400	1560	1	25	1	25
11	Youghal	Below road bridge	14.15	0.45	sandy mud	1000	488				
12	Youghal	Near launch place	15.30	2.00	mud	800	585	3			
13	Youghal	Near launch place	15.55	2.25	mud	800	390				
14	Dungarvan	Barna Wee	10.05	-4.35	sandy mud	800	146	12			
15	Dungarvan	Beside site 14	11.30	-3.10	sandy mud	1000	91				
16	Dungarvan	Behind the Coninger	12.55	-1.85	sand	1000	183	15			1
17	Dungarvan	Beside site 16	13.15	-1.25	sand	1400	256				
18	Dungarvan	Beside site 17, u/s	14.00	-0.40	sand	800	488		3		
19	Dungarvan	d/s site 18a	15.30	0.50	gravel, sand, rocks	800	122				
20	Dungarvan	d/s site 19	16.10	1.30	sand	1400	427	8			
18a	Dungarvan	Beside site 18	14.50	0.10	sand	800	146	4			
21	Tramore, backstrand		13.30	-2.30	mud	1000	123				
22	Tramore, backstrand	d/s site 21	13.50	-2.10	mud	1200	183	1			
23	Tramore, backstrand	d/s site 22	14.15	-1.45	sandy mud	1200	183	20			
24	Tramore, backstrand	d/s site 23	14.50	-1.10	sand	1000	91				
25	Tramore, backstrand	Lagoon, dead water	15.30	-0.30	sand	800	731				
26	Tramore, backstrand	Sileens	16.45	0.45	mud, rock, weed	1200	293	15			
27	Wexford, South slob	Muddy shore	16.00	-1.15	mud/mussel shells	800	146	8			
28	Wexford, South slob	Across & d/s f w outflow	16.45	-0.30	mud/mussel shells	1200	147			26	
29	Wexford, South slob	Across & d/s f w outflow	17.00	-0.15	mud/mussel shells	800	98				6
30	Wexford, South slob	Across outflow, between mussel banks	17.45	0.30	mud/mussel shells	800	98	5		10	

Appendix 2. Fish and crustacean species logged in the course of the survey

With notes on their distribution at the sites fished between 1996 and 1999 inclusive.

Nomenclature according to Wheeler (1969) [Fish] and Barrett and Yonge (1958) [Invertebrates].

Ammodytidae Sand eels
Common but not present in every haul; ***A. tobianus*** identified but majority not considered at species level.

Anguilla anguilla Eel
One specimen, Wexford Harbour.

Atherina presbyter Sand smelt
Abundant in Wexford Harbour.

Carcinus maenus Shore crab
At all sites, often in great abundance.

Clupea harengus Herring
Netted as shoals intermixed with ***Sprattus sprattus*** notably in Wexford Harbour.

Crangon vulgaris Shrimp
Ubiquitous; associated strongly with ***Pomatoschistus minutus***.

Crenimugil labrosus Thick lipped grey mullet
A dominant species in estuarine conditions and associated with ***Dicentrarchus labrax***.

Dicentrarchus labrax Bass
The target of the survey; localised distribution associated with ***Crenimugil labrosus.***

Gasterosteus aculeatus Stickleback
In small numbers at Dungarvan and in Wexford Harbour.

Gobius (Gobius) niger Black goby
Several specimens taken off the South Slob in Wexford Harbour

Merlangius merlangus Whiting
One specimen taken in Dungarvan Harbour

Mullus surmuletus Red mullet
Approximately 10 specimens taken in Dungarvan Harbour in 1996 but not the following year; a wanderer in these waters; there is a breeding population in the English Cannel.

Palaemon serratus Shrimp
Common but less abundant and more discontinuously distributed than ***Crangon vulgaris***. Generally occurring in association with a rocky or stony rather than a mud or sand substratum.

Platichthys flesus Flounder
Taken in almost every haul of the net.

Pleuronectes platessa Plaice

Taken in Tramore and Dungarvan in small numbers in 1997.

Pollachius pollachius Pollack
Rare, a single specimen taken at Duncormick.

Pomatoschistus minutus Common goby
Ubiquitous, often abundant.

Salmo trutta Sea trout
A single specimen taken on the River Tourig.

Sardina pilchardus Pilchard
Rare; only one specimen recorded in 1996.

Scophthalmus rhombus Brill
Rare, Dungarvan, Youghal and Tramore.

Sepiola atlantica Little cuttle
Rare, Wexford Harbour.

Solea solea Sole
Rare; specimens taken at Dungarvan and Wexford Harbour.

Spinachia spinachia Fifteen-spined stickleback
Taken with ***Gasterosteus aculeatus***.

Sprattus sprattus Sprat
In shoals occasionally intermixed with ***Clupea harengus*** which it greatly outnumbers at all sites.

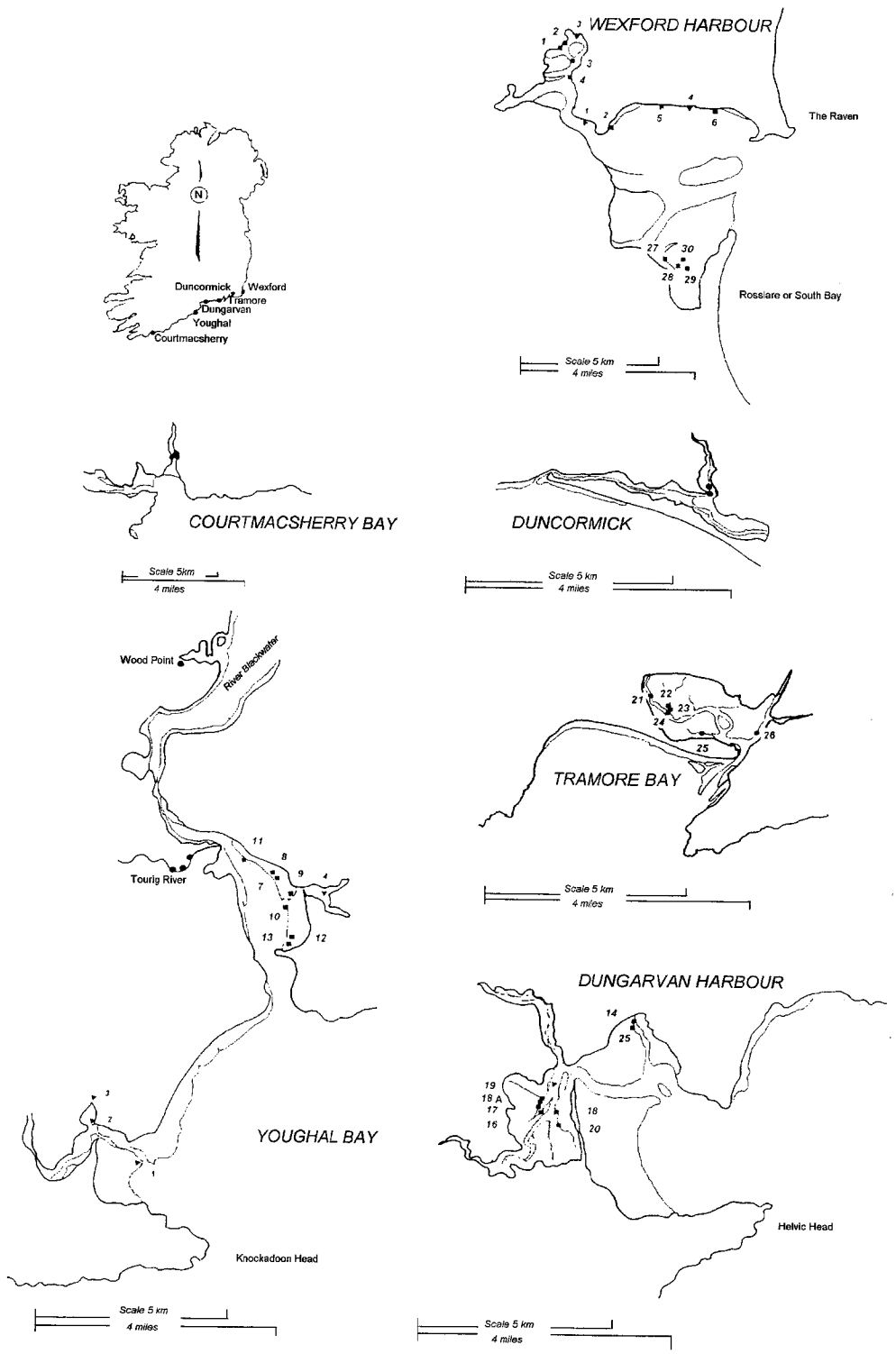
Syngnathidae Pipefishes
Species probably ***Nerophis lumbriciformis*** worm pipe fish, but not positively identified, from Dungarvan.
Syngnathus rostellatus Nilsson's pipe fish taken in small numbers in Youghal Harbour.

Taurulus bubalis Sea scorpion
Taken in Dungarvan and Wexford.

Trachinus vipera Weever
One specimen taken at Tramore Back Strand.

Trigla lucerna Tub gurnard
One specimen taken in Dungarvan Harbour in 1997.

Trachurus trachurus Scad
Taken in association with clupeids generally; in small numbers at all sites.



Appendix Figure Sites fished for pre-recruit bass between 1996 and 1999. The triangles and smaller script indicate sites examined in 1996 and the squares and larger figures 1997. Where a triangle is not accompanied by figures it is assumed that several net hauls were concentrated on the same place. Other locations fished at times during the 4 years are marked with a solid circle; these might represent multiple hauls or stop-net locations.