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Trout stocking in SAC rivers. Phase 1: Review of stocking practice

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Steve Killeen
Head of Science

Executive summary

This report describes the first phase of a project to provide a decision-making framework for Environment Agency, English Nature and Countryside Council for Wales staff for the assessment of Section 30 consents to stock trout into candidate Special Area of Conservation (cSAC) rivers. A literature review and its interpretation is given along with the findings of an earlier report (APEM, 2002) to English Nature.

Key potential ecological interactions between stocked brown and rainbow trout and cSAC species involve those with Atlantic salmon (competition from juvenile trout, predation by adult trout and, possibly, hybridisation between these species), white-clawed crayfish (possible disease transmission and predation by adult trout) and bullheads (predation by adult trout and, possibly, competition for resources).

The selected rivers for study are briefly described on the basis of their cSAC designations. Information collected from riparian managers and from the Environment Agency Live Fish Movements Database is then given on recent trout stocking activity in these rivers.

The key findings of this report are that trout stocking is relatively infrequent in six of the cSAC river systems studied (Eden, Yorkshire Derwent and Rye, Dove and Lathkill, Teifi, Wye and Usk). Because of this, important ecological interactions resulting from stocking are unlikely to occur except, possibly, via disease transmission (crayfish plague) to native crayfish populations. In order to reduce risks, close liaison between the Centre for Environment, Fisheries and Aquaculture Science (CEFAS, fish farm trout movements) and the Environment Agency, English Nature and Countryside Council for Wales (Section 30 consenting) is recommended.

On the rivers Itchen and Hampshire Avon, relatively large numbers of trout are stocked into areas where Atlantic salmon spawn. In 2003, the Itchen salmon stock reached only 23 per cent of its conservation limit and the Hampshire Avon reached only 30 per cent. More research is needed to investigate whether trout stocking is likely to be a significant factor in depressing wild salmon abundance in these rivers.

Initial analyses of trout catch records for the rivers Itchen, Nadder and Wylye show how catches relate to some extent to the timing of stocking and how trout fishery performance is finely regulated by managers. More information on typical trout residence times is needed.

Recommendations for Phase 2 of the study include analyses of electric fishing data and published reports to establish:

- expected densities of brown trout in rivers;
- actual densities of trout generated in rivers after stocking;
- whether the stocked trout remain resident in habitat areas used by juvenile salmon and how long stocked trout typically survive within fisheries;
- the expected size ranges of stocked and natural trout stocks in rivers.

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1 Introduction

This report describes the first phase of a project to provide a decision-making framework for Environment Agency, English Nature and Countryside Council for Wales (CCW) staff for the assessment of Section 30 consents to stock trout in candidate Special Area of Conservation (cSAC) rivers. The report provides a literature review and interpretation of the potential ecological impacts on certain riverine SAC species of stocking with brown and/or rainbow trout, along with information on trout stocking and trout residence in fisheries.

Firstly, the literature review and interpretation is compared with the findings of a previous unpublished report to English Nature (APEM, 2002). Next, the selected rivers for study are briefly described on the basis of their cSAC designations. Information on recent trout stocking activity in these rivers, collected from riparian owners/managers and from the Environment Agency Live Fish Movements Database (LFMD), is also given. Initial analyses of trout catch records are then used to further explore methods of stocking and possible residence times for stocked trout. Finally, the report presents its conclusions and recommendations for Phase 2 of the study.

2 Literature review: potential impacts of stocked trout on SAC species

This review builds upon the unpublished review by APEM (2002) and covers brown and rainbow trout interactions with certain Special Area of Conservation (SAC) species, especially salmon, crayfish, bullhead and lampreys.

2.1 The APEM report

The APEM (2002) report to English Nature identified risks to SAC species associated with introductions of various fish species, summarised in Table 3.1 in the 2002 report. The table is reproduced below (Table 2.1).

Table 2.1: Sensitivity table for fish introductions (SAC species) (from Table 3.1, APEM 2002).

SAC Species group	SAC species	SAC site	Predation on fish, inverts., amphibia	Competition with indigenous fish species	Hybridisation with indigenous fish	Detrimental effect on overall ecology	Introduction of disease
Anadromous fish	**Salmon**	R. Avon, R. Derwent and Bassenthwaite Lake, R. Eden, R. Wye/Afon Gwy	✓	✓	✓	✓	✓
	Sea lamprey	R. Avon, R. Derwent and Bassenthwaite Lake, R. Eden, R. Wye/Afon Gwy	✓			✓	
	River lamprey	R. Derwent and Bassenthwaite Lake, R. Eden, R. Usk/Afon Wysg, R. Wye/Afon Gwy	✓			✓	
Non-migratory fish and inverts of rivers	**Bullhead**	Craven Limestone Complex, R. Avon, R. Eden, R. Usk/Afon Wysg, R. Wye/Afon Gwy, R. Camel	✓	✓		✓	✓
	Brook lamprey	R. Avon, R. Derwent and Bassenthwaite Lake, R. Eden, R. Usk/Afon Wysg, R. Wye/Afon Gwy	✓			✓	
	Spined loach	Ouse Washes	✓	✓		✓	✓
	Atlantic stream crayfish	Craven Limestone Complex, Ensor's Pool, Peak District Dales, R. Eden, R. Wye/Afon Gwy	✓	✓		✓	✓

The principal hazards are identified above, whereby a direct or indirect effect is likely to occur on the SAC features of interest. These hazards, reproduced directly from the guidance document, are:

- Predation by introduced fish on fish, invertebrates or amphibians which are interest features of the site or are the prey of interest features.
- Competition by introduced fish with indigenous fish species, which are interest features of the site for food, cover or spawning sites.
- Hybridisation of introduced fish with indigenous fish.
- A detrimental effect on the overall ecology of the site caused by a fish introduction. These effects may include uprooting of macrophytes, a reduction in water quality, increased turbidity or microbial contamination, which may have an adverse effect on the interest features.
- The introduction of disease from fish stocking which affects interest features. This is a particular hazard for SACs which have Atlantic stream crayfish. Atlantic stream crayfish are very susceptible to crayfish plague. There are 'no-go areas' for crayfish introductions, which help to reduce the risk to Atlantic stream crayfish. However, plague can still be introduced to a site in the water brought with fish that have been reared in a fishery where crayfish also occur.

The guidelines recommend that, in order to judge an application to stock fish into a SAC river, it is necessary to assess the extent and timing of the hazard over the site against the distribution of the interest features. This determines whether the features of interest will be exposed to the hazard. Fish introductions are regarded as being likely to have more widespread effect than other more localized hazards resulting from, for example, habitat improvements. The potential magnitude of the impact of the hazard also needs to be taken into consideration; for example, a series of fish introduction applications would need to be considered in the context of their cumulative impact in combination (APEM, 2002).

Section 3.2 of the APEM (2002) report goes on to explain:
"The Fisheries Guidance specifically warns that the effects of fish introductions can be long term and it is usually impossible to recover introduced fish, making the effects generally irreversible, at least for as long as the fish remain within the system. The point is made that a long term irreversible effect on a SAC is more likely to be significant than a short term, reversible effect."

Potential sources of information to help assess these effects are given as:
- surveys specifically undertaken to determine the status of the interest feature;
- fish surveys;
- catch returns;
- River Habitat Surveys (RHS not yet very extensive national coverage on European sites);
- river corridor surveys;
- HABSCORE assessments (assess value of site mainly as salmonid fish habitat);
- PHABSIM (Physical Habitat Simulation – model at early stages of development);
- NVC (national vegetation classification) surveys or Phase I vegetation surveys (if these exist, they are likely to be held by English Nature or CCW).
- macro-invertebrate surveys (may be undertaken by Environment Agency biologists).
- macrophyte surveys for Urban Waste Water Treatment Directive sites.

English Nature should also be approached for a record of the existing condition of the features of importance in the site.
In conclusion, the Fish Introductions Guidance document indicates the general circumstances for refusal of a Section 30 consent. These include:

- where ecological, conservation or health factors indicate the introduction would compromise the fishery;
- where any feature of ecological or conservation value could be compromised by the proposed introduction;
- where the introduction may adversely affect the integrity of a European or Ramsar site.

In order to ensure and monitor compliance with the regulations, the administration of Section 30 is subject to periodic checks within each region and to internal Environment Agency audit procedures.

Section 6 of the APEM report describes potential interactions between SAC species and various fish species which may be stocked into an SAC river, of which the most significant are:
- direct predation
- introduction of disease and/or parasites
- competition for space
- competition for food
- disruption of habitat.

Different stocked species vary in their potential to disturb SAC species. The degree to which SAC species are susceptible will vary according to their life cycle and ecological characteristics. For instance, different parts of the riverine habitat are frequented by the various SAC and stockee species at different life cycle stages. Thus, the time of year at which a particular life cycle stage is present will determine the impact of particular stocking exercises.

The terms "juvenile" and "adult" when applied to stockee species refer to fish less than 100 mm or greater than 100 mm respectively. For SAC species, the term "juvenile" refers to individuals in their first year of life, and "adult" to fish of one year or older. It should not be assumed that the impacts indicated will inevitably occur, and ways of minimising the risks are discussed.

The perceived degree of risk for each combination of stockee and potential impact is indicated as follows (from APEM, 2002):

-	=	No risk
*	=	Potential risk, but no evidence of it actually occurring.
**	=	Some localised impact probable, but no evidence that it is significant at the population level.
***	=	High risk of significant impact.

2.2 The present study

The different levels of perceived risk are ascribed by APEM in a series of tables. The table elements below are reproduced from Section 6 of the APEM report (2002). An updated review and separate interpretation of available literature identified during the present project for both brown and rainbow trout stocked at various developmental stages is appended to each set of tables. Weber and Fausch (2003) provide an excellent review of experimental designs required to study competitive ecological interactions between hatchery and wild salmonids under field conditions, and on the robustness of a range of published studies.

2.3 Interactions of Atlantic salmon with rainbow and brown trout

Table 2.2: Threats posed by stockee species on Atlantic salmon (from Table 6.1, APEM 2002)

Stocked species/ life stage	Predation	Disease/ parasites	Competition for territory/food	Habitat disturbance
Brown trout	**	*	***	-
Rainbow trout	**	*	***	*

Threats from trout considered to be of particular significance to Atlantic salmon are:

- mortality of ova resulting from over-cutting of redds by later spawning fish;
- predation on eggs, fry, parr and smolt stages;
- reduced availability of juvenile rearing areas due to aggressive territorial behaviour;
- competition for food;
- disease and parasite introduction.

The following tables from APEM (2002) break down these perceived threats by salmon life cycle stages:

Table 2.3: Threats posed by specific life stages of stockee species upon salmon ova and alevins (from Table 6.2, APEM 2002)

Stocked species/ life stage	Predation	Disease/ parasites	Competition for territory	Competition for food	Habitat disturbance
Brown trout juvenile	*	-	-	-	-
Brown trout adult	*	-	-	-	-
Rainbow trout juv	*	-	-	-	-
Rainbow trout adult	*	-	-	-	*

Where stocking with salmon ova or fry is taking place it is possible that, in areas used for natural spawning, disturbance of the gravel might damage existing redds. Existing salmon redds could also potentially be over-cut by spring-spawning rainbow trout (APEM, 2002).

2.3.1 European studies

Juvenile brown trout and Atlantic salmon have similar habitat requirements; the closeness of the species is demonstrated by their ability to produce natural hybrids. Potentially, young brown trout and salmon compete strongly for riverine habitats. Kennedy and Strange (1986) manipulated wild trout abundance in a small upland stream with an impassible waterfall, removing trout from the upstream section and stocking juvenile salmon over two years into both sections. Their key findings were:

- Salmon fry stocked in the cleared area spread out to use a wider range of micro-habitats, grew twice as rapidly and to larger sizes than those stocked in the stream containing trout and older wild salmon parr.
- In year two of the study, 1+ salmon surviving in the cleared area significantly reduced the growth and survival of 0+ fry stocked into the stream. However, these 0+ fry still fared better than those stocked in the stream section containing trout and wild salmon parr.
- Trout immigrating back into the cleared section showed rapid growth rates, indicating the reduced intra-specific competition of food and space in the cleared section.

Ecological interactions between Atlantic salmon and brown trout are evidently marked and important. Bremset and Heggenes (2001) make the following key points in their recent review paper:

- Trout are generally more aggressive and faster growing than salmon.
- Juvenile trout of similar body size to salmon often seem to out-compete them.
- Juvenile salmon are able to live in faster current-speed habitats (riffles and runs) than young trout, which preferentially select slower glides and pools.
- Trout prefer to lie closer to banks and safe cover than juvenile salmon, which often occupy more open mid-stream habitats, but lie close to the river bed.
- Aggressive encounters, food availability and perceived predation risk are all likely to affect individual juvenile salmonid behaviour.

Bremset and Berg (1999) show that juvenile brown trout and juvenile Atlantic salmon living in pools show a three-dimensional pattern of distribution such that:

- Young of year fish hold closer to the bed and banks.
- Distance from physical cover increases with fish size.
- Brown trout hold station significantly higher in the water column but closer to the bank than salmon.

Micro-habitat availability probably has a great bearing on which species dominates in any stretch of river (Vassen, 1998). Juvenile salmon are adapted to fast riffle habitats where they may often out-compete young trout (Egglishaw and Shackley, 1982) and young salmon may spread out into slower current-speed habitats where competition from trout is absent or low (Egglishaw, 1983). A potential risk to salmon fry and parr, from juvenile trout stocking, is an increase in competition for food and territory between introduced brown trout fry and parr and wild (or stocked) salmon fry and parr (Shearer, 1992; Mills, 1989). This could restrict salmon distribution and production to the shallower and faster flowing reaches, rather than occupying the whole habitat in the relative absence of trout. Much depends on the quality and quantity of habitat types available to fish on a given river stretch and the degree of competition operating between species. Heggenes *et al.* (1999) review this topic, forming the following conclusions:

- Spatial overlap between young salmon and brown trout is substantial where the species occur together.

- Water flows and stream temperatures are important components of juvenile salmon and trout performance.
- In summer, larger salmon parr have a wider spatial habitat niche than small parr and show plastic behaviour, modified by inter and intra-specific competition and by predation risk. In winter, salmon parr hide for significant periods in spaces between stony substrates.
- In summer, brown trout parr choose low current velocities, the best lies being occupied by the highest ranking individuals (often the largest individuals); water depth is critically important to preferred locations.
- In winter, young trout also seek the sanctuary of boulder habitats where these are available (and where environmental conditions tend to be harsh).

Salmon and brown trout parr can interact in summer for open water feeding stations, and in winter for stream bed refuges and nocturnal feeding stations (Harwood *et al.*, 2001).

Wild and stocked adult brown and rainbow trout are potentially able to prey on salmon fry and small parr (Shearer, 1992; Scott and Crossman, 1973). Brannas (1995) demonstrated under laboratory conditions how vulnerable Atlantic salmon fry are to brown trout predation. Huntingford *et al.* (1988) have shown how brief exposure to a model brown trout causes a fright response in laboratory-held salmon parr, often causing them to vacate their preferred feeding lie for an hour or longer.

Barnard *et al.* (1997) studied the impact on juvenile wild brown trout and Atlantic salmon of stocking adult (25 to 30 cm) brown trout into the River Coln, Gloucestershire and the River Ewenny, South Wales. Each river had an experimental (stocked) stretch and an unstocked control. Differences in habitat quality between experimental and control stretches were measured and allowed for during the analysis of results. The key findings from this study were:

- There was little evidence of impacts of stocked trout on wild juvenile trout in the River Coln, but very gradual recruitment into younger age classes in this brown trout stock may have obscured actual effects operating in the field.
- Stocked trout appeared to displace mature wild trout from preferred habitat on the Coln. On the Ewenny, many larger trout are migratory and therefore absent when such competitive interactions might have taken place.
- On the River Ewenny, where recruitment of juvenile brown trout and salmon was more rapid, the stocked stretch had lower densities of juvenile trout and salmon than the control stretch, indicating an impact of the stocked trout.
- Stomach content analyses confirmed piscivory by stocked trout, although fish made up a minor component of their diet (estimated 3.5 per cent occurrence River Coln, 8.7 per cent River Ewenny). Nevertheless, on the Coln stocked brown trout ate an estimated 1.2 to 1.5 salmonid (trout) fry per 100 square metres of habitat per stocking and, on the Ewenny, predation rates were estimated to be between 1.8 and 7.5 (salmon/trout) fry per 100 m^2 per stocking. This could amount to a substantial cumulative predation loss if stocked trout were present for appreciable periods. The study assumed that 50 per cent of fish eaten were salmonids. This figure was chosen as around half of the identifiable remains (six sets of fish remains) were of young trout or salmon, the rest probably being minnows or bullheads.
- Residence time of stocked trout was relatively short (with more than 90 per cent disappearing from the study stretches very rapidly, probably within a month after stocking), giving a limited window of opportunity for predation of juvenile salmonids from young fry up to 1+ age class brown trout and salmon. Whether this degree of predation pressure exceeded the salmon and sea trout populations' ability to

compensate through any density-dependent survival to smolt output is unknown. This is an important question to resolve.

In their literature review for the report (Barnard *et al.*, 1997), the authors cite examples of studies where stocked trout appear to have depressed wild trout stocks (Nielson *et al.*, 1957 (rainbow trout); Harcup *et al.*, 1984 (brown trout); Berg and Jorgensen, 1991 (brown trout); Naslund, 1992 (brown trout)) and also note that some other studies (such as Miller, 1958) have found no such effect. Where spawning success is adequate, stocking may not increase subsequent standing stocks (Millard and McCrimmon, 1972; Kelly-Quinn and Bracken, 1989; Naslund, 1992); density-dependent factors may be operating in such situations (Barnard *et al.*, 1997). Genetic introgression of domesticated trout may also be seriously damaging for long-term viability of wild trout stocks (McGinnity *et al.*, 2003). A report by the Scottish Salmon Strategy Task Force (1997) noted that rainbow trout may be significant local predators of Atlantic salmon in Scotland, although an analysis of the diet of 34 escapee rainbow trout from Loch Tay in early summer revealed no salmon smolts (SOAFD, 1991).

A review of impacts of stocked rainbow trout on resident salmonid populations by Welton *et al.* (1997) found the following:

- In Britain, despite extensive stocking, rainbow trout have founded very few self-sustaining populations. The two riverine examples (Derbyshire River Wye and Carl Beck, a tributary of the River Lune) may show competition between brown and rainbow trout production.
- Rainbow trout were found to eat juvenile salmonids in the South West Environment Agency Region (Devon), but no impact at population level was established.
- Examples from abroad show that, where rainbow trout become established, the species can have severe detrimental effects on native salmonid species.
- Large numbers of rainbow trout occasionally escaping from fish farms tend to disappear within a year, probably due to predation and/or downstream displacement.
- Care should be taken to limit rainbow trout stocking in catchments where natural salmonid populations are in decline and the number of smolts needs to be maximised (such as in SAC rivers where Atlantic salmon are in decline).
- Whilst UK Atlantic salmon tend to spawn from December to February, rainbow trout are likely to attempt to spawn later in the spring and so represent little risk of redd over-cutting. Atlantic salmon spawn early in cold streams and later in warmer streams (Heggberget, 1991).

Salmon parr and smolts are vulnerable to predation by adult trout and competition for food from stocked salmonids. Hilton *et al.* (2001) used a modeling approach to investigate the power of different River Frome (Dorset) management strategies, including modifying trout stocking, to increase stocks of wild Atlantic salmon. They found that:

- The density of adult *Salmo trutta* in the river Frome was estimated (from Ibbotson, 1993) at around 100 per hectare.
- Salmon parr density-dependent mortality in the River Frome appears largely to have occurred by July each year and so predation of parr by trout after this time is likely to be additive (reducing smolt output correspondingly).
- Trout predation on salmon parr was assumed to occur mainly from July to October, with minimal impact over winter and with parr and smolts in the spring being generally too large to be eaten by brown trout. Trout and sea trout have, however, been observed feeding on smolts on the lower River Frome (G. Lightfoot, pers. comm.)

- The simulation model was run using three trout predation rates: one parr per trout per week (over four months), one parr per trout over four months and one parr per trout per month (over four months).
- A predation rate of only two to three salmon parr per trout per four-month period in the River Frome would make a significant difference to surviving salmon parr numbers.
- Hilton *et al.* (2001) had access to the study reported by Ibbotson *et al.* (1996) which found PIT tags recovered from stocked Atlantic salmon parr in the stomachs of stocked brown trout in the River Anton (a tributary of the River Test).
- In the River Frome, if trout eat only one parr per active month and if 8,000, 30 cm trout were stocked (250 fish per km of river), over 47,000 salmon parr would be eaten and, at any time, only about three per cent of sampled trout would have a fish in the gut, underlining the difficulty of detecting this type of predation under natural conditions. Note the findings of Ibbotson *et al.* (1996) in this context. Note also the consented stocking of trout on the rivers Itchen and Hampshire Avon in areas where salmon are known to spawn, which is discussed later in this report.

Hilton *et al.* (2001) underline the potential of predation by stocked trout to impact severely on salmon smolt production and, corresponding adult salmon runs. Confirmation of the importance of predation by stocked trout on salmon parr is urgently required.

Pedley and Jones (1978) found that spring-stocked Atlantic salmon fry introduced into Llyn Dwythwych, North Wales, suffered substantial predation losses from resident brown trout. Shearer (1992) describes brown trout weighing upwards of one pound, sampled from the River North Esk, Scotland, containing remains of up to 20 salmon smolts in their stomachs. It is worth noting that, because of the size of their feeding grounds, salmon smolt losses to predation both in-river and in the marine environment are most unlikely to be compensated for via density-dependent survival; that is, they probably represent absolute losses to the returning adult salmon stock. As a result of the probable lack of density-dependence operating at sea, salmon smolt marine survival varies greatly between years. For instance, in the Scottish River North Esk from 1964 to 1985, marine survival of different Atlantic salmon smolt cohorts varied between an estimated 14 and 53 per cent (Shearer, 1992).

It is important to note that by no means have all brown trout dietary studies shown high incidences of piscivory; very low levels (less than one per cent weight of food) were found for Irish brown trout in rivers (Lobon-Cervia and Fitzmaurice, 1988) and in Norwegian brown trout living in lakes (L'Abee-Lund *et al.*, 1992).

2.3.2 North American studies

Henderson and Letcher (2003) found that Atlantic salmon fry stocked in three Massachusetts streams were very vulnerable to predation by both brown and brook trout (char), especially over the first two days after stocking when up to 60 per cent losses took place. It is worth noting that the presence of potentially predatory large brown trout causes juvenile Atlantic salmon to modify their behaviour, becoming less aggressive and showing reduced feeding activity (Vehanen, 2003). Subtle behavioural interactions between stocked trout and wild juvenile salmon require field-testing to assess their impacts on wild salmon survival.

Rainbow trout eat small fish as part of their natural diet in native fresh waters (Wydoski and Whitney, 1979). Brown *et al.* (1992) found over one third of British Columbian rainbow trout stomachs to contain fish remains. Levin and Williams (2002) have demonstrated a negative association between wild Chinook salmon survival and large-scale releases of hatchery-produced steelhead smolts (migratory rainbow trout) on the Snake River. On the Lewis River, Washington, Hawkins and Tipping (1999) found that wild Chinook salmon fry are vulnerable to predation by steelhead rainbow trout stocked as smolts and releases of such hatchery smolts are recommended to be carried out well downstream of Chinook spawning habitats. In contrast, Brown (1995) found that rainbow trout were relatively unimportant as predators of juvenile Chinook salmon in the Nechako and Stuart rivers, British Columbia.
Fresh and Schroder (1987) recorded rainbow trout as active predators of juvenile chum salmon in small Washington State coastal streams where enhancement stocking projects are carried out. Cartwright *et al.* (1998) found that predatory salmonids (cutthroat trout) in Alaskan waters (such as Margaret Lake) can substantially depress the survival of stocked sockeye salmon fry, threatening the success of the enhancement project.

Scott and Crossman (1973) found that brown trout in Canadian waters eat a wide variety of fish species; fish are noted as important dietary items of larger trout (greater than 12 inches, 30cm). This is supported by the study of Alexander (1977) who recorded large (greater than 30cm) brown trout regularly eating small trout in the Au Sable River, Michigan. In Japan, Mayama (1999) found that brown trout eat substantial numbers of stocked, newly-emerged masu salmon fry in the Chitose River, Hokkaido; fry are stocked into slowly-flowing habitats where trout can easily prey upon them. Introduced rainbow trout are spreading into streams on Hokkaido, causing declines in native masu salmon populations (Tanguchi *et al*., 2002).

Note, however, that salmon and trout fry and parr losses to predation may often be compensated for by better survival of surviving individuals (density-dependent regulation, see Shearer, 1992 and Anon, 1989). Salmon are known to hybridise with brown trout and this effect might be significant on river systems where salmon are scarce and brown trout densities are substantial (Garcia-Vazquez *et al*. 2003; Matthews *et al*. 2000; Hartley, 1996). Disease and parasite transfer from stocked trout to wild salmon of all sizes is also a potential risk to natural stocks.

These and other perceived threats are included in the tables below (APEM, 2002):

Table 2.4: Threats posed by specific life stages of stockee species upon salmon fry (from Table 6.3, APEM 2002)

Stocked species/ life stage	Predation	Disease/ parasites	Competition for territory	Competition for food	Habitat disturbance
Brown trout juvenile	*	*	***	***	-
Brown trout adult	**	*	-	*	-
Rainbow trout juv.	*	*	***	***	-
Rainbow trout adult	**	*	-	*	-

Table 2.5: Threats posed by specific life stages of stockee species upon salmon parr (from Table 6.4, APEM, 2002)

Stocked species/ life stage	Predation	Disease/ parasites	Competition for territory	Competition for food	Habitat disturbance
Brown trout juvenile	-	*	***	***	-
Brown trout adult	**	*	-	**	-
Rainbow trout juv.	-	*	***	***	-
Rainbow trout adult	**	*	-	**	-

Table 2.6: Threats posed by specific life stages of stockee species upon salmon smolts (from Table 6.5, APEM, 2002)

Stocked species/ life stage	Predation	Disease/ parasites	Competition for territory	Competition for food	Habitat disturbance
Brown trout juvenile	-	*	-	**	-
Brown trout adult	*	*	-	**	-
Rainbow trout juv	-	*	-	**	-
Rainbow trout adult	*	*	-	**	-

Threats from stocked trout considered to be of particular significance to Atlantic salmon are summarised below (APEM, 2002):

- mortality of ova resulting from over-cutting of redds by later spawning fish;
- predation on eggs, fry, parr and smolt stages;
- reduced availability of juvenile rearing areas due to aggressive territorial behaviour;
- competition for food;
- disease and parasite introduction.

2.3.3 Conclusions from this literature review:

- The literature certainly supports the view that there is potential for food and territorial competition between salmon and trout fry and parr which could be significant at population level, especially where key habitat availability (riffles and runs) is limited.
- Predation risk to salmon fry, parr and smolts from adult stocked trout is also potentially significant, depending upon local circumstances. The relatively intensive stocking of the rivers Hampshire Avon and Itchen with brown trout in areas where salmon spawn require detailed consideration. Further studies on these chalk streams to examine the actual impact of predation by stocked trout on overall salmon production are required, to establish whether impacts occur at population level. In 2003, the Itchen salmon stock reached only 23 per cent of its conservation limit and the Hampshire Avon reached 30 per cent (CEFAS/Environment Agency, 2004).
- Risks of hybridization between wild salmon and stocked brown trout are possible and might be significant.

- Risks of disease and parasite introductions via stocked trout are also potentially serious for salmon, native crayfish and for wild trout.

2.4 Interactions of pearl mussel with rainbow and brown trout

Pearl mussel (*Margaritifera margaritifera*) populations, already rare in the UK owing to habitat damage, appear generally to be suffering from a lack of recruitment of juveniles. However, the species is long-lived (30-60 years of reproduction) and natural recruitment rates may always have been modest, given that annual adult survival is likely to have been high, larval and juvenile mortality high and female fecundity very high (three to four million larvae per female per year) (Young and Williams, 1984). Grundelius (1987) reviewed 54 possible pearl mussel localities in the Swedish Province of Dalarna, finding 20 mussel populations but only two quite small populations where juvenile recruitment was appreciable. Pearl mussels, in common with many other freshwater mussel species, depend upon fish as dispersal hosts for their larvae (glochidea). The larvae encyst within the skin of various host fish species, including salmonids. In Young and Williams' review of Scottish pearl mussel populations (1984), brown trout were found to be the usual fish hosts for the ecto-parasitic larval stage of the life cycle. Bauer and Vogel (1987) explain how pearl mussel glochidea encyst on the gill tissues of brown trout, but that many larvae fail to survive this phase of the life cycle.

Given that pearl mussels tend to live on stable riffle heads in shingle-bedded upland river systems, the species may naturally have depended upon salmonids to a great extent for dispersal. With recent declines of salmon, sea trout and wild brown trout stocks in many rivers, such natural dispersal mechanisms may have been disrupted.

Altmueller and Dettmer (2000) report on a fifteen year project which has sought to conserve pearl mussels in the Lueneburg Heath area of Lower Saxony, North Germany. In this area, excessive sedimentation with sand released from poor land use practice has led to serious habitat damage in pearl mussel areas. In parallel with better land use guidance to improve riverine habitats, brown trout were caught using electric-fishing techniques, artificially infected with pearl mussel glochidea larvae and released back into the wild. This appears to have been successful with the sampling of young pearl mussels, where there were very few before the project. It is possible, therefore, that routine trout fishery management operations could be integrated with UK projects on suitable rivers where there is a need to stimulate pearl mussel recruitment. Such an approach may not, however, have wide applicability; Bauer (1988) had previously reviewed data on threats to pearl mussel populations in Central Europe and concluded that brown trout declines probably hadn't been the reason for most mussel population crashes. A decline in water quality (particularly nutrient increase) was the factor most usually correlated with decreasing survival of young mussels. Clearly, local factors in pearl mussel population dynamics will vary between sites and require individual conservation consideration.

2.4.1 Conclusions from this literature review:

- Habitat management to improve wild brown trout fisheries could help pearl mussel populations.
- Stocked brown trout might act as useful hosts for mussel glochidea where wild fish stocks have declined to low levels.

2.5 Interactions of bullhead with rainbow and brown trout

According to APEM (2002), the main threats to bullheads from stocked fish are:

- predation, particularly on smaller individuals which are more active during the daytime, and on adult males which are more active immediately prior to the spawning season;
- competition for food;
- disease and parasite introductions.

APEM (2002) states that “actual competition for food can be difficult to demonstrate. Overlaps in diet are frequently observed, but if a food source is not limiting, or different parts of the habitat are being exploited, significant competition is unlikely to occur.”

Bullheads tend to be widely distributed on many SAC rivers. They live on the river bed, preferring stony or cobbled riffles and runs in summer, glides in spring and pools in winter (Hoffman, 1996, cited in APEM, 2002). This habitat use coincides largely with that of brown trout.

Holmen *et al.* (2003) found that Alpine bullhead (*Cottus poecilopus*) appeared to out-compete wild brown trout for larger chironomid and trichopteran larvae in a Norwegian stream, with trout living at markedly lower population densities when sympatric with bullheads. Competition may not, therefore, always favour the salmonid species. Naslund *et al.* (1998) found that brown trout densities in Swedish streams were negatively correlated with the presence of other fish species, indicating possible resource limitation. Adult brown trout are thought to be a potential predatory threat to bullheads, especially where trout densities are maintained at high levels (Hofer and Bucher, 1991; Utzinger *et al.,* 1998).

Table 2.7: Threats posed by stockee species upon bullhead (from Table 6.6, APEM, 2002)

Stocked species/ life stage	Predation	Disease/ parasites	Competition for territory/food	Habitat disturbance
Brown trout	**	*	**	-
Rainbow trout	**	*	**	-

Table 2.8: Threats posed by specific life stages of stockee species upon bullhead juveniles (from Table 6.7, APEM, 2002)

Stocked species / life stage	Predation	Disease/ parasites	Competition for territory	Competition for food	Habitat disturbance
Brown trout juvenile	*	*	*	**	-
Brown trout adult	**	*	-	**	-
Rainbow trout juv	*	*	-	**	-
Rainbow trout adult	**	*	-	**	-

Table 2.9: Threats posed by specific life stages of stockee species upon bullhead adults (from Table 6.8, 2002)

Stocked species/ life stage	Predation	Disease/ parasites	Competition for territory	Competition for food	Habitat disturbance
Brown trout juv.	-	*	-	**	-
Brown trout adult	*	*	-	**	-
Rainbow trout juv	-	*	-	**	-
Rainbow trout adult	*	*	-	**	-

2.5.1 Conclusions from this literature review:

- Bullheads are at risk from predation by trout but, where cover habitat is of adequate quality, this is unlikely to affect overall bullhead populations.
- Competition for invertebrate food resources may occur on some river types.

2.6 Interactions of crayfish with rainbow and brown trout

Native white clawed crayfish populations are at serious risk from infection by crayfish plague, to which they have no immunity and are wiped out by at population level. New outbreaks of plague usually seem to be associated with the stocking of or immigration by signal crayfish which can carry the fungus but are immune to the disease (Rogers and Holditch, 1995). Crayfish plague spores can also potentially be carried on the skin of trout (Alderman and Polglase, 1988) and for this reason, the Environment Agency, English Nature and CCW collaborate on S30 consents to stock trout to ensure that movements of fish from potentially infected waters to waters still supporting native crayfish are avoided (Giles *et al.*, 2003).

Juvenile and adult crayfish are potentially vulnerable to predation by many fish species, especially if they are captured soon after moulting when the new exoskeleton is still soft (Hogger, 1988). Crayfish tend to hide at this time, minimizing predation risk, although they may still be very vulnerable to predatory eels which hunt by smell and are probably able to access many crayfish hiding places.

The author has received two personal communications supporting the fact that adult brown trout have been found in England with native crayfish in their stomachs:

1. Mr Julian Mills has shown the author photographs of crayfish retrieved from the stomach contents of large brown trout stocked into the Sherston Avon (Bristol Avon headwater, above Malmesbury, Wiltshire).
2. John Garner (Assistant Conservation Officer, English Nature Cumbria Team) has, over the past two years, found occasional bullheads and crayfish in the stomachs of brown trout stocked into the River Eden.

Scott and Crossman (1973) note that brown trout in Canadian waters eat a wide variety of food items; fish and crayfish are noted as important dietary items of larger trout (greater than 12 inches). Rainbow trout in summer in Newcastle Reservoir, Utah, were found to eat large numbers of the crayfish *Oronectes virilis* (Hepworth and Duffield, 1987). Similarly, the crayfish Cherax destructor was a major dietary item for both brown and rainbow trout in Lake Eucumbene, New South Wales (Faragher, 1983).

Table 2.10: Threats posed by stockee species upon crayfish (from Table 6.15, APEM 2002)

Stocked species / life stage	Predation	Disease/ parasites	Competition for territory/food	Habitat disturbance
Brown trout	**	***	*	-
Rainbow trout	**	***	*	-

Table 2.11: Threats posed by specific life stages of stockee species upon crayfish juveniles (from Table 6.16, APEM, 2002)

Stocked species / life stage	Predation	Disease/ parasites	Competition for territory	Competition for food	Habitat disturbance
Brown trout juv.	*	***	-	*	-
Brown trout adult	**	***	-	*	-
Rainbow trout juv	*	***	-	*	-
Rainbow trout adult	**	***	-	*	-

Table 2.12: Threats posed by specific life stages of stockee species upon crayfish adults (from Table 6.17, APEM 2002)

Stocked species / life stage	Predation	Disease/ parasites	Competition for territory	Competition for food	Habitat disturbance
Brown trout juv.	-	***	-	*	-
Brown trout adult	**	***	-	*	-
Rainbow trout juv	-	***	-	*	-
Rainbow trout adult	**	***	-	*	-

2.6.1 Conclusions from this literature review:

- The threat of crayfish plague transmission should lead to very cautious consenting of fish introductions to waters still supporting native crayfish stocks. These restrictions may also be pertinent to certain fish farms (overseen by Defra) and appropriate liaison between government departments and agencies is important in this context.
- The literature plus observations of anglers supports the view that trout can and do sometimes eat native crayfish. This sort of predation is unlikely, however, to have consequences at population level in UK rivers.

2.7 Interactions of lampreys with rainbow and brown trout

APEM (2002) identified the following potential significant threats to lampreys:

- predation on ammocoetes and newly metamorphosed adults, during periods of exposure associated with the lamprey life cycle;
- competition for food.

Sterba (1962, cited in APEM 2002) has reported predation on lampreys by trout, but the literature otherwise appears to be lacking.

Table 2.13: Threats posed by stockee species upon lampreys (from Table 6.12, APEM, 2002)

Stocked species / life stage	Predation	Disease/ parasites	Competition for territory/food	Habitat disturbance
Brown trout	*	*	*	-
Rainbow trout	*	*	-	*

Table 2.14: Threats posed by specific life stages of stockee species upon lamprey ammocoetes (from Table 6.13, APEM 2002)

Stocked species / life stage	Predation	Disease/ parasites	Competition for territory	Competition for food	Habitat disturbance
Brown trout juv.	*	*	-	*	-
Brown trout adult	*	*	-	-	-
Rainbow trout juv	*	*	-	-	-
Rainbow trout adult	*	*	-	-	-

Table 2.15: Threats posed by specific life stages of stockee species upon lamprey adults (from Table 6.14, APEM 2002)

Stocked species / life stage	Predation	Disease/ parasites	Competition for territory	Competition for food	Habitat disturbance
Brown trout juv.	No risk				
Brown trout adult	*	-	-	-	-
Rainbow trout juv	No risk				
Rainbow trout adult	*	-	-	-	*

2.7.1 Conclusions from this literature review:

- There would appear to be little threat to brook, river or sea lampreys from trout stocking activities.

3 cSAC river designations and trout stocking activity

3.1 Rivers selected for this study

A decision was taken by the project steering group to include the rivers Eden, Yorkshire Derwent and Rye, Dove and Lathkill, Teifi, Wye, Usk, Itchen and Hampshire Avon in the study. An additional decision was made to concentrate on Atlantic salmon as the key SAC species which may be affected adversely by trout stocking in these rivers.

3.2 Stocking of trout in SAC rivers in the study

Names and addresses for riparian owners, fishery managers and fishing clubs were obtained from either the Environment Agency or English Nature, depending on which organisation was able to produce listings for a given river. Access to personal information was often hampered by Data Protection Act considerations and considerable numbers of potential contacts withheld their information. Some individuals who have withheld their information may be stocking with trout without consent – this is known to be the case on more than one river in this study.

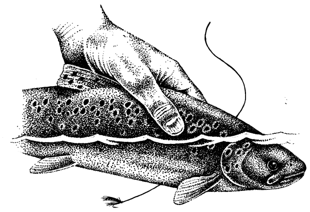
English Nature-derived information covered all riparian owners (including householders in towns), many of whom are not involved in fishery matters. Environment Agency-derived information often included fishing clubs and fishery managers, many of whom are directly involved in stocking waters. Some of the lists were long out-of-date. Thus, the coverage obtained for this study is considered good but far from complete.

Section 30 consented stockings of trout for each SAC river were accessed directly by the Environment Agency from the Live Fish Movements Database and included in the study.

The following letter and questionnaire was sent to all known riparian owners and fishery managers:

Dr Nick Giles & Associates,
50 Lake Road,
Verwood,
Dorset,
BH31 6BX.

Telephone 01202 824245
Fax 01202 828056
email gilesassociates@btopenworld.com



Consultants : Freshwater Fisheries, Conservation & Wetland Ecology

October 2003

Dear Sir

We are undertaking a project on behalf of the Environment Agency, English Nature and the Countryside Council for Wales, that will examine the range of current trout stocking practices on rivers that are designated as Special Areas of Conservation in England and Wales. The reason for gathering this information is to ensure that the Agency and fishery managers are not contravening the EU Habitats Directive legislation by adversely impacting the designated SAC species, particularly (but not exclusively) salmon and crayfish.

It is recognised that stocking is essential to the success of many fisheries. In the circumstance that any adverse impacts might be identified, the Agency will seek to establish a balance that will allow a more appropriate stocking in order to minimise any impacts on the designated conservation species, while still allowing satisfactory fishing. We realise that the Agency may already have information for your club - please could you let us know whether you are happy for us to use existing information in this study.

The key information needed is how many trout (including ova in incubation boxes) are stocked (if any) in each fishery, their size and time of year when they are stocked. We will use this information to develop a suitable risk assessment methodology for the impacts of trout stocking.

Could you therefore please complete the enclosed brief questionnaire for each separate fishery that you may control, and return in the sae provided. Please answer as fully as possible. All information will be treated in the strictest confidence. If you would like any further information about this project, please contact Nick Giles.

Thank you for your help,

Yours sincerely,

Nick Giles.

Questionnaire

River Name…...........................

Location of fishery …………………………….. Fishery length (approx) ....………..

Do you stock trout into this fishery? Yes / No

If Yes, please identify which species Rainbow / Brown

How many fish do you stock per calendar year?
....

What size of fish do you stock? (length or weight)
....

How often do you stock each year?
....

Do you distribute the stock fish throughout the fishery, or release them at one location?
....

Do you keep catch records or have any other indications of the typical return of fish to rods or residence time of trout in your fishery?
....

Would you be prepared to allow us to analyse your catch records or other information?
....

How best to contact you (name; phone, fax or email)..

Thank you for your help.

The number of questionnaires sent out and returned is shown in Table 3.1.

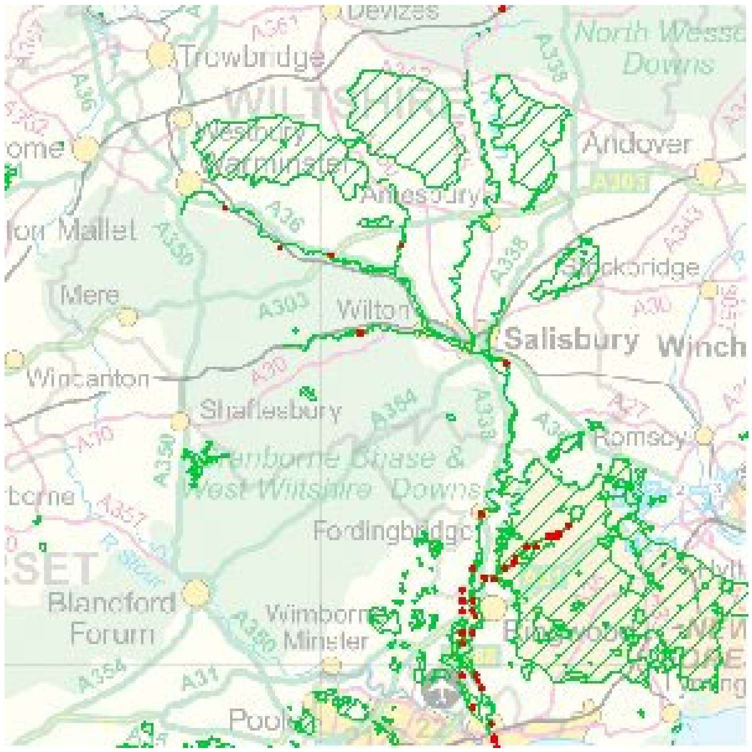
Table 3.1: Numbers of contacts and replies to questionnaires from study SAC rivers

River	Number of contacts	Number of replies (%)	Notes
Lathkill	2	1 (50%)	No useful data
Dove	3	2 (66%)	Dr Mark Williams study – (marked stocked brown trout and recaptures).
Eden	29	11 (38%)	Agency stocking project with wild-parented brown trout.
Itchen	18	14 (78%)	
Avon	292	164 (56%)	Blandford Office Review of recent trout stocking into SAC, contact Emily White / Nicole Caetano
Teifi	14	9 (64%)	Agency stocking project with wild-parented brown trout Contact Dave Mee.
Rye	16	7 (43%)	
Derwent	123	40 (32%)	
Usk	165	50 (30%)	
Wye	224	87 (39%)	

Stocking information for the eight SAC rivers from the Environment Agency Live Fish Movements Database (LFMD) and from returned questionnaires was collated and cross-checked to produce the annotated maps presented below. Note that consented stockings, although authorised, were not necessarily carried out. Note also that unconsented stocking is known to have taken place on some of the rivers included in this study.

3.3 Locations, cSAC designations and stocking information for study rivers

3.3.1 Hampshire Avon



(From National Biodiversity Network (NBN) website)

Figure 3.1: Hampshire Avon cSAC

From JNCC website: site designation criteria

Annex I habitats that are a primary reason for selection of this site

3260 Water courses of plain to montane levels with the *Ranunculion fluitantis* and *Callitricho-Batrachion* vegetation

The Avon in southern England is a large, lowland river system that includes sections running through chalk and clay, with transitions between the two. Five aquatic *Ranunculus* species occur in the river system, but stream water-crowfoot *Ranunculus penicillatus* ssp. *pseudofluitans* and river water-crowfoot *R. fluitans* are the main dominants. Some winterbourne reaches, where *R. peltatus* is the dominant water-crowfoot species, are included in the SAC.

Annex I habitats present as a qualifying feature, but not a primary reason for selection of this site
Not applicable.

Annex II species that are a primary reason for selection of this site

1016 Desmoulin`s whorl snail ***Vertigo moulinsiana***

There is an extensive population of Desmoulin's whorl snail *Vertigo moulinsiana* along about 20 km of the margins and associated wetlands of the rivers Avon, Bourne and Wylye. This is one of two sites representing the species in the southwestern part of its range, in chalk stream habitat. It occurs here in a separate catchment from the Kennet and Lambourn, within an environment more heavily dominated by arable agriculture.

1095 Sea lamprey ***Petromyzon marinus***

The Avon represents sea lamprey *Petromyzon marinus* in a high-quality river in the southern part of its range. There are excellent examples of the features that the species needs for survival, including extensive areas of sand and gravel in the middle to lower reaches of the river where sea lampreys are known to spawn.

1096 Brook lamprey ***Lampetra planeri***

The Avon is a high-quality river that represents the southern part of the range of brook lamprey *Lampetra planeri*. A healthy, stable population occurs in the main river and in a number of tributaries. The main river, and in particular its tributaries, provides clean beds of gravel for spawning and extensive areas of fine silt for juveniles to burrow into.

1106 Atlantic salmon ***Salmo salar***

The Avon in southern England represents a south coast chalk river supporting Atlantic salmon *Salmo salar*. The salmon populations here are typical of a high-quality chalk stream, unaffected by the introduction of genetic stock of non-native origin. The Avon has an excellent mosaic of aquatic habitats, which include extensive areas of gravels essential for spawning and growth of juvenile fry. There has been limited modification of the river course by comparison with many other southern lowland rivers in England.

1163 Bullhead ***Cottus gobio***

The Avon represents bullhead *Cottus gobio* in a calcareous, relatively unmodified river in the southern part of its range in England. The River Avon has a mosaic of aquatic habitats that support a diverse fish community. The bullhead is an important component of this community, particularly in the tributaries.

Annex II species present as a qualifying feature, but not a primary reason for site selection

Not applicable.

The stocking of trout and distribution of salmon spawning habitats on the Hampshire Avon system are shown in Figures 3.2 to 3.4.

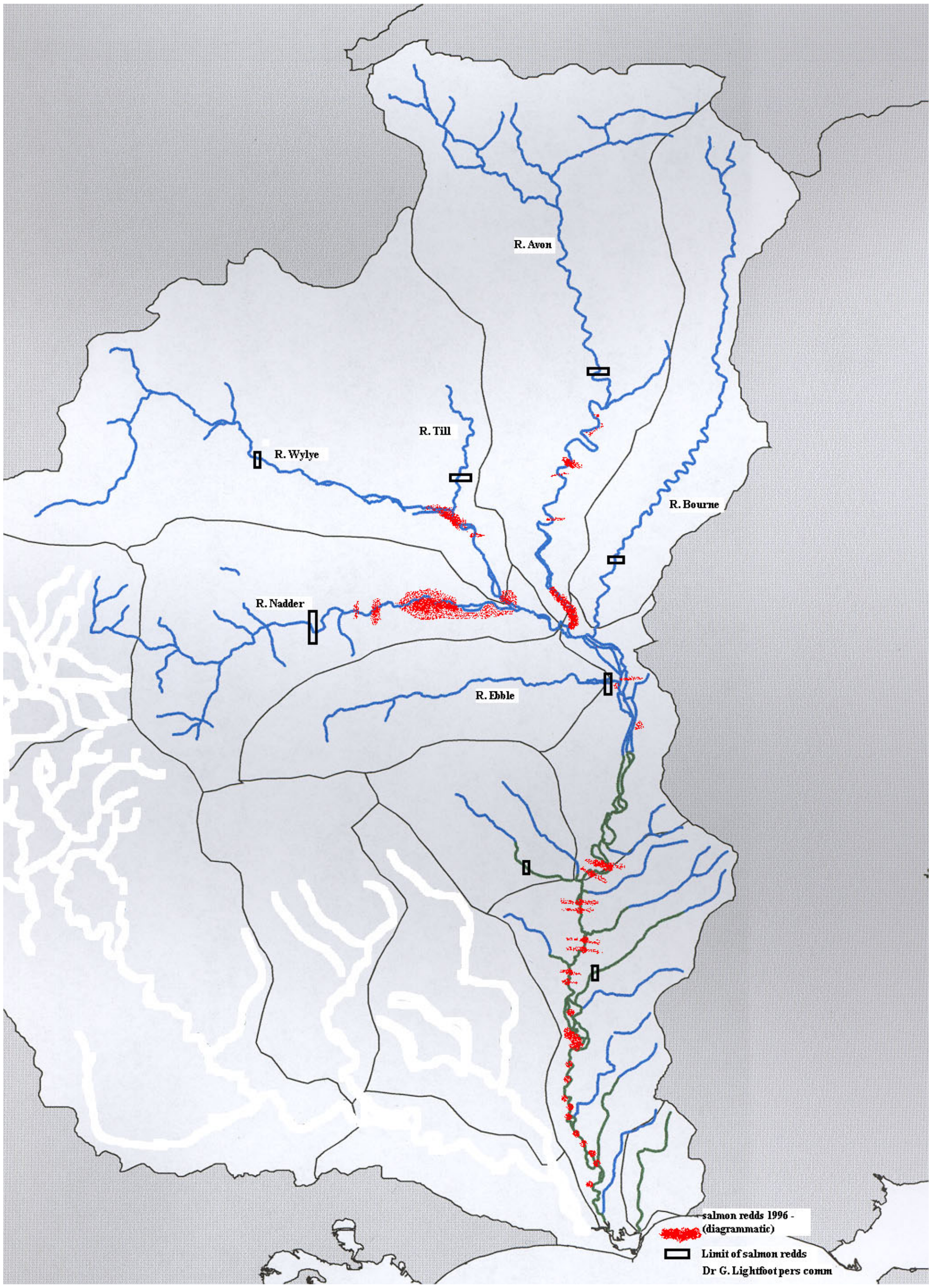


Figure 3.2: Diagrammatic map of distribution of large salmonid (probably largely salmon) redds on Avon system in 1996 (after Environment Agency, 1997)

Modified from R&D Technical Report W2-062/TR

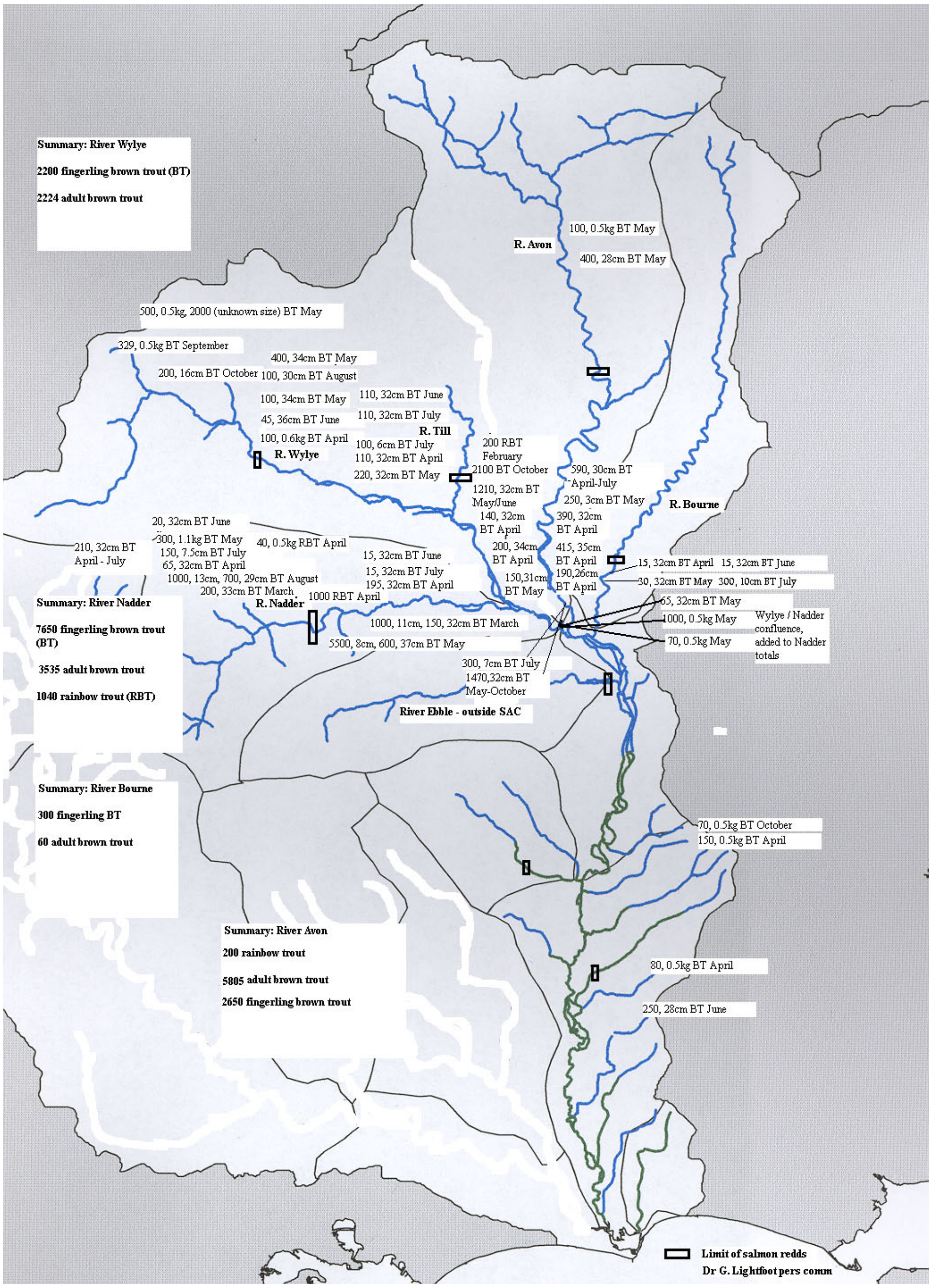


Figure 3.3: S30-consented stocking information for Avon system 2002

Modified from R&D Technical Report W2-062/TR

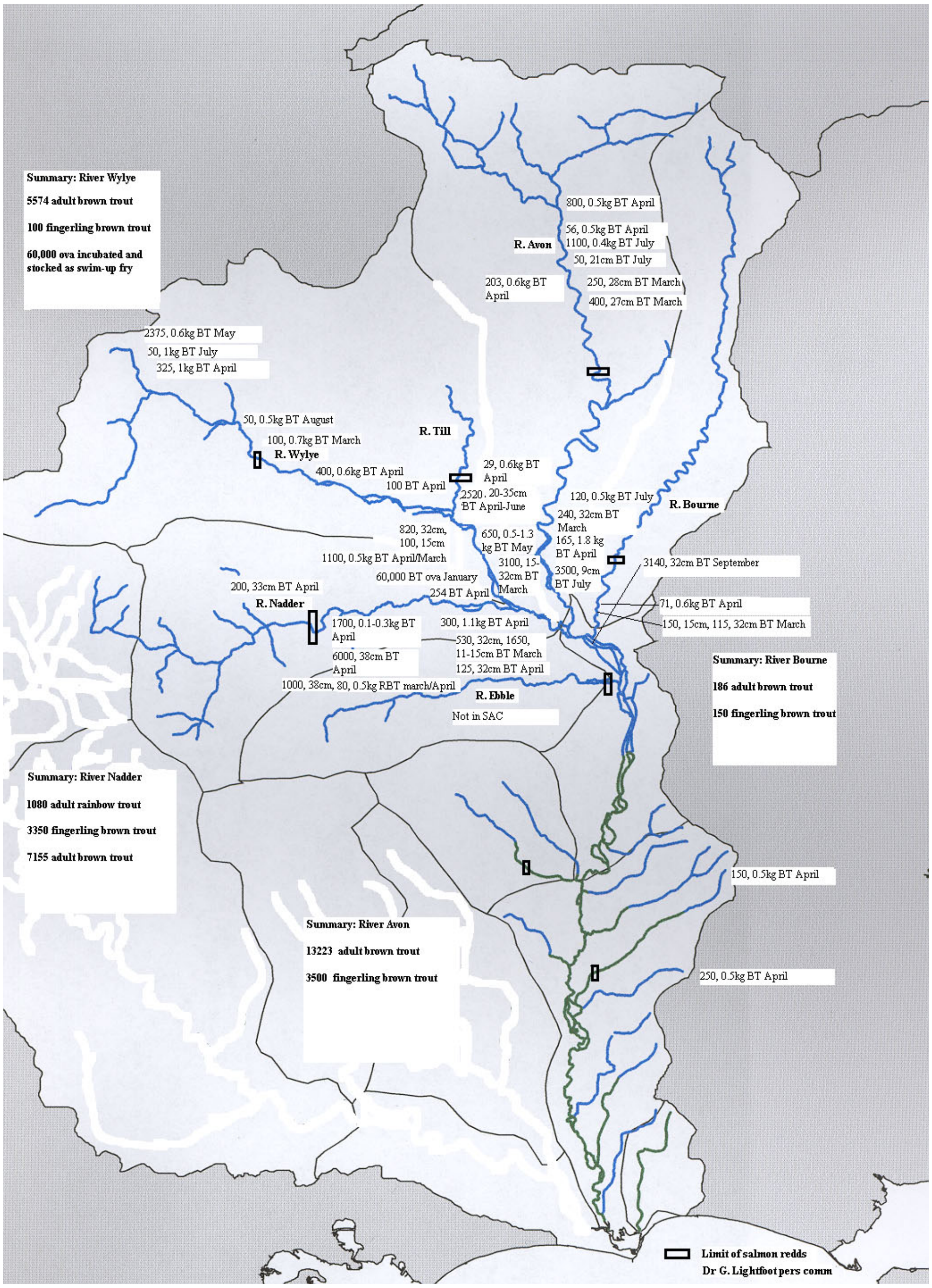
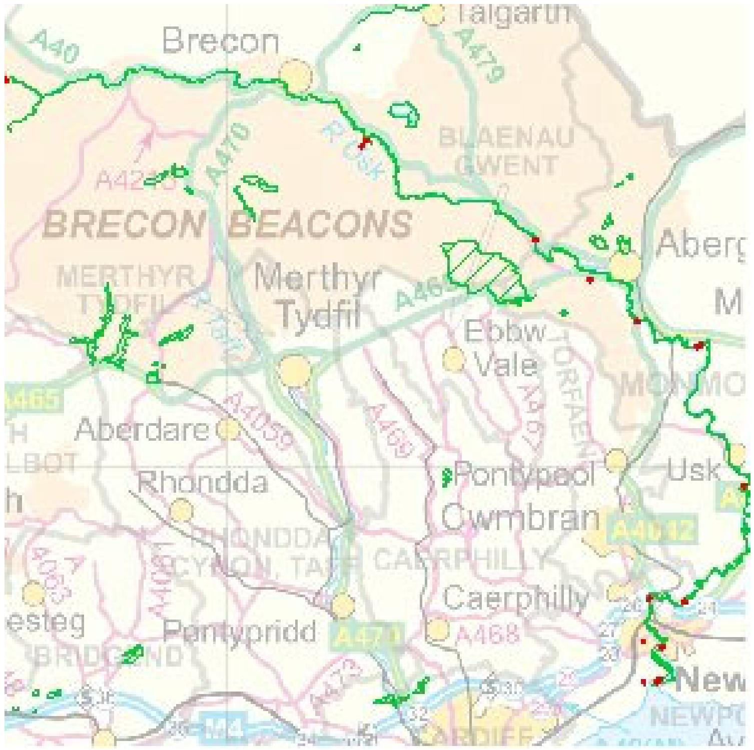


Figure 3.4: S30-consented stocking information for Avon system 2003
Modified from R&D Technical Report W2-062/TR

3.3.2 River Usk



(From National Biodiversity Network (NBN) website)

Figure 3.5: River Usk cSAC

From JNCC website: site designation criteria

Annex I habitats that are a primary reason for selection of this site

Not applicable

Annex I habitats present as a qualifying feature, but not a primary reason for selection of this site

3260 Water courses of plain to montane levels with the *Ranunculion fluitantis* and *Callitricho-Batrachion* vegetation

Annex II species that are a primary reason for selection of this site

1095 Sea lamprey ***Petromyzon marinus***

The Usk is a medium-sized catchment in South Wales, important for its population of sea lamprey *Petromyzon marinus*. Survey of juveniles and observation of spawning adults indicates that this species is mainly restricted to the lower reaches of the catchment. The site supports a range of Annex II fish species.

1096 Brook lamprey ***Lampetra planeri***

The Usk in South Wales supports a healthy population of brook lamprey *Lampetra planeri* and is considered to provide exceptionally good quality habitat likely to ensure the continued survival of the species in this part of the UK.

1099 River lamprey ***Lampetra fluviatilis***

The Usk in South Wales supports a healthy population of river lamprey *Lampetra fluviatilis* and is considered to provide exceptionally good quality habitat likely to ensure the continued survival of the species in this part of the UK. The river also supports important populations of 1096 Brook lamprey *Lampetra planeri*, for which it is also selected.

1103 Twaite shad ***Alosa fallax***

The River Usk is one of the largest rivers in South Wales, and twaite shad *Alosa fallax* has long been known to spawn there. The Usk is one of only four sites in the UK where a known breeding population of twaite shad occurs (the rivers Wye and Tywi are other SAC sites). Water quality and quantity are considered favourable for this species. The main channel is largely unmodified and a variety of aquatic habitats are present, including good quality spawning gravels and deep pools used for cover by adults and fry. However, Trostrey and Rhadyr Weirs may be a barrier to shad migration under low flow conditions.

1106 Atlantic salmon ***Salmo salar***

The river Usk is a river famous for its salmon *Salmo salar*, with a high proportion (30 to 40 per cent) of multi sea winter fish recorded in the rod catch. In 1999, the Usk had highest estimated egg deposition of any British river south of Cumbria, and was one of the few rivers in England and Wales to exceed its spawning target for salmon. The Usk has a mixed catchment with a largely unmodified river channel, no significant obstructions to salmon migration, good quality spawning gravels and a diversity of habitats providing excellent habitat for salmon parr. The most important tributaries for salmon spawning are included within the site boundary.

1163 Bullhead ***Cottus gobio***

The Usk represents bullhead *Cottus gobio* in the southern part of its range in Wales. It is considered to have exceptionally high quality habitat with good water quality, abundant cover and a variety of aquatic habitats. Bullhead are widespread throughout the Usk system.

1355 Otter ***Lutra lutra***

The River Usk is an important site for otters *Lutra lutra* in Wales. They are believed to be using most parts of the main river, from Newport upstream, and in recent years signs of otters have increased. In 1991, an expansion upstream of known otter ranges was recorded on several tributaries, including the Honddu, Senni and Crai. The upper Usk may have acted as a 'refuge' during the decline of the 1950s, and had subsequently acted as a 'source' population for recolonisation of South East Wales.

Annex II species present as a qualifying feature, but not a primary reason for site selection

1102 Allis shad ***Alosa alosa***

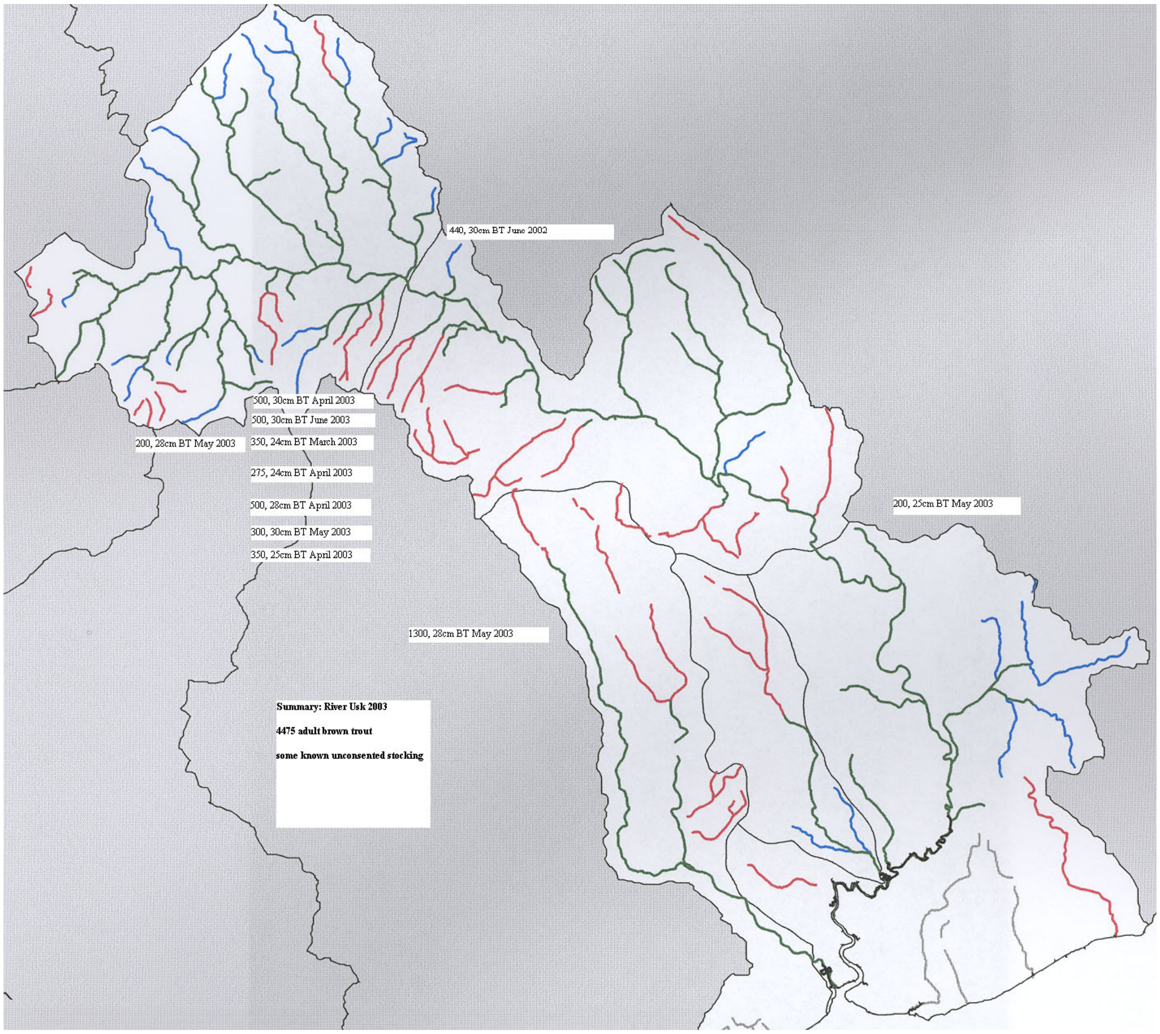
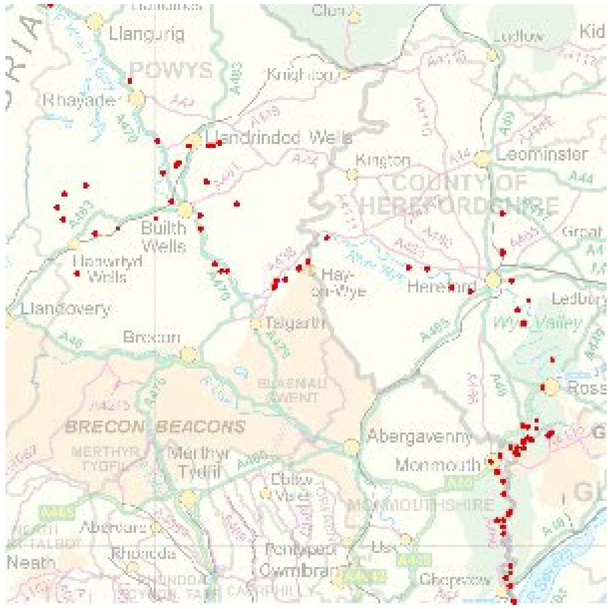


Figure 3.6: S30-consented stocking information for Usk system 2003
Modified from R&D Technical Report W2-062/TR

Note that salmon may spawn throughout the main stem system and in many headwaters and tributaries (contact Bill Purvis, Environment Agency, St Mellons, Cardiff).

3.3.3 River Wye



(From National Biodiversity Network (NBN) website)

Figure 3.7: River Wye cSAC

From JNCC website: site designation criteria

Annex I habitats that are a primary reason for selection of this site

3260 Water courses of plain to montane levels with the *Ranunculion fluitantis* and *Callitricho-Batrachion* vegetation

The Wye, on the border of England and Wales, is a large river representative of sub-type 2. It has a geologically mixed catchment, including shales and sandstones, and there is a clear transition between the upland reaches, with characteristic bryophyte-dominated vegetation, and the lower reaches, with extensive *Ranunculus* beds. There is a varied water-crowfoot *Ranunculus* flora; stream water-crowfoot *R. penicillatus* ssp. *pseudofluitans* is abundant, with other *Ranunculus* species – including the uncommon river water-crowfoot *R. fluitans* – found locally. Other species characteristic of sub-type 2 include flowering-rush *Butomus umbellatus*, lesser water-parsnip *Berula erecta* and curled pondweed *Potamogeton crispus*. There is an exceptional range of aquatic flora in the catchment including river jelly-lichen *Collema dichotum*. The river channel is largely unmodified and includes some excellent gorges, as well as significant areas of associated woodland.

Annex I habitats present as a qualifying feature, but not a primary reason for selection of this site

7140 Transition mires and quaking bogs

Annex II species that are a primary reason for selection of this site

1092 White-clawed (or Atlantic stream) crayfish ***Austropotamobius pallipes***

The Welsh River Wye system is the best site known in Wales for white-clawed crayfish *Austropotamobius pallipes*. The tributaries are the main haven for the species, particularly at the confluences of the main river and the Edw, Dulas Brook, Sgithwen and Clettwr Brook.

1095 Sea lamprey ***Petromyzon marinus***

The Wye is an extensive river system crossing the border between England and Wales and the sea lamprey *Petromyzon marinus* population is found in the main stem below Llyswen. The site provides exceptionally good quality habitat for sea lamprey and supports a healthy population.

1096 Brook lamprey ***Lampetra planeri***

The Wye is an extensive river system spanning the border between England and Wales and the brook lamprey *Lampetra planeri* population is widely distributed in its catchment. The river provides exceptionally good quality habitat for brook lamprey and supports a healthy population.

1099 River lamprey ***Lampetra fluviatilis***

The Wye is an extensive river system crossing the border between England and Wales, and the river lamprey *Lampetra fluviatilis* population is widely distributed in the catchment. The Wye provides exceptionally good quality habitat for river lamprey and supports a healthy population.

1103 Twaite shad ***Alosa fallax***

Twaite shad *Alosa fallax* have long been abundant in the Wye, an extensive river system spanning the border between England and Wales. Twaite shad often spawn at or just above the tidal limit, but in the Wye they migrate over 100 km upstream, the highest spawning site being at Builth Wells. Data held by the Environment Agency indicate that, of the three selected rivers, the largest spawning areas for this species occur on the Wye. The river has relatively good water quality, adequate flows through an unobstructed main channel and a wide range of aquatic habitats conducive to supporting this fish species. In particular, there are a number of deep pools essential for congregation before spawning.

1106 Atlantic salmon ***Salmo salar***

Historically, the Wye is the most famous and productive river in Wales for Atlantic salmon *Salmo salar*, with high quality spawning grounds and juvenile habitat in both the main channel and tributaries; water quality in the system is generally favourable. It is also one of the most diverse river systems in the UK with a transition from hard geology, high gradients, rapid flow fluctuations and low nutrient content in its upper reaches, to a more nutrient-rich river with lower gradient, more stable flow and softer geology in the lowlands. The effect of river engineering work on migration and spawning has been limited, although there is a localised influence from the Elan Valley reservoirs, through inundation of spawning and nursery habitat and fluctuations in flow and water levels in the upper Wye. The most important tributaries for spawning are included in the SAC. Although in the past non-native salmon may have been released into the system, the impact of this is likely to have been minimal. The Wye salmon population is particularly notable for the very high proportion (around 75 per cent) of multi sea winter (MSW) fish, a stock component which has declined sharply in recent years throughout the UK. This pattern has also occurred in the Wye, with a consequent marked decline in the population since the 1980s. However, the Wye salmon population is still of considerable importance in UK terms.

1163 Bullhead ***Cottus gobio***

The Wye represents bullhead *Cottus gobio* in an extensive river system crossing the border between England and Wales. The Wye is one of the most diverse river systems in the UK, with a range of nutrient conditions and aquatic habitats and generally good water quality for fish species. The diversity of habitat types in the Wye means that it is likely to represent most of the habitat conditions in which bullhead occurs in Britain, highlighting the conservation importance of this river.

1355 Otter ***Lutra lutra***

The Wye holds the densest and most well-established otter *Lutra lutra* population in Wales, representative of otters occurring in lowland freshwater habitats in the borders of Wales. The river has bankside vegetation cover, abundant food supply, clean water and undisturbed areas of dense scrub suitable for breeding, making it particularly favourable as otter habitat. The population remained even during the lowest point of the UK decline, confirming that the site is particularly favourable for this species and the population likely to be highly stable.

Annex II species present as a qualifying feature, but not a primary reason for site selection

1102 Allis shad ***Alosa alosa***

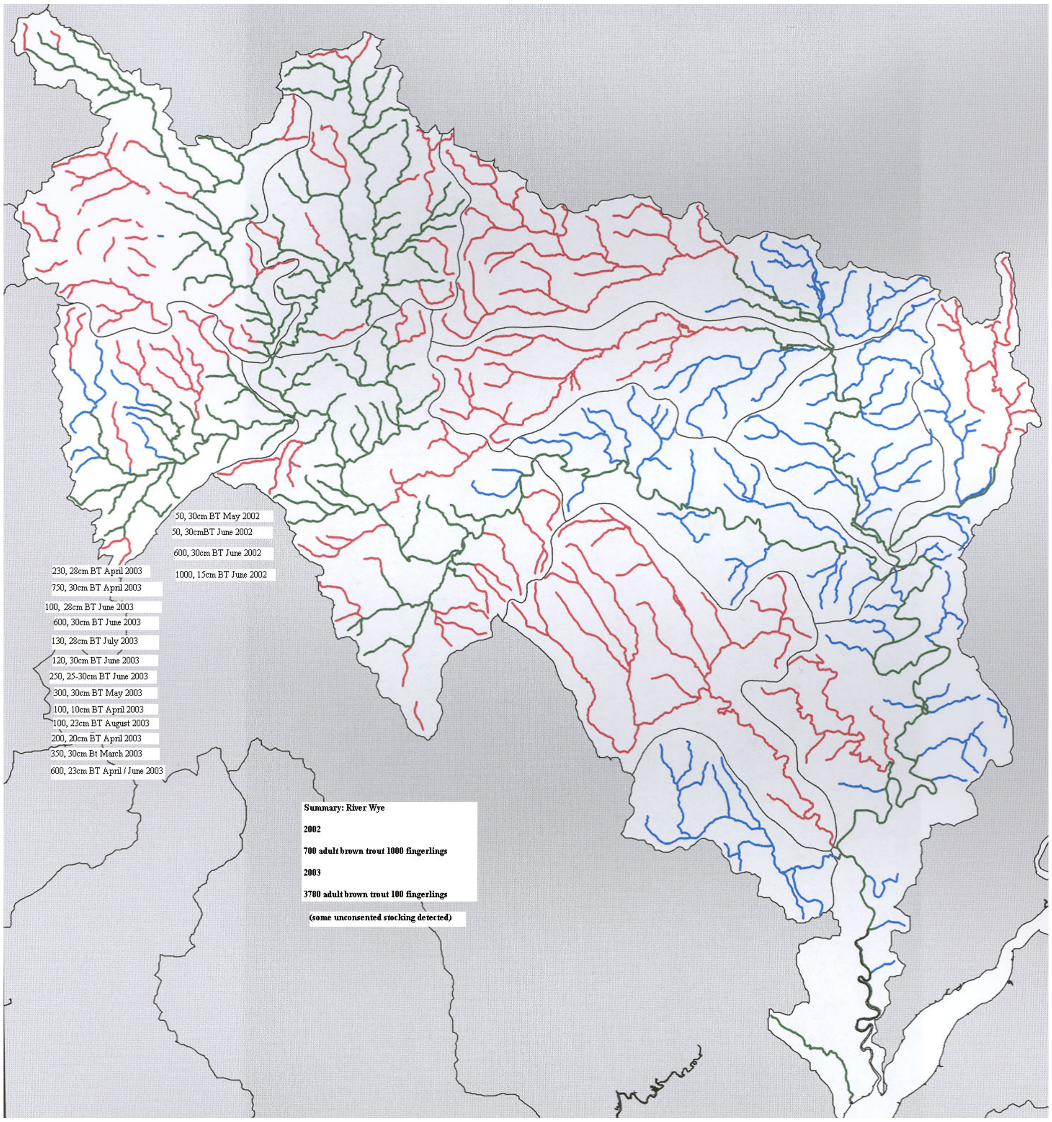
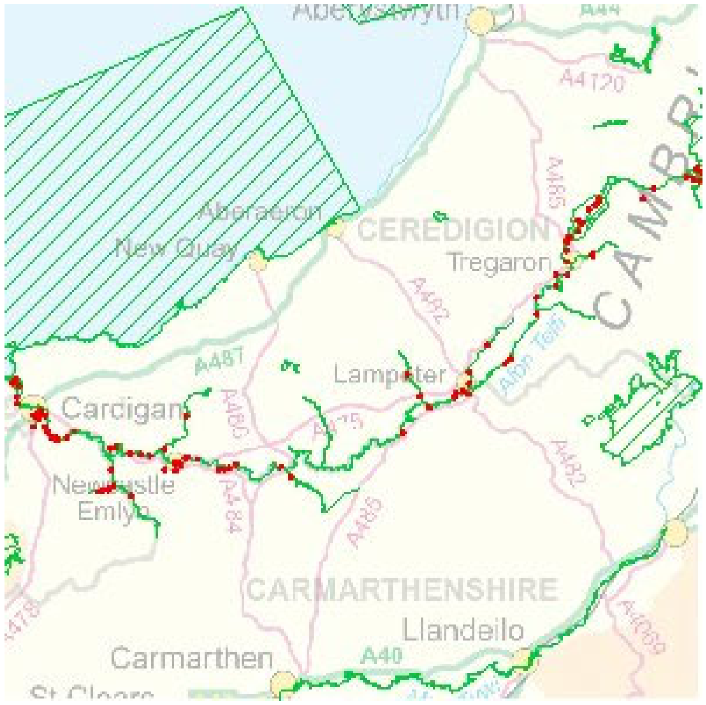


Figure 3.8: S30-consented stocking information for Wye system 2002 and 2003
Modified from R&D Technical Report W2-062/TR

3.3.4 River Teifi



(From National Biodiversity Network (NBN) website)

Figure 3.9: River Teifi cSAC

From JNCC website: site designation criteria

Annex I habitats that are a primary reason for selection of this site

3260 Water courses of plain to montane levels with the *Ranunculion fluitantis* and *Callitricho-Batrachion* vegetation

The Teifi in \west Wales is a large river flowing over hard rock, with some spectacular gorges in the lower section. It is mainly mesotrophic but also has oligotrophic sections in the upper reaches, and represents an outstanding example of a sub-type 3 river with water-crowfoot *Ranunculus* vegetation in western Britain. The river has a spatey flow regime, and in-stream vegetation is dominated by stream water-crowfoot *Ranunculus penicillatus* ssp. *penicillatus*, water-starworts *Callitriche hamulata* and *C. obtusangula* and the aquatic moss *Fontinalis squamosa* in a diverse macrophyte community characteristic of oligo-mesotrophic base-poor rocks. A small amount of *R. penicillatus* ssp. *pseudofluitans* is present where one tributary flows over base-rich rocks. The river is also noteworthy for an unusually low gradient section flowing through Cors Caron, a large area of 7110 Active raised bog that is an SAC in its own right.

Annex I habitats present as a qualifying feature, but not a primary reason for selection of this site

3130 Oligotrophic to mesotrophic standing waters with vegetation of the *Littorelletea uniflorae* and/or of the *Isoëto-Nanojuncetea*

Annex II species that are a primary reason for selection of this site

1096 Brook lamprey ***Lampetra planeri***

The Teifi is a predominantly mesotrophic river in West Wales supporting a large population of brook lamprey *Lampetra planeri*. A mixture of habitat and substrate types provides the combination of spawning gravels adjacent to silt beds that are favoured by this and other lamprey species. A large number of tributaries have been included in the SAC; these are thought to be important for lampreys in the Teifi because the main channel is prone to severe floods that may result in washout of smaller ammocoetes.

1099 River lamprey ***Lampetra fluviatilis***

The Teifi is a large catchment of high conservation value in West Wales. It contains a healthy population of river lamprey *Lampetra fluviatilis*. The semi-natural channel containing a mixture of substrates and in-stream features provides excellent habitat for juvenile lampreys.

1106 Atlantic salmon ***Salmo salar***

The Teifi is a medium-sized mesotrophic river system in West Wales. In 1999 the salmon *Salmo salar* rod catch in the Teifi was the third largest in Wales, and the system has not experienced the steep decline in stock numbers seen in many other rivers in the area. This is likely to reflect the high quality of the catchment, with a semi-natural channel largely unaffected by poor water quality or artificial barriers to migration. However, in common with many other Welsh rivers, acidification in the upper reaches is a cause for concern. In common with many other rivers in West Wales, grilse are the main stock component. There is a small traditional coracle fishery that exploits the salmon and sea trout *Salmo trutta trutta*.

1163 Bullhead ***Cottus gobio***

The Teifi represents bullhead *Cottus gobio* in West Wales. Water quality is generally good, and the diversity of semi-natural habitat and predominance of stony substrates provides excellent bullhead habitat throughout much of the catchment. Environment Agency electro-fishing data shows this species to be widespread throughout the system. Bullheads show marked differences in growth and longevity between upland and lowland streams, and the Teifi includes sections representing both types of habitat.

1355 Otter ***Lutra lutra***

The Teifi in West Wales holds otter *Lutra lutra* throughout much of its catchment. The river has suitable resting and breeding sites along its length. Evidence from surveys and sightings suggest the tidal reach is being increasingly used by otters.

1831 Floating water-plantain ***Luronium natans***

The Teifi is a mixed habitat supporting floating water-plantain *Luronium natans* at the western margins of its range in the UK. This species has been recorded in the nutrient-poor standing waters of the Teifi pools in the headwaters of the river. It has also been recorded in a moderately nutrient-rich stretch of the river immediately downstream of Cors Caron.

Annex II species present as a qualifying feature, but not a primary reason for site selection

1095 Sea lamprey ***Petromyzon marinus***

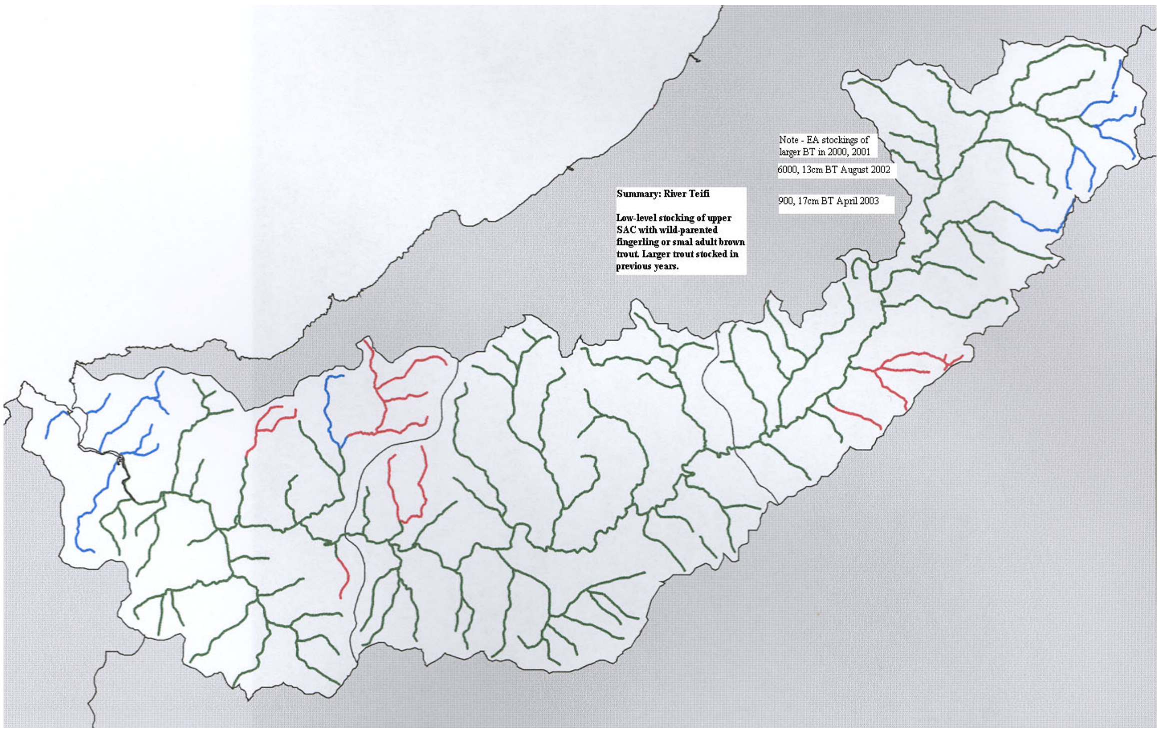
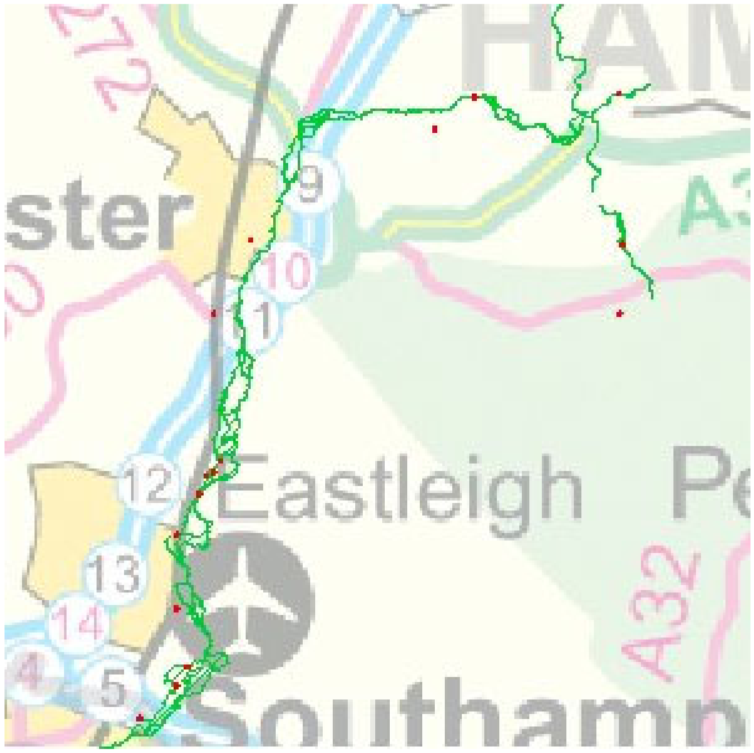


Figure 3.10: S30-consented stocking information for Teifi system 2002 and 2003

Modified from R&D Technical Report W2-062/TR.

Note that salmon are present throughout the catchment but are scarce in smaller (less than four metre) streams (Dave Mee, personal communication).

3.3.5 River Itchen



(From National Biodiversity Network (NBN) website)

Figure 3.11: River Itchen cSAC

From JNCC website: site designation criteria

Annex I habitats that are a primary reason for selection of this site

3260 <u>Water courses of plain to montane levels with the *Ranunculion fluitantis* and *Callitricho-Batrachion* vegetation</u>

The Itchen is a classic example of a sub-type 1 chalk river. The river is dominated throughout by aquatic *Ranunculus* spp. The headwaters contain pond water-crowfoot *Ranunculus peltatus*, while two *Ranunculus* species occur further downstream: stream water-crowfoot *R. penicillatus* ssp. *pseudofluitans*, a species especially characteristic of calcium-rich rivers, and river water-crowfoot *R. fluitans*.

Annex I habitats present as a qualifying feature, but not a primary reason for selection of this site

Not applicable.

Annex II species that are a primary reason for selection of this site

1044 Southern damselfly ***Coenagrion mercuriale***

Strong populations of southern damselfly *Coenagrion mercuriale* occur here, estimated to be in the hundreds of individuals. The site in central southern England represents one of the major population centres in the UK. It also represents a population in a managed chalk-river flood plain, an unusual habitat for this species in the UK, rather than on heathland.

1163 Bullhead ***Cottus gobio***

The Itchen is a classic chalk river that supports high densities of bullhead *Cottus gobio* throughout much of its length. The river provides good water quality, extensive beds of submerged plants that act as a refuge for the species, and coarse sediments that are vital for spawning and juvenile development.

Annex II species present as a qualifying feature, but not a primary reason for site selection

1092 White-clawed (or Atlantic stream) crayfish ***Austropotamobius pallipes***

1096 Brook lamprey ***Lampetra planeri***

1106 Atlantic salmon ***Salmo salar***

1355 Otter ***Lutra lutra***

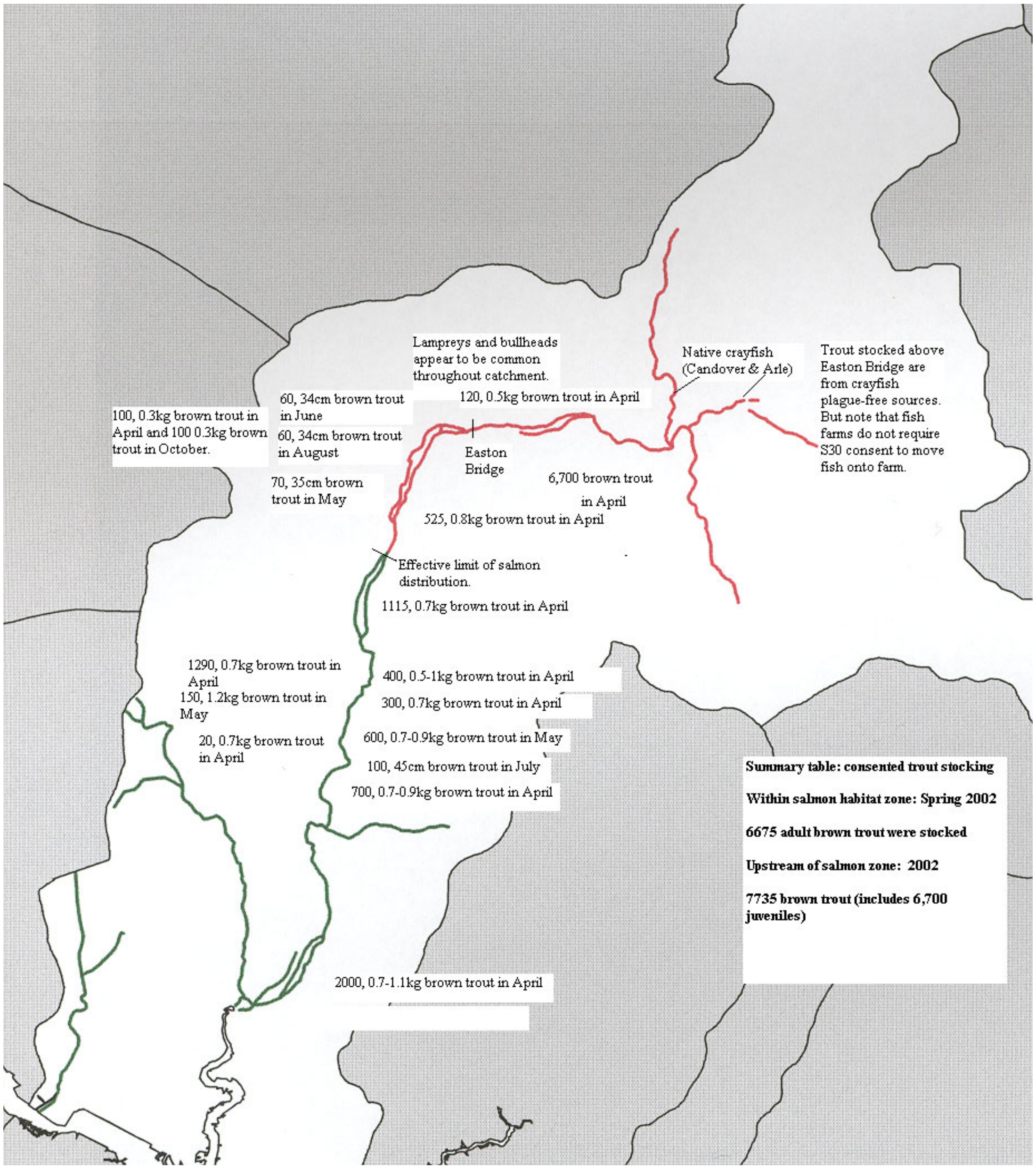


Figure 3.12: S30-consented stocking information for Itchen system 2002
Modified from R&D Technical Report W2-062/TR

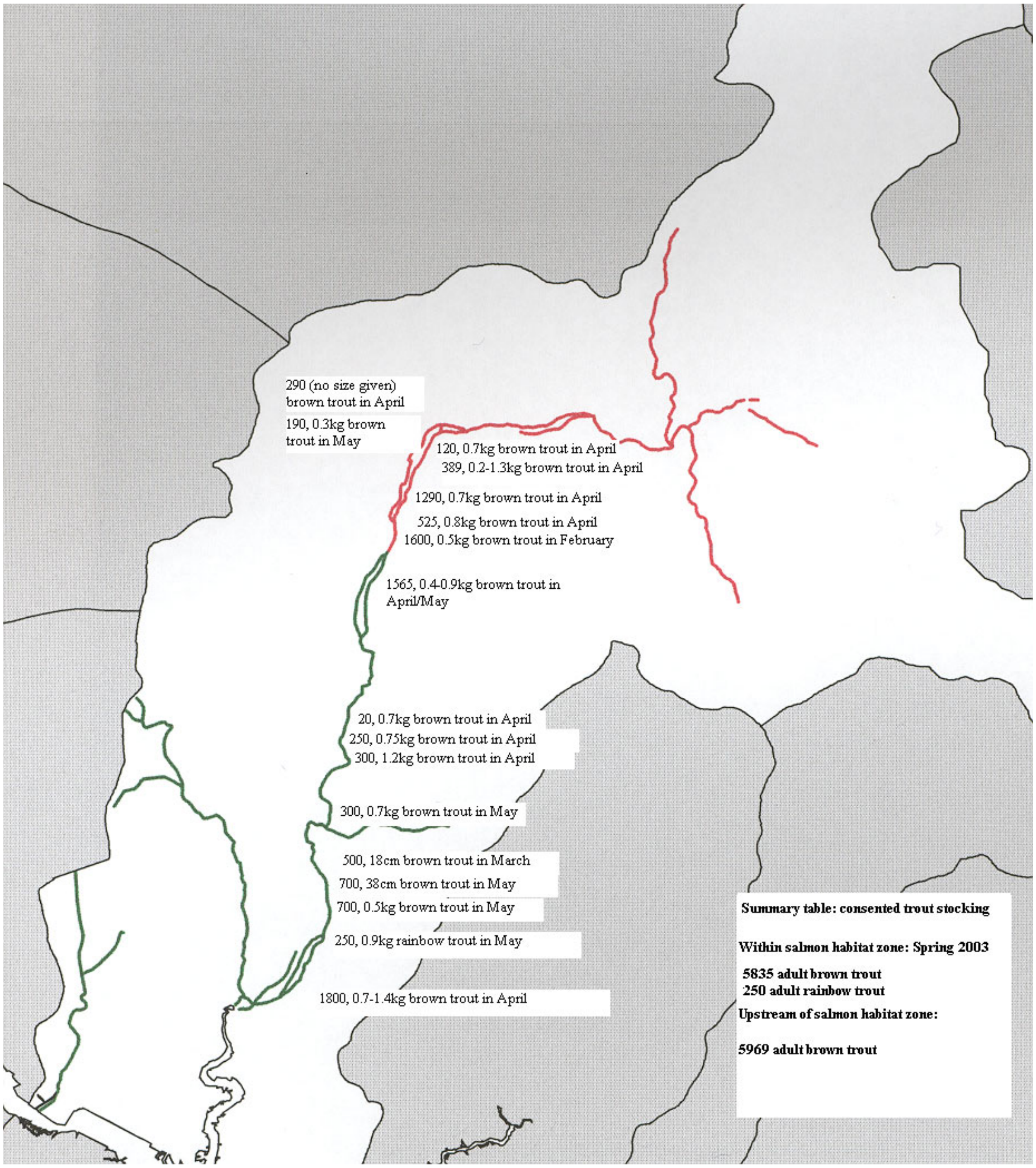
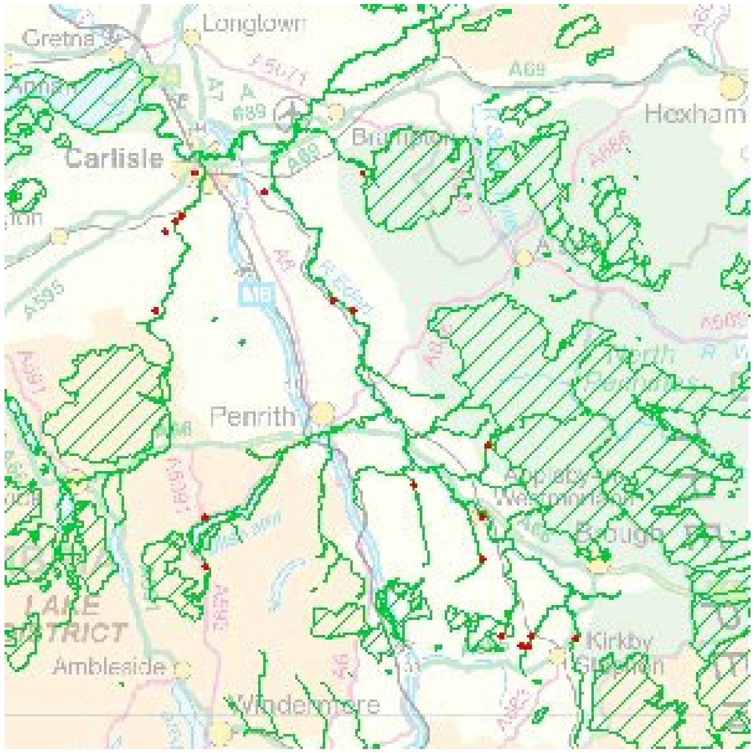


Figure 3.13: S30-consented stocking information for Itchen system 2003
Modified from R&D Technical Report W2-062/TR

3.3.6 River Eden



(From National Biodiversity Network (NBN) website)

Figure 3.14: River Eden cSAC

From JNCC website: site designation criteria

Annex I habitats that are a primary reason for selection of this site

3130 <u>Oligotrophic to mesotrophic standing waters with vegetation of the *Littorelletea uniflorae* and/or of the *Isoëto-Nanojuncetea*</u>

Ullswater, in the catchment of the River Eden, is the second-largest of the Cumbrian lakes. It is chosen as an example of a relatively deep lake with both oligotrophic and mesotrophic elements in its fauna and flora. The southwestern part of the lake is surrounded by high fells of the Borrowdale Volcanics with enclosed farmland confined to the valley bottoms. The northeastern arm is in gentler terrain with deeper soils and a greater extent of enclosed farmland. The lake flows into the River Eamont, one of the major tributaries of the River Eden. The lake has an extremely rich aquatic flora, including eight species of *Potamogeton*. These include various-leaved pondweed *P. gramineus*, red pondweed *P. alpinus* and long-stalked pondweed *P. praelongus*. The nationally scarce six-stamened waterwort *Elatine hexandra* is also found in some of the bays. Ullswater supports one of the few populations of powan *Coregonus lavaretus* in the UK. Arctic charr *Salvelinus alpinus* was formerly present but is believed to have become extinct in the 1940s, possibly because of mining pollution in spawning areas.

3260 Water courses of plain to montane levels with the *Ranunculion fluitantis* and *Callitricho-Batrachion* vegetation

The Eden is a northwestern representative of sub-type 2. The river flows over both calcareous limestone and sandstone, giving a diversity of ecological conditions, ranging from oligotrophic to mesotrophic. This river has 184 recorded plant species, more than any other river in the UK. The *Ranunculus* species of the river system include stream water-crowfoot *Ranunculus penicillatus* ssp. *penicillatus* occurring here at the edge of its range, and others, such as *R. penicillatus* ssp. *pseudofluitans* and river water-crowfoot *R. fluitans*.

91E0 Alluvial forests with *Alnus glutinosa* and *Fraxinus excelsior* (*Alno-Padion*, *Alnion incanae*, *Salicion albae*)

Throughout the length of the River Eden stands of alder *Alnus glutinosa* and willow *Salix* spp. occur associated with backwaters and seasonally-flooded channels. The least disturbed stands are on the tributary River Irthing, where they occur on the shingle and gravels of actively moving channels. The ground flora includes patches of common nettle *Urtica dioica*, butterbur *Petasites hybridus* and hogweed *Heracleum sphondylium* that grade into hollows with greater tussock-sedge *Carex paniculata*.

Annex I habitats present as a qualifying feature, but not a primary reason for selection of this site

Not applicable.

Annex II species that are a primary reason for selection of this site

1092 White-clawed (or Atlantic stream) crayfish ***Austropotamobius pallipes***

The Eden is a river with high water quality that supports a large population of white-clawed crayfish *Austropotamobius pallipes* in the northern part of its range in England. As with the River Wye, the tributaries of the Eden, especially those flowing off limestone, are of particular importance.

1095 Sea lamprey ***Petromyzon marinus***

The Eden represents a sea lamprey *Petromyzon marinus* population associated with an extensive river system on a varied and base-rich geology in northern England. The highly erodible nature of the rock results in extensive areas of gravel and finer silts being deposited throughout the system, providing conditions for spawning and nursery areas. A large and healthy population of sea lamprey is supported in the middle to lower regions of the river.

1096 Brook lamprey ***Lampetra planeri***

The Eden is an example of a brook lamprey *Lampetra planeri* population associated with an extensive river system on a varied and base-rich geology in northern England. The highly erodible nature of the rock results in extensive areas of gravel and finer silt being deposited throughout the system, providing conditions for spawning and nursery areas. Brook lamprey is supported widely within the catchment.

1099 River lamprey ***Lampetra fluviatilis***

The Eden is an example of a river lamprey *Lampetra fluviatilis* population associated with an extensive river system on a very varied and base-rich geology in northern England. The highly erodible nature of the rock results in extensive areas of gravel and finer silt being deposited throughout the system, providing conditions for spawning and nursery areas. The high quality of these habitats and their accessibility, even in the upper reaches, means that a large, healthy population of river lampreys occurs widely within the catchment.

1106 Atlantic salmon ***Salmo salar***

The Eden represents one of the largest populations of Atlantic salmon *Salmo salar* in northern England. It is an excellent example of a large river system that flows over varied, base-rich geology. This, coupled with its large range in altitude, results in the development of distinct habitat types, supporting diverse plant and invertebrate communities. The high ecological value of the river system and the fact that the salmon are able to use most of the catchment (even above Ullswater, a large natural lake on the main river), mean that the Eden is able to maintain a large population of salmon.

1163 Bullhead ***Cottus gobio***

The Eden represents bullhead *Cottus gobio* in a high quality, relatively unmodified river in the northern part of its range in England. The presence of extensive areas of gravel and generally good quality water provides good habitat for bullheads, which are widely distributed throughout the system. The tributaries, in particular those flowing over limestone, hold abundant numbers of bullhead.

1355 Otter ***Lutra lutra***

The River Eden provides an example of lowland otter *Lutra lutra* habitats in North West England and complements the selection of the River Derwent and Bassenthwaite Lake.

Annex II species present as a qualifying feature, but not a primary reason for site selection

Not applicable.

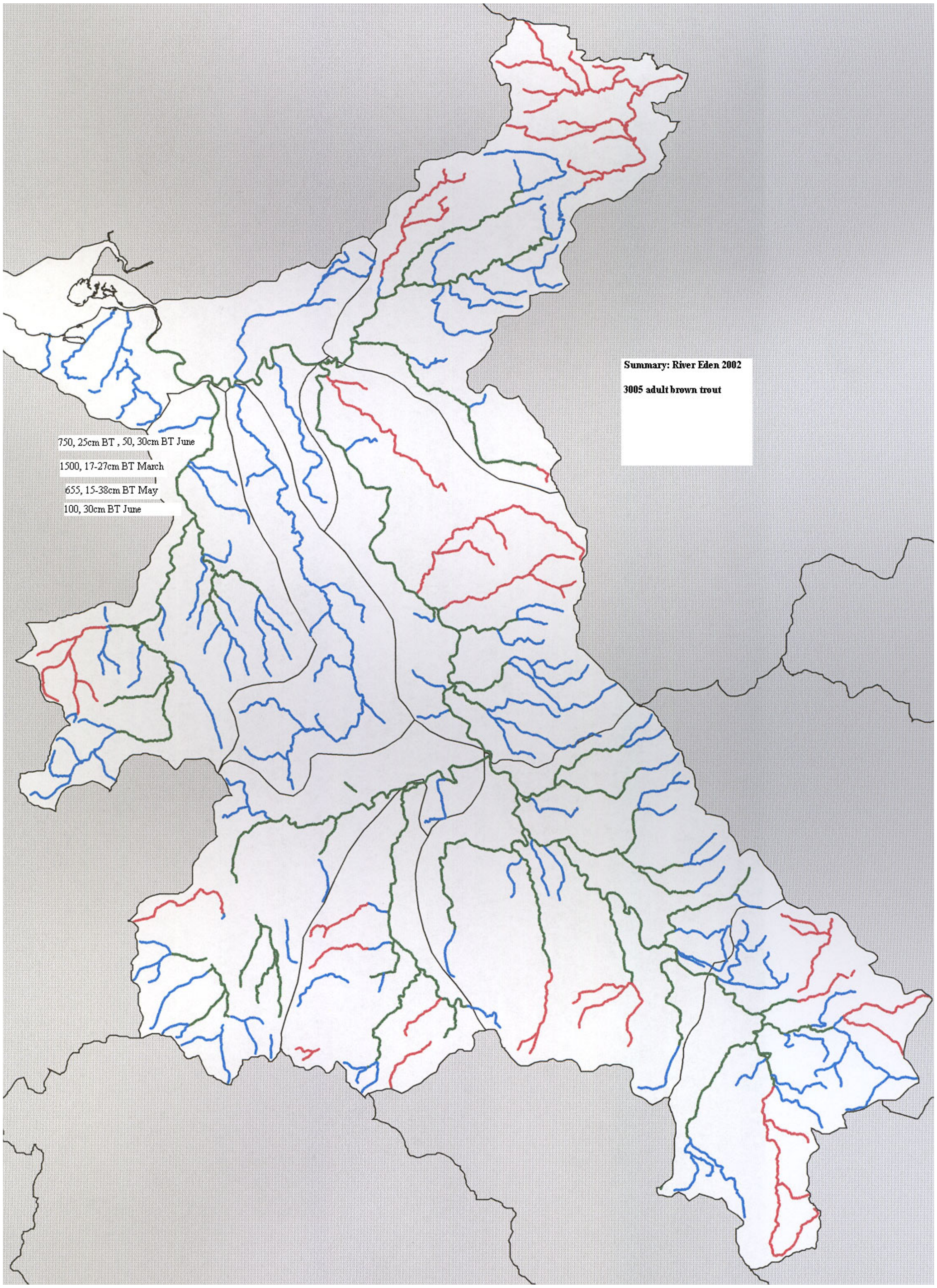


Figure 3.15: S30-consented stocking information for Eden system 2002
Modified from R&D Technical Report W2-062/TR

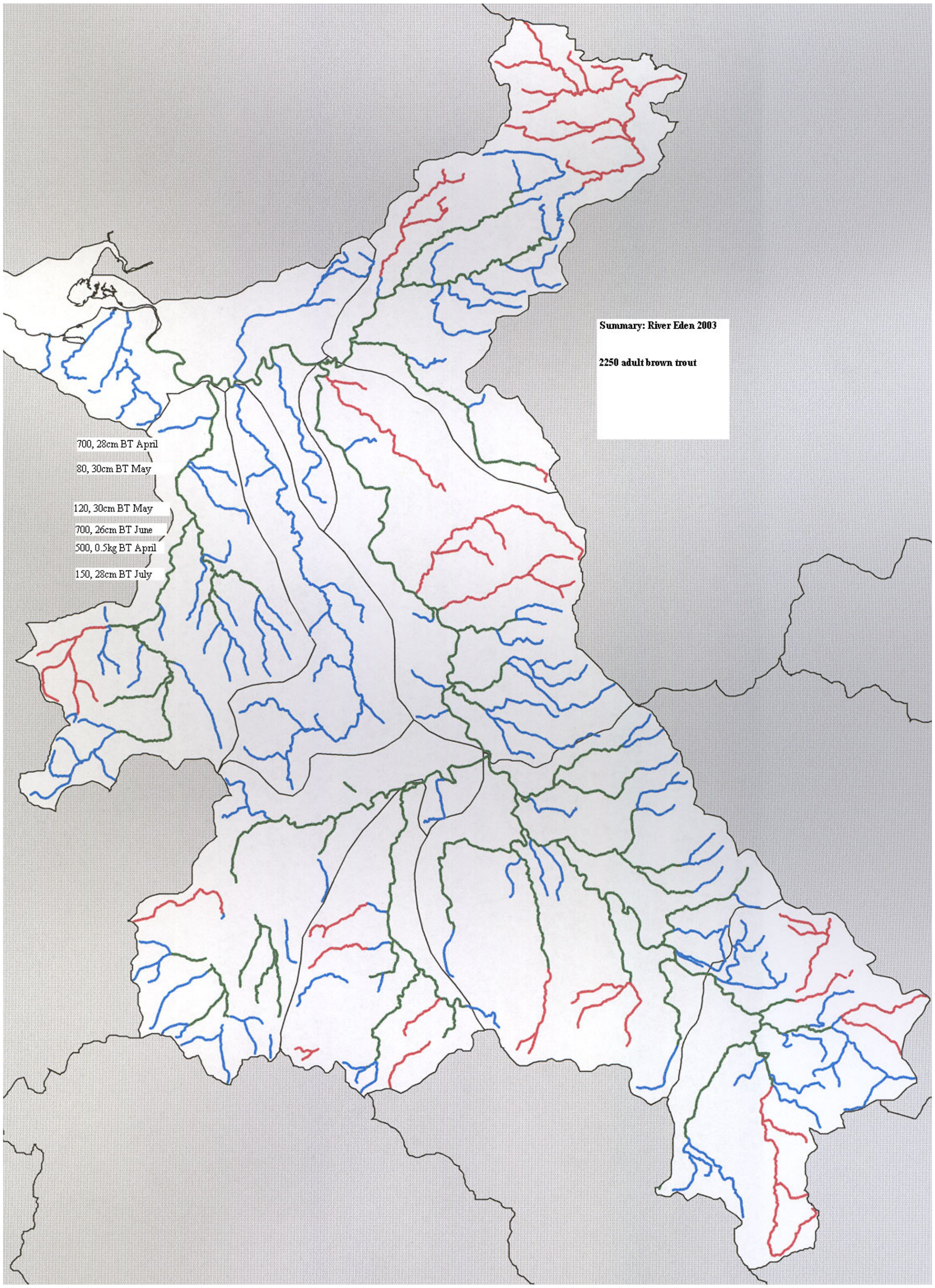
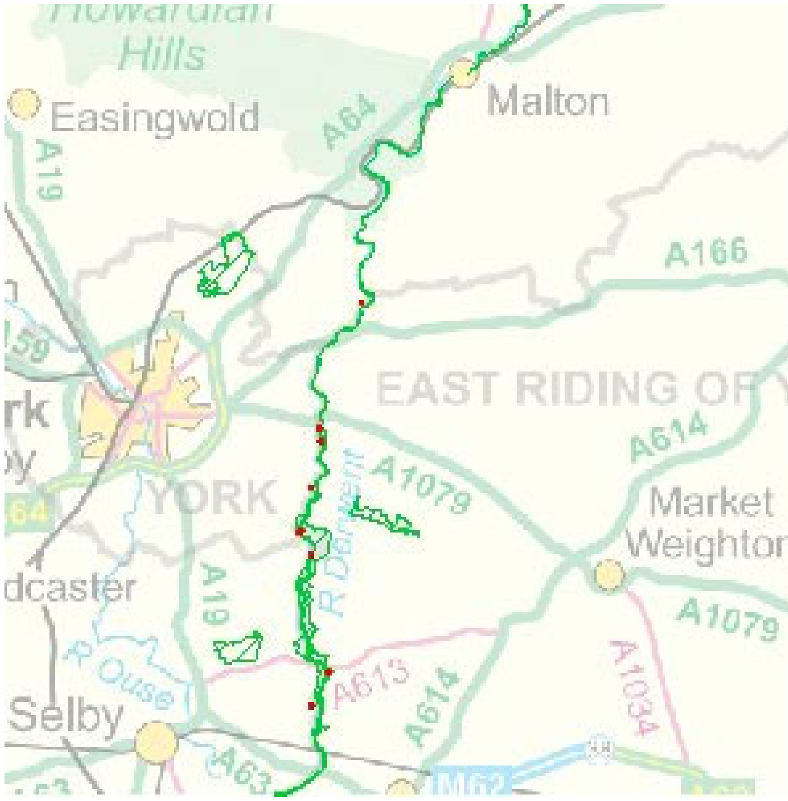


Figure 3.16: S30-consented stocking information for Eden system 2003
Modified from R&D Technical Report W2-062/TR

3.3.7 River Derwent



(From National Biodiversity Network (NBN) website)

Figure 3.17: River Derwent cSAC

From JNCC website: site designation criteria

Annex I habitats that are a primary reason for selection of this site

Not applicable

Annex I habitats present as a qualifying feature, but not a primary reason for selection of this site

3260 Water courses of plain to montane levels with the *Ranunculion fluitantis* and *Callitricho-Batrachion* vegetation

Annex II species that are a primary reason for selection of this site

1099 River lamprey ***Lampetra fluviatilis***

The Derwent is one example of river lamprey *Lampetra fluviatilis* populations which inhabit the many rivers flowing into the Humber estuary in eastern England. Only the lower reaches of the Derwent are designated, reflecting the spawning distribution of the species.

Annex II species present as a qualifying feature, but not a primary reason for site selection

1095 Sea lamprey ***Petromyzon marinus***

1163 Bullhead ***Cottus gobio***

1355 Otter ***Lutra lutra***

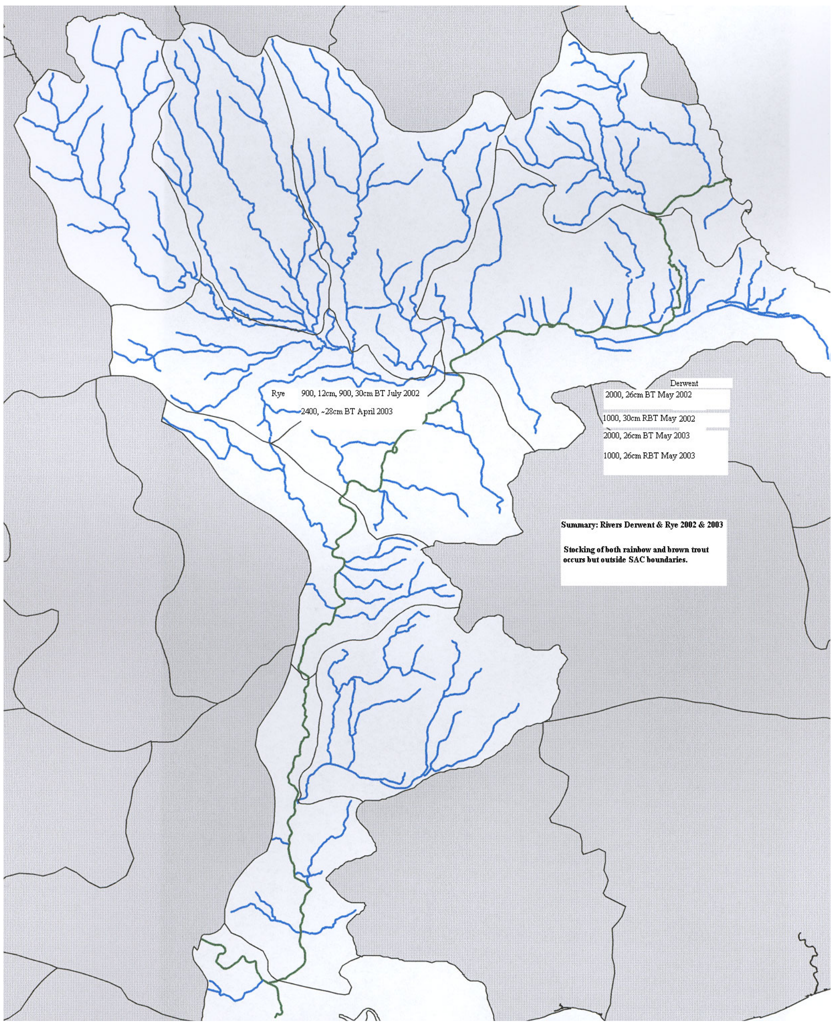
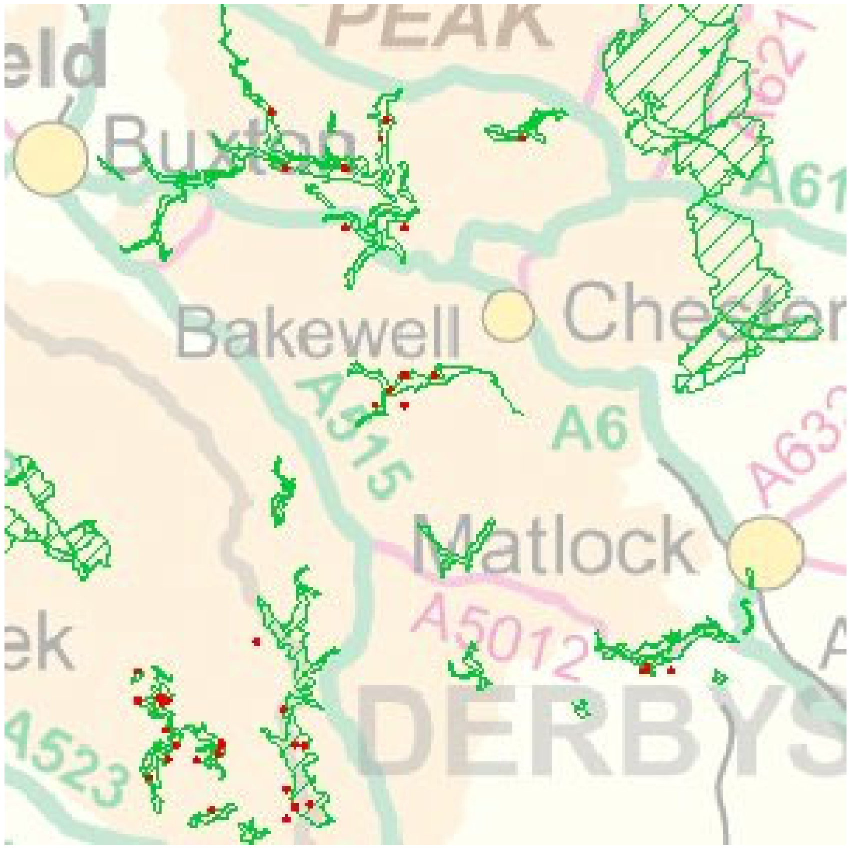


Figure 3.18: S30-consented stocking information for River Derwent system 2003
Modified from R&D Technical Report W2-062/TR

Note that occasional salmon are reported from lower Derwent, and sea trout scarce except in the northeastern corner of the catchment (David Hopkins, personal communication).

3.3.8 Rivers Dove and Lathkill



(From National Biodiversity Network (NBN) website)

Figure 3.19: Rivers Dove and Lathkill cSAC

From JNCC website: site designation criteria

Annex I habitats that are a primary reason for selection of this site

6210 Semi-natural dry grasslands and scrubland facies: on calcareous substrates (*Festuco-Brometalia*)

Peak District Dales is one of the most extensive surviving areas in England of CG2 *Festuca ovina* – *Avenula pratensis* grassland. Grasslands at this site range from hard-grazed short turf through to tall herb-rich vegetation, with transitions through to calcareous scrub and 9180 *Tilio-Acerion* forests – a diversity of structural types unparalleled in the UK. There is also a great physical diversity due to rock outcrops, cliffs, screes and a variety of slope gradients and aspects. In contrast to examples of *Festuca* – *Avenula* grassland on chalk to the south, these grasslands are less at risk from the threat of invasion by upright brome *Bromopsis erecta* and tor-grass *Brachypodium pinnatum*, which are at the edge of their range here and have limited vigour. The relatively cold oceanic nature of the climate means that there is enrichment with northern floristic elements, such as limestone bedstraw *Galium sterneri* and globeflower *Trollius europaeus*.

9180 *Tilio-Acerion* forests of slopes, screes and ravines

Representing the north central part of its UK range, this site in the English Midlands contains a large area of *Tilio-Acerion*, dominated by ash *Fraxinus excelsior*. Locally, sycamore *Acer pseudoplatanus* is abundant. The Dales provide good examples of woodland-scrub-grassland transitions, with associated rich invertebrate populations and plant communities. Among the uncommon plants present in the woods are mezereon *Daphne mezereum* and green hellebore *Helleborus viridis*, as well as whitebeams *Sorbus* spp. on the crags.

Annex I habitats present as a qualifying feature, but not a primary reason for selection of this site

4030 European dry heaths

6130 Calaminarian grasslands of the *Violetalia calaminariae*

7230 Alkaline fens

8120 Calcareous and calcshist screes of the montane to alpine levels (*Thlaspietea rotundifolii*)

8210 Calcareous rocky slopes with chasmophytic vegetation

Annex II species that are a primary reason for selection of this site

1092 White-clawed (or Atlantic stream) crayfish ***Austropotamobius pallipes***

The River Dove represents **white-clawed crayfish *Austropotamobius pallipes*** in a high-quality, upland limestone river, in the north-east of the species' UK range.

Annex II species present as a qualifying feature, but not a primary reason for site selection

1096 Brook lamprey ***Lampetra planeri***

1163 Bullhead ***Cottus gobio***

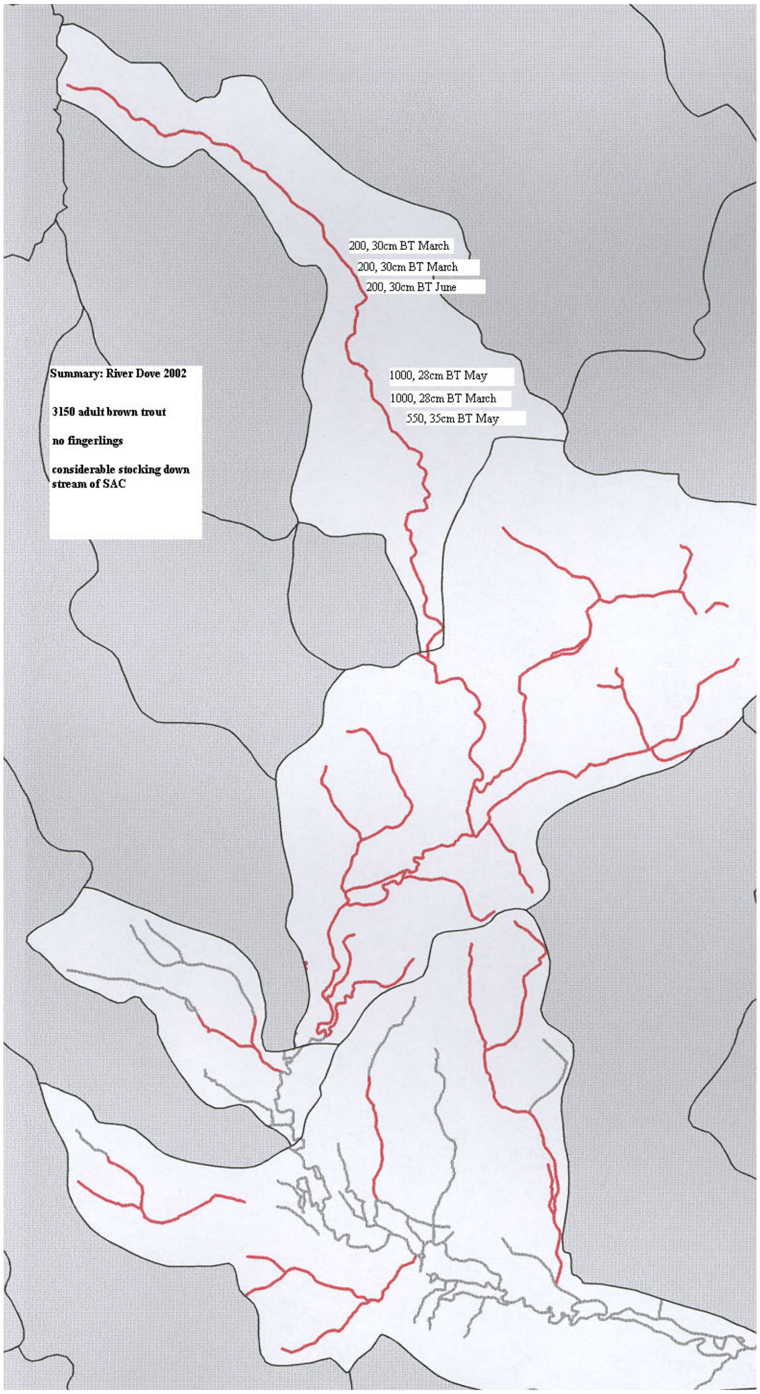


Figure 3.20: S30-consented stocking information for Dove system 2002
Modified from R&D Technical Report W2-062/TR

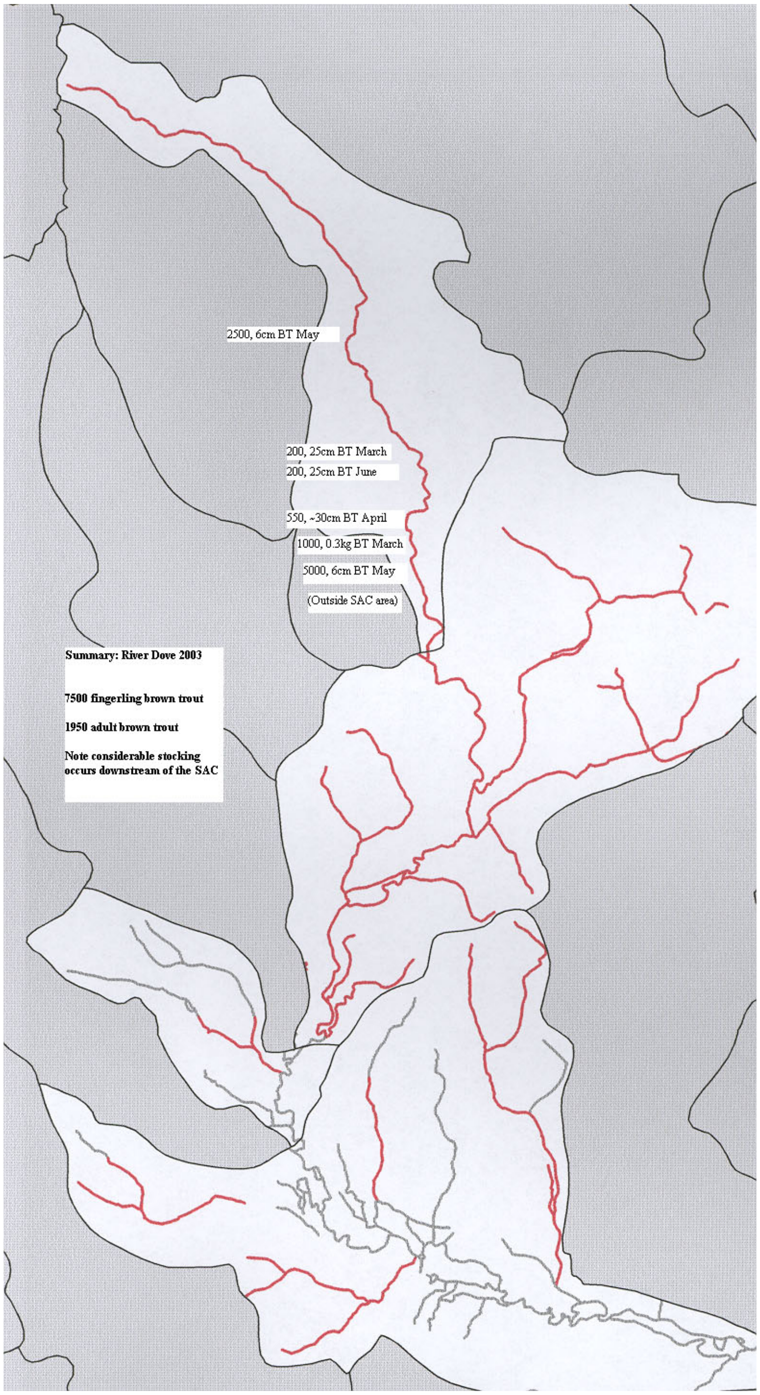


Figure 3.21: S30-consented stocking information for Dove system 2003
Modified from R&D Technical Report W2-062/TR

River Lathkill cSAC

Neither the Environment Agency LFMD search nor the questionnaire survey (to two estates) yielded information on stocking of trout in the River Lathkill.

4 Residence time of stocked trout

4.1 Trout stocking and residence in fisheries

Barnard (1997) carried out a review of riverine Salmon and Freshwater Fisheries Act Section 30 consents to stock trout issued over the three year period 1991–1993 in all National Rivers Authority regions, together with records of trout stocking by the NRA itself in the North West and Thames regions. Key findings were:

- stocking with trout by angling clubs and fishery owners was more important than stocking by the NRA;
- brown trout were usually stocked in higher numbers than rainbow trout, and some NRA regions (such as the North West region) had a policy of not consenting to stocking of rainbow trout in rivers (see Environment Agency National Trout and Grayling strategy (2004) for details of policy at the time of writing this report);
- brown trout were usually stocked in the 7 to 10 cm and the 25 to 30 cm size ranges, with some at lengths of up to 38 cm;
- rainbow trout were usually stocked at larger than 24 cm, generally at 28 to 30 cm, with some larger fish up to 38 cm;
- larger trout were usually stocked during the period February to August, peaking in March and April, while trout smaller than 12 cm were usually introduced during late spring/early summer or in late autumn;
- trout stocked by the NRA were mainly small, of less than 18 cm in length, presumably introduced for fishery enhancement purposes, while angling clubs and fishery owners generally stocked with larger 'takeable' trout;
- numbers of trout stocked in each NRA region varied widely over the three year study period, and no trends emerged.

Welton *et al.* (1997) reviewed available information from Section 30 consents for 1994 and 1995 on the impact of stocked rainbow trout on resident salmonid populations and added further information on introductions of rainbow trout into rivers in England and Wales. The key findings paralleled those of Barnard (1997) for the 1991 to 1993 period.

A study of trout genetics on the River Dove identified a mitochondrial DNA marker gene which could be used to distinguish wild and stocked fish. Interbreeding between wild and stocked brown trout was commonplace, with around 35 per cent introgression of stocked trout genes into the wild population (Dr Roy Sedgewick, personal communication and cited in Williams, 2002), indicating substantial brown trout survival into the winter. Such introgression of relatively inbred hatchery genes is thought to be damaging to the vitality and viability of wild Atlantic salmon stocks in Ireland and, very probably, to wild brown trout stocks (McGinnity *et al.,* 2003). McClean *et al.* (2003) report similar results for the fitness of hatchery versus wild steelhead (migratory rainbow) trout in Washington, USA. Alvarez and Nicieza (2003) found that wild brown trout have better developed anti-predator behaviour than either hatchery bred or hatchery reared, wild-parented brown trout. Einum and Fleming (2001) provide a useful review of the implications of stocking salmonids into wild populations. This topic falls outside the current project, but is important with respect to the management of stocking domesticated brown trout into habitats supporting wild trout stocks in the British Isles (Environment Agency, 2004).

4.2 Persistence of stocked trout

There is a good deal of support within the published literature for the view that stocked trout disappear from a typical fishery relatively rapidly. These fish may die of natural causes, be caught by anglers or may migrate either upstream or downstream.

Barnard *et al.* (1997, Figures 3.13 and 3.14) estimated from their periodic electric-fishing surveys on both the River Coln (Cotswolds) and River Ewenny (South Wales) soon after stocking, that more than 90 per cent of stocked brown trout were no longer present after about one month. This residence time is supported by the studies of Cresswell (1981) and Skurdal *et al.* (1989) and may prove to be typical for a range of habitats.

Cresswell (1981) reviewed the literature on post-stocking movements and recapture of hatchery-reared trout released into flowing waters, finding that:

- all recapture data are estimates which rely for their accuracy on the design of individual experiments;
- the percentage recapture of takeable trout stocked as small individuals (less than 20 cm parr or sub-adults) tends to be low and so the effective cost of such fish tends to be high compared with usual returns derived from stocking takeable-sized fish;
- percentage recapture of brook, brown and rainbow trout stocked either in spring or summer tends to be around one third, whilst autumn-stocked trout (which must over-winter before being fished for) has a markedly lower recapture ratio, averaging around 10 per cent;
- usually, a high proportion of stocked trout is recaptured relatively close to the release site;
- where trout move, they usually (but by no means exclusively) move downstream. Brook and rainbow trout seem more inclined to move than brown trout, which appear to be more sedentary.

Cresswell and Williams (1982) describe the results of field work carried out on the River Taf, South Wales, where:

- higher percentages (31-65%) of stocked takeable brown trout were recaptured following ‘spot-planting’ compared with ‘scatter-planting’ (16%);
- stockings carried out one week before the start of the season yielded a 17% return, whilst those made three weeks earlier yielded only 2% of fish to the rods;
- the majority of trout stocked were caught in the area of stocking, irrespective of the method or timing of release.

Skurdal *et al.* (1989) followed the fate of stocked 27-67 cm brown trout (at a relatively low stock density) in the rivers Lagen and Otta, southern Norway, finding that:

- May releases returned lower recaptures (23%) than those in June/July (41-58%);
- within 15 days of release 50% were recaptured, and 90% within 67 days;
- around 95% of recaptures were from within one km of the release site;
- over the course of six experiments, between 19% and 55% of takeable brown trout was recaptured by anglers;
- the over-winter survival of stocked trout was low (0.02-0.14%).

Weiss and Schmutz (1999a) studied the population responses of resident brown and rainbow trout in a small Austrian limestone stream to stocked brown trout. At each stocking site, the overall resident trout stock (greater than 20 cm) density was doubled through the addition of a similar number of stocked trout. Trout greater than 20 cm were visible implant (VI) tagged and stretches were electric-fished to establish the following results:

- After one month, stocked brown trout had 86% survival compared with 89% for resident trout of both species. This relatively high short-term survival of stocked trout was thought by the authors to be real and revealed by careful double tagging and sampling effort (the implication being that stocked trout in other studies may often survive longer than results commonly indicate).
- Survival of stocked trout declined to 14% after eight months, compared with 52% for resident trout.
- About 49% of recaptured hatchery trout moved away (usually downstream) of the stocking point. About 11% of recaptured wild trout also moved, where those in stocked areas moved more than those in unstocked areas. Trout which moved tended to be large individuals.
- Over-winter survival of stocked trout was low.

Weiss and Schmutz (1999b) carried out further experiments with stocked adult hatchery brown trout on two stream types - hard water (limestone) and soft water (granite) - in Austria, either doubling or trebling existing wild trout population densities. Wild trout were VI tagged and micro-tagged, while stocked trout were VI tagged and pan-jetted (controlling for any VI tag loss). The streams were unfished and had not been stocked for at least ten years. The authors found that:

- In a limestone stream, survival to three months was 80% for stocked brown trout and 90% for wild fish. Wild trout moved fairly often in response to the stocking of hatchery fish. Stocked trout lost weight over the three months, but wild trout growth was unaffected.
- In a soft water stream, survival to three months was 48-62% for stocked trout of two different strains and 49% for wild fish. Wild trout appeared not to move much in response to stocking. Stocked trout gained weight over the three months, whilst wild trout growth was suppressed.
- After 12 months, hatchery trout survival dropped sharply to 1-19% compared with 13-52% for wild fish.
- After three months, around half of the stocked trout had migrated out of the 200m stretches in which they were stocked.
- Despite recorded fish movements, wild trout biomass and stock densities were unaffected by stocking in either stream.
- As in the previous study (Weiss & Schmutz, 1999a) the authors concluded that it is easy to underestimate real survival rates of stocked trout if only stocked stretches are surveyed – many fish move out of their original locations (see also Gowan *et al.*, 1994 for a similar argument).

APEM (2002) reviewed UK studies of the fate of stocked brown trout, reporting the proportions of initial stockings subsequently recaptured.

Table 4.1: Reported recapture rates for brown trout from various rivers in the UK (various authors) (from Table 4.6, APEM 2002).

River	Recapture rate	Source
Ure	17%, 19%	Templeton (1970)
Tweed	41%	Mills and Ryan (1973)
Taff	3%	Scullion and Edwards (1979)
Taff	16%, 31%, 45%	Cresswell and Williams (1982)
W. Cleddau	60%	Cresswell and Williams (1983)
Dysynni	26%	Cresswell and Williams (1983)
Ribble	27%	Clifton-Dey and Walsingham (1996)
Lune	18%	Aprahamian (*pers comm*)

To optimize returns of stocked trout to the rod, the following management practices are recommended:

- Stock close to the intended time of capture (spring or early summer).
- Spot-planted fish are often recaptured more efficiently than fish scattered over a wider area, and batch-planting may give the best balance of challenging angling plus acceptable returns from stocking (Cresswell and Williams, 1982).
- Larger fish (around 40 cm) can give better returns than smaller ones (20 to 25 cm) (Hestagen *et al.,* 1989). Note that such large trout may not be ecologically appropriate for a given fishery.
- Most trout are caught within a kilometre of their release point, but some are recaptured much farther away (10 km or more).
- Because of the (perceived) typically short residence time of stocked trout, if angling pressure is sustained throughout the season restocking to maintain catch rates should be repeated fairly often. Note that this could potentially have appreciable knock-on effects on SAC species such as juvenile salmon.

Scullion and Edwards (1979) reported a 22 per cent recapture of rainbow trout stocked into the River Taff. Welton *et al.* (1997), quoting from Helfrich and Kendall (1982), give a figure of 59 per cent for recapture of stocked catchable rainbow trout.

Williams (2002) reports on 2001 results from his River Dove trout-marking project, where stocked brown trout were batch-marked (alcian blue pan-jet marks) according to release site and then monitored for distribution amongst anglers' reported catches. The 2001 fishing season was late in starting because of access restrictions caused by foot and mouth disease and so results may be atypical. Nevertheless, key findings were:

- Marked trout constituted 49% of captures, though catch-and-release was commonplace and so this did not represent a 49% recapture of stocked fish.
- Unmarked trout were either wild or over-wintered stock fish.
- Stocked brown trout moved between different river stretches, but were generally caught fairly close to where they were introduced. Trout moved both upstream and downstream, probably more so downstream.

- A single medium-level stocking early in the season resulted in high catch-per-unit-effort (CPUE: trout per visit or per hour) early in the season, falling sharply to a lower stable level for the rest of season. This is consistent with the concept of low residence time of stocked trout.
- A single high-level stocking early in the season was sufficient to maintain a high CPUE (around five trout per visit) throughout the season. This is inconsistent with short residence times, unless this stretch of river had a relatively high population of unmarked fish which kept up CPUEs.
- Three low-level stockings through the season produced consistently moderate CPUE (around three trout per visit) trout fishing performance.

This project is continuing (Dr Mark Williams, personal communication).

4.3 Analysis of trout rod catch data collected in this study

Rod catch data were gathered from helpful fishery owners and managers on three fisheries, one on each of the rivers Itchen, Nadder and Wylye (Hampshire Avon). These fisheries were chosen as they are situated in chalk (and greensand) stream habitats close to where salmon spawning and nursery areas occur. Data were analysed in relation to available information on trout stocking and any additional information from electric-fishing surveys.

4.3.1 River Nadder fishery (Hampshire Avon cSAC)

This Nadder-based club leases around 2.8 km and the fishery is split into four beats, A to D; currently C and D are stocked with a total of 150 (30 cm) trout, 75 stocked in March and 75 in June. An additional 1,000 (10 cm) fingerlings are introduced throughout the fishery in mid-summer, where this fingerling stocking has taken place since 1997. Annual (October) electric-fishing surveys have revealed good brown trout stocks of several hundred fish over the whole fishery. Grayling numbers have declined in recent years, possibly in response to climatic variation, but may now be recovering. Many trout caught are released and so multiple catches of both stocked and wild fish are possible.

Stocking practices have varied over the years; see Figure 4.1 below.

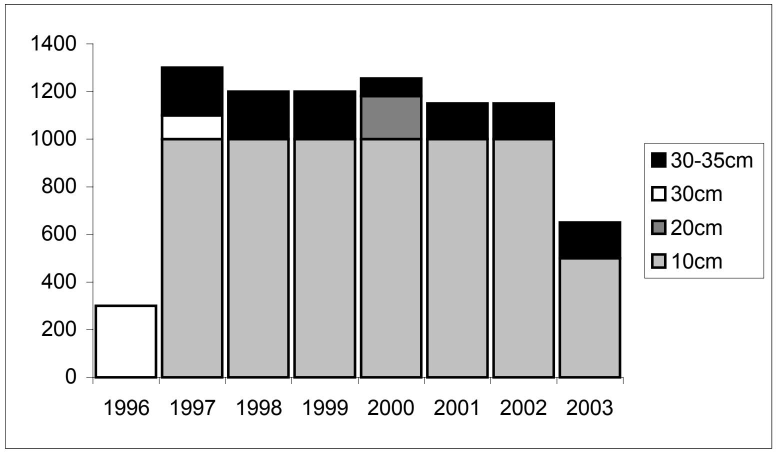


Figure 4.1: Numbers and sizes of brown trout stocked, River Nadder, 1996 to 2003

Reported catches are given in Figures 4.2 (numbers) and 4.3 (percentages) below

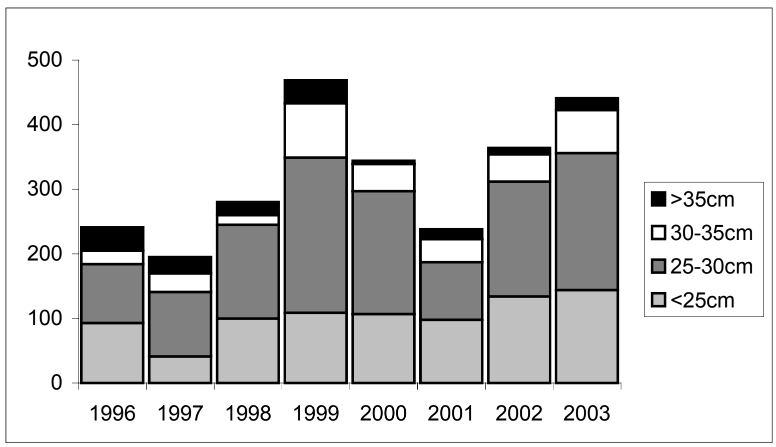


Figure 4.2: Numbers and sizes of trout caught, River Nadder, 1996 to 2003

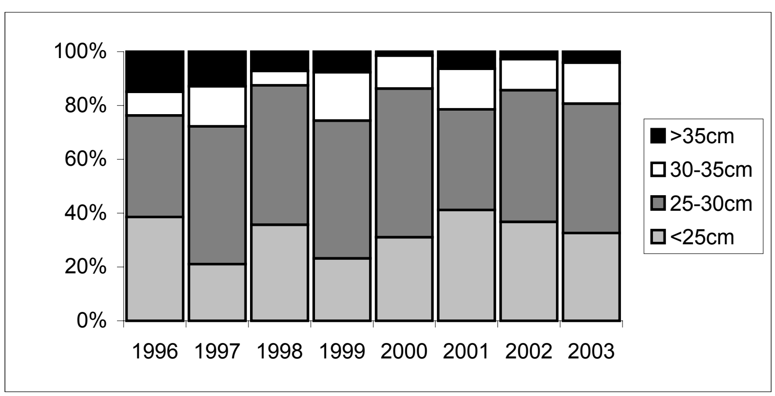


Figure 4.3: Percentage size composition of River Nadder trout catches

Interesting points to note from these figures include:

- Small trout caught in 1996 (before fingerling stocking began) were as high a proportion of catches and generally as numerous in catches as in later years.
- Overall stock size composition judged from catches has remained quite stable over the years, despite substantial changes in stocking practice.
- Stocked 30 to 35 cm trout are consistently present in catches but do not dominate them.

Anglers catch returns include columns for both stocked (adipose clipped) and wild trout. In Figure 4.4, the number of stocked trout caught by anglers has formed a consistently low percentage of annual catches. Note, however, that unmarked stocked fingerlings probably grow to look like wild fish, increasing the apparent numbers of trout recorded as wild. It would be interesting to know the real level of wild recruitment on this fishery.

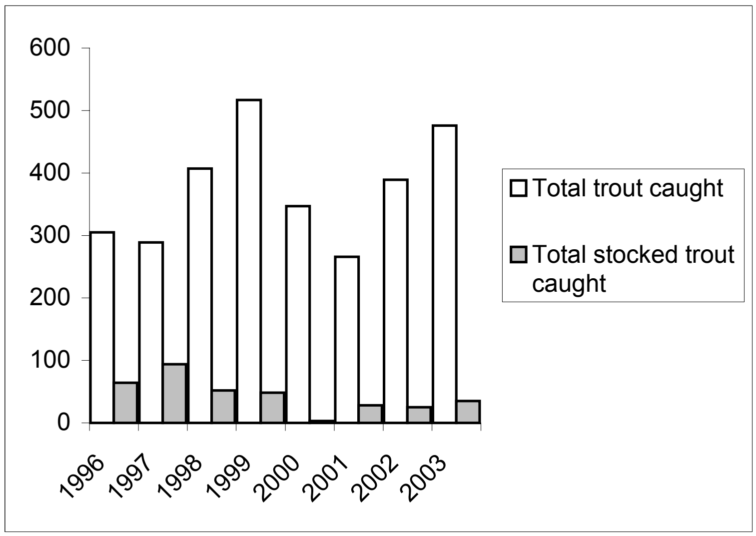


Figure 4.4: Total trout and stocked brown trout caught on River Nadder fishery

Overall, average catches per visit for all 40 club members is given for the years 1996 to 2003 in Figure 4.5 below. Fishery performance has remained, on average, very stable.

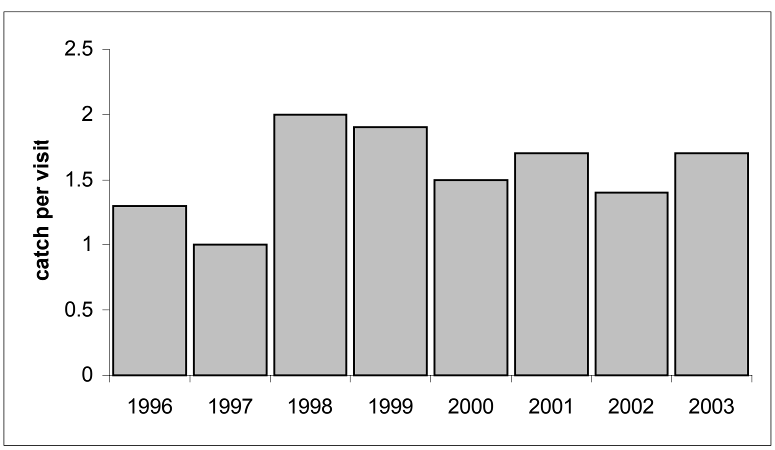


Figure 4.5: Average number of trout caught per visit, River Nadder, 1996-2003

The individual catch records of six anglers for the 2003 season were analysed to calculate average catch per visit through the season. The results are given in Figure 4.6 below.

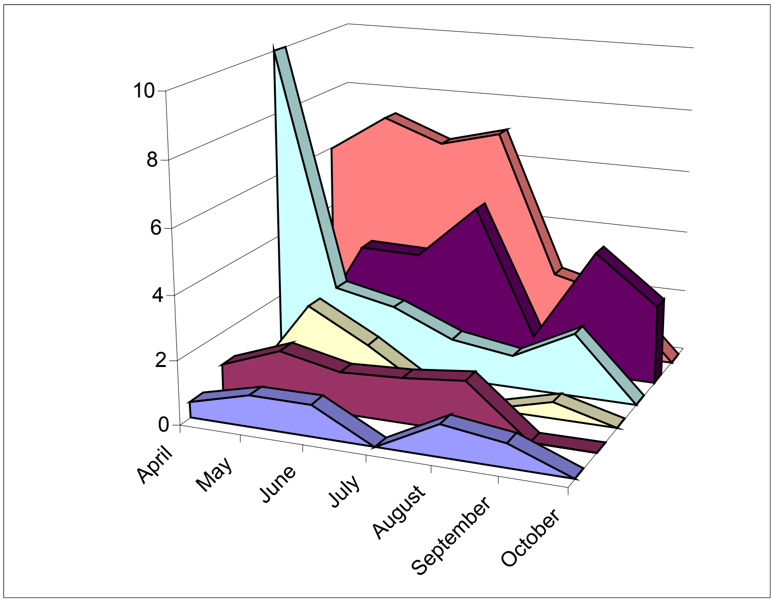


Figure 4.6: Individual catch per visit of six River Nadder trout anglers

Points to note are that:

- Average catches per visit tend to drop as the season progresses
- There is some suggestion that the June stocking of 75 adult trout may help to keep catches up, but seasonal factors (fly hatches, weather, flows) may be more important determinants of fishery performance.
- As most fish are returned, dropping catches could be due either to trout emigrating from the fishery or reduced catchability of the fish as the season progresses. The reported presence of high overall numbers of trout during the October electric-fishing survey (in most years) indicates that the fishery is certainly not devoid of trout at the latter stages of the season.

4.3.2 River Wylye fishery (Hampshire Avon cSAC)

This privately owned water of 2.8 miles is fished by a 20 rod syndicate plus guests. The fishery is stocked each year in early May with 250 adult brown trout. Annual electric-fishing at the end of the season has revealed 10 to 50 adult brown trout, plus larger numbers of naturally spawned juvenile fish. There is a good head of grayling which has steadily built up since 1996 when habitat improvement works were carried out on the fishery. Trout catches, by comparison, have fluctuated over the last ten years. Juvenile salmon caught during the annual electric-fishing survey are thought to have increased in recent years.

Annual trout (Figure 4.7) and grayling (Figure 4.8) catches, including fish caught and released, are given below.

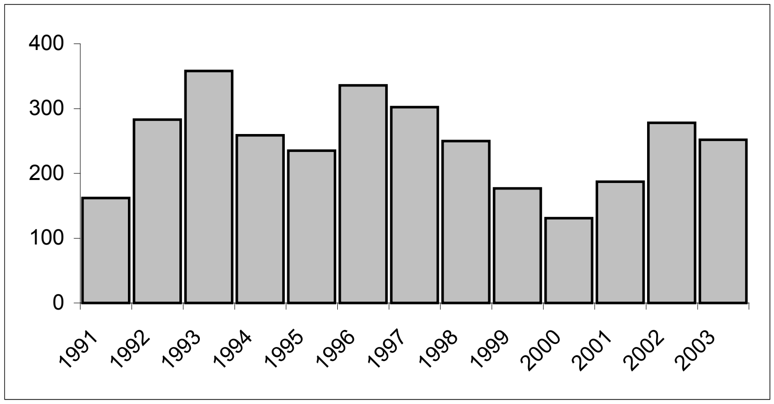


Figure 4.7: River Wylye brown trout catches 1991-2003

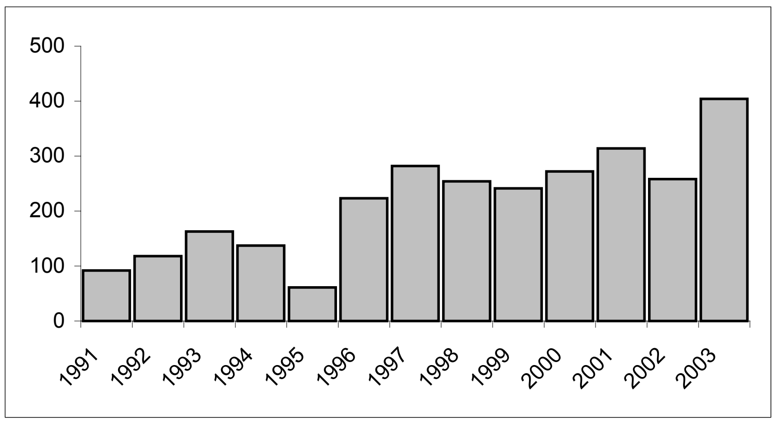


Figure 4.8: River Wylye grayling catches 1991-2003

Seasonal catches of brown trout are illustrative of the likely fate of most stocked fish. The following figures, Figure 4.9a to 4.9d, show monthly brown trout catches for the years 2000 to 2003 respectively.

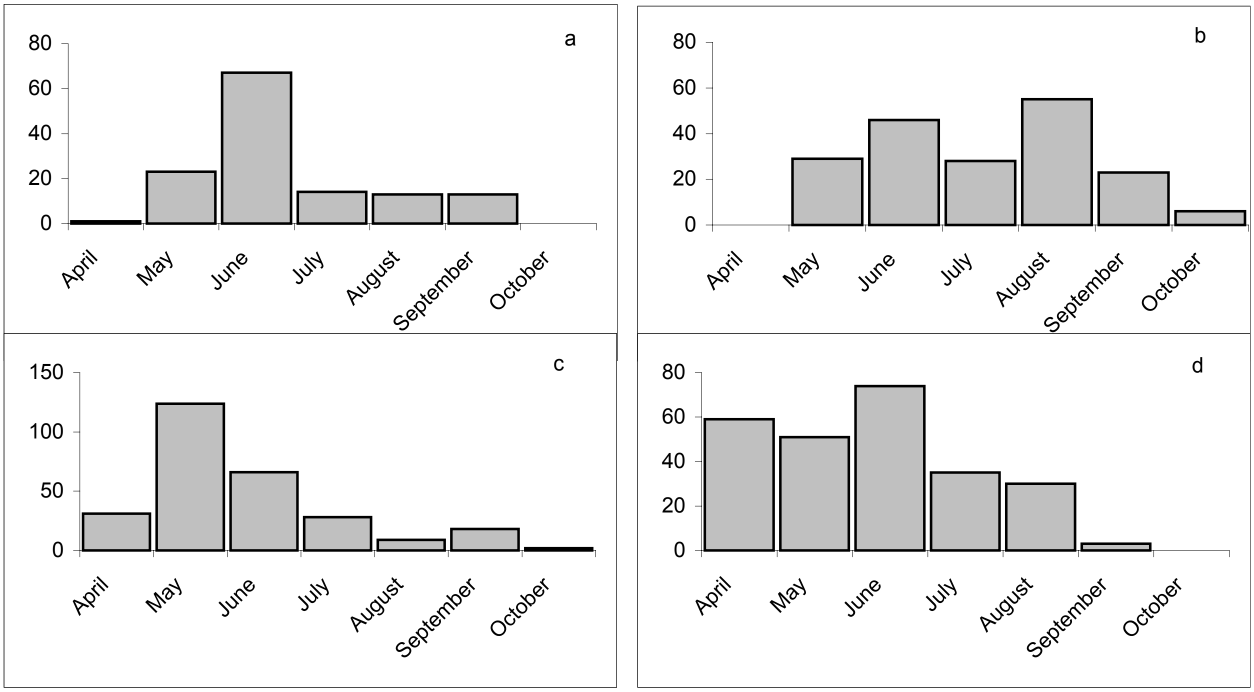


Figure 4.9: Seasonal trout catches, River Wylye, 2000 (a) to 2003 (d)

Interesting points to note include:

- The average number of brown trout caught annually is 247, and typical catch per day is around 1.5 trout (plus 1-2 grayling). This is very similar to the performance of the River Nadder fishery (Figure 4.5 above). The annual trout catch over the last two years has been at or above the long-term average.
- Numbers of grayling caught annually have approximately doubled between the early 1990s and the late 1990s.
- The monthly catch statistics (2000-2003, Figure 4.9 above) show a typical peak catch in May/June, soon after stocking, with a gradual decline thereafter. This is likely to be due to an actual decline in numbers of surviving stocked trout, with few being present in this fishery at the end of the season.
- The fishery immediately downstream of this one often produces stocked brown trout, despite the fact that no stocking takes place there (personal observation by the author). These trout are almost certainly downstream-moving stocked fish; they markedly lose condition towards the end of the season, indicating poor feeding ability. This downstream fishery has abundant juvenile salmon present.

4.3.3 River Itchen fishery (Itchen cSAC)

This fishery is comprised of a section of main river plus associated carriers totalling around three miles of water. There are 25 rods. Stocking is carried out fortnightly from April to October, totalling 1,000 adult brown trout, and an annual electric-fishing survey is carried out. Data from 1975 to 1992 are presented below. Further analyses will follow if data from 1992-onwards can be found by the fishery manager.

Considering first the numbers of trout caught and killed each year, Figure 4.10 provides brown trout data for 1980-1992.

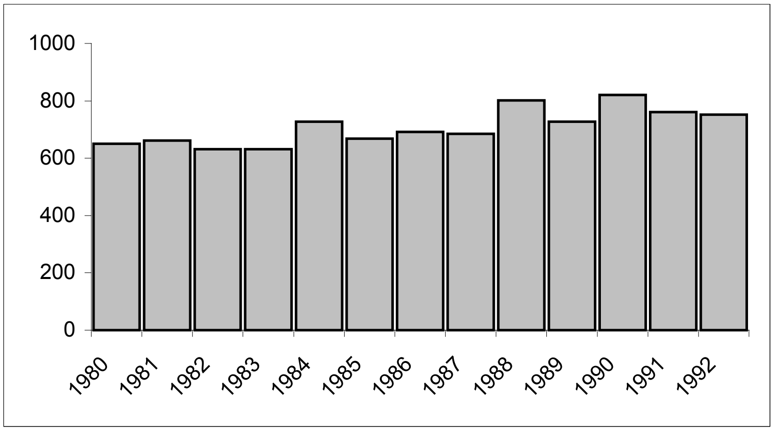


Figure 4.10: Annual catch of brown trout, River Itchen, 1980 to 1992

Note that 60 to 80 per cent of stocked trout are taken from the river within the fishing season. When numbers of brown trout caught (whether killed or released) are related to fishing effort (days fished), the long term fishery performance appears remarkably stable, averaging around 1.5 trout per day (very similar to both the Wylye and Nadder fisheries), as shown in Figure 4.11.

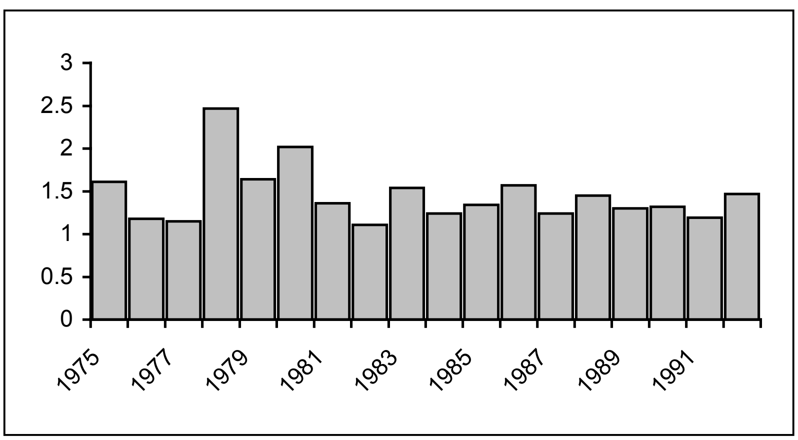


Figure 4.11: Average trout catch per day, River Itchen, 1975 to 1992

When the average weight (in pounds) of brown trout killed is plotted over time (1975-1992), a steady increase in the average size of stocked fish is evident, as shown in Figure 4.12.

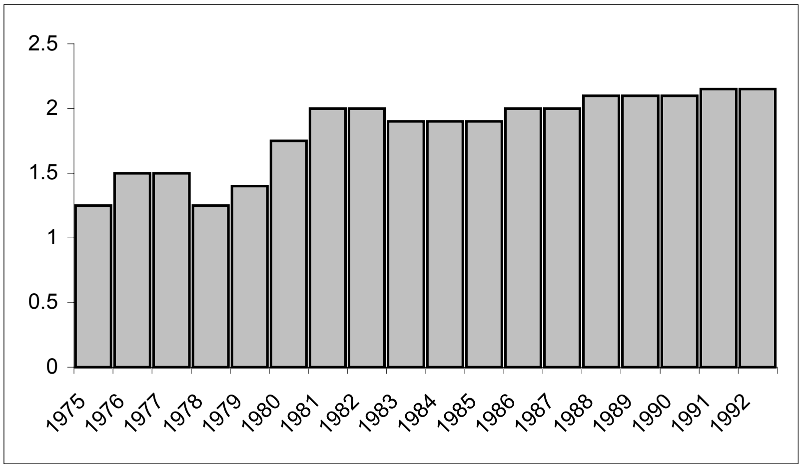


Figure 4.12: Average weight (lbs) of brown trout caught, River Itchen, 1975 to 1992

When the percentage of trout caught and released is plotted, a decline over time is evident, as shown in Figure 4.13.

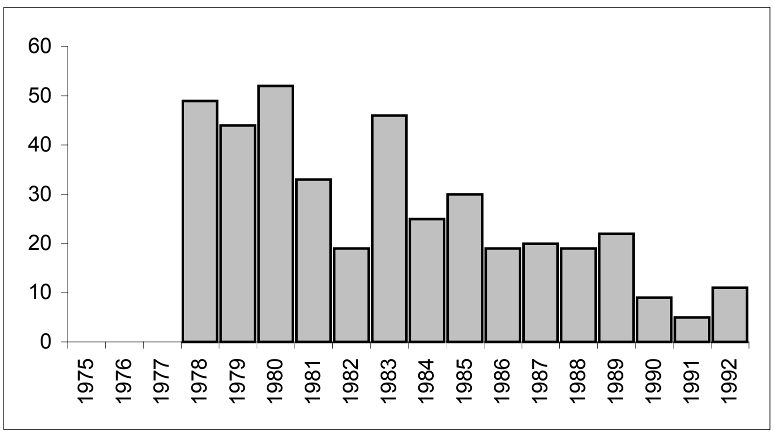


Figure 4.13: Percentage of brown trout caught and released, River Itchen, 1975 to 1992

Fortnightly stocking on this fishery generally stopped in mid-September, although in many years angling continued to mid-October.

When average trout caught per day is plotted on a monthly basis over a run of years (1980-1992), the following pattern emerges, shown in Figure 4.14:

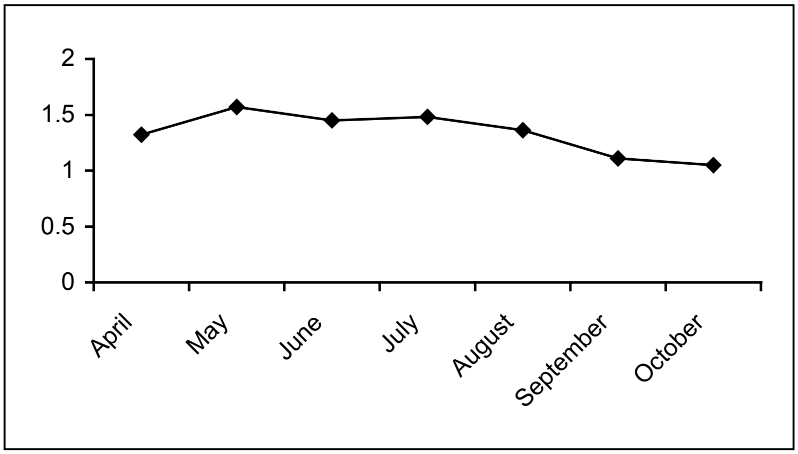


Figure 4.14: Average monthly brown trout catch per day , River Itchen, 1980 to 1992

There was a tendency for overall fishery performance to dip at the end of the season (Figure 4.14), but Figure 4.15 (below) shows that, for three regular anglers, average daily catches in the year 2000 tended to be both higher than the average throughout the season and to be maintained until the end of the season. Very similar results are illustrated for the same three anglers in 1999 (Figure 4.16).

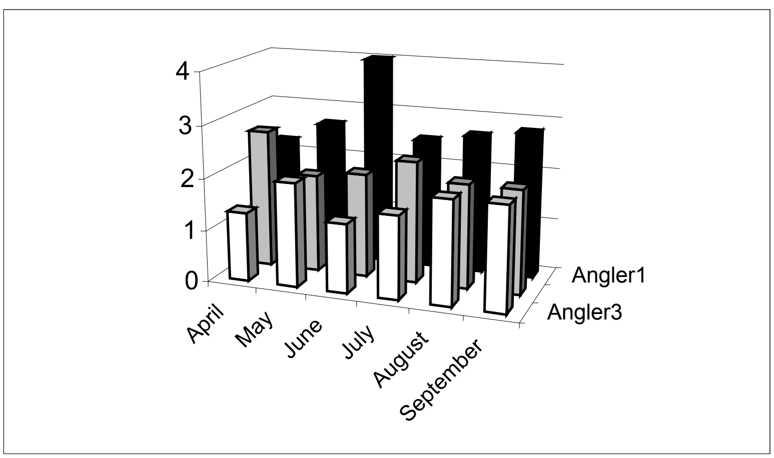


Figure 4.15: Average monthly catch per visit by three regular anglers River Itchen, 2000

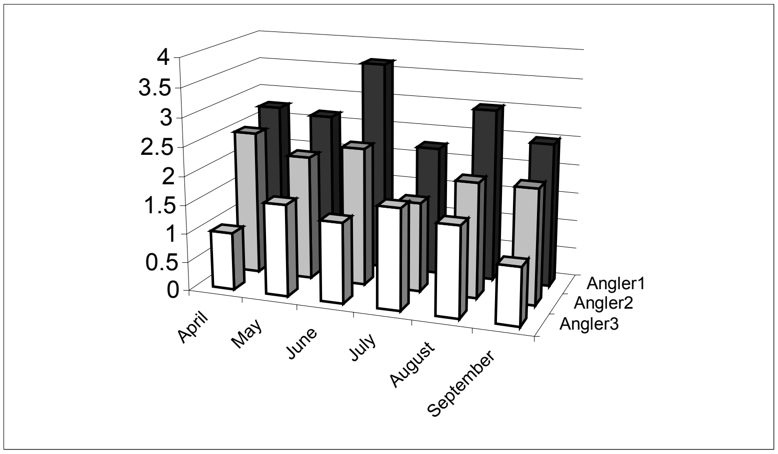


Figure 4.16: Average monthly catch per visit by three regular anglers River Itchen, 1999

Key points to note from these analyses are:

- Well-judged monthly stocking, with fish distributed throughout the fishery, has led to long-term stable fishery performance at around 1.5 trout per visit. Regular anglers catch more fish than average and more consistently; comparison between results of three anglers in 1999 and 2000 is surprisingly constant, given the vagaries of angling.
- Over time, the average size of brown trout killed has increased from less than 1.5 pounds to greater than two pounds, whilst the proportion of smaller trout returned alive has declined.
- Of the 1,000 brown trout stocked each year (assuming minimal movement between fisheries), between 60 and 80 per cent have been caught and killed each year, with overall average catches per day tending to dip at the end of the season.
- Autumnal electric-fishing surveys generally indicated a modest population of remaining stocked trout, together with a variable head of smaller wild brown trout. The latter increased after habitat improvement work was carried out in the early years of the tenure by the current fishery manager.
- Few stocked brown trout over-winter successfully.

From the analysis of available information, there are indications that trout catches on the three fisheries studied are related, to some degree, to the timing and intensity of the stocking of trout. Management of the three fisheries has maintained a typical overall average daily catch rate of one to 1.5 trout per day. As in all fisheries, more detailed analyses revealed that keen and able anglers tend to catch the bulk of the fish.

More data are required to reveal how typical the above results are. Further analyses are recommended to assess both the densities of brown trout that might naturally be expected on these types of river and how numbers of stocked trout actually relate to these densities. The sizes of stocked trout could also be compared with sizes of trout naturally expected from these waters. These further analyses would be of great value in helping to determine Section 30 consents for this type of fishery.

5 Conclusions

The updated literature review, building on the 2002 APEM report, supports the view that the most important negative impacts on SAC-qualifying rare species are likely to occur between stocked trout and native crayfish and stocked trout and Atlantic salmon. Some significant negative impacts on bullheads may occur.

The key interaction between trout and crayfish is the potential for crayfish plague transmission, a disease which can wipe out entire crayfish stocks. Defra farm fish movements and Environment Agency/conservation agencies Section 30 consents must dovetail to ensure that remaining native crayfish stocks are not placed at risk by movements of live trout or water.

Key potential interactions between trout and salmon include competitive interactions between juvenile stocked brown trout and juvenile salmon, potential hybridisation between salmon and stocked brown trout and predation by stocked brown and rainbow trout on wild and stocked juvenile salmon.

The review of available information on trout stocking indicates that, because stocking is relatively infrequent on the rivers Eden, Yorkshire Derwent and Rye, Dove and Lathkill, Teifi, Wye, and Usk, it is unlikely to pose serious problems for resident Atlantic salmon. Problems with native crayfish could, however, potentially occur.

On the rivers Itchen and Hampshire Avon, both of which are currently far below their revised conservation limits for Atlantic salmon (Defra/Environment Agency, 2003), a large amount of trout stocking occurs in areas where salmon spawning and nursery habitats are believed to be sited. The potential exists, therefore, for negative impacts of stocked trout on wild salmon stocks on these rivers. This requires further research.

Recommendations for further research

To help formulate decision-making procedures for cSAC river Section 30 consenting, further work is required to assess:

- expected densities of wild adult brown trout on rivers;
- actual densities of trout generated on rivers after stocking;
- whether the stocked trout remain resident in habitat areas used by juvenile salmon, and how long stocked trout typically survive within fisheries;
- the expected size ranges of stocked and natural trout stocks in rivers.

It is likely that existing electric-fishing and other data held by the Environment Agency and other organisations and individuals, together with a review of published scientific information, would yield many of the required answers to these questions.

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