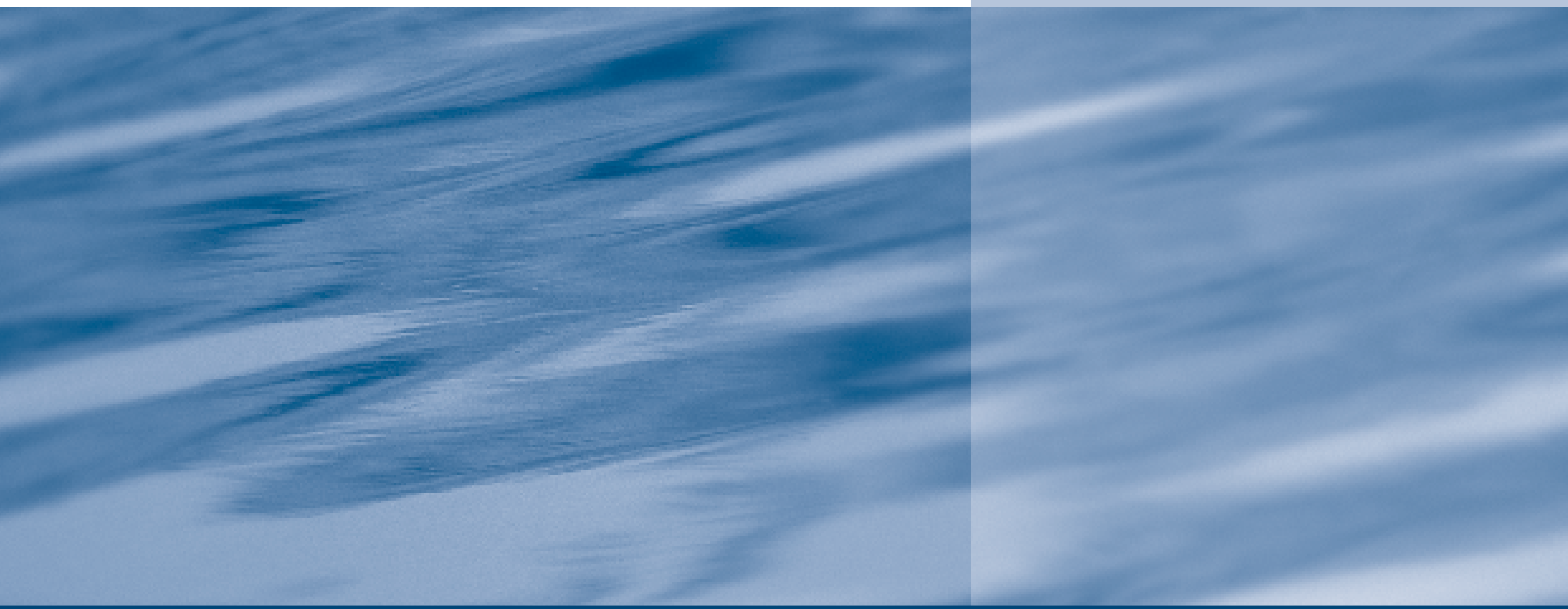

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Defining Angler Opportunity: Phase 2 Report

Technical Report W2-084/TR2

ENVIRONMENT AGENCY

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Statement of Use:
This report extends the pilot study, described in Technical Report W2-084/TR, which explored and quantified the relationship between angling opportunity and participation within South East Area of Environment Agency Wales. This phase describes the development of a GIS-based tool to assist in the strategic development of fisheries, and applies the methodology to three case study examples. It will be of interest to Agency Fisheries staff and others involved in the provision and planning of facilities for the sport of angling.

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Science Project reference:
W2-084

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Professor Mike Depledge Head of Science

EXECUTIVE SUMMARY

The aims of the project are to develop a GIS-based method or tool to assist in the strategic development of fisheries, and to apply the methodology in a pilot study area – South East Wales.

The tool is intended to enable spatial analysis of angling opportunity and participation across an Area or Region. This will help fisheries managers in deciding on locations where development of fisheries will result in the greatest social and economic benefits, thereby prioritising investment in fisheries.

The tool can be applied on two levels, a basic map-based level and a more advance spatial and statistical level. The map-based level involves visually assessing the distribution of anglers and fisheries across an Area or Region, which can provide a kind of 'gap analysis' of fishing opportunity.

The spatial-statistical level involves more in-depth spatial analysis and quantifying the effect of angling opportunity on participation. The results of such spatial-statistical models can then be used to compare between sites on the basis of numbers of population zones affected and/or numbers of new licence holders generated.

The results of the spatial-statistical models using South East Wales data, show that angling opportunity does indeed have a significant affect on participation.

A 1km decrease in straight-line distance to fisheries increases licence holders by between 3 and 10%. Similarly a 10% decrease in travel time to fisheries increases licence holders by between 3 and 10%. And an additional fishery within 10km of postcode sector centroids increases licences by 1%.

The report applies these results to three case study examples of fisheries development sites in South East Wales, to illustrate how the spatial-statistical component of the tool could be used in fisheries management decisions.

Recommendations to take the work forward include to:
- Produce maps of angling opportunities by type for other Agency Areas;
- Develop the measure of angler opportunity e.g. obtain data on size of fishery;
- Develop the measure of angling participation, e.g. estimate more accurate levels of use using the ratio of licence holders to days fished.
- Link spatially referenced databases of fisheries with databases of river characteristics.

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1. INTRODUCTION

1.1 Introduction

The aim of this project has been to create a tool to assist in the strategic development of fisheries[1]. It is intended to help fisheries managers to identify locations in an Area where developing a fishery will result in the greatest social and economic benefits, in terms of angling participation, and thereby help to prioritise investment into fisheries development.

The aim is to develop a tool that can be used on two levels: one that visually analyses the spatial distribution of anglers and fisheries across a region, and a second that uses more advanced spatial and statistical analysis to quantify the relationships between angling opportunity and participation. The results of the spatial-statistical analysis can then be used to compare between sites on the basis of numbers of population zones affected and/or numbers of new licence holders generated.

Whilst predicting angling participation in terms of numbers of rod licence holders is useful on a local management level, the approach also promotes thinking in a broader sense about how and why people interact with their environment and efforts to gain an understanding of what influences peoples' behaviour and choices. Such an approach is central to showing that interaction with the natural world, through activities such as angling, directly and profoundly affects peoples' quality of life.

In summary then, the aims of this research are to:

- Develop a GIS-based strategic management tool for investigating how opportunity for angling relates to participation in angling that can be applied at two different levels, a) map-based and b) using spatial and statistical modelling.
- To apply the methodology in the South East Wales Area.

As noted above, this report extends the work carried out in the R&D Project 'Defining Angler Opportunity' (W2-084/TR). One of the conclusions of that project was that our understanding of how angling opportunity affects participation could be developed by improving the data and looking at the relationships in more detail. This additional research sets out to do this in two main ways. Firstly, the relationship between angling opportunity and participation is investigated on a finer spatial scale, and secondly, the modelling is extended to junior licence holders. This is intended to provide a more in-depth analysis of the opportunity-participation relationships and will hopefully improve the accuracy of the quantitative estimates of opportunity.

1.2 Structure of Report

The structure of this report is as follows. Section 2 describes the new data and methodology for deriving the measures of angling opportunity. In Section 3, the

[1] This report builds on the research carried out in the R&D Project 'Defining Angler Opportunity' (W2-084/TR).

opportunity-participation relationships are modelled with the new data for all and junior licence holders. Section 4 discusses the results and Section 5 offers some conclusions and recommendations.

2 DEVELOPING THE DATA AND METHODOLOGY

2.1 Measures of Angling Participation

As in the previous report noted above, angling participation is measured in terms of the numbers of rod licence holders in a defined area. In that report, rod licence numbers were aggregated to postcode district level, which resulted in a sample size of between 54 and 64 postcode districts (depending on number of outliers) for the study area of South East Wales. As noted above, the purpose of this further research was to explore the opportunity-participation relationship on a finer spatial scale. The next smallest spatial scale is postcode sector, of which there are 224 in SE Wales. The smallest spatial scale available is that used for the national census – the enumeration district[2], which results in a sample size of 4863 observations for SE Wales. In this report, both postcode sector and enumeration districts are used so the angling opportunity-participation relationship can be compared across different spatial scales.

2.2 Population Data

In this additional analysis, population data from the 2001 Census are used in order to provide a more up-to-date and accurate picture of population levels. An additional benefit of using enumeration districts as a spatial unit of observation is that population data are readily available at this level with no need for spatial aggregation, as it is collected by enumeration district for the Census.

2.3 Measures of Angling Opportunity

This additional analysis builds on the previous research project by using two different measures of angling opportunity, the straight-line distances that the previous project used, although as noted above, in this analysis the data are calculated at a much finer spatial scale, and also a 'cost-weighted' measure of angling opportunity. The cost-weighted method produces a measure of opportunity that theoretically can more accurately reflect the relative accessibility of local fisheries, in terms of how long it takes to travel to the fishery via the road network. Figures 1 and 2 below show an example of cost-weighted travel times to migratory salmonid fisheries for the Environment Agency Wales Region[3]. The cost-weighting uses the average speeds of the road network. In this example, the pink areas represent a higher travel time and the light blue areas a lower travel time.

[2] Enumeration districts represent approximately 200 households on average (http://www.statistics.gov.uk/geography/census_geog.asp)

[3] Figures 1 and 2 show a raster data layer produced in Arcmap, which has been 'clipped' by the Environment Agency Wales Region layer. The actual data layer used to provide the travel time values used in the models, whilst mathematically identical, covered a larger geographical area to account for fisheries falling outside the Wales Region boundary.

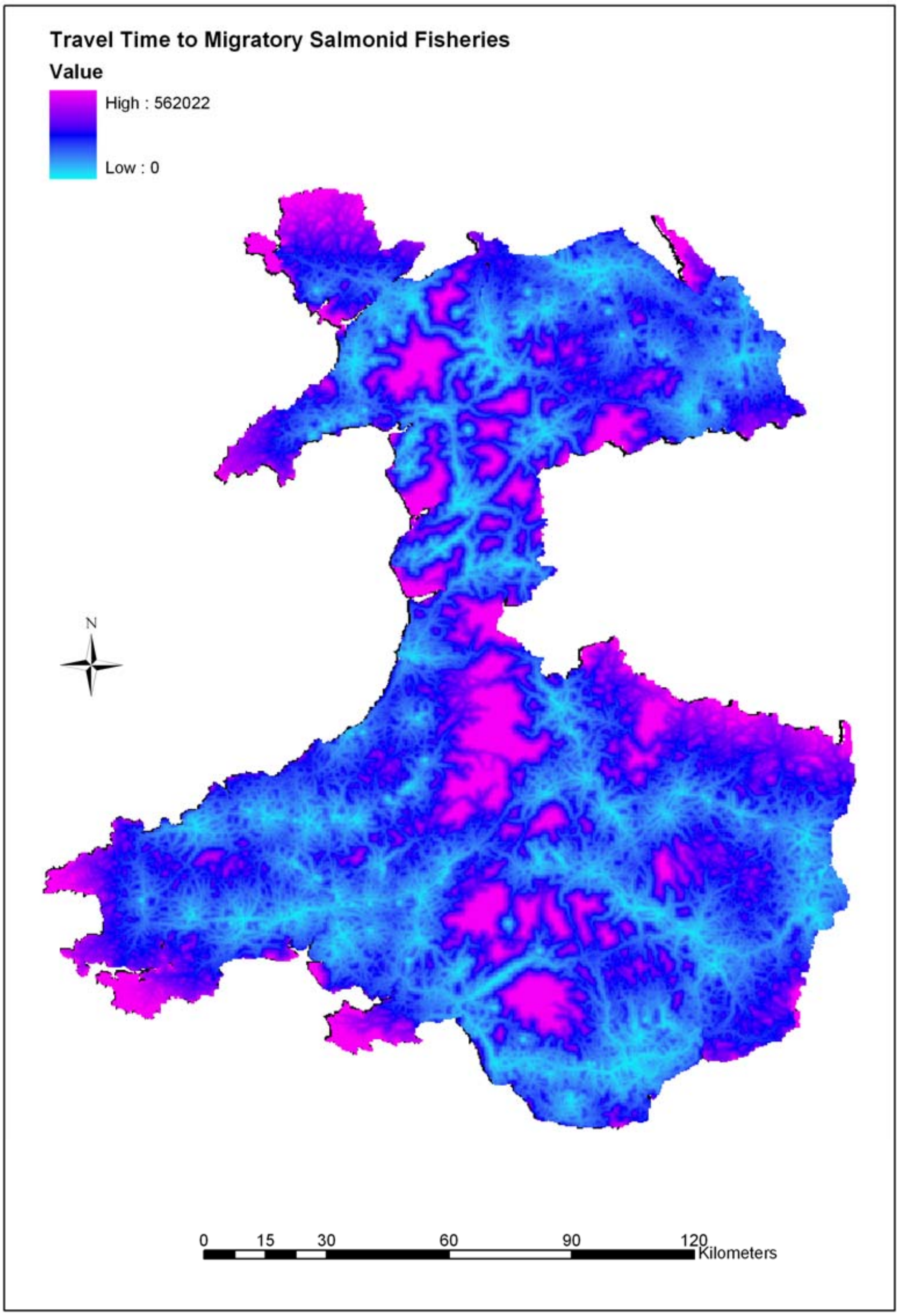


Figure 1 **A travel time 'surface' to migratory salmonid fisheries, based on the average speeds of the road network, for Environment Agency Wales Area**

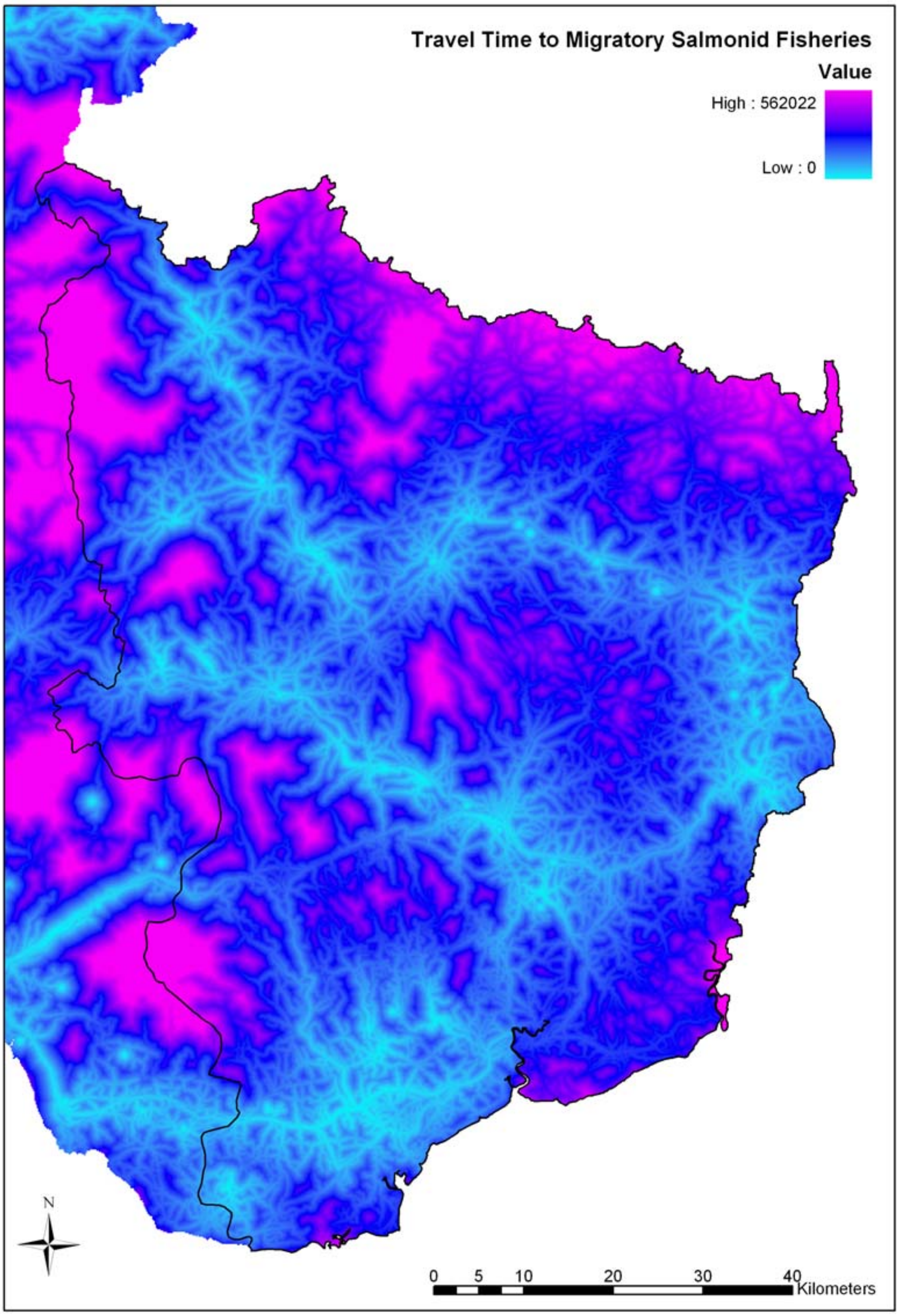


Figure 2 **The travel time surface shown in Figure 1, magnified to show South East Wales Area**

The cost-weighted distance methodology results in values that are not in spatial or temporal units, but an index of travel time (TT) based on the average road travel speed in miles per hour. Thus the interpretation of the model results is different to those of the straight-line models, which show the change in licence holders for a unit change (1km) in distance. The coefficient on the travel time value is interpreted as the change in the number of licences sold for a given percentage change in the travel time value, based on average road speeds.

A weakness of the travel time value as a measure of angling opportunity is when licence holders' perception of opportunity doesn't match with this travel time value. For example, when a licence holder is aware of a fishery that is close to where they live, but it is in an area with poor road access/minor roads that would result in a high travel time value. In this situation, the straight-line distance may more accurately reflect anglers' perceptions of opportunity.

2.4 Fisheries Density

Because there is relatively little variation in the distance and travel time to coarse fisheries across the study area (and potentially also across the country), the variables distance-to-fishery or travel-time-to-fishery on their own may not explain much of the variance in participation/rod licence sales. Including the number of fisheries within a specified distance, e.g. 10km as an additional measure of the opportunity for recreational fishing in an area may more accurately reflect peoples' perceptions of opportunity or availability.

Ideally we would want a measure of opportunity that also took into account the amount of fishing in terms of size of fishery (kilometres of bank or hectares of stillwater). Using the number of fisheries within a specified radius does not account for size differences between fisheries that may have important implications for perceptions of fishery quality, such as congestion at a site. Unfortunately at the current time data on size is not available on a consistent enough level – as noted in the previous report, only about a third of fisheries in the Welsh database had size information.

3 EXTENDING THE ANALYSIS

In the following two Sections, the relationship between angling opportunity and participation is analysed for all fishing licences (adult and junior) in Section 3.1 and separately for juniors in Section 3.2.

3.1 Spatial Analysis of Licence Holders and Fisheries

The following maps show the distribution of licence holders and day-ticket fisheries across the study area. Both trout and coarse and migratory salmonid licence holders/fisheries are mapped. And both postcode sector and enumeration district scale are mapped. The darker shaded areas are represent higher numbers of licence holders. The circles represent the fisheries.

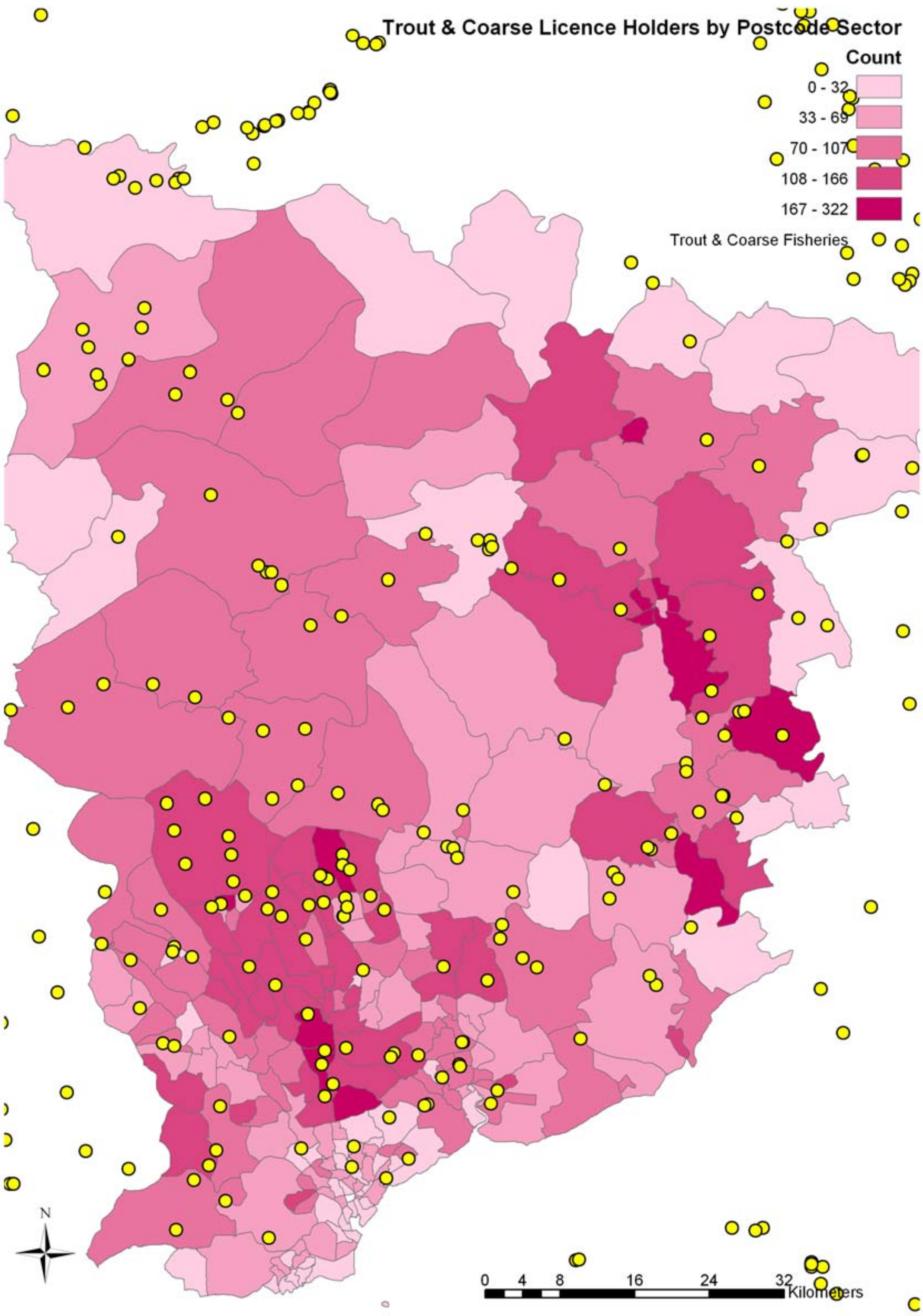


Figure 3 **Map showing Trout & Coarse licence holders and fisheries by Postcode Sector across the study area**

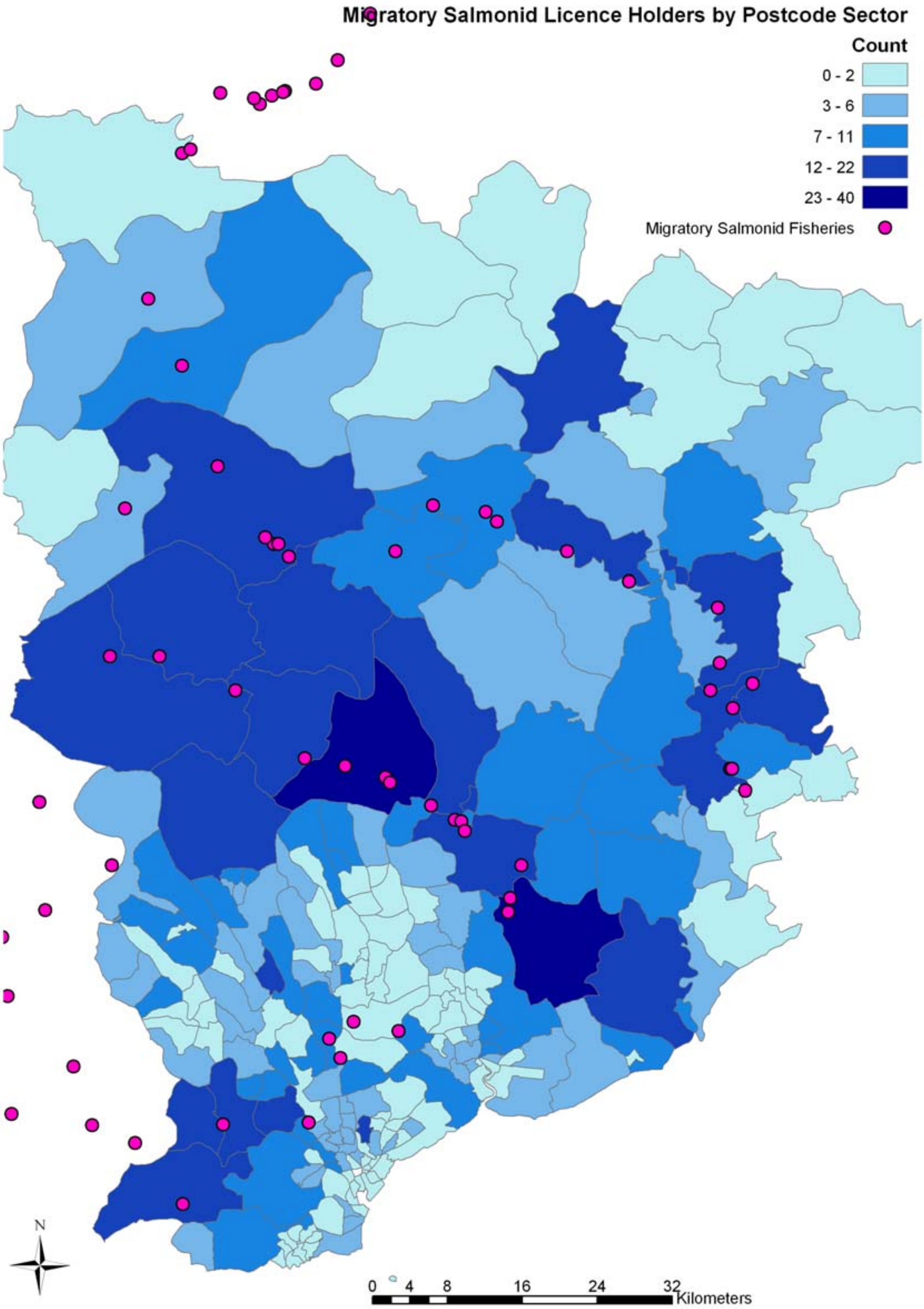


Figure 4 **Map showing Migratory Salmonid Licence Holders and Fisheries by Postcode Sector across the study area**

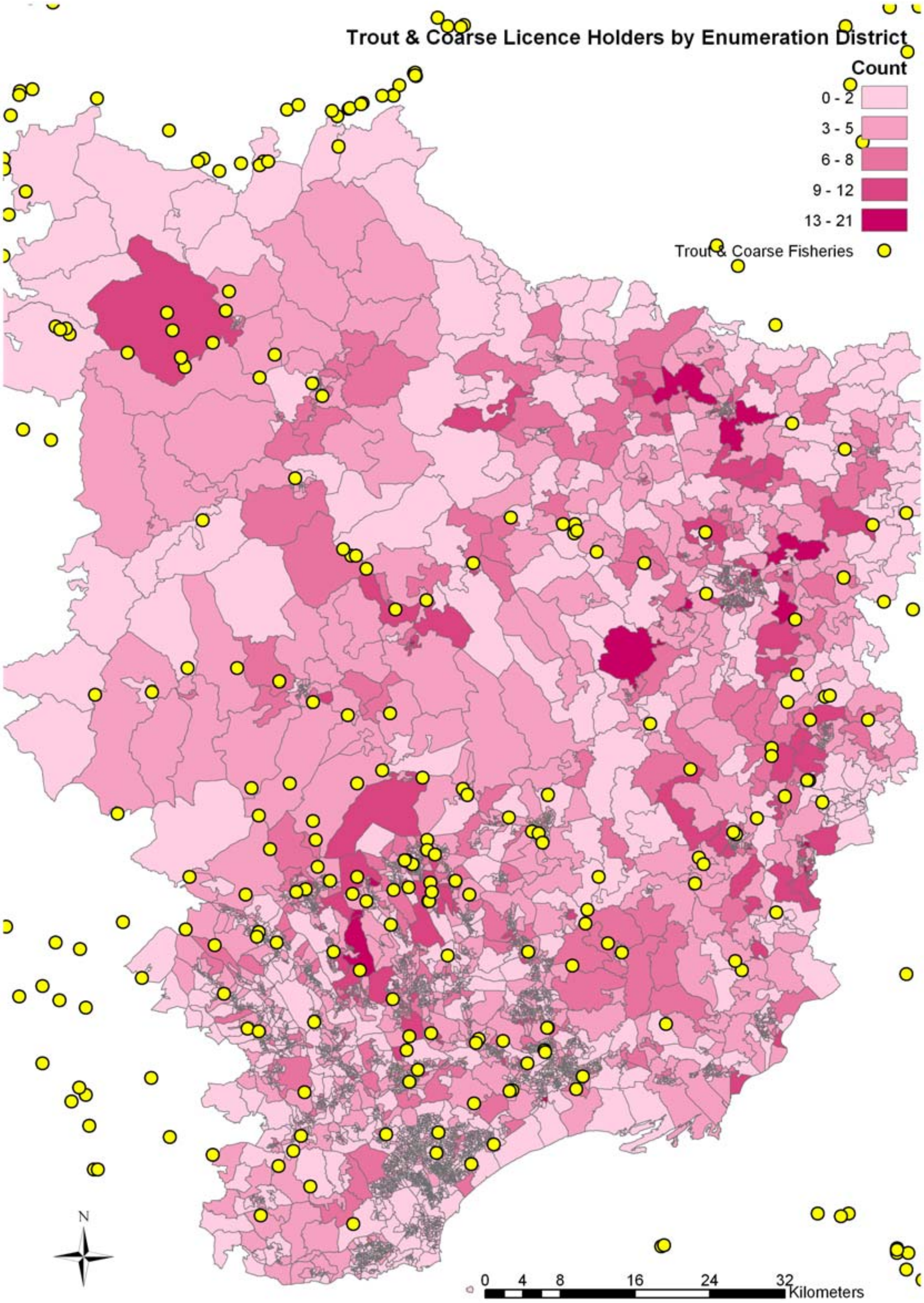


Figure 5 **Map showing Trout & Coarse Licence Holders and Fisheries by Enumeration District for South East Wales**

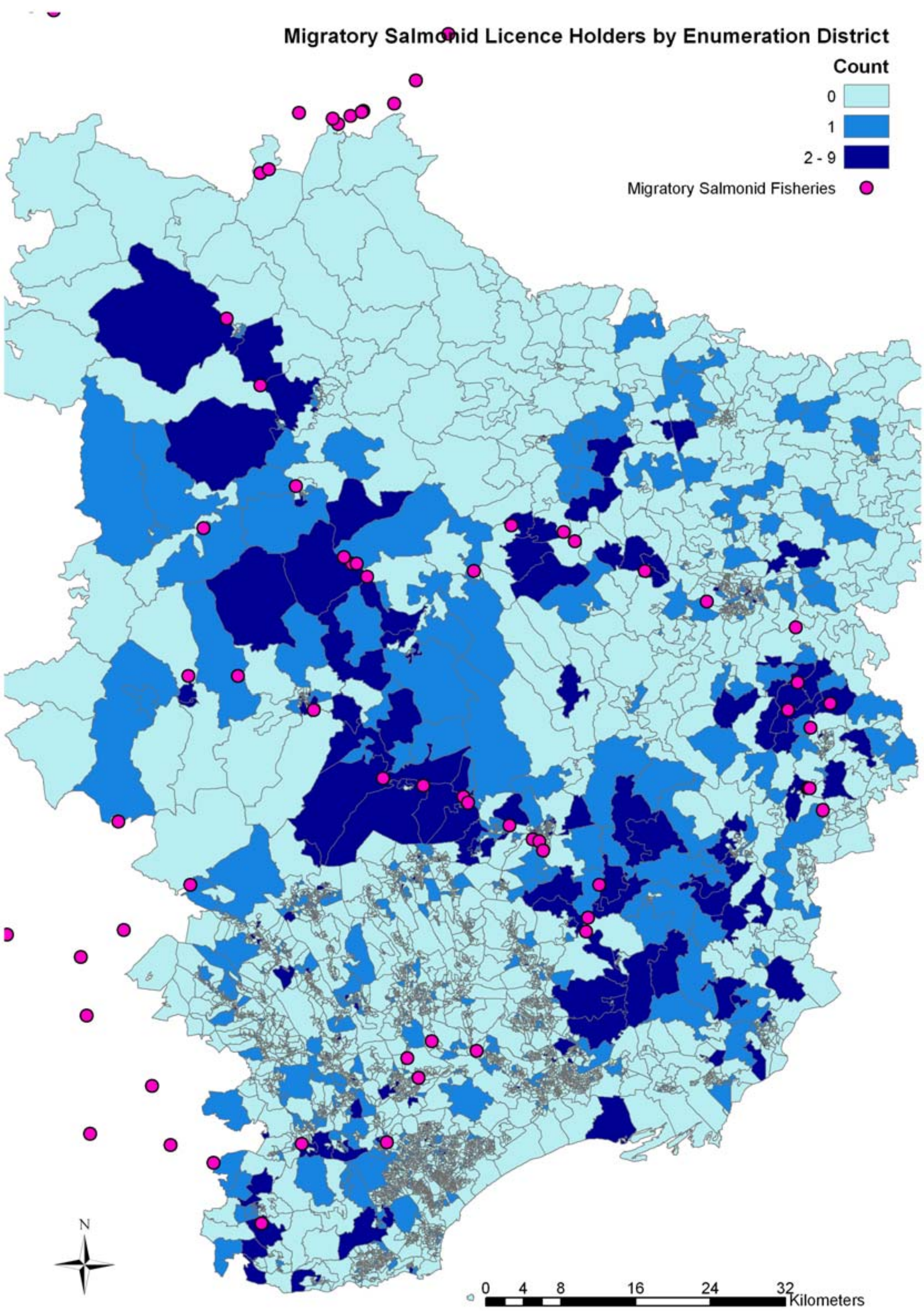


Figure 6 **Map showing Migratory Salmonid Licence Holders and Fisheries by Enumeration District across the study area**

Figures 3 – 6 show that trout and coarse licence holders and fisheries are fairly evenly spread across the Area. However, at both postcode sector and enumeration district scale, postcode sectors with higher numbers of migratory salmonid licence holders are those located closest to migratory salmonid fisheries. In other words, there seems to be a proximity effect for migratory salmonid fisheries, suggesting that we may see a significant linear relationship between these types of licence holders and fisheries in the models analysed below.

3.2 Correlation

As a preliminary analysis, the correlation coefficients between the total number of licence holders[4] and the independent variables - distance, travel time and numbers of fisheries within 10km – were calculated for both postcode sector and enumeration district scales.

Table 1 below shows the correlations for licence holders by postcode sector and Table 2 for licence holders by enumeration district. Coefficients in grey if they are not significant at a probability level of <0.01%. A number of different fishery types are analysed, four types of river fishery and three types of stillwaters.

Table 1 Correlations between numbers of rod licence holders by postcode sector and distance, travel time and number of fisheries within 10km for seven fishery types

Type of fishery	Straight Line distance	Travel Time	Nos. fisheries within 10km
River General Coarse	-0.08	0.00	0.20
Grayling	-0.29	-0.19	0.19
River Trout	-0.40	-0.19	0.34
Migratory Salmonid	-0.38	-0.30	0.29
Still Carp	-0.25	-0.18	0.21
Still General Coarse	-0.27	0.00	0.24
Still Trout	0.21	0.09	0.06
Any fishery	**-0.15**	**-0.14**	**0.22**

Table 2 Correlations between numbers of rod licence holders by enumeration district and distance, travel time and number of fisheries within 10km for seven fishery types

Type of fishery	Straight Line distance	Travel Time	Nos. fisheries within 10km
River General Coarse	-0.03	0.04	0.18
Grayling	-0.04	0.00	0.13
River Trout	-0.10	0.07	0.17
Migratory Salmonid	-0.11	-0.05	0.12
Still Carp	0.06	-0.07	0.00
Still General Coarse	0.04	-0.08	0.02
Still Trout	0.25	0.21	-0.07
Any fishery	**-0.05**	**-0.06**	**0.11**

[4] This analysis could also be carried out using the variable licence holders per capita.

3.3 Modelling

The model specification is determined by the dependent variable (numbers of rod licence holders) which, as a relatively coarse measure of angling participation, suggests a correspondingly simple specification for the explanatory variables. It was initially thought that the opportunity-participation relationship might be modelled for a number of different types of fishery, e.g. those analysed in Section 3.2 above. However, as the dependent variable is only differentiated at the general level of trout and coarse or migratory salmonid, it would have been inappropriate to have detailed specific fishery types for the right-hand side variables.

As the dependent variable – numbers of rod licence holders – are count data, Ordinary Least Squares (OLS) regression is not appropriate. In the previous report 'Defining Angler Opportunity', a generalised linear model (GLM) specification was used to get round this problem. The GLM model is similar to OLS but does not require a continuous distribution for the dependent variable, and has a logarithmic transformation 'built in', avoiding the problem of logging zeros in the dependent variable. In these models, the error distribution is specified as Poisson, and the link function as logarithmic. Stata 7.0 software was used to run the models.

Three models are estimated, one that uses the straight-line distance, one that uses the travel time value, and one that uses the number of fisheries within 10km of population centre.

The straight-line distance model is specified as

$$L = g\,(\alpha + \beta D + \gamma P) + \varepsilon$$

The travel time model as

$$L = g\,(\alpha + \beta TT + \gamma P) + \varepsilon$$

And the number of fisheries within 10km model as

$$L = g\,(\alpha + \beta N + \gamma P) + \varepsilon$$

Where g is the inverse of the link function (so with a log link function, g is the antilog). The dependent variable L is the number of all trout and coarse licences per enumeration district(ed)/postcode sector(ps) for the trout and coarse models, and the number of migratory salmonid licences for migratory salmonid fishery models.

D, TT, N, P are independent variables, where D is the straight-line distance to fishery from ed/ps in kilometres, TT is the travel time to fishery value, and N is the number of fisheries within 10km of the ed/ps centroid. P is the (log) population density of the ed/ps and ε is the error term. The number of fisheries model is not estimated for migratory salmonid licence holders, as the numbers of fisheries was considered to be too low for any meaningful analysis.

The opportunity-participation model results are shown for the total and junior number of licence holders, at both postcode sector and enumeration district levels, in Tables 3 – 5 below. Both log and untransformed versions of the travel cost variable were used, to see if the log forms provided a better fit. Where the coefficients are in grey they are not significant at a probability level of 0.01. The results are for models with outlier[5] observations excluded. The R^2 is calculated by dividing the model deviance (Dev) by the deviance for the null model[6] (Dev0) and then subtracting from 1:

100 x [1 – Dev / Dev0]

The relationship between numbers of licence holders and the angling opportunity variables are shown graphically in Figures 7 – 11 below.

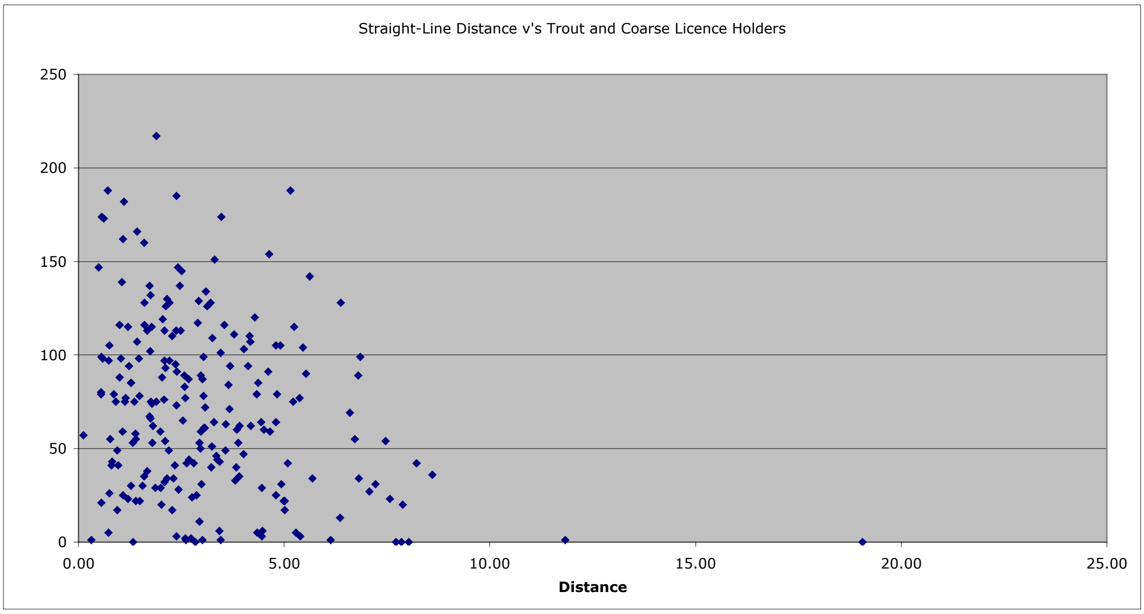


Figure 7 **Straight line distance to nearest trout or coarse fishery v's trout and coarse licence holders by postcode sector**

[5] An 'outlier' is defined as observations greater than 2 standard deviations away from the mean.
[6] The null model is the model run without any explanatory variables, i.e. with only the constant term.

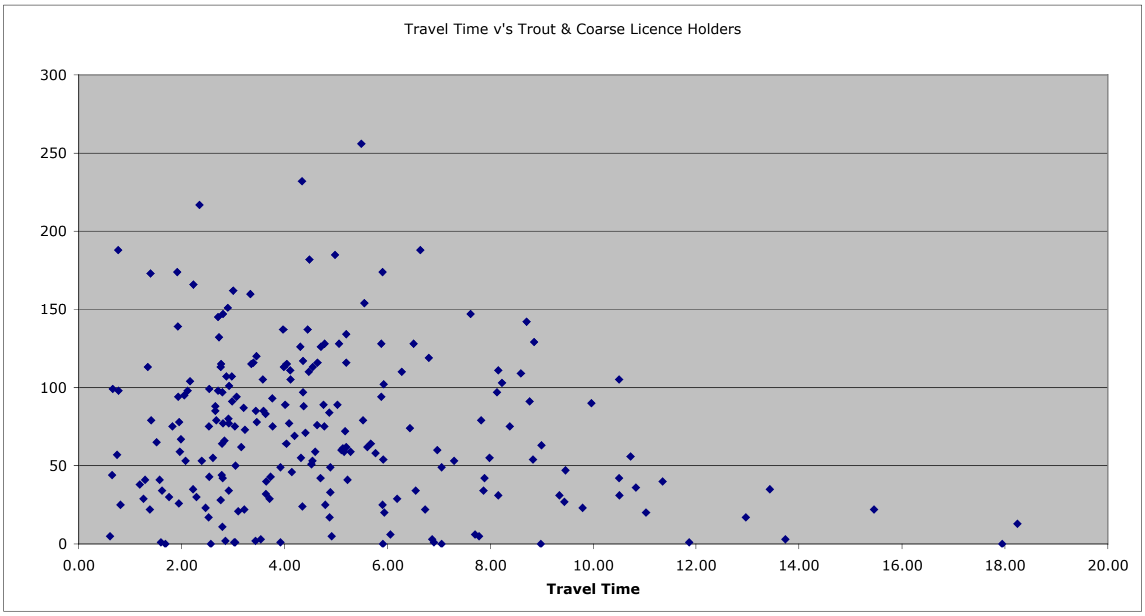


Figure 8 **Travel time to nearest trout or coarse fishery v's trout and coarse licence holders by postcode sector**

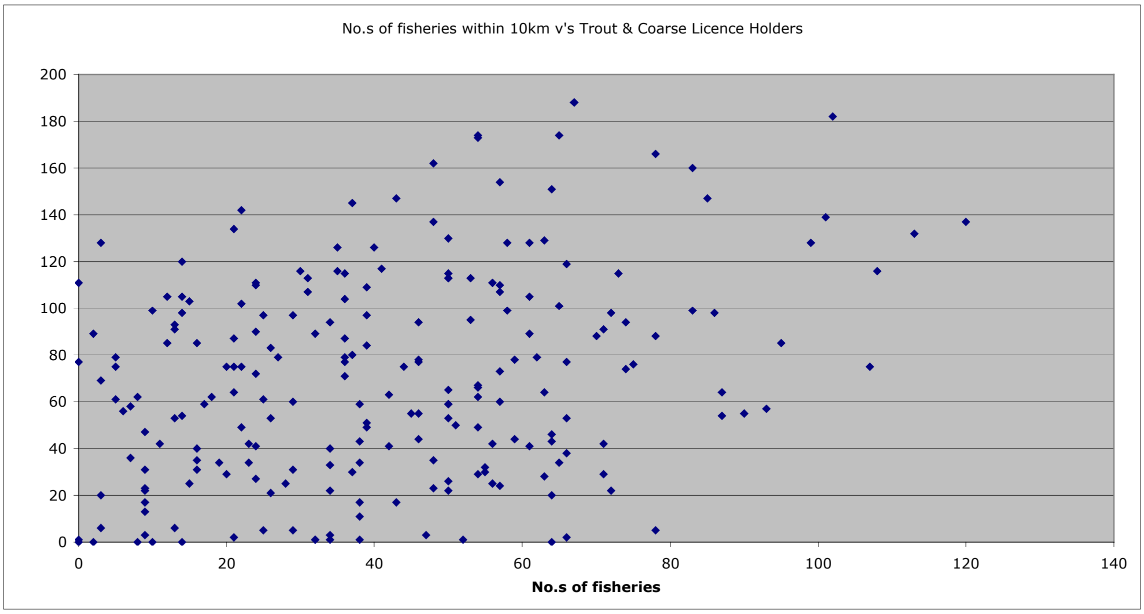


Figure 9 **Number of trout & coarse fisheries within 10km of postcode sector centres v's trout and coarse licence holders**

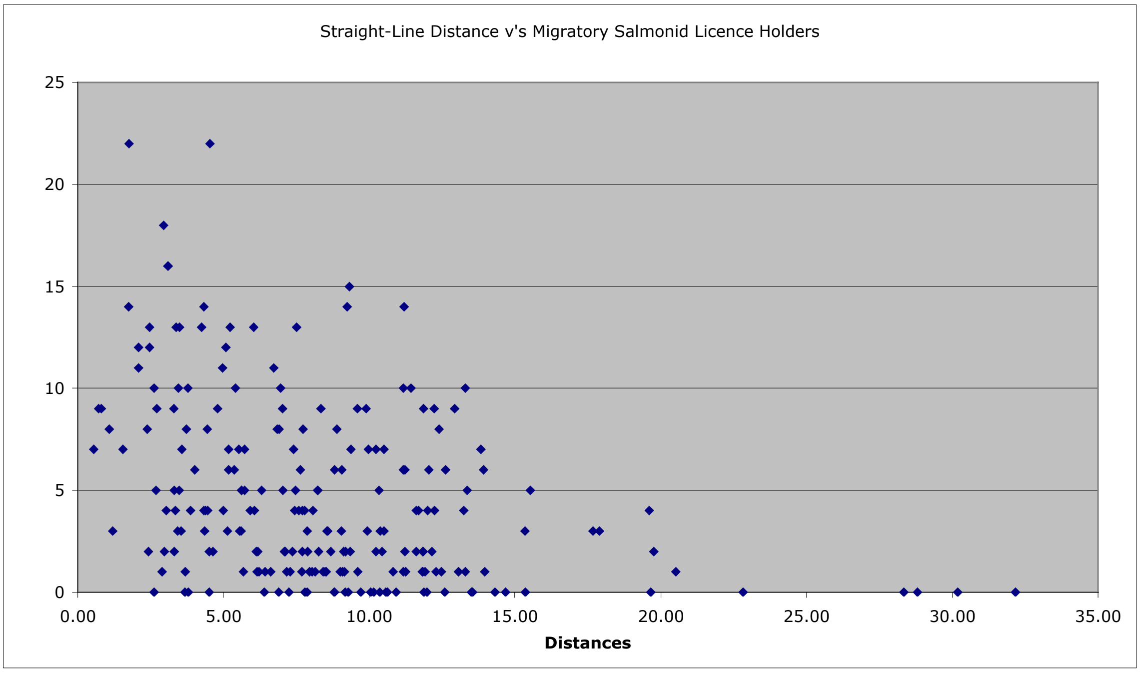


Figure 10 **Straight-line distance to the nearest migratory salmonid fishery v's migratory salmonid licence holders by postcode sector**

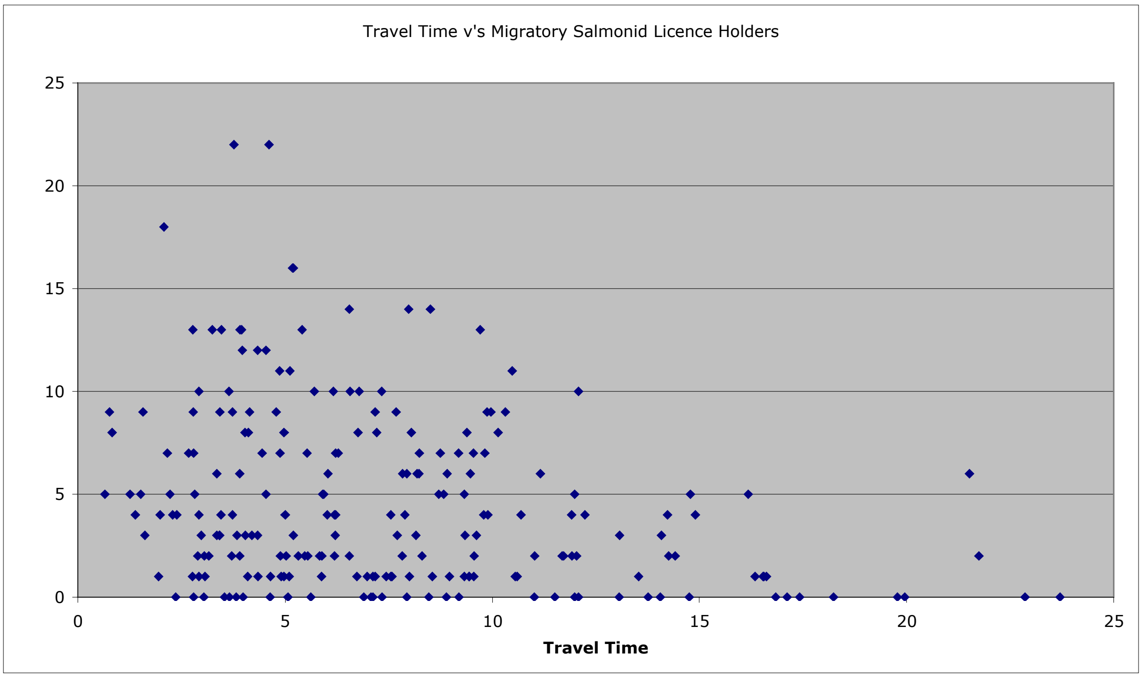


Figure 11 **Travel time to the nearest migratory salmonid fishery v's migratory salmonid licence holders by postcode sector**

All licences

Table 3 Model results for all licences by postcode sector (n=224)

Model Fishery / licence type	**Straight Line Dist**		**Travel Time**		**No. fisheries <10km**	
	Coeff.	R^2	Coeff.	R^2	Coeff	R^2
Trout & Coarse	-0.10	8%	-0.05	4%	0.01	9%
Migratory Salmonid	-0.09	26%	-0.10	23%	-	-

Table 4 Model results for all licences by enumeration district (n=4864)

Model Fishery / licence type	**Straight Line Dist**		**Travel Time**		**No. fisheries <10km**	
	Coeff.	R^2	Coeff.	R^2	Coeff	R^2
Trout & Coarse	-0.03	2%	-0.03	9%	0.004	3%
Migratory Salmonid	-0.07	10%	-0.07	10%	-	-

Junior licences

Only trout and coarse models are estimated for junior licences, as there are no junior migratory salmonid licences.

Table 5 Model results for junior licences

Model Fishery / licence type	**Straight Line Dist**		**Travel Time**		**No. fisheries <10km**	
	Coeff.	R^2	Coeff.	R^2	Coeff	R^2
Trout & Coarse by postcode sector	-0.11	6%	-0.03	1%	0.01	10%
Trout & Coarse by enumeration district	-0.07	1%	-0.03	.05%	0.01	1%

4 DISCUSSION OF THE SPATIAL MODEL RESULTS

Comparing between the two spatial scales, the postcode sector level seemed to be more successful than the enumeration district level, in terms of model fit. An exception to this is the travel time model for trout and coarse fisheries/licence holders, which provides a better fit of the data at the enumeration district level.

The results correspond to expectations in that the 'travel cost' variables - straight-line distance and travel time – are negative, and the number of fisheries within 10km variable, which is a more general measure of availability of fishing, is positive.

The results show that a 1km decrease in straight-line distance-to-fishery increases licence holders by between 3 and 10%. Similarly a 10% decrease in travel time increases licence holders by between 3 and 10%, and an additional 1 fishery within 10km of postcode sector centroids increases licences by between 0.004 and 1%.

The model results suggest that travel cost/angling opportunity has more of an effect on participation in migratory salmonid fishing than for trout and coarse fishing. This means that reductions in distance to migratory salmonid fisheries will result in greater increases in migratory salmonid licence holders than similar distance decreases to trout and coarse fisheries. Put another way, it appears that in South East Wales, anglers' demand for trout and coarse fisheries is less sensitive to cost than demand for migratory salmonid fishing.

The general fishery availability variable 'No. of fisheries within 10km', whilst much smaller than the travel cost variables, is positively and significantly related to the number of rod licences in an area. This could indicate that fisheries are complementary, rather than competitive, in nature, i.e. that general availability of angling sites increases participation levels.

Interestingly the variable log of population density is always negative. The coefficient ranges between -0.03 and -0.07 in the trout and coarse models, and -0.16 and -0.29 for the migratory salmonid models. This implies a possible 'rural effect', whereby people living in less densely populated rural areas are more likely to own a fishing licence than those in more populated urbanised areas. This result might also be linked to a fishery quality effect, in that fisheries in rural areas may be of higher quality and/or of higher aesthetic value than those in urban areas, particularly with respect to migratory salmonid fisheries.

The results for junior licence holders are similar to those for the total licence holders, especially at the postcode sector level, where the 'No. of fisheries' model explains the most variance, followed by the straight-line distance model, with the travel time model explaining the least variance in the data. One difference is that, at the enumeration district level, the travel time model for total licence holders explains more variance than the other two models, but for junior licence holders this model is the worst fit of the three, explaining only half-a-percent of the variance.

The main difference between junior and total licence holders, however, is that the effect of straight-line distance is twice as large for juniors (7%) as it is for all licence holders (3%) at enumeration district level, suggesting proximity to fisheries has a greater effect on junior anglers. Interestingly though, the other model coefficients are of a similar size.

Overall, the rather small amount of variance in licence holders explained by the models (between 10 – 26% for migratory salmonid fisheries and 2 – 9% for trout and coarse fisheries) suggests that other factors are likely to affect numbers of rod licence holders. These may include for example whether the fishery is riverine or stillwater, the quality characteristics of the fishery such as likelihood of catch, ticket price and level of congestion of the fisheries, information that was not available at the time of this research. The simple specification of these models is important to consider when using the model results to estimate the affect of fisheries development, as the numbers of licence holder increases are likely to be very conservative as the influence of these other factors is not captured.

If in the future more detailed information on participation becomes available, for example information on numbers of trips to specific fishery types in an Area, the models could be developed to look at the opportunity-participation relationships for specific types of fishing.

Whilst the use of a relatively broad measure of angling participation means that strong relationships between participation and opportunity are unlikely to be seen, considering the nature of the data, i.e. cross-sectional ‘noisy’ data, the models provide a reasonable picture of the affect of angling opportunity.

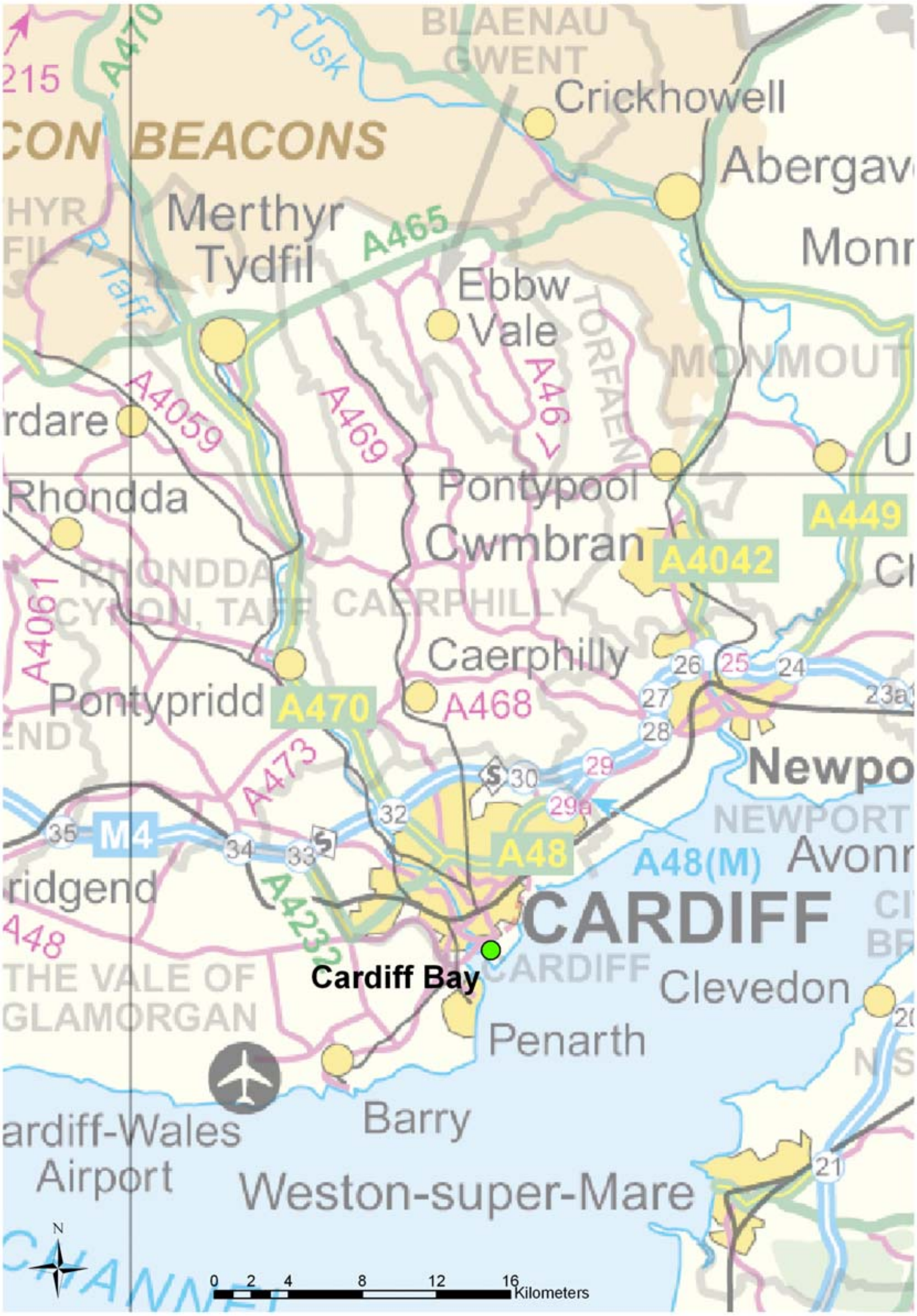
4.1 Applying the Results

In this Section, the model results are applied to three examples of fisheries development sites in South East Wales, in order to investigate how the quantitative estimates might be used in a ‘real world’ fishery prioritisation exercise. The model results at postcode sector level are used as these provided a better fit of the data.

To model the effect of a new fishery on the numbers of licence holders involves the following 3 steps:

- Adding the example site to the spatial databases of fisheries in a GIS;
- Re-running the spatial analysis to obtain the new measures of angling opportunity with the additional example site, namely the straight-line distance or proximity, travel time and number of fisheries within 10km radius of centres of population;
- Calculating the difference between these three variables with and without the additional fishery and then multiplying this difference by the model coefficients.

Case study 1 – 'Norwegian Church' on Cardiff Bay – Site on a large mixed coarse stillwater/estuarine fishery – ST194742



For this site the trout and coarse model results are used to give an approximate indication of the impact of this fishery development site on numbers of licence holders in the region. The results are shown in Table 6 below.

Table 6 The effect of Norwegian Church site on Cardiff Bay on number of licence holders in the region

	No. of postcode sectors affected	Total kms / Average travel time decrease	Original no. of licence holders in affected postcode sectors	Total increase in no. of licence holders due to fishery	Overall % increase in licence holders
Distance	13	35km	238	67	28
Travel Time	5	36%	58	7	12
No's < 10km	51	-	1879	19	0.01

In this application, the results mirror the model coefficients, in that the straight-line distance or proximity variable has the greatest affect on participation, and the fisheries density variable the least, only a half-a-percent increase.

Case study 2 'Cadoxton Ponds': Small mixed coarse stillwater fishery – ST137686

In this example the relevant coefficients to use are also those from the trout and coarse model; the results are shown in Table 7 below.

Table 7 The effect of the Cadoxton Ponds fishery on the number of licence holders in the region

	No. of postcode sectors affected	Total kms / Average travel time decrease	Original no. of licence holders in affected postcode sectors	Increase in no. of licence holders	Overall % increase in licence holders
Distance	14	36km	396	90	23
Travel Time	14	47%	396	100	25
No's < 10km	31	-	984	10	0.01

This site differs slightly to the previous example, in that the reduction in travel time has a slightly larger affect on the numbers of licence holders generated, showing that the particular postcode sectors affected will influence the estimates of licence numbers.

Case study 3 'River Taff at Quakers Yard': Migratory salmonid river fishery – ST084964

In this example, the migratory salmonid model results are the appropriate coefficients to use. The results of applying these coefficients to this potential fishing site are shown in Table 8 below.

Table 8 The effect of the fishery at Quakers Yard (River Taff) on the number of licence holders in the region

	No. of postcode sectors affected	**Total kms / Average travel time decrease**	**Original no. of licence holders in affected postcode sectors**	**Increase in no. of licence holders**	**Overall % increase in licence holders**
Distance	25	94km	116	42	36
Travel Time	25	22%	132	30	23

In this example, straight-line distance again has the greatest affect on licence holders: the importance of this proximity effect was indicated in the Migratory Salmonid maps (Figures 4 and 6) and in the correlation analysis.

4.2 Case Study Conclusions

As these three case studies have shown, the number of new licence holders estimated using the results of the opportunity-participation models depends on the type of the angling opportunity variable used, i.e. straight-line distance, travel time or fisheries density, and also the type of fishery under consideration. Specifically, in South East Wales, reductions in straight-line distance has a greater affect for migratory salmonid angling than trout and coarse angling.

Perhaps more significantly, the estimates are also dependent upon the population levels in the specific postcode sectors affected by the fishery development. Where population, and therefore licence holders, are initially higher, the fishery development will result in a higher number of licence holders.

Because there is no size of fishery information in the models, the effect on licence holders of opening the whole of Cardiff Bay, or the whole of the River Taff, cannot be estimated. At the moment the models can only account for specific points and not areas.

In addition it is important to be aware that the benefits of developing new fisheries are not just the generation of new licence holders, but will also result in increased levels of participation - numbers of fishing trips - for existing licence holders.

5 CONCLUSIONS

- This research has aimed to do two things, firstly to develop a methodological tool that can be used as an input into strategic fisheries management, and secondly to apply this methodology in one Agency Area, South East Wales.

- The purpose of the tool is threefold. Firstly to identify areas where fisheries development will result in the greatest social and economic benefits. Secondly, to develop our understanding of how opportunity for angling affects levels of participation. And finally, to model the opportunity-participation relationship statistically to enable us to predict participation in angling.

- The management tool developed in this project can be applied on two levels: a basic spatial level, and a spatial-statistical level. The basic spatial level maps the distributions of fisheries and licence holders in an Area. This is useful as it can help fisheries managers to identify areas in a region where developing fisheries will 'fill the gaps' and reduce the distance to fisheries.

- Given GIS training and access to statistical software, this tool can also be applied in a more in-depth way to estimate the levels of participation from developing fisheries at specific locations, which can be used to compare between different potential (and potentially competing) sites.

- The main conclusion of the spatial-statistical modelling is that angling opportunity[7] does indeed have a significant affect on participation, as measured by the number of licence holders.

- Whilst the tool can be readily applied to other Agency Areas, the statistical model results are specific to South East Wales and cannot be transferred to other Areas. This is because we cannot assume that the mathematical relationships would be the same in other regions around the country.

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[7] As measured by the parameters straight-line distance/proximity, travel time and number of fisheries within a 10km radius.

6 RECOMMENDATIONS

Recommendations to take this project forward are to apply the tool, at least to the spatial map-based level, in all Agency Areas and/or at a Regional level.

Initially, once the data on fisheries has been collected at the Area/Regional level, the more in-depth statistical modelling could potentially be a service provided at a national level by the National Fisheries Technical Team (NFTT).

More precise measures of use, specifically numbers of fishing trips, would provide a more accurate measure of angling participation. An initiative to collect data on numbers of fishing trips, along with other socio-economic information is being piloted in South East Wales with at least two angling clubs[8].

As an approximate estimate of use, the ratio between numbers of trips by distance and numbers of licence holders by distance could be estimated from the National dataset collated by Area in the report 'Survey of Rod Licence Holders', 2001). Once this ratio was identified, given the number of licence holders, rough estimates of numbers of trips could be estimated.

A potentially valuable way of estimating angling participation levels would be to use the GIS methodology developed by Bateman *et al*., to predict the number of trips to fisheries.

Spatially referenced (GIS) databases of fisheries need to be linked by grid reference to GIS databases of river quality and fish populations. This would be very useful as it would allow us to include river fishery quality data (which is likely to be significant in explaining demand) in modelling angling participation.

[8] The Sustainable Fisheries Officer in South East Wales is the contact for this work.

ANNEX A

The methodology for generating the travel time values uses the Arcmap function 'Spatial Analyst'. This involves analysing a combination of two raster layers, namely the different types of fisheries, the road network with associated travel speeds for different types of roads, and a feature class layer of the licence holder address points. The procedure is as follows:

1. Create raster layers for each fishery featureclass shapefile and reclassify so only 1 value.

2. Create raster layer of the road network and reclassify so high speed = low cost and vice versa, and 'no data' areas, i.e. where there are no roads = 3mph.

3 Run spatial analysts 'cost-weighted distance' function, where 'distance to' is the fishery raster, and 'cost raster' is the road network raster.

4 Run the VB code to attach the resulting cost-weighted value from step 3 above to the licence holder point shapefile.