Defining Angler Opportunity

R&D Technical Report W2-084/TR

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Statement of Use
This report describes a pilot study which explores and quantifies the relationship between angling opportunity and participation within South East Area of Environment Agency Wales. It helps to improve the understanding of how to encourage angling participation and thereby promote socio-economic and ecological benefits. A geo-spatial tool is proposed which can be used to input into the strategic development of fisheries. It will be of interest to Agency Fisheries staff and others involved in the provision and planning of facilities for the sport of angling.

Key Words
Angling, Opportunity, Participation, Fisheries, Models, South East Wales.

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GLOSSARY AND ABBREVIATIONS

Centroid	The centre point of a geographical (spatially referenced) area.
Coarse fishing	Fishing for cyprinid species, i.e. all other species than those below
Game fishing	Fishing for salmon, migratory trout, non-migratory trout and Grayling
Hettest	Tests whether t=0 in Var(e) = S^2exp(2t) (extracted from ‘Stata’ version 7 help file).
LFMD	Live Fish Movement Database
MS	Migratory Salmonid fisheries
Outliers	Atypical observations (data points) that do not appear to follow the characteristic distribution of the rest of the data.
Postcode district	A geographical zone represented by the first section of the postcode, e.g. CF24
RAD	Rod licence Administration Database
TC	Trout and Coarse fisheries
VIF	VIF calculates the variance inflation factors (VIFs) for the independent variables specified in the fitted model (extracted from ‘Stata’ version 7 help file).

EXECUTIVE SUMMARY

- The overall objective of this project was to explore and quantify the relationship between angling opportunity and participation. The project is closely linked to, and directly contributes to, the Making it Happen targets of improving our understanding of how to encourage angling participation and thereby promote socio-economic and ecological benefits.

- The empirical aims of the study were to a) provide quantitative estimates of the effect of angling opportunity on angling participation, at both a national and area level; and b) classify and then map the distribution of fishery types in the South East Wales Area. The methodological aim was to pilot a geo-spatial tool which can be used to provide input into the strategic development of fisheries.

- The study used a Geographical Information System (GIS) to analyse the distances between a database of fisheries and centres of population on a relatively broad spatial scale. The methodology was used to produce a number of maps showing angling opportunity in the study Area. After a number of preliminary and descriptive analyses, statistical models were used to estimate the relationship between the supply of fisheries and angling participation.

- The main finding of the study is that availability, as measured by distance-to-fishery[1], has a significant and measurable impact on the number of rod fishing licences purchased. These results confirm the findings from a large number of previous studies that have modelled recreation demand, both in the UK and abroad.

- The preferred models showed that a 1km increase in distance to trout and coarse fisheries decreases trout and coarse licence sales by between 4 and 10%. The same increase in distance to migratory salmonid fisheries reduces licences sold by 6%. The relationships were modelled using both Ordinary Least Squares (OLS) and Generalised Linear Models (GLM); goodness of fit measures indicated that the GLM provided a better fit of the data than OLS regression, and a log-linear specification of the relationship between the number of licences and distance-to-fishery in the GLM provided the best fit of the data.

- An example is given in Section 6 of how the quantitative results can be used in conjunction with the GIS tool to predict approximate increases in the numbers of rod licences in postcode districts. The example used is a new day ticket trout fishery on the River Rhymney in Cardiff, which results in distance reduction for 6 postcode districts and a resulting approximate increase of 230 licences across these 6 districts.

- In general the results are encouraging, although the limited timeframe of the study meant that there are a number of recommendations for refinements to the methodology and additional modelling. These include: using rod licence data on a finer spatial scale and GIS route-finding capabilities to calculate distances;

[1] The study looked at day-ticket fisheries only

modelling the angling opportunity-participation relationship for junior licence sales/holders, and for more specific types of fishery.

- On a wider level, developing the models to include more/other explanatory variables and applying the methodology to other Agency Areas are the more immediate research opportunities.

KEY WORDS

Angling, Opportunity, Participation, Fisheries, Models, South East Wales.

1 INTRODUCTION

1.1 Introduction

The overall objective of this project is to identify and quantify factors that influence demand for fishing. The purpose of this to increase understanding of how the Agency can encourage participation in fishing and thus meet Agency objectives of enhancing both people's quality of life and the natural environment. As an initial step in answering this question, the study pilots a method for relating angling opportunity to participation in South East Wales.

This objective can be broken down into two main aspects of this research project. These are:

a) to map the availability (supply) of angling opportunity in relation to centres of population, and
b) to quantify the relationship between the supply of angling opportunity and the demand for angling.

1.2 Motivation for Study

In this Section, the Agency objectives that are directly related to the aims of the study are briefly described.

1.2.1 General Agency objectives

This project provides a link between regeneration of rivers and the environmental enhancement work of the Agency, and the social and economic objectives, such as providing recreational opportunities that improve quality of life and can contribute to psychological wellbeing as well as physical health. It does this by providing a tool that will enable fisheries managers to identify locations for fishery creation or river regeneration that results in fishery creation, which will provide the greatest social and economic benefits.

There are three 'Making it Happen' objectives that are directly relevant to this research project. These are:

- "Enhancing the quality of life through the promotion of navigation, fishing and other recreation on our rivers."
- "…promote participation in fishing, especially by disadvantaged groups, and promote other water-based recreation opportunities."
- "Boosting local tourism and recreational opportunities by promoting greater access to inland and coastal waters, including our waterways and providing higher standards of navigation management. Maintaining and improving our assets and supporting fishing, **including development of fishing opportunities close to centres of population**."

This project is directly linked to the target of promoting angling participation, and will contribute to this goal by improving our understanding of recreation (angling) demand. Specifically, the project aims to do this by quantifying how the availability or supply of angling opportunities is related to the purchase of fishing licences, at both national and Area levels.

The actions set out in 'Making it Happen' for achieving the above objectives include one to "Develop and promote improved market information". The project is consistent with this action in that it pilots a method that uses market information (rod licence sales) to develop our understanding of the demand for angling and how availability, as measured by the distance from centres of population to day-ticket fisheries, affects demand. This information can then be used to model the effect of fishery location on licence sales.

These objectives are also emphasised in Defra's Section 4 guidance, which states that the Agency should: "enhance the social value of fishing as a widely available and healthy form of recreation".

1.2.2 Fisheries management / strategic objectives

The specific aim of the project is to provide strategic input into fisheries management that is based on observed market behaviour, in order to contribute to sustainable development of angling.

The two main practical motivations for the study are firstly, the need for fisheries managers to identify the best potential locations for new fisheries, in order to increase angling participation and licence sales. This relates to the 'Making it Happen' objective of improving access to fisheries by locating them close to centres of population. And secondly to understand the factors that have an effect on participation and that can potentially be directly (or indirectly) influenced by fisheries managers, so that they can develop policies and strategies to encourage participation in angling.

The need to improve our understanding of how to encourage angling participation is noted in the National Trout and Grayling Fisheries Strategy, which states that "Information on the types of fishery anglers prefer and choose will aid fisheries managers and the strategic development of fisheries" (p.6). Policy 30 in the strategy also states that "We will develop ways of analysing opportunities available to different sectors of the population in individual districts to help develop a diverse range of angling opportunities in each area" (p.18).

This research project links with and indeed makes use of other current Agency research in Fisheries, the 'Fishing Wales Project'[2], in which a comprehensive database of fisheries has been created, including grid references so that they can be mapped in a Geographical Information System (GIS). This geo-referenced database of fisheries has allowed this research project to be carried out and will hopefully encourage other Agency Areas to follow suit.

[2] Andy Schofield, Sustainable Fisheries Programme Manager, Environment Agency Wales.

1.2.3 Economics in recreation and fisheries

A large part of economic science is dedicated to understanding and modelling people's preferences and consumer behaviour, including preferences for environmental goods and services. How can economic theory and methodologies be used to help understand the factors that influence demand for angling?

There are two main ways that economics can help us understand and predict peoples preferences for a certain product or service, such as angling, which are often used in assessing preferences for 'non-market' environmental goods and services such as outdoor recreation. These are a) to use people's stated preferences, and/or b) their revealed preferences. Studies using the stated preference approach work by asking people directly to state their preferences (in monetary terms), for example, for a fishing trip, or characteristics of a fishing site that might influence their decision to participate in angling[3]. Previous Agency funded research has used this approach for example in the 'Economic Evaluation of Inland Fisheries' project (Spurgeon *et al*., 2001).

A commonly used economic approach for revealing peoples' preferences for non-market recreation activities is to use observations on market-related behaviour. A popular method is to use the distance travelled to recreation site as a proxy for the cost of a recreation trip, combined with the number of trips to estimate a demand curve, from which the economic benefits of the trip can be derived. Many researchers both in this and other countries have used this 'travel cost' technique for exploring demand for various forms of recreation and for different types of natural resources. In the UK, travel cost studies have looked at the recreational value of forests and woodlands (Hanley, N. and R.J. Ruffell, 1991; Willis, K., and G. Garrod, 1991; Willis, K., *et al*., 1988); inland and coastal waters (Willis, K. and G. Garrod, 1991; Radford, A.F., 1984; Hanley, N., *et al*., 2003) and mountains (Hanley *et al*., 2001).

This study draws on the travel cost approach in that it uses distance-to-fishery (travel cost) as a proxy cost of angling, but relates this to actual market behaviour, the number of rod licences purchased by postcode district, as opposed to the level of use, for example the number of fishing trips[4]. It builds on previous Agency research that suggests that availability of fisheries, as measured by distance, is a determining factor in licence sales (Diamond *et al.,* 2000). In addition, research looking at trout angling opportunity specifically in South East Wales Area also showed that among other things, distance was a significant factor in demand[5].

[3] Other stated preferences approaches used for investigating factors that affect demand for angling are contingent behaviour studies, which develop hypothetical scenarios that are based on actual behaviour (such as making fishing trips), or using choice experiments, where respondents choose between alternatives with different attribute bundles, for example, choosing between four fishing sites that had varying levels of catch rate, aesthetic value, travel costs etc.
[4] Data on recreational fishing trips were not available for this pilot study, although in Section 3 some previously gathered data on fishing trips is analysed.
[5] Mawle, G.W. (1984).

As a pilot project, the methodological aim was to develop a methodology that could then be refined and applied in other Agency Areas, and to provide an indication of where future research can be focused, rather than to carry out a full revealed preference recreation demand study.

1.3 Structure of Report

The rest of this report is structured as follows. In Section 2, data from a previous angling study[6] is used to model the relationship between distance-to-fishery and numbers of fishing trips and licence holders, for various types of fishery. In Section 3, a classification for angler opportunity in South East Wales is described, and Section 4 describes the methodology used for gathering the data and presents some preliminary descriptive analysis of the types of fisheries in the study area. In Section 5, the relationship between distance-to-fishery and licence holders in South East Wales is modelled, and the results discussed. Section 6 presents some conclusions and recommendations for further research.

[6] Simpson, D. and G. W. Mawle (2001), "Survey of Rod Licence Holders 2001", R&D Technical Report W2-057/TR.

2 NATIONAL-LEVEL ANALYSIS OF DISTANCE AND ANGLING PARTICIPATION

2.1 Introduction

This Section investigates the relationship between angling opportunity and participation using national-level data, providing an introductory study of the relationships, which are then explored in more detail at an Area level in Sections 4 and 5. This Section is split into 4 parts: Section 2.2 explores the supply-demand relationship using mean trips per person as the demand variable. Section 2.3 carries out the same modelling but using the per capita number of licence holders instead of the mean number of trips as the measure of angling participation. Section 2.4 describes some post-regression diagnostic analyses, and Section 2.5 offers some conclusions.

The specific research question that this part of the project sought to answer is: what is the relationship between the perceived distance to a fishery and angling participation? We would expect the relationship between distance and recreational use of fisheries to be negative, i.e. the lower the distance to the fishery, the greater the participation and vice versa. As noted in Section 1, previous economic and Agency research (e.g. Diamond *et al*., 2000) suggests that demand for fishing licences is strongly related to the availability of fishing.

The data used to quantify the relationship between angling opportunity and participation are drawn from the national 'Survey of Rod Licence Holders' (Simpson and Mawle, 2001), and consist of 26 mean variables for the 26 Environment Agency Areas in England and Wales. The variables used to measure angling availability are the perceived distances between anglers' homes and the nearest fishery for seven different types of fishing (listed below). It was proposed in the National Trout and Grayling Fisheries Strategy that this variable be used as a measure of angling opportunity. There are two measures of participation used, the stated number of days spent fishing ('trips') and the number of licence holders per capita who take part in each of these types of fishing.

2.2 Participation as Mean Number of Trips

Initially, the relationships between mean trips and distance were investigated by plotting the untransformed data in a series of scatter plots. These suggested that the distribution of the trips variable for most of the fishing types was not Normal, and would benefit from some form of transformation for Ordinary Least Squares (OLS) regression. In addition, two different types of 'subset' models using subsets of the dataset were run, to explore the relationships between availability and use for river and stillwater fishing separately. In the following sections the results of these regression models are described.

The relationship between participation and distance for the seven different fishing 'products' was analysed using various forms of regression model. The basic model is specified as:

$T_j = a + \beta D_j$

Where T_j is variously the mean number of trips in each of the 26 Agency Areas to the following fisheries:

Salmon and Sea Trout (SST)
Trout River (TR)
Trout Stillwater (TS)
Grayling (G)
Coarse River (CR)
Coarse Stillwater (CS)
Coarse Canal (CC)

And D_j is the mean perceived distance from the anglers' home to the nearest example of that type of fishery. To explore the suitability of different functional forms, the models were run with the data transformed as log-log

$\ln T_j = a + \beta \ln D_j$

and semi-log (log of the dependent variable 'trips')[7]

$\ln T_j = a + \beta D_j$

The results are shown in Table 1 below; Figure 1 shows an example of the data in semi-log form (coarse river fishing trips).

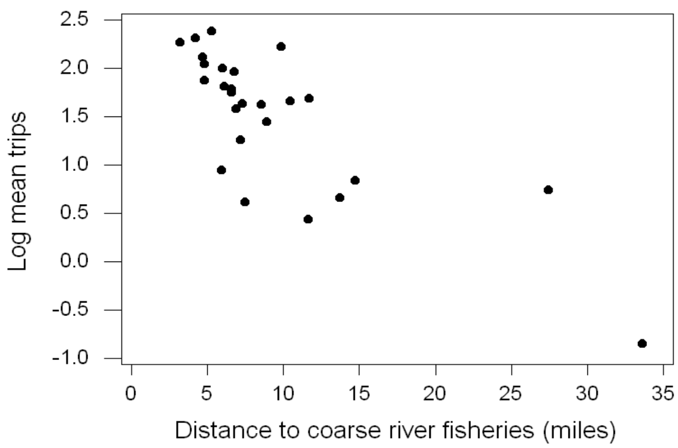

Figure 1 Plot of log mean trips versus distance to coarse river fisheries

[7] The models were also initially run using the untransformed data for comparison purposes (results not reported).

Table 1 Results of the single-variate trips vs distance models for 7 different types of fishing.

Fishery Type	Functional Form	Distance coefficient	Adjusted R^2	Untransformed Adjusted R^2	F-stat
Salmon & Sea Trout	Log-log Semi-log	-1.24 -0.03	0.44 0.26	0.22	20.4*** 9.8***
Trout – River	Log-log Semi-log	-1.49 -0.10	0.48 0.43	0.30	23.5*** 19.8***
Trout – Stillwater	Log-log Semi-log	-1.51 -0.12	0.13 0.08	0.14	4.5** 3.3*
Grayling	Log-log Semi-log	-2.99 -0.08	0.11 0.20	0.02	3.9* 7.2***
Coarse – River	Log-log Semi-log	-1.08 -0.08	0.61 0.61	0.38	39.5*** 39.4***
Coarse – Stillwater	Log-log Semi-log	-0.45 -0.10	0.07 0.08	0.06	2.8* 3.2*
Coarse – Canal	Log-log Semi-log	-1.43 -0.07	0.61 0.68	0.29	39.2*** 55.1***

T-stat / F-stat significant at probability levels: *** 99% ** 95% * 90%

The results of the semi-log models show that distance-to-fishery has a significant and negative affect on the (log) number of fishing trips. The distance coefficients mean a unit (1 mile) increase in distance decreases log mean trips by between 3 and 12%. The results indicate that distance explains much more of the variation in trips to rivers and canals than it does of the variation in trips to stillwaters. This might be because the average distances travelled to stillwaters are much smaller - between 5 miles (coarse) and 11 miles (trout), compared to rivers - between 9 miles (coarse) and 44 miles game).

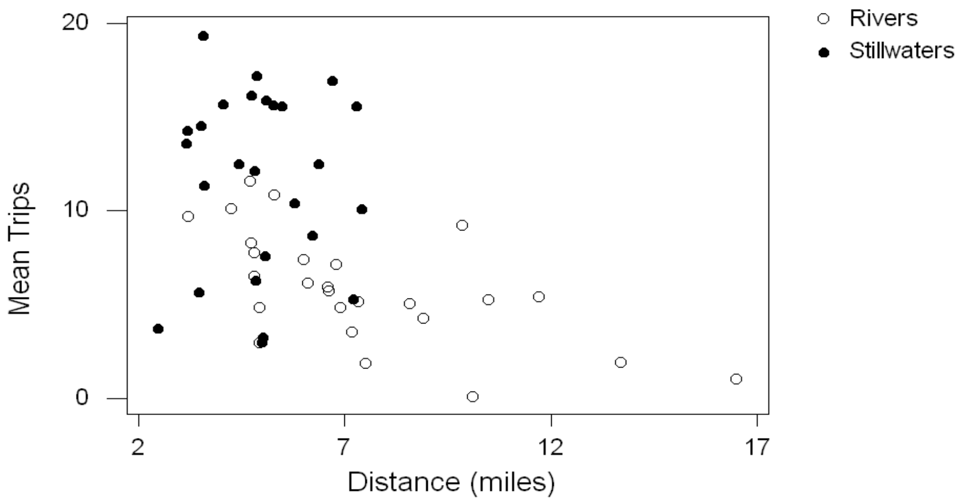

Figure 2 Comparison of mean river and stillwater fishing trips versus distance

These results also suggest that there may be other factors, such as quality of fishing, ticket price or congestion at fishing sites, that are important in predicting demand for stillwater fishing. The relatively low explanatory power of the trout and coarse stillwater models means that we need to use the stillwater coefficients with caution in terms of predicting demand based on reduced prices (increased availability).

The Grayling equation is not particularly robust compared to the other regressions – the line seems to be almost flat, especially if the two outliers are removed. This implies that anglers who fish for grayling have an almost zero price elasticity (i.e. are almost completely insensitive to travel cost). To a certain extent this is consistent with what we know about grayling anglers, in that they are prepared to travel large distances to fish different rivers containing grayling. This also has implications for developing tourism opportunities for grayling fishing, as it is likely to draw visitors into an area.

2.3 Participation as Number of Licence Holders Per Capita (pc)

The relationship between a different measure of demand for fishing, the number of licence holders, and availability (distance to fishery) was also explored using the same dataset.

Basic (single-variable) OLS regression models were run for each type of fishing as described in Section 2.2 above, using the per capital number of licence holders in place of the mean number of trips as the dependent variable. This 'licence holder per capita' variable was obtained by multiplying the proportion of licence holders who participated in each type of fishing[8] by the total number of licence holders and then dividing by the population, for each Agency Area. Both the semi-log and double-log (log-log) functional form was used; the results of these regressions are presented in Table 2.

[8] As elicited by the questionnaire (Simpson & Mawle, 2001)

Table 2 Results of the single-variate licence holders pc versus mean distances: double- and semi-log form

Fishery Type	Functional Form	Distance coefficient	Adjusted R^2	Untransformed Adjusted R^2	F-stat
Salmon & Sea Trout	Log-log Semi-log	-0.49 -0.01	0.26 0.09	0.15	9.7** 3.5*
Trout – River	Log-log Semi-log	-0.68 -0.04	0.44 0.37	0.36	20.9*** 15.8***
Trout – Stillwater	Log-log Semi-log	-0.33 -0.02	0.00 0.00	0.00	0.45 0.14
Grayling	Log-log Semi-log	-2.42 -0.07	0.28 0.53	0.07	10.8*** 29.4***
Coarse – River	Log-log Semi-log	-1.13 -0.09	0.56 0.61	0.35	32.3*** 39.3***
Coarse – Stillwater	Log-log Semi-log	-1.21 -0.24	0.34 0.33	0.35	13.8*** 13.1***
Coarse – Canal	Log-log Semi-log	-0.90 -0.04	0.79 0.83	0.42	94.9*** 120***

T-stat / F-stat significant at probability levels: *** 99% ** 95% * 90%

The results using this measure of angling participation are quite similar to the model results using the mean trips variable, in that distance is a significant and negative predictor in all of the models except the trout stillwater model. Similarly, the log-log form is better suited to the salmon and sea trout and the trout river fishing models. The semi-log models show that distance reduces the log number of licence holders between 1 and 9%, with the exception of the coarse stillwater distance coefficient, which is much higher - 24%. This suggests that anglers who fish for coarse species on stillwater are much more sensitive to availability of angling in terms of the distance they need to travel to fish.

As with the fishing trip data, the river fishing models seem to perform better than the stillwater models. However an interesting difference is that the distance to coarse stillwater fisheries explains much more of the variance in the number of licence holders per capita who fish these types of fisheries than it explained in the trips model.

The Coarse Canal model provided the best fit of the data, distance explaining over 80% of the variation in the number of licence holders per capita taking part in this type of fishing. The model that performed the worst was the Trout Stillwater (TS) model, distance explaining 0% of the variation in licence holders who fished for trout on a stillwater. Interestingly, the transformation to semi-log form also did not improve the fit of the data in this model either, whereas it did for most of the other models[9]. The Grayling model appeared to improve the most significantly from transformation to semi-log form, going from 7 to 53% of variation explained. As an example, Figure 3 below shows (log) licence holders per capita fishing for coarse species on a river v's distance to this type of fishery.

[9] With the exception of the Coarse Stillwater model, which was made slightly worse through semi-log transformation.

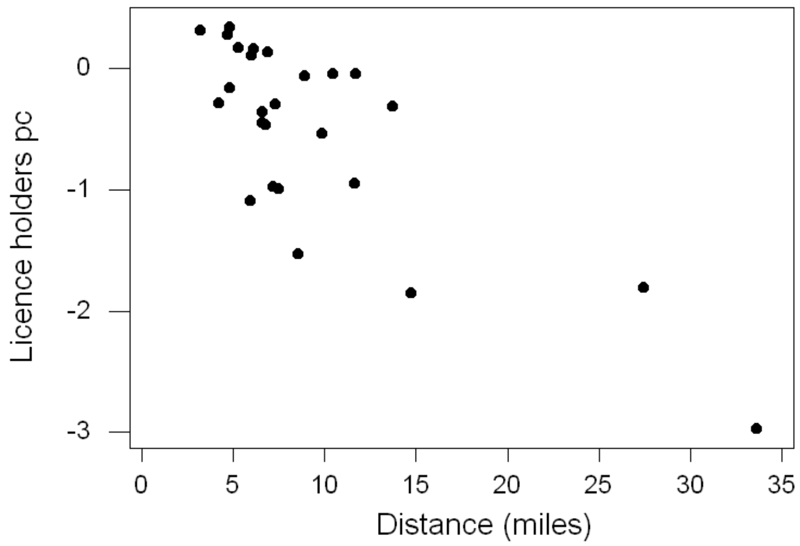

Figure 3 **Semi-log (log licence holders) versus mean distance to coarse river fishery**

2.4 Additional Analyses and Regression Diagnostics

Additional analyses that were carried out were multiple regressions[10] for both number of trips and number of licence holders; the results are presented in Appendix A. The purpose of this was to investigate whether availability of other types of fishing affected participation in each of the 7 types of fishing.

This analysis suggested that some types of fishing seemed to be substitutes for each other, for example, lower availability of salmon & sea trout fishing may result in an increase in grayling fishing. Equally, some types of fishing seemed to be complementary products, in that, as availability of one increased, participation in another also increased. This was the case, for example, for coarse river and grayling fishing. These relationships should be viewed with caution however, as the different distance variables were significantly correlated with each other (see discussion below) which could have been affecting these results.

Post analysis (using the semi-log functional form) a number of tests were carried out to assess whether the assumptions of OLS regression were violated. The variation between the distance variables for each type of fishing was assessed by creating a correlation matrix. This showed that distances to the game fisheries (migratory salmonid, grayling, trout stillwater and trout river) were significantly positively correlated with each other, and distances to coarse fisheries were similarly positively correlated with one another.

[10] Regression of mean trips or licence holders variable against all 7 distance-to-fishery variables.

The matrix also showed that distances to game fisheries were significantly negatively correlated with distances to coarse fisheries, and vice-versa. This makes sense intuitively, in that availability of coarse fishing is negatively correlated with availability of game fishing, i.e. where distances to coarse fishing are low, distances to game fishing are high, and vice-versa. This suggests that there may be multicolinearity problems with the multiple regression models (see Appendix A), so a VIF test for multicolinearity between independent variables was carried out. This test showed however that the independent variables were not significantly colinear (highest VIF was < 3.00 for all distance variables; multicolinearity is not present if VIF < 20) and therefore that this regression assumption is not broken. These results were also found to hold for the licence holder analysis described below.

The relationship between coarse and game trips and distances was also examined visually by plotting them on one graph:

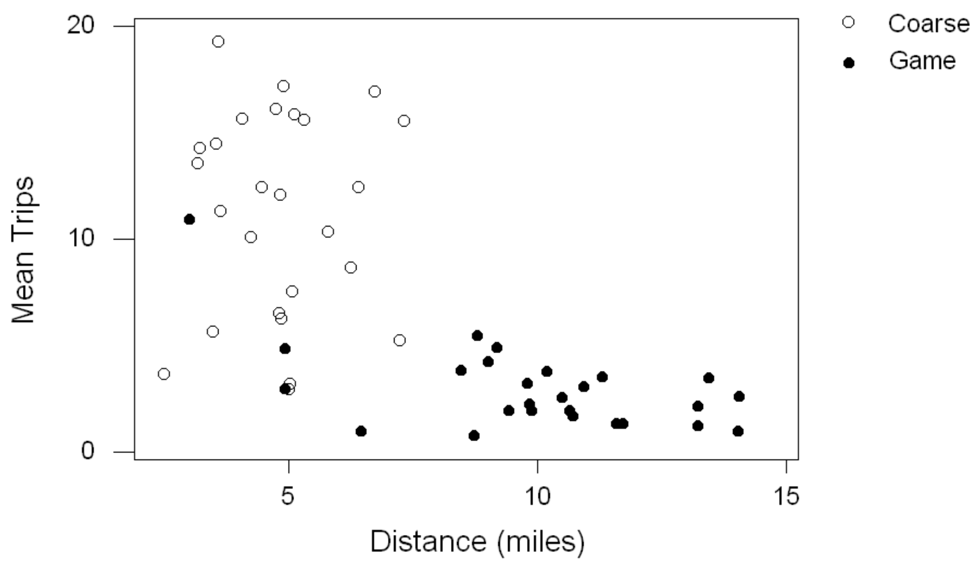

Figure 4 Comparison of mean game and coarse trips versus distance

Plots were created for each dependent variable to assess Normality of distribution; these showed that some of the variables conformed to the Normal distribution more closely than others, specifically, the grayling trips variable was most skewed.

The data were also tested for heteroskedasticity ('hettest' in statistical software package Stata) for each fishing model, and variance amongst the errors was not found to be significant, in other words heteroskedasticity was not present, in all except the coarse canal fishing model (chi-square = 14.35). In addition, residuals-versus-fitted value plots were created for each model, which is a useful way of identifying outlier values. Again, trips to grayling fisheries, and coarse canal fishing trips showed some significant outlying observations.

2.5 Conclusions

A summary of the key findings of this national-level analysis are:

- The effect of distance on numbers of trips and licence holders confirms results of previous studies and economic theory, in that it is negatively related to angling participation fisheries (as distance increases, participation decreases).

- Anglers travel significantly further to fish for migratory salmonid species than for trout and coarse.

- Distance to river fisheries is more significant in explaining both numbers of trips and numbers of licence holders per capita than distance to stillwater fisheries. This is because of the lack of variability in distance to stillwater fisheries, as the distances were all relatively short.

- The relationship between both trips and numbers of licence holders per capita and distance benefits from logarithmic transformation, suggesting that the relationships are more log-linear than linear. Thus model specification and functional form has an influence on the resulting coefficient and data fit.

- The multiple regression analysis carried out in Appendix A suggests that availability of different types of fishing interacts to affect participation, in that availability of some types of fishing decrease other 'competing' types of angling (substitute goods) and availability of some types of fishery can increase participation in other types of angling (complementary goods).

The analysis carried out at this national level has broadly demonstrated the significance of availability as measured by distance-to-fishery on demand for fishing. However, there are a number of caveats that should be borne in mind in applying the results, which centre around the potential problem of biases that arise from using means instead of the raw data. Notwithstanding the limitations of this analysis, it has provided a useful investigation into the likely relationships that can be expected, and which can now be examined in detail on an Area level for South East Wales.

3 CLASSIFICATION OF ANGLING OPPORTUNITY

3.1 Introduction

This Section introduces the variables used in this project to define the set of fishery types for which angling opportunity (availability) in South East Wales is assessed. The Section is structured as follows: Section 3.2 describes the requirements of the classification and briefly how it relates to the spatial methodology adopted in this research project. In Section 3.3 the variables used are presented, and in Section 3.4 the research methodology to be piloted is described.

3.2 Rationale for the Angling Opportunity Classification

The fishery classification used in this project is a key element in the wider geo-spatial methodology for identifying and assessing angling availability in an Area, which is piloted in this project in SE Wales. The aim of the methodology is to provide a means of evaluating the availability of a number of different types of fishery within an Area or in relation to a specific geographical district. This information will allow fisheries managers to identify the areas where creating new or regenerating existing types of fisheries will be most socially and economically productive. Increasing angling opportunity and participation will create a number of economic and potentially, ecological, benefits and contribute to the Agency's targets and objectives for enhancing inland waters and recreational opportunities.

The fishery attributes included in this classification provide the basis, in terms of data structure, for this geo-spatial methodology (outlined in Section 3.4 below and described in more detail in Section 4). The classification is therefore based on a number of angling-related variables, such as water type and fish species. To be useful to fishery managers, the fishery attributes need to both reflect the characteristics that anglers perceive and respond to, i.e. what they base their angling decisions upon, and also to contain information about the fishery that managers can use in formulating their policies. It consequently needs to be as accurate as possible, however, the information also needs to be reasonably easy (inexpensive) for Area Managers to collect. There will therefore be a trade-off between the extent and usefulness of the tool and the cost of it in terms of data gathering.

An additional consideration for this project is the use of the classification system in the angling demand models estimated in Section 5. Whilst the classification system can provide us with a large number of angling products, in other words, we can define the supply of angling opportunity on a relatively detailed level (see Figure 5 below), the use data are only broken down by broad fish species type, namely trout and coarse licences and migratory salmonid licences. Thus as the dependent variable is on a relatively coarse level, this suggests that the number of angling products should be assessed on a similar scale.

3.3 Suggested Parameters for Angling Opportunity Classification:

A. Water type – three variables

a) River
b) Stillwater
c) Canal

B. Environment – two variables

a) Urban
b) Rural

This attribute will be determined using a Geographical Information System, where fisheries that are less than 100m from an urban area are classified as 'urban' and those further than 100m from an urban area are classed as 'rural'.

C. Fish species – three variables, broken down into a number of sub-categories:

a) Migratory salmonid
   i) Salmon
   ii) Sea trout

b) Non-migratory salmonid
   i) Stocked trout
   ii) Unstocked trout
   iii) Grayling

c) Coarse
   i) General coarse
   ii) Carp
   iii) Barbel
   iv) Pike

D. Fishing method (trout fisheries) – two variables:

a) Fly only
b) Mixed method

Whilst not included in the classification, two other fishery attributes will be included as parameters in the angling demand model once the distance calculations have been carried out (the methodology for these calculations are discussed further in Section 4). These are:

Size of fishery/angling space – this will be expressed in terms of km of river bank or perimeter of stillwater. For stillwater fisheries, these data will need to be converted to perimeters of bank in kilometres from its current form as acres or kilometres square.

Price – this will be the price for a standard adult day ticket. It is envisaged that this variable will be incorporated, along with the distance (travel cost) variable, into a combined 'fishery price' variable.

The fishery classification can be applied at a number of levels. Figure 5 below shows how these four variables make up the set of potential fisheries available in an Area.

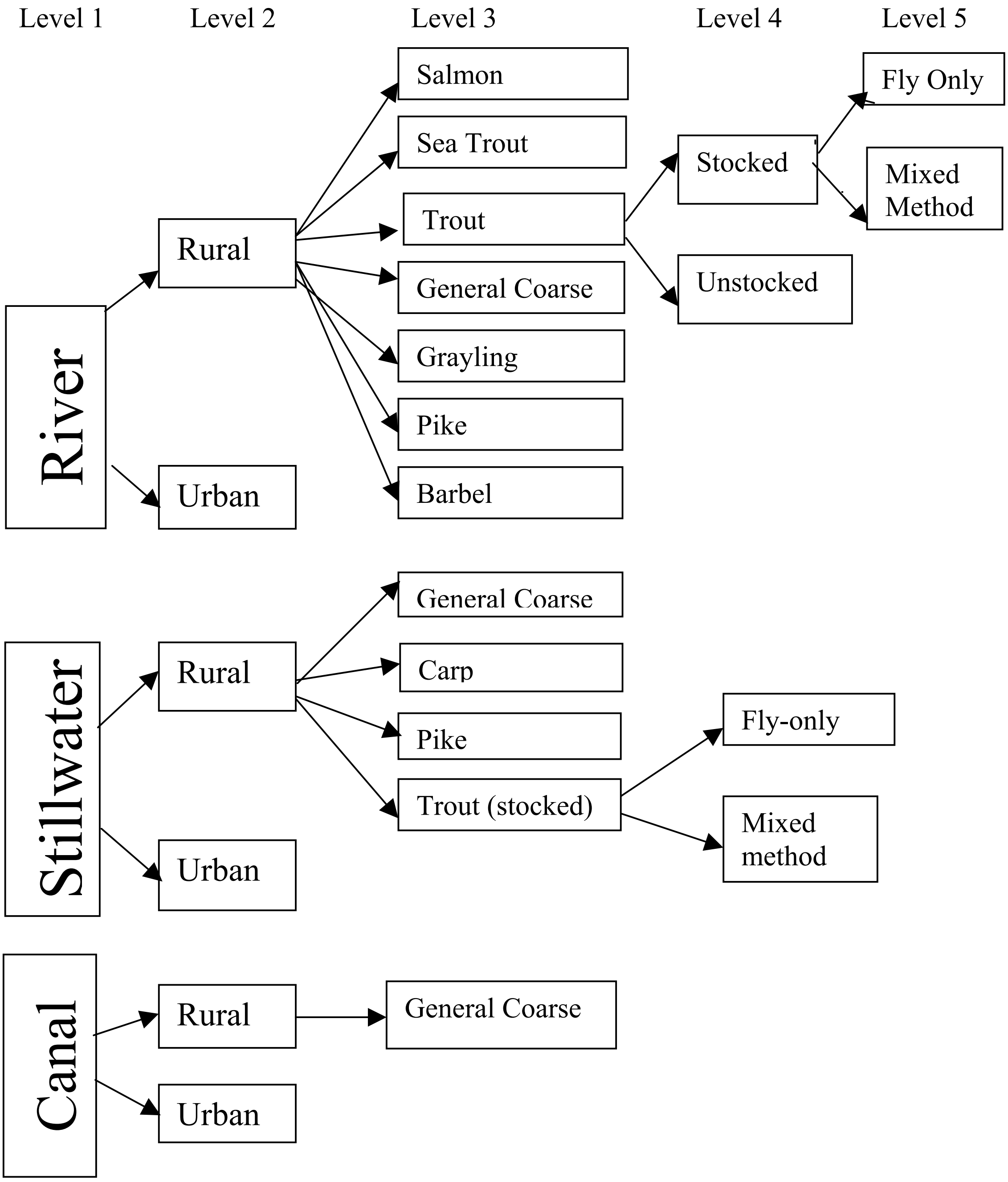

Figure 5 Angling opportunity classification system (urban arrows not shown[11])

[11] The urban fishery types are expected to be broadly similar to the rural ones, however, urban land use impacts on fisheries means that migratory salmonid populations are likely to be limited or not present.

This encompasses 22 types of river fishery, 12 types of stillwater fishery and 6 types of canal fishing, making 40 different types of fishing product in total.

Using catch data as a further classification of the fisheries was considered, but the data gathering requirements were outside of the scope of this pilot project. Whilst catch data (mean number of fish caught per angling day) are available by river, this would have meant using the river mean for each fishery on that river, which arguably would not contribute very much information, and moreover this information is only available for salmon and sea trout.

3.4 Geo-Spatial Methodology

As noted above, the aim of the methodology is to provide a means of assessing the angling opportunities in an area, both visually and quantitatively. A visual assessment of angling opportunity can be made by using a GIS to create maps showing the distribution of different types of fishery across the study area; some examples of such maps are given in Section 4. The GIS is also used in this project to provide estimates of the distances between each postcode district centroid in South East Wales and a number of different types of fishery. This is used in a number of quantitative analyses to explore distance-to-fishery and licence sales within the Area (Section 5 of this report).

A key component of this methodology/tool is a spatially referenced dataset of day ticket fisheries, in which each row is a fishery, and each of the classification variables are columns (see Figure 6 below). This fishery database will be analysed in a Geographical Information System (GIS) in conjunction with another spatially referenced dataset of licence holders and population by postcode district in South East Wales.

	Water type	**Envir.**	**Fish species**	**Fishing method**	**Size of fishery in km**	***etc…***
Fishery A	River	Urban	Salmon		2	
Fishery B etc.	Still	Rural	Brown Trout	Fly-only	5	

Figure 6 Example of the GIS database structure

The flexibility of this GIS-based methodology means that it will be possible to query the fisheries database on a number of different levels, including a very coarse or high level, for example to just select all the game, all the urban, or all the fly-only method fisheries, within an Area. Conversely, if the relevant information is available, the GIS database can also be queried to select very specific information by specifying combinations of a number of different fishery parameters, for example to select rural fly-only, or urban carp fisheries.

Thus, the level of detail in which the angling availability in an Area is assessed will be determined by how much information the GIS database contains, in other words, the more information is available, the more specific and detailed an analysis of angling opportunity the methodology can provide. The parameters or fishery attributes that will be used in this pilot project are those set out in Section 3.3 above.

Distance from postcode district centroids to fisheries can be calculated in two different ways: a) use a GIS route-finding function to calculate the least cost distance on the road network from postcode centroids to fisheries or b) use the spatial join function in a GIS to join the fisheries and postcode databases, possibly applying a 'road network factor' to account for non-straight line travel routes between these two points. Once distances between postcode centroids and fisheries have been calculated, they can then be translated into conservative travel cost estimates (e.g. 8p per km, as per Bateman *et al.*, 2003) – this would be conservative because travel cost usually includes a cost for travel time, but it would not be possible to incorporate this.

4 IDENTIFYING ANGLER OPPORTUNITY

4.1 Data Gathering

In this Section the process of collecting and generating data to be used in mapping fisheries and modelling recreation demand is described. Section 4.1 describes how the data and variables were defined and gathered; Section 4.2 gives some descriptive statistics for the study area and Section 4.3 presents preliminary and correlation analyses.

4.1.1 Fishery data

The first stage was to define the study areas. The remit of the project was to analyse the day-ticket fishing opportunities to residents of South East (SE) Wales, so day-ticket fisheries within 100km of the boundary of SE Wales were included in the study. This decision was influenced by the mean distances given in a previous angler survey[12]. The study areas were therefore South East, South West and North Wales, West Midlands (Lower and Upper Severn) and South West (North Wessex).

A spreadsheet was created for each Area into which data on fisheries in these Areas was entered. Data on fisheries in Wales already existed in a useable electronic format, it was just necessary to add variables to it (see variables i-v below). For the South West it was necessary to create a spreadsheet from scratch using the hardcopy angling guide 'Get Hooked'. The Midlands Areas held some data on fisheries but this was in a different format and had to be transformed to same format as the Wales database.

The data were arranged so that each fish species existing at a fishery was entered on a row of the spreadsheet, so each fishery occupied as many rows as it had fish species. Data obtained for each fishery included: Agency Area; National Grid Reference; name of water; name of club; location; water type; fishery type; fish species present; stocking information; size of fishery (length of bank available in kilometres); environment type; contact details; disabled access; fishing method (trout); and restrictions.

i) Grid references: this data already existed for Welsh fisheries; for Midlands fisheries, some grid references were obtained from Lower Severn Area fisheries team, the rest were found manually by searching on Google and Streetmap websites; for North Wessex fisheries, all had to be found manually using Google and Streetmap.

ii) Size of fishery (kilometres): For Wales, size information existed for 30% of the fisheries. This was then transformed into kilometres of fishery bank. For stillwaters, the circumference of the fisheries was obtained by transforming the size in acres to metres square (m^2), then using the formula 2 x pi x the squareroot of the m^2 divided by pi: $2\pi\left(\sqrt{m^2/\pi}\right)$. This will underestimate the actual sizes because the formula is based on a circle, and fisheries are unlikely to be perfectly circular in shape. Mean

[12] i.e. game fishing up to 100 miles, canal fishing up to 150 miles (Simpson & Mawle, 2001)

sizes were obtained for 6 different types of fishery: river and stillwater, broken down by coarse, mixed and game. For Midlands fisheries, the mean Welsh fishery sizes were used and for South West, size information was available from the 'Get Hooked' guide and entered at the time of input. Using the means was a practical expedient necessary for those fisheries which didn't have these data.

iii) Stocking: Information on which river fisheries were stocked on a yearly basis was gathered from the Live Fish Movement Database (LFMD) for the relevant Areas. Unfortunately there was no way to link stocking data in the LFMD to the fishery spreadsheets unless the 'applicant' field in stocking database included the name of the fishery, but quite often it only had the owner's name. In addition, the grid references did not match up. This means that it is likely that more fisheries are actually stocked than it has been possible to identify and so this will result in a higher number of apparently unstocked native trout waters (wild brown trout) than is actually the case, i.e. availability of these types of fisheries will appear higher than it is in reality.

iv) Day Ticket Price: this was obtained by phoning a sample of the main types of fishery – river coarse and game, and stillwater coarse and game – for each of the three study Areas, and then taking the average of these and using this where data were unavailable. South West Area fisheries already had most of the prices in their angling guide.

v) Urban or Rural Environment: this was obtained by identifying the fisheries in each Area that were 100m or less from an urban area polygon in a GIS. Those that were 100m or less from an urban area were classed as urban, and those that were further than this as rural. This relatively short distance was chosen in an effort to capture the most pronounced amenity impacts of urban areas, and as such it is likely to underestimate the amount of urban fisheries, and overestimate the amount of rural fisheries.

4.1.2 Rod licence data

The numbers of licences sold and licence holders by postcode district were obtained from the RAD. There are 5 measures of trout and coarse (TC) licences: numbers of full licences sold; numbers of junior licences sold; total number of licences sold; number of junior licence holders, and total numbers of licence holders. There are 3 measures of salmon and migratory trout licences: number of full licences; total number of licences sold, and number of licence holders. These raw data were transformed into numbers of licence sales/holders per capita, by dividing by the population of the postcode district. The population of each postcode district was obtained by spatial joining the postcode district layer to the census enumeration layer.

Centroids of the postcode districts were then found and compared to the enumeration layer to check whether they were approximately reflecting the centre of population of the district, and in the vast majority they were. Districts in which the centroid does not accurately reflect the population centroid will result in larger error in the estimation of angling availability. However, as this was the only the case in 8% of the dataset, this is not considered to be a significant source of error in this study.

4.1.3 Distance data

The method for calculating the distances between centres of population and fisheries was influenced by the level of disaggregation of rod licence data. Because the licence data was only available on a relatively coarse spatial scale, i.e. by postcode district, rather than by postcode sector or full postcode, it would not have been worthwhile determining precise distances between centroids and fisheries via the road network, because the centroids themselves are not precise points of origin. It was therefore considered appropriate for this pilot study to derive the straight-line distance between the postcode district centroids and fisheries, calculated by carrying out spatial joins of the postcode district centroid layer with the fisheries layer in a GIS, for each type of fishery. The 'spatial join' function joins the attributes of the fishery closest to the postcode district centroid to the postcode district layer, and gives the straight-line (Euclidean) distance between the two points. However, for comparison purposes, distances were also calculated by the road network and compared to the straight-line distances for one type of fishery, which showed that the road network distances were between 10 and 30% higher on average. In future such studies, where rod licence data is available at a finer spatial scale, it is recommended that distances are calculated using the road network, as this will give more accurate travel times and distances.

Originally it was hoped that this distance value could be weighted to reflect the number of fisheries at that distance (or approximate distance). This would have involved manually finding the number of fisheries for each of the type (between 36 – 40) and for each postcode centroid (64), i.e. more than 2300 calculations, which was not feasible within the timeframe of this pilot project.

Once the distance data had been generated for each type of fishery, the database files were exported and the relevant variables for modelling (distance, ticket price, size of fishery) were copied to a new database for analysis.

4.2 Descriptive Statistics of Study Area

This Section provides a brief description of the study area in terms of the parameters used in the angling classification set out in Section 3.

How are the types of day ticket fisheries in the study area distributed?

- 52% of fisheries are river fisheries, 42% of fisheries are stillwater fisheries and 6% are canal fisheries (Figure 7)
- 77% are rural fisheries & 23% are urban (Figure 8)
- 49% are coarse fisheries; 25% are game, and 26% are mixed (Figure 9)
- 1-2% are stocked[13] (river brown trout only)
- 6% are fly only.

[13] This will be an underestimate of the true number of stocked fisheries, as noted in Section 4.1.1 above

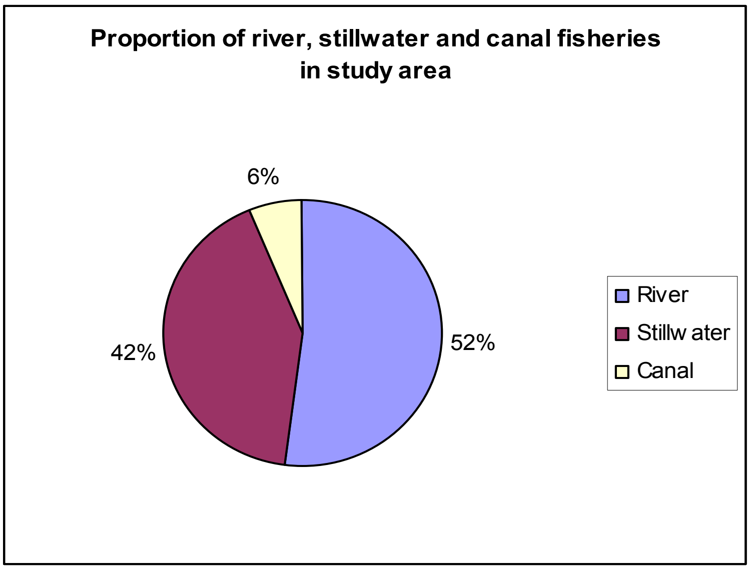

Figure 7 Percentage of different water types across study area

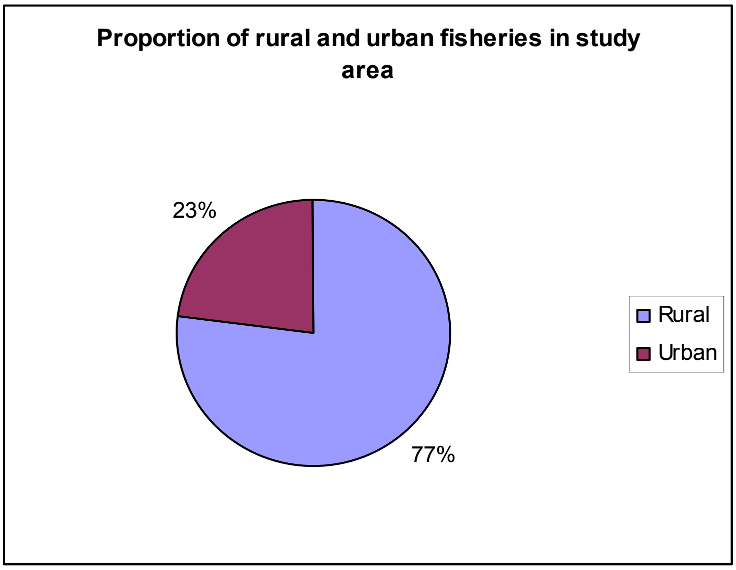

Figure 8 Percentage of rural and urban fisheries in study area

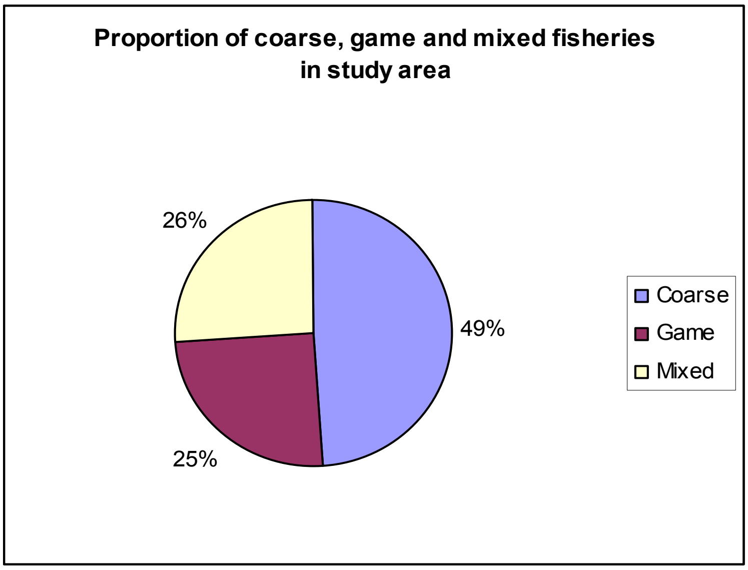

Figure 9 Percentage of fishery types in study area

Figures 10 and 11 on the following pages show maps of the distributions of coarse, game and mixed fisheries across the study area and also the distribution of river and stillwater fisheries. Figures 12 - 16 that follow show angling opportunity by postcode district in terms of the distance to the nearest type of fishery from the postcode centroid for a sample of fishing types in South East Wales. Figures 17 and 18 show graphs of the mean distances to river and stillwater fisheries.

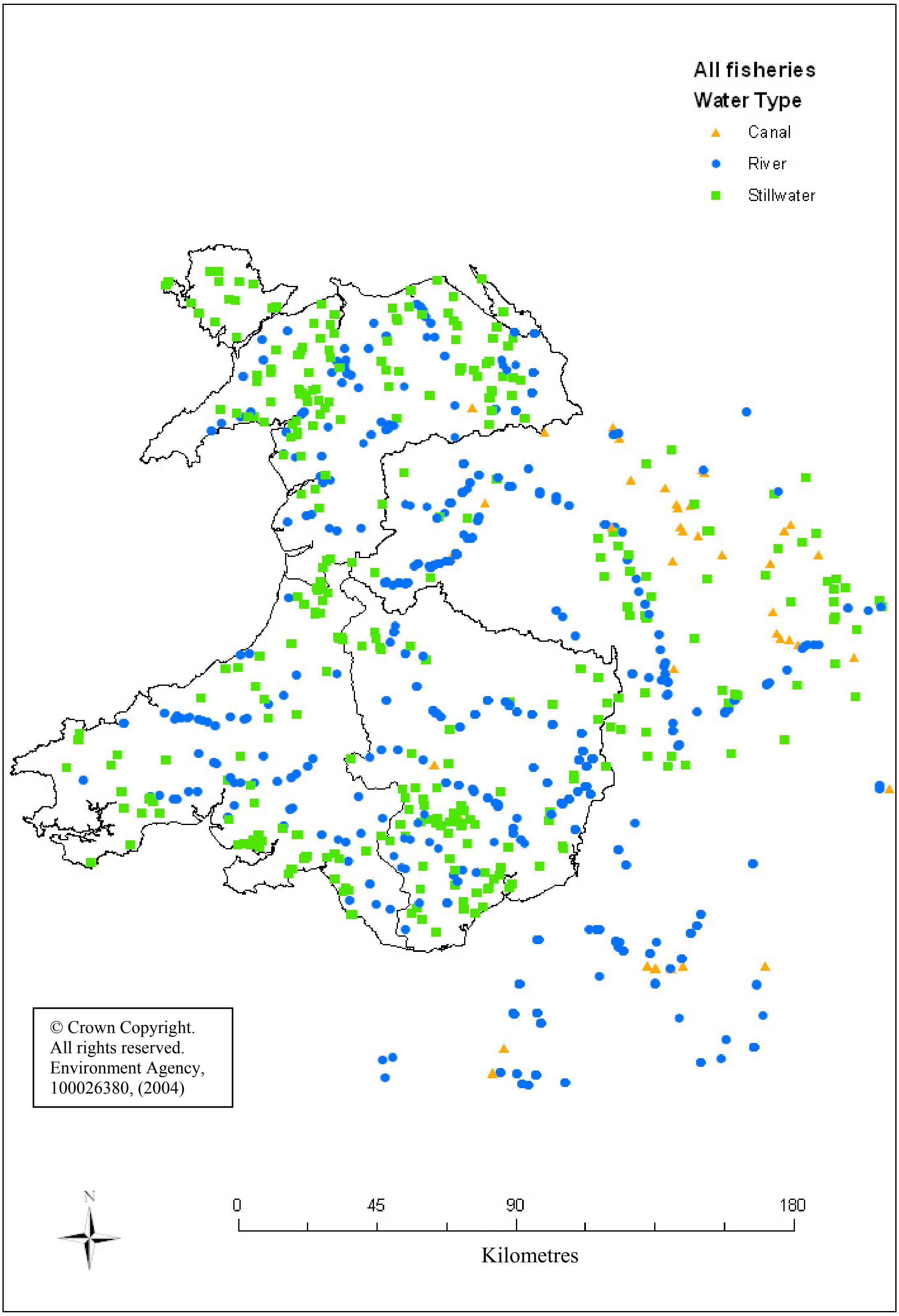

Figure 10 Map showing distribution of different types of water across the study area

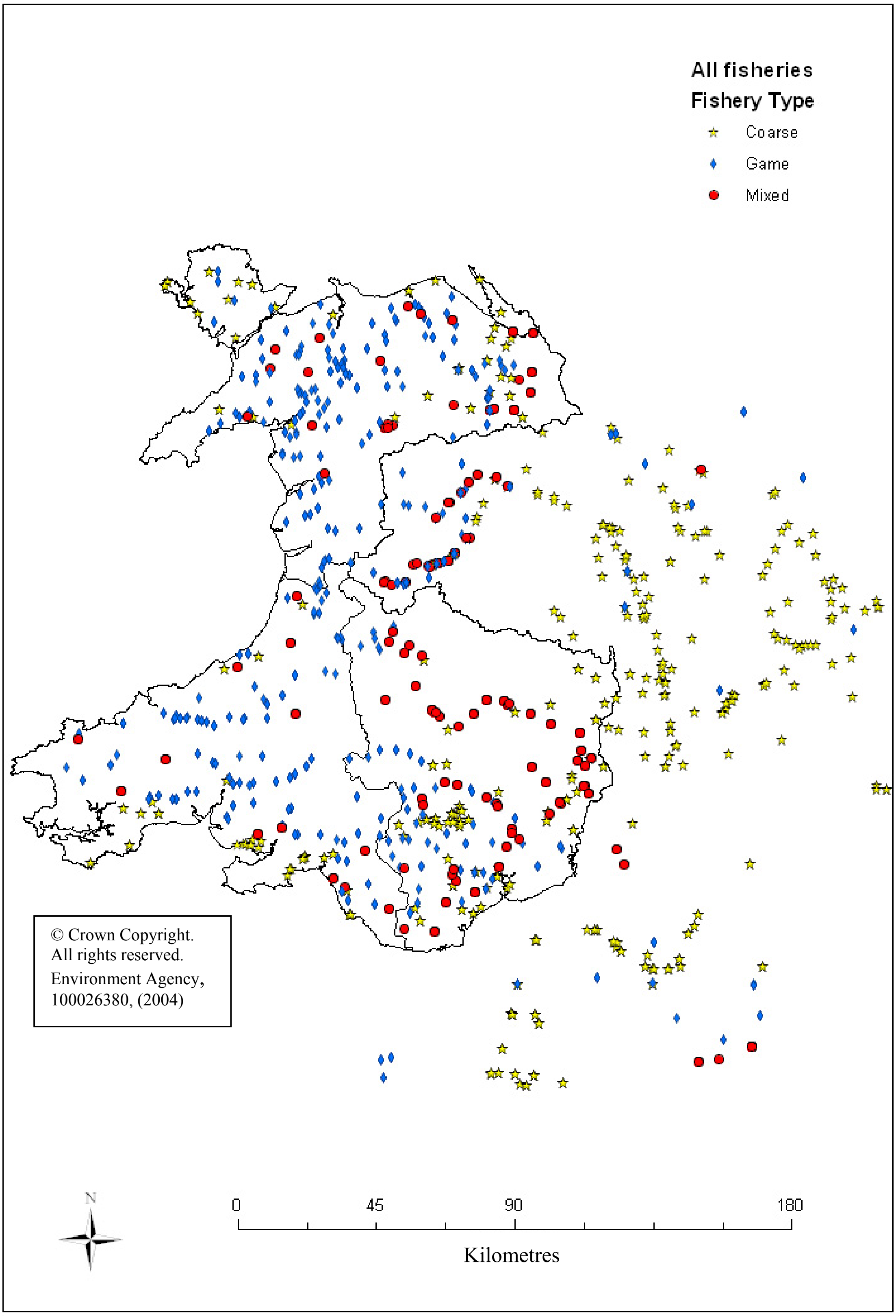

Figure 11 **Map showing distribution of different fishery types across the study area**

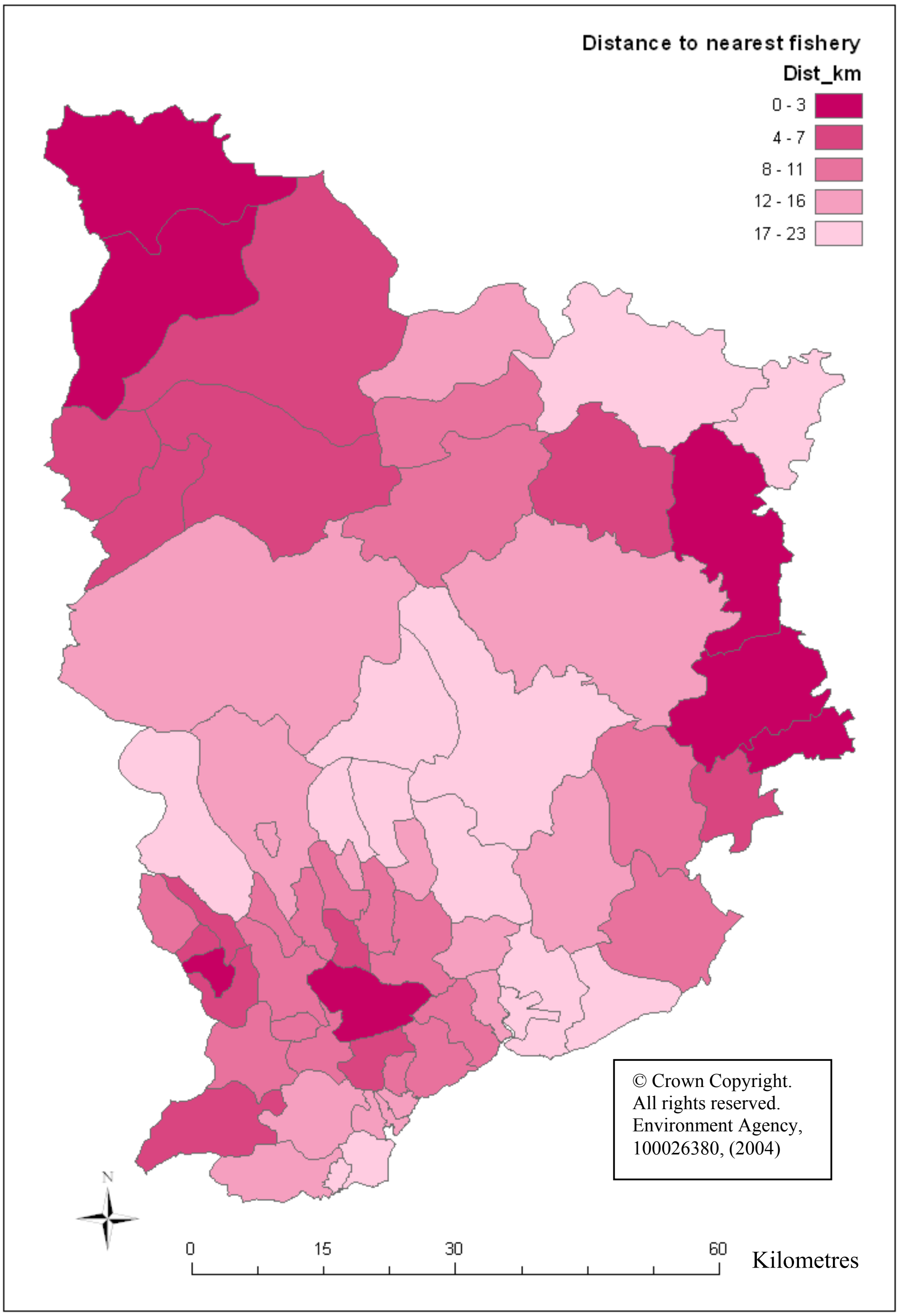

Figure 12 **Map showing the opportunity for *grayling* fishing by postcode district**

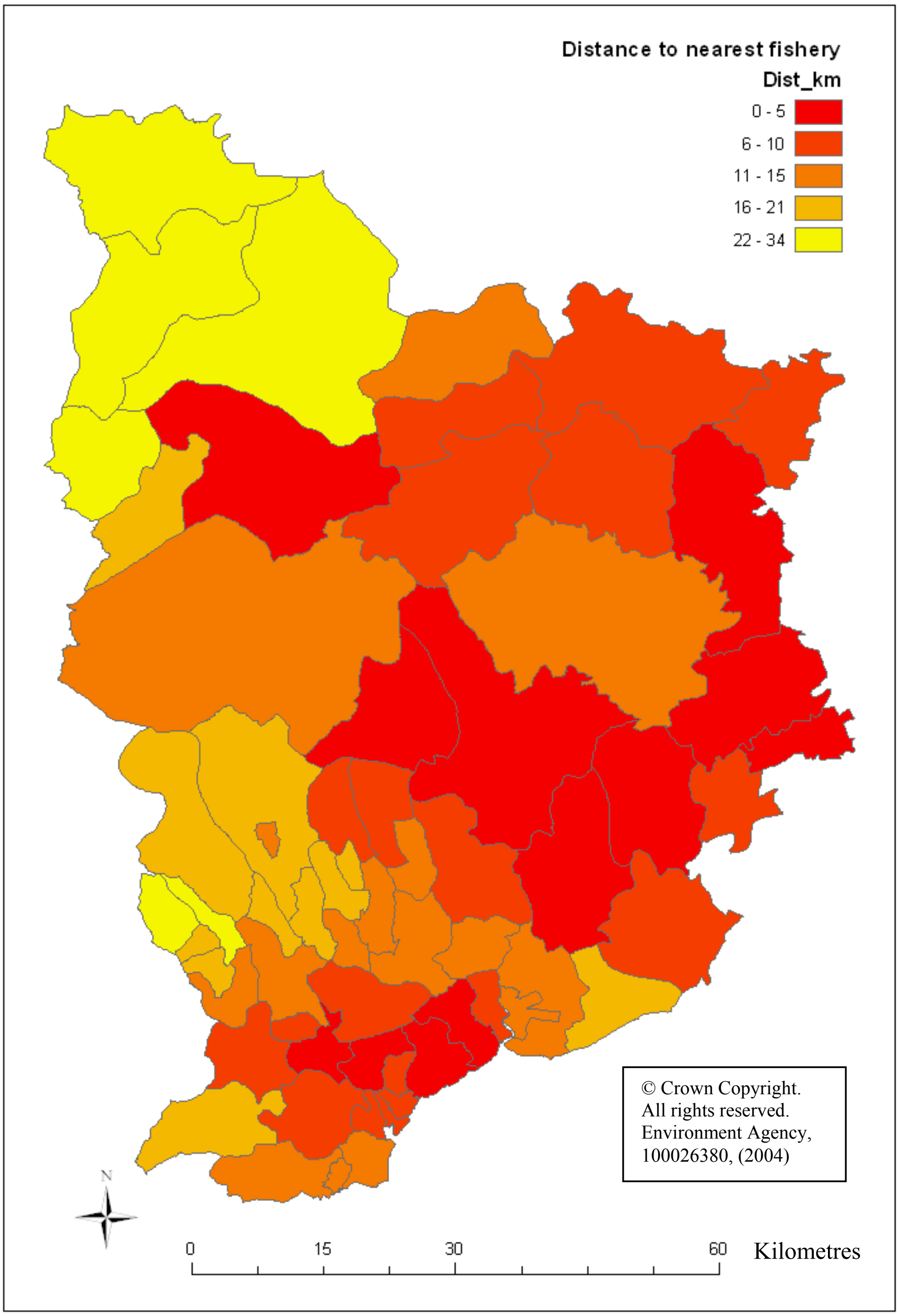

Figure 13 **Map showing the opportunity for *barbel* fishing by postcode district**

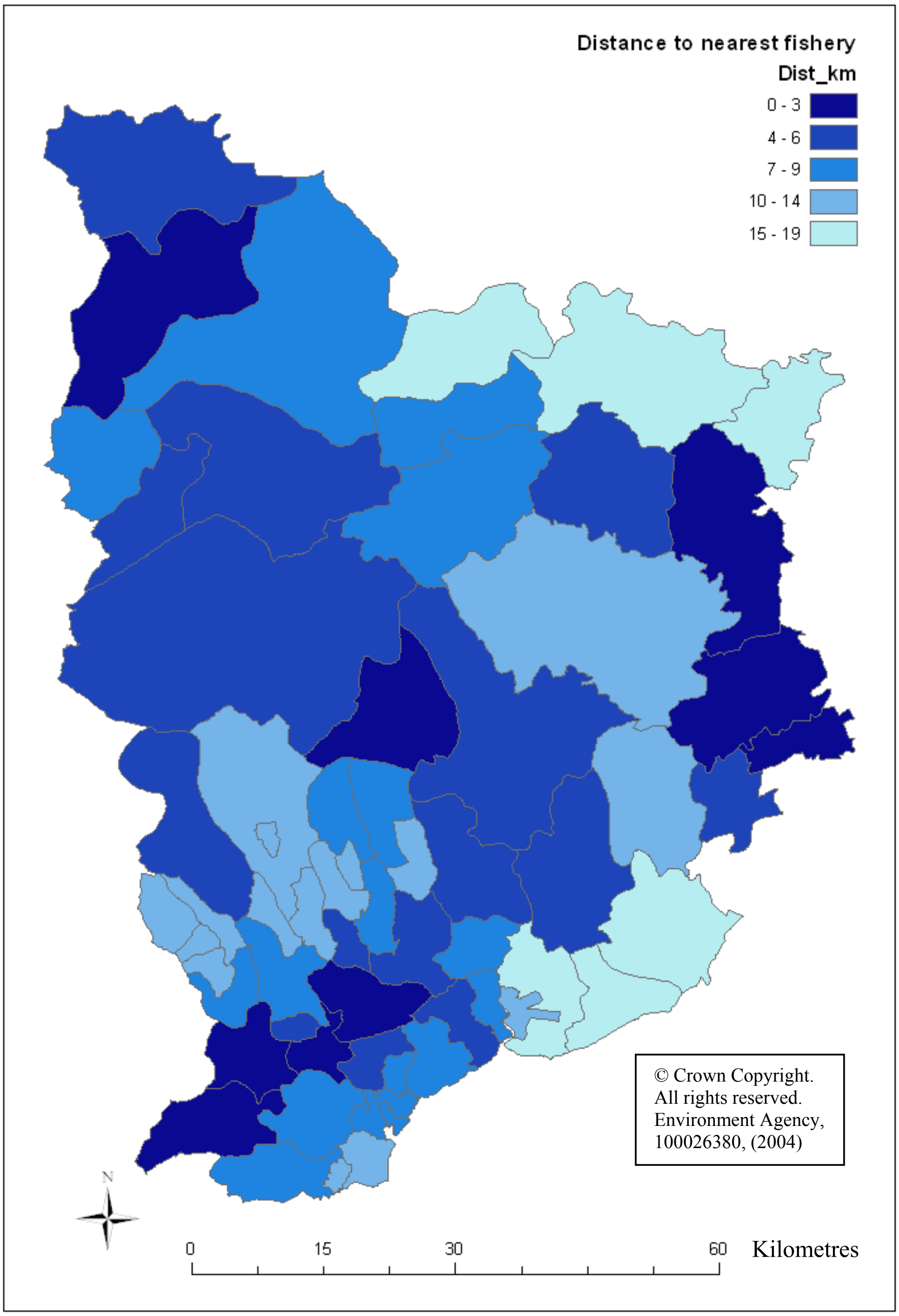

Figure 14 **Map showing the opportunity for *salmon* & *sea trout* by postcode district**

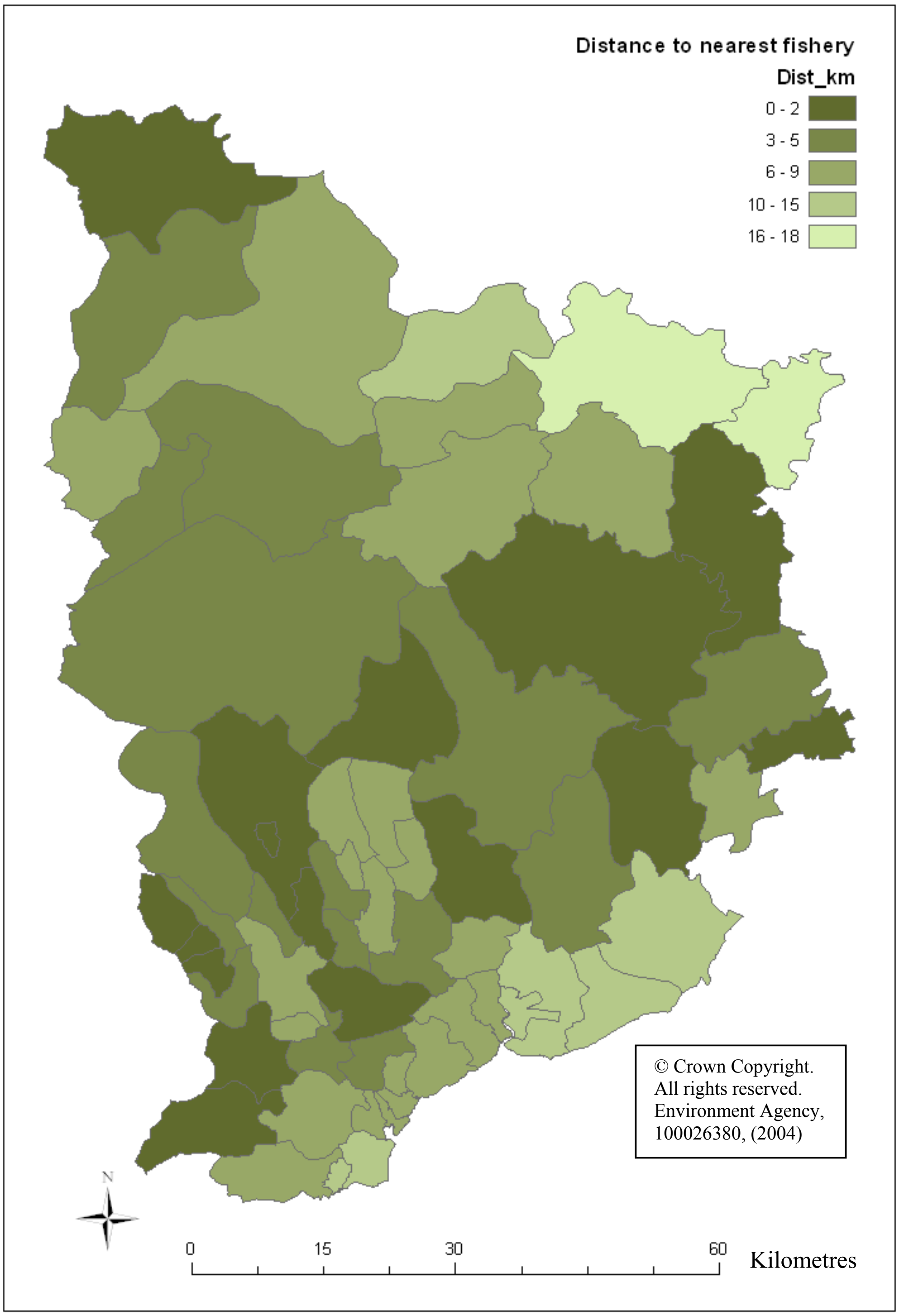

Figure 15 **Map showing the opportunity for *trout* fishing on a river by postcode district**

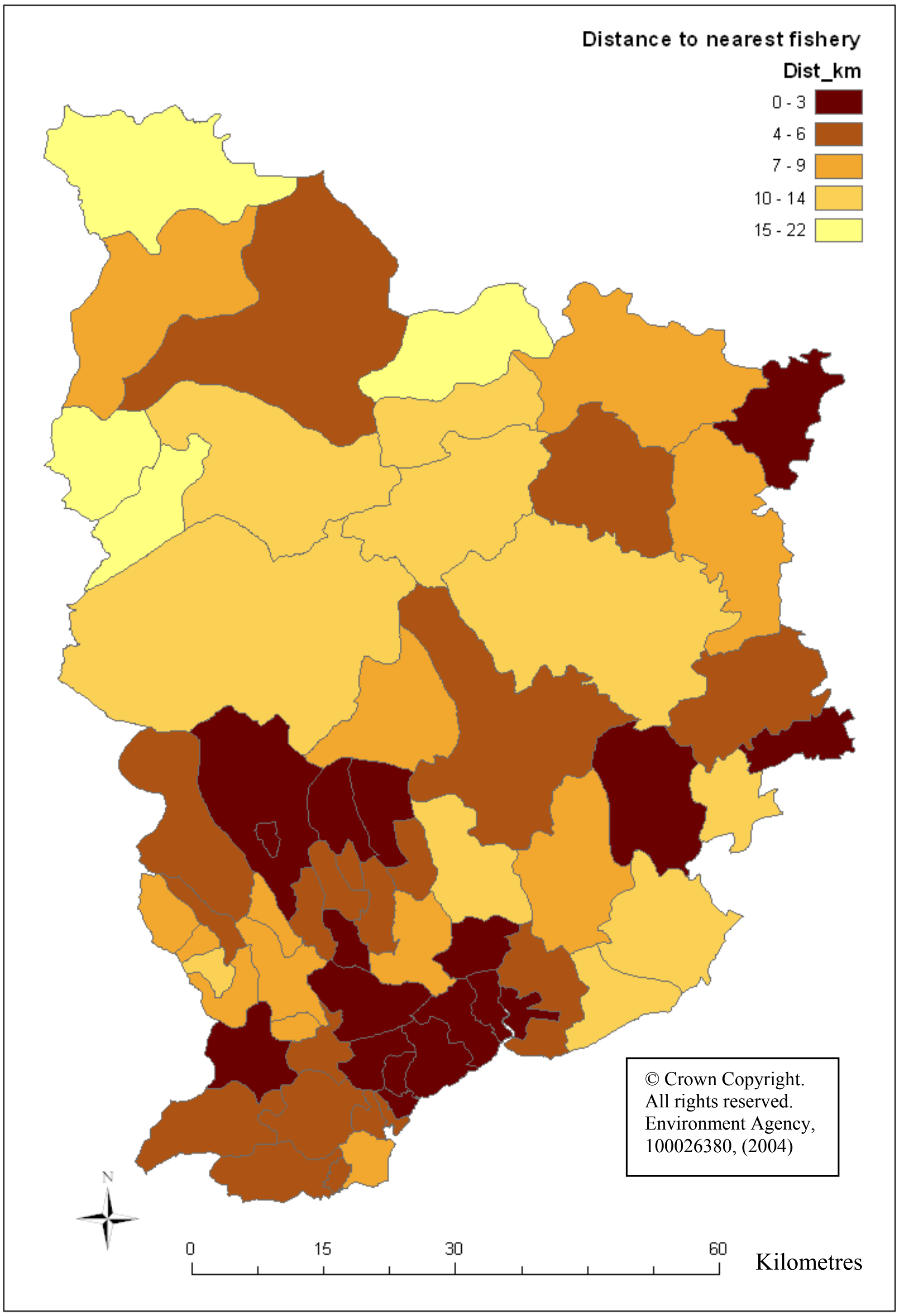

Figure 16 Map showing the opportunity for *carp* fishing by postcode district

Figures 12-16 above show that angling opportunities vary according to fishing type, and that some fishing types are much more evenly spread across the Area than others. In particular trout river, migratory salmonid and carp fishing are more widely available than barbel, grayling or migratory salmonid, which are concentrated in the mid and northern parts of the Area. An alternative way to map angling opportunity would be by the numbers of fisheries of each type of fishing by postcode district.

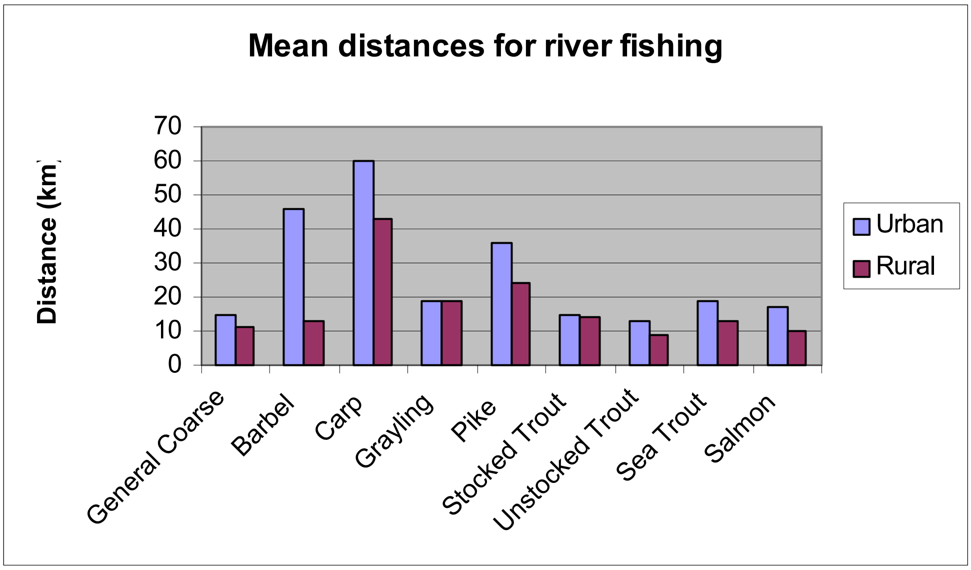

Figure 17 Average distance to river fisheries

Figures 17 and 18 show that availability of specialist river fisheries such as barbel or pike is more limited than general coarse or trout, and that in general, availability of rural fisheries is greater than urban fisheries. This is likely to be related to how the fisheries were classified as urban and rural (Section 4.1.1 p18), in that there are many more rural than urban fisheries. For river fisheries, the greatest availability (lowest mean distance) is for unstocked trout and salmon fisheries, but there is a marked difference in the mean distances to trout fisheries between rivers and stillwaters, where stillwater distances are much higher. This is likely to be particular to the South East Wales Area however, which is particularly abundant in trout river fisheries.

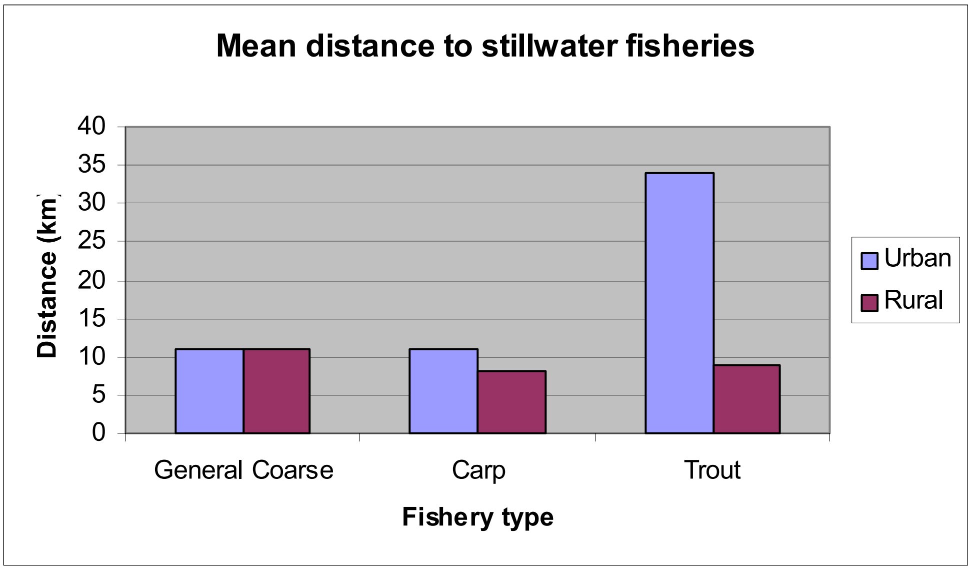

Figure 18 Average distance to stillwater fisheries[14]

4.3 Preliminary Analysis

Sections 4.3.1 and 4.3.2 below present the results of a number of correlation analyses between angling availability (distance-to-fishery) and participation (rod licences purchased).

4.3.1 Correlations and plots

Initially distance to the nearest fishery, i.e. river, stillwater or canal, coarse or game, although negative, was not significantly correlated with total number of licences sold/holders per capita (pc). The data were plotted – Figure 19 – which identified 3 main outliers which were skewing the relationship: postcode districts HR6, LD8 and LD7. These observations were identified as atypical or unusual in Minitab post-regression diagnostics; they are circled in Figures 19, 22 and 24 below.

Once these outliers were removed, distance-to-fishery was found to be significantly negatively correlated with the number of licences sold per capita[15]. This confirms expectations and is in line with economic theory, i.e. that as availability or supply of angling products increases (distance to fisheries decreases) demand increases. The correlation with these outliers in the dataset is -0.07, and without it is -0.30 (Table 3 below); the relationship was plotted again with outliers removed (Figure 20).

[14] There were fewer than 5 barbel and pike stillwater fisheries, so these types of fishery were not included.

[15] Correlation coefficients of 25% or above are significant at the 5% probability level; coefficients of 20% are significant at the 10% level for 64 observations.

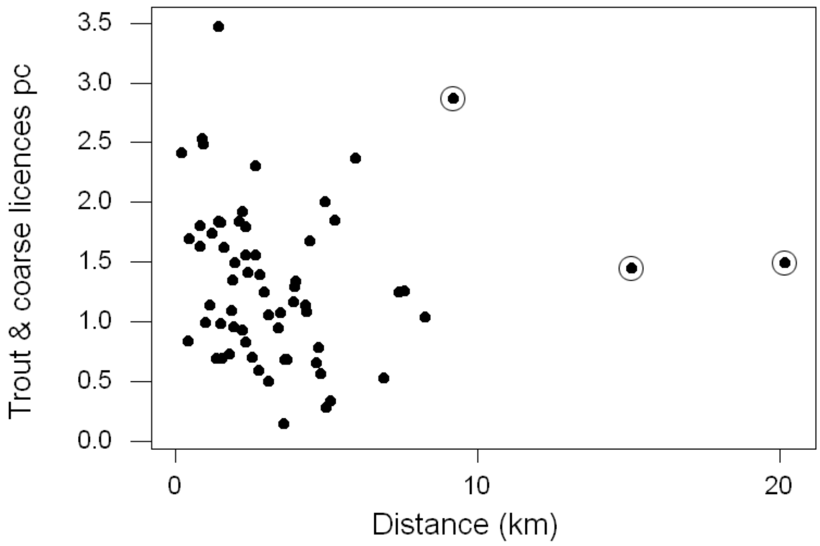

Figure 19 **Total licences sold per capita versus distance to the nearest (any type) fishery**

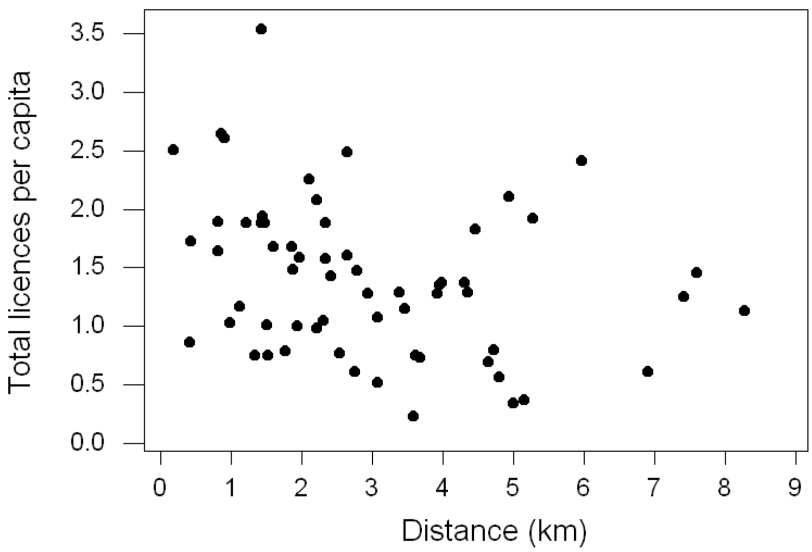

Figure 20 **Total licences sold per capita versus distance to the nearest (any type) fishery** ***– outliers removed***

Table 3 **Correlation coefficients between distance to any type of fishery and the total licences sold and total licence holders**

	Total Licences	Total Licence Holders
All data	-0.07	-0.07
Outliers removed	-0.30	-0.29

The relationship between distance to migratory salmonid and trout and coarse fisheries were also plotted, to investigate presence of outliers and get an idea of the nature of the relationships, see Figures 21 and 22 below.

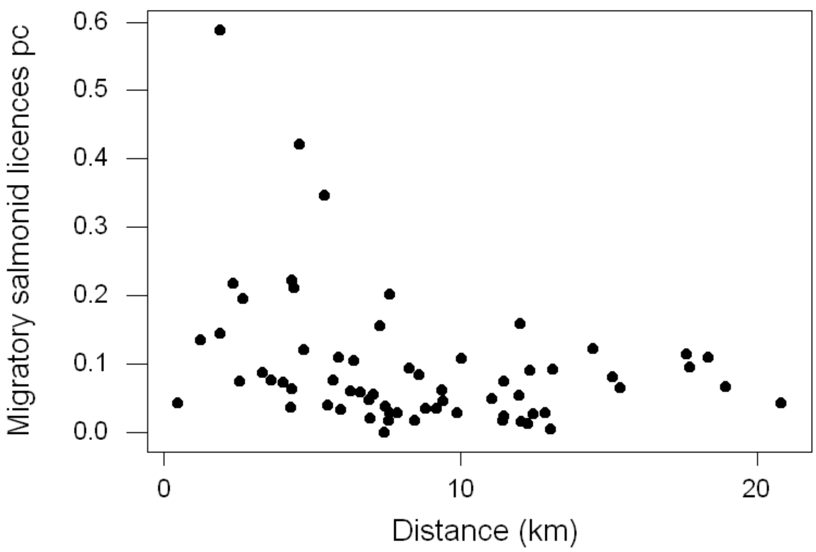

Figure 21 **Migratory salmonid (MS) licences sold per capita vs distance to the nearest MS fishery**

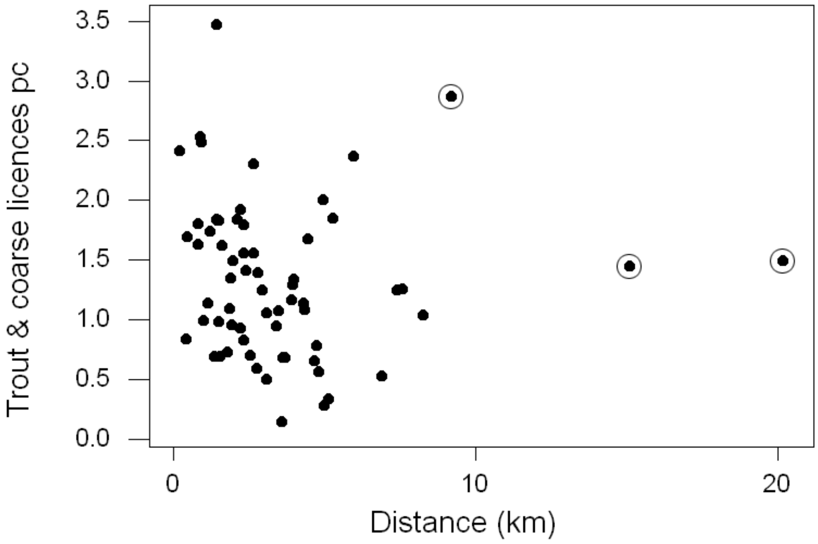

Figure 22 Trout and coarse (TC) licences sold per capita vs distance to the nearest TC fishery.

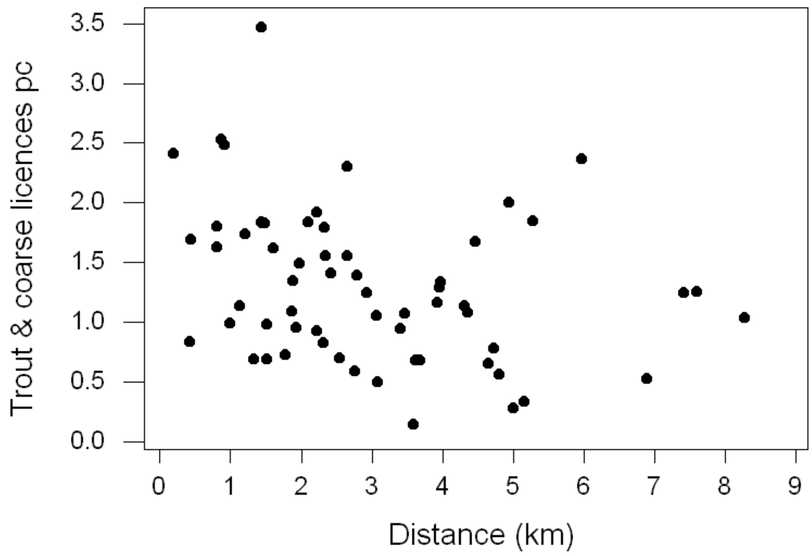

Figure 23 Trout and coarse licences sold per capita vs distance to the nearest TC fishery – *outliers removed*

With all observations included, stronger correlations (around 30%) exist between the distance to migratory salmonid fisheries and the number of licences sold/holders pc than numbers of licence holders and distance to trout and coarse fisheries. However, with outliers removed, the correlations are of a similar magnitude for both types of fishery, as shown in Tables 4 and 5 below.

Table 4 Correlation coefficients between distance to Migratory Salmonid (MS) fisheries and licences sold/holders pc

	Full Licences	All Licences	All Licence Holders
All data	-0.31	-0.33	-0.32

Table 5 Correlation coefficients between distance to Trout and Coarse (TC) fisheries and licences sold/holders pc

	Full Licences	Junior Licences	All Licences	Junior Licence Holders	All Licence Holders
All data	0.02	-0.08	-0.06	-0.10	-0.06
Outliers removed	*-0.26*	*-0.32*	*-0.37*	*-0.32*	*-0.36*

4.3.2 Correlations for specific fishery types

In this Section the results of correlation analysis between distance to specific types of fishery and licence sales/holders per capita are discussed briefly[16]. Separate correlations were carried out for any water types, river fisheries and for stillwater fisheries. Full tables showing correlation coefficients for the fishery types are given in Appendix B.

The main findings from this correlation analysis are that in general, distances to urban fisheries were found to be less significant than distances to rural fisheries; significant differences in correlations were found between adult and junior licence sales/holders, in that junior licences/holders figures are less often significant and negative (i.e. distance was not as significantly correlated with junior licences); and there were also found to be significant differences between the specific types of fishery. Differences between river and stillwater fisheries are expanded on briefly below.

i) Any type of fishery

Distance to rural salmon and sea trout fisheries was found to be negative (and significant for salmon), but distance to urban migratory salmonid (MS) fisheries was positively correlated with the licence data. Distance correlations to general coarse rural fisheries were significant and negative with 4 outliers removed (NP26, LD5, LD7 and LD8). Distance to barbel, carp and unstocked trout fisheries were the least significantly correlated with licence data and distance to pike and stocked trout fisheries were found to be the most significantly correlated with licences/holders pc.

[16] Correlation analysis was carried out for a few of the main types of fishery set out in the fishery classification (see Section 4).

ii) River fisheries

Results for migratory salmonid and grayling fisheries were the same as those for any type (as there are very few or no stillwater MS fisheries[17]). Distance to rural general coarse fisheries are correctly signed and significant with 3 outliers removed (HR6, CF46 and CF82); barbel and carp fisheries are non-significant and only numbers of adult licences are significant for distance to grayling fisheries. As with the any type of fishery correlations, stocked trout and pike are significant and negative, although pike is only significant for adult and total licences. A difference to the any type of fishery analysis is that unstocked trout is now significant (with outliers removed) for adult and all (adult and junior) licences.

iii) Stillwater fisheries

Correlations were carried out for both TC and MS stillwater fisheries, although as noted above the number of MS stillwater fisheries was very low. In general, correlations for TC stillwater fisheries were similar to the river fisheries, i.e. distance was negative and significant[18] once outliers were removed. However, the correlations for MS fisheries did not perform as expected in that distance was positive and significant. It is possible that the low number of observations for this type of fishery means that the results are not particularly robust, and as a result, no further analysis was carried out for these types of fisheries. Interestingly in contrast to river fisheries, distance to *urban* stillwater carp and general coarse were significantly negatively correlated with licence sales (with outliers removed), but distance to *rural* fisheries of this type were not. Distance to both urban and rural trout fisheries was not significantly correlated with licence sales, even with outliers removed.

Overall, there are more - almost double - the number of outliers for stillwater fisheries than for river fisheries. When stillwater fisheries are plotted (see Figure 24 below), there appear to be two 'clumps' of observations, one group which shows a good negative correlation between distance and licences, and one which is much more randomly distributed. In these latter districts, numbers of licences is high, even though distance-to-fishery is high. A possible reason for this is that there were a significant number of stillwater fisheries in the Midlands region for which grid references were not available and so were not captured in the database: therefore the distances calculated are higher than they actually are (i.e. availability is higher than it appears).

[17] There are a few natural stillwater lakes in North Wales that contain Sea Trout populations.
[18] Correlation coefficients of between 26 and 39%

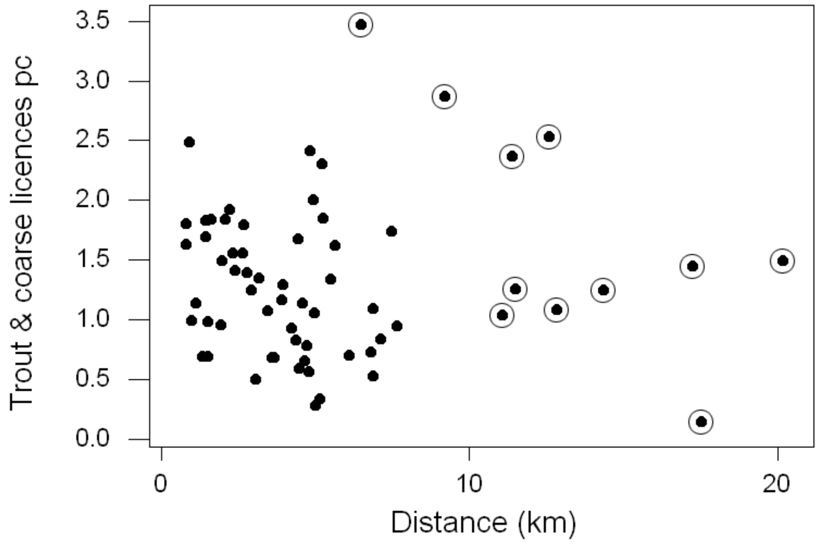

Figure 24 Trout and coarse (TC) licence holders per capita vs distance to TC stillwater fisheries

These outlier observations were investigated in a GIS and it became apparent that the outlier postcode districts were in the northern part of South East Wales (see Figure 25 below). With the exception of SY18 (top left), the other outlier postcode districts were those where the distance between the postcode centroid and stillwater fisheries was the greatest; this was also the same for river fisheries. Interestingly, 4 of these outliers (HR2, HR3, LD7 and LD8) were the postcode districts that had the poorest spatial match between postcode centroid and population centroid, so these outliers may also be related to methodological inaccuracies.

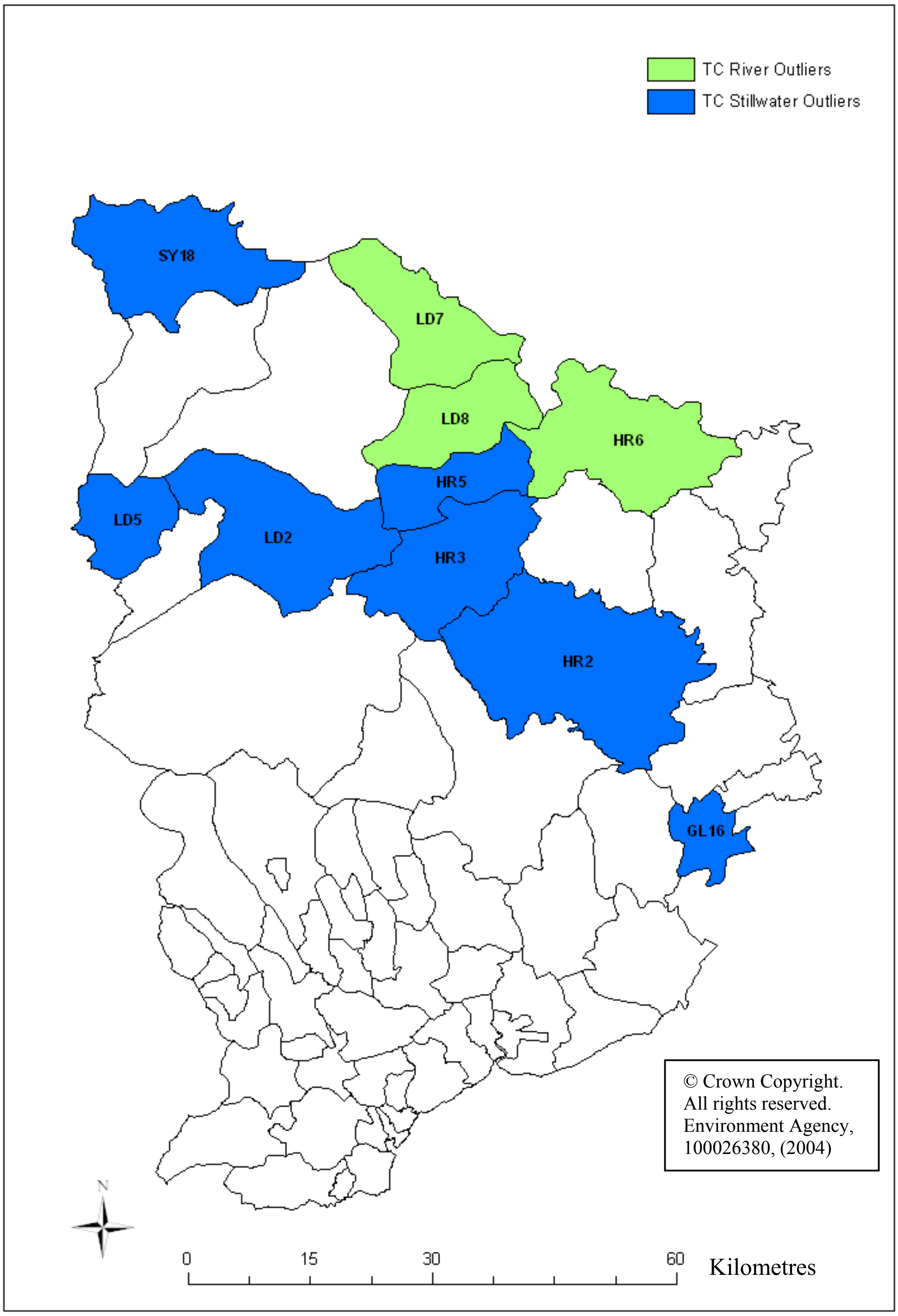

Figure 25 **Map showing the river and stillwater outlier postcode districts in the study area**

Another possible reason why these are outliers, i.e. no fisheries identified in the areas but demand, in terms of numbers of licences, is still high, is that anglers in these districts travel outside the study Area (for example into Lower Severn Area) to fish.

4.4 Conclusions

There are a number of sources of potential error that suggest that strong relationships between availability, as measured by distance, and demand, as measured by numbers of licences sold/licence holders per capita, are unlikely to be found. Error is likely to arise from:

- the imperfect alignment of postcode district centroids and actual centres of population
- the fact that the influence of distance on demand will be underestimated because it is a straight-line distance, rather than using the road network.
- the fact that only a partial measure of availability is being used, i.e. distance to nearest fishery, and not including the number of fisheries at this distance.
- population is an overestimate for each postcode district, because of the way it is calculated in Arcview.

In light of these inherent sources of error in the dataset, the fact that distance is found to be consistently negatively, and for most types of fishing significantly (once outliers are removed), correlated with demand for licences, is encouraging and suggests that the ‘true’ relationships are strong. In the following Section these relationships are analysed in more detail.

5 MODELLING DEMAND FOR ANGLING IN S.E. WALES

In this Section, the relationship between angling availability and demand for anglers in South East Wales is analysed, and some quantitative estimates of the effect of availability on numbers of rod licences are presented. Section 5.1 describes the aims of the analysis; in Section 5.2 the models to be tested are set out and Section 5.3 presents the model results; Section 5.4 shows how the results could be applied and Section 5.5 offers some concluding remarks on the results of the analysis.

5.1 Study Aims and Research Questions

The overall research question to be investigated is whether greater availability of fishing products increases demand for fishing. The specific research questions to be answered are:

a) Whether the number of trout and coarse fishing licences[19] bought in a region is related to the availability of that type of fishery;

b) Whether the number of migratory salmonid fishing licences bought in a region is related to the availability of that type of fishery.

Compared to trout and coarse, there are relatively few day ticket migratory salmonid fisheries, therefore distances will be greater, so we would expect demand to be lower for this type of fishing.

5.2 Defining Angling Availability

Angling availability or opportunity can be expressed in a number of ways, for example as the number of fisheries in a region, distance to fishery, amount of 'angling space' at a fishery, cost of entry to fishery or indeed a combination of any of these variables. In this research project, three aspects of availability are included: distance-to-fishery, size (in kilometres) of fishery bank and price of day fishing ticket. An aggregate variable for availability was also created, which was specified as distance converted into travel cost[20] combined with ticket cost, called 'Cost'. Economic theory and previous studies predict that distance/travel cost and ticket cost will be negatively related to measures of use. We would also expect size of fishery to be positively related to number of licences sold/holders per capita, i.e. that as the amount of 'angling space' increases then this stimulates demand for fishing.

How many versions of availability to use?

Model 1: using the basic distance variable

$$L = a + {}_{\beta}D + {}_{\gamma}P + {}_{\delta}S \qquad (1)$$

[19] Initially it was proposed to look separately at how availability affected the number of junior licences as well as adult licences, but this was not possible within the limited timeframe of this pilot study.
[20] By multiplying the number of kilometres by 8 pence per kilometre.

Model 2: using an aggregate variable of travel cost plus ticket price

$$L = a + {}_{\beta}C + {}_{\delta}S \qquad (2)$$

Where L = the number of licences per capita (trout & coarse or migratory salmonid); D = distance between postcode district centroid and fishery; P = standard adult day ticket price; C = travel cost plus ticket price; S = size of fishery (kms), and β, γ and δ are coefficients.

It should be noted that no measures of fishery 'quality', in terms of ecological productivity such as catch rate, species richness etc. or site amenities, such as aesthetic quality of site or ease of access are included in the models. Previous research[21] suggests that these can be important factors in angling participation, and therefore the models are not expected to explain a high proportion of the variance in the licence data.

5.3 Model Results

In this Section, the results of models 1 and 2 set out above are presented. The analysis was carried out for the broad fishery types, and not for each separate fishery type set out in the fishery classification (Section 3), as the timescale for this pilot project did not permit this more in-depth analysis. Consequently, it should be noted that applying the model to each fishery type described in the classification would be a valuable exercise, and relatively straight-forward area for further research effort.

The rest of this Section is as follows: Section 5.3.1 describes the results for any type of fishery, any migratory salmonid (MS) and any trout and coarse (TC) fishery, and then the following Section describes the results of model 1 for the two main water types in the study area, rivers and stillwaters. Section 5.3.3 presents the results using Generalised Linear Models. The response variable is total (adult and junior) number of licences sold per capita in the OLS models, except 'Any type', which uses the total (sum TC and MS) licences sold per capita. The outliers identified in the previous section have been omitted.

5.3.1 Results for nearest (any) fishery, any MS and any TC fisheries

Table 6 and 7 below show a summary of the results of models 1 and 2 for the above types of fisheries using OLS regression. Following the success of the semi-log form in the national level analysis in Section 2, the models were also run with the dependent variable (licences sold per capita) in log form. Transforming the dependent variable can help the data conform to the regression assumptions, i.e. that the data follow a straight line, and are symmetrically distributed above and below the regression line. In all three cases this significantly reduces the goodness of fit of the models, showing that the licences sold per capita variable does not benefit from logarithmic transformation, i.e. is not particularly non-normally distributed.

[21] G.W. Mawle (1984) "The Demand in South Wales for Trout Fishing in Stillwaters", Unpublished Report, Part of PhD Thesis 'Angling in South Wales', University of Wales; and C.A. Johnstone (2004) "An Ecological and Economic Approach to Valuing River Quality", PhD Thesis, University of Bath.

The models were also run with the independent variables in log form (see Figures 26 and 27 below), which can help them conform to the straight-line assumption. This improved the fit of the models from both the linear and the semi-log dependent variable versions, suggesting that in their original form the distance data do not follow a straight line, which is as expected.

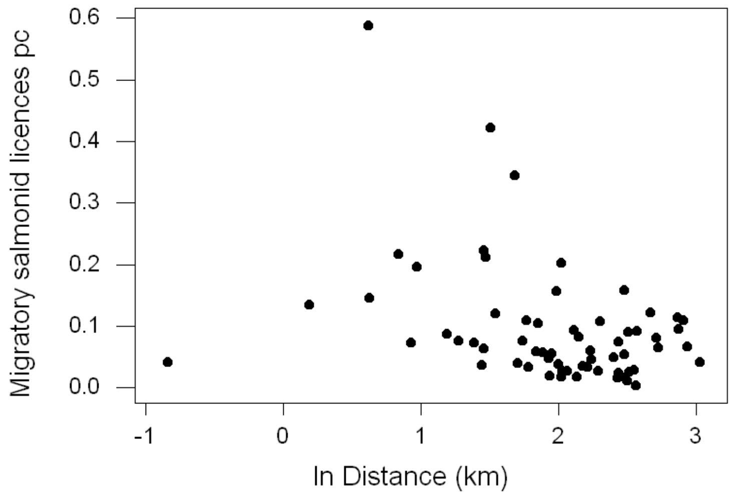

Figure 26 Plot showing migratory salmonid licences per capita vs the log of distance

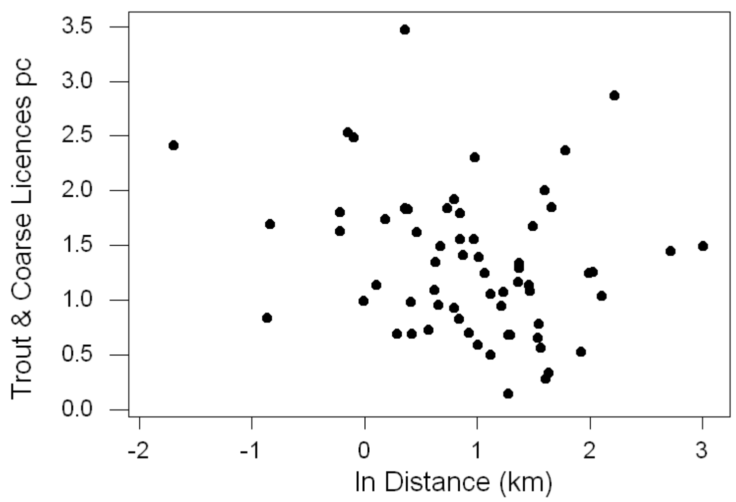

Figure 27 Plot showing trout and coarse licences per capita vs the log of distance

The results for the linear versions of model 1 show that for a unit increase (1 km) in distance, the number of licences sold per capita decreases by 1% for migratory salmonid licences or 10% for trout and coarse licences. The semi-log versions show that the same increase in log distance decreases the number of licences sold per capita by between 5 and 32%; and the semi-log (log dependent variable) that a 1km increase in distance decreases log licences by between 4 and 31%; however, the low explanatory power of these models mean that these coefficients should not be used as predictors of angling participation.

Table 6 Summary of results for model 1; semi-log is log licence holders per capita

Fishery Type	Functional Form	Distance coefficient	Ticket price coeff.	Size co-efficient	Adjusted R^2	F-stat
Any type	Linear	-0.10**	-0.02	0.04	9.50	3.11
	Semi-log (log indep vars)	-0.31***	-0.18	0.05	11.5	3.59
	Semi-log (log dep var)	-0.08	-0.01	0.02	0.05	2.19
Any MS (obs = 63)	Linear	-0.01***	-0.003	-0.002	11.90	3.84
	Semi-log (log indep vars)	-0.05***	-0.02	-0.02	16.8	5.26
	Semi-log (log dep var)	-0.04	-0.02	0.02	0.0	0.17
Any TC (obs = 61)	Linear	-0.10**	-0.02	0.04	9.20	3.03
	Semi-log (log indep vars)	-0.32***	-0.17	0.04	12.1	3.74
	Semi-log (log dep var)	-0.31	-2.80	0.02	3.6	1.55

*** T stat significant at the 99% probability level or higher ** at the 95% level * at the 90% level

Table 7 Summary of results for model 2

Fishery Type	Functional Form	Cost coefficient	Size coefficient	Adjusted R^2	F-stat
Any type	Linear	-0.02	0.05	3.1	1.97
	Semi-log (log indep vars)	-0.19	0.09	0.07	1.21
	Semi-log (log dep var)	-0.01	0.03	-0.01	0.80
Any MS	Linear	-0.004	-0.002	2.8	1.91
	Semi-log (log indep vars)	-0.03	-0.02	5.6	2.85
	Semi-log (log dep var)	-0.02	0.00	-0.03	0.07
Any TC	Linear	-0.02	0.05	2.5	1.76
	Semi-log (log indep vars)	-0.16	0.07	0.00	1.00
	Semi-log (log dep var)	-0.01	0.03	-0.01	0.59

*** T stat significant at the 99% probability level or higher ** at the 95% level * at the 90% level

Model 1 performs better than model 2 in terms of significance of explanatory variables and adjusted R^2. Model 2, which combines the travel cost and ticket price variables, is non-significant for all three types of fishery. This is because the ticket price variable, although correctly signed (i.e. negative) is non-significant, so adding it to the distance variable results in the aggregate variable 'Cost' being non-significant. The reason for this is that ticket price dominates the effect, as in this sample, ticket price is much greater than travel cost.

The smaller coefficients from the MS models suggest that distance has less of an influence on licence sales for these types of fisheries than for TC fisheries. This implies that demand for MS fisheries is less affected by availability and that anglers are more willing to travel further to fish for migratory salmonid species than for coarse or trout species.

The results for the size-of-fishery variable are slightly disappointing in that although it is positively signed for any type and TC fisheries it is non significant, and furthermore it is incorrectly signed and non-significant for MS fisheries. For 'any type of fishery' models, the size variable is positive because of the predominance of TC type fisheries in the dataset (twice as many TC as MS). However, given that for many fisheries (36%), size information was not available and mean sizes had to be used, this result is perhaps unsurprising. This is also likely to be the reason that the ticket price variable is correctly signed (negative) but non-significant, as mean values were also used where data was missing for this variable (75%).

The F-stat is significant at the 95% probability level or higher for model 1 but not for model 2. The relatively low adjusted R^2 of the OLS models (between 0 and 17% for model 1) supports this. Adjusted R^2 for previous revealed preference recreation demand models range from 14-22% (Hanley et al., 2001), 26-36% (Willis & Garrod, 1991) and 36-44% (Sorg & Loomis, 1986).

5.3.2 River and stillwater fisheries

Results for model 1 are shown for TC and MS river fisheries and TC stillwater in Table 8 below. As above, the dependent variable is all (adult and junior) licences sold per capita; the semi-log versions are the log of the independent variables.

Table 8 Summary of results for model 1 – River and Stillwater fisheries

Fishery Type	Functional Form	Distance coefficient	Ticket price coeff.	Size co-efficient	Adjusted R^2	F-stat
River TC	Linear	-0.06**	-0.004	0.03	8.4	2.80
	Semi-log	-0.04**	0.01	0.02	8.1	2.75
River MS	Linear	-0.01***	-0.003	-0.002	12.3	3.84
	Semi-log	-0.04	-0.02	0.00	-0.04	0.17
Stillwater TC	Linear	-0.07**	-0.01	-0.07	13.0	3.65
	Semi-log	-0.11***	-0.00	-0.03	23.6	6.47

*** T stat significant at the 99% probability level or higher ** at the 95% level * at the 90% level

The linear model predicts a 6-7% decrease in licence sales per capita for a 1km increase in distance for TC fisheries. The stillwater coefficient is slightly higher than for river fisheries, suggesting that distance to stillwater fisheries has a slightly greater affect on licence sales than distance to river fisheries, although this is not statistically significant. Distance to MS fisheries is estimated to reduce licence sales per capita by 1% for the same unit increase in distance.

The other difference between stillwater and river TC fisheries is that the size-of-fishery variable is negatively related to numbers of licences sold for stillwaters, where we would expect it to be positive. A possible explanation of this might be that larger fisheries are located away from centres of population (where licence sales pc are high), thus resulting in a negative relationship. This is plausible considering town waters are more likely to be smaller and the larger reservoirs will be in rural areas.

5.3.3 Generalised Linear Models

As the results of OLS regressions were rather disappointing, model 1 was run for the same types of fisheries using a Generalised Linear Model (GLM) to see if this produced better results. With GLM the distribution of the dependent variable can be explicitly non-normal and is not assumed to be continuous, which is useful where the dependent variable is discrete or as counts. As the licence data in its raw form is essentially count data (numbers of licences sold per postcode district), the Poisson distribution, which is often used for count data, was appropriate for this model. The population variable was then used as a right-hand-side explanatory variable in the equations. GLMs also have an advantage over OLS where variables have to be transformed logarithmically before regression, in that the transformation is 'built in' to the model in a 'link function', which can be specified as log, logit, etc. The model was therefore specified as a Poisson distribution with a log link function:[22]

$$L = g\ ({}_{\alpha} + {}_{\beta}D + {}_{\gamma}P + {}_{\delta}S) + \varepsilon \qquad (3)$$

Where g is the inverse of the link function (so with a log link function, g is the antilog) and ε is the error term. As with the OLS regressions, the dependent variable 'L' was all (adult and junior) licences sold per postcode district, except as the 'raw' numbers of licences instead of licences per capita. The results of the GLM models for any TC and any MS fisheries are shown in Table 9 below; and for river and stillwater fisheries in Table 10.

Table 9 Summary of the results of GLM regression of model 1 for the nearest (any type) TC or MS fisheries

Fishery Type	Distance coeff.	Ticket pr. coeff.	Size coeff.	LnPop. coeff.	Adj. R^2	Dev.*	LL**
Any (obs = 61)	-0.09	-0.01	0.03	0.78	65	3492	-1973
Any TC (obs = 61)	-0.10	-0.01	0.03	0.82	65	3454	-1952
Any MS (obs = 64)	-0.06	-0.03	-0.03	0.45	27	569	-427

* Deviance
** Log-likelihood

[22] The log-link function affects just the response variable, so is 'equivalent' to a semi-log OLS with the dependent variable in log form.

Table 10 Summary of the results of GLM regression of model 1 for river and stillwater TC and MS fisheries

Fishery Type	Distance coeff.	Ticket pr. coeff.	Size coeff.	LnPop. coeff.	Adj. R^2	Dev.*	LL**
River TC (obs = 60)	-0.05	0.01	0.02	0.90	66	3340	-1891
River MS (obs = 64)	-0.06	-0.03	-0.03	0.45	27	569	-427
Stillwater TC (obs = 54)	-0.04	-0.01	-0.03	0.79	55	3306	-1855

* Deviance
** Log-likelihood

All of the coefficients were highly significant (p level of 99.9% or higher) in the GLMs, and the adjusted R^2 are markedly higher than the OLS versions, particularly for the TC models.

The models show that a 1 kilometre increase in distance to trout and coarse fisheries results in a decrease of between 4 and 10% (depending on type of fishery) in number of licences sold. For migratory salmonid fisheries, the decrease in the number of licences sold is 6%. Interestingly the trout and coarse and migratory salmonid distance coefficients are very similar in size (4-5 and 6), in contrast to the OLS models which showed a marked difference between these two types of fisheries (10 and 1).

A further difference between the OLS and GLM regressions, was that the ticket price coefficient is positive for TC river fisheries using GLM, where we would expect it to be negative. The ticket price coefficient is correctly signed for stillwater fisheries in the GLM regression however. Also, in the Generalised Linear models the size-of-fishery variable is significant, although it is still negative in the MS and TC stillwater models.

5.4 Applying the Model Results

In this Section, an example is presented illustrating how the model results could be applied using a GIS to estimate how the creation of a day-ticket fishery is likely to affect numbers of licence holders. The first stage is to identify which type of fishery is least available, and pick a possible location for the new fishery - in this example, the creation of a new day-ticket (publicly accessible) brown trout fishery on the River Rhymney on the edge of Cardiff is modelled. Figure 28 below shows postcode districts shaded to show population densities, existing trout fisheries (blue dots) and the river network for part of the study area. The yellow dot shows the site of the potential new day-ticket brown trout fishery. The stretch was classified as GQA Biological grade C in 2000, which is described as ‘fairly good’.

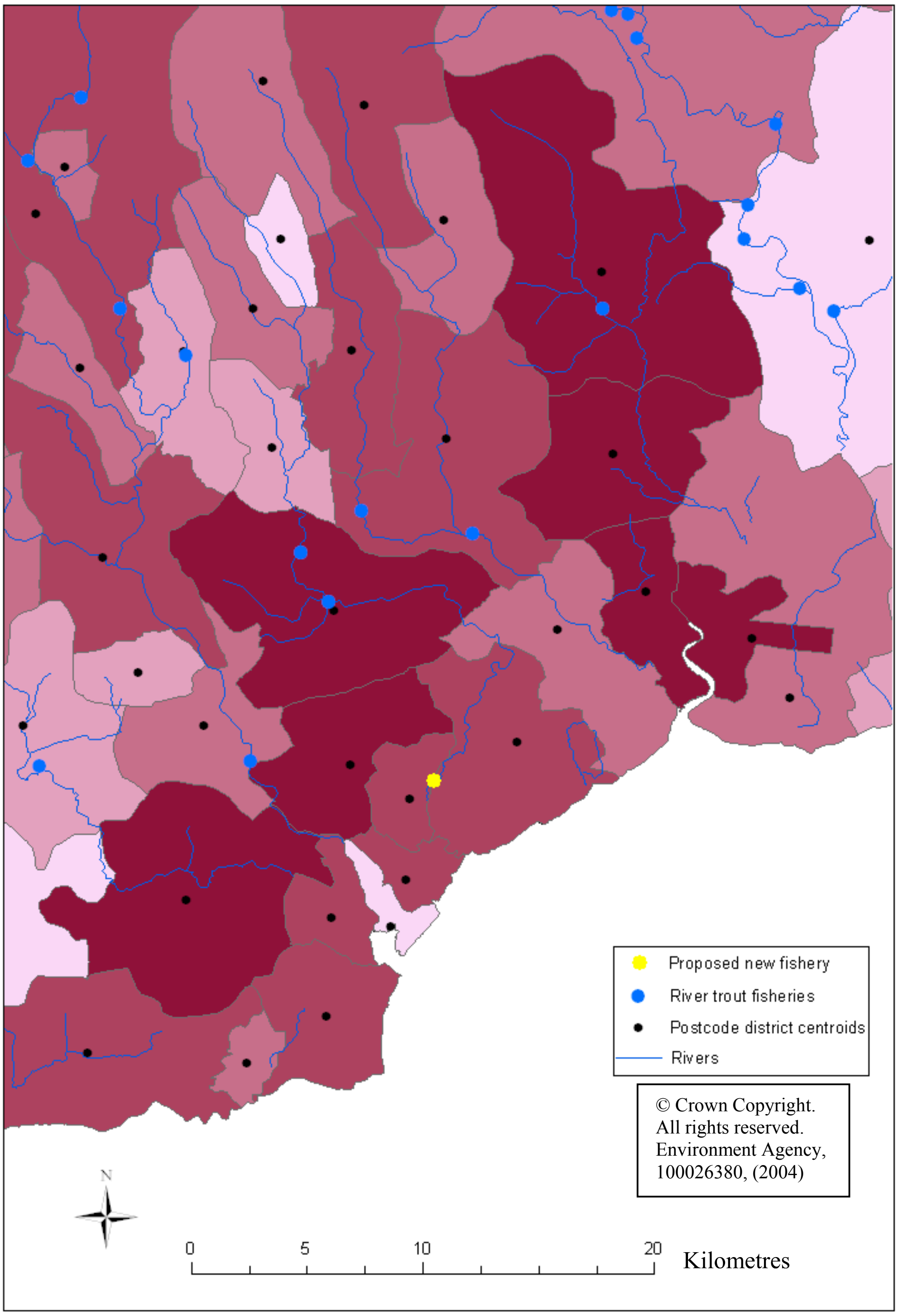

Figure 28 **Map showing possible location for new day-ticket trout fishery (yellow dot)**

The second stage is to identify the postcode districts for which the creation of the fishery represents a reduction in distance. The distance from the centroid of the postcode district to the current fishery of that type is calculated and then the distance from centroid to the new fishery, giving the reduction in kms: this process is carried out for each postcode district where the new fishery will result in a reduction in distance. In this example, there are 6 postcode districts for which the creation of a new fishery at this location results in a reduction in distance – CF3, CF10, CF11, CF14, CF23 and CF24 shown in Figure 29 below.

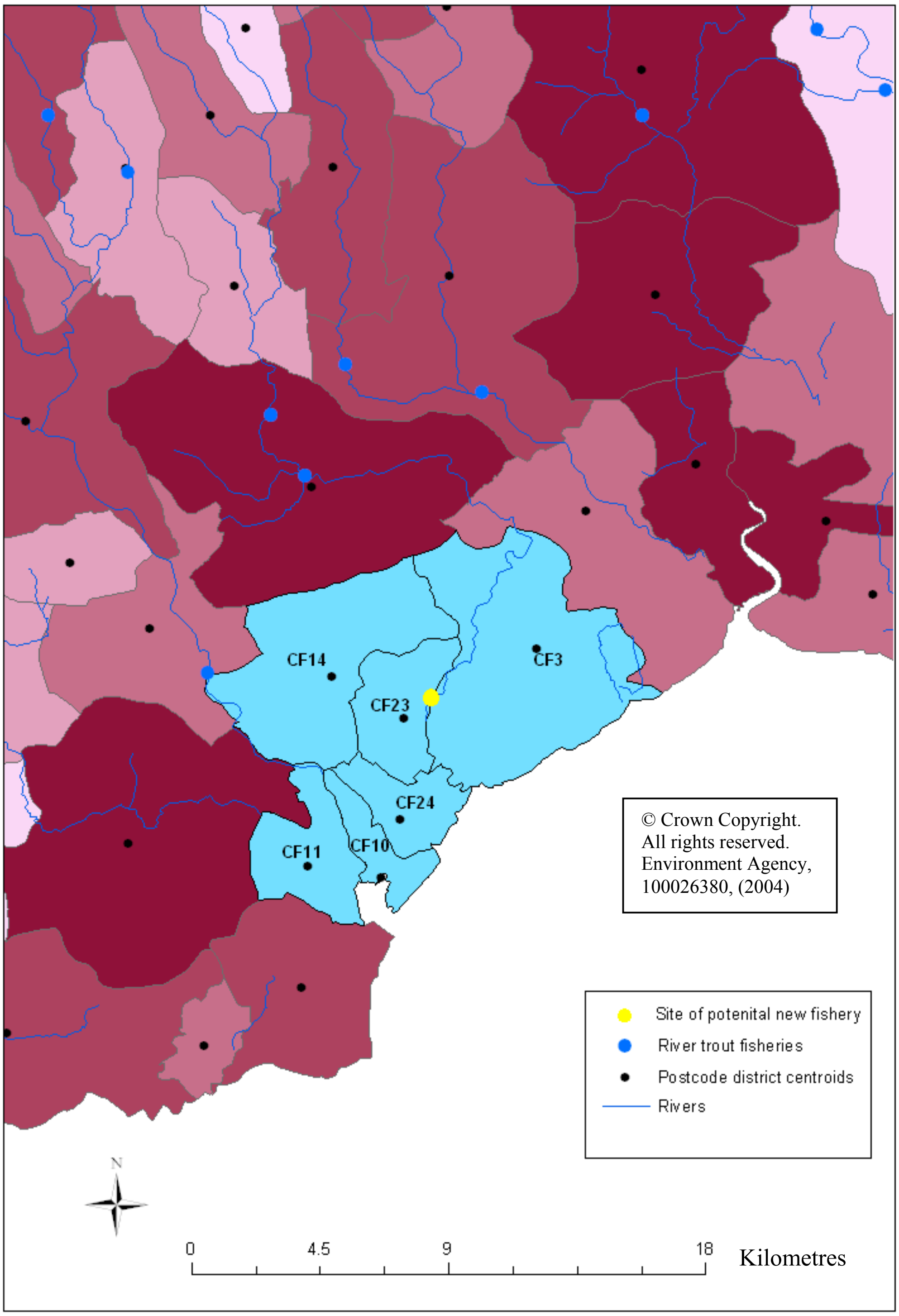

Figure 29 Map showing postcode districts affected by new fishery (highlighted in blue)

The estimated increase in licence sales can then be estimated by multiplying the distance reduction in each postcode by 4%, which is the distance coefficient for trout and coarse river fisheries shown in Table 10. For example, in CF24, the distance reduction is 3.9km x 0.04 = 16, so this reduction results in a 16% increase in licence sales. To estimate the actual number of additional licences purchased in these districts, multiply the existing number of licences in each district by the relevant percentage change. For example in CF24, the original number was 221, which multiplied by 16% gives 34 additional licences. In this worked example, the total increase in licences for the 6 postcode districts is 233.

It should be noted however that the 'noise' associated with the distance generation means that results should be used in this way with caution. They should be viewed as demonstrating the methodology on a relatively coarse spatial scale – as a ballpark estimate as to the likely impact of reducing distance/travel costs on licence sales. Using postcode sector centroids would provide more accurate estimates, and for the same reason, the smaller population districts will also give more accurate predictions.

5.5 Discussion

Considering the limitations of the data (noted in Section 4), the results of this pilot study are encouraging and suggest that with more accurate explanatory variables, stronger relationships would emerge, and that this would be a useful avenue for further research effort. In general, the variables have the expected signs and the distance / travel cost variable is always significant. The only unintuitive result is the negative relationship between size of fishery variable and numbers of licences sold for MS fisheries and for TC stillwater fisheries; however as noted above, this may be at least partially cause by a link to other variables not included in the model.

The results also show that the models work better (are more significant) using the raw numbers of licences than licence numbers per capita, i.e. licences divided by the population of the postcode district. This is likely to be because of the nature of the dependent variable in its unaltered state, i.e. as counts, rather than a continuous, normally distributed variable.

From the model results we can conclude that both travel costs and entry (ticket-price)[23] costs have a negative affect on the demand for licences and thus angling participation. The effect of the size of the fishery in kilometres of bank was unclear, in that it was negative for MS fisheries and TC stillwaters but positive for TC river fisheries. The results also suggest that if, as was the case in this study, means are used in place of missing data, that the specification of angling availability is important, and will affect model results. The analysis showed that the disaggregated form of availability had the most explanatory power. However, as noted above, with more accurate ticket price data, this may have produced different results.

Comparing the National-level and Area-level analysis in this and Section 2 shows broadly similar results, in that distance is negative and significant. However, in general, the OLS models in the national-level analysis explain more of the variation in licence holders per capita than the Area-level models. A possible reason that distance

[23] Although the unintuitive result using the GLM for TS river fisheries merits further investigation.

was more significant in national-level models might be because this was a respondent-reported measure of distance rather than straight-line GIS calculated distance. A further possible reason that national-level models performed better than area-level models was that a slightly different measure of licence holders was used in each, i.e. national-level measure was the number of licence holders weighted by the percentage of respondents fishing for that type, and the area-level was just straight per capita.

6 CONCLUSIONS AND RECOMMENDATIONS

In this Section, the implications of the study are considered and the scope for future research in this field is discussed. In Section 6.1, the key findings of the study are reviewed; in Section 6.2 these key issues are discussed with suggestions as to how refinements to the data and methodologies could improve the study and finally in Section 6.3 some wider recommendations for future work are briefly proposed.

6.1 Conclusions

- This study has provided a useful first step in understanding the factors that influence demand for angling in South East Wales, and has identified ways that the methodology can now be refined and applied to other Agency Areas; these are discussed below in Section 6.2.

- The project has successfully answered the research questions set out in Section 5, showing that on a relatively broad spatial scale, distance/travel cost is significantly negatively related to the number and distribution of licence holders in the Area. This finding is consistent with a large body of previous economic research and as such confirms expectations and economic theory.

- The model results provide some initial quantitative estimates of the relationship between availability of day-ticket fisheries and angling participation, showing that across the study area a 1km decrease in distance-to-fishery increases the number of licences sold by between 4 and 6% for stillwater and river fisheries.

- Linking the model results to the 'Making it Happen' objectives noted in the Introduction (Section 1), the results show that reducing distance to day-ticket fisheries, for example regenerating urban fisheries or fisheries close to centres of population would result in socio-economic benefits, increasing angling participation and rod licence sales.

- In Section 5.4 an example was given showing how the quantification of the availability-participation relationship could be used to model the increase in licence sales resulting from the creation of a new day-ticket trout fishery in the Cardiff area. As such the project successfully demonstrated how GIS can be used as a tool to assess angling opportunity and contribute valuable strategic input to fisheries management.

- The analysis indicated that ticket price is likely to have a significant (negative) affect on licence holders, which also confirms expectations, although the unintuitive result for trout and coarse river fisheries suggests further investigation is needed.

- The effect of size of fishery was also inconclusive, in that it was positive for river trout and coarse but negative for migratory salmonid and stillwater trout and coarse fisheries; it is likely that better data would show a positive relationship.

- The Generalised Linear models provided a better fit of the data than the OLS. Also it is likely that the models would be improved by the inclusion of additional explanatory variables, which would improve our understanding of variation in licence sales; in Section 6.2 below some of the variables that could be used are noted.

6.2 Recommendations for Improving the Methodology

Despite the methodological and scope limitations (noted in Section 4), the model results suggest that distance/travel cost is an important influence on demand for fishing. There are however a number of improvements to the methodology that may result in more significant relationships; these are outlined below.

- Previous research[24] has found that, perhaps unsurprisingly, in calculating travel distances, the more spatially precise the origin zone the more accurate the calculations, and the stronger the affect of distance/travel cost on demand. By starting with more accurate origin points, for example using licence numbers by postcode sector, not postcode district, the accuracy of the distance variable would be increased.

- Related to this is the use of route-finding functions in a GIS to calculate the distance between point-of-origin and fishery by road network. It was not appropriate with the spatial scale of licence data used in this study, however if more spatially disaggregated licence data were available, this would increase the accuracy of the distance variable and the subsequent quantitative analysis.

- In addition, the accuracy of the population variable used in the model could be improved, which would allow us to model the affects of distance on licence holders per capita more precisely. A possible way this could be done is by creating a population density variable, and using the GIS Spatial Analyst tool to get more precise population estimates for postcode districts.

- As stated in Section 4, for many fisheries, average values had to be used as actual data was not available and it was not possible to gather this within the timeframe of the study. Thus the effect of these variables on angling demand could be modelled more accurately if more detailed and accurate ticket price and fishery size data were gathered.

- It would be useful to carry out more in-depth modelling looking at the availability-participation relationship for specific types of fisheries, in other words to carry out the models for more of the fisheries identified in the classification described in Section 3.

- While the linear correlation coefficients were not particularly encouraging for junior licence holders, and the time constraints in this pilot project did not permit more in-depth analysis of the relationships, it would be interesting to carry out some further investigation into how and why numbers of junior licence holders varied, for example using the Generalised Linear models applied in Section 5.3.4.

[24] Bateman *et al.*, 2003.

- Although it was not possible to incorporate fishery quality into the models, a broad grouping of fisheries on a very simplistic level was made by categorising fisheries as urban or rural; it would therefore be interesting to investigate the differences in the opportunity-participation relationship for urban and rural fisheries[25].

- As this study looked just at the opportunity-participation equation for day ticket fisheries, it would be worthwhile applying the methodology and modelling the relationships for the entire set of fisheries in the study area, and see whether the similar results are obtained.

6.3 Developing the Research Area

In this Section some recommendations for ways in which this area of research could be developed in greater depth are put forward.

- As was noted in Section 4, the quality of fisheries in terms of ecological/habitat and amenity aspects, are likely to be some of the more important factors affecting angling participation. Including some measure of fishery quality, such as fish species diversity, or extent of river habitat modification, could increase our understanding of angling choice, and could provide more insight into how angling participation varies within an Area. Potentially other types of variables could also be introduced into the models, such as socio-economic data by postcode district.

- The recommendations and improvements suggested above relate to the methodology and increasing the analysis in the pilot study Area. A wider avenue for future research is to apply the methodology to other Agency Areas. This would allow us to investigate how Region-specific the results obtained in this pilot study are, and could provide valuable insight into Regional differences in the angling supply-demand relationship. It would also improve our understanding of the factors that influence this relationship, and how they vary across Regions.

- As noted in Section 4.1.3 it was initially thought that it might be possible to include a measure of the number of fisheries at each distance, which would provide a more accurate and comprehensive measure of angling opportunity. This might also be carried out by creating maps of distance bands from centres of population, (e.g. postcode centroids).

- The model results suggest that increasing angling opportunity by decreasing the distance between centres of population and fisheries will stimulate angling participation and licence sales. A way of testing whether this expected relationship holds true in practice would be to analyse changes in licence sales in an area where a fishery has been created, for example over a five-year period. In other words, to test the model results using temporal data on licence sales. Providing the necessary data are available, this would be a useful and interesting way to extend the research area.

[25] Or to use different parameters to classify fisheries as urban or rural to see if the same results were obtained.

6.4 Wider Agency Economic Research into Fisheries and Angling

- As noted in the introduction to this Report, the Agency's aims and objectives relating to recreational fisheries and angling as set out in 'Making it Happen' are to increase participation in angling, and thereby enhance socio-economic welfare and ecological quality of freshwaters at the same time. These objectives shape the research questions, which are thus how can we encourage participation in angling? And how can we identify the factors that affect participation in, and demand for angling?

- As briefly described in Section 1, there are a number of techniques that have been developed to analyse and model recreation demand, and to identify attributes that affect consumer choice. Recent advances in econometric modelling for revealed preference studies, such as Random Utility Method (RUM) site choice studies[26] which are based on choice theory, mean that many researchers are now using these techniques to model recreation demand. This would be a constructive avenue for future Agency research, and would provide valuable data on the factors affecting fishing site choice and thus angling participation.

- Similarly, the RUM framework can be applied to stated preference studies, in order to identify the recreational value of various fishery attributes. A similar study has recently been documented in Hanley *et al.* (2004), which sought to estimate the value of various river attributes such as ecological and aesthetic quality. A choice modelling study such as this could be envisaged, where anglers are asked directly to trade-off between different aspects of fishing, which would also provide invaluable insight into the factors affecting angling choice.

- There are a number of ways that existing mechanisms for data gathering and storage could be improved to facilitate economic analysis of angling. For example, databases like the catch returns, the LFMD, and others need to be more strategically 'joined up', for example include commensurate grid references and be able to be cross-referenced to other agency databases like the GQA rivers network, river habitat survey database etc. The value of doing this is that it would enable for example the inclusion of fishery quality variables in demand models such as the one piloted in this report.

- An example of how the Agency has begun to do this is the excellent work of the Sustainable Fisheries Team in South East Wales in mapping fisheries and creating a database on their attributes. This could be done in all Agency Areas, and would greatly facilitate socio-economic research such as has been demonstrated in this pilot project.

- Another example of how the Agency could use existing data gathering procedures to in recreation demand modelling is the catch returns database. Asking anglers to be more specific about where they fished on catch returns, for example to give fishery or fishing site name or nearest village/district, would

[26] For example, Hanley *et al.*, 2001.

provide the necessary data to carry out a full recreation demand study from which consumer's surplus estimates of fishery attributes could be obtained.

REFERENCES

Bateman, I.J., A.A. Lovett, J.S. Brainard and A.P. Jones (2003), "Using Geographical Information Systems (GIS) to estimate and transfer recreational demand functions", in 'The New Economics of Outdoor Recreation', Hanley, N. (Eds.), Edward Elgar, Cheltenham.

Diamond, M., M. Aprahamian, M. Atherton (2000), "A development programme for urban fisheries in England & Wales", Environment Agency, Richard Fairclough House, Knutsford Road, Warrington, WA4 1HG, UK.

Hanley, N *et al*. (2004) *forthcoming* in 'Estimating the Economic Value of Improvements in River Ecology using Choice Experiments: an Application to the Water Framework Directive', in Rolfe, J. and Bennett, J. (eds) Transferring Environmental Values from Choice Modelling Applications. Cheltenham, Edward Elgar.

Environment Agency (2003), "National Trout and Grayling Fisheries Strategy", Rio House, Waterside Drive, Aztec West, Almondsbury, Bristol, BS32 4UD.

Hanley, N., D. Bell and B. Alvarez-Farizo, (2003) "Valuing the Benefits of Coastal Water Quality Improvements Using Contingent and Real Behaviour", Environmental and Resource Economics, 24, 273-285.

Hanley, N., Gary Koop, Begona Alvarez-Farizo, Robert E. Wright and Ceara Nevin, (2001), "Go climb a mountain: an application of recreation demand modelling to rock climbing in Scotland", Journal of Agricultural Economics, Vol. 52(1), 36-52.

Hanley, N. and R.J. Ruffell (1991), "Recreational Use Value of Woodland Features", University of Stirling for the Forestry Commission.

Mawle, G.W. (1984) "The Demand in South Wales for Trout Fishing in Stillwaters", Unpublished Report, Part of PhD Thesis 'Angling in South Wales', University of Wales

Klein, R.J.T. and I.J. Bateman (1998), "The Recreational Value of Cley Marshes Nature Reserve: An Argument Against Managed Retreat", Water and Environmental Management, 12(4), 280-285.

Radford, A. F. (1984), "The Economics and value of recreational salmon fisheries in England and Wales: an analysis of the Rivers Wye, Mawddach, Tamar and Lune." CEMARE Report No. R8, ISBN 0-900234-67-9.

Simpson, D. and G. W. Mawle (2001), "Survey of Rod Licence Holders 2001", R&D Technical Report W2-057/TR.

Sorg, C.F. and J.B. Loomis (1986), "Economic Value of Idaho Sport Fisheries with an Update on Valuation Techniques", North American Journal of Fisheries Management, 6, 494-503.

Spurgeon, J., Colarullo, G., Radford, A.F., and Tingley, D. (2001), "Economic evaluation of inland fisheries", Environment Agency R&D Project Record W2-039/PR/1 (Module A).

Willis, K & G. Garrod (1991), "Valuing Open Access Recreation on Inland Waterways: On-site Recreation Surveys and Selection Effects", Regional Studies Vol. 25(6), 511-524.

Willis, K. (1991), "The Recreational Value of The Forestry Commission Estate in Great Britain: A Clawson-Knetch Travel Cost Analysis", Scottish Journal of Political Economy 38(1), 58-75.

Willis, K. and G. Garrod (1991), "An Individual Travel-Cost Method of Evaluation of Forest Recreation", Journal of Agricultural Economics 42(1), 33-42.

Willis, K. and J.F. Benson (1988), "A Comparison of User-Benefits and Costs of Nature Conservation at Three Nature Reserves", Regional Studies 22(5), 417-428.

Willis, K., J.F. Benson and M.C. Whitby (1988), "Values of User-Benefits of Forest Recreation and Wildlife", Report to the Forestry Commission by the Dept. of Town & Country Planning, University of Newcastle-upon-Tyne.

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APPENDIX A
Multiple regression analysis of distance versus mean trips and numbers of licences holders per capita – *using National level data (cont. from Section 2)*

A1 Multiple OLS Regression of Mean Trips Versus Mean Distances

The aim of this analysis was to investigate how the mean distance to fisheries affects demand for fishing at each of the seven types of fishery, in other words, to explore the interaction effects of availability for different types of fishing. Two different types of model were run, a full model, which had all 7 mean distances as predictive variables,

$$T_j = a + {}_{\beta}D_j + {}_{\gamma}D_k \ldots {}_{\delta}D_p$$

and a 'subset' model for two sub-groups of the dataset, river and stillwater fisheries. In the subset models, the mean number of trips to each type of river or stillwater fishery was regressed against the mean distance to the other river or stillwater fisheries. Thus for the river fishery model (4 independent variables as Grayling fishing is a on a river):

$$T_{r\text{-}j} = a + {}_{\beta}D_{r\text{-}j} + {}_{\gamma}D_{r\text{-}k} + {}_{\delta}D_{r\text{-}l} + {}_{\eta}D_{r\text{-}m}$$

and for the stillwater model (3 independent variables):

$$T_{r\text{-}j} = a + {}_{\beta}D_{s\text{-}j} + {}_{\gamma}D_{s\text{-}k} + {}_{\delta}D_{s\text{-}l}$$

The stillwater models were run both including and excluding the distance to coarse canal fisheries, as in terms of flow rate and fish species present canals are closer to stillwaters than to rivers.

A semi-log (log of the dependent variable – 'trips') functional form was chosen for the models, and trips was regressed against the independent variables using backwards stepwise regression. The statistical significance level for variables to be removed from the model was 0.20.

Table A1 Summary of the results of stepwise regression for the full model - trips versus mean distances (n=26)

Fishery Type	Distance coefficient	Adjusted R^2	F-Stat
Salmon & Sea Trout	-0.03***	0.26	9.8***
Trout River	-0.06**	0.51	13.97***
Trout Stillwater	-0.11	0.18	1.8
Grayling	-0.07***	0.27	5.7***
Coarse River	-0.07***	0.65	24.6***
Coarse Stillwater	-0.07	0.21	2.0
Coarse Canal	-0.08***	0.75	19.77***

T-stat / F-stat significant at probability levels: *** 99% ** 95% * 90%

The distance coefficients for these multiple regression models are generally similar to the basic (single variable) regressions, and are identical for the Salmon & Sea Trout model. The distance coefficients are 0.01 lower in the Grayling and Coarse River models than in the single-variate versions (Section 2), and the Trout River distance coefficent reduces from -0.10 to -0.06. Again excepting the SST model, the F-statistics are slightly lower and the Adjusted R^2 slightly higher.

Salmon & Sea Trout model

Regression of trips to SST fisheries against the seven distance variables resulted in one variable, distance to SST, being a significant predictor of trips. The SST distance coefficient was -0.03, which means that if distance increases by one mile, the mean number of trips decreases by 3%.

The subset model of SST fishing trips versus distance to river fisheries produced the same results as the full model.

Trout – River model

Significant negative predictors of trips to trout fisheries on a river were the distance to the trout river fisheries and also the distance to salmon & sea trout fisheries. The TR distance coefficient was -0.06, which means that for a unit increase in distance, the mean number of trips decreases to 94% of trips, or by 6%.

The subset river fishing model for Trout River fishing produced the same results as the full model.

Trout – Stillwater model

Distance to a different type of fishery (salmon & sea trout) had a negative effect on trips to stillwater trout fisheries. This suggests that SST and T-S fishing are complementary products, in that availability of SST fishing increases T-S fishing also increases. However, as the relevant distance (i.e. to stillwater trout fisheries) was not a significant predictor, we cannot use this model to model the affect of distance on demand for stillwater trout fisheries.

With only two explanatory variables in the subset stillwater model, the regression produced the same results as the full model. However, when the distance to coarse canal fisheries variable was included, this becomes a significant (at the 95% probability level) positive predictor, suggesting that coarse canal and trout stillwater fishing may be substitutes.

Grayling model

The model showed that greater distance to grayling and stillwater coarse fisheries reduces the number of days spent fishing for grayling – distance to grayling fisheries is significant at 99% probability, distance to stillwater coarse is only significant at the 90% level. Again distance to fisheries in general has a negative affect on grayling fishing trips, suggesting that these two types of fishing are complementary goods –

price decrease in one increases consumption of another. The coefficient for distance to grayling fisheries is -0.07, which means that for a unit increase in distance, trips to grayling fisheries decreases by 7%.

The subset model of trips to grayling fisheries produced slightly different results to the full model, in that the distance coefficient is larger (-0.09 compared to -0.07) and, whilst only significant at the 90% probability level, distance to SST fisheries is a positive predictor of trips to grayling fisheries. In other words, where availability of SST fisheries is lower, anglers fish for grayling more frequently. This suggests that to a certain extent, SST and grayling fishing may be substitutable goods.

Coarse – River

This model showed that, as expected, distance to coarse river fisheries has a significant negative impact on trips to this type of fishery, reducing trips by 7%. Interestingly, distance to salmon & sea trout fisheries was shown to have a significant positive affect on coarse river fishing, which suggests that SST and CR fishing are substitutes, i.e. when SST fishing is less easily available (more expensive), anglers will fish more at coarse rivers. A possible explanation for this is perhaps if anglers had a strong preference for fishing rivers as opposed to stillwaters, then they would prefer to catch coarse species rather than go to a game stillwater site. The subset river-fishing model for this type of fishing produced the same results as the full model.

Coarse – Stillwater

This model performs poorly, in that as with the trout stillwater model, the relevant distance variable (distance to coarse stillwater fisheries) is not a significant predictor. The only significant predictor of trips to this type of fishery is distance to canal fisheries, suggesting that coarse fishing on a canal and coarse stillwater fishing are complementary goods, so increasing availability of one encourages consumption of another. However, as the relevant distance variable is not significant, we cannot use the results to model demand affects for CS fishing from changes in distance to CS fisheries. The subset stillwater model for coarse stillwater trips produced the same results as the full model.

The disappointing results for this model for numbers of trips[27] suggest that disaggregating coarse fishing by species may allow us to identify whether distance affects different types of coarse fishing to varying degrees. This is a potentially useful avenue for future research.

Coarse – Canal

Distance to SST and CC fisheries both have a negative affect on trips to CC fisheries, distance to CC fisheries reducing trips by 8%, but interestingly, distance to Grayling (G) and trout stillwater (TS) fisheries has a positive affect on trips. This suggests that CC, TS and Grayling fishing might be substitutes; in other words, as TS and grayling

[27] Although interestingly this model explained variation in licence holders to a significant extent – see Section A2 below.

becomes more expensive, trips to CC fisheries increase. As coarse fishing on a canal is quite different to both trout still and grayling (river) fishing, it seems unlikely that these actually are substitutable goods.

The subset stillwater model for coarse canal fishing produced different results from the full model, in that in the subset version only the distance to canal fisheries was a significant predictor of trips.

A2 Multiple OLS Regression of Licence Holders Per Capita Versus Mean Distances

The interaction between availability of different fishing products was also explored for this measure of use, via multiple stepwise regressions, using the same process as described above in Section A1. A summary of the results is shown in Table A2 below.

Table A2 Results of the multiple regression models of licence holders per capita versus mean distance to fishery

Fishery Type	Distance coefficient	Adjusted R^2	F-Stat
Salmon & Sea Trout	-0.01*	0.09	1.1
Trout River	-0.04***	0.37	2.7**
Trout Stillwater	-0.01	0.19	1.4
Grayling	-0.05***	0.73	10.0***
Coarse River	-0.07***	0.79	12.7***
Coarse Stillwater	-0.09	0.61	5.8***
Coarse Canal	-0.04***	0.89	27.6***

T-stat / F-stat significant at probability levels: *** 99% ** 95% * 90%

The relevant distance variables are significant in all the river and canal models (however only at the 90% level in the SST equation), but not for the stillwater models. This is interesting as in the single-variate version of the Coarse Stillwater model, distance to Coarse Stillwater models was significant.

Game fishing models

The SST and the T-R model produced the same results as the single variate models. The T-S model found distance to SST fisheries had a negative affect on anglers participating in T-S fishing, suggesting that increasing availability of SST fishing increases T-S fishing, i.e. that they are complementary products. The Grayling equation suggested that Coarse River fishing may be a complementary product to this type of fishing. The relationships for these fishing types are shown in Figure A1 below.

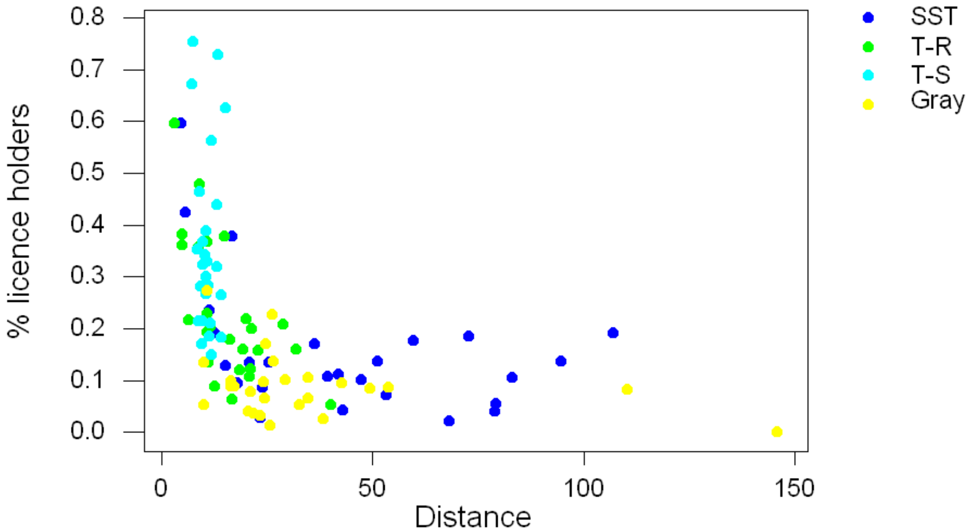

Figure A1 Plot of distance versus licence holders per capita for game fishing (untransformed data)

Coarse fishing models

As was found in the mean trips model, the Coarse River licence holder model implied that SST was a substitute for this type of fishing, and that Coarse fishing on a Canal was a complementary product. As noted above, the multivariate version of the Coarse Stillwater model was poor, in that distance to Coarse fishing sites was not a significant predictor of the number of licence holders per capita taking part in this type of fishing. Distance to C-C fishing was however, implying that if cheap (close) canal fishing is available, demand for stillwater coarse fisheries is likely to be enhanced. Distance to both T-S and Grayling fisheries was positive and significant, suggesting a substitution effect between these fishing types.

The Coarse Canal fishing model showed that availability of T-R and T-S reduced the number of licence holders participating in C-C fishing; in other words, these two types of game fishing may be substitutes for coarse fishing on a canal.

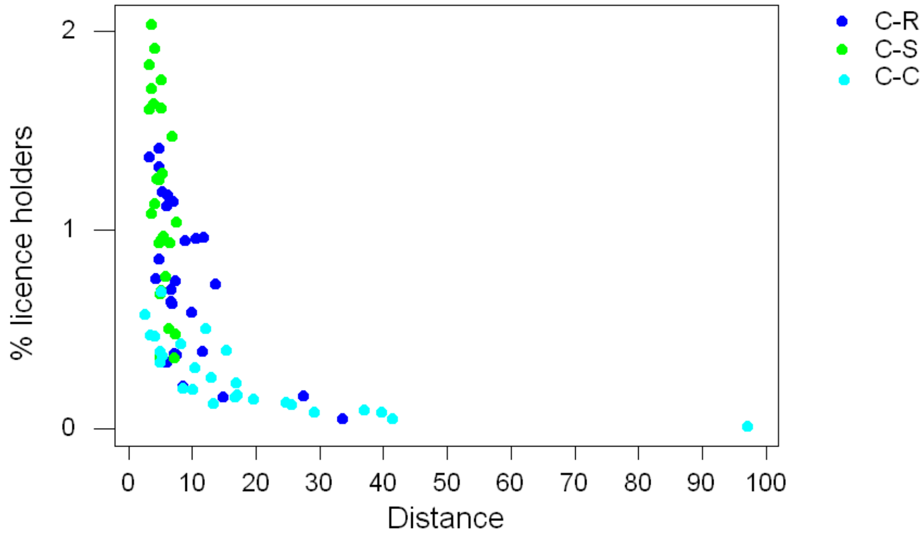

Figure A2 **Plot of distance versus licence holders per capita for coarse fishing (untransformed data)**

Distance-as-median models

The full model of trips versus distances to all 7 fishery types was also run using the median rather than the mean distances; again stepwise regressions were used and the data were untransformed. In general, these models were not as successful, in that fewer explanatory variables were found to be significant, the relevant distance variables (i.e. the distance to the fishery in question) were not significant (SST, CS), or even that no distance variables predicted trips at all (Grayling model).

The only successful model was for Coarse River fishing trips, which differed from the mean distance version in that the TS and TR distances are significant positive predictors of fishing trips, although TR is only significant at the 90% level. This perhaps makes more sense intuitively as TS and TR fishing are more likely to be substitutes for CR fishing than SST and grayling, which are less common.

APPENDIX B
Correlations between distance and licence holders per capita[28] - *Area level analysis (cont. from Section 4)*

1 Any fishery

Rural Migratory Salmonid

Distances	Full Licences	All Licences	All Licence Holders
Salmon	**-0.38**	**-0.40**	**-0.40**
Sea Trout	-0.19 **(-0.27)**	-0.13 (-0.19)	-0.13 (-0.18)

Urban Migratory Salmonid

Distances	Full Licences	All Licences	All Licence Holders
Salmon	0.05	0.09	0.09
Sea Trout	-0.01	0.09	0.09

Rural Trout & Coarse

Distances	Full Licences	Junior Licences	All Licences	Junior Licence Holders	All Licence Holders
Gen. Coarse	-0.13 (-0.34)	-0.00 (-0.15)	-0.13 (-0.36)	-0.08 (-0.14)	-0.13 (-0.35)
Barbel	0.10 (-0.18)	-0.00 (0.13)	0.17 (0.00)	-0.02 (0.07)	0.16 (-0.01)
Carp	0.23 (-0.10)	-0.08 (-0.11)	0.14 (-0.12)	-0.12 (-0.17)	0.14 (-0.11)
Gray	**-0.37** (no outliers)	0.13	-0.18	0.05	-0.19
Pike	**-0.36** **(-0.49)**	**-0.27** **(-0.33)**	**-0.38** **(-0.50)**	**-0.34** **(-0.40)**	**-0.38** **(-0.51)**
Trout (stocked)	-0.02 (-0.24)	**-0.25** **(-0.34)**	-0.12 **(-0.36)**	**-0.26** **(-0.33)**	-0.12 **(-0.36)**
Trout (unstocked)	0.15 (-0.17)	0.02 (-0.12)	0.12 (-0.23)	-0.04 (-0.20)	0.11 (-0.24)

[28] In bold where coefficient is negative and significant at the 95% level; coefficient below in brackets is with outlier/s removed.

Urban Trout & Coarse

Distances	Full Licences	Junior Licences	All Licences	Junior Licence Holders	All Licence Holders
Gen. Coarse	0.25	-0.17	0.08	-0.12	0.08
Barbel	**-0.49**	-0.16	**-0.38**	-0.23	**-0.38**
Carp	0.37	-0.05	0.21	-0.02	0.01
Gray	0.45	0.21	0.39	0.26	0.39
Pike	0.05	0.07	0.08	0.01	0.08
Trout (stocked)	0.57	0.07	0.48	0.15	0.47
Trout (unstocked)	0.19	-0.04	0.12	-0.06	0.11

2 River Fisheries

Rural Migratory Salmonid

Distances	Full Licences	All Licences	All Licence Holders
Salmon	**-0.38**	**-0.40**	**-0.40**
Sea Trout	-0.19	-0.13	-0.13

Urban Migratory Salmonid

Distances	Full Licences	All Licences	All Licence Holders
Salmon	0.05	0.09	0.09
Sea Trout	-0.01	0.09	0.09

Rural Trout & Coarse

Distances	Full Licences	Junior Licences	All Licences	Junior Licence Holders	All Licence Holders
Gen. Coarse	-0.37 -0.41	0.11 0.06	-0.22 -0.29	0.03 -0.03	-0.23 -0.31
Barbel	0.07	-0.02	0.12	-0.06	0.11
Carp	0.15	0.11	0.20	0.10	0.20
Gray	-0.36	0.13	-0.18	0.05	-0.19
Pike	-0.51	0.00	-0.37	-0.05	-0.36
Trout (stocked)	-0.02 (-0.24)	-0.25 (-0.34)	-0.12 (-0.36)	-0.26 (-0.33)	-0.12 (-0.36)
Trout (unstocked)	-0.06 (-0.28)	-0.08 (-0.14)	-0.14 (-0.34)	-0.17 (-0.23)	-0.15 (-0.35)

Urban Trout & Coarse

Distances	Full Licences	Junior Licences	All Licences	Junior Licence Holders	All Licence Holders
Gen. Coarse	0.05	-0.08	0.00	-0.07	-0.01
Barbel	-0.46	-0.14	-0.35	-0.22	-0.34
Carp	0.28	0.01	0.28	0.01	0.27
Gray	0.45	0.21	0.39	0.26	0.39
Pike	-0.61	-0.23	-0.54	-0.31	-0.53
Trout (stocked)	0.57	0.07	0.48	0.15	0.47
Trout (unstocked)	0.18 (0.02)	-0.06 (-0.17)	0.11 (-0.08)	-0.07 (-0.18)	0.10 (-0.09)

3 Stillwater Fisheries[29]

Migratory Salmonid (any stillwater)

Distances	Full Licences	All Licences	All Licence Holders
Salmon & Sea Trout	0.22	0.24	0.24

Rural Trout and Coarse

Distances	Full Licences	Junior Licences	All Licences	Junior Licence Holders	All Licence Holders
Carp	0.25 (0.12)	-0.07 (-0.07)	0.15 (0.01)	-0.10 (-0.04)	0.14 (0.01)
Gen. Coarse	0.37 (0.04)	-0.04 (-0.22)	0.22 (-0.11)	-0.01 (-0.21)	0.21 (-0.12)
Trout	0.34 (-0.03)	0.16 (**-0.28**)	0.30 (-0.20)	0.19 (**-0.27**)	0.29 (-0.19)

Urban Trout and Coarse

Distances	Full Licences	Junior Licences	All Licences	Junior Licence Holders	All Licence Holders
Carp	0.37 (-0.17)	-0.04 (**-0.34**)	0.22 (**-0.32**)	-0.01 (**-0.34**)	0.21 (**-0.32**)
Gen. Coarse	0.37 (-0.12)	-0.04 (**-0.30**)	0.22 (-0.24)	-0.01 (**-0.30**)	0.21 (-0.24)
Trout	0.52 (0.73)	0.28 (0.39)	0.49 (0.68)	0.32 (0.43)	0.47 (0.66)

[29] There were only 3 types of stillwater fishery with > 5 obs in the study area.