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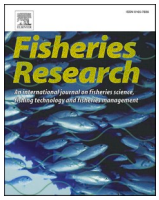

Full length article

The impact of data type and analytical method in developing recreational sea angler typologies

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ABSTRACT

Recreational sea angler typologies inform fishery management by describing participation and behaviour. In some sectors, typologies are questioned due to inconsistency across methodologies and impacts that different analytical techniques have on results. Ways to efficiently capture typology data and identify statistical distortion are also important considerations in their development. These issues are relevant to the UK where a policy-facing typology of recreational sea anglers, involving a complex data framework, was first published in 2025. The study presented in this paper tested a simplified version of the original framework. Two-step clustering was performed on raw angler responses and compared to the outcomes of the original analysis. This generated insights on the impact of the different analyses and the theoretical nature of typologies. Due to an insufficient silhouette co-efficient and necessary removal of variables from the data framework, it was not possible to replicate the original typology (consumers, trophy, leisure-identity and social anglers). A new model described diversity in the sample consisting of mid- and high-level environmentalist clusters. The alternative typology offered simpler design and demonstrated a closer relationship between raw angler responses and case positioning. It did not perform as well as the original when explaining variation in angler stewardship behaviours and is therefore considered weaker in its predictive and practical utility. The study demonstrated that typologies are dependent on the data type and associated analytical methods used in their development and, relatedly, their conceptualisation at design stages. As a result, important observations are made on the theoretical nature of typologies.

1. Introduction

There is a substantial amount of scholarly literature focused solely on heterogeneity among recreational sea anglers or that has employed classification methods to understand participation and responses to fishery management (Arlinghaus and Mehner, 2005; Arlinghaus, 2006b; Arlinghaus et al., 2007; 2013 2016; 2017; 2019; 2020; Beardmore et al., 2011; 2013; Hunt et al., 2013; Johnston et al., 2013; Magee et al., 2018; Matsumura et al., 2019; van den Heuvel et al., 2020; Fisher et al., 2025). Theories commonly adopted in understanding angler heterogeneity include: motivation which has been conceptualised as a binary concept involving catch related and non-related factors (Fedler and Ditton, 1994; Finn and Loomis, 2001; Beardmore et al., 2011); and, specialisation, which has been operationalised in research as a combination of affective psychological commitment, behavioural commitment, and cognate ability (Bryan, 1977; Ditton et al., 1992; Salz et al., 2001; Arlinghaus et al., 2007; Li et al., 2010). Enduring involvement also has relevance to angling (as a leisure activity) but has mainly been applied in wider recreation contexts (McIntyre and Pigram, 1992; Havitz and Dimanche, 1997; Kyle et al., 2007).

Characterizing diversity among angling communities in the form of digestible typologies is complex (Hunt et al., 2021). Angler behaviours, preferences, policy responses and participation vary significantly and are influenced social structures such as age, gender, socio-economic status, in addition to individual autonomy, catch orientation, trip circumstance, costs and species (Fisher, 1997; Floyd et al., 2006; Kyle et al., 2007b; Hunt et al., 2019; Mehner et al., 2005; Hyder et al., 2024). For example, site choice, species and culinary value of fish are specific factors that have made scholars rethink previous assumptions about 'specialized' anglers, therefore questioning its strength in predicting angler characteristics such as catch orientation (Dorow et al., 2010; Beardmore et al., 2011). Despite such limitations, specialisation is still

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perceived as one of the key theories that describes angler preferences and behaviours, including support for environmental conservation (Oh and Ditton, 2008).

Debate around the usefulness and legitimacy of typologies has emerged in the scholarly literature beyond fisheries research. Characterising the diversity of European farmers has been considered key for delivering effective and sustainable agri-environmental policy (Dessart et al., 2019; Malek and Verburg, 2020; Brown et al., 2021). Research has demonstrated that the legitimacy of related typologies is diluted by the sheer variation in methods employed and variables (data) used in their development, which hinders comparisons and transferability across geographies and policy areas (Bartkowski et al., 2022). Focusing on forestry policy and management, Ekstrom et al. (2024) argued that very little attention has been given in the typology literature to the impact that analytical methods have on typology outcomes: their work replicated attitudinal data from Swedish forest owners across five different types of quantitative analysis (k-means, latent profiling, principal component, hierarchical and archetypal analysis), demonstrating that individual cases were assigned to different clusters as a result of the analytical method employed.

The role of data type and analytical method is rarely discussed in the angler typology literature, yet presents important issues that must be considered in study design and application. For example, a researcher theorising that specialisation is the most appropriate tool to apply in their research will design and collect data aligned with specialisation theory. The outcome will be a (hierarchical) model expressing level of specialisation. There is no room for the resulting typology to reveal diversity outside the context of specialisation. The same logic applies to exploratory studies that do not justify the conceptual forging of measures into a 'specialisation' continuum; such work requires different approaches and collection of wider data based on (lateral) distinction across conceptually diverse metrics (see Fisher et al., 2025). Furthermore, a standard, authoritative, methodology for applying these different kinds of typology (lateral or hierarchical) is lacking. The scholarly field requires work in this area in order to develop methodological consistency.

Typology studies also need to consider efficient forms of data collection. This is important for two reasons: firstly, to enable the simplification of data collection tools that reduce chances of methodological error during analysis; and, secondly, to reduce research fatigue among anglers, which causes high drop-out rates. While lengthy survey questionnaires are more appropriate for exploratory work in uncharted angling communities, they cannot realistically be replicated regularly due to logistical and financial constraints. Data reduction and efficiency in studying angler heterogeneity has been addressed in European studies on specialisation, focusing on the identification of best-performing metrics (Beardmore et a., 2013). In studies that use lateral methods for capturing angler diversity (see Fisher et al., 2025; Magee et al., 2018), the impact of data type and reduction on typology outcomes has not been tested.

The role typologies play, the debate surrounding typology legitimacy, and the need to consider efficient data collection methods is particularly relevant to the UK. The Fisheries Act 2020 stated a need to integrate recreational sea angling into fisheries management alongside commercial fishing. To inform this general policy intention, an inaugural typology propositioned that in a mixed-species, open access marine fishery, with limited capacity for regulatory enforcement, a four-type, lateral, model best described diversity in the angling community: consumers, trophy anglers, leisure identity anglers; and, social anglers (Fisher et al. (2025). The work provided a data collection framework for exploratory studies seeking to uncover angler heterogeneity, including: specialisation; involvement (conceptualised as social bonding, centrality, identity and attraction (Seimer and Knuth, 2001; Kyle et al., 2007a)); attitudes to catch (conceptualised as general consumptiveness, catching numbers of fish, catching large or trophy game fish, and retaining fish (Anderson et al., 2007)); environmental attitudes (involving awareness of consequence, feeling of responsibility and protection for the environment, and angler bio-centrism/anthropocentrism (van den Heuvel et al., 2020; Arlinghaus and Mehner, 2005; Bruskotter and Fulton, 2007; Schwartz, 1977; Shindler et al., 1993); and, motivation (Fedler and Ditton, 1994). The data-driven analytical approach involved exploratory factor analysis with extraction methods based on principal components, which reduced data into digestible metric scores for subsequent k-means clustering. The results showed close fit between the statement groups (components) and the range of pre-conceived concepts drawn from the literature in designing the data collection framework, apart from behavioural and cognate measures constituting parts of angler specialisation. As a result, the angler types were identified and defined in a lateral fashion using their unique performance across these domains. There was no data-driven rationale to suggest that these areas of measurement correlated or converged into a theory of specialisation (Fisher et al., 2025).

The components (Table 1) developed by Fisher et al. (2025) represented numeric measures based on a regressed line of best fit. These reflected concepts drawn from literature in which the analytical technique was slightly different, mostly using extraction methods based on the presence of latent constructs that grouped measures into factors (e.g. Anderson et al., 2007; Beardmore et al., 2011). This did not present significant problems because of the synergy between their components the literature-based factors. If this were not the case, the rationale for differences could easily have been due to the different data reduction (extraction) methods used. In fact, the similarity in outcomes stands to support an argument that both methods represent accurate manipulations of multiple variables into statistical outcomes that reflect accurate pictures of reality. The notion was supported by Fisher et al. (2025) when comparing typology outcomes to the positioning of anglers in the typology based on participant self-selection. This raises important questions that are rarely discussed in the typology literature: how far does multivariate analysis skew or blur real distinctions between humans? Is there a recognised level of detachment between the basic response of people in a survey questionnaire and typology classification based on the complex analytical techniques (requiring transformation of data types)? Answers to these questions are practically important: knowing raw responses to related survey questions per typology classification is useful when, in fishery management contexts, quickfire

Table 1
Highest loading statements for each typology component identified in Fisher et al. (2025).

Component and survey statement	Loading
1: Keep and consume	
"I want to keep the fish I catch"	0.897
2: Awareness of environmental consequence	
"Humans are severely abusing the environment"	0.845
3: Central to life	
"Recreational sea angling occupies a central role in my life"	0.840
4: Social bonding (friendship)	
"Participating in recreational sea angling provides me with an opportunity to be with my friends"	0.824
5: A 'catch' orientation	
"A fishing session can be successful even if no fish are caught"	-0.803
6: Catch characteristics (trophy)	
"I would rather catch 1 or 2 big fish than 10 smaller fish"	0.800
7: Identity	
"You can tell a lot about a person by seeing them take part in recreational sea angling"	0.793
8: Environmental responsibility	
"We anglers do not do enough to protect aquatic ecosystems"	0.786
9: Catch numbers	
"The more fish I catch, the happier I am"	0.785
10: Biocentrism	
"Fish have as much right to exist as humans"	0.726

Likert scale used: 1 =strongly disagree; 2 =Disagree; 3 =neither disagree or agree; 4 =agree; 5 =strongly agree.

stakeholder profiling may be needed to inform intervention programmes that require rapid turnaround.

Considering the aforementioned issues, the primary research aim of this study was to use the sample and typology of recreational sea anglers in England and Wales developed by Fisher et al. (2025) as a case study to assess the impact of applying alternative data types and associated analytical methods aiming to reduce the metrics needed to classify respondents. Specifically, the study presented in this paper evaluated the use of raw Likert (ordinal) data reflecting the highest scoring single-statement response for each component used in the original typology (Table 1). This removed the principal component analysis stage which involves multiple time-intensive tests to evaluate concept-measure relationships. Insights were generated into the nature of typologies, the role of method, the strength of typologies in predicting angler behaviour and, provided further knowledge on the nature of the recreational sea angling community in the UK. To meet the overarching aims, the study addressed a series of specific research questions: what analytical methods are required for using raw survey data to create angler typologies? Can the original typology of anglers in the UK be replicated by using unmanipulated raw (ordinal) data? If not, what would the structure of a new typology look like, how rich is the description of diversity, and are there any indications that it may predict other behaviours. The final level of comparison focuses on the level of connection between raw data collection and typology positioning. This assessed whether the statistical intervention adopted across these two pieces of work distorted reality. Combining these focal points revealed important observations on the utility of respective typologies to both researchers and those involved in fishery policy and management.

The following Section describes the research methodology, including a summary of the data used, sample characteristics and an overview of the analytical techniques employed. Results are then presented, including: revised cluster analysis; comparison-description of typology outcomes; predictive validity; and exploration of angler survey responses. The discussion positions the study findings in the context of scholarly debate, albeit addressing relatively new ideas which are unparalleled in the literature. The paper concludes with observations on what the study findings mean for the role of methods in studying angler heterogeneity, the nature of typologies and a comparison of utility in fishery management and policy.

2. Methodology

Data collected by Fisher et al. (2025) in 2022 was used in this study, involving an e-survey of 46,172 recreational sea anglers (defined as those who used rod and line in marine settings to capture fish for non-economic or fundamental dietary requirements). The sample included 453 anglers after initial responses were cleaned and assessed for quality as part of the principal component and cluster analysis (e.g. multicollinearity and Keiser-Meyer Measure of Sampling Adequacy). The sample was predominantly male (99.2%), White British (97.6%), and 56% had no known disability. Compared to characteristics of other UK angling studies (Hyder et al., 2020), the sample was older (80% aged over 55 years) and more avid (23% fished for 35 + days over previous 12 months prior to survey completion). The majority lived in the Southwest and Southeast of England (23% and 22% respectively).

The original typology employed a suite of variables (n = 34) per component (n = 10). The statement-based variables were grouped into components and both hierarchical and non-hierarchical clustering performed (based on k-means and centroids) to generate angler segments. See Fisher et al. (2025) for full description of methodology and associated results. The purpose of the methodology employed in the study presented in this paper was to test the simplification of the approach adopted by Fisher et al. (2025) by using raw data for the statements with the highest component loading. Whereas the original typology required raw data for 34 statements, converted into metric component scores, the current study only required ten statements (Table 1). Data for each statement was expressed as Likert (ordinal) scales in which: 1 =strongly disagree; 2 =disagree; 3 =neither disagree or agree; 4 =agree; and, 5 =strongly agree. The statements were derived from literature which used the respective concepts to either describe differences between angler profiles or described aspects of the psychometric profile that may predict responses to management or policy changes. Statements corresponding to components 'keep and consume', 'a catch orientation', 'catch characteristics', and 'catch numbers' derive from the attitudes to catch framework which developed in response to the conceptualisation of 'consumption orientation' (Anderson et al., 2007). The statement for 'centrality', as a component of specialisation, has been used in several angling studies, notably Kyle et al. (2007a) in developing 'enduring involvement'. Statements for 'identity' and 'social bonding' was also taken from Kyle et al. (2007a). Components collectively representing environmental attitudes (awareness, responsibility and biocentrism) derive from a collection of literature, including Dunlap, (2000), Arlinghaus and Mehner, (2005), Arlinghaus, (2006a), Bruskotter and Fulton, (2007), and, van den Heuvel et al., (2020). Additional data collected by Fisher et al. (2025) was used to help explore the distinctiveness of resulting angler clusters, notably: personal stewardship norms and private stewardship behaviours drawn from Landon et al. (2018); basic demographic information (gender and residency); behavioural data such as spend and avidity; and, motivation. There is a considerable amount of literature on angling motivation (e.g. Fedler and Ditton, 1994; Beardmore et al., 2011). In this and the original typology study, motivation was simplified to those predominantly related to catching fish, those related to things other than catching fish such as relaxation, and parity of both catch and non-catch factors.

Two-step clustering (SPSS v30.0.0) was used to analyse the ordinal data in this study. The two-step technique simultaneously (and covertly) created a tree and node cluster diagram against which a hierarchal approach was applied to generate cluster membership. While the technique uses a hierarchal approach, it employs a fundamentally different method to generate case positions in the dimensional space. In approaches for continuous data, such as K-means analysis, cluster membership in dimensional space is based on suitable distance measure (e.g. Euclidean). This is unsuitable for non-continuous data where the quantifiable distance between two points of measurement is unknown. The two-step technique overcomes this problem by allocating final cluster membership based on a modelled probability algorithm; this approach positions each case based on comparison (log-likelihood) to a multinomial normal distribution applied to the sample data (Bacher et al., 2004; Tkaczynski, 2017).

The model (number of recommended clusters) is penalised for complexity according to either Schwarz's Bayesian (BIC) or (AIC) Akaike Information Criterion. Performance of each criterion is affected by complexity in the data range with BIC demonstrating more severe penalties in more complex models compared to AIC (Akaike, 1974; Schwarz, 1978). In the following analysis, the effect of each type of criterion was tested but showed no effect on results. The penalties applied by the information criterion affects the quality score given to the cluster model in the form of the silhouette and separation coefficient. This value simultaneously represents the degree of tightness between data points within a cluster and the degree of separation (difference) between the recommended segmentations based on the specified regression criterion (Bagirov et al., 2023). As recommended by Rousseeuw (1987) coefficients closer to 1 (>0.5) represent a good fit between the generated model and data; the model is considered 'fair' when the coefficient is between 0.2 and 0.5; values below 0.2 demonstrate poor fit, suggesting unsuitability of the analysis technique and/or poor definition between segments in the model (see Rousseeuw, 1987; Bagirov et al., 2023). Two-step clustering is sensitive to data order, therefore cases were uniformly randomised in SPSS prior to analysis. The process of generating an appropriate silhouette coefficient was iterative by nature and decisions were intrinsically linked to the result itself. This process is therefore described in detail alongside results (Section 3.1).

Cluster results were verified by independent sample comparisons for non-parametric data. The test type, associated hypotheses and quality thresholds related specifically to the outcomes of the clustering process and are therefore presented alongside results in Section 3.

3. Results

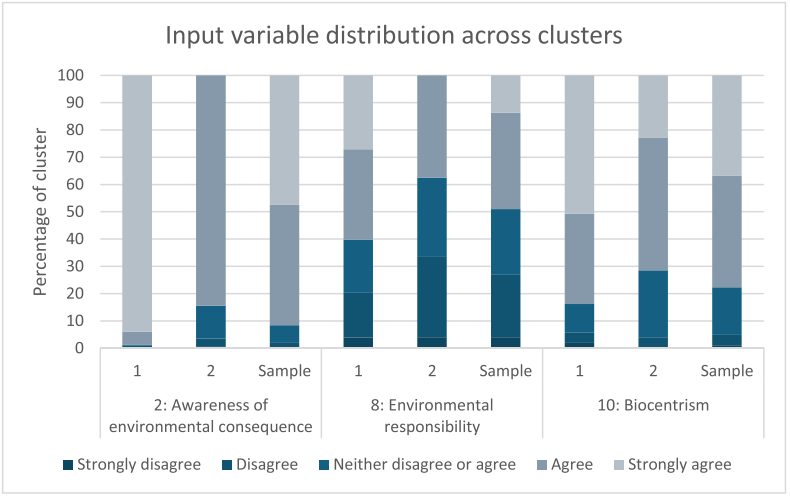
Several independent analyses were required to generate results to inform the overarching research aim and associated research questions outlined in Section 1. This involved: cluster analysis (Section 3.1), validity testing (Section 3.2), typology model description (Section 3.3) and comparisons (Section 3.4). A separate description of raw survey responses from the sample of respective typology studies was also required (Section 3.5).

3.1. Two-step cluster analysis

The initial two-step clustering involving ten component-based variables resulted in a two-cluster model with an unacceptable silhouette coefficient (0.1). To improve the coefficient value, variables were individually removed based on their predictive importance (PI), defined as a variable's sensitivity to variation in a given cluster model. Values closer to 0 are less sensitive to data variability and are therefore least useful in a statistical exercise aimed at retaining variability. Variables performing poorly in predictive importance are likely to create statistical noise that effects other variables showing improved sensitivity to the model outcomes. Pragmatism therefore dictated the sequential removal of the lowest performing variables with clustering re-performed at each stage until the silhouette coefficient reached a fair (acceptable) threshold (>0.2). The sequential process was important as each variable removal impacted on subsequent PI scores. The order of variable reduction was as follows (PI values): centrality to life (0.08); social bonding (0.10); catch numbers (0.11); identity (0.15); and, keep and consume (0.09). At this stage, the silhouette coefficient was borderline acceptable (0.2) based on a two-cluster model involving five variables. Following protocol to improve the silhouette coefficient above the borderline threshold, the catch characteristics variable was removed (0.04) which resulted in a seven-cluster model but with no improvement of the silhouette coefficient. Subsequent removal of the catch orientation variable (0.51) improved the coefficient (0.3) based on a model involving two clusters and three input variables. Although the number of input variables was critically low, one further variable removal was tested (biocentrism: 0.11), which improved the silhouette coefficient (0.9) but created nine very small and difficult-to-define (unusable) clusters with a poor cluster ratio (2.71). Scenarios were then tested based on the two input variables with reduced (user-specified) cluster numbers to aid in simpler definition. The best performing scenario involved five clusters with a 0.6 silhouette coefficient. However, descriptive data for this scenario revealed incoherent definition between clusters: in three of the five clusters all respondents agreed that anglers do not do enough to protect aquatic ecosystems.

Thus, the two-cluster model provided the most suitable solution to describing an acceptable level of diversity in the sample, proving a balance between data parsimony and model strength. The model involved three input variables (awareness of environmental consequence; environmental responsibility; and, biocentrism) and two clusters (1: n = 229; 2: n = 224) with a 0.3 silhouette coefficient. Visualised distribution of Likert responses (Fig. 1) show that both clusters were distinguished by their positive awareness of the consequences angling causes on the environment with Cluster 1 showing propensity to 'strongly agree' (n = 214; 94% of cases) and Cluster 2 mostly agreeing with statements reflecting this sentiment (n = 189; 84% of cases). In cluster 1, there was a greater number of respondents agreeing (n = 76; 33%) or strongly agreeing (n = 62; 27%) that more could be done by anglers to protect the environment. This contrasted to Cluster 2 in which no angler strongly agreed and more disagreed or strongly disagreed to this sentiment (n = 66; 29% and n = 9; 4% respectively). Cluster 1 showed more propensity for biocentric viewpoints: 51% of cases (n = 116) strongly agreed to the corresponding statement when compared to Cluster 2, in which the majority of cases only 'agreed' (49%; n = 109).

It is important to highlight that the results (segmentations) presented in this Section (3.1) are a product of the order in which variables were removed. Other scenarios of variable removal were not tested, which can be considered a limitation of the results. However, it is also important to highlight that there is no theory-based approach relevant to concepts in the study that would have guided the sequential removal process. Removal based on poorest performing sensitivity provided a logical and reasoned process in relation to the aim of retaining as many variables as possible without such variables negatively affecting the silhouette coefficient. While an adequate model may have resulted from testing alternative, random, variable removals, such results would not have been based on any supporting, theoretical, justification.



PI: awareness of environmental consequence: 1.00; environmental responsibility: 0.17; biocentrism: 0.11.

Fig. 1. Likert responses (percentages) across input variables for clusters 1, 2 and total sample. PI: awareness of environmental consequence: 1.00; environmental responsibility: 0.17; biocentrism: 0.11.

3.2. Predictive validity of cluster solution

Based on the outcomes of the clustering (binary model), Mann-Whitney-U tests examined whether there was significant distinction between Clusters 1 and 2 regarding input and additional (predictive validity) variables for which there were expected, theoretically driven, differences. This process measured the strength of the typology externally to the context and data used in its creation; it can be viewed as the first basic step in which the typology's predictive nature is considered. Predictive validity variables replicated Fisher et al. (2025) where it was demonstrated that angler type explained salience in personal stewardship norms and private stewardship behaviours. These variables were considered particularly suitable considering that the input variables emerging from the results of the clustering measured degree of pro-environmentalism. Null hypotheses were as follows:

H_{0_1}: there is no significant difference in the awareness of environmental consequences of angling between clusters 1 and 2.
H_{0_2}: there is no significant difference in feelings of responsibility for environment between clusters 1 and 2.
H_{0_3}: there is no significant difference in biocentric views between clusters 1 and 2.
H_{0_4}: there is no significant difference in normative beliefs that other anglers should protect fishery resources and aquatic ecosystems between clusters 1 and 2.
H_{0_5}: there is no significant difference in feelings of moral obligation to protect fishery resources between clusters 1 and 2.
H_{0_6}: there is no significant difference in feelings of guilt for not protecting fishery resources between clusters 1 and 2.
H_{0_7}: there is no significant difference between clusters 1 and 2 in the frequency anglers cradled fish in water before being released.
H_{0_8}: there is no significant difference between clusters 1 and 2 two in the frequency fish were kept in water before being released.
H_{0_9}: there is no significant difference between clusters 1 and 2 in the frequency anglers used barbless hooks.

To aid the interpretation of predictive validity results below, it is important to briefly note the relevant quality metrics for the application of Mann-Whitney-U tests in samples with more than 40 cases. The z-score is a measure of standard deviation from the mean when accepting the null hypotheses (i.e. an undifferentiated sample) assuming that distribution normalises as sample size increases (Nachar, 2008). It is a measure of the magnitude to which the distribution, based on the U-statistic (cluster with lowest combined rank scores), compares to the distribution when accepting null hypotheses (Wonu and Anaekwe, 2023). A value with greater distance from 0 indicates that the metric has a greater distance from the mean. Negative or positive values indicate the direction of difference. Z-score probability values (<0.05) indicate the rejection of null hypotheses. The impact of the independent variable (cluster membership) on dependant variables can be further assessed by the effect size in form of rank-biserial correlation ($r = \frac{Z}{\sqrt{N}}$). There is no authoritative guidance on the interpretation of rank biserial effect size thresholds relating to Mann-Whitney-U tests. The standard assumption is that the effect is stronger as values approach 1.0. Most literature using rank biserial correlation applies a substituted set of effect thresholds borrowed from Pearson's correlation as reported by Cohen (1988): small (0.1); medium (0.3); and large (0.5). See Tak and Ercan (2023) and Gignac and Szodorai, (2016) for a discussion of thresholds and use of rank biserial values.

As demonstrated in Table 2, there was a significant difference between clusters 1 and 2 in terms of performance across all three input variables. The mean rank score of cluster 2 (120.00) was significantly lower than the sample mean and therefore cluster 1 which had a higher mean rank; this is represented by the significant probability of z-scores (-19.154, -6.290 and -5.594 respectively). Corresponding null hypotheses were therefore rejected (H_{0_1}; H_{0_2}; H_{0_3}). The impact of cluster membership on the input variables varied with small effect for biocentrism, medium for environmental responsibility, and high for awareness of consequence. As demonstrated in Table 3, the predictive validity variables show mixed results. The null hypotheses were rejected for personal stewardship norms (H_{0_4}; H_{0_5}; H_{0_6}) meaning there are significant differences between clusters 1 and 2 regarding beliefs that others should conserve fishery resources, moral obligation to protect the environment and feeling of guilt for not protecting aquatic resources. Effect sizes fall within the small-medium range. Cluster 2 had a mean rank higher than cluster 1 regarding feelings of moral obligation which is contrary to trends for other variables; this is an effect of the reversed meaning of the corresponding statement rather than an anomalous result. Importantly, the clusters are not significantly difference from one another in the frequency of uptake for any of the stewardship behaviours (cradling fish, retaining in water and the use of barless hooks). Results therefore fail to reject the corresponding null hypotheses (H_{0_7}; H_{0_8}; H_{0_9}). This is supported by very small effect sizes, meaning that as a variable cluster membership does not determine patterns in fish release behaviour.

3.3. Summarising key characteristics of the two clusters[1]

This Section provides summary descriptions of the key distinctive features for each individual cluster developed in this study using the input data (Table 2), predictive validity variables and additional demographic data collected in the original survey (see Section 2). This provides important background information to inform typology comparisons in Section 3.4.

Cluster 1 (n = 229): all but 14 anglers (94%; n = 215) showed strong awareness of the consequences recreational sea angling has on the natural environment. Eighty-four percent (n = 192) held biocentric viewpoints. The majority (96%; n = 219) held strong personal stewardship norms towards other people protecting aquatic environments, felt a moral obligation to do so themselves (87%, n = 199) and would feel guilt for not protecting fisheries (88%, n = 202). Less visible distinctiveness was observed regarding private stewardship behaviours; worth noting is that 73% (n = 164 of 226) of Cluster 1 often or always cradled fish in water before their release whilst fishing in the preceding 12 months. The majority resided in the Southwest of England (24%, n = 55) and were aged 55 + years (79%, n = 181), which replicated the wider sample demographic. Twenty-four percent fished for 35 + in the previous 12 months before completing survey. Catch-related and non-catch related motivations were equally paramount for 86% (n = 198) of anglers in Cluster 1, which was slightly higher than the sample score (84%, n = 382 of 453).

Cluster 2 (n = 224): Eighty-four percent (n = 189) of anglers showed strong awareness of the consequences recreational sea angling has on the natural environment. Seventy-one percent (n = 160) held biocentric viewpoints. The majority (90%; n = 202) held strong personal stewardship norms towards other people protecting aquatic environments, felt a moral obligations to do so themselves (81%, n = 182) and would feel guilt for not protecting fisheries (81%, n = 182). Similar to Cluster 1, less visible distinctiveness was observed regarding stewardship behaviours with the only notable feature being that 75% (n = 169) often or always cradled fish in water before being released. Note that this was not, however, a statistically significant feature in mean performance. The majority resided in the Southeast of England (25%, n = 55) and were aged 55 + years (82%, n = 183). Twenty percent of anglers in the cluster fished for 35 + in the previous 12 months before completing survey. Catch-related and non-catch related motivations was equally

[1] Positive reporting is based on combined agree and strongly agree responses to corresponding statement and components. Negative results are based on combined strongly disagree and disagree responses.

Table 2
Mann-Whitney-*U* test comparing independent cluster performance against input variables used in the two-step clustering.

Cluster input variables	Sample mean	Cluster (n)	Cluster mean	Mean ranks	M-W-U	Z	P*	R
2: awareness of consequence								
	4.37	1 (229)	4.92	331.66	1681.000	-19.154	< 0.001	0.90
		2 (224)	3.80	120.00				
8: environmental responsibility								
	3.32	1 (229)	3.63	263.85	17209.500	-6.290	< 0.001	0.30
		2 (224)	3.00	189.33				
10: biocentrism								
	4.09	1 (229)	4.27	258.86	18352.000	-5.594	< 0.001	0.26
		2 (224)	3.90	194.43				

* Asymp. 2-tailed. R = rank biserial effect size

Table 3
Mann-Whitney-*U* test comparing cluster predictive validity in relation to strategic variables.

Personal stewardship norms	Sample mean	Cluster (n)	Cluster mean	Mean ranks	M-W-U	Z	P*	R
People like me should do whatever they can to conserve fishery resources and aquatic ecosystems								
	4.27	1 (229)	4.46	266.43	16618.500	-7.420	< 0.001	0.35
		2 (224)	4.07	186.69				
I do not feel morally obliged to try and conserve fishery resources and aquatic ecosystems								
	1.90	1 (229)	1.76	195.52	18439.500	-5.629	< 0.001	0.26
		2 (224)	2.05	259.18				
I would feel guilty if I didn't do my part to conserve fishery resources and aquatic ecosystems								
	4.13	1 (229)	4.31	261.46	17757.500	-6.256	< 0.001	0.29
		2 (224)	3.94	191.77				
Private stewardship behaviours	**Sample mean**	**Cluster (n)**	**Cluster mean**	**Mean ranks**	**M-W-U**	**Z**	**P***	**R**
Cradled fish in water to ensure they can swim before being released								
	4.03	1 (226)	4.07	226.25	23559.500	-.756	0.450	0.04
		2 (217)	3.99	217.57				
Kept fish to be released in water while being unhooked								
	3.16	1 (226)	3.19	224.74	23902.000	-.474	0.636	0.02
		2 (217)	3.12	219.15				
Used barbless hooks								
	3.00	1 (226)	3.07	228.14	23134.000	-1.053	0.292	0.05
		2 (217)	2.93	215.61				

* Asymp. 2-tailed. R = rank biserial effect size

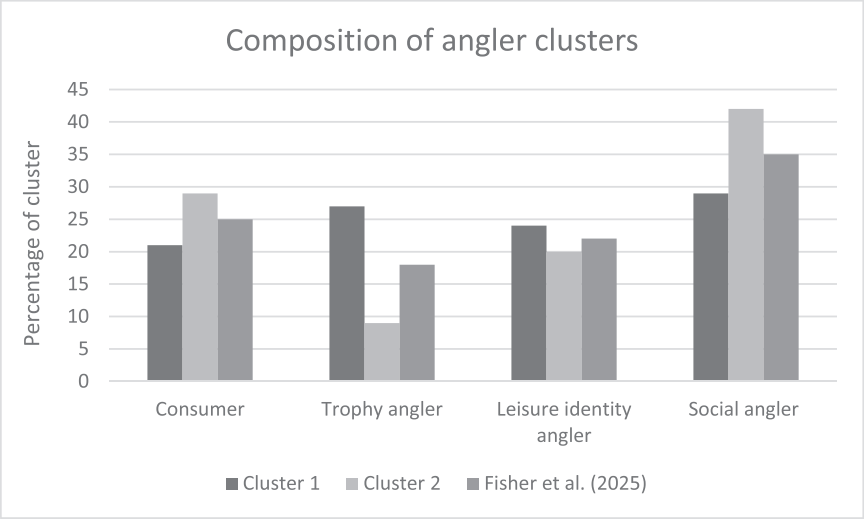
paramount for 82% (n = 184) of anglers in Cluster 1, which was slightly lower than the sample score (84%, n = 382).

Reflecting the comparison of means in Section 3.2, clusters 1 and 2 hold anglers with similar, positive, response patterns regarding personal stewardship norms and one type of private stewardship behaviour (cradling fish). Minor differences were observed in attitudes towards the environment, where cluster 1 showed more awareness of environmental consequences and feelings of responsibility to protect aquatic resources. The clusters showed similar demographic characteristics, avidity and motivation. There were slight differences in residency, with a large concentration of Cluster 1 residing in the Southwest and Cluster 2 in the Southeast. The lack of distinctiveness across clusters is likely a reflection of the 0.3 (fair) silhouette coefficient, implying that the modest separation between clusters is blurred further in other data domains. The ramifications of this are discussed in Section 4. At this stage, it is difficult to name each cluster with a title that describes their own identity in context of the differences they express to one another. The only logical recommendation would be 'high-level environmentalists' (Cluster 1) and 'mid-level environmentalists' (Cluster 2). It is of note that these labels are subjective by nature and are not based on appropriate objective or statistically informed bounds. Further work to establish such bounds is required but currently beyond the scope of this paper (discussed in Section 4).

3.4. Comparing typologies

The suite of characteristics (specifically, input variables) defining the typology presented in this study and in Fisher et al. (2025) are different. The cluster structures (sizes) are also fundamentally different. There is a smaller segment structure but wider conceptual coverage in Fisher et al. (2025) and reversal of such features in the current typology. Formally comparing their defining characteristics is therefore inappropriate because any meaningful insights would be hindered by too many caveats regarding compositional differences. Comparisons, albeit limited, can be made regarding the predictive ability of the two typologies: each demonstrated some magnitude of statistically significant difference between angler types and variation in normative beliefs towards the environment. In the current study, the two clusters differed marginally as both were mainly positive in their normative support. In Fisher et al. (2025) these differences manifested in complex ways, largely because of the existence of multiple clusters: for example, trophy anglers were more positive than consumers regarding normative beliefs on conservation and feelings of guilt; regarding feelings of moral obligation to conserve fisheries consumers, the most positive sentiments were among trophy anglers, followed by consumers and lastly, social anglers. These differences are likely masked when these smaller clusters are aggregated into two larger clusters as per the results of the current paper and provides an example of why it is difficult to compare typologies in metric performances.

Some insight in this respect is offered, however, by simply understanding the overlay of angler types developed by Fisher et al. (2025) on the model developed in this study. This exercise revealed distinction between the two clusters (Fig. 2). In cluster 2, there was a larger representation of social anglers (42%, n = 93) and consumer anglers (29%, n = 65) compared to cluster 1 (29%, n = 67 and 21%, n = 47 respectively) and patterns in the wider sample observed in Fisher et al. (2025) (35%, n = 160 and 25%, n = 112 respectively). Cluster 2 had a smaller representation of trophy anglers (9%, n = 21) compared to cluster 1



Sample sizes: cluster 1, n=229; cluster 2, n=224; Fisher et al. (2025), n=453.

Fig. 2. Composition of angler clusters compared to Fisher et al. (2025). Sample sizes: cluster 1, n = 229; cluster 2, n = 224; Fisher et al. (2025), n = 453.

(27%, n = 61) and Fisher et al. (2025) (18%, n = 82). Cluster 2 replicated the sample size order of Fisher et al. (2025) with social anglers being the largest group, followed by consumers, leisure identity and finally trophy anglers. Composition of cluster 1 differed. While social anglers remained the largest group (42%, n = 67), the second largest was trophy anglers (27%, n = 61), which was higher than representation in cluster 2 and Fisher et al. (2025). Consumers were the smallest group in cluster 1 (21%, n = 47) which is contrary to both cluster 2 and Fisher et al. (2025) where consumers were the second largest group. Cluster 1 showed a greater level of evenness across the types in Fisher et al. (2025) with representation falling between 21% (consumers) and 29% (social anglers).

The analysis of cluster compositions presented above is mildly complex and becomes slightly more complex when only accounting for the balance of types in Fisher et a. (2025) where statistical difference occurred (between consumers, trophy and social anglers). Reflecting sample distribution, social anglers were the largest proportion in each of the new clusters, therefore the best and most simple way to understand the overlay of typologies is through the balance of consumers and trophy anglers: Cluster 1 has more trophy anglers and less consumers and Cluster 2 has more consumers and less trophy anglers. One may loosely hypothesise that the new cluster structure may reflect the performances in normative measures observed in Fisher et al. (2025). For example, Cluster 1 will have stronger support for normative measures regarding other anglers conserving resources and feelings of guilt for not doing so. This prediction is supported as there is a higher representation of trophy anglers and Cluster 1 demonstrated slightly more positive support (mean responses) compared to Cluster 2 for each respective statement (Table 3: 4.46 against 4.07; 1.76 against 2.05 (reversed); 4.31 against 3.94). Thus, while the characteristics used to define each angler type in the respective typologies are fundamentally different, there is a synergy in performance among support for normative statements. This is not unexpected as the typologies essentially employ the same underpinning data.

3.5. *Assessing angler responses and positionality in the typologies*

A specific utility of angler typologies is to inform quick-turnaround fishery management initiatives. Fisher et al. (2025) recommended that researchers or fishery managers attempting to replicate their typology in such circumstances may benefit from using single question-statements reflecting each of the ten components to allocate anglers into the appropriate category within the model. The assumption, however, is that there is a direct relationship between raw angler survey responses and typology category and that the statical analysis does not skew reality. The is particularly relevant when the data and analysis is more complex, involving multiple statements and conversion of aggregated data types from ordinal to metric. This assumption was tested in the current study by analysing randomly selected (raw) angler responses for each component (highest loading statement) across segments in both typologies (Table 4).

Regarding the typology developed in this study, the main difference between clusters 1 and 2 is observed in the selection of ‘strongly agree’ to two of the three input variables (awareness of environmental consequence and biocentrism). Although the other seven components (italicised) were not used in forming the two-cluster model, polar responses (agree versus disagree) are evident for keeping and consuming fish, centrality, and catch numbers. As anticipated, observations are more complex for the Fisher et al. (2025) typology. The consumer segment is evidently easy to identify with the only ‘agree’ response to the most relevant component for that type of angler (keep and consume). Differences in the other segments are also apparent for centrality and catch numbers. Trophy anglers were also identifiable through disagreement to the importance of keeping fish in comparison to the other three segments in that typology. However, this cluster shared similarities with other types across the suite of component statements. The leisure identity angler was more difficult to identify with most responses being shared with at least one other angler type, and specifically two others (consumers and trophy anglers) regarding the statement most relevant to their definition (identity). The social angler offered slightly more complexity: this case shared the same response (agree) with all other types in relation to its key metric (social bonding); however, the case showed distinctiveness in reference to the identity component (‘disagreed’ compared with ‘agree’ for all other angler types). It is important to note, however, that the analysis specifically tested the application of typology logic to a singular statement from each component; in practice, a range of statements were used for each component developed in Fisher et al. (2025) to determine case positions. This current analysis specially focused on the application of single statements as an efficiency process in replicating the typologies developed by Fisher et al. (2025); therefore, the slightly anomalous findings do not discredit the proven statistical robustness and outcomes of Fisher et al. (2025).

Table 4
Matric of anglers (randomised) responses to highest loading statements per components used across typologies.

Component and survey statement	Consumer	Trophy	Leisure identity	Social	Cluster one	Cluster two
Keep and consume: I want to keep the fish I catch	Agree	Disagree	Neither agree or disagree	Neither agree or disagree	*Disagree*	Agree
Awareness of environmental consequence: Humans are severely abusing the environment	Strongly agree	Agree	Strongly agree	Agree	Strongly agree	Agree
Central to life: Recreational sea angling occupies a central role in my life	Disagree	Agree	Agree	Agree	*Agree*	*Disagree*
Social bonding: Participating in recreational sea angling provides me with an opportunity to be with my friends	Agree	Agree	Agree	Agree	*Neither agree or disagree*	*Neither agree or disagree*
A catch orientation: A fishing session can be successful even if no fish are caught"	Strongly agree	Agree	Agree	Strongly agree	*Strongly agree*	*Disagree*
Catch characteristics: I would rather catch 1 or 2 big fish than 10 smaller fish	Neither agree or disagree	Agree	Neither agree or disagree	Strongly agree	*Strongly agree*	*Neither agree or disagree*
Identity: You can tell a lot about a person by seeing them take part in recreational sea angling	Agree	Agree	Agree	Strongly disagree	*Disagree*	*Disagree*
Environmental responsibility: We anglers do not do enough to protect aquatic ecosystems	Agree	Agree	Agree	Strongly agree	Agree	Agree
Catch numbers: The more fish I catch, the happier I am	Strongly disagree	Neither agree or disagree	Neither agree or disagree	Strongly agree	*Disagree*	*Agree*
Biocentrism: Fish have as much right to exist as humans	Strongly agree	Agree	Agree	Strongly agree	Strongly agree	Neither agree or disagree

Anonymised randomiser case reference numbers: Consumer = 289; Trophy = 241; social = 240; leisure identity = 5; cluster 1 = 180; cluster 2 = 442.

4. Discussion

The discussion of results is guided by the research questions outlined in Section 1. Please note that certain features of the sample used in the current study must be considered when interpretating results. These are highlighted where relevant in Sections 4 and 5, but permeate all findings, hence a summary is provided here to make readers aware. Firstly, the sample is skewed by older, white and male anglers, which is likely a result of the non-probabilistic sampling method used. Sample bias is an inherent problem in angling research. While it is not possible to accurately predict the impact this has had on the findings, it is plausible to suggest that the results may have been different in samples consisting of alternative demographics. For example, research has demonstrated that women are more likely to retain fish for consumption, and men more likely to release fish (Schroeder et al., 2006). Therefore, increasing the representation of women in subsequent sampling could affect the outcomes, perhaps increasing the likelihood of retaining the 'keep and consume' component in the final model. Secondly, the data represents a snapshot in time and does not account for the temporal shift in angler psyche and behaviour. These are important caveats in the research findings and future studies should endeavour to compile samples that are representative of demographic characteristics such as age, gender and ethnic background, in addition to longitudinal study design.

What method was required for analysing the slimline data and did it allow the replication of the original typology?

The data reduction method employed in this study, involving raw (ordinal) responses to single statements representing ten multi-faceted components, required a two-step clustering technique in order to segment the sample. While the conceptual framing of the research and analytical approach was the same as that used by Fisher et al. (2025), focusing on the same dimensions of angling experience, attitudes and preference, the resulting typologies of recreational sea anglers were fundamentally, and starkly, different. The original typology comprising consumers, trophy anglers, leisure-identity anglers and social angers, could not be replicated, and was replaced with a binary model comprising 'mid' and 'high' level environmentalists. While the two typologies are independent from one another, there are observational patterns suggesting that 'trophy' anglers are represented more in the 'mid' level environmentalist cluster developed in this study, at the expense of lower numbers of consumers; more consumers are apparent in the 'high' level environmental cluster. Further research may wish to focus on the correlation between these distributions at individual variable level.

What does the structure of the new typology look like and how does it compare in its ability to provide rich descriptions of sample diversity and differences in angler behaviours?

In the typology of Fisher et al. (2025) all ten components, representing the outcome of a data reduction process, were employed to shape accurate descriptions of the four angler types emerging from the cluster analysis. In this study, the strength of the cluster model could only be improved to an acceptable level by removing seven of the ten components, leaving only three variables on which the clustering and resulting model was based. The poor performance of the initial ten item model was a likely result of too much complexity across the data, which was therefore penalised by the selection criterion as per the Bayesian information algorithm. Thus, variables removed prior to the adequate ('fair') model score hindered the ability of the analysis technique to produce cluster solutions with enough in-group homogeneity and between-group heterogeneity. The reduction of components has served not only to produce angler clusters that are defined on fewer components of angler psyche, but clusters where the differentiation (while acceptable to the Bayesian information algorithm) is, in reality, minimal. The analysis has produced a cluster that demonstrated a good degree of pro-environmental support, and a further cluster with slightly more (positive) support in this respect. This result was significant: using different data types and applying the appropriate methods to test data reduction reduction has not only resulted in a different typology (using the same data) but a typology that is fundamental different in how it structures diversity. The new typology required to describe sample diversity in this study is not only binary, but also hierarchical. Lateral distinction between angler types based on fundamental differences in data reflecting various parts of the angling experience and angler psyche (as given in Fisher et al., 2025) is replaced with a typology based on one group performing 'better' than the other in, essentially, one singular domain. An important, and slightly more positive, observation is that these angler clusters are unique; they do not feature strongly in other key studies of recreational sea angler heterogeneity (Beardmore et al., 2011; Johnston et al., 2013; Magee et al., 2018).

It is important to note here that explaining why the data required a significant reduction in the suite of input variables requires further study investigating the analytical algorithm, the relationship between individual pairs of variables, and potential qualitative work with anglers to explore how constructs coalesce with one another. At this stage, it is possible to highlight that the original model of 10 variables was heavily

penalised for offering too much complexity across the different dimensions and across responses in the sample. The probable reason why the results focused on the three related variables is because, in reality, and as a result of the analytical method employed, they each offered similarity in variation. They are conceptually related. What might seem obvious is that the result of the study is therefore an effect of the data and analytical method used, which supports the underlying premise of the paper: researchers must tread carefully when developing angler typologies because they are inherently linked to the methodology of their creation.

It must also be highlighted that the suppression of variables could also be an artefact of a biased sample based on non-probabilistic recruitment. It is difficult, however, to determine the exact effect of this feature as the evidence, in certain respects, does not fit the observations. For example, evidence suggests that environmental attitudes are affected by demographic characteristics: women exhibit more support for the New Environmental Paradigm perspective than men (Gyurián Nagy, 2025). However, this is counter-intuitive to the results presented in this paper (i.e. a convergence on pro-environmentalism within a male sample). In fact, the suppression of variables into pro-environmentalism would be an implied result of a female orientated sample. The effect of sample demographic on outcomes is therefore difficult to determine within the scope of the current study. What is apparent, however, is that without testing on further samples that are more representative of the general population, it cannot be known whether the binary typology presented in this study is a true reflection of the angling community or an artefact of a skewed sample. Future work must consider this important caveat, although it is understood that probabilistic and representative sampling in angling research is a gold standard that few studies achieve.

The loss of richness (or diversity in metrics) in describing heterogeneity in the current sample of anglers using the clustering input data is amplified regarding the predictive validity variables. Again, different methods were required compared to Fisher et al. (2025): their study utilized one-way analysis of variance methods because the recommended cluster scenarios were greater (than 2) in number and based on metric principal component scores; subsequent analysis of predictive validity variables was caveated with the standard violations in employing *t*-tests when dealing with non-parametric data; two-tailed Mann-Whitney tests were applied to the data in this paper as the focal variables consisted of ordinal (non-parametric) data and the preceding analysis formulated only two clusters within the sample. Differences aside, it was evident that while the two-cluster typology held strong in explaining differences in personal stewardship norms, differences in the uptake of stewardship behaviours was not explained by sample segmentation based on two-step clustering. In this respect, the typology developed in this study is weaker compared to Fisher et al. (2025). The loss of richness in describing angler characteristics across several dimensions of the angling experience should not be underestimated. While it is acknowledged that further work is required to statically test whether the three input variables truly represent a second order construct (see below), the new typology is, essentially, environmentally focused. This affects its utilisation in either research management or policy that require models of angler diversity that reach beyond the remit of pro-environmental attitudes (discussed further in Section 5).

How do the typologies compare in the level of connection between raw data and multi-variate analytical outcomes (typology positioning)?

The ability of angler typologies to accurately reflect attitudes, preferences and viewpoints based on combined and statistically manipulated metrics is vitally important whether their replication is used for future scholarly research or to support fishery management. There is a likelihood that a robust, lengthy, methodology and analytical technique is unachievable; fishery managers may require speedier ways to understand anger characteristics for specific time-limited purposes using unmanipulated (raw) data and corresponding questions. In the UK, for example, the implementation of Fishery Management Plans based on stakeholder co-development witnessed the need for rapid assessment of community characteristics. The connectivity between data and typology positioning is, therefore, important. It was evident in the analysis of raw responses regarding the Fisher et al. (2025) typology that for some segments (trophy, leisure-identity and social anglers), it is difficult to use the raw data responses to position (or predict positioning of) anglers accordingly; the typology can only be replicated by incorporating the additional statements for each component and running the multivariate component and cluster analysis. A much brighter prospect is offered by the binary typology developed in this study. While the richness in understanding the characteristics of communities may be significantly limited by using only three metrics that are somewhat related (environmentalism), it is evident that membership to each of the two clusters is identifiable through the simple presence of 'strongly agree' responses. This means that, in theory, just three questions and corresponding statements could be used to indicate where anglers are likely to be positioned in the model.

There are two caveats to this finding, which may guide future work in this area. Firstly, it was not possible within the scope of this paper to test the effect of larger proportions of anglers who may hold less-positive views towards the environment. This is a limitation of the work. There is a realistic assumption that, in other angler samples, there may exist a category of anglers who hold far less positive (perhaps negative) views towards the environment. Whether this scenario would have affected the structural outcomes of the typology developed in this study is unknown and dependant on further work with wider samples. Based on the conceptual relatedness of input variables used in the new typology, however, it can be recommended that future work aiming to develop a typology based on environmentalism among anglers may wish to focus on testing associated measures as a second order construct representing a singular dimension. Furthermore, because the work presented in this paper indicates some degree of hierarchical division within the sample, it is suggested that indexing techniques are explored to determine appropriate sample segmentation (bounds) in the single domain score (such as quantile regression). Secondly, and more practically, the narrow focus of the current typology naturally limits its utility. The reference above to its strength in allocating anglers to the binary segments based on raw responses is only valid where users are focused purely on environmental attitudes and norms. Utility is discussed further in Section 5.

5. Conclusion

The concluding Section focuses on the overarching research aims of the study and contribution to the existing knowledge base on angler typologies: primarily, what can be observed regarding the theoretical nature of typologies, the role of data type and analytical method in their development, and the practical utility different typologies offer researchers and policy makers.

On the utility of angler typologies as predictive tools

The research literature presents theories that typologies predict angler behaviour and preference: specialisation has been used to predict harvest and catch and release behaviour (Ditton et al., 1992; Arlinghaus et al., 2007); Johnston et al. (2013) used a three-segment typology (generalist, consumption-focused and trophy anglers) in predicting participation and effort; differences in levels of 'involvement' has been used to predict environmental concern among anglers (Seimer and Knuth, 2001). These theoretical approaches have not been without criticism; specialisation and motivation, in particular, have been evaluated and in some circumstances criticised for under-performing compared to other factors such as trip characteristics (Beardmore et al., 2011; 2013; Arlinghaus et. al., 2020). The binary typology of UK recreational sea anglers developed in this study, involving mid-and high-level environmentalist anglers, is different to that developed previously from, fundamentally, the same data, same anglers and same geographies (albeit with application of a different analytical technique).

The new typology is less rich in the description of sample characterises and has less predictive power, specifically, underperforming in explaining differences in stewardship (catch release) behaviours. Therefore, specifically in terms of the theoretical utility as a predictive tool, the typology presented in this study is weaker than that developed by Fisher et al. (2025).

This finding is important when considering whether typologies (or certain attitudinal constructs on which they are based) do actually predict behavioural variation among anglers. Models utilising behaviour theory may well place attitudes and norms as key antecedents in the linear array of factors that drive angler actions, but in fact the relationship is far from straightforward: in many cases, proven, statistically significant, relationships between attitudes, norms and behaviours are often indirect and reliant on certain variables acting as mediators or moderators on the relative connecting pathways shaping dependant (behavioural) variables (see Bruskotter and Fulton, 2007; Landon et al., 2018). The presence of such relationships slightly counters the acknowledged gap between attitudes and behaviours recognised in the psychology literature on environmentalism (see Zaikauskaitė et al., 2023). Thus, while it can be argued that the current typology is weaker compared to the original in predicting variation in stewardship actions, according to the wider literature, perhaps one may not expect such a simple and visible link between the typology and behavioural outcomes. This highlights that further research is needed beyond the scope of the current paper involving appropriate modelling to fully understand the relationship between each angler type presented in both studies, norms and behaviours. A degree of realism must still be acknowledged based on the current study regarding the practical utility of the binary model (as discussed in the concluding narrative of this section, below).

On the role of data type and analytical method in understanding the general nature of typologies

Study findings offer wider observations relating to the fundamental nature and conceptualisation of typologies in both angling and other areas. Wider literature demonstrates that angler typologies differ in their pre-conceived conceptualisation and intended implementation (see Hunt et al., 2021; Fisher et al., 2025). This study has proven how the same data, from the same people, can be construed into two different models of angler heterogeneity by changing the type of data used and the analytical technique. This impacted on the effectiveness in describing diversity in behaviours. One could ask why typologies are used if they are so sensitive to change, manipulation and application. As noted earlier, these arguments have been made in relation to other nature-based industries such as farming and forestry (Bartkowski et al., 2022; Ekstrom et al., 2024). Rather than using these arguments to discredit their use, however, future work should focus on systematically mapping such models (assessing conceptual lenses, contexts, aims, data collection methods, and analytical technique) in order to form a typology of angler typologies with recommended methodologies to make their application consistently uniform across different studies. It can be loosely hypothesised based on the knowledge generated in the literature to date, that different typologies may be appropriate for different study aims, for example: specialisation for studies involving single, hard to catch species, and perhaps the typology of Fisher et al. (2025) in exploratory, mixed, multi-species fisheries. For studies focusing specifically on stewardship norms, the current typology may be worth exploring. Such mapping could be used as a toolbox for both scholars, policy makers and fishery managers in choosing which typology is best used for their intended purposes. Beyond this, future work can then begin to focus on methods to streamline their application in research or policy settings, and at a practical level begin to adapt data collection tools (including question phrasing) relevant to their cultural context and study aims. The core message is that typologies are only as strong as the relationship between their conceptualisation, design, data, analytical technique and appropriate use.

On the practical utility of different typologies in policy and fishery management

The methodology employed for the two-cluster typology does not offer a streamlined approach for replicating the same angler types developed in Fisher et al. (2025). The result is a different typology that is simpler in its design and that shows a simpler relationship between raw data and angler type/positioning. This may prove attractive to fishery managers. However, the new typology is narrow in focus, does not predict variation in behaviour well, has a 'fair' silhouette coefficient (modest separation between clusters), and is based on a skewed sample. The practical fishery management utility is therefore limited. If the loose hypothesis above is accepted and different typologies are suited for different aims and applications, there is potentially a place in fishery management for the binary, attitudinal-norm, typology. For example, campaigns that specifically require a strict and confined understanding of attitudes to the environment among anglers. In this scenario, the typology is beneficial to users, as it can be applied (replicated) using a very simple method based on just three variables. However, it cannot be recommended at this stage that fishery managers would benefit from using the typology to inform interventions or campaigns aiming to change environmental (stewardship) behaviours. In fact, it would be dangerous to do so. The typology does not offer enough predictive ability. The attitudes and norms were not reliable proxies for related behaviours. The original typology developed by Fisher et al. (2025) may prove more reliable in the context of campaigns aimed at stewardship behaviour among anglers. This supports the recommendation that policy makers must carefully consider how angler typologies can inform fishery management interventions, giving appropriate attention to the context in which they are intended to be used, the data used in their creation and their statistical strength in relation to the analytical methods upon which they are based. The recommendation is relevant to the management of all nature-based sectors involving a need to systematically characterise diverse stakeholders.

CRediT authorship contribution statement

Kieran Hyder: Writing – review & editing, Visualization, Validation. **Julie Urquhart:** Writing – review & editing. **Adam Fisher:** Writing – review & editing, Writing – original draft, Project administration, Methodology, Investigation, Funding acquisition, Formal analysis, Data curation, Conceptualization.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Data availability

Data will be made available on request.

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