Case Study Description

Rivers Piddle and Frome, and Poole Harbour

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1 Introduction

The River Frome is a chalk stream in SW England, with a main stem of 48 km in length. It rises in the Dorset Downs at Evershot, and passes through Maiden Newton, Dorchester, West Stafford and Woodsford. A key tributary of the River Frome is Tadnoll Brook, which enters the river 10 km upstream of the tidal influence (Figure 1). The River Piddle rises in Alton Pancras and flows for ~30 km south and then south-east, approximately parallel to the River Frome. Two key tributaries of the River Piddle are the Bere Stream and Devils Brook. The combined Frome and Piddle catchment area is 454 km².

Both rivers drain into Poole Harbour, which has an area of 38 km². The harbour is extremely shallow (average depth: 48 cm), with one main dredged channel, and is characterized by extensive mud flat and salt marsh habitats, as well muddy shores, sandy shores and seagrass meadows.

There are no significant barriers to eel migration on either the Frome or the Piddle, other than possibly the flood alleviation scheme in the upper Piddle (see below). The surrounding land usage is predominately agricultural with no industry or major settlements within their catchments. As a consequence, water quality remains very good and both rivers have the fauna and flora typical of lowland chalk streams.

A flood alleviation scheme was completed in October 2005 at Piddletrenthide (2.5 km downstream from the source of the River Piddle). Floodwater bypasses the village via a culvert 560 m in length. Eels were present in this area in 2003, both above (density 0.02 eels.m^{-2}, n = 7) and below the village (density 0.14 eels.m^{-2}, n = 58). There is no information regarding what, if any, effect the culvert may have on the eel population in this part of the upper catchment. The rivers Piddle and Frome have been extensively studied for their trout and salmon populations, fish habitats and invertebrates. Angling on both rivers is very popular, especially for salmon, trout and grayling.

There are two silver eel racks, one on the River Piddle and one on the Frome. The Frome rack tends only to be run for research purposes. The River Piddle rack operates each year during the silver eel run and the catch is sold for UK consumption. This trap was fitted with new rack in 2000 with 10 mm bar spacings to ensure all male silver eels were caught.

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Slime - Study Leading to Informed Management of Eels

Sixth Framework Programme, Priority 8.1, Policy-oriented research, Scientific Support to Policies.

Poole Harbour supports a fyke net fishery. Local eel fishermen claim that stocks and fisheries have declined and the average size of eels in catches has fallen over the last 20-30 years. The situation was investigated for the Environment Agency (Knights & White, 1997) and a summary of key points and conclusions is given below.

Fyke nets were introduced into the Harbour fishery in the 1950s and catches in the 1960-70s were about 30 t year^{-1} (Morrice, 1989). At the end of the 1960s, five 'punts' were laying up to 650 fyke-net ends per night. Increasing effort (as much as a tenfold increase in numbers of ends deployed per day) was needed to maintain catches in the early 1980s. Subsequent declines in catches have, it is claimed, led to reduced numbers of fishermen and hence total effort since the mid-1980s. Given the area of Poole Harbour as 38 km^2, and extrapolating from estimated total commercial yields, Knights & White (1997) calculated that catches could have fallen from about 7.9 to 1.3 kg ha^{-1} year^{-1} in the between the 1960-70s and the 1990s, a decline of 80-85%. Although firm evidence is lacking, growth-overfishing is implicated, probably exacerbated by reduced recruitment.

In relation to more recent changes, quantitative information on fishery yields was first collected by the former NRA in 1988, licensing of the fishery began in 1991, and catch returns are probably inaccurate. In 1988, the declared catch was 17,045 kg (including 1270 kg caught by a tidal seine net), but there are no records for fishing effort. Between 1991-96, the average catch was 19.6 (range 10.9-28.0) kg fyke-net-end^{-1} year^{-1}, shared between 2 to 8 licensees, with no apparent trend.

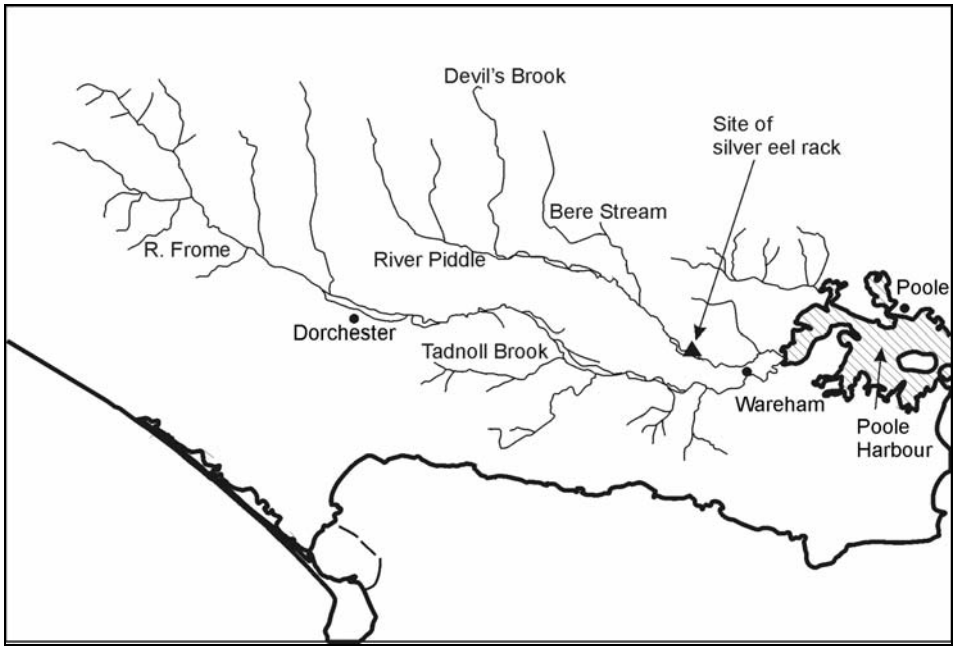

Figure 1 The River Piddle, River Frome and Poole Harbour.

2 Fishing capacity

There is no limit on fishing capacity

3 Fishing effort

There is no limit on fishing effort, the total fishing effort recorded in 2005 was 800 fyke net days.

4 Catches and Landings

In 2005 the declared catch was 300 kg of yellow eel and 126 kg of silver eel.

5 Catch per Unit of Effort

In 2005 the CPUE was 0.53 kg per fyke net per day

6 Scientific surveys of the stock

6.1 Recruitment surveys

No surveys on glass eel/elver recruitment have been carried out for the Piddle/Frome system.

6.2 Yellow eel surveys

Electric fishing surveys were conducted throughout the Piddle in 1977, 1999 (16 sites), 2003 (20) and 2004 (5). The data set for 1977, based on two single-pass runs of 14 km one month apart, does not include eels <250mm in length. The 1977 data are available in 10 mm length frequency classes, with age data only for silver eels. No habitat characteristics or water quality data are available for 1977. Surveys in more recent years recorded length, weight, age and sex of all eels caught, along with estimates of density and biomass, and habitat characteristics (flow and substrate type, cover, mean depth and width, site area, and temperature and conductivity of the water).

Eels were found throughout the River Piddle catchment from tidal limit to 100 m below the source. Eels were absent only where streams had dried up, but are found above and below these temporary barriers.

The lower mainstem of the Frome is generally too deep and wide for effective survey by electric fishing, but eels have been surveyed in Tadnoll Brook and on upper main stem and tributaries. Eight sites were surveyed on the Tadnoll Brook in 1999, and four sites were surveyed in 2000 and then annually since 2002, with two passes at each site. Surveys recorded length, weight, age and sex of all eels, along with density and biomass, and habitat characteristics (flow and substrate type, cover, mean depth and width, site area, and temperature and conductivity of the water). Six sites on the upper main stem and tributaries were surveyed in 1990 and 1999, with length, weight and age recorded in 1999.

Survey data suggests that Tadnoll Brook recruits larger numbers of smaller, younger elvers than the Piddle. It is not known how tidal currents and flow regimes in Poole Harbour may influence this unequal recruitment of glass eel and elver migration.

Yellow eels were sampled using fyke nets at five sites in Poole Harbour in 2004.

6.3 Silver eel surveys

Silver eel were measured for length and weight from catches at licensed fixed eel racks fished on a varying number of nights over the period of the silver eel run from September to December, in 1977 (Piddle) and 2003–2004 (Piddle and Frome).

7 Catch composition by age and length

'Catch' composition by age and length are available for all the electric fishing and fyke netting (yellows), and eel rack (silvers) surveys.

8 Other biological sampling (age and growth, weight, sex, maturity, fecundity).

See Section 6, above.

9 Literature references.

Knights B. & White E.M. (1997) An appraisal of stocking strategies for the European eel, *Anguilla anguilla* L. In *Stocking and Introduction of Fish* (ed. I.G. Cowx), pp. 121-140. Fishing News Books, Oxford.

Knights, B., Bark, A., Ball, M., Williams, F., Winter, E. and S. Dunn (2001). *Eel and elver stocks in England and Wales – status and management options*. Environmental Agency, Research and Development Technical Report W248. 294 pp.

Morrice, C.P. (1989) Eel fisheries in the United Kingdom. *MAFF Internal Report No. 18*, 33pp. MAFF, Lowestoft, England

10 Application of the Models

For the purposes of testing models in SLIME, it was decided to focus on the freshwater portion of the Piddle catchment and exclude the estuarine Piddle Harbour, since the latter is the site of a mixed stock eel fishery (with the River Frome).

Two models were applied to the Piddle dataset; SMEP and GlobAng.

10.1 SMEP

The Piddle population was appropriate for modelling with SMEP because catchment data were readily available, along with eel population data sufficient to inform the parameters file.

10.1.1 Parameter Setting

At the time of the workshop, SMEP applied growth according to the Von Bertalanffy model, and 'UK eel' default values for L_∞ and k were used. It was recognised, however, that the VB model is probably not appropriate for simulating growth of eel, and this is an area of continued model development.

Recruitment: No direct recruitment measures were available for the Piddle, but a trend was applied to simulate changes in CPUE of UK glass eels fisheries since 1980. Elvers recruit to the Piddle after a period of growth in Poole Harbour: the mean length of recruits was increased above the default value for glass eel in order to reflect this.

Carrying Capacity (biomass): maximum densities observed for streams were converted to biomass, although these may still be well below maximum possible biomass of yellow eel standing stock. Both the concept, and representative values, of carrying capacity for eel require further exploration.

10.1.2 Population Data

Preliminary estimates based on mark-recapture exercises suggest that recent silver eel escapement from the Piddle is in the region of 6000 eels per year.

The most complete data set for yellow eel was for 2003, so this was used as a reference year, against which to compare the model outputs in terms of the yellow eel production.

10.1.3 Model Outputs

Modelling with SMEP suggested that a recruitment of 1.2 million elvers would be required to produce an average annual silver eel escapement of 6000 eels. Based on this level of present-day recruitment, the SMEP model suggested that historic (pre-1980) recruitment and silver eel escapement would have been 4.8 million elvers and 24,000 silver eels, respectively. However, both modelled silver eel runs were dominated by male eels (97-100%), whereas catches of silver eels since 1999 have had much higher proportions of females (46-99%). Furthermore, SMEP required yellow eel densities in the three reaches that were orders of magnitude higher than observed in order to produce this level of silver eel escapement.

Calibrating the model with the yellow eel densities observed in 2003 suggested a recruitment of about 70,000 but a silver eel run of only 400+.

10.1.4 Conclusion

SMEP has definite potential for modelling eel populations and silver eel output, but will require considerable further parameter testing and development to cope with application to data-poor rivers. Describing the catchment in reaches, setting an appropriate level of recruitment where no actual data exist, and using parameter settings suitable for the river type appear be the key constraints to useful model outcome. These three aspects are all featured in the ongoing development of SMEP.

10.2 GlobAng

GlobAng is designed to perform simulations of eel population dynamics within a hydrographical network. After calibration with real field data, the model is able to evaluate silver eel escapement in response to a variety of management scenarios, especially when spatial dimension is important. The model integrates ageing, recruitment, sexual differentiation, silvering, natural mortality and for the first time migration within a watershed. Fishing mortality and impacts of migration barriers can also be simulated.

Similar data were applied to the GlobAng model as were applied to SMEP and the same recruitment and carrying capacity comments made under SMEP apply here. However, as GlobAng requires reaches of equal length, the three SMEP reaches were split into seven, each of nearly 10 km long. Also, as GlobAng is an age-related model, the observed length distributions were transformed to age distributions using a length-age key developed from the 2003 data.

10.2.1 Model Outputs

Calibration of the model with the recruitment trend and the observed yellow eel population in the three reaches in 2003 suggested a historic (pre-1980) recruitment level of around 550,000

and an annual escapement of 6250 silver eels, most of which were female. According to the CPUE trend, therefore, the present-day recruitment would be about 140,000 elvers, which the model suggests should produce about 3000 silver eels per year, most of which will be females.

The model overestimated the abundance of young eels, especially in the lower reaches. However, the model set-up required recruitment from Poole Harbour to reach 1 at elver age 2, whereas, as suggested by PL and others before, Poole Harbour may be acting as a recruitment sink from which elvers migrate upstream at a range of ages.

The model underestimated both the abundance of older eels throughout, and the average age of silver eels, at 4 and 10 years for males and females, whereas the average age of silver eels sampled in 2000 to 2004 was 17 years, and ranged from 9 to 29 years old. This suggests that the growth and probably maturation modelling were inappropriate for the Piddle eel population.

10.2.2 Conclusion

GlobAng predicted a level of present-day silver eel escapement that, while it was half that of the mark-recapture estimate, was a much better prediction than that provided by SMEP. Improvements are needed to simulate a more effective colonisation of the catchment, age structure of silver eels and to shift the sex ratio in favour of males. It was noted, however, that the observed densities did not correspond to the typical case of diffusive colonisation with higher abundance in the reaches closest to the estuary. Perhaps, therefore, a more comprehensive survey programme would facilitate better representation of the yellow eel stocks in each reach, and allow GlobAng to better model the Piddle eel stock.