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Changes in the species composition of anglers' catches in the River Trent (England) between 1969 and 1984

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Data on anglers' catches on the River Trent were collected for the seasons 1969/70 to 1983/84 using postal questionnaires. During this period 60·4 t of fish were caught during a total fishing effort of 526 871 man-h or 60·15 man-years, and more than 20 species of fish were recorded. The percentage of anglers making a catch (70–80%) and the catch per unit effort, mean 114·7 g man-h^{-1}, were comparable with those reported for other waters.

Roach and gudgeon were the most commonly captured species with chub, bleak, bream, eels and dace also forming major components of anglers' catches. Since 1969 chub, bream, eels and perch have made an increasingly greater contribution to catches, coupled with a decline in numbers of roach and dace. It is suggested that improvement in water quality and its implication on interspecific competition was the most likely cause of the changes.

I. INTRODUCTION

The River Trent is the major river of the East Midlands of England and has a rich and varied history (Lord, 1968). Its angling potential was popularized by the writings of the ' Trent Otter ' (Martin, 1906), and good catches of both coarse and salmonid species were commonplace for many centuries. Unfortunately, the increased industrialization and urbanization which followed the Industrial Revolution resulted in a deterioration in the water quality of the river and a synchronous decline in the angling success. In recent years, much effort has been expended by the Severn-Trent Water Authority and its predecessor, the Trent River Authority, to reduce pollution levels (Lester, 1979), and the fish populations appear to have recovered much of their former status . For example, the Trent now supports about 40 species and is regarded by many anglers as one of the most productive rivers in the British Isles (Braddock, 1977).

Despite the importance of the River Trent as a prime fishery, the fish populations therein have received little scientific attention (Whiting *et al.*, 1976; Sadler, 1980; Cooper & Wheatley, 1981). This can be attributed to the widely accepted problems associated with sampling fish populations in large rivers (EIFAC, 1974). Many workers have, however, overcome these sampling difficulties by utilizing anglers to sample the fish populations (Parry, 1974; Ayton, 1976; Axford, 1979; North, 1980; Cooper & Wheatley, 1981; Hickley & North, 1981; Pearce, 1983). In an attempt to monitor the fish populations of the River Trent, a census of anglers' catches, using postal questionnaires, was established by the Trent River Authority and inherited by Severn-Trent Water Authority. This paper reports on the analysis of the results from the first 15 years of the scheme, 1969–84.

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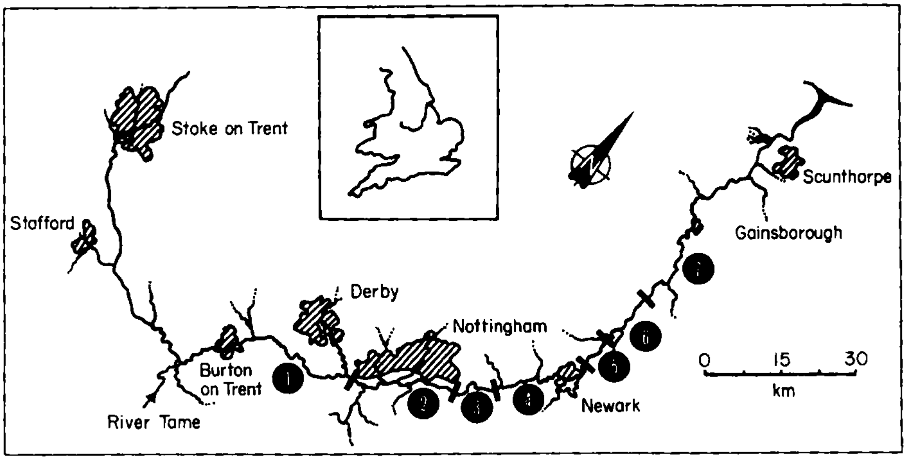

FIG. 1. Map of the River Trent to show location of fishing zones.

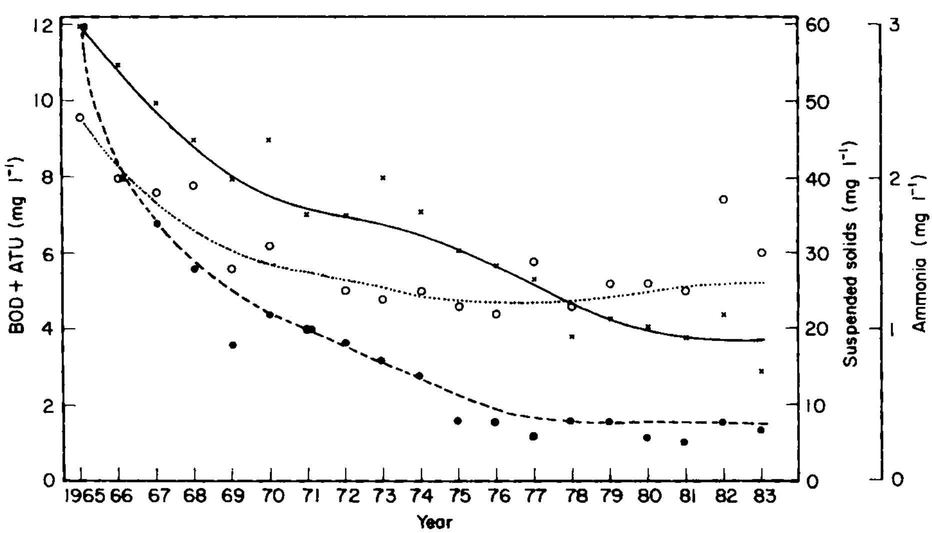

FIG. 2. Mean annual biochemical oxygen demand (BOD + ATU) (×), suspended solids (○) and ammonia (●) levels recorded at Trent Bridge, Nottingham, on the River Trent between 1965 and 1983. (ATU is the alkyl thio-urea mechanism for testing BOD.)

THE RIVER TRENT

The Trent is approximately 280 km long from its source in North Staffordshire (NGR: SJ 896548) to its confluence with the Humber Estuary (NGR: SE 865233) (Fig. 1). It is polluted in its headwaters by effluents from the industrial areas around Stoke on Trent and receives further pollution loading via the River Tame which carries the domestic and industrial effluent of Birmingham and the Black Country (Fig. 1). There has, however, been a marked improvement in the river's water quality since the Trent River Authority and its successors, Severn-Trent Water Authority, imposed improved pollution control measures in the late 1960s. This is exemplified by the dramatic decline in mean annual biochemical oxygen demand (BOD), ammonia and suspended solids levels recorded at Trent Bridge, Nottingham since 1965 (Fig. 2). The Trent is also subject to considerable thermal pollution from power stations along the valley which use the river for cooling purposes. In the last decade, however, several of these have gone out of commission and thermal enhancement has diminished.

For the purposes of this study, the River Trent was divided into seven zones (Fig. 1). Zone 1 included results of angling above Long Eaton, although in practice no data were recorded for the reaches above Burton-on-Trent, and Zone 7 stretched downstream of Dunham bridge, although no catches were recorded below Gainsborough.

The Trent throughout the study zones is a mature river which supports little aquatic vegetation, although some stands of water lillies, *Nuphar lutea* (L), and reeds, *Glyceria maxima* (Hartm.), grow in the margins. The river is relatively narrow (15–20 m) and shallow (0·2–2 m) in zone 1 when compared with downstream where the width and depth ranges are 60–80 m and 2–4 m, respectively. In Zone 1 the flow rate is extremely fast but it abates markedly downstream of Sawley weir (Zones 2–7) where the river is navigable and used by a wide variety of commercial and pleasure traffic.

II. METHODS

Catches of coarse fish were monitored by distributing catch return cards to secretaries of angling clubs holding organized competitions, and occasionally to individual anglers, during each fishing season from 1969/70 to 1983/84.

The returned cards were filed according to zone and season. Two measures of angling success were derived from correctly completed cards: (i) the percentage of anglers fishing that catch fish, and (ii) the overall catch rate, expressed as g man-h^{-1}, achieved during the competition or by the individual angler.

In addition, an assessment of the species composition of catches in relation to general and long-term trends was undertaken. The simple measure of percentage composition based on a subjective points scale, as previously adopted by Whiting *et al.* (1976) and North (1980), was considered unacceptable because it only shows changes in proportion of species relative to each other and may not reflect real changes in the population structure. To overcome this problem an index of relative importance (RI), similar to that employed by O'Hara *et al.* (1977) and Hickley & North (1981), was used. This modified index was calculated as:

$$(\%\ \text{abundance} + \%\ \text{frequency of occurrence}) \times 0{\cdot}5$$

The percentage abundance was determined using a subjective method (North, 1980) which involves weighting species on a points scale according to their recorded dominance in the catches. Thus, when a species was recorded in the catches as the most common it was awarded 4 points, as next most common 2 points, and as other captured species 1 point. Percentage abundance was derived by expressing the total points score for each species in each zone or angling season as a percentage of the total points awarded to all species. Percentage frequency was calculated as the percentage of all matches held in each zone or during each angling season in which each species was represented in the catches. With the exception of the 1978/79 and 1979/80 seasons in Zone 1 and 1982/83 and 1983/84 seasons in Zone 7, fishing effort remained relatively constant with both angling seasons and zones.

III. RESULTS

ANGLING SUCCESS

(i) *Percentage of anglers catching fish*

Factors such as rumours of a large individual catch or adverse weather conditions are known to influence the measure of angling quality (Whiting *et al.*,

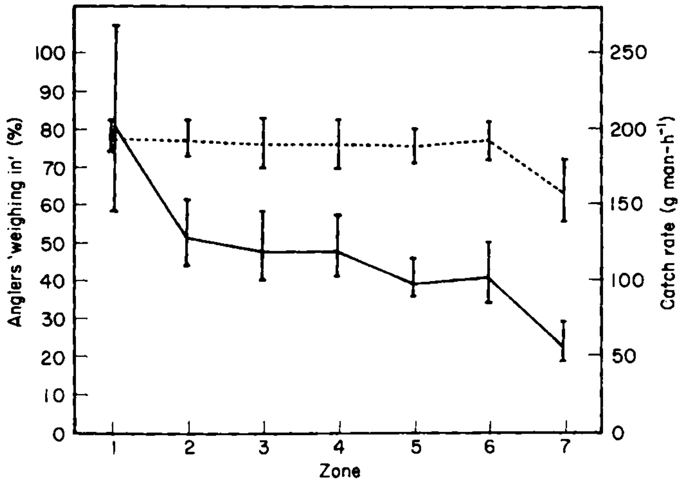

FIG. 3. Variation in the percentage of anglers with catch (- - -) and the mean catch rate (——) in different zones of the River Trent. Data for all seasons combined; vertical lines represent 95% confidence limits.

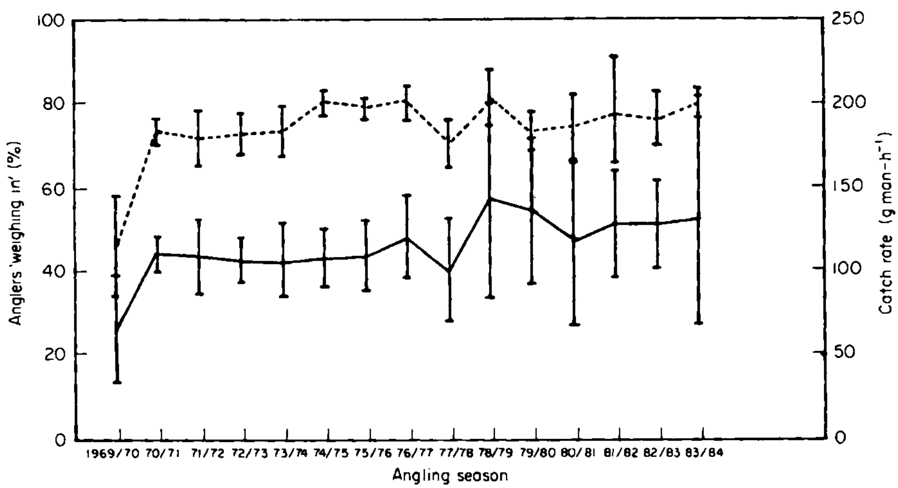

FIG. 4. Variation in the percentage of anglers with catch (- - -) and the mean catch rate (——) in the River Trent between different angling seasons. Percentage of anglers catching fish determined from data from all zones combined; mean catch rate determined from data for zones 2–6 combined; vertical lines represent 95% confidence limits.

1976). However, it appears that zone and season have little effect, as the percentage of anglers 'weighing in' was consistently between 70 and 80%. These observations, that zone and season had no effect on the percentage of anglers weighing in, were confirmed ($P>0{\cdot}05$) using the Friedmann multiple factorial test. It was thus acceptable to combine data according to zone and season, and these are displayed in Figs 3 and 4, respectively.

(ii) Catch rate

The calculated catch rates (g man-h^{-1}) for each zone over the 15 angling seasons are presented in Table I. The overall mean catch rate was 114·7 g man-h^{-1}, although there was variation between zones and seasons. Friedmann's

TABLE I. Mean annual catch rates (g man-h^{-1}) in different zones of the River Trent between 1969 and 1984

Zone	Grid Ref.	Season														
		1969/ 1970	1970/ 1971	1971/ 1972	1972/ 1973	1973/ 1974	1974/ 1975	1975/ 1976	1976/ 1977	1977/ 1978	1978/ 1979	1979/ 1980	1980/ 1981	1981/ 1982	1982/ 1983	1983/ 1984
Burton–Sawley lock	SK267252 SK472312	120·5	124·0	141·0	131·8	183·3	132·2	212·1	233·4	159·9	—	—	532·4	302·8	93·7	289·0
Sawley lock–Holmes sluices	SK472312 SK650405	122·8	108·5	94·3	76·3	137·0	93·7	137·9	148·4	137·3	224·1	218·4	84·3	109·1	89·4	144·9
Holmes sluices–Gunthorpe bridge	SK650405 SK681437	59·4	96·1	71·0	115·0	101·3	139·9	110·0	70·6	—	147·0	161·5	224·2	161·0	110·8	121·8
Gunthorpe bridge–S. Muskham bridge	SK681437 SK787563	17·1	99·9	143·5	110·0	98·3	104·7	130·0	124·8	124·7	199·3	96·9	129·6	111·0	177·7	145·0
S. Muskham bridge–Cromwell weir	SK787563 SK809612	87·7	129·7	109·7	120·6	127·3	118·2	78·7	116·1	64·5	47·1	85·1	75·7	82·4	135·9	109·8
Cromwell weir–Dunham bridge	SK809612 SK819745	42·2	116·5	124·3	110·6	65·3	81·0	85·5	142·8	77·6	96·7	115·1	78·6	177·5	122·4	494·7
Dunham bridge–Gainsborough	SK819745 SK814892	9·0	64·7	53·3	62·9	101·1	54·6	49·8	100·4	45·6	51·3	58·3	73·3	20·4	—	—

test showed that there was no statistically significant difference in the mean catch rates between seasons ($\chi^2 = 10{\cdot}36$ for 14 d.f.; $P > 0{\cdot}05$) but significant differences ($\chi^2 = 38{\cdot}96$ for 6 d.f.; $P < 0{\cdot}01$) were found between zones. Catch rates were consistently higher in zone 1, and lower in zone 7 than those recorded in zones 2–6 over the 15 angling seasons ($P > 0{\cdot}01$).

All seasonal catch data relating to each zone were grouped (Fig. 3) to show the general trend in catch rates with zone; this clearly illustrates the variation between zones. However, because of the significantly different catch rates recorded in zones 1 and 7, only data relating to zones 2–6 were combined to illustrate overall trends in catch rate with season (Fig. 4). These data suggest an improvement in catch rates over the last six seasons (1978–84) compared with earlier years (1970–76), but it proved to be not statistically significant (t-test; $P > 0{\cdot}05$).

SPECIES COMPOSITION

Twenty-two species of fish were caught during the 15 angling seasons monitored. Of these, only 10 [roach, *Rutilus rutilus* (L.); dace, *Leuciscus leuciscus* (L.); chub, *Leuciscus cephalus* (L.); bleak, *Alburnus alburnus* (L.); bream, *Abramis brama* (L.); gudgeon, *Gobio gobio* (L.); perch, *Perca fluviatilis* L.; eel, *Anguilla anguilla* (L.); carp, *Cyprinus carpio* L.; barbel, *Barbus barbus* (L.)] were caught in sufficient frequency to be of importance to anglers' catches.

(1) *Variation with fishing season*

The relative importance of the major angling species varied considerably with fishing season (Fig. 5). Since 1969/70 there has been a steady decline in the importance of roach and dace with a corresponding increase in the relative importance of chub, bream and, to a lesser extent, perch. Eels and carp exhibited a gradual increase in importance between 1969/70 and 1977/78 but, thereafter, declined in relative numbers. Bleak, in contrast, contributed significantly to angler's catches between 1969 and 1977/78 but suddenly became of minor importance in the 1978/79 and subsequent seasons. The importance of gudgeon fluctuated considerably but they were of least prominence during the seasons associated with the summers of 1975 and 1976.

To facilitate the comparison of seasonal changes in the relative importance of fish species to anglers' catches, further analysis was carried out using the Czekanowski Similarity Index (Czekanowski, 1913) and the resultant coefficients were plotted as an average linkage cluster dendrogram (Fig. 6). Although this array gives poor discrimination (all values of C_s in the range 0·77–0·94), because of the consistently high contribution roach and gudgeon make to the catches in all seasons, it does identify change in species composition with time. Of particular significance is the shift from a predominantly roach/dace/bleak fishery in the early 1970s to a chub/perch/bream fishery in the 1980s. Other discrete associations appear to be linked to fluctuations in importance of gudgeon, eels and carp in the catches.

(ii) *Variation with zone*

As data relating to seasonal changes in species composition with fishing season fell into two discrete periods (1969–76 and 1976–83), assessment of zonal variation in the relative importance of fish species in anglers' catches (Fig. 7) was made in relation to these categories.

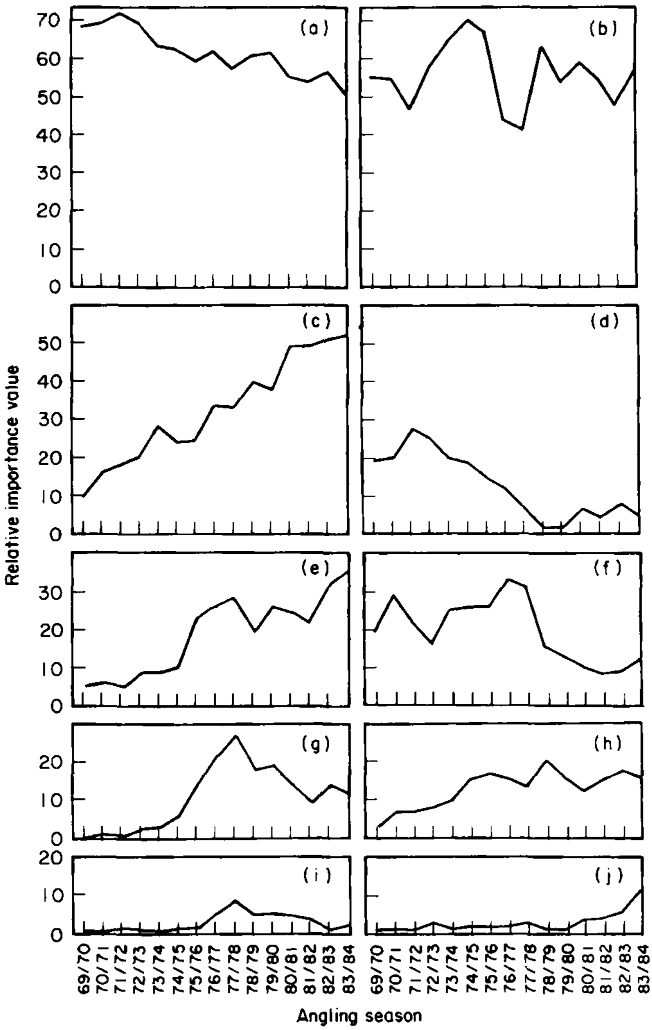

FIG. 5. Seasonal variation in the relative importance (RI) of major angling species in catches from the River Trent between 1969 and 1984. (a) Roach, (b) gudgeon, (c) chub, (d) dace, (e) bream, (f) bleak, (g) eel, (h) perch, (i) carp, (j) barbel.

Prior to 1976 the most obvious trends were towards a decline in importance of dace and barbel farther downstream, coupled with an increase in relative importance of eels, bream and perch. Chub comprised an increasingly significant proportion of catches with progression downstream, but were of little importance below Dunham bridge (zone 7).

In recent years these trends persisted but the decline in importance of dace and barbel farther downstream was more dramatic, as was the increase in eels. Chub and bream also made a consistently higher contribution to catches in the majority of zones, whilst gudgeon declined in importance downstream of Cromwell weir.

IV. DISCUSSION

In any study of fish populations as revealed by angler catch, several basic assumptions are made. One of the most important of these is that the species,

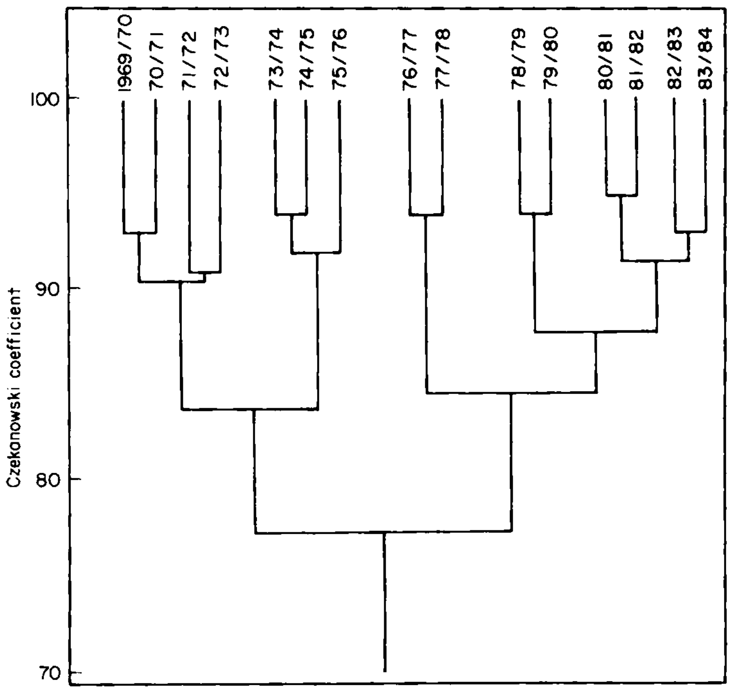

FIG. 6. Similarity in species composition of anglers' catches in the River Trent between seasons. Groups derived from average linkage clustering of Czekanowski's Similarity Index.

numbers and weights of fish caught by anglers are representative of fish populations present. This is obviously not true in most investigations, as anglers' catch is influenced by the type of tackle and bait that is presented to the fish. Cooper & Wheatley (1981), who undertook a short-term detailed investigation of anglers' catches from a stretch of the River Trent in zone 3, found that fish of less than 12 cm were rarely caught as their mouth gape was too small to ingest the smallest bait presented by anglers. However, for fish above this size, they found little evidence that angling was more selective than any other fish sampling technique, e.g., gill netting (Hamley, 1975); indeed, Axford (1979) considered that angler catch was far more representative of the fish populations present in the River Nidd than that revealed by electric fishing.

Unfortunately, anglers are prone to misinterpretation of the numerical dominance of species in catches. They tend to consider the contribution made by a few large fish of a favoured species to be greater than that made by a large number of 'small' species fish. This error was reduced at source by stressing to the anglers the importance of accurately recording numerical dominance. The use of the relative important index in the analysis also counteracts this tendency because it includes a large frequency of occurrence factor.

Errors may also arise from the paucity of 'nil' returns made on the record cards, suggesting a reluctance by anglers to record 'nil' catches. However, as Whiting *et al.* (1976) reported, this may be offset by the number of cards recording 'nil' returns completed by anglers wishing to draw attention to the poor quality of their fishing. In practice, the percentage of 'nil' returns received was similar to that observed by bailiffs on the bank.

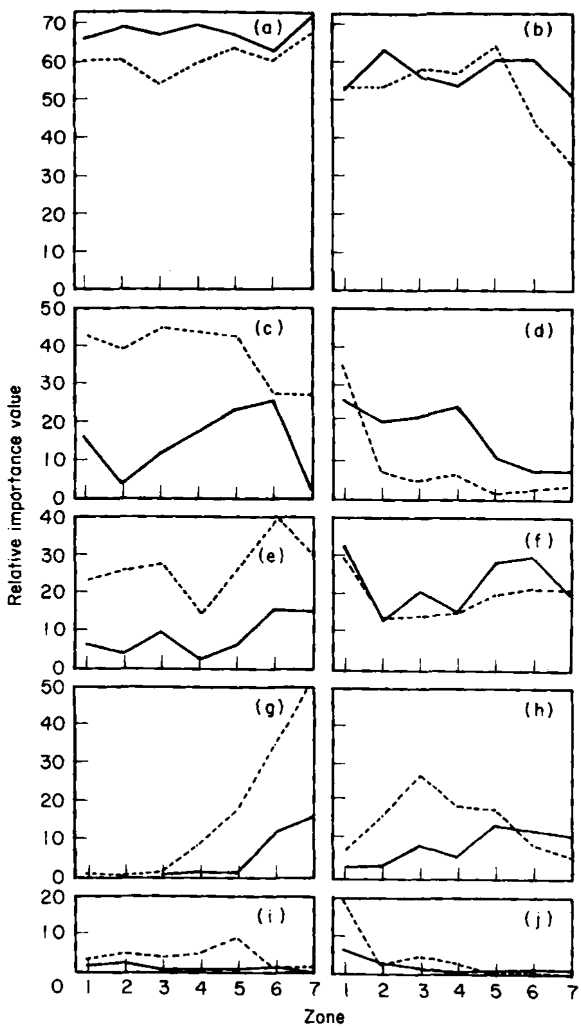

FIG. 7. Variation in the relative importance (RI) of major angling species in catches from different zones of the River Trent (——, 1969/70–1975/76 seasons, ----, 1976/77–1983/84 seasons). (a) Roach, (b) gudgeon, (c) chub, (d) dace, (e) bream, (f) bleak, (g) eel, (h) perch, (i) carp, (j) barbel.

In one of the more comprehensive studies of anglers' catches, North (1980) concluded that, on the River Severn, the percentage of anglers catching fish was the most reliable indicator of angling success. On this basis anglers fishing the Trent enjoyed consistently 'good sport' over the past 15 seasons, with 70–80% catching fish. Confirmation of the quality of the fishing was gained from the catch rate data: the mean annual catch rate of 114·7 g man-h^{-1} compares favourably with other riverine coarse fisheries, e.g., River Ouse, 58 g man-h^{-1} (Axford, 1979); River Severn, 82–176 g man-h^{-1} (Hickley & North, 1981).

Despite the generally good quality of the fishing, variation in catch rates with season and zone were evident (Figs 3, 4). The significantly higher catch rate achieved in Zone 1, upstream of Sawley Lock, compared with elsewhere, was directly attributable to the rivers Derwent and Dove which join the Trent in this reach. These rivers support high biomass fisheries (Cowx, 1986) which enhance the adjacent reaches of the Trent through downstream migration of fish. By contrast, catch rates below Dunham bridge (zone 7) were significantly poorer than in the upstream zones because saline intrusion allows estuarine species, not caught by coarse anglers, to dominate the fish community structure. The slightly elevated catch rates in the post-1977/78 seasons were directly related to the shift in status of the Trent fishery in terms of numbers of each fish species caught. In these later seasons, anglers tended to catch a greater proportion of chub and bream, individuals of which have a greater mean weight than roach, dace and bleak, which previously dominated catches. Pearce (1983) similarly found long-term stability in catch rates in the River Dee despite changes in fish community structure.

Perhaps the most striking outcome of this study was the change in species composition of anglers' catches with both season and zone. These changes were, in the main, considered representative of real shifts in fish community structure in the River Trent, although changes in angling practice were also responsible.

' Natural ' long-term changes in fish community structure have been reported in both lacustrine and riverine environments: water quality, with particular relevance to eutrophication (Svardson, 1976; Persson, 1983), outbreak of fish disease incidence (Axford, 1979; Pearce, 1983; Kipling, 1984) or a combination of both (Burrough *et al.*, 1979) were the prime factors responsible.

The mechanism behind the shift in the River Trent from a roach/dace to a chub/bream/perch fishery appears to be linked to the overall improvement in water quality (Fig. 2) over the past 20 years and its implication on species dominance. Svardson (1976), Burrough *et al.* (1979) and Persson (1983) all associated interspecific dominance in roach populations with nutrient-rich, turbid, eutrophic conditions. If this relationship is generally applicable, competitive dominance of roach in the Trent would have declined with improvement in water quality, thus allowing previously suppressed species to become more established. Chub, bream and perch were the species to take maximum advantage of the reduced competition from the roach population, probably because abiotic factors (e.g., reduced turbidity and elevated dissolved oxygen levels) favour these species. The demise of the dace population was probably linked to increased competition from the enhanced chub population coupled with the low habitat heterogeneity of the River Trent. These species are known to occupy similar niches, and the emergence of chub as a dominant species initiated the decline of the sympatric dace population.

A second indirect influence on the change in fish populations observed was natural fluctuations in year class strength (Mann, 1979). Cooper & Wheatley (1981) showed that this mechanism occurred within the roach populations of the Trent, but it appears unlikely that natural fluctuations were responsible for the long-term shift in the status of the Trent fishery; however, they probably contributed towards short-term trends, such as were observed in the gudgeon population (Fig. 5).

Several factors relating to angling itself indirectly contributed towards the observed change in catch composition. Perhaps the most important was the change in fish community structure towards species of large mean weight, e.g., chub and bream, which encouraged anglers to deliberately seek these fish, and their tackle and techniques thus became more specialized. For example, the sharp increase in the use of swim-feeders in the late 1970s effectively eliminated the exploitation of individuals of the smaller sized species, unless water conditions were unfavourable to angling: the 'smaller' species only became popular quarry when floods or low water temperatures indicated that few individuals of any species were likely to be captured. For this reason the numerical importance of many of the 'smaller' species recorded was probably an under-estimate of the actual situation that existed in the river. This was particularly evident with respect to bleak, whose contribution to catches declined dramatically after the 1977/78 season (Fig. 5) although electric fishing surveys showed large numbers still persisted throughout the river.

North (1980) presented evidence to show that whilst some species, such as bleak, bream, dace and eels, make an increasing contribution to catches as temperatures rise, others, especially chub and roach, predominate at lower temperatures. The closing down of several power stations along the Trent valley in the last decade has reduced thermal enhancement in the river and lowered ambient water temperatures by several degrees. This may have indirectly affected the susceptibility of species to capture and contributed towards the shift in species composition of anglers' catches.

The variation in anglers' catches with zone was not entirely unexpected as, in part at least, it reflects habitat preferences of the appropriate species. For example, zone 1 is a fast-flowing glide/pool region, typical of the barbel, dace, chub, roach of any river (Huet, 1962). In the downstream zones (6 & 7), the river is deep, slow-flowing and subject to considerable tidal influence, restricting its suitability to species tolerant to elevated salinity levels such as eels, bream and perch. The within-zone differences between the pre- and post-1976 periods of the study merely reflect major changes in species dominance in anglers' catches with time. Similar zonal variation in species composition of anglers' catches was recognized by Hickley & North (1981) for the River Severn.

It is interesting to note that many anglers view the demise of the roach in the Trent as a serious detriment to the fishery. Although they switched to exploit other species available and managed to achieve similar match catch rates, this did not affect what anglers perceived to be good quality angling for the Trent, i.e., mixed catches based on roach. Pearce (1983) noted similar reaction to the demise of the roach and perch populations in the lower catches of the River Dee.

It is a pleasure to thank all those anglers who co-operated in recording their catch data, and Messrs G. A. Wheatley and A. S. Mosley for their assistance with the laborious task of collating the catch-return data. The opinions expressed are those of the authors and not necessarily of Severn-Trent Water Authority.

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