Fishing for Data: Potential for Citizen Science to Conserve Freshwater Ecosystems

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List of Acronyms and Abbreviations

AMI: Anglers Monitoring Initiative

CEFAS: Centre for Environment, Fisheries & Aquaculture Science

CPUE: Catch Per Unit Effort

EA: Environment Agency

ESD: Experienced Scheme Developers

FEK: Fishers' Ecological Knowledge

GPS: Global Positioning System

IFM: Institute of Fisheries Management

NFMP: National Fisheries Monitoring Programme

SDF: Scheme Development Framework

SFCC: Scottish Fisheries Coordination Centre

WFD: Water Framework Directive

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Thank you.

Best fishes.

Abstract

Using fish as indicators of freshwater ecosystem health provides information that can be used by fisheries managers and for the development of environmental policy at local, regional, national and international levels. Angler catch returns provide some useful data for the Environment Agency (EA) in the United Kingdom, but on a localised and small scale. This paper investigates whether 'fishers' ecological knowledge' can be collected as part of a citizen science scheme. Citizen science projects form a collaborative reciprocal relationship between scientists and volunteers who report data. Based on previous angler catch return schemes and citizen science initiatives a scheme development framework was created. The opinions and experiences of 33 participants, via either interviews or focus groups formed the basis for a stakeholder perspective analysis. Anglers, angling club committee members, EA employees and experienced scheme developers formed the four different stakeholder perspectives which validated and enriched the theoretical perspective of the scheme development framework. Findings highlight several fundamental barriers to anglers reporting their catch data as part of a citizen science scheme, namely, angler mistrust of the EA, concerns of data privacy and angler apathy. Recommendations are made for the development of a collaborative angler catch citizen science scheme.

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1. Introduction

1.1 Freshwater Ecosystems

Water sustains all forms of life on Earth. The benefits of freshwater ecosystems are understood universally. Many of the underpinning requirements for human society are either directly or indirectly provided by access to freshwater (Abell et al., 2008; Dodds & Whiles, 2010). Ranging from the ancient, glacially eroded lakes of the Lake District, to the 2200 miles of navigable canals and rivers, the United Kingdom (UK) has extensive and diverse freshwater ecosystems (Sharpe & Maclean, 2010; Eden, 2012).

The UK's freshwater ecosystems are home to a rich array of biodiversity, of which the complex webs of freshwater life are a key indicator to the health of the ecosystems and the services they provide (Sharpe & Maclean, 2010; EA, 2004). Freshwater ecosystems support agricultural, domestic, industrial and recreational services, making a significant contribution to both the environment and society (Sharpe & Maclean, 2010; Eden, 2012; Mawie & Peirson, 2009; EA, 2006).

Currently, the UK's freshwater ecosystems are viewed as relatively healthy and on a positive upward trend (Sharpe & Maclean, 2010). However, the UK's waterways are highly managed, manufactured landscapes. For example, 49% of lowland rivers are considered 'obviously modified' (EA, 2006).

The Environment Agency (EA) is the governmental body in England and Wales that is responsible for managing and protecting the environment, including freshwater ecosystems. A major component of this is managing freshwater fisheries, which are used by millions of anglers (Eden. 2012). Angling is widely accessible, providing a healthy form of recreation and enabling people to connect with nature and their local environment. It also makes an important contribution to local and rural economies (EA, 2004).

In order to facilitate appropriate regulation and management of fishery resources, the EA requires high-quality data of the status and dynamics of fish populations (Williams, 2012). The abundance and distribution of fish stocks is an excellent indicator of fresh water quality and the ecosystem's health (Sharpe & Maclean,

2010; EA, 2004; Eden, 2012). This information can support the development and implementation of policy at national, regional and global scales (www.unep-wcmc.org).

Fish are not easy to count. They are out of human sight under water and highly mobile. Variations in detectability due to range, abundance, density and cryptic appearance or behaviour, influence the monitoring of species. As a result the EA currently incorporates a mixture of methods into its monitoring of fisheries (Baldwin, 2012).

Monitoring data from angler catch currently involves compulsory returns of game angler logbooks and the collection of coarse angler match catch results (Eden, 2012; EA, 2006). Games anglers catch species such as salmon, trout and grayling whereas coarse anglers fish more generally for all other species (Eden, 2012). In the UK, coarse anglers out number game nearly four to one (Robinson et al. 2003), mainly because there are many more species of coarse fish to be caught, but accessibility, social and economic boundaries also affect angling participation trends (Sharpe & Maclean, 2010; Eden, 2012).

Known as 'fishers' ecological knowledge' (FEK), anglers are in a unique position where they regularly interact with the environment (Eden, 2012), and are therefore valuable sources of information (Cowx, 1991). Angler catch return schemes are hard to administer, receiving varied amounts of angler and club support. Recently there have been calls from the EA to enhance the angler catch data, collaborating with anglers and angler clubs to reap the benefits of their unique knowledge (Williams, 2012).

1.2 What can Citizen Science Do?

"Citizen science enlists the public in collecting large quantities of data across an array of habitats and locations over long spans of time" (Bonney et al., 2009, p.977). As mentioned above this data is vital for the monitoring of biodiversity and informing management and policy. As well as providing valuable data, citizen science schemes include other benefits such as education and awareness, publicising conservation issues, re-connecting people with nature and empowering people to make a difference to

causes about which they care (Jordan et al., 2012; Chandler et al., 2012; Devictor et al., 2012).

Citizen science allows for people to be at the centre of providing solutions to conservation issues. It provides a vehicle for conservation to try and move away from the days of so called 'fortress conservation' (Heatherington, 2012) where nature protection means humans are banished. Citizen science also enables conservation to broaden its horizons, not just restricting itself to emblematic or rare species. Perhaps most importantly citizen science means that conservation becomes more accessible - a collaboration between science and people and no longer just an academic discipline (Devictor et al., 2012).

Citizen science projects often take advantage of ways that humans relate and interact with biodiversity and because of this they are particularly effective at monitoring 'everyday nature', a term which is frequently used in conservation science and land-use policy (Devictor et al., 2012). Anglers hold a unique amount of FEK; perhaps citizen science may hold the key to harnessing this knowledge effectively.

1.3 Aims and Objectives

This project aims to answer the research question: "Can a citizen science approach to collecting recreational angler catch data be used for monitoring freshwater fish?" The current study will be addressing the validity of such a scheme with coarse anglers and with in the EA's jurisdiction of English and Welsh freshwater bodies.

The objectives of the project include:

1. How can anglers be motivated to provide their catch data?
2. What is the most appropriate tool/platform/medium to report this data?
3. What are the implications for the different stakeholders when engaging in a citizen science project (e.g. fisheries management, conservation policy, education and awareness)?

2. Background

2.1. Freshwater Ecosystems

2.1.1 Current State of the UK's Freshwater Ecosystems

The current state of the UK's freshwater ecosystems is, as a whole, seen as one of a positive upward trend, but it has not always been this way (Sharpe & Maclean, 2010). The outpouring of pollution since the boom of the industrial revolution and increased chemical run-off (due to agricultural intensification post World War II), saw the freshwater quality of the UK's ecosystems deteriorate significantly (Sharpe & Maclean, 2010). The last three decades have resulted in a suite of costly management practices aimed at cleaning up the UK's freshwater ecosystems, driven by the demands of the European Union Water Quality Directives.

At a localised level the UK's freshwater ecosystems are subject to a variety of anthropogenic threats (EA, 2006), which risk the provision of their resources and services. Threats such as pollution, water abstraction, altered flow regulation, habitat loss and the introduction of invasive species, make them vulnerable to degradation and a priority for sustainable management and conservation efforts.

2.1.2 Angling

Fresh water ecosystems have been fished commercially and recreationally for centuries in the UK. Anglers are key stakeholders in the freshwater ecosystems, their regular use and immersion in the environment gives them a wealth of useful knowledge (EA, 2006; Eden, 2012).

Fishing provides social benefits, providing a healthy form of recreation and enhancing the well being of millions of people (EA, 2004; Williams, 2012; Robinson et al. 2003; Sharpe & Maclean, 2010). Angling also makes an important contribution to local and rural economies (Mawie & Peirson, 2009), with a total annual expenditure of approximately £3 billion spent on recreational angling in England and Wales (EA, 2006).

2.1.3 Fisheries Management

The broad diversity and sheer magnitude of the UK freshwater fisheries has resulted in several agencies and organisations, at local, regional and national level being involved in their management (EA, 2004). Private fisheries, river trusts and government agencies each have their own aims and objectives. All inland fisheries in England and Wales are in private ownership, but their regulation is the responsibility of both the government, via the EA and private sectors (Robinson et al., 2003).

The EA is responsible for protecting and managing the environment of England and Wales (www.environment-agency.gov.uk). The Government and Welsh Assembly Government issued a statutory right to the EA to "maintain, improve and develop salmonid and freshwater fisheries" (EA, 2004).

The EA works towards the goals of the European Water Framework Directive (WFD) which came into force in 2000, becoming part of UK law in December 2003. The Directive aims to simplify inconsistent legislation in order to achieve 'good' ecological and chemical status of all surface waters by the year 2015 (EA, 2004). Fish populations are one of the WFD's ecological indicators. Strategy plans, such as the four year 'Better Fisheries for Our Nations' document (EA, 2006), aims to increase the economic, social and environmental benefits of fisheries, of which monitoring is an integral part.

2.1.4 Role of Monitoring

In order to facilitate appropriate regulation and management of fisheries resources, policy advisors and fisheries management agencies, such as the EA, require high-quality observations and analysis of the status and dynamics of fish populations (Williams, 2012). The abundance and distribution of fish stocks can be an excellent indicator of fresh water quality and the ecosystem's health (Sharpe & Maclean, 2010; EA, 2004; Eden, 2012). The EA's annual budget for fresh water monitoring is approximately £48 million, whose findings in turn direct the billions of pounds of investment it spends on the environment (Walmsley, 2012).

The EA's National Fisheries Monitoring Programme (NFMP) was established in 2001. Its principles are to monitor, report findings and use data to underpin its own work and to influence others to take action (Walmsley, 2012). The NFMP's guidelines regulate monitoring so that the data can a) meet specific management needs, b) meet predetermined statistical criteria and c) be based on robust scientific principles (EA, 2004). The annual budget currently allocated to cover coarse and game fisheries monitoring costs is £3.5 million, with approximately one third of the funding going into regional, locally guided monitoring (Baldwin, 2012). This dissemination of the data is important as it can be used at three levels; policy makers require it at national and European level, planners can use it at a catchment level and the public can use it at site level (Walmsley, 2012).

No one method of monitoring fish stocks can account for the diversity of fish species and the waters they live in. Therefore the NRMP utilises several techniques in an attempt to provide an indication of fishery status and population trends at a local, regional and national level (EA, 2006).

Estimating fish numbers can be an extremely difficult task (Eden, 2012), with several techniques available. The EA uses a mixture of methods including electric fishing on smaller rivers, and seine netting, hydroacoustic and angler catch data on larger rivers (Baldwin, 2012). Each have their strengths and weaknesses, so a strategy involving several techniques is often needed to form a robust measurement of trends in fish abundance (Sharpe & Maclean, 2010). A mixture of temporal monitoring (to assess changes over time) and spatial monitoring (to detect changes between sites) attempts to address the most important management issues, whilst maintaining flexibility to challenging needs (Baldwin, 2012).

Monitoring data is used by the EA to evaluate and classify rivers based on their fisheries status and water quality. Reports from this data such as "Our Nation's Fisheries" (EA, 2004) present the results of the NFMP which are then to be used as a fisheries management tool. Electric fishing data in particular is used to classify the ecological status of freshwaters to help achieve the WFD's objectives (Eden, 2012). Monitoring is needed to provide evidence to inform, rationalise and justify management

decisions. The reports that may be created from it are also an important tool for the EA, to demonstrate to their stakeholders that they are acting in their best interests (Williams, 2012).

2.1.5 Monitoring via Angler Catch Data

Angler catch data itself can take several forms and be collected by various means. The EA currently runs two schemes which collect angler catch data to monitor freshwater fish. Firstly, all game anglers are legally required by the Water Resources Act 1991, to return their salmon and sea trout catch data via a small printed logbook which is provided by the EA (Eden, 2012). The logbook standardizes what is recorded, bridging the two groups and allowing data to be shared (Eden, 2012). They are required to record data on each fish caught, its weight, location and unit of effort of time spent fishing, allowing for the calculation of Catch Per Effort Unit (CPUE).

Secondly, in certain locations, particularly the north east of England, the EA has long-term data sets from competitive matches (Lee, 2009; Cowx, 1991). The EA asks angling club secretaries to collate and submit their match catch data. Clubs are even paid an incentive to do so - £1 for every match return, plus a £200 bonus if they return at least 85% of their matches (Eden, 2012). Match catch data is particularly useful because it automatically provides a unit of effort (duration of match), as well as being convenient, because the data is a by-product of an activity that would be happening anyway. Collection of this data is not always consistent (Lee, 2009). The number of returns is subject to multiple variables such as land ownership rights (Eden, 2012), perceived quality of fishing spots and facilities (Lee, 2009), environmental conditions (Frear, 2008) and land use restrictions during incidences such as the 2001 Foot and Mouth disease outbreak (Eden, 2012; Sharpe & Maclean, 2010).

A region that has been particularly successful in the collection of angling catch returns, is the Yorkshire area (Lee, 2011). In 2010 a total of 439 match returns, over 61 venues were collected in 2010 in the Yorkshire area (Lee, 2011), a slight drop from previous years but this was presumed to be because of adverse weather. Forty-four of the 61 venues achieved the top status in the Fisheries Classification system, a 6.3% reduction from the previous year. On some rivers an increased presence of Perch fish

provided positive signs of improvement in water quality. An increase in species diversity was also noted in several areas. The absence of eels from certain sites provides evidence that supports the claims of a decline of eel stocks nationwide (EA, 2004; Lee, 2011).

Care must be taken when drawing conclusions from catch data alone (EA/CEFAS, 2009) and it is therefore combined with data collected by measures as mentioned above. EA staff report congruency between catch data and other methods, with any errors or individual variations lost when averaged out over 1000s of angler days (Eden, 2012). Catch data can only provide a relative measure in trends between waters and over a certain time period (O'Hara & Steel, 1998; Cowx, 1991). It is not an absolute measure of fish stocks. Catch data's real value lies in being an important part of a more extensive fish monitoring suite, showing long term trends, highlighting problems and therefore demonstrating the need for further investigation (Eden, 2012; Axford, 1991; Cowx, 1991).

Other schemes and organisations have attempted different methods of collecting angler catch data. Table 1 provides a summary of these. Apart from a few locations where regular match catch reports have been returned successfully, no scheme has been able to maintain the collection of large quantities of quality coarse angler catch data that can assist in the robust monitoring of freshwater fish populations. The EA's 'Our Nations Fisheries' report in 2004 highlighted that for many years it has collected match catch data from only a limited number of rivers and intended to expand the programme by engaging with more angling clubs across England and Wales.

Table 1. Summary of previous angler catch schemes.

	Sources	Organiser	Participants	Data Collected	Collection Method	Use of Data	Additional Notes
Trout & Grayling National Logbook Scheme	Reports. Interviews.	EA and Grayling Society.	Members of the Grayling Society.	Date, location, size in length categories, water height of river, clarity of river, weather conditions, bycatch (other species), effort in hours.	Angler completed log book and return via post	Monitor and compare the performance of grayling fisheries. Fisheries management. Advance scientific knowledge.	Significant early support, providing useful information, but declined and ended after 8 year trial period. Greater returns with locally run initiatives Limited to Grayling anglers only.
Angler Creel Census Scheme	Reports.	EA.	Coarse anglers.	Location, date, river or water body, weather and water condition observations. Effort, baits and methods used, number fish, species, size category, other methods used unsuccessfully, type of fishing, target species, examination of catch, biological details of individual fish (age, growth, health status).	Area teams perform bankside interviews to collect, analyse and report data locally. 30 interviews per day, 16 weekend days per annum recommended	Monitor and compare the performance of grayling fisheries. Fisheries management. Advance scientific knowledge.	Large array of data can be collected in both qualitative and quantitative capacity. Collects data which cannot be monitored by postal questionnaires. Can help build relations between anglers and the EA Labour and resource intensive – amount of data limited to number of researchers.
Go-fish	Website. Interview.	Private developer.	Any anglers, potentially worldwide.	Photo, species, weight, bait. App automatically records time, location, weather.	App and website.	Angler interest. Directory to locate good fishing spots.	3 million hits in first year, currently 6 million hits per year 150,000 downloads, 80,000 registered users. No unit of effort recorded. Blanks not recorded.
Anglers Database	Website. Interview.	Private developer.	Any anglers.	Date, location, species, weight, length, girth, weather, moon phase, photos.	Private computer software.	Angler interest. Improve angler fishing.	50 copies sold. Purchase software online. Information private and not shared.

2.2 Citizen Science

2.2.1 What is Citizen Science?

Citizen science is the partnership between scientists and non-scientists, or volunteers, that involves the non-scientists collecting data (Dickinson et al., 2012; Jordan et al., 2011). By providing a standardised protocol for enthusiastic people to report their observations, or by finding ways to motivate people to make observations and record them, everyday people can provide huge amounts of valuable data across large spatial and temporal scales (Dickinson et al., 2012; Devictor et al., 2012).

The idea of using citizen science in ecology and conservation is not new. For centuries, amateur ecology enthusiasts (first referred to as naturalists) have kept diaries recording their observations, becoming a recreational pastime for many people (Devictor et al., 2012; Miller-Rushing et al., 2012). The UK in particular has a rich knowledge and understanding of its fauna and flora, going back for generations thanks to the observations and recording of the general public (Sharpe & Maclean, 2010). Scientists realised that these observations were useful to their research, so what were amateur observations became scientific data sets and the term 'Citizen Science' was born.

Citizen science projects can be organized into three types based upon the level of collaboration between the scientist and the volunteer (Bonney et al., 2009).

1. Contributory projects: Scientists design the scheme and volunteers contribute data
2. Collaborative projects: Scientists design the scheme and volunteers aid in the design, and provide data
3. Co-created projects: Scientist and volunteers are involved in all parts of the project

2.2.2 Strengths

The collection of data from a large number of participants from a wide geographical dispersal creates an opportunity for ecological research to be carried out on unparalleled spatial and temporal scales (Dickinson et al., 2012; Rotman et al., 2012; Devictor et al., 2012). Large data sets offer greater statistical power, providing a more

robust picture of the area being studied (Devictor et al., 2012). Data from citizen science schemes can increase the effect of conservation work, providing essential information on species' populations, such as their presence, absence, abundance, distribution, recruitment and dispersal.

Monitoring of species is key to understanding a conservation problem, directing its management and assessing its conservation impact. Citizen science schemes can be undertaken on a variety of scales, and are not only capable of providing information at the local level but also internationally, across political boarders (Dickinson et., 2012; Devictor et al., 2012; Mackechnie et al., 2011).

There are many reports of citizen science schemes positively supporting conservation programmes. Examples of these schemes include providing evidence for the decline in shark species through citizen science scuba divers (Dickenson et al., 2012), quantifying the effects of climate warming on birds (Devictor et al., 2012) and assessing protected area efficiency (Devictor et al., 2007). The Riverfly Partnership is a network of stakeholders working together to protect the water quality of rivers (www.riverflies.org). Their Anglers' Monitoring Initiative (AMI) has engaged mainly with game anglers across the UK to provide monitoring data of riverflies, raising awareness, stimulating further scientific research and improving the conservation status of riverfly species (www.riverflies.org; Waterton, 2003).

Data sets obtained through citizen science are providing vital biodiversity indicators which can be used by scientists and policy makers when designing biodiversity policy. Citizen science data collected on UK birds, assessing wild breeding bird population trends, is one of 15 headline indicators adopted by the UK government to gauge the sustainability of lifestyle and quality of human health in the UK (Devictor et al., 2012; www.birdlife.org; www.bto.org).

The participatory nature of citizen science projects means that people engage with conservation issues. In an increasingly urbanized world, people are becoming disconnected from nature and the environment (Devictor et al., 2012). Participation in a citizen science scheme can not only elevate the public's understanding of the

environment, but also empower them to contribute to environmental issues which they care about (Dickinson., et al., 2012).

Educational benefits include acquiring skills needed to collect data accurately and the ability to critically analyse this data, as well as developing an appreciation for science and its role in society (Dickinson., et al 2012; Devictor et al., 2012). Educational gains in citizen science can be reciprocal. Rotman et al. (2012) found that some scientists realised that they were not always the ones doing the teaching, but by working with people from different backgrounds, they gained new perspectives about their work (Waterton, 2003).

As well as increasing people's awareness and knowledge, citizen science can alter their behaviour. Jordan et al. (2011) found that people partaking in a citizen science project about invasive plants gained an increased awareness and knowledge of invasive plant issues, resulting in more conversations about the issue and rethinking what plants to put in their gardens.

People power can provide a huge amount of data at relatively low cost. Scientific research is expensive and citizen science schemes can enable scientists to record large amounts of data, relatively cheaply (Hand, 2010). Citizen science schemes can be resilient to scientific funding cuts that impinge continued data collection (Mackechnie et al., 2011).

Many contemporary citizen science schemes have enlisted the assistance of modern Information Technology (Dickinson et al., 2012; Rotman et al., 2012; Hand, 2010), for example websites that provide ways to explore and document wildlife (www.projectnoah.org; www.ebird.org) and smart phone apps to gather bat population data through acoustic monitoring (www.ibats.org.uk). The incorporation of modern technology with an age-old obsession of recording natural phenomenon can enhance the effectiveness of these schemes. This allows standardisation of data collection, the easy amalgamation of data into one electronically centralized database and also increases participant interest and learning impacts (Dickinson et al., 2012).

2.2.3 Weaknesses

There are biases and uncertainties often inherent in extensive data collection, such as a compromise between quality of data and the quantity which has been reported (Devictor et al., 2012). The large data sets created from a diverse sample can be a doubled edged sword. Whilst data sets created can have the desirable qualities of large samples over space and time, this can also result in differing degrees of sampling bias, observer variability and detection probability. Variation in the detectability of animals creates a bias when counting animals is a methodological issue for many ecologists (Devictor et al., 2012). However, these issues can be accounted for with careful design of the scheme and its data collection protocol (Bonner et al., 2009). Dickenson et al. (2012) states that recent developments in statistical analysis is revolutionising scientist's ability to analyse large and complex data sets.

Rotman et al. (2012) observed a tendency from some scientist to be very wary of volunteers involvement in data collection. Worried about quality control and assurance, scientists question volunteers level of commitment and quality of work, often being extremely selective when recruiting.

2.2.4 Angler Citizen Scientists

The EA already engages in what is known as FEK to aid in its NFMP (Eden, 2012; EA, 2004; Lee, 2011). The EA uses angler match catch data, it has performed angler creel surveys (which records angler catch data and angler behaviour) and several targeted schemes have been attempted to formally collect more angler catch data, but failed. Several game angling catch return schemes work successfully to monitor game fish stocks. Could an angler catch citizen science scheme be developed that would help the EA meet the demands of its fisheries monitoring programme?

Citizen science literature states that the best approach to engage with volunteers is to target audiences, matching the citizen science scheme activities that the target participants find rewarding (Dickinson et al., 2012). In this case it would be anglers and fishing. Recently, the England and Wales Fisheries group, a mixture of representatives from the angling community who provide guidance for the EA on how to deliver its

fishery targets and outcomes, stated that they are "actively exploring ways to improve the collection of fishing catch returns, including use of the web" (Williams, 2012).

FEK and angler catch data forwarded to fisheries scientists and managers provide the perfect building blocks for a collaborative citizen science scheme. When one angler catches less fish than he used to, it's an observation. When ten's of anglers report their catch data, a local trend is revealed. When hundreds of anglers report their catch data in a consistent fashion, over time, it becomes an extremely important data set that can be used to assess fish populations and the health of entire ecosystems.

3. Methods

In order to address the research question, "can a citizen science approach to collecting recreational angler catch data be used for monitoring freshwater fish?" a scheme development framework was built based upon the review of previous angler catch monitoring schemes and citizen science schemes (see table 1). The framework's validity was then addressed by undertaking a stakeholder perspective analysis through interviews and focus groups with appropriate stakeholders.

3.1 Scheme Development Framework

A framework organises the key themes, constructs and variables of a phenomenon, assuming their relationships in an attempt to provide understanding (Jabareen, 2009). A framework emerges as a result of the qualitative process of theorization (Newing, 2011), based upon the continuous interplay between data and its analysis.

In order to build the framework, a review of previous angler catch monitoring initiatives and citizen science schemes was undertaken. Suitable schemes were highlighted via online searches. An amalgamation of sources on the angler catch programmes, including associated literature, formal reports, media articles, publications and websites were collated which provided the basis for analysis of the successes and failures of the schemes assessed. Concepts discovered during analysis were then grouped together with others that had similarities to each other. The continuous interplay of these concepts resulted in a framework being created.

A framework needs to be validated (Jabareen's, 2009). This process checks that it makes sense, not only to the researcher, but also to the stakeholders who would be engaging in the practical application of the framework. Jabareen (2009) also highlighted that frameworks are dynamic constructs, subject to transformations over time. In order to validate and enrich the theoretical perspective of the framework a stakeholder analysis was undertaken. Engaging with stakeholders is key during the developmental stages of collaborative citizen science scheme design (Bonney et al., 2012; Rotman et al., 2012).

3.2 Stakeholder Perspective Analysis

A stakeholder analysis identifies the individuals, groups and organisations that are affected by or can affect a social and/or natural phenomenon (Gray et al., 2012; Reed et al. 2009). Stakeholders can have diverse and conflicting interests, needs and priorities. A stakeholder analysis can help to understand these (Reed et al 2009).

3.2.1 Selection of Participants

An initial list of stakeholders was drafted. Individuals, groups or institutions that have significant influence in or importance to the project were considered stakeholders (Reed et al. 2009; Salam & Noguchi 2006). The following stakeholder groups were identified:

- Coarse anglers
- Committee members of coarse angling clubs
- EA staff
- Experienced scheme developers (ESD) and/or designers of previous angler monitoring schemes.

It is important to note that fisheries managers were initially highlighted as a separate stakeholder. However, it became apparent throughout the data collection, that this role was integral to many of the committee members of coarse angling clubs or societies at the local level and EA staff on either a regional or national level.

The stakeholders did not fit into clear distinct groups. There was crossover, for example, EA staff were anglers as well. This led to the participants being grouped into a typology of perspectives. Instead of grouping separate stakeholders, participants were grouped into themes originating from a certain stakeholder perspective (see table 2).

Table 2. Break down of participant stakeholder perspectives and research qualitative research methods used.

Stakeholder Perspective	**Data Collection Method**		**n**
	Interview	**Focus Group**	
Angler	4	1	5
ESD*	1	0	1
Angler/Committee	6	9	15
Angler/EA	3	2	5
Angler/ESP	2	0	2
Angler/Committee/ESD	3	0	3
Angler/EA/ESD	2	0	2
Total	21	12	33

*NB Participant was interviewed because of their involvement with a scheme which engaged with anglers to monitor their waters.

A comprehensive internet search for angling clubs and societies within a 30 mile radius of the researcher's institution resulted in the initial email contact being sent out to gain prospective participants. Snowball sampling was used, where personal recommendations from participants guided subsequent participants being identified (Reed et al., 2009; Newing, 2010). This led to new participants being easily identified and a higher participant acceptance rate. Snowball sampling does potentially lead to bias based on the social networks (Reed et al., 2009) but given the difficulties inherent in gaining a random sample, this was the most efficient way of identifying participants. Some participants were specifically targeted due to their expertise and or experience as an identified stakeholder.

Two qualitative data collection methods were used to understand the views and experiences of the stakeholders. Qualitative research enables researchers to gain an in-

depth understanding of participant motivations and experience, which is often neglected by more formal quantitative methods (Newing, 2010). This was crucial when attaining stakeholders perspectives when developing a new citizen science scheme (Rotman et al., 2012; Bonney et al., 2009).

3.2.2 Focus Groups

Three semi-structured focus groups were organised with participants (n=12) to gain their experiences and opinions on citizen science approaches to collecting angler catch data for monitoring freshwater fish. Focus groups relied on a number of participants being able to meet at a convenient time and place, resulting in three focus groups. Structured by open-ended questions (see appendix A) based around the Scheme Development Framework (see Fig.1), the focus groups stimulated group discussion which encouraged ideas, experiences, contrasting opinions, reflection and reasoning behind their views (Krueger, 2009). Focus groups are excellent for generating ideas and gaining in-depth understanding of stakeholder perspectives (Newing, 2011). The focus group discussions were recorded and transcribed.

3.2.3 Interviews

Similar to the semi structured focus groups, semi structured interviews were undertaken with participants (n=21) to gain their experiences, thoughts and opinions on citizen science approaches. They were either conducted face to face (n=6) at a convenient time and place for both the interviewer and interviewee or via phone or Skype (n=10). One to one interviews provide a safer environment for participants not wanting to open up in front of a larger group situation like a focus group (Newing, 2010). The interviews were recorded and transcribed.

If participants were unable to meet in person or undertake a phone or Skype interview, but were willing to share their opinions, they were encouraged to do so via email (n=5). They were asked open-ended questions via email, based around themes of the framework and asked to return them electronically. Some participants were asked to elaborate upon their responses in order to gain further detail and follow up interesting leads, but qualitative data collection in this form is not as effective as face to face collection (Newing, 2010).

3.2.4 Ethics

The intentions and objectives of the study were explained to each participant. It was explained that their information would be kept anonymous and participant's permission was sought if interviews and focus group discussions were to be recorded.

3.2.5 Data Analysis

Data were imported and stored in NVivo 9 (QSR International, 2007). Analysis involved coding themes, known as nodes, from the participant responses in the data (see Appendix B). The themes were then analysed and grouped together as patterns arose from the different stakeholder perspectives. This process allowed the participant responses to validate and reconsider the framework. Once saturation of themes was complete, data collection and analysis ceased (Newing, 2010).

4. Results

4.1 Scheme Development Framework

A scheme development framework (SDF) based upon the review of previous angler catch initiatives (see table 1) was created (Fig. 1).

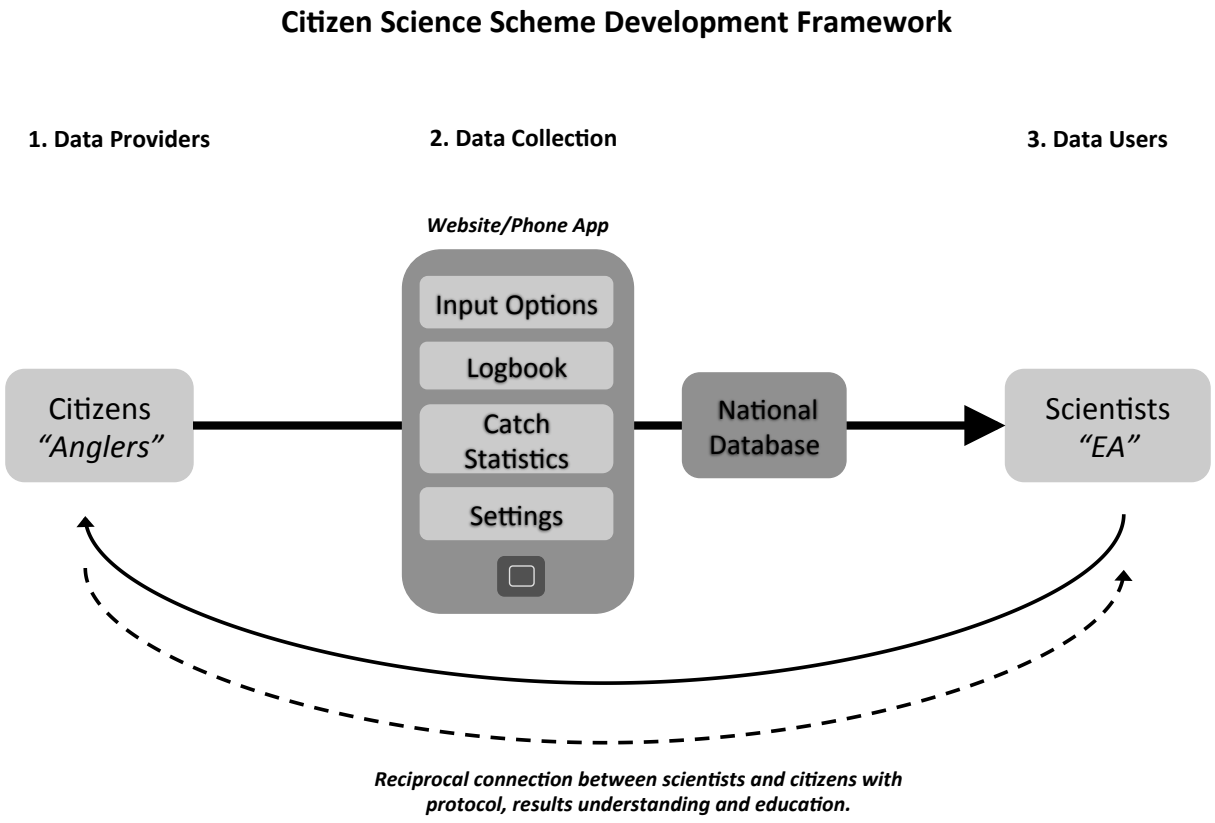

Figure. 1. Scheme Development Framework of the proposed angler catch citizen science scheme.

The structure is grounded on three sections:

1. Data Providers – Citizens or in this case specifically recreational coarse anglers
2. Data Collection – Data collection protocol, including the website and app options
3. Data Users – Scientists, in this case the EA or other fisheries management

Being a reciprocal relationship between citizen and scientist, a feedback loop, which travels in both directions, is an important incorporation to the framework.

4.2 Stakeholder Analysis

The structured stakeholder analysis below, is a result of data collected from interviews and focus groups that were collated and analysed for patterns and themes. Using the SDF as a guide, the themes that appeared during data collection and analysis are presented to validate and enrich the framework's theoretical underpinning, in light of the stakeholder's perspectives. The structure is grounded on the three sections of the SDF (fig. 1) and themes that were highlighted during analysis based on research questions. The analysis is illustrated with quotes that are representative of the stakeholder's perspectives. The perspectives of different stakeholders are not clearly delineated because most (n=27) participants often came from two or more perspectives. Table 3. summarises the results of the themes from each stakeholder.

4.2.1 Data Providers

4.2.1.1 Environmentally Minded

Some anglers are environmentally minded and therefore more likely to buy into and support a scheme that aims to support a conservation and environmental cause:

"You'll find most anglers are very very concerned about the environment… We are the eyes of the rivers aren't we. We're the first to notice the pollution or things that are going wrong." (I.4 Angler & Club Committee. 45-54 age bracket).

Anglers have a unique relationship and affinity with the environment because they spend considerable amounts of time engaged with it. Specialist species anglers and rivers anglers were highlighted as probably being more environmentally minded than still water and "happy to catch anything" anglers:

"I think that river anglers have a very special association with the waters they fish and they all want them to be better than they are. If they think the match data or the catch data they provide can help in the management of those fisheries then yes I think they would. I think you're appealing to a sector of the market that is the most concerned as opposed to other sectors that are basically turn up and catch merchants." (I.5. Angler & Club Committee. 65+ age bracket).

Experience gained from the Grayling logbook scheme does not appear to support the notion that specialist anglers will be more inclined to support a monitoring scheme:

"I know for example that the Grayling Society scheme rather tailed off because it wasn't succeeding in getting quality support from anglers and I don't really know why that was, because it struck me that for members of a particular specialist group, who are interested in a particular species of fish, just collating catch returns of every time they caught one of those species of fish and sending them in, it wasn't really much of an ask and it really wasn't rocket science." (I.15. Angler & Club Committee & ESD)

Game anglers are perceived to be more environmentally minded than their coarse counterparts. It is implied there is a social class divide, between coarse and game anglers, which may contribute to this phenomenon:

"Game anglers are very much conservationists at heart, oh I think most anglers are to be fair, but the game angler always has that stigma of being the upper, Scottish waters and all that crap. I think there is a little bit more, I don't know if the word is respect or appreciation for the environment you're in; because you've got crystal clear water, you are by definition in a nice environment, you're not going to be at the back of some factory somewhere are you." (I.7. Angler & Club Committee. 45-54 age bracket).

Game anglers more commonly support waterways clean up schemes than coarse anglers. This notion is supported by experiences from the River Fly Partnership's, AMI scheme, where they often find if more difficult to engage with coarse anglers:

"Coarse fishermen don't get it, where as game fishermen do and I think that's why you get more game fishermen involved in this and also I think because they try to imitate the bugs that live in the river, they're quite engaged, want to see what they're like and what the life cycle is. I've come up with this at AMI meetings and at the IFM conference Iinstitute of Fisheries Management) and no one has ever come up with a good way to engage with coarse anglers in the AMI." (I.16. Angler & ESD)

4.2.1.2 Desire to Improve Fishing

Anglers want to catch fish, and whilst this might also have environmental motivations attached to it, anglers may wish to report their catch data purely so it enhance their fisheries performance:

"(anglers) are all screaming and saying that fish stocks are dropping, the rivers aren't fishing as well, why is it not doing it?... I'd be interested to know the kind of results I'd get from my local water, because it impacts on me. So that's one idea of a way to make people want to do it." (FG.1. Angler. 45-54 age bracket).

The incentive for those anglers who keep logbooks is often because they use it as a resource to improve their fishing skills and abilities. For many anglers this would be the motivation to collect their catch data. Passing it on to a third party for the purpose of monitoring may be a byproduct they are uninterested in. Previous schemes that have provided the service of a digitized log book have done it with the intention for anglers to either improve their fishing or to provide a resource of where is good to go fishing.

4.2.1.3 Feedback

Experience from previous angler catch return schemes and the opinions of angler stakeholders suggests that providing anglers with feedback, via reports etc. is crucial in providing an incentive for contributing information:

"Sometimes you ask for information and you don't get any back, this is one of the problems with this kind of thing, if we do give them more information, how much are we going to get back? I would like to see the results for our fisheries". (I.2. Angler & Club Committee. 65+ age bracket).

EA staff also commented that for anglers to contribute towards a scheme, they would want to see results that are leading towards a clear outcome:

"If you want to keep people motivated for any long term project and they're doing something on a purely voluntary basis, you need to give them the feeling that they are contributing to something worthwhile and that in turn involves you giving them fairly

regular updates on what's happening, reassuring them that what they are contributing to is important and then give them results." (I.15. Angler, Club Committee & ESD).

A function of such a scheme suggested in the SDF is the capacity for a website or app to actually be a digitised logbook, but with the unique capability for anglers to view their results easily on maps and in graphs. This possibility was positively received by all stakeholder perspectives and recognised as another motivation for anglers to input their catch data into a scheme:

"that'd be good to have a bit more detail to it, so they can look over what they've caught in the years. It's very important that they're not just feeling used to provide data for another party." (FG.2. EA & Angler. 25-34 age bracket).

4.2.1.4 Angler Apathy

According to many of the participants (n=24), across all stakeholder perspectives, there is a large section of the coarse angling community who will have a tendency to either not care or not be willing to report their catch returns and the factors that motivate some, may not motivate others:

"Unfortunately, inherent in all this is angler apathy and a large majority of anglers that just can't be bothered. That's always going to be the case so in my mind you want to target the hardcore, a small proportion of anglers you want to target. (I.11. Angler, EA & ESD)

4.2.2 Data Collection

4.2.2.1 Data Collection Organisers

The body that would be the most appropriate to organize such a scheme and collect all the data, was something that many (n=18) of the participants thought was integral to the angler's willingness to report their catch data. Lack of trust in the EA was something numerous (n=26) anglers mentioned. Opinions of the EA appear to vary significantly depending upon previous experiences, quite often due to location and the relationship with local EA staff, but also as a result of generalized hearsay and reputation of the EA. Anglers and club committee members (n=8) were very skeptical of the EA's ability to deliver their intended goals when it comes to fisheries management:

"It would be quite useful to have a body other than the EA involved in this. It varies from place to place… It might make sense to have it with an angling interest rather than with a government interest." (I.10 Angler & Club Committee. 55-64 age bracket).

Another angler's perspective highlighted, that was shared by several (n = 15), is the common perception that the EA is not using the money they generate from rod license sales to monitor fisheries effectively. By the EA recruiting volunteers to undertake bailiff and monitoring work, anglers feel they are not getting value for money from the EA service:

"The other down side though, is as soon as you mention the data goes to the EA, that will kill 50% of your respondents. In my mind they don't trust them, don't believe in them and with the thing with the volunteer bailiffs at the moment, you've got a lot of people thinking hang on a minute we're doing their job for them, what have we paid for? We're not seeing results but we are seeing they want volunteers everywhere" (FG.1 Angler. 45-54 age bracket).

It was suggested that educational institutions could organise an angler catch returns scheme and that might increase angler buy in:

"I think run by an educational body like a good university, particularly if the university had a strong fisheries department in it… then anglers may well buy into that more strongly." (I.5 Angler & Club Committee. 65+ age bracket).

4.2.2.2 Tools

Several Club Committee participants (n = 5) identified that the way their club currently collects match catch data, via paper returns which are then inputted onto a spread sheet, can be a laborious and resource demanding task.

When asked what would be their preferred method of reporting their catch data, all participants from all stakeholder perspectives mentioned that an electronic process would be most suitable due to their ease of use and accessibility. The following are

examples of methods that participants have either successfully used in the past or suggest would be the most appropriate medium for reporting their catch data in the future; either by email (n=2), website (n=10) facebook (n=2), online forums (n=3), tweeting (n=2), texting (n=2) or phone app (n=8).

"Log into a data base, electronically, go fishing, get back, bang, use my login. Fished this, four fish, end of matter. Quick. Easy. Accessible. Convenient. They're the drivers for behaviour change. If your starting to talk about forms and filling in - forget it. Posting it - forget it. Get yourself an app." (I.7. Angler & Club Committee. 45-54 age bracket).

4.2.2.3 Access To Technology

There were mixed views across stakeholder perspectives about whether the use of modern technology would alienate some users. Anglers thought that they themselves and most of their peers would have access to and the ability to report their data via the internet. Fisheries managers, however particularly at the EA level, were more commonly concerned that many anglers would not have access, or the ability to use such technology, mainly because of their age:

"the vast majority of anglers, particularly on the rivers we're interested in are a dying breed - the baby boomers. In all fairness a lot of them aren't that technologically minded in terms of IT, whilst some of the younger guys are. So it's not like we could roll out one form of electronic system that's going to be fit for all purposes. I think that will change as (older) people cease fishing, and people who are a bit more tech savvy come through." (I.6. EA & Angler).

Anglers themselves, whose age range predominantly fell in the 55-64 and 65+ categories, believed that access and ability to use the Internet would not be an issue but the use of smart phone apps might be:

"I've been using computers for years. Phone apps are a new thing to me so I'd have to learn how to use a phone app, so for any phone app you've got to consider the market, it is a fairly aged market and therefore the phone app has to be totally muppet proof. Its got to

be really simple to use cause if its complicated you'll loose us. (I.5. Angler & Club Committee. 65+ age bracket).

The same participant, in the age category of 65+, went on to say that he believed there to be no access issues to using modern information technology and that it is already being embraced as part of the fishing experience, commenting that:

"I don't know an angler who doesn't have access to a website and nearly all my friends now, when they say they've caught big fish, they get their phone out first to show them to me. (I.5. Angler & Club Committee. 65+ age bracket).

One angler commented that the type of angling (Coarse or Game) undertaken may signify a social economic trend which could lead to explaining why game anglers might have greater access to using such technology:

"I think you will find with the game angling fraternity, they do tend to be fairly articulate, educated folk…. they tend to be at home with this sort of kit. That's not to say some poor person in a deprived area, that fishes a canal every now and then, pulling out a shopping trolley, is actually not gonna be in that fold. That's a sad fact of life." (I.7. Game Angler & Club Committee).

4.2.2.4 Data Privacy

One of the most frequently mentioned themes was that of data privacy. The vast majority of anglers interviewed (n = 28) said that they would not mind who could see their catch data, yet they stressed that typically anglers are very secretive and protective of their angling locations and catch successes. One angler and club committee member commented that some members of his club report in detail on their forum, what they catch and how they caught it, but that is a rarity:

"some are quite honest with what they put and advise on how they caught it, particularly baits, even the peg they caught the fish on, but what you'll find is lots of anglers are very secretive and don't like to preach what they catch and where they catch." (I.4 Angler & Club Committee. 45-54 age bracket).

One angler explained he was very protective of his favourite fishing locations and would not want his catch data to be made public, but was willing to share it with the EA. He went on to suggest that if the tool had privacy settings to determine who could see the data, that would be beneficial:

"Oh if I was fishing rivers, yes I'd be more than happy to report it. I'd be happy to report it, but not in a public sense. I wouldn't mind the agency knowing where I was fishing, I wouldn't want to report it so that other people could know where I was fishing or what I was catching… If I can have settings to let those I wanted to see it, that would be ok." (I.5 Angler & Club Committee. 65+ age bracket).

The proposal of privacy settings was supported across stakeholder perspectives. Some anglers suggested that in order to provide feedback to the users of such a system, vague statistics of general locations of catches could be reported on a website or app, also suggesting that a time delay in the publishing of catch results may also be sufficient to protect productive fisheries from being swamped:

"It would very much depend on how it was made public. For example if the data was anonymous and traceable to only a fishery, the fish was caught from lower 'X', there are three different stretches, it would not give the information about which stretch it was caught on. And make it publicly available too late for anyone who wants to cash in on someone else's knowledge, so maybe make it one month or two months out of date." (I.10 Angler & Club Committee. 55-64 age bracket).

4.2.3 Data Users

4.2.3.1 Fisheries Management

Club committee members in particular mention their own fisheries management use of angler's catch data. They often use match catch data to inform future stocking, evaluate the effectiveness of previous stocking, monitor fish stock levels, inform habitat enhancement initiatives and to evaluate a fishery's performance.

Current EA use of fish monitoring data is to manage fisheries to enhance their performance but also to meet the WFD needs. The type of fish monitoring data that can be used for the WFD is quite specific. Match catch returns and angler catch data cannot be used for this purpose because only quantitative electrofishing surveys can contribute to formal classification of rivers. However, this data can be used as additional complimentary data to inform decision making.

Due to its limitations, angler catch monitoring data does not meet WFD requirements for coarse fish, yet for formal salmon and sea trout classification via the WFD, catch data can be used:

"with salmon and sea trout the formal mechanism is that we're required to report on the status of salmon and sea trout statutorily, and we do that using catch data. But the same formal reporting requirements, using angler catch data, isn't there for coarse fishing. We are formally required to report on fish status, which includes coarse fish but that's done through the WFD. So if you see what I mean, angler catch data is in a little bit of a no man's lands in that formal reporting process." (I.3 Angler and EA).

The reporting of game angler catch as a statutory requirement does not necessarily improve the chances of more catch returns, as an EA and Angler participant admitted:

"As an angler myself, fishing on trout water, I'm pretty terrible at filling in the catch book because I've sometimes finished fishing a mile from the catch book, and its dark, so I go home rather than fill in the catch book. So that's an illustration of a bad practice, but it's the realities of it all." (I.3. EA & Angler).

EA staff who undertake more formalized, quantitative methods of fish monitoring, which do meet the requirements of the WFD, recognize that catch data, when recorded suitably, can reflect similar results:

"if they're not catching well and then if we electric fish the same stretch, or seine netted the same lake, we find a similar result. It generally does compare fairly well, so that does

suggest that it's more robust than you initially think." (FG.2 Angler & EA. 25-34 age bracket).

Another EA member of staff mentioned that angler catch data is particularly useful when reporting back to the anglers and clubs, as they are more likely to believe and buy in to a scheme based on their results and experience:

"anglers do listen to other anglers, its why all the forums do so well" (FG.1 Angler & Club Committee. 45-54 age bracket).

4.2.3.2 Prompt Further Investigation

Anglers and committee members see an angler catch monitoring scheme as a way of producing facts and figures in a robust format that can provide them with a voice to approach the EA and ask for their assistance:

"it gives us another sort of stick to beat the necessary people over the head, who we're trying to get to and help" (I1. Angler & Club Committee. 45-54 age bracket).

From the EA's perspective, angler catch data is just a part of their monitoring suite, giving an overview of fish stock trends and highlighting where further investigation needs to happen:

"yeah it's a good indicator for us to maybe go and investigate further, especially if catches drop off… it would be used as a tool to direct work, direct stocking practices, or habitat enhancement." (FG2. Angler & Club Committee. 25-34 age bracket).

One club committee member and angler described how his club have recently set up a catch returns report system on their website, with the aim of being able to monitor their own fisheries more thoroughly:

"The plan was to build up evidence of the health of the river, of its stocks so that if we had a major pollution incident we can prove that there had been reasonable catch returns from

various elements of the river and so just have that historic record." (I.16. Angler, Club Committee & ESD. 55-64 age bracket).

4.2.3.3 Local Empowerment vs National Jurisdiction

A theme that came through strongly, particularly from the angler and club committee members perspective, was that an angler catch monitoring scheme provided empowerment for individuals on a local level. Such a bottom up scheme - rather than a top down - would also bring benefits of greater motivation for anglers to participate and provide their catch data:

"start small and empower local clubs that their information is really useful for them and as a by product it can be useful for the EA, if they're willing to let them on board. Rather than the other way round, they're doing it for themselves and the EA gets to have it rather than doing it for the EA and they get to have it." (FG.1 Angler & Club Committee.45-54 age bracket).

The idea of a localised scheme was supported by experiences with the River Fly Partnership's AMI scheme:

"Our experience is that it's something that works very much on a local level, its empowering people to take responsibility and have the ability to keep track of what's going on in the rivers that essentially (the) community's own, but it's all sort of building up to a national thing." (I. 13. ESD).

Table. 3. Table highlighting the main differences in stakeholder perspectives across themes.

	EA	Committee	Angler	ESD
4.2.1 Data Providers				
Environmentally Minded	Unreported.	Strong motivator.	Strong motivator.	Distinction between coarse & game anglers.
Improve fishing	Supports EA objectives.	Strong motivator.	Strong motivator.	Strong motivator.
Feedback		Want feedback and see action.	Want feedback and see action.	Providing reports crucial.
Apathy	See as issue.	Agree that many anglers are not motivated.	Agree that many anglers are not motivated.	Experienced as issue.
4.2.2 Data Collection	Scientific / technical focus.	Recorded for management / report to EA.	Not recorded / or for personal use.	Must meet demands of data users.
Organisers	See benefits of non-EA org. involvement.	Mixed relations with EA.	Little confidence in EA. Suggest another body.	Angler opinion with organizer vital.
Tools	What ever makes data entry easy for user.	Website.	Website & phone app.	Website & phone app.
Access to Technology	Concern age affect accessibility.	Mildly concerned age would affect accessibility.	Less concerned age affects accessibility.	Mildly concerned age would affect accessibility.
Recording Effort/Blanks	Needed for analysis.	Needed for analysis. Unlikely to be reported.	Unlikely to be reported.	More easily reported with match data.
Spatial & Temporal	Potential in angler data.	EA not using data already provided to them.	EA not using data already provided to them.	Issues maintaining participation longevity.
Validity & Reliability	Concern of inaccurate data.	Concern of inaccurate data.	Concern of inaccurate data.	Concern of inaccurate data.
Data Privacy	Anglers won't share data.	Privacy settings vital.	Reluctant to provide data. Privacy settings vital.	Found some anglers reluctant to provide data because of this.
4.2.4 Data Users	Part of monitoring. Not suitable for WFD.	Useful for their own fisheries management.	Analyse own catch and their fishery's.	Non / fishery management.
Fisheries Manag.	Angler catch data important.	Angler catch data important.	Mixed understanding from anglers.	Angler catch data important.
Promt. Invest.	Good indicator.	Important use of catch data.	Mixed understanding from anglers.	Depends on scheme objectives.
Local vs National	Both.	Empower local.	Empower local.	Unreported.

5. Discussion

The current study addressed the research question "can a citizen science approach to collecting recreational angler catch data be used for monitoring freshwater fish?" This question cannot be answered explicitly yes or no, but components can be analysed and recommendations made. Many parts contribute to the success of a citizen science scheme (Bonney et al., 2009). The design of a citizen science project, its aims, data collection methods, means of engagement, data analysis, dissemination of results, application of findings, intended and actual education outcomes are all important (Devictor et al., 2012; Dickinson et al., 2012; Rotman et al., 2012; Bonney et al., 2009).

5.1 Motivations

Any citizen science project needs its citizen volunteers. In this case, anglers, who are willing to contribute data to the scheme. The strongest motivating force from the angler's perspective was the desire to contribute to a programme that was going to enhance the fresh water ecosystems they use, often being referred to as being 'environmentally minded'. There appeared to be a combination of motivations behind this term. Many were anglers who wanted a better environment, with improved fisheries which therefore would improve their own fishing. Some were collectivist; they wanted better fishing for their local angling community. The strongest motivation seemed to be that of principle, they would provide their angler catch data, because as users of the freshwater ecosystems they feel they have a responsibility to do so. This supports Rotman et al's. (2012) findings that volunteers participate in citizen science activities out of interest and commitment to conservation. However, all of the anglers with this perspective were also club committee members, some also EA staff, so their "environmentally minded" attitudes are not representative of the angling community at large - particularly those anglers who are not also involved in fisheries management.

The SDF (Fig. 1) illustrated the potential of 'logbook' and 'catch statistics' features of such a scheme. These would provide anglers with their own digitized logbook and unique plug-in features to be able to explore their own catch data and gain a better understanding of their fishing results. Many anglers keep manual logbooks (Aprahamian et al., 2010) and the possibility of the further functions and source of information that a digitised version could bring were received positively. Dickinson et al. (2012) mention

the benefits that new technologies bring in enhancing participant interest. Anglers can see a direct benefit of keeping their own logbook. It provides them with useful information which enhances their knowledge, angling success and experience, supporting Rotman et al.'s (2012) finding that these self-beneficial motivators are primary drivers for initiating volunteer participation in citizen science.

Angler and club committee members endorsed the provision of reciprocal feedback. Feedback creates a communication route between scientists and volunteers and is also a strong motivator (Rotman et al., 2012). The view was expressed that the EA's current level of feedback did not provide reward for the effort of reporting angler catch results. Eden (2012) found that providing feedback was "the biggest carrot" for anglers to return their catch data to the EA. This data was seen as a means of empowerment, which can be used by the angler or angling club to request the assistance of the EA, should they suspect a problem with fish stocks or the health of the ecosystem as a whole - a finding also shared with Eden (2012).

5.2 Barriers

'Angler apathy' was a trend highlighted across the stakeholder perspectives, suggesting that a large contingent of the angling community will not provide their catch data. This supports the lack of success seen in previous angler catch return initiatives (Eden, 2012). www.ebird.org has created one of the largest biodiversity data sets in the world, but what percentage of birdwatchers are contributing to it? All citizen science schemes contend with this notion of apathy, even with ready-made target audiences such as anglers and birdwatchers (Wood et al., 2011). Understanding the volunteer's motivations and designing the scheme accordingly, is key to improving participation and swaying those of the apathetic persuasion to have a go at citizen science (Dickinson et al., 2012; Rotman et al., 2012).

Another key barrier that arose in all the perspectives of the stakeholders was that of 'data privacy'. Anglers will not be willing to divulge their catch data for fear that publishing their catch success might result in their favourite fishing spots being overwhelmed by other anglers. A citizen science scheme does not automatically mean that the citizen's data is shared with other participants in the cloud. Whilst this open

source presentation of results occurs in some schemes (www.ebird.org; Wood et al., 2011), which undoubtedly provides a motivation for participation for some, the core concept of citizen science is the collection and amalgamation of data for the use of science (Devictor et al., 2012). Suggestions for an angler catch citizen scheme to have privacy settings, where anglers would control what data can be seen publically, was met with positive responses and seen as a possible solution to the privacy barrier. If they wished, anglers could create online community friendship groups, so only data could be shared between them. The experiences of the go-fish app (see table 1) found that some anglers would hide the locations of their catches by marking each of their catch sites at the same residential GPS reference, probably their own home, far from any water source. This is not to say that an angler catch scheme could not provide interesting trend results back to the angler, but still protecting the anonymity of favoured productive fishing spots.

Using an internet based platform to report their angler catch data was suggested to be the most appropriate from an angler's perspective. Contradictorily, access and usability to the proposed website and smart phone technology was also suggested as a possible barrier. This was mainly attributed to age, older anglers not being able to use the technology, coupled with the fact that anglers are an ageing group (Aprahamian et al., 2010; EA, 2004). A social economic trend was also alluded to (Eden, 2012), coarse anglers having less access to using the technology compared to their game angling counterparts for example.

The use of modern technology brings many benefits including standardisation of data collection protocol, automatic GPS data, centralised digital databases, education and learning functions, even "cool gadget" appeal (Dickinson et al., 2012; Hand, 2010). To ensure access does not become a barrier, Devictor et al. (2012) highlighted the importance for citizen science programmes, and any technology they employ, to be designed around the target participants, for example by considering their nationality, age, language, access, habits and skills.

Something that can shape the success of a citizen science scheme is the relationship, or perceived relationship, between the volunteer(s) and scientist(s) or

scientific body (Devictor et al., 2012). Anglers in particular and to a considerable degree, club committee members, appear to have little trust in the EA. This appears to be a general perception of mistrust, rather than distrust in individuals who work for them. Some club committee members reported very good relations with their own regional EA representatives but still commented on angler's mistrust of the EA. This appears to be an ingrained "us vs them" mentality. The reason for the success of match catch returns in the North East of England is attributed to the particularly good relations with EA staff in that area (*I.3 Angler & EA*), and perhaps goes to explain why other areas of England and Wales fail to receive as many match catch returns.

Rotman et al. (2012) found that volunteers are eager to support and aid scientists. In fact, volunteers may have feelings of awe for science's professionalism, integrity and upholding of rigid standards. This contrasts the relationship alluded to between the EA and anglers. An important distinction to highlight is that the EA is also a political body working to uphold statutory rights issued by the Government. It is part funded by anglers licence fees and administers direct management policies that affect anglers directly and indirectly, in positive and negatives ways. This political element adds another dynamic to the conventional citizen science scenario.

It appears anglers remember previous policy which has influenced their fisheries. Unpopular policy administered by the EA or its predecessor's decades ago, are still cited as reasons to not trust the EA. This mistrust can affect volunteer participation (Rotman et al., 2012; Gray et al., 2012) and in turn decrease the quantity and quality of data returned. Anglers were concerned that if the EA were the body responsible for organising the collection of data, there may be a detrimental effect on the commitment to the scheme. However, they did think it appropriate for the EA to be involved and use the catch data for fisheries management. Two other bodies were suggested to organise the data collection, the Angling Trust (a representative body for game, coarse and sea anglers in England - www.anglingtrust.net) or an academic institution with strong reputations in fisheries science. The Riverfly Partnership's AMI scheme holds an interesting interim role between data collection, by anglers, and data use, by the EA. A similar intermediate administrator may be appropriate for an angler catch citizen science scheme.

The hierarchical culture and structure of the academic world can also result in a "them and us" social divide. Scientists can have an aversion to what non-scientists say about science and non-scientists can have the opinion of science being inaccessible and elitist (Rotman et al., 2012). Citizen science schemes have been responsible for making science accessible, enabling it to "come down off its Ivory tower" (Devictor et al., 2012 p.358). Maybe it holds the key to appeasing and enhancing angler/EA relations?

5.3 Benefits

Like the game angling logbook and regionally successful match catch data schemes, the EA could use angler catch citizen science data as part of their NFMP to monitor trends in fishery performance, aid fisheries management and as a tool to direct further monitoring, thus shaping English and Welsh freshwater ecosystems (Eden, 2012; O'Hara & Steel, 1998), thus the system becomes reflexive. Angler's catch data detects a trend in fish decline, which influences management and policy, which in due course affects how many fish anglers catch and report – "recreational predators thus become part of the process of protection" (Eden, 2012, p.1020).

As previously stated, coarse angler catch data cannot be used by the EA in their fisheries classification to meet the needs of the WFD, in contrast to the use of game angler catch records. Perspectives from the current study suggest that the compulsory nature of the game catch return scheme may enhance not only the quantity but also the reliability of the data returned, thus making it worthy of WFD use. Other suggestions that game anglers care more for their environment and typically are of a different socioeconomic background to the average coarse angler, may also affect angler catch returns. These are complex issues that require focused research, beyond the scope of the current study. However, if coarse catch returns were to provide data sets (through a citizen science scheme) equivalent to those of game returns, then the use of that data to categorise water bodies for the WFD could be readdressed.

Engagement in citizen science also brings benefits of education and enhanced public awareness of conservation issues (Devictor et al., 2012). The results of the present study suggest that anglers willing to provide their catch data would do so

because they are already aware and wanting to use their FEK to support conservation work. Engaging more coarse anglers through an angler catch citizen science scheme may spread this desire, something that Devictor et al. (2012) refer to as developing "values-led conservation".

Anglers who are engaged in the environment have varying levels of appreciation for the benefits it provides them. They may or may not care for its protection, or realise that their intimate knowledge and understanding of the ecosystems is valuable to its management (Eden, 2012). Most anglers concur that as a community they are "the eyes of the river" (*I.4 Angler & Club Committee. 45-54 age bracket*). This level of awareness and understanding of human's place and reliance upon the environment comes as a consequence of engaging in the environment via recreational activities such as angling (EA, 2004; Sharpe & Maclean, 2010), but are also a goal of citizen science schemes (Devictor et al., 2012). Even anglers, who are already engaged in the environment, can be 'reconnected to nature' (Miller, 2005), to a higher degree than they were aware of previously. The benefits of this enhanced 'Earth stewardship' (Devictor et al., 2012) can permeate far and wide within the conservation movement.

Section 5.2 highlights the generalised poor relationship between angler and the EA. This could be a barrier to participation and of detriment to an angler catch citizen science scheme. Trust building between scientists and volunteers relies upon building a sustainable collaborative environment that meets the expectations and motivations of both (Rotman et al., 2012). This is hard to orchestrate, but one way is through a collaborative or co-created citizen project design (Bonney et al. 2009; Rotman et al., 2012). The current studies attempt to develop a citizen science scheme and gage stakeholders opinions, could be considered the beginnings of collaborative design. Many citizen science schemes are initiated with limited understanding of the motives and needs of both the citizen and the scientist, or any other stakeholder involved. Often a top down approach is taken. Scientists know what data they want and develop a collection protocol to meet their needs, often not fully understanding what will drive the volunteers initial engagement and continued support (Rotman et al., 2012). Research has shown that volunteer's motivations are complex and dynamic (Rotman et al., 2012). There are two significant points in time; the initial encounter and when a project ends

and the volunteer is deciding if they want to contribute to subsequent projects. Understanding the motivations of volunteers is crucial in developing a strong and sustainable relationship between citizens and scientists.

5.4 Recommendations

The perspectives of anglers and club committee members suggest that an effective angler catch citizen science scheme should start small, engaging with a localised group of anglers, probably based in a club. Therefore they will be interested in their own fisheries performance and motivated to report their catch data to monitor the health of their freshwater ecosystems. Self-benefitting and collectivist motives drive initial buy into citizen science schemes and locally benefiting schemes appear to maintain engagement for longer periods of time (Rotman et al., 2012). It makes sense for anglers to want to contribute to a local scheme because they will see the benefit to their fisheries thus feeling empowered to make a difference. Data could be networked, passed on to the EA, via a digitised central database. Angler and club committee members felt that data going straight into a national scheme, where the results seems distant and far removed from the volunteers would reduce motivation (Devictor et al., 2012). Success at a localised level would provide an example for other angling communities to follow.

Included in a website and smart phone app design could be the ability to incorporate the collection of match catch data. This would speed up the administration process for club secretaries, hopefully increasing the number of match catch returns, an objective stated by the England and Wales Fisheries group (Williams, 2012).

Other functions to incentivise catch returns are possible. Online live fishing competitions where individuals or groups could compete against each other and upload their catches via the phone app. The comparison of return statistics could be made into a competition, individuals, groups, or areas that provide the best catch data can be acknowledged and perhaps rewarded. Recognition and attribution are powerful motivators for volunteers (Rotman et al., 2012).

5.5 Limitations

A critique of the current study's findings and that of snowball sampling – is that "like breeds like". The current study ended up with what appeared to be a homogenous participant sample in terms of age, gender, ethnicity and social background. Future studies should seek sampling methods that would achieve a greater variation in participants. It would be interesting to interview more anglers who do not have any affinities to club committees or fisheries management to assess their motivations for participating in an angler catch citizen science scheme.

A noteworthy counter argument to this is that snowball sampling did lead the researcher to participants with significant experience and expertise on the topic. Indeed, as data collection came to an end, a new angler catch returns website, based in Scotland, was identified (www.anglingdiary.org.uk). Interviewing active participants of the angling diary scheme would have been very interesting, although third party privacy restrictions may not have allowed this. Further investigation of such leads would have been beneficial to extending the study's findings.

Based upon the recommendations from some anglers interviewed, posts were made on six angling website forums in an attempt to stimulate online focus groups discussions (for an overview see appendix C). The responses were mixed. This format of online discussion provided some extremely interesting results from a large sample size, which echoed many of the stakeholder opinions gained from interviews and focus groups. Forums obviously provide a useful and easily accessible platform for anglers to discuss topics of interest. As a means for qualitative research, future studies could explore the use of this form of data collection.

5.6 Concluding Remarks

The current studies findings suggest that a citizen science approach to collecting angler catch data to be used to monitor freshwater fish is possible. However, overcoming the barriers, particularly angler apathy and addressing the angler's negative perceptions of the EA, are crucial. Further development of an angler catch citizen science

scheme requires a collaborative approach (Bonney et al., 2012) and a thorough understanding of anglers and the EA's motives (Rotman et al., 2012).

The Scottish Fisheries Coordination Centre (SFCC) has recently created a new angling diary website (www.anglingdiary.org.uk), a "free online angling diary that will bring many benefits to the angler who wants to record their catches of freshwater fish in the UK. In return, partners of the SFCC would like to make use of your diary records to better understand the fisheries that they are responsible for". Going live in January 2012, the site is very new receiving little promotion or marketing. Months and years to come will provide an interesting case study to gain a greater understanding of whether a citizen science approach to collecting angler catch data can be used to monitor freshwater fish and its associated benefits.

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Appendix A:

Interviews Questions

Can recreational angler catch data be collected to be used for monitoring freshwater fish?

- *How long have you been an angler?*
- *What kind of fishing do you do?*
- *What kind of waterways do you fish?*
- *Have you provided your catch data before? To who? In what format? Do you know what happened to the data?*
- *Are you a member of a club?*
- *Does your club collect catch data? Do you know what happens to that data?*
- *Do you compete in matches? What happens to the data?*
- *Would you be willing to provide your match catch data for monitoring purposes?*
- *Do you think other anglers would be willing to provide their catch data?*
- *Can you think of reasons why anglers would be willing to provide their catch data?*
- *Can you think of reasons why anglers would not be willing to provide their catch data?*
- *What is/would be the easiest way for you to provide your catch data?*
- *Do you know what the EA use angler catch data for?*

Angling Trust questions:

- *What role does or has the Angling Trust have in monitoring fish stocks at the moment?*
- *Does the trust use monitoring data? If so what for?*
- *Does the trust organize the collection of angler catch data?*
- *If data were available, would you use it? How? Why?*

EA Questions:

- How does EA use angler catch?
- How does EA motivate clubs and individuals to provide angler catch?
- How does centralized data base work?

Brief outline of how angler catch data could be collected.

1. Tools. Website. Phone App.
   - *Do you have access to such technology?*
   - *Are you comfortable with using a website or phone app?*
   - *Do you think other anglers you know would have access to such technology?*
   - *Do you think other anglers you know would be comfortable with using a website or phone app?*
   - *Would you be more likely to input data on the river side or back at home?*
   - Do you think a touch screen, fixed terminal, to input your data, would be used where you fish?

2. Tool Design. Interface
   2.1 “Start fishing”

- *What data/information do you think would be useful for an angler catch monitoring scheme?*
- Automatic data entry - GPS location – time – date – generic weather –
- Manual data entry – duration of fishing trip, start and end time – specific weather - fish caught – picture – species – length – weight – technique/bait used – species specific fishing – health of fish??
- *Would you be prepared to provide such data from your fishing trips?*
- *Why would you or would you not provide such data?*
- *Can you think of any other information, that's not angler catch data, that could be useful if reported?*
- Report problem – illegal fishing – pollution – disease
- *What would motivate you to provide such data?*

2.2 Logbook

- *Do you keep your own logbook?*
- *What do you record in your logbook?*
- *What features would you like an electronic logbook to have?*
- View your individual profile – catches - maps – graphs – profile status

2.3 Catch Statistics

- *Would you be interested in being able to compare your catch statistics to others? Individuals? Groups?*
- *Would you be interested in seeing the statistics of other peoples catches? Why?*
- *Would you be ok with other people to see yours? Why?*
- *What if there was a filter in the settings that meant you could control who could see your data?*
- Compare your catch statistics to friends, fishery, regionally, nationally
- Provide an easy access input for match catch data
- Live Fish Off – sync with other fishermen – live feedback

2.4 Settings

- The settings would be the way you control and personalize your tool and your data.
- *What settings would you like to have control over?*
- Control who can see your catch data
- Create groups to share catch information with

3. Centralised National Database
   - Historical records, paper returns and angler census data could be incorporated
   - *Who would be best to organise such a scheme?*

4. Data Users
   - Data used by Environment Agency for analysis, in order to:
     - Protect wild fish stocks
     - Ensure that habitat is sustainable for fish
     - Meet legislative requirements e.g. Water Framework Directive
     - Optimise exploitation
     - Balance demand and resource access and availability

- Meet the needs of other functions and other agencies

- *Any further questions about how an angler catch monitoring scheme would work or points you would like to make?*
- *What role could you see the Angling Trust playing in an angler catch monitoring scheme such as this?*

Appendix B:

NVivo Coding

Appendix C:

Online Forum Focus Groups

It was recommended by several participants that using online angling forums to gain angler's opinions would provide a noteworthy source. Six online forums were chosen to initiate informal online forum focus group discussions. An introductory statement of a proposed scheme was posted as a thread and forum members were asked why they would or would not participate in such a scheme. Forum members were free to respond as they wished and as a facilitator, the researcher answered questions and posed further questions to stimulate online debate. The threads went live for 31 days, see table below for a summary of their activity.

Table: Summary of six online forum threads

Forum	Views	Replies	Participants
Forum 1	20	0	0
Forum 2	355	15	3
Forum 3	1,550	50	16
Forum 4	138	17	4
Forum 5	751	29	8
Forum 6	626	25	11
Total	3,440	136	42

The forums provided a useful source of data, enabling people to comment anonymously and at their own time, requiring less commitment from the participants. Generally they were active, threads receiving 3,440 views and a total of 136 responses by 42 participants. Additional data such as stakeholder perspective could not be determined, but it can be assumed all 42 participants were a part of the angling community, actively having to log onto the angling forums to post a response.

Example posts:

Post by GeorgeXXXX on Thu Jul 12, 2012 4:28 pm
Well I most defiantely would, if the information that I deliver to people is actually put to good use and the collective data is fed back to me I would see no reason not too.

I think something like this is desperately needed, I also think you would get a lot of contributors if you get it out there!

If you are actually going to do this then good luck to you!

stu_XXXX - 13-07-2012 18:01
Re: Would you report your catch data to help monitor the health of the waters you fish

Hi Theo,

My syndicate does exactly that and has been doing so for a long time. Data on growth rates, general health etc is used for fishery management.

However, even with our tiny membership it is still difficult to get everybody to buy into it and very difficult to enforce without co-operation.

Stu

alan W - 14-07-2012 14:58
Re: Would you report your catch data to help monitor the health of the waters you fish

No,for one reason,good waters are getting so hard to find,that it would be a suicidal gesture,the bad waters are easily spotted,NO B*gg*r on them.

XXXX- 14-07-2012 17:11
Re: Would you report your catch data to help monitor the health of the waters you fish

NO way in the world would i tell anyone if i catch anything, i go out of my way to keep it a secret. all the time ive spent raking and baiting a swim, and then someone see,s you catch and you dont get that swim again. Its even worse with with piking, if someone see;s you catch a nice pike they will fish that swim and within 5 or 6 trips they will catch it ,then tom , dick and harry will catch it and then it be dead, i have seen it happen time and time again

dannyXXXX 17-07-2012 05:36
Re: Would you report your catch data to help monitor the health of the waters you fish

Its a tricky one. The angling club im in already asks for catch returns to be filled in. I understand that this is beneficial for the clubs management and stocking of there waters and as said catch returns can be a good indicator of a waters health. However as others

have said i would be reluctant to submit catch returns relating to pike for obvious reasons.

Do we need to do this? Id say we already know that there are problems RE fish predation and poaching on public waters so would efforts and resources not be better channeled addressing these issues rather than "wasting" time setting up and collating data?

Peter XXXX 17-07-2012 05:49
Re: Would you report your catch data to help monitor the health of the waters you fish

I don't see what the problem is regarding making catch returns, the game fishing fraternity have been doing so for many years.

On almost every stretch of the Test, Itchen and Avon that I've ever fished we have had to make a catch return, the same thing goes for evey stillwater trout fishery I've ever fished as well.

As to who gets to see that information, from a coarse fishing standpoint, then the fishery owners/clubs definitely and maybe the local area of the EA as well.

11th July 2012, 11:39 AM

Rive tXXX

All fishermen are cheats and liars and most are illiterate, but i wish you all the best in your findings

11th July 2012, 11:58 AM

lambXXXX

Quote: Originally Posted by **Rive t** All fishermen are cheats and liars and most are illiterate, but i wish you all the best in your findings

I didnt realise that we were held in such high esteem Rive t. But as you can see I am not illiterate lol

mutleyXXX -16-2012 06:11 PM
Re: Would you report your catch data to help monitor the health of the waters you fish

Perhaps a look at the Wye and Usk foundation website might give an indication of the benefits of catch reports and fish stock monitering by other means to validate river reinstatement projects and stocking policy. The problems of catch reports leading to overpressured waters is a difficult one so possibly the information should not be in the public domain.