Ecological Economics 149 (2018) 285–293

Contents lists available at ScienceDirect

Ecological Economics

journal homepage: www.elsevier.com/locate/ecolecon

Sea Bass Angling in Ireland: A Structural Equation Model of Catch and Effort

Gianluca Grilli[a,b,*], John Curtis[a,b], Stephen Hynes[c], Paul O'Reilly[d]

[a] Economic and Social Research Institute, Sir John Rogerson's Quay, Dublin, Ireland
[b] Trinity College Dublin, Dublin, Ireland
[c] Socio-Economic Marine Research Unit, Whitaker Institute, National University of Ireland, Galway, Ireland
[d] Inland Fisheries Ireland, 3044 Lake Drive, Citywest Business Campus, Dublin, Ireland

ARTICLE INFO

Keywords:
Recreational angling
Fisheries management
Dicentrarchus labrax
Structural equation models

ABSTRACT

The relationship between angling effort and catch is well-recognised, in particular that effort influences catch rates. But increased catch, which can be considered an attribute of fishery quality, may influence effort in terms of number of fishing trips. This suggests bi-directional feedback between catch and effort. In many travel cost applications little attention has been given to this endogeneity problem. In this paper we expand the application of structural equation models to address this issue by jointly estimating demand (effort) and catch functions. Using a cross-section dataset of sea bass anglers we propose two separate joint models. First, we include expected catch as an explanatory variable in the demand equation. In the second, we reverse the causality and use the expected number of fishing days as a covariate in the catch function. The two approaches produce similar model estimates, and perform better at predicting anglers' catch and effort than standard models. The findings confirm that sea bass angling is highly valued, with a consumer surplus of about €282–318 per angler per day, though this is likely to be biased upwards. Furthermore higher catches result in more days fished, on average in a 2:1 ratio. Whereas on average, an additional fishing day results in 3–4 additional bass caught.

1. Introduction

Sea angling is a popular and economically important recreational activity. For example, during 2010 there were 353,000 sea anglers in Canada (FOC, 2012), 884,000 in England who spent Stg£1.23 billion on the sport (Armstrong et al., 2013) and in excess of 100,000 anglers in Ireland spending €174 million, including on travel and accommodation (IFI, 2015). In addition to the economic contribution, sea anglers appreciate and value a variety of cultural ecosystem services associated with the marine environment (Armstrong et al., 2013; Jobstvogt et al., 2014). Continued sustainable management of sea angling target species is important to maintain angler satisfaction, as well as, protect associated economic benefits, which often accrue in coastal communities.

Sea bass (*Dicentrarchus labrax*) is a popular species among Irish and UK sea anglers, with 30% of sea anglers in Ireland specifically targeting this quarry (IFI, 2015). Due to its biological characteristics sea bass is a particularly vulnerable species and can be easily overfished. Sea bass grow slowly and in Irish coastal waters only reach sexual maturity at 5–8 years old (Pickett and Pawson, 1994). In addition, sea bass exhibit strong site fidelity, returning to the same coastal site each year after spawning. Juvenile bass are also vulnerable, as they tend to occupy nursery areas close to exposed estuaries (Pickett et al., 2004). In European Union (EU) waters total biomass of sea bass has declined in recent years due to an extended period of poor recruitment and increasing fishing mortality (Graham et al., 2014). There have been both national and EU controls on commercial and recreational fisheries for sea bass, which range from a moratorium on commercial fishing for sea bass around Ireland, minimum landing sizes, weekly or monthly boat limits in some commercial fisheries, closures of nursery areas in England and Wales, and some closed seasons for French fleets (Graham et al., 2014). These controls were further extended for the 2018 season (EU Council, 2018). Commercial fishing is just one source of pressure on sea bass stocks, as roughly 25% of bass harvested in European waters are caught by recreational anglers (Graham et al., 2014). In some sea bass stocks the recreational catch exceeds commercial catches (EU Council, 2018). Bag limits for recreational fisheries exist in several countries. In 2015 the EU set a 3-fish bag limit per day for recreational anglers in all member states, and in Ireland there was a more restrictive bag limit of 2 fish. For the 2018 season the EU has further regulated commercial sea bass fisheries, designated recreational sea bass fisheries in the North Sea and the seas around the UK and Ireland as catch & release, and only permitted recreational harvest of sea bass in the Bay of Biscay (EU Council, 2018). Concern about potential overfishing by recreational anglers is not unique to sea bass. In general recreational

* Corresponding author.
E-mail address: gianluca.grilli@esri.ie (G. Grilli).

https://doi.org/10.1016/j.ecolecon.2018.03.025
Received 2 November 2017; Received in revised form 21 March 2018; Accepted 22 March 2018
0921-8009/

angling is responsible for about 12% of the worldwide fish catches (Cooke and Cowx, 2006), while Lewin et al. (2006) report that worldwide recreational landings of some popular species, such as largemouth bass (*Micropterus salmoides*), rainbow trout (*Oncorhynchus mykiss*), sockeye salmon (*Oncorhynchus nerka*) and yellow perch (*Perca flavescens*) are larger than commercial catches.

Feedback between the ecological and the socio-economic dimensions of fishing is fundamental to assure a sustainable management of a complex system such as a fishery (Arlinghaus et al., 2017; Fenichel et al., 2013; Ward et al., 2016). McPhee et al. (2002) argue that recreational angling without constant monitoring is not sustainable in the long-term. Zarauz et al. (2015) is a particularly relevant example with respect to sea bass in the Basque Country, where the first estimate of recreational sea bass landings represented between 48 and 68 % of the total catch. Quantifying the recreational catches and harvest, as well as understanding the factors that influence catches are critical for effective stock management. This is just as important within fisheries that are designated as catch & release, as data on catch per unit effort (CPUE) is useful for stock assessment. Recreational harvests are broadly determined by two factors: anglers' demand for recreational fishing, and success in catching fish. Fishery managers may increase the effectiveness of bass conservation by policies controlling either angling demand or catch efficiency (i.e. CPUE). The relationship between anglers' effort and fish abundance is not always clear (Camp et al., 2016) but they may be endogenous to each other. For example, catch rates may be a predictor of recreational demand, because catch may be perceived as a measure of site quality (Parsons and Needelman, 1992; Englin and Lambert, 1995). Yet, using self-reported catch as a demand predictor also leads to measurement error due to recall bias (Tarrant et al., 1993; Morey and Waldman, 1998). Structural equation models have been used to circumvent this issue. A catch function is estimated in a first equation, the predicted value of which is then used as an explanatory variable in a second equation, the demand model (Englin et al., 1997; Huszar et al., 1999). A similar approach has also been recently used in examining how hunting success affects hunting demand (Pang, 2017). But the relationship between catch and recreational demand is bidirectional. Catch is a function of anglers' fishing effort, while effort is increasing in the number of fishing occasions. It is reasonable to assume that people who spend more days angling will also catch more fish, all else equal. For this reason, recreational demand may enter the catch model as a predictor, measuring effort in the fishing activity; and catch may enter the demand model, measuring fishery quality. Ideally a panel dataset is necessary to estimate such a reciprocal model in which catch and angling occasions are observed over time (Kline, 2006). But most recreational activity datasets have a cross-sectional format only, from which it is generally not considered appropriate to estimate reciprocal relations (Cook and Campbell, 1979; Organ and Bateman, 1991), though a mathematical solution for feedback loops is potentially available (Wong and Law, 1999).

The objective of this paper is twofold. First, we develop a sea bass angling model in which demand and catch are structurally related. From a sea bass management perspective this approach enables fishery managers to better understand which management changes potentially have the greatest ability to influence bass angling and conservation. The approach could also assist decision makers to identify whether management options can influence the number of angling trips, anglers' catch efficiency or both. Second, within the context of a cross-sectional dataset we consider a methodological issue with respect to the feedback relationship between catch and demand. Previous papers assume a feedback loop in one direction; initially estimating a catch function and using the predicted catch value as an explanatory variable in the demand equation (Englin et al., 1997; Huszar et al., 1999; Pang, 2017). We investigate the feedback loop between catch and demand in both directions, estimating two models separately. In one model predicted catch enters demand as a measure of individual skill, similar to prior approaches. In the second model predicted angling days (i.e. angler demand) enters the catch model as a measure of effort. We show how the two approaches affect model parameter estimates and welfare analysis.

2. Methods

2.1. Data

Inland Fisheries Ireland (IFI) undertook a survey of bass anglers between April and June 2016 to elicit angler feedback on the current and proposed regulations pertaining to the Irish recreational bass fishery. The survey targeted domestic and visiting anglers who fished for bass in Ireland during 2015. The survey was conducted on-line and was advertised via a number of channels including the Inland Fisheries Ireland website, Facebook page, and Twitter account. Notice of the survey was also emailed to subscribers of IFI's Angling newsletter. Specialist tackle shops who cater for bass anglers were requested to alert their customers to the survey. On-line surveys are susceptible to sampling bias (Fleming and Bowden, 2009), for example older people could be under-represented, but no method of survey administration has been proven superior to any other (Champ, 2003). However, we acknowledge that self selection bias may arise within our sample. On-line surveys do have several advantages over traditional survey methods, not least the low costs incurred and also the speed and accuracy of data collection. Data can be collected continuously regardless of date or time and also without geographical limitation (Madge, 2006). On-line survey questionnaires can be designed to filter respondents to questions that are relevant to their circumstances based on their prior responses. While acknowledging that a cautious view should be taken of the representativeness of our sample to the population of bass anglers fishing in Ireland, we believe the survey approach undertaken was the most feasible given the absence of an angler register and the difficulty of carrying out a full on-site survey of bass anglers or of locating them in randomised household surveys.

The survey generated 266 responses, of which 230 were used in the models estimated. Observations from two anglers with in excess of 200 angling days per annum were excluded as outliers, though this did not have a substantial impact on mean welfare values but reduced the estimates of the standard error.[1] The balance of omitted observations were due to item non-response of critical questions. The survey itself comprised 35 questions and took approximately 15 min to complete. The majority of respondents were from the Republic of Ireland (69%), 5% from Northern Ireland, 10% from Great Britain with the remainder of the sample from other European countries. Almost all respondents were male with only 5 responses from women. Table 1 provides an overview of the variables used in the analysis. The variables *Fishing_Days* and *Total_Catch* are the number of fishing days undertaken in 2015 and the number of fish caught and are the dependent variables in the demand and catch functions estimated. On average, respondents fished for 30.8 days during 2015 with a median of 25. Mean annual catch is roughly 31 bass (st.dev. = 50) up to a maximum of 300. In 2015 there was a 2 fish bag limit per 24 h and a minimum size limit of 40 cm for retained fish. Catches here reflect all sea bass caught, irrespective of size or whether they were retained. The variable *Trip_Cost* is an important variable in the demand model and measures average angling trip expenses, including items such as travel, food, bait and angling guides. Average expenditure per angling day was roughly €48, with a high variability across respondents (standard deviation is €96). Average annual expenditure on angling equipment (*Tackle_Inv*) includes expenditure on equipment that can be used on recurring basis, e.g. rods. *Session_length*, with a mean of just above 4 h, represents the number of

[1] The words 'trips' and 'days' are used interchangeably in what follows, though the survey specifically asked "how many separate days did you participate in bass angling in 2015?"