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Substitution behavior in German recreational anglers in response to the closure of the harvest fishery for western Baltic cod (*Gadus morhua*)

Master degree thesis in the study program: Integrated Natural Resource Management (INRM)

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Summary

Understanding how anglers respond to management restrictions is essential for anticipating spillover effects on other species, fishing sites, and recreational activities. This thesis examined substitution preferences and behaviours among German recreational cod anglers following the 2024 harvest ban on Atlantic cod (*Gadus morhua*), investigating shifts toward alternative recreational activities, fish species, and fishing sites, and exploring how angler characteristics influenced these responses. The relation between perceived perfect substitutes and post-ban stated behaviours was also analysed. Data came from two survey waves: a first survey conducted in 2020–2021 and a follow-up survey in 2024 after the ban was implemented. Descriptive analyses were used to characterise the population and substitution patterns, and regression models were used to identify predictors of substitution.

The most commonly identified perfect substitutes were fishing for other marine species in the German Baltic Sea, freshwater fishing within Germany, and outdoor active recreational activities. Stated behaviours only partially reflected these preferences. The strongest stated substitution behaviour occurred within the German Baltic Sea, with sea trout (*Salmo trutta)* being the most selected substitute target species. Potential increases in freshwater fishing, marine fishing abroad, and non-fishing activities were also reported, while relatively few anglers reported increased their fishing activity in the German North Sea or travelled abroad for cod fishing.

Angler characteristics shaped substitution responses in distinct ways. Psychological commitment and age were the most consistent predictors of the selection of perfect non-fishing activity substitutes, while place dependence on the Baltic Sea and attachment to cod were consistent predictors of perfect resource substitution. Regarding stated substitution behaviours following the ban, psychological commitment, place identity, and distance to the preferred fishing site were negatively related to stopping fishing or engaging in other activities as a response. In contrast, place dependence, cod attachment, and cod retention orientation predicted a decrease in fishing activity as a reaction. Place identity predicted resource substitution behaviours within the German Baltic Sea, while cod attachment and distance to the preferred fishing site predicted behaviours related to marine fishing in other locations.

These findings contribute to substitution theory by exploring how anglers adapt to a complete harvest closure and what drives variation in their responses. Moreover, this thesis suggests that the selection of perfect substitutes predicts corresponding behaviours, although the strength of the relationship depends on the type of substitution. Importantly for management, the results indicate that the cod retention ban is likely to increase targeting pressure on alternative species particularly within the German Baltic Sea and may reduce overall recreational fishing participation in the region, with potential economic consequences for coastal communities.

1. Motivation and background

1.1 Substitution in recreational fisheries

The conceptualization of recreational fisheries as coupled social-ecological systems highlights the need to understand the factors that influence recreational anglers' behavior in response to fishery management policy changes (Arlinghaus et al. 2017). This understanding is central for identifying potential conflicts between management and users, predicting spillover effects from policy changes to other species and fishing sites, and assessing the impact of policies on anglers' well-being and ecosystems (Aas et al., 2000; Arlinghaus, 2005; Arlinghaus et al., 2017; Carpenter & Brock, 2004; Gentner & Sutton, 2008; Arlidge, et al; 2026). The particular interest in the present thesis was to examine the heterogeneity by which anglers respond to drastic policy choices, especially the closure of the possibility to harvest cod in the Western Baltic Sea.

Anglers vary immensely in different characteristics (e.g. Bryan 1977; Arlinghaus et al. 2008; Hunt et al. 2023) and so do their responses to constraints or changes in harvest policies (Aas et al., 2000; Johnston et al. 2010; Rempel et al., 2025). Anglers can respond to constrained harvest opportunities by altering which activities are chosen during recreation (extensive margin) (Ditton & Sutton, 2004; Jun, 2017), altering how often they fish for the original target species (intensive margin) (Johnston et al. 2011; Koemle et al., 2022; Hyman et al., 2024; Hunt et al., 2007; Suter et al., 2019), by changing target species (Gentner, 2004; Smith et al., 2021), localities (Beard et al., 2003; De Freitas et al., 2013; Hunt et al., 2019), or fishing times (Hunt et al., 2007). Therefore, via anglers' adaptive behaviors, management actions can have unintended economic (Steinback, 1999) and ecological repercussions (Chagaris et al., 2019; Gao & Hailu, 2018).

Given the need to predict the unintended consequences of management action in recreational fisheries, the concept of recreation substitution, common in leisure and outdoor recreation science, becomes important as it has been used to explain how anglers shift their preferred fishing activities in response to changes affecting their targeted fishery (Manning, 1986; Ditton & Sutton, 2004; Oh et al., 2013; Sutton & Ditton, 2005; Sutton & Oh, 2015). An early insight in the field emphasized that what constitutes an actual substitution can only be accurately defined by users through the value they place on the multiple attributes of an activity, and not be uncritically assumed by researchers or managers (Manfredo & Anderson, 1987; Vaske et al., 1983).

Taking into account that different users value the attributes of an activity in varying ways, heterogeneity in substitution behavior is to be expected (Choi et al., 1994; Tienhaara et al., 2021). For example, a highly involved and species-specialized angler might have a harder time substituting a different recreational activity for fishing as conditions change compared to a less involved and less specialized angler (Sutton & Oh, 2015). Similarly, a highly retention-oriented angler might be more affected by policies that constrain harvest of a given species than a less retention-oriented angler and show greater shifts in effort from the affected to unaffected fisheries (Carlin et al., 2012; Johnston et al., 2011).

Substitution in recreational fishing has been studied under a social psychological and an economic perspective (Gentner & Sutton, 2008). The social–psychological approach can be

traced back to the framework developed by Hendee and Burdge (1974). In their seminal paper, the authors define substitutability as “the interchangeability of recreation activities in satisfying participants' motives, needs, wishes and desires”; and emphasize the importance of user characteristics in determining what constitutes actual substitution. Shelby and Vaske (1991) expanded on the concept of substitution by applying it to recreational fisheries, defining it as “replacing one recreation activity or resource with another which provides the same benefits that were provided by the original”. They distinguished between activity substitution and resource substitution (Figure 1).

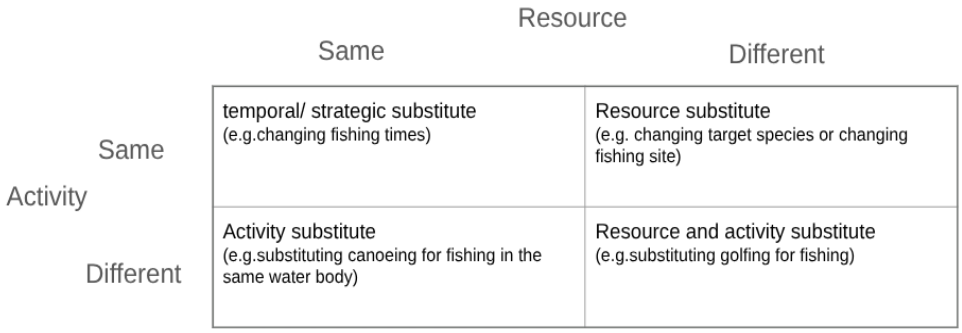

Figure 1. *Typology of substitution alternatives for recreational fishing. Figure based on the Typology presented by Shelby and Vaske (1991) and Genter and Sutton (2008).*

Activity substitution refers to engaging in equally satisfying non-fishing activities, either at the same or a different location (e.g., playing football or going bird watching). Resource substitution, refers to engaging in an equally satisfying fishing activity that involves a change in fishing site or target species. Finally, a substitution that involves only a change in the fishing time or in the style of fishing would be a temporal or strategic substitute (Gentner & Sutton, 2008; Shelby & Vaske, 1991). Most importantly is the conceptualization of substitutes as being other activities or resources that are equally satisfying. In this conceptualization, substituting fishing for cod with fishing for a different species would only be a substitute if fishing for the alternative species provides the same level of enjoyment to the angler. Several empirical papers have used this social-psychological conceptualization of substitution (Choi et al., 1994; Oh et al., 2013; Shelby & Vaske, 1991; Ditton & Sutton, 2004; Sutton & Ditton, 2005; Sutton & Oh, 2015; Ahtiainen et al., 2022).

The economic perspective on substitution adopts a broader definition of the concept, viewing it as an expression of demand for goods and services under the assumption of utility maximization (Gentner & Sutton, 2008). The recreational fishing experience provides utility to anglers from the contributions of utility components (and associated costs) from different aspects of the experience (e.g., catch, scenic beauty, harvest, travel distance, infrastructure). The assumption is that people would choose those activities that provide maximum utility of the entire experience, and that different options might be composed of different levels of the attributes that define the experience (Hunt et al., 2019). Therefore, attributes and their levels can be trade-offs against each other, and different configurations can create higher or lower overall utility than the base alternative. From this understanding, substitution occurs when a person shifts their use (demand) from one resource to another, or from one activity to the next, because the alternative offers greater utility than the previously used resource/activity, and not necessarily because it provides the same level of satisfaction (Hunt et al., 2019). Under the social-psychological perspective, a change to an activity that

does not provide the same level of satisfaction is considered a complement but not a (perfect) substitute (Shelby & Vaske, 1991). However, from an economist's perspective, substitutes might not be perfect, but simply constitute better alternatives than the current option in terms of overall utility.

The entire field of choice experiments takes advantage of the economic perspective on substitution, where the behavior of people is studied in response to a range of utility-determining attributes of the fishing experience (Hunt et al., 2007; Hunt et al., 2019). The concept of "marginal rate of substitution (MRS)" is particularly relevant, as it captures the importance placed on different attributes of the fishing experience and the utility (or cost) of enjoying them relative to one another. The MRS measures how getting more of one attribute compensates for the loss or restriction of enjoying another one, without losing utility (Gentner & Sutton, 2008). Based on these utility and demand principles, quantitative demand models can predict behavioral choices of recreational anglers, both at the extensive as well as the intensive margin (Massey et al., 2006; Hunt et al., 2007; Fenichel et al., 2013; Gao & Hailu, 2018), and substitution behaviors in response to policy choices (Johnston et al., 2010, 2013).

In summary, economists are not interested in capturing perfect substitutes; their main focus is on the induced behavioral and welfare change expected from a given policy through demand choices made by consumers. In contrast, social psychologists are more interested in identifying what a perfect substitute activity or fishing resource is, and which people's characteristics help to explain the existence of such (perfect) substitutes. I will follow the latter tradition in this thesis, but I will also explore the actual stated decisions taken by recreational cod anglers, which can involve suboptimal substitutes that are simply better than the alternative.

Activity substitution

Activity substitution, the decision of an angler to replace fishing with another activity as conditions of the fishing activity change, has been found to be negatively related to specialization, a psychological construct that reflects the importance an angler places on fishing and the involvement that angler has shown in fishing (Ditton et al., 1992; Ditton & Sutton, 2004). The definition of specialization can be traced back to the classic paper by Bryan (1977), in which he defines and investigates the concept among trout fishermen in the United States. Bryan described specialization as the degree of interest that individuals place in a leisure activity and proposes that this characteristic occurs along a continuum from the general to the particular and can be measured through factors such as equipment use, avidity, skill level, and site preference (Bryan, 1977). Scott and Shafer (2001) revisited the concept and suggested measuring it through the subdimensions of behavioral commitment, skill/cognition, and psychological commitment. Psychological commitment is defined as the degree to which an activity becomes central to a participant's self-expression and self-concept (Buchanan, 1985; Sutton & Oh, 2015), while behavioral commitment is the degree of investment of time and resources in the activity (e.g., through gear and time investments). Skill and cognition refer to cognitive aspects, such as knowledge about fishing sites, ecological relationships, or the skill of fishing (Scott & Shafer, 2001).

Sutton and Oh (2015), in a study of recreational fishers in Queensland, Australia, developed a model showing that greater psychological commitment to fishing was inversely related to anglers' willingness to substitute fishing with another activity. A similar conclusion was reached by Jun (2017) in a study of coping behaviors among non-resident anglers in Texas. These results are consistent with expectations, as more committed anglers place greater importance on fishing and are therefore less interested in pursuing alternative leisure activities (Manfredo & Anderson, 1987).

In addition to psychological commitment, the catch orientation that an angler carries appears to be an important predictor of the existence of perfect activity substitutes for fishing (Ditton & Sutton, 2004; Sutton & Oh, 2015). Catch orientation is a psychological construct defined as the importance an angler places on catching fish as part of the fishing experience (Anderson et al., 2007; Fedler & Ditton, 1986). Anderson et al. (2007) identified four distinct subdimensions of this attitudinal concept: attitudes toward catching something, attitudes toward catching numbers of fish, attitudes toward catching large or trophy fish, and attitudes toward retaining fish (retention orientation). Ditton and Sutton (2004) found that anglers who placed greater value on the challenge-seeking experience of catching fish, were less likely to report having activity substitutes for recreational fishing.

Sutton and Oh (2015), explored the relationship between anglers' psychological commitment to fishing, catch orientation and their recognition of activity substitutes. They found that higher commitment has a positive effect on catch orientation and that, in turn, a stronger catch orientation is negatively related to activity substitution. This suggests that, in some angler populations, fishing centrality is negatively related to activity substitution through the mediating effect of catch orientation subdimensions (importance placed on retaining fish, on catching something and on catching many fish) (Sutton & Oh, 2015).

Species substitution

Beyond activity substitution, specialization has been examined as a potential predictor used to understand anglers' willingness to substitute their preferred species with another as a coping mechanism in the event of fishing constraints. Sutton and Ditton (2005) found no statistical relationship between any of the specialization subdimensions (skill, behavioral commitment, and psychological commitment) and anglers' willingness to substitute their preferred species. Therefore, they insinuated that the willingness to substitute a preferred species is not a characteristic that is restricted to a particular subtype of anglers. In contrast, a study of recreational fishing guides using a self-classification measure of specialization (based on skill) found that less specialized guides were more willing to substitute targeting spotted seatrout (*Cynoscion nebulosus*) with another species when faced with a perceived population decline (Smith et al., 2021). These findings suggest that, at least in some contexts, angler skill level may influence the willingness to substitute one species for another.

The catch orientation that the anglers carry, could be a psychological construct helpful for predicting willingness to substitute species among recreational fishers. The importance of the catch orientation subdimension for species substitution depends on the experience anglers seek when targeting their preferred species. Taking a social psychological perspective, for a species to be considered an acceptable substitute, it must offer a similar

fishing experience and comparable outcomes to those provided by the original species (Gentner & Sutton, 2008; Sutton & Ditton, 2005). Sutton and Ditton (2005) found that species that were perceived by anglers to offer a comparable fishing experience (e.g., intensity of fight, ease of capture) to their usual target species were more likely to be recognized as appropriate substitutes. Similarly, in a previous study, shark anglers identified substitute species that provided a comparable challenge and similar environmental settings for catching the fish (Fisher & Ditton, 1993).

In the Ditton and Sutton study (2005), retention orientation (measured through the value placed on the edibility of the targeted fish) was suggested as a factor influencing the recognition of species substitutes. Relatedly, in the German context, recreational fishers with a high retention orientation, such as among eel and cod anglers (Bronnmann et al., 2023; Dorow et al., 2010), would presumably be influenced by the motivation of harvesting fish in their recognition of substitutes.

A study of salmon fishing in New Zealand rivers found that most anglers could not identify a suitable species substitute for trout, suggesting that in some cases, particularly with iconic species in specific settings, no perfect substitutes exist (Gentner & Sutton, 2008; Shelby & Vaske, 1991). Dorow et al. (2010) made a similar discovery among eel anglers in Germany, where the strong positive relation between specialization and retention orientation likely makes it very difficult for anglers to identify suitable species substitutes. Accordingly, the welfare loss experienced from constrained harvesting by highly specialized eel anglers was predicted to be particularly large (Dorow et al., 2010). Therefore, anglers' attachment to their preferred species may be an additional important predictor in determining whether a species substitute exists.

Site substitution

The substitutability of fishing sites has primarily been studied from an economic perspective using revealed and stated preference models, focusing on how changes in fishing quality, management actions, or other changes influence anglers' decisions to visit, or not visit, a specific site (Massey et al., 2006; Hunt et al., 2007; Hunt et al., 2019). Non-economic data has also been used to study site choice behavior. For example, the authors of a study on the distribution of walleye (*Sander vitreus*) angling effort across lakes with varying harvest regulations hypothesized that lakes with higher bag limits would be more attractive to anglers and therefore receive greater fishing effort than more restrictive lakes. The authors found no significant difference in angler effort between lakes and suggested that heterogeneity among anglers in their reactions to policy regulations could explain this result (Beard et al., 2003).

Specialization, catch orientation, and place attachment have been angler characteristics used to explain site substitution behavior. Place attachment has been a well-researched psychological construct within leisure sciences, conceptualized to measure how recreationists relate to particular places both functionally and emotionally (Kyle et al., 2003; Williams et al., 1992; Williams & Roggenbuck, 1989). The concept is commonly understood to consist of two subdimensions: place dependence, which refers to the extent to which a location supports the performance of a given leisure activity, and place identity, which reflects the emotional or symbolic meaning an individual assigns to a place (Williams &

Roggenbuck, 1989). Kyle et al. (2003) developed a set of survey items to measure these subdimensions among hikers in relation to specific trails. This approach has since been applied in other contexts, including the study of recreational fishers' perceptions of fishing regulations (Slaton et al., 2023).

Oh and colleagues (2013), using data from freshwater anglers in Texas, proposed a model in which specialization (measured with the subdimensions of behavioral commitment, psychological commitment, and skill) increases place dependence and identity and influences the substitutability of fishing sites. Importantly, the authors distinguished between catch-oriented (anglers motivated by the possibility of catching fish) and non-catch-oriented anglers. For non-catch-oriented anglers, higher specialization decreases the likelihood of site substitution due to stronger emotional place attachment. In contrast, for anglers that place greater importance on catching and keeping fish, the potential for site substitution appears to be more strongly driven by the likelihood of catching fish rather than specialization (Oh et al., 2013).

Harvest/retention orientation, the level of motivation of anglers to keep the fish they catch, seems to be a decisive factor also relevant for predicting anglers' site preference. Carlin et al. (2012) and Beard et al. (2003), in studies focusing on walleye anglers choosing between lakes with different harvest regulations, found that anglers with a stronger retention orientation preferred lakes with higher bag limits. This finding suggests that in some contexts the motivation of anglers to keep the fish they catch influences their decision to substitute a more regulated site with a less regulated one. A similar conclusion was reached by Robinson and Rash (2023), who found that harvest-oriented mountain trout anglers in North Carolina preferred streams with less restrictive regulations. In contrast, anglers who were not catch-oriented were motivated by more general activity-based motives, such as appreciation of "nature," and their preferred angling sites were not influenced by harvest permissiveness.

Site substitution also seems to be mediated by the place attachment that the angler carries (Jun, 2017; Oh et al., 2013). Hunt (2008) found that anglers with higher place dependence were more likely to concentrate their fishing effort within sites located close to one another, whereas no evidence was found that place identity influenced site choice.
In summary, substitution in recreational fisheries is a complex process shaped by anglers' level of specialization, catch and retention orientation, specific species attachment, place attachment, and likely other factors (e.g., demographic characteristics, gear choice, income, or site proximity) (Gentner & Sutton, 2008). The decision of anglers to engage in an activity, resource, or strategic substitution depends on how closely alternatives match the benefits of the original experience and whether those alternatives are reachable at reasonable costs (Sutton, 2007), which vary among individuals and places. Human dimensions research from a social-psychological perspective highlights the importance of understanding anglers' relations to the fishing sites and preferred species, specialization, catch, and retention orientation to predict substitution behavior and its implications for fisheries management.

1.2 The Western Baltic Cod recreational fishery in Germany

Recreational fishing in the Baltic Sea is a major leisure activity in Germany, with the western Baltic stock of Atlantic cod (*Gadus morhua*) as one of the primary target species (Hyder et al., 2018; Lewin et al., 2021; Weltersbach et al., 2021). This recreational fishery is

characterized by a strong retention orientation, particularly in the German context, where, similarly to the eel recreational fishery, cod anglers do not get any utility from releasing the fish they catch (Arlinghaus, 2007; Bronnmann et al., 2023; Dorow et al., 2010). The cod recreational fishery becomes particularly important to understand given that cod populations globally have been declining for decades due to a combination of ecosystem changes and overexploitation (Eero et al., 2023; Lindegren et al., 2009; Möllmann et al., 2021). In 2016, the western Baltic cod stock was declared collapsed (ICES, 2022).

Since 2017, the recreational fishery for western Baltic cod has been increasingly regulated through the introduction of daily bag limits, which restrict the number of fish an angler may harvest per day (Lewin et al., 2023). These limits were progressively tightened, from five cod per angler per day in 2017 to just one cod per day by 2022 (Haase et al., 2022), and a closure in 2024. In line with the retention-oriented nature of the fishery, such regulations have been shown to negatively impact anglers' welfare because most prefer some opportunity to harvest cod (Bronnmann et al., 2023; Haase et al., 2022). Additionally, these restrictions have led to a decline in both the number and travel distances of non-resident anglers participating in charter vessel trips (Lewin et al., 2021). In 2024, due to the critically low biomass of the stock, a total ban on harvest-oriented recreational cod fishing was implemented along the entire German Baltic coast, with the daily bag limit lowered to zero (Council of the European Union, 2023). This essentially means cod can only be fished under a catch-and-release policy or not at all due to welfare concerns for catch-and-release fishing in Germany (Arlinghaus, 2007). This drastic regulation is likely to have significant implications for the lifestyles and behaviors of recreational cod anglers along the German Baltic coast (Haase et al., 2022) and opens questions about the substitutes adopted by German anglers.

The socio-psychological framework of substitution in recreational activities provides a useful model for studying how different groups within the cod angling community may respond to the ban through activity and resource substitution. It can help assess how activity or resource substitution may contribute to spillover effects, such as increased fishing pressure on other species, shifts in the use of fishing sites, and broader changes in the practice of leisure activities in the region. Additionally, it provides a theoretical background to explain substitution behaviors using angler characteristics.

The broad aim of this thesis was to explore the substitution preferences of German recreational cod anglers and their substitution behaviours following the 2024 cod retention ban in the western Baltic Sea. Despite a growing body of research on substitution in recreational fisheries, no study has examined substitution responses to the cod harvest regulation in Germany, nor has the relationship between stated substitution preferences and actual post-ban behaviour been empirically tested. The findings could be important for the prediction of spillover effects arising from drastic fisheries management interventions, including potential increases in fishing pressure on alternative species and sites, as well as broader changes in recreational activity patterns along the German Baltic coast.

Beyond describing substitution patterns, the closure of the German cod recreational fishery provides a unique opportunity to examine how anglers' characteristics, including their specialization, attachment to cod, catch orientation, and place attachment to the German Baltic Sea, shape substitution preferences and behaviours. Understanding these relationships contributes to substitution theory in recreational research by testing the

predictive value of established psychological constructs in a strict regulatory context, and to assess whether angler characteristics measured prior to a harvest ban can serve as useful predictors of effort spillover, with practical implications for anticipating the ecological and social consequences of restrictive fisheries management policies.

2. Objectives and hypothesis

The specific objectives of this thesis were:

- To study the activity substitution potential resulting from the closure of the German recreational fishery for Atlantic cod (*Gadus morhua*) in the western Baltic Sea to alternative recreational activities other than recreational fishing.

- To study the species substitution potential from Atlantic cod in the western Baltic Sea to other marine or freshwater fishes as targets in response to the harvest closure of cod.

- To study the site substitution potential from the German Baltic Sea to other fishing areas inland and abroad.

- To examine the actual fishing patterns of German recreational cod anglers in terms of species and sites, and the shift to other activities that emerged from the closure of the fishery.

- To explore the relation between perfect substitution preferences and substitution behaviors among German recreational cod anglers.

For all the different substitution behaviour, the objective is to explain the heterogeneity in the behaviours as a function of angler specialization, catch orientation, place attachment and other human dimensions concepts.

I tested the following hypothesis:

H1. Angler specialization subdimensions (psychological commitment, behavioural commitment, and skill) are negative predictors of non-fishing activity substitution.

H2. Angler specialization subdimensions are predictors in the selection of non-fishing activity types as perfect substitutes for cod fishing.

H3. Anglers' psychological and behavioural variables related to cod fishing (cod attachment, cod avidity, cod fishing skill) are negative predictors of the existence of a perfect species substitute for Atlantic cod.

H4 Anglers with low attachment to the German Baltic Sea are more likely to perceive sites away from the German Baltic Sea as equally enjoyable as anglers with high place attachment.

H5. Catch orientation subdimensions towards cod (catching something, retention orientation, trophy orientation, quantity orientation) of anglers are predictors in the selection of perfect species substitutes for cod.

H6. Anglers who identify perfect substitutes for cod fishing are more likely to exhibit corresponding substitution behaviours following the 2024 cod harvest ban in the western Baltic Sea.

H7. Fish species perceived as perfect substitutes for cod are more likely to be targeted by anglers after the 2024 cod harvest ban in the western Baltic Sea.

In addition to the testing of the seven hypotheses, I did an explorative analysis to test the relation between anglers' psychological and behavioural characteristics and stated substitution behaviours following the 2024 cod harvest ban in the German Baltic Sea.

3. Methods

3.1 Data sources

The online survey data I used in this study was collected during two periods. The first survey was conducted between December 2020 and March 2021, in the context of a reduction in the daily bag limit for western Baltic cod from five cod per angler to two. Its purpose was to investigate anglers' preferences for harvest regulations and catch outcomes. A detailed description of the survey implementation is provided in Bronnmann et al. (2023). In brief, the questionnaire (Annex I) was distributed to 3,957 German cod anglers who had been recruited by a professional survey company (imug, Hannover, Germany). Most of the recruitment was achieved through social media advertising. Eligible participants were required to be at least 14 years old and to have fished for cod on the German Baltic coast at least once in the past or to have plans to do so within the following three years. Of the 3,957 invited anglers, 1,795 valid responses were obtained.

The second survey was conducted between October and December 2024 as a follow-up to the 2020/2021 survey, this time in the context of a zero-bag-limit harvest ban for cod. The 1,795 valid respondents from the first survey were recontacted by email and invited to answer a new set of questions (Annex II). This follow-up survey included items on perceptions of the harvest ban and, crucially for this investigation, questions regarding substitution preferences and substitution behaviors from cod fishing in the German Baltic Sea. A total of 641 individuals responded and confirmed that they were the same person who had participated in the 2020/2021 survey. After applying a data-quality check involving three hidden attention-check questions (items that required participants to select a specific pre-defined answer to confirm they were reading carefully) 76 responses were excluded due to missing answers and 42 due to incorrect responses to at least one attention-check item, yielding a final analytical sample of 523 observations. Excluded respondents (n = 118) and retained respondents (n = 523) did not differ systematically on age, fishing avidity, fishing experience, or a composite score of fishing centrality (all $p > 0.05$). Residential state within Germany was also comparable between groups, with no statistically significant differences detected. These results suggest that the last exclusions were largely random and unlikely to introduce systematic bias into the analysis.

All data preparation and statistical analyses were conducted using R (version 4.4.1; R Core Team, 2024). Data visualizations were created using the ggplot2 package (Wickham, 2016).

3.2 Operationalization of substitution variables

3.2.1 Perfect activity substitution

To investigate the existence of perfect activity substitution among German cod recreational anglers, I used responses to the 2024 open-ended survey question: *"Are there any other leisure activities, apart from fishing, that bring you just as much joy as cod fishing on the German Baltic Sea coast?"*. The activity substitution variable was treated as binary, with respondents answering "yes" coded as 1, and those answering "no" or "unsure" coded as 0. Respondents who answered affirmatively were additionally asked to list the activities they considered perfect substitutes. A subset of participants (N = 59) listed only other types of fishing activities as substitutes, which indicated a misunderstanding of the intended meaning of the question. These respondents were recorded as having no non-angling related substitute activity (i.e., coded as 0).

To further investigate the types of activities mentioned as perfect substitutes for cod fishing, I classified the activities listed by respondents according to established activity typologies. First, I distinguished between outdoor and indoor activities following Leitner and Leitner (2012). Second, I differentiated between active activities, those requiring physical effort or movement, and passive activities, which require minimal effort and are not necessarily tied to natural settings (Hendee et al., 1971). Finally, I classified activities as consumptive, where participation involves extracting or acquiring a natural physical resource, or non-consumptive, where participation does not involve the acquisition of resources (Vaske & Roemer, 2013). Based on these distinctions, I derived the following activity categories for classifying perfect substitutes:

1. Outdoor active activities (e.g., swimming, hiking, cycling, birdwatching).
2. Outdoor consumptive activities (e.g., hunting, mushroom picking, gardening).
3. Outdoor passive activities (e.g., relaxing at the beach, nature contemplation).
4. Indoor active activities (e.g., fitness training, indoor sports, crafting).
5. Indoor passive activities (e.g., reading, watching television, attending concerts, videogames).

Each of the five activity categories were treated as binary variables, with respondents assigned a value of 1 if they listed at least one activity belonging to that category and 0 otherwise.

3.2.2 Perfect resource substitution

To investigate the existence of perfect resource substitutes, I used responses to the 2024 survey question: *"What exactly gives you as much angling enjoyment as cod fishing on the German Baltic Sea coast?"* Respondents answered this multiple-choice question by selecting one or more of the following options:

(1) Fishing for cod in the North Sea.
(2) Fishing for cod abroad.
(3) Fishing for other species in the German Baltic Sea.
(4) Fishing for other species in the German North Sea.
(5) Fishing for freshwater species in Germany.

(6) Fishing for freshwater species abroad.
(7) Fishing for other marine species abroad.

Each of the resource substitution questions were treated as binary variables, with a corresponding value of 1 for selection and 0 otherwise.

To further investigate the types of species that are considered perfect substitutes for German Baltic cod, I use responses to the survey question: *Which fish species do you enjoy fishing for as much as cod fishing on the German Baltic Sea coast?* This question prompted users to select from a list five preferred species that they consider perfect substitutes for German Baltic cod. If a species was not listed, they were encouraged to write it themselves. I grouped the different responses to create eight binary variables that reflected species of similar ecological and fishing characteristics:

(1) Cod, away from the German Baltic Sea.
(2) Demersal marine species (e.g., pollock, pollack).
(3) Marine flatfish species (e.g., flounder, halibut, dab).
(4) Small pelagic marine species (e.g., herring, garfish, mackerel)
(5) Marine predator species (e.g., sea bass, tuna, swordfish)
(6) Salmonid species (e.g., sea trout, salmon, brown trout)
(7) Freshwater (non-salmonid) predator species (e.g., eel, perch, pike)
(8) Coarse freshwater fish species (e.g., ide, bream, carp)

I treated each category as a binary variable, with respondents assigned a value of 1 if they listed at least one species belonging to that category and 0 otherwise.

3.2.3 Stated substitution behavior

To examine the actual stated shift from recreational cod fishing in the German Baltic Sea to other resources and recreational activities, I used anglers 'agreement scores to the survey items responses to the question *"Because in this year (2024) I can/could no longer specifically fish for harvest cod in the Baltic Sea"*:

(1) I have stopped fishing on the German Baltic Sea coast.
(2) I have stopped fishing altogether (whether on the coast or elsewhere).
(3) I go or went fishing on the German Baltic Sea coast much less often than before.
(4) I continue to fish on the German Baltic Sea coast, but for other target species.
(5) I go or went fishing on the German Baltic Sea coast much more often than before.
(6) I fish or fished for the first time or more often than before in inland waters in Germany.
(7) I fish or fished for the first time or more often than before in inland waters abroad.
(8)I fish or fished for the first time or more often than before on the German North Sea coast.
(9) I fish or fished for the first time or more often in the lagoons or Bodden waters of the Baltic Sea.
(10) I fish or fished for the first time or more frequently than before on the coasts of other European countries (regardless of the type of fish).
(11) I fish or fished for other types of fish (whether on the coast or elsewhere).
(12) I pursue or pursued other leisure activities more often than fishing.

The agreement scores were derived from respondents' ratings to substitution statements on a five-point scale: 1 ("do not agree at all"), 2 ("rather do not agree"), 3 ("neither agree nor disagree"), 4 ("rather agree"), and 5 ("fully agree").

I operationalized the responses as 12 different variables.

To further investigate the types of fish species that respondents targeted or intended to target following the 2024 cod retention ban, I used responses to the following survey item: "*Please list, in descending order, up to five fish species that you have preferentially targeted since January 2024, i.e., since the introduction of the cod retention ban, regardless of whether in freshwater or saltwater. Please also include species that you may still target by the end of the year*." Respondents selected species from a predefined list or entered species manually if they were not listed. Reported species were subsequently grouped into the same eight species categories used to classify perfect species substitutes, as described in Section 3.2.2. Each species category was treated as a binary variable, with respondents assigned a value of 1 if they listed at least one species belonging to that category and 0 otherwise.

3.3 Operationalization of independent variables

To analyze the relationship between anglers' characteristics and their substitution preferences and behaviors related to cod fishing in the German Baltic Sea, I operationalized several types of independent variables from the survey data. The first category consisted of psychological constructs, including angler specialization and fishing experience, cod catch orientation, cod attachment, cod avidity, self-perceived cod fishing skill, and place attachment to the Baltic Sea. As a second category, I included perceived cod fishing constraints experienced by anglers since the introduction of cod bag limits in 2017. A third category of variables comprises demographic characteristics that may influence substitution behavior, namely age and household income. As an additional independent variable, I included the distance between the angler's residence and their preferred fishing site.

3.3.1 Operationalization of angler psychological constructs

To operationalize anglers' psychological constructs, I used methodologies described by several other recreational fishing studies (Anderson et al., 2007; Arlinghaus & Mehner, 2005; Ditton & Sutton, 2004; Jun, 2017; Oh & Ditton, 2006; Slaton et al., 2023; Sutton & Oh, 2015). Anglers' psychological constructs were measured using responses to five-point scale items in the survey. Responses to items intended to measure the same latent construct were combined and subjected to exploratory factor analysis (EFA) with varimax rotation (Kaiser, 1960) to identify the underlying subdimensions (factors) of each construct. The number of factors retained was determined first visually using parallel analysis (Hayton et al., 2004) and confirmed using the Kaiser criterion, which specifies retaining factors with eigenvalues of 1.0 or greater (Kaiser, 1960). To be included as an indicator of a subdimension, an item was required to have a primary factor loading of at least 0.4 on a given factor; items with factor cross-loadings were assigned to the factor on which they loaded most strongly.

Items forming a factor were then evaluated for internal consistency using Cronbach's α when three or more items were present, or the Spearman–Brown coefficient when the subdimension consisted of only two items (Nunnally, 1994). Constructs with a Cronbach's α (Cα) or Spearman–Brown coefficient (SB) of 0.7 or higher were retained for analysis (Nunnally, 1994). An exception was made for the construct of place dependence, which was

retained despite a Spearman–Brown coefficient of 0.65. This is justified on two grounds: first, two-item scales tend to have lower reliability values (Eisinga et al., 2013) and second, the construct is well supported by previous literature using comparable operationalizations (Kyle et al., 2003).

The constructs identified through this analysis were composed of items measured on the same scale; therefore, construct scores were calculated by averaging responses across all corresponding items, without the need for value transformation. Latent constructs that were not reliably represented by multiple items were instead analysed using single-item responses.

3.3.1.1 Angler specialization and fishing experience

Angler specialization was operationalized following Scott & Shafer's (2001) conceptualization of Bryan's (1977) original definition, as a measure of behaviors, skills, and commitment to fishing. Three subdimensions were used to measure angler specialization (Table 1): behavioral commitment (SB = 0.95), psychological commitment (Cα = 0.87), and skill.

Fishing experience and fishing avidity were measured with questions designed to reflect the length and the frequency of participation in angling (Table 1); similar scales have been used to measure behavioral commitment (Ditton et al., 1992; Oh & Ditton, 2006; Oh & Ditton, 2008; Slaton et al., 2023). Items reflecting the number of years since first fishing (fishing experience) and the total days fished per year (fishing avidity) have been reported as part of the behavioral commitment construct in other studies (Slaton et al., 2023). In our case, the items related to fishing experience (SB = 0.76) formed a separate construct from behavioral commitment and were therefore treated independently from the usual specialization subdimensions (Table 1).

Psychological commitment, was measured using a shortened set of items adapted from Sutton (2003), originally derived from a longer scale developed by Kim et al. (1997; Table 1). Finally, skill was measured using a single item that measured respondents' self-perceived fishing skills relative to other anglers (Table 1). Similar self-assessed skill measures have been used in prior recreational fisheries studies (e.g., Beardmore et al., 2013; Slaton et al., 2023; Arlidge et al., 2026).

Table 1. *Fishing experience and specialization subdimensions values (behavioral commitment, psychological commitment and skill), with corresponding survey item components, and reliability metrics.*

Subdimension	Mean	S.D	Factor loading	Cronbach's α	α if item deleted	Corrected item-total correlation	Spearman-Brown
Fishing experience [a]	**27.83**	**12.12**	-	-	-	-	**0.76**
Total number of years fishing	34.16	14.19	0.99	-	-	-	-
Total number of years fishing for cod	21.50	12.60	0.65				
Behavioral	**47.01**	**40.75**					**0.95**

commitment [b]						
Fishing days in Germany or abroad (2019)	51.18	42.92	0.92			
Fishing days only in Germany (2019)	42.85	39.86	0.98			
Psychological commitment [c]	**3.35**	**0.78**		**0.87**		
A large part of my life revolves around fishing	3.75	1.12	0.83		0.83	0.82
I prefer fishing to doing anything else	3.82	0.98	0.83		0.84	0.80
Other hobbies do not interest me as much as fishing	3.51	1.16	0.67		0.85	0.69
If I couldn't fish, I wouldn't know what else to do	2.44	1.14	0.61		0.86	0.62
I would consider myself an expert angler	3.46	1.00	0.55		0.86	0.58
Most of my friends are also involved in fishing	3.11	1.07	0.43		0.88	0.46
Skill (fishing in general) [c]	3.53	0.93				
My angling skills are better than the average anglers						

[a] *Items were measured in years.*

[b] *Items were measured in days of fishing per year.*

[c] *Items were measured in a five-point agreement scale to the statements, following: 1 (do not agree at all), 2 (rather do not agree), 3 (neither), 4 (rather agree), 5 (fully agree).*

3.3.1.2 Cod avidity, cod specific fishing skill and cod attachment

Given that the survey questions for general fishing skills and cod-specific fishing skills, and the survey questions for general fishing avidity and cod-specific avidity did not form reliable constructs, I analyzed them separately. I treated the cod-specific items of cod avidity and cod fishing skills as distinct factors from the general fishing specialization dimension (Table 2).

To assess attachment to cod, I used six survey items that, similar to the place attachment scale, Kyle et al. (2003), captured both the functional value and the emotional value that anglers associate with cod. These items loaded onto a single factor, which I refer to as cod attachment (Table 2).

Table 2. *Cod fishing avidity, cod-specific fishing skill and cod attachment subdimension values, corresponding survey item components, and reliability metrics.*

Subdimension	Mean	S.D	factor loading	Cronbach's α	α if item deleted	Corrected item-total correlation	Spearman-Brown
Cod avidity [a]	**9.51**	**13.78**					**0.91**
Cod fishing days in Germany or abroad (2019)	10.60	14.58	0.98				
Cod fishing days only in Germany (2019)	8.42	13.40	0.92				
Skill (specifically for fishing cod) [b] *My skills specifically in cod fishing are better than the average cod anglers*	3.26	1.00					
Cod attachment [b]	**3.36**	**0.77**		***0.77***			
I would consider myself a specialist in Baltic Sea cod	2.87	1.16	0.69		0.73	0.65	
*Baltic Sea cod is just one fish species among many for me****	3.18	1.26	0.45		0.78	0.45	
I have a very deep, personal connection to cod	3.20	1.19	0.74		0.71	0.72	
No other fish species is comparable to cod for me in terms of angling	2.81	1.23	0.58		0.74	0.59	
Cod fishing in the Baltic Sea is important to me because cod is a valued source of food for me	4.29	0.88	0.48		0.77	0.48	

Cod fishing is especially appealing to me	3.80	0.96	0.74		0.71	0.74

[a]*Items were measured in days of fishing per year.*

[b] *Items were measured in a five-point agreement scale to the statements, following: 1(do not agree at all), 2(rather do not agree), 3(neither), 4(rather agree), 5(fully agree).*

**The score of this survey item was reversed to be consistent with the positive towards cod rating of the other components.*

3.3.1.3 Angler Catch Orientation

The survey included items designed to capture subdimensions of catch orientation toward cod, based on selected items taken from the catch orientation scale developed by Anderson et al. (2007). Due to space limitations, the survey contained seven of the original sixteen items. Only the two items associated with the subdimension 'Trophy cod' formed a reliable construct *(SB = 0.70*). For the remaining subdimensions, 'Quantity of cod', 'Catch some cod', and 'Retention of cod', I relied on single survey items designed to measure each of these orientations, as the multi-item combinations did not achieve acceptable reliability (Table 3.). I did not include the subdimension 'Release cod' in the analysis because the survey item intended to measure it explicitly referred to releasing undersized fish and this wording likely did not capture the general tendency toward releasing cod regardless of size.

Table 3. *Catch orientation subdimensions survey items values. For the composite of 'Trophy cod' the reliability metrics and corresponding survey item components are listed.*

Subdimension	***Mean***	***S.D***	***Factor loading***	***Spearman-Brown***
Catch some cod* *(A Day of fishing can still be successful even if I didn't catch a cod)*	**2.01**	**1.17**	-	-
Quantity of cod *(The more cod I catch the more satisfied I am)*	**2.60**	**1.19**	-	-
Trophy cod	**3.18**	**1.02**	**-**	**0.70**
I prefer to fish where I at least have a chance to catch a trophy-sized cod	3.32	1.09	0.73	-
The bigger the cod I catch, the better the fishing day	3.05	1.23	0.70	-
Retention of cod (*I want to take home all of the legal-sized cod I catch*)	**2.56**	**1.32**	-	-

Items were measured in a five-point agreement scale to the statements, following: 1(do not agree at all), 2(rather do not agree), 3(neither), 4(rather agree), 5(fully agree).

***The score of the survey item designed to capture the Catch some cod subdimension was reversed for the analysis.*

3.3.1.4 Place attachment

To measure cod anglers' place attachment to the Baltic Sea coast, I used five survey items adapted from the eight-item scale developed by Kyle et al. (2003). One item "*The German Baltic Sea coast is incomparable to other waters*" did not load onto any factor during the analysis and was therefore excluded. As a result, I used four items to measure the two theoretical subdimensions (Table 4).

***Table 4**.Place attachment subdimensions subdimension values, corresponding survey item components, and reliability metrics.*

Subdimension	Mean	S.D	*Factor loading*	*Spearman-Brown*
Place dependence*	**3.07**	**1.10**		**0.65**
The German Baltic Sea coast is the best fishing water for cod	2.49	1.29	0.59	
I would be very reluctant to replace the German Baltic Sea coast with another water for cod fishing	3.64	1.25	0.80	
Place identity	***4.51***	***0.72***		***0.72***
Fishing on the German Baltic Sea coast means a lot to me	4.46	0.83	0.67	
I feel very connected to the German Baltic Sea coast	4.57	0.77	0.88	

Items were measured in a five-point agreement scale to the statements, following: 1(do not agree at all), 2(rather do not agree), 3(neither), 4(rather agree), 5(fully agree).

**The Spearman–Brown coefficient for the internal consistency of the place dependence subdimension was slightly below the established acceptance threshold of 0.7. However, because this construct is supported by theory (Kyle et al., 2003), it was retained for further analysis.*

3.3.1.5 Anglers cod fishing constraints

Leisure constraints have been defined as factors that inhibit participation in leisure activities, limit the amount of time spent on such activities, restrict the use of leisure services, or prevent individuals from achieving a desired level of satisfaction when undertaking a leisure

activity (Jackson, 1988). Crawford & Godbey (1987) categorized three types of leisure constraints: (1) intrapersonal constraints involving individual psychological states and attributes that restrict leisure preferences, such as perceived skill level or subjective evaluations of the appropriateness of engaging in a leisure activity; (2) interpersonal constraints that shape leisure preferences from interactions with others, for example, not having friends who participate in a leisure activity; and (3) structural constraints, which are external factors that intervene between leisure preferences and participation, such as limited economic resources.

To account for anglers' perceived constraints for fishing for cod prior to the 2024 harvest ban, I used their responses from the 2020 survey. In response to the implementation of a bag limit of five individuals for cod, respondents were first asked whether they had fished less after 2017 than before. The majority of respondents (N = 381) responded that they fished at the same frequency after the 2017 cod bag limit than before, whereas 131 respondents answered that they fished less frequently, and only ten answered that they fished more frequently. Those who reported fishing less frequently for cod were then asked to rate using a five-point scale a list of potential reasons that included interpersonal, intrapersonal and structural constraints:

1. It is no longer worthwhile to fish for cod (in terms of catch).
2. It is no longer worthwhile to keep cod (in terms of harvest).
3. The cod have become too small.
4. I cannot justify targeting a severely depleted stock.
5. My fishing friends no longer like going to the Baltic Sea to fish for cod.
6. I cannot compensate for my reduced annual catch by fishing more.
7. There are no longer enough charter fishing boats ("Angelkutter") available locally.
8. There are no longer enough rental boats available.
9. I don't know where I can still catch cod.
10. Angling pressure on the coast is too high.
11. Commercial fishing pressure on the coast is too high.
12. Due to the COVID-19 pandemic.

Respondents could also list an additional reason (13) as a constraint. The rating followed: *1 (Does not apply at all), 2 (rather does not apply), 3 (neither), 4 (rather applies), 5 (applies completely).* For analysis, I considered agreement scores of 4 or 5 on the five-point scale as indicating the presence of a constraint. Using this approach, I created a continuous variable representing the number of constraints identified by each respondent, ranging from 0 (anglers with no reduction in fishing frequency or no constraints identified) to 13 (all constraints with agreement scores ≥4; Table 5).

Table 5. *Descriptive values of the number of cod fishing constraints variable; mean, standard deviation (S.D.), minimum value (Min) and maximum value (Max)*

Variable name	Mean	S.D.	Min	Max
Number of cod fishing constraints	1.13	2.27	0	11

3.3.2 Operationalization of other independent variables

3.3.2.1 Anglers 'residence distance from the preferred fishing site

To account for the distance between anglers' residences and their preferred fishing sites (Table 6), I used survey data on respondents' postal codes and their selected preferred fishing area along the German coast (nine sections in the Baltic Sea and two in the North Sea). For the calculations I use the "geosphere" package in R (Hijmans, 2010). Geographic coordinates for the centroids of each postal code and each fishing zone were used to calculate straight-line distances in kilometers. To reduce missing data, for respondents who did not provide a postal code, I assigned the centroid of their federal state of residence. In total, distances were calculated using postal codes for 454 respondents, while the federal state was used for 9 respondents. For 60 respondents, distance could not be calculated because they did not select a preferred fishing site. In this case I calculated a central point between the Baltic Sea nine sections, and estimated a distance between this point and the respondents postal code or federal state centroid.

3.3.2.2 Anglers' household equivalence income

Anglers' household equivalence income (Table 6) was calculated using survey data on net monthly household income and household size. Respondents selected their net income from 13 categories, each spanning €500, with the lowest being "less than €500 per month" and the highest "more than €8000 per month". Using this income information and the reported number of household members, household income was estimated by dividing the midpoint of each income category by the square root of the number of household members.

Because 55 of the 523 valid survey responses contained missing information needed to calculate household equivalized income, I applied multiple imputation by chained equations (MICE) using the 'mice' package in R (van Buuren & Groothuis-Oudshoorn, 2011). The imputation model included household size, net household income, age, federal state of residence, education level, and political orientation as predictors. After imputing household size and net income, I computed household equivalized income using the square-root equivalence scale. To evaluate the quality of the imputation, I compared the distributions of observed and imputed values. Visual inspections and plausibility checks (e.g., absence of negative or extreme values) indicated no abnormal patterns in the imputed data. A Kolmogorov–Smirnov test confirmed that the distributions of observed and imputed equivalized income did not differ significantly ($p = 0.55$).

3.3.2.3 Anglers' age

I extracted angler's age (Table 6) directly from a 2024 survey question in order to capture anglers' age at the time they answered the substitution questions.

Table 6. *Descriptive values of anglers age, distance to preferred fishing site and household income variables; mean, standard deviation (S.D.), minimum value (Min) and maximum value (Max)*

Variable name	Mean	S.D.	Min	Max
Age	49.76	12.41	17	81
Distance to preferred fishing site	237.73 (km)	176.59	16.71(km)	840.69(km)
Household Income (month)	2552.79 (€)	1157.79	125 (€)	7750 (€)

3.4 Descriptive and statistical analysis

3.4.1 Data description

Because most of the survey recruitment occurred via social media, the sample is unlikely to represent a random selection of the German cod angler population (Lehdonvirta et al., 2021; Revilla & Höhne, 2020). To correct for potential selection biases, survey weights were applied to obtain population-representative descriptive estimates. The weighting scheme was constructed using representative target distributions provided by the Thünen Institute of Baltic Sea Fisheries in Rostock. Variables for which population target values were available and incorporated into the weighting procedure included centrality to lifestyle, federal state of residence, education level, age group, gender, angling avidity (number of angling days), and club membership. The weights were calibrated so the weighted sample closely matched the known population distributions for these variables.

Weighted descriptive estimates were obtained using the R 'survey' package (Lumley, 2004). Specifically, I used population-level estimates for the description of age, gender distribution, income, regional distribution of residence within Germany, fishing experience, general angling avidity, cod-specific angling avidity, preferred target species, preferred fishing sites in the German Baltic Sea, preferred fishing destinations outside Germany, and the distance from place of residence to preferred fishing sites in the German Baltic Sea.

In addition, I used weighted population estimates to describe the selection of activities and resources considered perfect substitutes for cod fishing in the German Baltic Sea, as well as for stated substitution behaviors. To describe the selection of perfect substitutes, I presented the weighted frequencies of positive (1) and negative (0) responses for each substitution option. For stated substitution behaviors, I recoded the original five-point response scale (1 "do not agree at all", 2 "rather do not agree", 3 "neither", 4 "rather agree", 5 "fully agree") to enhance interpretability, I classified responses scores of 1 and 2 as not engaging in the

behavior, a response of 3 as neutral, and responses of 4 and 5 as agreement with engaging in the behavior.

Additionally, I presented weighted frequencies for perfect activity substitution types, perfect species substitution categories, and targeted species categories starting in 2024, each coded as binary variables (selected vs. not selected).

3.4.2 Statistical analysis

To examine the relationship between respondents' characteristics and both perfect substitution preferences and stated substitution behaviours related to cod fishing in the German Baltic Sea, I conducted a series of logistic and linear regression analyses. Anglers' psychological, behavioural, and demographic characteristics were included as independent variables (Tables 1–6), while substitution preferences and stated behaviours were specified as dependent variables. To assess the correspondence between perfect substitution preferences and actual substitution behaviour, I performed additional statistical tests comparing reported perfect substitution preferences for cod fishing in the German Baltic Sea with the corresponding stated behavioural responses to the 2024 cod retention ban.

Given that the use of survey weights in regression models can increase model complexity, reduce the interpretability of results, and introduce bias in hypothesis testing (Winship & Radbill,1994), and because the primary objective of the statistical analysis was to explore associations between angler characteristics and substitution choices rather than to estimate population-level descriptive patterns, all regression analyses were conducted on unweighted data.

Prior to analysis, I examined collinearity among the independent variables. No problematic multicollinearity was detected, as the variance inflation factors (VIFs) for all variables were below three (Zuur et al., 2010). All independent variables were standardised using z-transformation to obtain standardised and comparable beta coefficients across predictors.

For each regression model, I first tested whether the full model provided a significantly better fit to the data than a null model using a likelihood ratio test for logistic models and an F-test for linear models. If the full model did not significantly improve upon the null model ($p > 0.05$), I applied a post-hoc exploratory backward elimination procedure based on the Akaike Information Criterion (AIC) (Burnham & Anderson, 2004). Independent variables were removed sequentially, retaining at each step the model with the lowest AIC, until no further removal reduced the AIC. If no candidate model improved upon the null model, model coefficients are not reported. This procedure was implemented using the step () function from the stats package in R (R Core Team, 2024).

For each logistic regression model, I report the likelihood ratio test result and McFadden R^2 as a measure of model fit. For each linear regression model, I report the F-test result and adjusted R^2 as a measure of explanatory power.

3.4.2.1 Perfect activity substitution

To test H1., I conducted a logistic regression analysis. I included anglers' psychological, behavioral and demographic characteristics as independent variables (Tables 1-6), and I used the binary response (yes/no) to the question *"Are there any other leisure activities,*

apart from fishing, that bring you just as much joy as cod fishing on the German Baltic Sea coast?" as the dependent variable.

To test H2. and to examine how angler characteristics predict the choice of perfect substitute activity types, I ran five additional logistic regression models. I restricted these analyses to respondents who indicated having a perfect activity substitute for fishing (n = 291). In these models, I used psychological, behavioral and demographic variables (Tables 1-6) to predict the selection of the following substitute activity categories: outdoor active activities, outdoor consumptive activities, outdoor passive activities, indoor active activities, and indoor passive activities.

3.4.2.2 Perfect species and site substitution

To test H3. and H4. I estimated seven logistic regression models. The dependent variables were the binary indicators of perfect resource substitution derived from the question: "*What exactly gives you as much angling enjoyment as cod fishing on the German Baltic Sea coast?*" (Description in section 3.2.2). Anglers' psychological, behavioral, and demographic characteristics were included as independent variables (Tables 1–6).

To test H5. and to examine how angler characteristics predict the selection of species as perfect substitutes for German Baltic cod, I conducted an additional eight logistic regression models. Anglers' psychological, behavioral, and demographic characteristics (Tables 1–6) were used as predictors of the selection of eight species categories that grouped the species reported as substitutes following the question *"Which fish species do you enjoy fishing for as much as cod fishing on the German Baltic Sea coast?"* (Description in section 3.2.2). This analysis was restricted to anglers who reported having a perfect resource substitute for German Baltic cod (N = 426).

3.4.2.3 Stated substitution behavior

To explore the relationship between respondent characteristics and anglers' stated behaviors after the 2024 cod harvest ban, I conducted 10 multiple linear regression models. As in the perfect substitution analyses, I used anglers' psychological, behavioral and demographic characteristics (Table 1-6) as independent variables, while I treated the agreement scores to the survey behavioral statements (1 "do not agree at all", 2 "rather do not agree", 3 "neither agree nor disagree", 4 "rather agree" and 5 "fully agree") as continuous dependent variables (description in section 2.3). I chose not to treat the responses as ordinal and fit ordinal models in favor of interpretability, following similar approaches in previous studies (Arlinghaus & Mehner, 2005; Slaton et al., 2023).

To determine whether some of the behavioral responses measured the same underlying construct, I conducted an exploratory factor analysis on the 12 behavioral items, using the same methodology described previously for the factor analysis of the psychological constructs. Three items: (1) "*I have stopped fishing on the German Baltic Sea coast*", (3) "*I go or went fishing on the German Baltic Sea coast much less often than before*", and (5) "*I go or went fishing on the German Baltic Sea coast much more often than before*", loaded on the same factor. Although the factor showed an internal consistency slightly lower than the acceptable threshold (0.7; Cronbach's $\alpha = 0.69$), I decided to keep the construct given that the questions had a clearly similar behavioral meaning. I reversed the score of items (5) and

calculated the average of items (1), (2), and (5), creating a composite “reduction of fishing in the German Baltic Sea” score, which I used as a single response variable in place of the three individual items.

To assess the relationship between the independent variables and species targeted after the 2024 cod harvest ban, I performed separate logistic regression models using anglers’ psychological, behavioral and demographic characteristics (Tables 1-6) to predict the selection of the eight species categories that grouped the species reported as substitutes in response to the survey item : “*Please list, in descending order, up to five fish species that you have preferentially targeted since January 2024, i.e., since the introduction of the cod retention ban, regardless of whether in freshwater or saltwater. Please also include species that you may still target by the end of the year*.”

3.4.2.4 Comparison between perfect substitution selection and stated behavioural responses.

To test H6., I examined the associations between perceived perfect substitution options (positive vs. negative selection) and agreement with corresponding stated behavioral responses (disagreement, neutral, agreement) using a chi-square test of independence (Table 7).

Although agreement with stated behavior is ordinal, I treated responses as categorical (1-2, disagreement; (3) neutral; (4-5) agreement) for the purposes of the chi-square test. An alpha level of 0.05 was used as the threshold for rejecting the null hypothesis of independence between substitution perceptions and stated behavior. The strength of statistically significant associations was assessed using Cramer’s V as an effect size measure. Following Cohen (1988), values of approximately 0.10–0.20 were interpreted as weak associations, values between 0.20 and 0.40 as moderate associations, and values greater than 0.40 as strong associations.

***Table 7**. Equivalent perfect substitution options for cod fishing in the German Baltic Sea and anglers stated behavioral responses following the 2024 cod harvest ban, used to assess consistency between perceived substitutes and actual behavior.*

What exactly gives you as much angling enjoyment as cod fishing on the German Baltic Sea coast?	***Because in this year (2024) I can/could no longer specifically fish for harvest cod in the Baltic Sea,***
Fishing for other species in the North Sea	*I fish or fished for the first time or more often than before on the German North Sea coast.*
Fishing for other species in the German Baltic Sea.	*I continue to fish on the German Baltic Sea coast, but for other target species.*
Fishing for freshwater species in Germany.	*I fish or fished for the first time or more often than before in inland waters in Germany.*
Fishing for freshwater species abroad.	*I fish or fished for the first time or more often than before in inland waters abroad.*
Fishing for other marine species abroad.	*I fish or fished for the first time or more frequently than before on the coasts of other European countries*
other leisure activities apart from fishing.	*I pursue or pursued other leisure activities more often than fishing.*

To test H7., I conducted a species-specific analysis for the 20 most frequently mentioned species identified as perfect substitutes for German Baltic cod. I examined whether anglers who selected a given species as a perfect substitute were more likely to target that species following the 2024 retention ban.

Participants were asked to rank up to five species they targeted most frequently after 2024. I used this ranking as a measure of targeting preference (rank 1 = most targeted; rank 5 = least targeted). I assigned a rank value of 6 if the species was not included in a respondent's top five target list. For each species, respondents were divided into two groups: those who listed the species as a perfect substitute and those who did not. Mean ranks for both groups were reported to facilitate interpretation. Differences in targeting rank between groups were assessed using the Mann–Whitney U test, a nonparametric test appropriate for ordinal data (Chicco et al., 2025). As I conducted 20 different tests, I adjusted the p-values using the Bonferroni correction to reduce the likelihood of Type I errors (Dunn,1961).

4. Results

4.1 Description of the population of German recreational cod anglers

I applied survey weights to the sample to produce population-level descriptions of German recreational cod anglers. Approximately 37% of cod anglers resided in German federal states with access to the Baltic Sea coast (22% in Schleswig-Holstein and 15% in Mecklenburg-Western Pomerania). 12.4% lived in the state of Niedersachsen, which has access to the North Sea coast (Figure 2). The remaining 51% lived in other German states, with highest proportions in Nordrhein-Westfalen and various Eastern German states (Saxony, Brandenburg, Saxony-Anhalt; Figure 2).

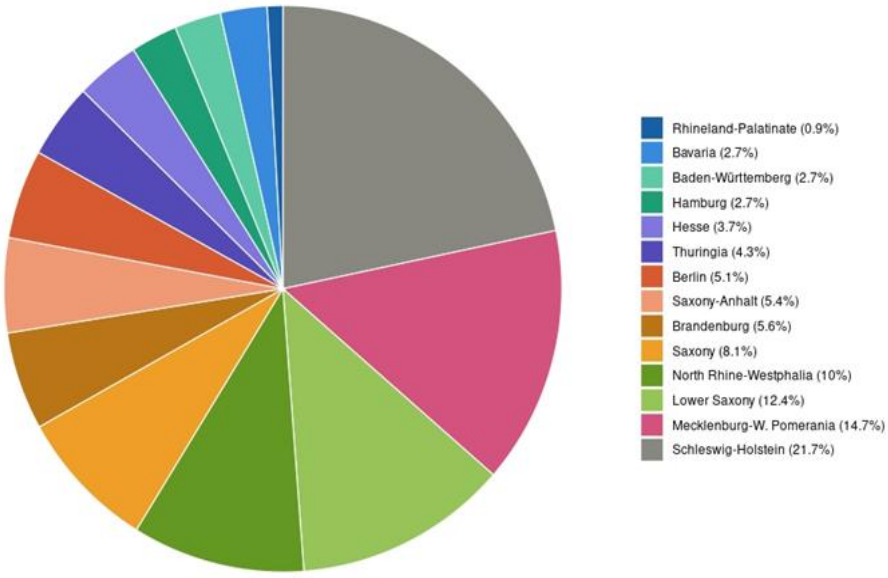

Figure 2. *Weighted percentage distribution of German recreational cod anglers by federal state of residence, 2020.*

The vast majority of cod anglers were male (97%), were on average 55 years old, and had an average monthly household income of 2.569 € (Table 8). Anglers who lived closer to the Baltic Sea coast, in the states of Schleswig-Holstein or Mecklenburg-Western Pomerania, were on average younger and had a lower income than anglers who lived in federal states farther away from the Baltic coast (Table 8).

Table 8. *Weighted percentage of males and weighted means of age and monthly household income (standard deviations in parentheses) for the German Western Baltic cod angler population, differentiated between anglers living in federal states with access to the Baltic coast (Baltic federal states) and anglers living in other German federal states.*

Variable	All anglers	Anglers (Baltic federal states)	Angler (other federal states)
Age	54.9 (1.14)	51.1 (2.04)	57.0 (1.03)
Percentage of males	97%	94%	98%
Monthly household income (€)	2569.1 (112.4)	2376.6 (181.0)	2679.5 (141.5)

The majority of anglers (98%) completed basic secondary school education, with 23% having a general school qualification degree (*Realschulabschluss*) and 15% a university entrance qualification degree (*Abitur*) as the highest educational qualification. Almost 25% of anglers who lived in the Baltic states had a university degree, the proportion was almost double for the population of anglers who lived in other German federal states (Table 9).

Table 9. *Weighted percentage distribution of the highest educational degree attained for the German Western Baltic cod angler population, differentiated between anglers living in federal states with access to the Baltic coast (Baltic federal states) and anglers living in other German federal states.*

Level of education	All anglers	Anglers (Baltic federal states)	Anglers (other federal states)
Lower secondary education (Hauptschulabschluss)	2.4%	5.3%	0.6%
General school qualification (Realschulabschluss)	23.2%	33.5%	17.3%
Polytechnic secondary school qualification (Polytechnische Oberschule)	10.1%	6.0%	12.5%
Technical college entrance qualification (Fachhochschulreife)	8.7%	12.1%	6.8%
University entrance qualification (Abitur)	14.9%	18.5%	12.9%
University degree	40.5%	24.5%	49.7%

Regarding fishing activity, the population's average fishing experience (i.e., number of years since first fishing) was 29 years, and the average fishing avidity was 46 fishing days per year. Specifically for cod, the average fishing avidity was approximately 10 fishing days per year (Table 10). Anglers who lived in federal states bordering the Baltic Sea coast exhibited higher general fishing avidity and higher cod-specific fishing avidity than anglers who lived in German federal states that do not border the Baltic Sea (Table 10). On average, anglers residing in federal states Baltic Sea coastline lived 101 kilometres from their preferred fishing site on the German Baltic coast, whereas anglers living in other federal states resided, on average, 365 kilometres from their preferred fishing site on the German Baltic coast (Table 10).

Table 10. *Weighted means of fishing experience, fishing avidity, cod fishing avidity and distance to preferred fishing site (standard deviations in parentheses), for the German Western Baltic cod angler population, differentiated between anglers living in federal states with access to the Baltic coast (Baltic federal states) and anglers living in other German federal states.*

Variable	***All anglers***	***Anglers (Baltic federal states)***	***Anglers (other federal states)***
Fishing experience (years)	29.2 (1.3)	28.4 (2.3)	29.6 (1.5)
Fishing avidity (days per year)	45.8 (5.0)	57.6 (10.6)	39.0 (4.7)
Cod avidity (days per year)	9.7 (1.2)	16.2 (2.9)	6.1 (0.7)
Distance to preferred fishing site at the coastline (kilometres)	269.1 (17.7)	101.1 (20.3)	365.3 (16.7)

In the 2020 survey wave, before the implementation of the cod retention ban in Germany, anglers were asked to rank up to five fish species they preferred to target. Cod was selected by more than 80% of respondents. The second most frequently selected species was zander (*Sander lucioperca*) (47%), followed by sea trout (*Salmo trutta*) (45.6%) and pike (*Esox lucius*) (43.5%) (Table 11). A similar set of species were also most frequently selected as the primary (top-ranked) species actually targeted, but frequency of choice varied for some species. Cod was most often ranked first (27%), followed by sea trout (16.4%), pike (10.9%), and zander (10.3%) (Table 11).

Table 11. *Weighted percentages of the 20 species most frequently mentioned among the top five preferred target species by German cod anglers, and weighted percentages of species ranked as the top target (descending order of selection in parentheses). The species categories used to group species for the substitution analysis are also indicated.*

Species	Percentage of anglers selecting a species among the top five targets	Percentage of anglers selecting a species as the most targeted	Species category
Cod (*Gadus morhua*)	83%	27.0% (1)	Marine demersal
Zander *(Sander lucioperca)*	47%	10.3% (4)	Freshwater predator
Sea trout (*Salmo trutta*)	45.6%	16.4% (2)	Salmonid (Marine)
Pike (*Esox lucius*)	43.5%	10.9% (3)	Freshwater predator
Perch *(Perca fluviatilis)*	35.1%	7.5% (5)	Freshwater predator
Flounder *(Platichthys solemdali)*	27.7%	3.2% (9)	Marine flatfish
Plaice *(Pleuronectes platessa)*	27.3%	2.5% (10)	Marine flatfish
Garfish *(Belone belone)*	21.9%	<1%	Small pelagic marine
European eel *(Anguilla anguilla)*	21.4%	4.8% (7)	Freshwater predator
Herring *(Clupea harengus)*	18.5%	<1%	Small pelagic marine
Carp *(Cyprinus carpio)*	16.4%	7.3% (6)	Coarse fish (Freshwater)
Salmon *(Salmo salar)*	13.6%	1.7% (12)	Salmonid
Brown trout (*Salmo trutta)*	12.3%	4.7% (8)	Salmonid
Tench *(Tinca tinca)*	10.5%	1.19% (13)	Coarse fish (Freshwater)
Rainbow trout *(Oncorhynchus mykiss)*	9.4%	2.3% (11)	Salmonid
Dab *(Limanda limanda)*	5.4%	<1%	Marine flatfish
Small-bodied cyprinids (Weissfische)	5.2%	<1%	Coarse fish (Freshwater)
Catfish (*Silurus glanis*)	4.0%	<1%	Freshwater predator
Flatfish (general)	3.45%	<1%	Marine flatfish
Pollock *(Pollachius pollachius)*	3.39 %	<1%	Marine demersal

In 2020, anglers were presented with a map of the German coast and asked to select their preferred fishing zone (Figure 3). The vast majority of anglers (98%) preferred fishing sites located along the German Baltic Sea coast.

In the state of Schleswig-Holstein, Zone 1 (the coastline near the cities of Kiel and Eckernförde) was selected by 18% of anglers, and Zone 2 (near the harbor of Heiligenhafen) was selected by 30.5% (Figure 3). In the state of Mecklenburg–Western Pomerania, Zone 3 (the coastline near the city of Wismar) was selected by 5% of anglers, Zone 4 (near the city of Rostock) by 17%, and Zone 5 (the coast of the island of Rügen) by 25% (Figure 3). The remaining fishing zones along the German Baltic coast (Figure 3) were each selected by less than 3% of the population.

***Figure 3**. Map of the German Baltic coast, subdivided in 9 different fishing sites. Participants were asked to select their preferred fishing site for cod. Taken from Weltersbach, M. S., Riepe, C., & Lewin, W.-C. (2021). Ökologische, soziale und ökonomische Dimensionen des Meeresangelns in Deutschland. Johann Heinrich von Thünen-Institut. https://doi.org/10.3220/REP1611578297000*

Regarding fishing outside Germany, more than 33% of anglers reported having gone fishing in Norway and 31% in Denmark during the previous three years (2017–2019). Denmark was the preferred foreign destination among anglers living in federal states with access to the Baltic coast, whereas Norway was the preferred destination among anglers living in other German federal states (Table 12). Other countries were visited by only a small minority of anglers (< 5%; Table 12).

Table 12. *Weighted percentage of foreign countries were German cod anglers fished between 2017-2020, differentiated between anglers living in federal states with access to the Baltic coast (Baltic federal states) and anglers living in other German federal states.*

Country	***All anglers***	***Anglers (Baltic federal states)***	***Anglers (other federal states)***
Norway	33.6%	24.4%	38.9%
Denmark	31.0%	34.3%	19.1%
Sweden	3%	4%	2%
Iceland	2.8%	0%	4.5%
Poland	2%	0%	3.3%
Other*	4.6%	3.1%	5.3%

**Other countries with less than 2% of selection (Faroe Islands, Netherlands, Italy, Spain, Lithuania, Great Britain, U.S.A., Canada).*
Note: multiple answers were aloud

4.2 Perfect substitution analysis

4.2.1 Description of non-fishing activity substitution

More than 60% of German cod anglers reported having a non-fishing activity that gave them the same amount of enjoyment as cod fishing in the German Baltic Sea (Figure 4).

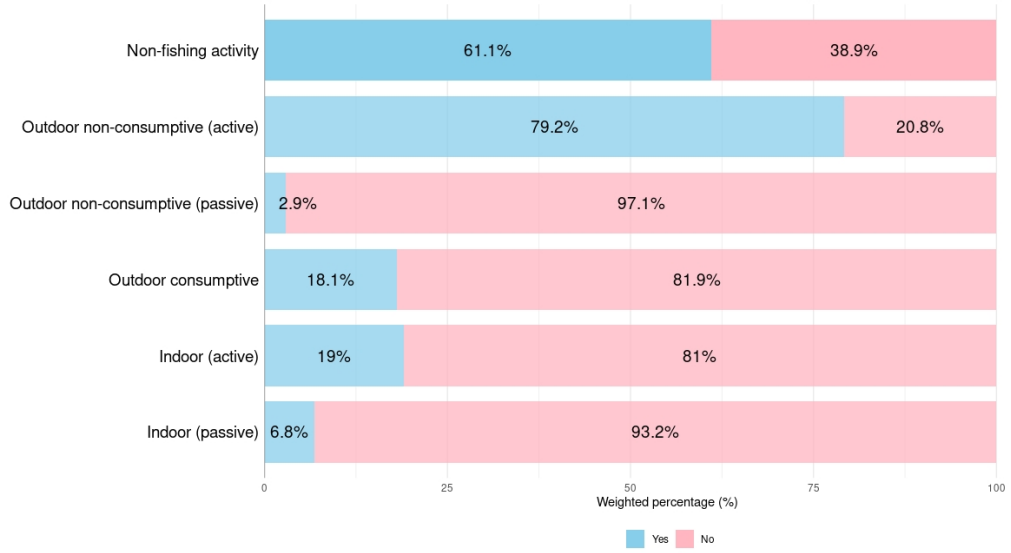

Figure 4. *Weighted percentages of selection (Yes) and non-selection (No) of non-fishing activities as perfect substitutes for cod fishing in the German Baltic Sea. The first bar shows the percentage of anglers reporting any non-fishing activity substitute. The following bars show the types of activities selected by anglers who reported a non-fishing activity substitute*

The majority of non-fishing activities identified as perfect substitutes for cod fishing were those that can be pursued outdoors and require physical activity, with cycling (22.9%) and hiking (16.7%) being the most frequently mentioned (Table 13). Some non-fishing activities that share the consumptive nature of fishing were also selected, specifically gardening (6.7%), hunting (5.4%), and mushroom picking (4.1%) (Table 13). Indoor activities, such as making music or writing (3.2%), were less frequently selected as perfect substitutes for cod fishing (Table 13). Overall, taking into account that anglers could mention multiple substitute activities, the most frequently selected category of non-fishing activities (79%) was outdoor non-consumptive active activities, followed by indoor active activities (19%), outdoor consumptive activities (18%), and indoor passive activities (7%) (Figure 4).

Table 13. *Weighted percentage of angler's selection of the top 20 non-fishing substitute activities for cod fishing in the German Baltic Sea, with their corresponding categorization into activity types. Multiple responses were possible.*

Activity	Percentage of anglers	Activity type
Cycling	22.9%	Outdoors non consumptive (active)
Hiking	16.7%	Outdoors non consumptive (active)
Sports (unspecified)	9.6%	Outdoors non consumptive (active)
Motorbiking	8.0%	Outdoors non consumptive (active)
Gardening	6.7%	Outdoors consumptive
Hunting	5.4%	Outdoors consumptive
Family time	4.7%	Unspecified
Sailing	4.5%	Outdoors non consumptive (active)
Dog walking	4.3%	Outdoors non consumptive (active)
Boat driving	4.2%	Outdoors non consumptive (active)
Traveling (unspecified)	4.2%	Unspecified
Mushroom picking	4.1%	Outdoors consumptive
Camping	3.9%	Outdoors non consumptive (active)
Van traveling	4.2%	Outdoors non consumptive (active)
Making music	3.2%	Indoors active
Writing	3.2%	Indoors passive
Mineral collecting	3.2%	Outdoors consumptive
Swimming	2.9%	Outdoors non consumptive (active)
Playing football	2.3%	Outdoors non consumptive (active)
Table tennis	2.3 %	Indoors active

4.2.2 Predictors of having a non-fishing perfect activity substitute

The logistic regression model used to test the likelihood of German cod anglers reporting a non-fishing activity substitute indicated improved fit relative to the null model (likelihood ratio $\chi^2 = 78.4$, $p < 0.001$; McFadden pseudo-$R^2 = 0.11$; Table 15).

The results partially supported the first hypothesis of this thesis:

H1. Angler specialization subdimensions (psychological commitment, behavioural commitment, and skill) are negative predictors of non-fishing activity substitution.

Of the three specialization subdimensions, only psychological commitment was a significant predictor. Anglers with lower psychological commitment were more likely to report having a non-fishing activity that provided an equivalent level of enjoyment to cod fishing. Behavioural commitment and fishing skill were not significant predictors of activity substitution (Table 14).

Regarding cod catch orientation, anglers with a lower retention orientation towards cod were also more likely to report having a perfect non-fishing activity substitute. No other catch orientation subdimension was a significant predictor of perfect activity substitution (Table 14).

Among the demographic variables examined, only age was a significant predictor. Older anglers were more likely to report a non-fishing activity as providing a comparable level of enjoyment to cod fishing (Table 14).

Fishing experience, attachment to cod, cod-specific fishing avidity, cod fishing skill, place attachment to the Baltic Sea coast, residential distance to the preferred fishing site, the number of perceived fishing constraints and income were not significant predictors of having a perfect non-fishing activity substitute for cod fishing (Table 14).

4.2.3 Predictors of perfect substitution by non-fishing activity types

The logistic regression models testing the selection of non-fishing activity types as perfect substitutes for cod fishing did not improve upon the respective null models when all predictors were included. For this reason, we decided as a post-hoc analysis to test models retaining only predictors associated with the lowest AIC values (Annex III). For indoor active activities, no predictor combination resulted in a model that outperformed the null model; this activity category was therefore excluded from further analysis. For outdoor non-consumptive, outdoor consumptive, outdoor passive, and indoor passive activities, the reduced models showed improved fit relative to the null models, though overall explanatory power remained weak across all categories (McFadden $R^2 < 0.10$) (Table 14).

The results did not support the second hypothesis of this thesis:

H2. Angler specialization subdimensions are predictors in the selection of non-fishing activity types as perfect substitutes for cod fishing.

Of the specialization subdimensions, only psychological commitment was a significant negative predictor for the selection of outdoor non-consumptive activities as perfect substitutes. No other specialization subdimension was significantly associated with the selection of any other activity type (Table 14).

Among the place attachment subdimensions, place dependence was a significant positive predictor of the selection of outdoor non-consumptive activities as perfect substitutes. Place identity was not a significant predictor of any activity type selection (Table 14).

Regarding cod catch orientation, anglers who attributed greater importance to catching large quantities of cod were more likely to select an outdoor consumptive activity as a perfect substitute. No other catch orientation subdimension was a significant predictor of any non-fishing activity type selection (Table 14).

Both age and residential distance to the preferred fishing site were significant predictors of activity type substitution. Younger anglers were more likely to select an outdoor non-consumptive active activity as a perfect substitute, and less likely to choose a consumptive or indoor passive activity. Anglers living in closer proximity to their preferred fishing site were more likely to select a consumptive or indoor passive activity as a perfect substitute (Table 14).

Finally, aanglers who had identified a greater number of cod fishing constraints prior to the ban were more likely to select outdoor passive activities as perfect substitutes for cod fishing (Table 14).

Fishing experience, cod attachment, cod-specific fishing avidity, cod fishing skill, and household income were not significant predictors of the selection of any non-fishing activity type as a perfect substitute for cod fishing (Table 14).

Table 14. *Logistic regression results for specialization, cod related fishing behavior and attitudes, place identity and dependence, and demographic predictors of having a non-fishing activity substitute, and of selecting non-fishing perfect substitute activity types for cod fishing on the German Baltic Sea coast.*

Predictor	Having a non-fishing activity substitution	Outdoor non consumptive (active) activities	Outdoor non consumptive (passive) activities	Outdoor consumptive activities	Indoor passive activities
Fishing experience (years)	-0.264 (0.141)	0.307 (0.169)	—	—	—
Behavioural commitment (days/year)	-0.209 (0.122)	0.306 (0.200)	—	—	—
Psychological commitment [a]	**-0.524*** (0.135)**	**−0.599*** (0.176)**	—	—	—
Skill fishing (general)[a]	-0.103 (0.131)	—	—	—	—
Cod avidity (days/year)	-0.003 (0.112)	—	—	—	—
Cod attachment[a]	-0.229 (0.129)	—	—	—	—
Skill for cod fishing[a]	0.209 (0.128)	—	—	—	—
Catch some cod[a]	-0.185 (0.105)	—	—	—	—
Cod quantity[a]	0.022 (0.117)	—	—	**0.431** (0.164)**	0.353 (0.238)
Trophy cod[a]	0.028 (0.106)	—	—	−0.233 (0.160)	—

Retention of cod[a]	**-0.229*** **(0.108)**	—	—	—	—
Cod fishing constraints[b]	-0.147 (0.097)	—	**0.555*** **(0.251)**	—	—
Place dependence[a]	0.006 (0.112)	**0.293*** **(0.139)**	—	—	—
Place identity[a]	-0.026 (0.114)	—	—	—	—
Distance to preferred fishing site (km)	-0.041 (0.102)	—	**−0.828*** **(0.251)**	—	**−0.677*** **(0.307)**
Age (years)	**0.296*** **(0.144)**	**−0.496 ** ** **(0.187)**	—	**0.403*** **(0.162)**	**0.635**** **(0.245)**
Income (€)	-0.057 (0.100)	0.239 (0.150)	—	−0.238 (0.166)	−0.499 (0.279)
LR χ^2	**78.42*****	**19.93****	**7.75***	**13.93****	**13.54****
McFadden R^2	**0.11**	**0.06**	**0.07**	**0.05**	**0.09**
Sample size	**523**	**291**	**291**	**291**	**291**

[a] items scales detailed in Table1 to Table 4.

[b] item scale detailed in Table 5.

Note. Standardized β coefficient estimates are presented. Significant ($p < 0.05$) estimates are shown in boldface. Standard errors are in parentheses below. The level of significance is presented with asterisks next to the coefficient: *$p < 0.05$, **$p < 0.01$, ***$p < 0.001$.

Missing values (*—*) indicate predictors that were not retained in the final models. When the full models (including all predictors) did not outperform the null models, a backward selection procedure based on the Akaike Information Criterion (AIC) was applied. Only predictors included in the model with the lowest AIC are reported.

No model was estimated for predicting the selection of Indoor active activities, because no logistic regression specification performed significantly better ($p > 0.05$) than a null model.

4.2.4 Description of perfect resource substitution (species and site)

Approximately 62% of anglers reported that fishing for other species within the German Baltic Sea provided the same level of enjoyment as fishing for cod in the same location (Figure 5).

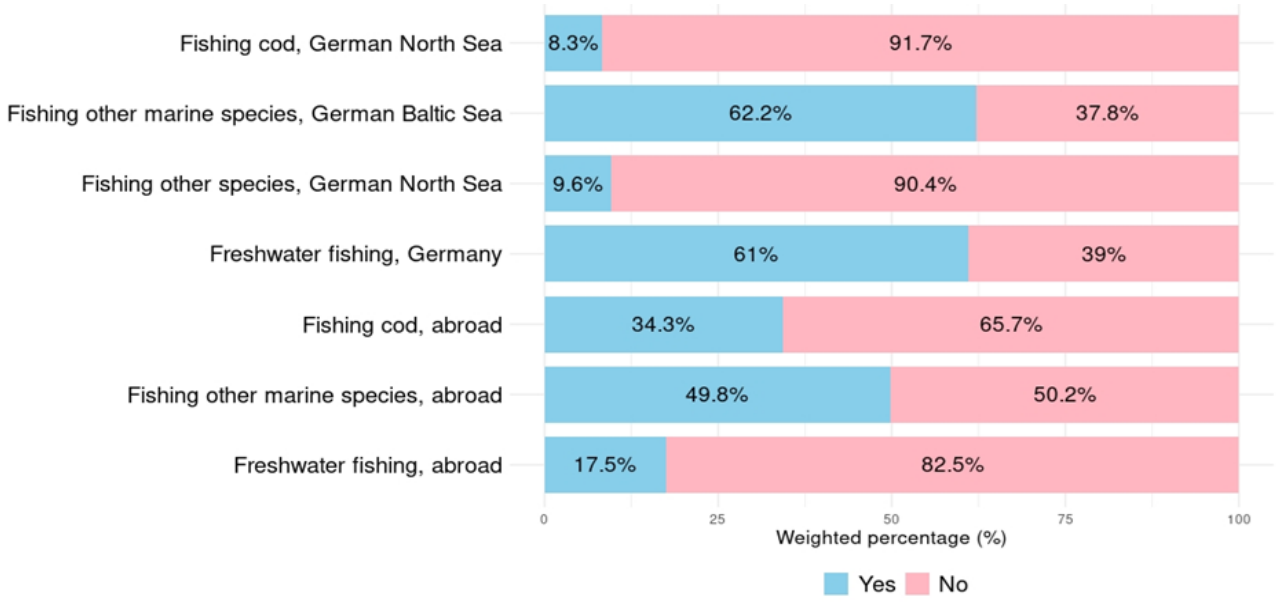

Figure 5. *Weighted percentages of positive (Yes) and negative (No) responses from German cod anglers regarding perfect fishing substitution activities in response to the question: "What activities provide you with the same level of enjoyment as cod fishing on the German Baltic Sea coast?"*

Many anglers also identified fishing opportunities outside the German Baltic Sea as perfect substitutes. Nearly half (49%) considered fishing for other marine species abroad to offer an equivalent enjoyment, while fishing for other species in the German North Sea was the least frequently selected alternative, cited by approximately 10% of anglers (Figure 5). Regarding freshwater substitution, 61% of anglers considered fishing for freshwater species within Germany to provide equal enjoyment to cod fishing in the German Baltic Sea, while 34% selected freshwater fishing abroad as equally enjoyable (Figure 5).

In terms of target species, salmonids were the most commonly selected substitute group, chosen by nearly half of all anglers (47%). Sea trout, predominantly targeted in marine waters, was the most frequently mentioned salmonid species (39%). Other Salmonids were selected by a minority, brown trout (7 %) (*Salmo trutta*), rainbow trout (3 %) (*Oncorhynchus mykiss*), and Atlantic salmon (3%) (*Salmo salar*) (Table 15, Figure 6).

Marine flatfish constituted the second most commonly selected group (43%), with flounder (21%) and plaice (*Pleuronectes platessa*) (12%) being the most frequently identified substitute species within this category. Marine pelagic species were selected by 33% of anglers, with garfish (*Belone belone*) (15%) and herring (*Clupea harengus*) (11%) being the most commonly mentioned substitutes (Table 15, Figure 6).

Marine demersal species ecologically similar to cod were selected by a comparatively small proportion of anglers as perfect substitutes (8%), with pollock (*Pollachius pollachius*) being the most frequently mentioned (7%).

Marine predatory species were the least commonly selected category overall, with sea bass (*Dicentrarchus labrax*) cited by only 2% of anglers (Table 15, Figure 6).

Among freshwater species, predatory fish were the most commonly selected substitute group, identified by 37% of anglers. Zander (*Sander lucioperca*) and pike (*Esox lucius*) were the most frequently mentioned examples, each cited by approximately 19% of respondents. Freshwater coarse fish, including various cyprinids, were selected by 10% of anglers, with carp (*Cyprinus carpio*) being the most commonly mentioned species within this group (Table 15, Figure 6).

***Table 15**. Weighted percentage of selection of the top 20 perfect species substitutes for cod fishing in the German Baltic Sea. Anglers could select multiple species.*

Species	Weighted selection percentage	Species category
Sea trout (*Salmo trutta)*	38.8%	Salmonid (marine)
Flounder (*Platichthys solemdali*)	21.0%	Marine flatfish
Zander (*Sander lucioperca*)	19.9%	Freshwater predator
Pike (*Esox lucius*)	19.1%	Freshwater predator
Garfish (*Belone belone*)	15.4%	Small pelagic marine
Perch (*Perca fluviatilis*)	12.9%	Freshwater predator
Plaice (*Pleuronectes platessa*)	11.9%	Marine flatfish
Herring (*Clupea harengus*)	11.4%	Small pelagic marine
Cod (*Gadus morhua*) *	10.0%	Marine demersal
Halibut (*Hippoglossus hippoglossus)*	7.8%	Marine flatfish
Mackerel (*Scomber scombrus*)	7.5%	Small pelagic marine
Brown trout (*Salmo trutta*)	7.4%	Salmonid
European eel (*Anguilla anguill*a)	7.1%	Freshwater predator
Pollock (*Pollachius pollachius*)	6.8%	Marine demersal
Carp (*Cyprinus carpio*)	5.3 %	Coarse fish (freshwater)
Dab (*Limanda limanda*)	4.7%	Marine flatfish
Rainbow trout (*Oncorhynchus mykiss*)	3.4%	Salmonid
Atlantic salmon (*Salmo salar*)	3.1%	Salmonid (marine)
Turbot (*Scophthalmus maximus*)	2.3%	Marine flatfish
Sea bass (*Dicentrarchus labrax*)	1.6 %	Marine predator

*The selection of cod implies site substitution away from the German Baltic Sea.

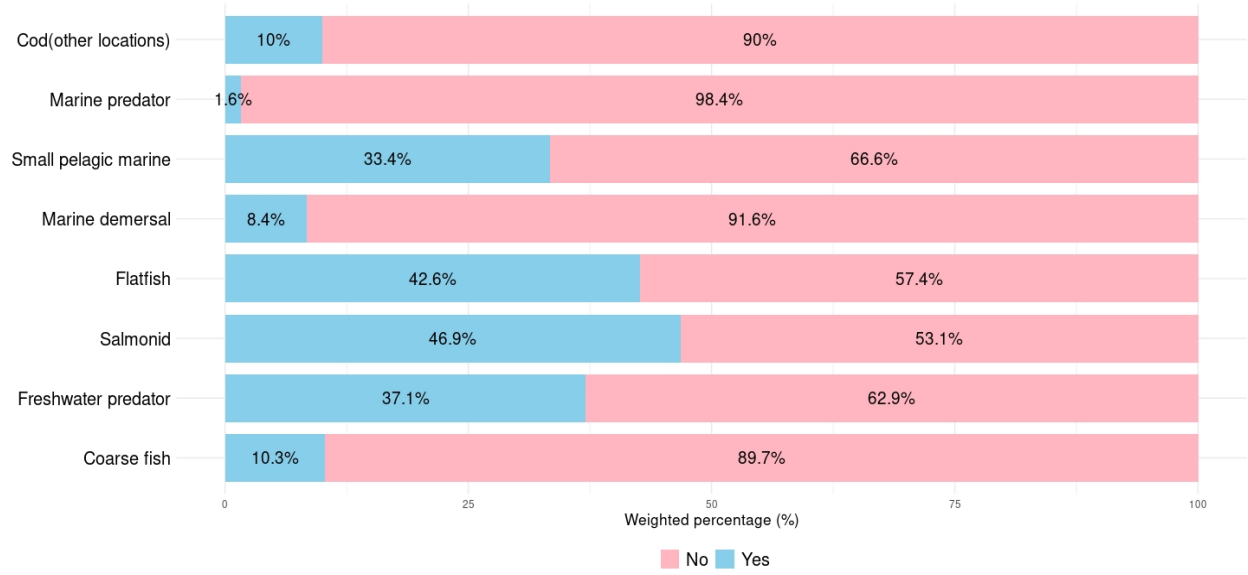

Figure 6. *Weighted percentages of German cod anglers who mentioned (Yes) or did not mention (No) different fish species types as perfect substitutes for cod fishing in the German Baltic Sea. The Selection of cod as a perfect substitute implies site substitution away from the German Baltic Sea coast.*

Beyond site substitution involving a change in target species, a subset of German cod anglers considered targeting cod outside the German Baltic Sea as a viable perfect substitute (Figure 5). Specifically, 34% of anglers reported that cod fishing in another country would provide an equivalent level of enjoyment to cod fishing in the German Baltic Sea, while the German North Sea was rarely regarded as a suitable substitute location for cod fishing, cited by only 8% of anglers (Figure 3). At the species level, approximately 10% of anglers included cod caught outside the German Baltic Sea among their five perfect substitute alternatives (Table 15, Figure 6).

4.2.5 Predictors for perfect resource substitution

Most logistic regression models testing species and site substitution provided a significantly better fit to the data than the null models when all predictors were included (Table 16). The two exceptions were the models predicting substitution towards the German North Sea, which failed to outperform their respective null models; for these, only predictors associated with the lowest AIC values were retained (Annex III). Overall model fit remained weak across all models, indicating limited explanatory power (Table 16).

These results partially supported the third hypothesis of this thesis:

H3. Anglers' psychological and behavioural variables related to cod fishing (cod attachment, cod avidity, cod fishing skill) are negative predictors of the existence of a perfect species substitute for Atlantic cod.

And fully supported the fourth hypothesis:

H4. Anglers with low attachment to the German Baltic Sea are more likely to perceive sites away from the German Baltic Sea as equally enjoyable as anglers with high place attachment.

Regarding cod-specific psychological and behavioural variables, anglers with higher cod attachment were more likely to consider fishing for cod abroad as a perfect substitute for cod

fishing in the German Baltic Sea, and less likely to consider other marine species within the German Baltic Sea or freshwater fishing in Germany as equally satisfying alternatives (Table 16). Cod-specific fishing avidity was a significant negative predictor of considering freshwater fishing in Germany as a perfect substitute, and cod-specific fishing skill was a significant positive predictor of considering cod fishing abroad as a perfect substitute (Table 16). Cod attachment, cod-specific avidity, and cod fishing skill were not significant predictors of considering fishing for cod in the North Sea, fishing for other species in the North Sea, fishing for other marine species abroad, or freshwater fishing abroad as perfect substitutes for cod fishing in the German Baltic Sea (Table 16).

Place attachment towards the German Baltic Sea was a significant predictor across the selection of all perfect resource substitution alternatives (Table 16). Place dependence was a consistent negative predictor of considering any substitution alternative away from the German Baltic coast as a perfect substitute, including fishing for cod in the German North Sea, fishing for other species in the German North Sea, fishing for cod abroad, fishing for other marine species abroad, freshwater fishing in Germany, and freshwater fishing abroad (Table 16). Place identity towards the German Baltic Sea was not a significant predictor of any substitution alternative away from the German Baltic Sea, but was a significant positive predictor of considering other species within the German Baltic Sea as a perfect substitute for cod (Table 16). Anglers living at a greater residential distance from their preferred fishing site along the German Baltic coast were less likely to consider other Baltic Sea species as perfect substitutes for cod (Table 16).

General fishing specialization subdimensions were not consistent predictors of perfect resource substitution. Anglers with higher behavioral commitment were more likely to consider freshwater species in Germany and marine species in the German North Sea as perfect substitutes for cod in the German Baltic Sea. Self-perceived general fishing skill was a significant negative predictor of considering other species within the German Baltic Sea as perfect substitutes for cod in the same location (Table 16). Psychological commitment to fishing was not a significant predictor of any species or site substitution outcome (Table 16).

Anglers with greater fishing experience were more likely to consider fishing for cod in the North Sea and freshwater fishing in Germany as perfect substitute alternatives for cod fishing in the German Baltic Sea (Table 16).

Regarding cod catch orientation, only two subdimensions were significant predictors. Anglers who placed greater importance on catching at least something during a cod fishing trip were less likely to consider fishing for cod abroad or fishing for other marine species abroad as perfect substitutes for cod fishing in the German Baltic Sea. Retention orientation towards cod was a significant negative predictor of considering other marine species abroad as perfect substitutes. No other cod catch orientation subdimension was a significant predictor of any perfect resource substitution outcome (Table 16).

Finally, younger anglers were more likely to consider freshwater fishing abroad as a perfect substitute option. Household income and the number of perceived cod fishing constraints were not significant predictors of any perfect resource substitution alternative (Table 16).

Table 16. Logistic regression results for specialization, cod related fishing behavior and attitudes, place identity and dependence, and demographic predictors of selecting perfect substitute activities for cod fishing on the German Baltic Sea coast.

Predictor	Fishing cod, German North Sea	Fishing cod, abroad	Fishing other marine species, German Baltic Sea	Fishing other species, German North Sea	Fishing for other marine species, abroad	Freshwater fishing, Germany	Freshwater fishing, abroad
Fishing experience (years)	**0.409 * (0.189)**	0.252 (0.158)	0.090 (0.138)	0.292 (0.165)	0.204 (0.135)	**0.313 * (0.138)**	0.162 (0.190)
Behavioural commitment (days/year)	—	-0.214 (0.146)	-0.038 (0.121)	**0.364** (0.121)**	-0.029 (0.117)	**0.284 * (0.137)**	0.201 (0.131)
Psychological commitment [a]	—	0.023 (0.146)	0.138 (0.134)	—	-0.054 (0.130)	0.228 (0.134)	-0.017 (0.167)
Skill fishing (general)[a]	—	-0.166 (0.147)	**-0.335 * (0.139)**	—	-0.162 (0.129)	-0.242 (0.136)	0.306 (0.157)
Cod avidity (days/year)	—	-0.066 (0.148)	0.210 (0.144)	—	-0.037 (0.108)	**-0.268 * (0.117)**	-0.013 (0.116)
Cod attachment [a]	0.397 (0.218)	**0.426 ** (0.144)**	**-0.586*** (0.138)**	—	0.051 (0.126)	**-0.550*** (0.133)**	-0.095 (0.154)
Skill for cod fishing [a]	—	**0.385 ** (0.146)**	-0.007 (0.133)	—	0.167 (0.126)	-0.020 (0.132)	-0.284 (0.151)
Catch some cod [a]	—	**-0.278* (0.119)**	-0.100 (0.107)	—	**-0.223 * (0.105)**	-0.067 (0.107)	0.011 (0.131)
Cod numbers [a]	—	0.127 (0.127)	0.177 (0.120)	—	0.108 (0.114)	0.199 (0.119)	0.065 (0.139)
Trophy cod [a]	—	0.109 (0.116)	-0.133 (0.110)	—	0.066 (0.105)	-0.080 (0.108)	-0.093 (0.127)
Retention of cod [a]	—	-0.163 (0.118)	-0.128 (0.109)	—	**-0.247 * (0.106)**	-0.11 0 (0.109)	-0.151 (0.135)
Cod fishing constraints [b]	—	0.060 (0.102)	-0.196 (0.103)	—	0.052 (0.097)	0.113 (0.099)	-0.125 (0.134)
Place dependence [a]	**−0.584** (0.214)**	**-0.808 *** (0.130)**	-0.117 (0.115)	—	**-0.642 *** (0.114)**	**-0.230 * (0.114)**	**-0.507*** (0.142)**
Place identity [a]	−0.294 (0.166)	0.027 (0.119)	**0.709*** (0.134)**	—	0.235 * (0.109)	0.107 (0.114)	-0.044 (0.125)
Distance to preferred fishing site (km)	—	0.217 (0.111)	**-0.361*** (0.106)**	—	0.102 (0.100)	-0.020 (0.102)	-0.065 (0.126)
Age (years)	—	-0.086 (0.159)	-0.267 (0.144)	—	-0.224 (0.138)	-0.453 ** (0.144)	**-0.616** (0.191)**
Income (€)	—	0.163 (0.108)	0.067 (0.101)	—	0.174 (0.099)	-0.079 (0.101)	0.1433 (0.119)

LR χ^2	**18.75*** **	**86.99*** **	**106.95*** **	**10.82***	**62.53*** **	**88.26*** **	**72.77*** **
McFadden R^2	**0.07**	**0.14**	**0.15**	**0.04**	**0.09**	**0.12**	**0.14**

N=523

[a] items scales detailed in Table1 to Table 4.

[b] item scale detailed in Table 5.

Note. Standardized β coefficient estimates are presented. Significant ($p < 0.05$) estimates are shown in boldface. Standard errors are in parentheses below. The level of significance is presented with asterisks next to the coefficient: *$p < 0.05$, **$p < 0.01$, ***$p < 0.001$.

Missing values (--) indicate predictors that were not retained in the final models. When the full models (including all predictors) did not outperform the null models, a backward selection procedure based on the Akaike Information Criterion (AIC) was applied. Only predictors included in the model with the lowest AIC are reported.

4.2.6 Predictors of perfect substitution by species categories

Some of the logistic regression models examining the selection of species categories as perfect substitutes for German Baltic cod provided a better fit than the respective null models when all predictors were included. This was not the case for the models predicting the selection of marine predatory species, flatfish species, and small marine pelagic species, for which only predictors associated with the lowest AIC values were retained (Table 17). For small marine pelagic species, no predictor combination improved upon the null model; this category was therefore excluded from further reporting (Annex III). The models predicting the selection of cod outside the German Baltic Sea, marine demersal species, and freshwater coarse species explained indicated considerable improved fit relative to the null model, while explanatory power was comparatively weak for the remaining models (Table 17).

The results did not support the fifth hypothesis of this thesis:

H5. Catch orientation subdimensions towards cod (catching something, retention orientation, trophy orientation, quantity orientation) of anglers are predictors in the selection of perfect species substitutes for cod.

None of the cod catch orientation subdimensions were significant predictors of selecting any species category as a perfect substitute for German Baltic cod (Table 17).

Regarding fishing specialization, behavioural commitment to fishing was negatively associated with considering cod outside the German Baltic Sea and marine demersal species as perfect substitutes. General fishing skill was negatively associated with the selection of marine demersal species. Psychological commitment to fishing was positively associated with considering freshwater predatory species as perfect substitutes. No specialization subdimension was a significant predictor of the selection of flatfish, salmonids, marine predators, or freshwater coarse species as perfect substitutes (Table 17).

Regarding cod-specific variables, cod fishing avidity was a significant positive predictor of considering cod outside the German Baltic Sea and marine demersal species as perfect substitutes. Cod attachment was a positive predictor of selecting cod outside the German Baltic Sea and a negative predictor of selecting freshwater species as perfect substitutes. Higher self-perceived cod fishing skill was positively associated with the selection of marine

demersal species. Cod-specific variables were not significant predictors of the selection of marine predators, salmonids, or freshwater coarse species as perfect substitution alternatives (Table 17).

Place attachment towards the German Baltic Sea emerged as the dominant predictor across the selection of most species categories. Anglers with lower place dependence were more likely to consider targeting cod outside the German Baltic Sea or selecting other marine demersal species as perfect substitutes. Anglers with higher place identity were more likely to select flatfish and salmonid species as perfect substitutes, and less likely to consider freshwater coarse species as perfect substitutes. The selection of freshwater predatory species was not significantly predicted by either place attachment subdimension (Table 17).

Residential distance to the preferred fishing site was a significant predictor only for the selection of cod outside the German Baltic Sea and marine predatory species as perfect substitutes, with anglers living further from their preferred fishing site being more likely to consider these alternatives (Table 17).

Household income was positively associated with the selection of salmonid species and negatively associated with the selection of freshwater coarse species as perfect substitutes (Table 17).

Anglers' age and the number of identified cod fishing constraints were not significant predictors of the selection of any species category as a perfect substitute (Table 17).

Table 17. *Logistic regression results for specialization, cod related fishing behavior and attitudes, place identity and dependence, and demographic predictors of selecting fish species categories as perfect substitutes for cod fishing in the German Baltic Sea coast.*

Predictor	Cod (other locations)	Marine predator	Marine demersal	Flatfish	Salmonid	Freshwater predator	Coarse freshwater fish
Fishing experience (years)	0.059 (0.249)	—	0.139 (0.261)	**0.307** ** **(0.107)**	0.058 (0.147)	−0.061 (0.151)	0.186 (0.265)
Behavioural commitment (days/year)	**−1.102** ** **(0.397)**	—	**−0.870** * **(0.442)**	—	−0.090 (0.131)	0.005 (0.134)	0.130 (0.193)
Psychological commitment[a]	0.086 (0.266)	0.425 (0.291)	0.136 (0.281)	—	0.205 (0.145)	**0.296** * **(0.147)**	0.200 (0.235)
Skill fishing (general)[a]	−0.122 (0.276)	—	**−0.524 (0.297)** *	—	−0.031 (0.141)	0.100 (0.143)	−0.008 (0.234)
Cod avidity (days/year)	**0.455*** **(0.232)**	—	**0.453** * **(0.218)**	—	0.009 (0.118)	−0.268 (0.169)	−0.357 (0.356)
Cod attachment[a]	**0.773** ** **(0.258)**	-0.486 (0.281)	−0.009 (0.257)	—	−0.232 (0.134)	**−0.276** * **(0.136)**	−0.078 (0.232)
Skill for cod fishing[a]	0.417 (0.251)	—	**0.607*** **(0.276)**	—	0.036 (0.137)	0.233 (0.140)	−0.181 (0.223)

Catch some cod[a]	−0.360 (0.214)	−0.682 (0.394)	−0.034 (0.218)	−0.159 (0.108)	0.037 (0.116)	0.007 (0.115)	−0.280 (0.207)
Cod numbers[a]	−0.044 (0.220)	0.523 (0.301)	−0.047 (0.245)	—	−0.198 (0.125)	0.227 (0.127)	0.077 (0.213)
Trophy cod[a]	0.351 (0.214)	−0.429 (0.288)	0.314 (0.241)	—	0.002 (0.115)	0.062 (0.117)	−0.127 (0.195)
Retention of cod[a]	0.171 (0.202)	—	0.115 (0.219)	—	−0.153 (0.114)	−0.168 (0.116)	0.060 (0.191)
Cod fishing constraints[b]	0.177 (0.145)	—	0.243 (0.158)	—	−0.019 (0.108)	0.138 (0.107)	0.277 (0.152)
Place dependence[a]	**−0.491* (0.210)**	—	**−0.474* (0.232)**	—	−0.110 (0.118)	0.002 (0.119)	0.369 (0.200)
Place identity[a]	−0.253 (0.197)	—	−0.196 (0.195)	**0.230* (0.117)**	**0.560*** (0.135)**	−0.196 (0.119)	**−0.462** (0.161)**
Distance to preferred fishing site (km)	**0.428 * (0.185)**	**0.555* (0.240)**	0.242 (0.202)	—	−0.053 (0.112)	−0.034 (0.113)	0.133 (0.179)
Age (years)	−0.031 (0.260)	—	0.345 (0.282)	—	0.015 (0.153)	−0.065 (0.155)	−0.042 (0.256)
Income (€)	0.157 (0.184)	—	−0.099 (0.204)	—	**0.353** (0.112)**	−0.042 (0.110)	**−0.440 * (0.206)**
LR χ^2	**54.3*****	**15.30***	**33.57****	**14.95***	**46.20*****	**44.93*****	**28.46***
McFadden R^2	**0.20**	**0.09**	**0.15**	**0.03**	**0.08**	**0.08**	**0.10**

N= 426

[a] items scales detailed in Table1 to Table 4.

[b] item scale detailed in Table 5.

Note. Standardized β coefficient estimates are presented. Significant ($p < 0.05$) estimates are shown in boldface. Standard errors are in parentheses below. The level of significance is presented with asterisks next to the coefficient: *$p < 0.05$, **$p < 0.01$, ***$p < 0.001$.

Missing values (--) indicate predictors that were not retained in the final models. When the full models (including all predictors) did not outperform the null models, a backward selection procedure based on the Akaike Information Criterion (AIC) was applied. Only predictors included in the model with the lowest AIC are reported.

4.3 Stated substitution behavior analysis

4.3.1 Description of stated substitution behavior

Each behavioural response was measured as a separate, independently rated survey item, meaning that anglers could agree with multiple statements simultaneously. The most commonly reported behavioural response to the 2024 German Baltic cod retention ban was an increase in fishing activity targeting species other than cod, regardless of site, reported by nearly 70% of anglers (Figure 7). Within Germany, 57% reported continuing to fish for other species in the German Baltic Sea, and 30% reported an increase in fishing activity in inland waters. Fishing along the German North Sea coast and in the Bodden brackish lagoon waters of the German Baltic coast were less commonly reported responses, cited by 9% and 12% of anglers, respectively (Figure 7). Regarding behavioural substitution outside Germany, approximately 36% of anglers reported fishing more frequently in marine waters abroad following the retention ban, and 20% reported increased inland fishing activity abroad (Figure 7).

Beyond resource substitution, a substantial proportion of anglers reported a reduction in overall fishing activity following the 2024 cod retention ban. Nearly 62% reported fishing less frequently in the German Baltic Sea, and 41% reported having stopped fishing there entirely. A smaller proportion (11%) reported stopping fishing altogether. Additionally, 32% of anglers reported engaging more frequently in non-fishing activities following the 2024 ban (Figure 7).

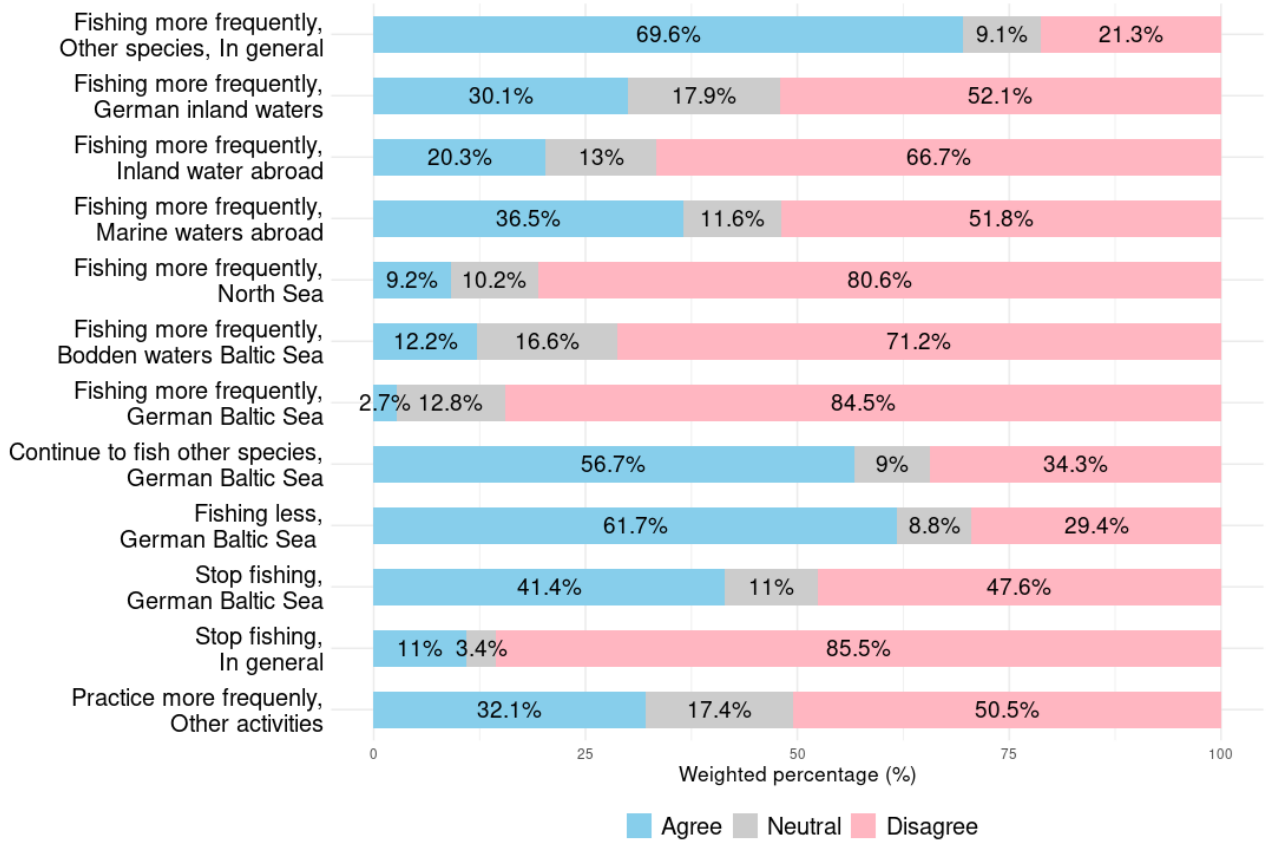

***Figure 7**. Weighted percentages of agreement (Agree), neutrality (Neutral), and disagreement (Disagree) with the survey statements following the prompt, "Because in this year (2024) I can/could no longer specifically fish to harvest cod in the Baltic Sea, …". Agreement, neutrality, and disagreement were derived from respondents' ratings on a five-point Likert scale. Responses of 1 ("do not agree at all") and 2 ("rather do not agree") were classified as disagreement; 3 ("neither agree nor disagree") as neutral; and 4 ("rather agree") and 5 ("fully agree") as agreement.*

4.3.2 Description of species targeted as substitutes

Following the introduction of the German cod retention ban in 2024, 88% of German cod anglers reported targeting specific species for recreation. More than half of these anglers reported targeting salmonids (64%), freshwater predators (61%), flatfish (59%), or small pelagic marine species (51%), with sea trout, pike, flounder, zander, and herring being the most frequently mentioned species among the top five targets (Table 18, Figure 8). Sea trout was also the most frequently selected top target species after the ban (21%), followed by plaice (*Pleuronectes platessa*), flounder, pike, and perch (Table 18).

Approximately one quarter of anglers reported targeting coarse fish species. Fewer than 10% reported targeting marine demersal species, and fewer than 2% reported targeting marine predator species (Table 18, Figure 8). Around 7% of anglers continued targeting cod after the 2024 retention ban, with approximately 5% placing it as their top target species (Table 18).

Table 18. *Weighted percentage of selection of the 20 species most often mentioned in the top five of intended target species among German cod anglers, after the 2024 cod retention ban.*

Species	Percentage of anglers selecting a species among the top five targets	Percentage of anglers selecting a species as the most targeted	Species category
Sea trout *(Salmo trutta)*	55.1%	21.3% (1)	Salmonid (Marine)
Pike (*Esox lucius)*	39.3%	8.0% (4)	Freshwater predator
Flounder *(Platichthys sp.)*	37.4%	9.3% (3)	Marine flatfish
Zander *(Sander lucioperca)*	37.0%	7.1% (6)	Freshwater predator
Herring *(Clupea harengus)*	35.1%	4.3% (11)	Small pelagic marine
Plaice *(Pleuronectes platessa)*	33.9%	11.9% (2)	Marine flatfish
Perch *(Perca fluviatilis)*	33%	7.4% (5)	Freshwater predator
Garfish *(Belone belone)*	26.1%	3.9% (12)	Small pelagic marine
Mackerel *(Scomber sp.)*	23.6%	—	Small pelagic marine
Carp *(Cyprinus carpio)*	15.3%	4.6% (8)	Coarse fish (freshwater)
Rainbow trout *(Oncorhynchus mykiss)*	13.5%	4.9% (7)	Salmonid
Brown trout *(Salmo trutta)*	13.1%	4.4% (10)	Salmonid
European eel *(Anguilla anguilla)*	12.3%	2.7% (13)	Freshwater predator
Dab *(Limanda limanda)*	10.3%	1.4% (14)	Marine flatfish
Pollock *(Pollachius sp.)*	8.5%	—	Marine demersal
Cod (*Gadus morhua*)*	7.1%	4.4% (9)	Marine demersal
Turbot *(Scophthalmus maximus)*	6.0%	—	Marine flatfish
Catfish *(Silurus glanis)*	3.1%	1.3% (15)	Freshwater predator
Roach *(Rutilus rutilus)*	4.8%	—	Coarse fish (freshwater)
Halibut *(Hippoglossus hippoglossus)*	4.8 %	—	Marine flatfish

**The Selection of cod implies site substitution away from the German Baltic Sea.*

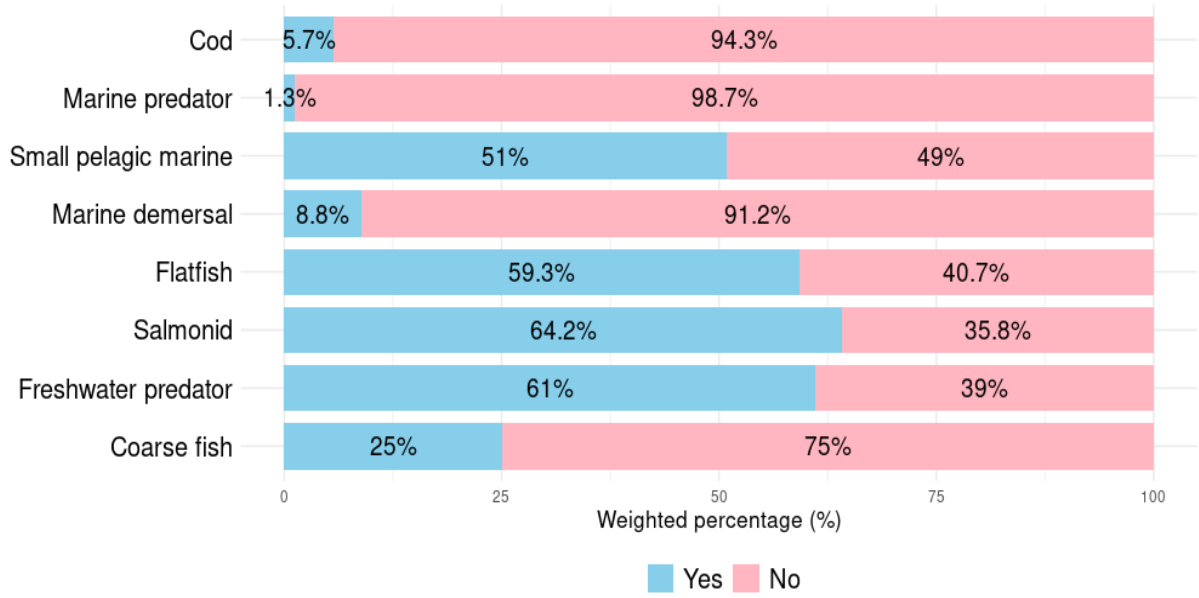

Figure 8. *Weighted percentages of German cod anglers who mentioned (Yes) or did not mention (No) different fish species categories among their top five targeted, following the introduction of the German Baltic Sea cod retention ban.*

4.3.3 Predictors for stated substitution behavior

The linear regression models examining the relationships between German cod anglers' characteristics and their stated fishing behaviours following the 2024 cod retention ban generally provided a better fit than the respective null models when all predictors were included. The exception was the model predicting fishing in inland waters abroad, for which a backward elimination procedure based on the Akaike Information Criterion (AIC) was applied (Annex III). The models predicting continued fishing for other species in the German Baltic Sea and reduced fishing frequency in the German Baltic Sea showed comparatively stronger overall fit (adjusted $R^2 > 0.15$). For the other models, overall explanatory power remained low. In particular, the models predicting fishing activity in the North Sea and in marine waters abroad (Table 19).

Anglers' specialization subdimensions were not significant predictors for most stated behaviours following the 2024 cod retention ban. Psychological commitment was negatively associated with both stopping fishing altogether and engaging more frequently in non-fishing activities, but was not a significant predictor of any resource substitution behaviour. Higher fishing skill was similarly negatively associated with increased engagement in non-fishing activities, and was not a significant predictor of any resource substitution behaviour. Behavioural commitment was not a significant predictor of any stated behavioural outcome (Table 19).

Fishing experience was a significant negative predictor of reduced fishing frequency in the German Baltic Sea following the cod retention ban, and was not a significant predictor of any other stated behavioural outcome (Table 19).

Among cod-specific psychological and behavioural variables, cod attachment was the most consistently significant predictor. Anglers with higher cod attachment were more likely to report fishing less frequently in the German Baltic Sea, ceasing fishing altogether, and increasing their fishing activity for marine species abroad and for other species in general, while being less likely to report continuing to fish for other species within the German Baltic Sea. Self-perceived cod fishing skill was positively associated with both fishing for other

species in general and engaging more frequently in non-fishing activities following the cod retention ban. Cod-specific avidity was a significant predictor only of increased fishing frequency in the North Sea following the ban, and was not a significant predictor of any other stated behavioural outcome (Table 19).

Among the cod catch orientation subdimensions, retention orientation towards cod was the only subdimension that predicted several substitution behaviours following the ban. Anglers with a higher retention orientation were more likely to stop fishing altogether and to engage more frequently in non-fishing activities as a reaction to the 2024 cod retention ban, and were less likely to report fishing in the Bodden brackish lagoons along the German Baltic coast. Anglers who placed greater importance on catching trophy-sized cod were more likely to fish more frequently in German inland waters as a reaction to the ban. No other catch orientation subdimension was a significant predictor of any stated substitution behaviour (Table 19).

Anglers who had identified a greater number of cod fishing constraints prior to the cod retention ban were more likely to report fishing less frequently in the German Baltic Sea and to engage more frequently in non-fishing activities following the ban. The number of identified cod fishing constraints was not a significant predictor of any other stated substitution behaviour (Table 19).

Place attachment towards the German Baltic Sea was a consistent predictor of stated behavioural responses following the 2024 cod retention ban. Anglers with higher place identity were more likely to report continuing to fish for other species within the German Baltic Sea and fishing more frequently in the Bodden waters, whereas those with lower place identity were more likely to report fishing less frequently in the German Baltic Sea, ceasing fishing altogether, increasing their fishing activity in the North Sea, or fishing more frequently in marine waters abroad. Anglers with higher place dependence were less likely to continue fishing for other species after the ban or to fish for marine species abroad, but more likely to report increased fishing in German inland waters and to report stopping fishing altogether. Neither place attachment subdimension was a significant predictor of engaging more frequently in non-fishing activities following the ban (Table 19).

Residential distance to the preferred fishing site was a significant predictor of several behavioural outcomes. Anglers living closer to their preferred Baltic Sea fishing site were more likely to report continuing to fish for other species in the German Baltic Sea, stopping fishing altogether, and engaging more frequently in non-fishing activities. Conversely, anglers living further away were more likely to report fishing less frequently in the Baltic Sea and fishing more frequently in the North Sea. Residential distance to the preferred fishing site was not a significant predictor of any stated behaviour related to substitution in inland waters or marine waters abroad (Table 19).

Anglers' age was a significant predictor only of behaviours related to continued fishing along the German Baltic coast following the cod retention ban. Older anglers were more likely to report reduced fishing frequency in the German Baltic Sea and less likely to report continuing to fish there (Table 19).

Household income was a significant negative predictor only of increased fishing frequency in German inland waters following the ban, and was not a significant predictor of any other stated behavioural outcome (Table 19).

Table 19. *Multiple linear regression results for specialization, cod related fishing behaviour and attitudes, place identity and dependence, and demographic predictors of stated substitution behaviours following the 2024 cod harvest ban in the German Baltic Sea.*

Predictor	Fishing for other species, In general.	Continue to fish other species German Baltic Sea	Fishing more frequently, Bodden waters Baltic Se	Fishing more frequently, North Sea	Fishing more frequently, German inland waters
Fishing experience (years)	0.028 (0.077)	0.032 (0.078)	0.105 (0.072)	0.093 (0.061)	0.132 (0.080)
Behavioural commitment (days/year)	−0.007 (0.067)	0.062 (0.069)	0.058 (0.063)	−0.037 (0.054)	0.058 (0.070)
Psychological commitment [a]	0.006 (0.075)	0.136 (0.077)	−0.101 (0.070)	0.039 (0.060)	0.059 (0.078)
Skill fishing (general)[a]	−0.046 (0.074)	−0.045 (0.076)	−0.002 (0.069)	0.082 (0.059)	−0.117 (0.077)
Cod avidity (days/year)	−0.024 (0.063)	0.040 (0.065)	−0.002 (0.059)	**0.153**** **(0.050)**	−0.052 (0.066)
Cod attachment [a]	**0.166 *** **(0.073)**	**−0.255**** **(0.074)**	0.027 (0.068)	0.038 (0.058)	0.092 (0.075)
Skill for cod fishing [a]	**0.190 **** **(0.072)**	−0.014 (0.074)	−0.035 (0.068)	−0.109 (0.058)	0.059 (0.075)
Catch some cod[a]	−0.095 (0.060)	0.115 (0.062)	0.089 (0.057)	0.008 (0.048)	0.070 (0.063)
Cod numbers[a]	−0.028 (0.066)	−0.060 (0.068)	0.064 (0.062)	−0.020 (0.053)	−0.066 (0.069)
Trophy cod[a]	0.091 (0.061)	−0.001 (0.062)	0.070 (0.057)	−0.006 (0.048)	**0.149 *** **(0.063)**
Retention of cod[a]	0.031 (0.061)	0.065 (0.062)	**−0.126 *** **(0.057)**	−0.006 (0.049)	−0.079 (0.063)
Cod fishing constraints [b]	0.078 (0.056)	−0.055 (0.057)	0.041 (0.053)	−0.002 (0.045)	0.102 (0.058)
Place dependence [a]	**−0.130 *** **(0.064)**	−0.067 (0.065)	−0.025 (0.060)	−0.092 (0.051)	**0.152 *** **(0.066)**
Place identity[a]	0.111 (0.063)	**0.579**** **(0.064)**	**0.177**** **(0.059)**	**−0.100*** **(0.050)**	−0.004 (0.065)
Distance to preferred fishing site (km)	0.032 (0.058)	**−0.187**** **(0.059)**	0.016 (0.054)	**0.099 *** **(0.046)**	−0.065 (0.060)
Age (years)	−0.046 (0.079)	**−0.170*** **(0.081)**	−0.029 (0.074)	0.015 (0.063)	0.022 (0.082)
Income (€)	−0.105 (0.057)	0.012 (0.058)	−0.055 (0.053)	−0.007 (0.045)	**−0.154 **** **(0.059)**
F-value	**2.74*****	**8.71*****	**1.75***	**2.16***	**2.79*****
R^2*(adjusted)*	**0.05**	**0.2**	**0.02**	**0.004**	**0.06**

N= 523

[a] items scales detailed in Table1 to Table 4.

[b] item scale detailed in Table

Note. Standardized β coefficient estimates are presented. Significant ($p < 0.05$) estimates are shown in boldface. Standard errors are in parentheses below. The level of significance is presented with asterisks next to the coefficient:

*p < 0.05, **p < 0.01, ***p < 0.001.

Table 19. *Continuation.*

Predictor	**Fishing less, German Baltic Sea** (a)	**Fishing more frequently, Marine waters abroad**	**Fishing more frequently, inland waters abroad**	**Stop fishing, in general**	**Practising other, non-fishing, activities**
Fishing experience (years)	**−0.125 *** (0.058)**	−0.014 (0.089)	—	−0.077 (0.044)	0.032 (0.071)
Behavioural commitment (days/year)	−0.025 (0.051)	−0.094 (0.078)	—	−0.027 (0.039)	−0.057 (0.062)
Psychological commitment [a]	−0.079 (0.057)	0.031 (0.087)	—	**−0.087* (0.043)**	**−0.237 *** (0.069)**
Skill fishing (general)[a]	−0.008 (0.057)	0.035 (0.086)	—	−0.052 (0.043)	**−0.140 * (0.068)**
Cod avidity (days/year)	−0.091 (0.048)	0.044 (0.073)	—	0.029 (0.036)	−0.024 (0.058)
Cod attachment[a]	**0.209** (0.055)**	**0.303 *** (0.084)**	0.09 (0.058)	**0.137** (0.042)**	0.014 (0.067)
Skill for cod fishing[a]	0.088 (0.055)	0.044 (0.083)	—	−0.007 (0.042)	**0.152 * (0.066)**
Catch some cod[a]	0.016 (0.046)	0.009 (0.070)	—	0.038 (0.035)	0.045 (0.056)
Cod numbers[a]	0.031 (0.051)	−0.010 (0.077)	—	−0.008 (0.038)	0.014 (0.061)
Trophy cod[a]	−0.034 (0.046)	−0.016 (0.070)	—	−0.012 (0.035)	0.060 (0.056)
Retention of cod[a]	0.020 (0.047)	−0.131 (0.071)	—	**0.095 ** (0.035)**	**0.118* (0.056)**
Cod fishing constraints[b]	**0.117** (0.043)**	0.089 (0.065)	—	−0.014 (0.032)	**0.115 * (0.052)**
Place dependence[a]	0.090 (0.048)	**−0.466*** (0.074)**	—	**0.081* (0.037)**	0.099 (0.058)
Place identity[a]	**−0.322 ** (0.048)**	−0.080 (0.073)	**−0.144 * (0.058)**	**−0.128** (0.036)**	−0.100 (0.058)
Distance to preferred fishing site (km)	**0.109 * (0.044)**	0.127 (0.067)	—	**−0.071* (0.033)**	**−0.112 * (0.053)**
Age (years)	**0.164** (0.060)**	0.140 (0.091)	—	0.082 (0.046)	−0.012 (0.073)
Income (€)	0.007 (0.043)	0.054 (0.065)	—	0.013 (0.033)	−0.021 (0.052)
F-value	**7.57*** **	**4.53*** **	**3.37***	**4.80*** **	**4.66*** **
R^2(adjusted)	**0.17**	**0.10**	**0.008**	**0.11**	**0.11**

N= 523

[a] items scales detailed in Table1 to Table 4.

[b] item scale detailed in Table

Note. Standardized β coefficient estimates are presented. Significant ($p < 0.05$) estimates are shown in boldface. Standard errors are in parentheses below. The level of significance is presented with asterisks next to the

coefficient: *p < 0.05, **p < 0.01, ***p < 0.001.
The missing values (--) in the table represent variables that were not used as predictors in a particular of the models.
Missing values indicate predictors that were not retained in the final models. When the full models (including all predictors) did not outperform the null models, a backward selection procedure based on the Akaike Information Criterion (AIC) was applied. Only predictors included in the model with the lowest AIC are reported.

(a) *The fishing less in the German Baltic Sea score was derived from the composite score of three survey items: (1)I have stopped fishing on the German Baltic Sea coast, (2) I go or went fishing on the German Baltic Sea coast much less often than before, and the reversed score of the item (3)I go or went fishing on the German Baltic Sea coast much more often than before.*

4.3.4 Predictors for stated species substitution

The logistic regression models examining the relationship between angler characteristics and the targeting of different species categories following the 2024 cod retention ban generally provided a better fit than the respective null models when all predictors were included. The exception was the model predicting the targeting of marine predatory species, for which a backward elimination procedure based on the Akaike Information Criterion (AIC) was applied (Annex III). The models predicting the selection of marine predatory species, salmonids, and freshwater coarse species showed weak overall fit (McFadden $R^2 < 0.10$) (Table 20).

Regarding fishing specialization, anglers with higher behavioural commitment were less likely to target marine flatfish following the ban but more likely to target freshwater predatory species. Anglers with higher psychological commitment were more likely to target freshwater coarse species after the ban and less likely to target small marine pelagic species. Higher general fishing skill was negatively associated with targeting freshwater coarse species, but was not a significant predictor of targeting any marine species category following the ban. Behavioural commitment, psychological commitment, and fishing skill were not significant predictors of targeting salmonids, marine demersal species, or cod outside the German Baltic Sea (Table 20).

Angler with more years of fishing experience were more likely to target flatfish species following the ban. The predictor was not significant for the targeting of any other species category (Table 20)

Regarding cod-specific psychological and behavioural variables, anglers with higher cod-specific avidity were more likely to target small marine pelagic species and marine flatfish, and less likely to target freshwater predatory species following the ban. Higher self-perceived cod fishing skill was positively associated with targeting other marine demersal species, and was not a significant predictor of targeting any other species category. Cod attachment was not a significant predictor of targeting any species category following the ban (Table 20).

Among catch orientation subdimensions, the importance placed on catching cod and retention orientation were significant predictors for the targeting of certain species categories. Anglers who placed greater importance on catching cod during a fishing trip were less likely to target small marine pelagic species or marine flatfish following the ban. Anglers with higher retention orientation were less likely to target freshwater predatory species. No other catch orientation subdimension was a significant predictor of targeting any species category following the ban (Table 20).

Anglers who perceived a greater number of cod fishing constraints prior to 2024 were less likely to target small marine pelagic species and more likely to target freshwater coarse species following the ban. The number of identified cod fishing constraints was not a significant predictor of targeting any other species category (Table 20).

Place identity towards the German Baltic Sea was a consistent predictor across most species' models. Anglers with higher place identity scores were less likely to target cod outside the German Baltic Sea or other marine demersal species following the ban, but more likely to target small marine pelagic species, marine flatfish, and salmonids. Anglers with higher place dependence towards the German Baltic Sea were less likely to target marine predatory species following the ban and more likely to target freshwater coarse species. Place dependence was not a significant predictor of targeting any other species category (Table 20).

Residential distance to the preferred Baltic Sea fishing site was negatively associated with targeting small marine pelagic species and marine flatfish, and positively associated with targeting freshwater coarse species, and was not a significant predictor of targeting any other species category. Younger anglers were more likely to target salmonids or freshwater predatory species in response to the ban, and age was not a significant predictor of targeting any other species category. Household income was not a significant predictor of post-ban species targeting for any species category (Table 20).

Table 20*.Logistic regression results for specialization, cod related fishing behaviour and attitudes, place identity and dependence, and demographic predictors of selecting fish species categories among top five targeted species, following the introduction of the German Baltic Sea cod retention ban.*

Predictor	Cod (other locations)	Marine predator	Small pelagic marine	Marine demersal	Marine flatfish	Salmonid	Freshwater predator	Coarse fish (Freshwater)
Fishing experience (years)	0.142 (0.288)	—	0.070 (0.134)	0.077 (0.238)	**0.334 * (0.137)**	0.039 (0.132)	−0.009 (0.145)	0.058 (0.152)
Behavioural commitment (days/year)	−0.188 (0.316)	—	−0.304* (0.133)	−0.620 (0.360)	**−0.312* (0.130)**	0.201 (0.136)	**0.415 * (0.186)**	0.154 (0.121)
Psychological commitment [a]	0.069 (0.282)	—	**−0.267 * (0.131)**	−0.067 (0.240)	0.003 (0.133)	0.077 (0.133)	0.087 (0.150)	**0.464 ** (0.146)**
Skill fishing (general)[a]	−0.404 (0.303)	—	−0.127 (0.128)	−0.372 (0.256)	−0.077 (0.130)	0.132 (0.133)	0.190 (0.157)	**−0.351 * (0.142)**
Cod avidity (days/year)	−0.010 (0.359)	—	**0.265 * (0.130)**	0.195 (0.281)	**0.492 ** (0.177)**	0.001 (0.138)	**−0.556 *** (0.157)**	−0.350 (0.189)
Cod attachment[a]	0.448 (0.286)	—-	0.121 (0.128)	−0.134 (0.238)	0.103 (0.131)	0.005 (0.131)	−0.051 (0.148)	−0.199 (0.145)

Skill for cod fishing[a]	0.439 (0.280)	—	0.181 (0.128)	**0.751** (0.253)**	0.203 (0.131)	0.004 (0.130)	−0.283 (0.156)	0.023 (0.139)
Catch some cod[a]	0.255 (0.204)	—	**−0.230 (0.105)***	−0.131 (0.202)	**−0.217 (0.106)***	0.046 (0.108)	0.094 (0.127)	−0.013 (0.116)
Cod numbers[a]	0.034 (0.242)	—	−0.042 (0.115)	0.003 (0.218)	−0.013 (0.118)	−0.128 (0.118)	0.017 (0.137)	−0.003 (0.128)
Trophy cod[a]	0.370 (0.248)	—	0.009 (0.106)	0.406 (0.219)	0.057 (0.108)	−0.052 (0.110)	0.122 (0.125)	−0.158 (0.119)
Retention of cod[a]	0.276 (0.228)	—	0.114 (0.106)	0.087 (0.199)	0.102 (0.108)	−0.164 (0.107)	**−0.346 (0.123)** **	0.203 (0.117)
Cod fishing constraints[b]	0.019 (0.181)	—	**−0.253 (0.098)*** *	−0.029 (0.173)	−0.031 (0.099)	0.051 (0.101)	0.102 (0.115)	**0.254 (0.100)***
Place dependence[a]	−0.457 (0.237)	**−0.596 (0.233)***	−0.208 (0.113)	−0.107 (0.205)	−0.051 (0.114)	−0.051 (0.113)	0.148 (0.130)	**0.324 (0.125)****
Place identity[a]	**−0.439 (0.190)***	—	**0.292 (0.115)***	**−0.571 (0.165)**** *	**0.285 (0.119)***	**0.403 (0.114)*****	0.061 (0.126)	−0.168 (0.113)
Distance to preferred fishing site (km)	0.360 (0.204)	0.354 (0.197)	**−0.204 (0.101)***	0.252 (0.178)	**−0.384 (0.105)**** *	**0.245 (0.107)***	−0.038 (0.117)	**0.332 (0.110)****
Age (years)	0.069 (0.301)	—	0.126 (0.139)	0.327 (0.250)	−0.096 (0.141)	**−0.317 (0.139)***	**−0.416 (0.156)****	−0.063 (0.156)
Income (€)	−0.018 (0.207)	—	−0.041 (0.100)	−0.256 (0.188)	0.020 (0.101)	0.195 (0.104)	0.033 (0.116)	−0.120 (0.112)
LR χ^2	**34.05***	**16.41***	**73.43*** *	**46.20****	**86.76*****	**51.34*****	**63.14*****	**54.72*****
McFadden R^2	**0.15**	**0.06**	**0.10**	**0.16**	**0.12**	**0.07**	**0.11**	**0.09**

N= 523

[a] items scales detailed in Table1 to Table 4.

[b] item scale detailed in Table

Note. Standardized β coefficient estimates are presented. Significant ($p < 0.05$) estimates are shown in boldface. Standard errors are in parentheses below. The level of significance is presented with asterisks next to the coefficient: *$p < 0.05$, **$p < 0.01$, ***$p < 0.001$.

The missing values (--) in the table represent variables that were not used as predictors in a particular of the models.

Missing values indicate predictors that were not retained in the final models. When the full models (including all predictors) did not outperform the null models, a backward selection procedure based on the Akaike Information Criterion (AIC) was applied. Only predictors included in the model with the lowest AIC are reported.

4.4 Comparison between perfect substitution selection and stated behavioral responses

The comparison test between perfect substitution selection and stated behavioural responses partially supported the sixth hypothesis of this thesis:

H6. Anglers who identify perfect substitutes for cod fishing are more likely to exhibit corresponding substitution behaviours following the 2024 cod harvest ban.

The Chi-square tests of independence used for the comparisons generally revealed strong associations, with the exception of substitution involving freshwater fishing (Table 21).

Specifically, the selection of fishing for other species in the German Baltic Sea as a perfect substitute was strongly associated with the stated behaviour of continuing to fish for other species in the same area following the ban. The selection of fishing for other species in the German North Sea, fishing for other marine species abroad, and engaging in non-fishing leisure activities as perfect substitutes each showed moderate associations with their corresponding stated behavioural responses (Table 21).

In contrast, the selection of freshwater fishing abroad as a perfect substitute exhibited only a weak association with the corresponding stated behaviour of fishing in inland waters abroad. The selection of freshwater fishing in Germany as a perfect substitute showed no statistically significant association with the corresponding stated behavioural response (Table 21).

Table 21. *Percentages and in brackets frequencies of responses, chi-square tests of independence scores and Cramér's V scores between the selection of perfect substitutes activities for cod fishing in the German Baltic Sea and equivalent sated behaviors reported after the 2024 German Baltic cod retention ban.*

		Perfect substitute: Fishing other species, German North Sea			
		No	**Yes**		
Stated behavior: Fishing more frequently, North Sea	**Disagree**	76% (326)	4.4% (19)		
	Neutral	7.7% (33)	2.3% (10)		
	Agree	5.6% (24)	14 (3.2%)	**$\chi^2(2) = 46.2^{***}$**	**Cramér's V=0.33**
		Perfect substitute: Fishing other species, German Baltic Sea			
		No	**Yes**		
Stated behavior: Continue to fish other species German Baltic Sea	**Disagree**	19.5% (83)	5.4% (23)		
	Neutral	5.2% (22)	5.2% (22)		
	Agree	11.7% (50)	53% (226)	**$\chi^2(2) = 123.8^{***}$**	**Cramér's V=0.54**
		Perfect substitute: Freshwater fishing, Germany			

		No	Yes		
Stated behavior: Fishing more frequently, German inland waters	**Disagree**	*17.4% (74)*	*35.7% (152)*		
	Neutral	7.5% (32)	16.2% (69)		
	Agree	5.6% (24)	17.6% (75)	**$\chi^2(2) = 2.43$**	
		Perfect substitute: Freshwater fishing, abroad			
		No	**Yes**		
Stated behavior: Fishing more frequently, Inland waters abroad	**Disagree**	54% (230)	14.3% (61)		
	Neutral	12.4% (53)	5.2% (22)		
	Agree	7.7% (33)	6.3% (27)	**$\chi^2(2) = 15.59$*****	**Cramér's V=0.19**
		Perfect substitute: Fishing for other marine species abroad.			
		No	***Yes***		
Stated behavior: Fishing more frequently, on the coasts of other European countries	**Disagree**	29.5% (126)	19.0% (81)		
	Neutral	5.2% (22)	9.2% (39)		
	Agree	7.3% (31)	29.8% (127)	**$\chi^2(2) = 63.62$*****	**Cramér's V=0.39**
		Perfect substitute: Other leisure activities apart from fishing.			
		No	**Yes**		
Stated behavior: pursuing other leisure activities more often than fishing.	**Disagree**	31.7% (166)	32.1% (168)		
	Neutral	6.5% (34)	11.1% (58)		
	Agree	6.1% (32)	12.4% (65)	**$\chi^2(2) = 10.98$****	**Cramér's V=0.14**

N= 426

Note. Chi square tests of independence χ^2 scores are presented. Significant ($p < 0.05$) estimates are shown in boldface. Degrees of freedom are shown in parenthesis. The level of significance is presented with asterisks next to the χ^2 scores:

*p < 0.05, **p < 0.01, ***p < 0.001.

Cramers V scores are presented for significant results. values between 0.1 and 0.2 were interpreted as weak associations, between 0.2 and 0.4 as moderate associations and greater than 0.4 as strong associations.

The frequency of stated behavior responses were derived from respondents' ratings to substitution statements on a five-point Likert scale: 1 ("do not agree at all") ,2 ("rather do not agree") ,3 ("neither agree nor disagree") , 4 ("rather agree") and 5 ("fully agree") .

The seventh and final hypothesis of this thesis was supported:

H7: Fish species perceived as perfect substitutes for cod are more likely to be targeted by anglers after the 2024 cod harvest ban.

For all 20 species most frequently identified as perfect substitutes for German Baltic cod, anglers who listed a given species as a perfect substitute assigned it a lower mean targeting rank, indicating higher targeting preference, than anglers who did not. These differences in targeting rank were statistically significant across all 20 species examined (Table 22).

For most substitute species, the proportion of anglers who targeted them after 2024 exceeded the proportion who had identified them as perfect substitutes. The opposite pattern was observed for a subset of species: cod targeted outside the German Baltic Sea and halibut (*Hippoglossus hippoglossus*) were more frequently listed as perfect substitutes than they were actually targeted after the ban (Table 22).

Table 22. *Top 20 species selected as perfect substitutes for cod fishing in the German Baltic Sea and their post-2024 target preferences among anglers who did and did not consider them perfect substitutes. The p value of Mann-Whitney U tests is presented for testing the difference between the groups.*

Top 20 perfect substitute species	**percentage of selection (perfect substitute)**	**percentage of selection (target species)**	**Mean target rank (Mentioned as a perfect substitute)**	**Mean target rank (Not mentioned as a perfect substitute)**	**Mann-Whitney *U* test p value**
Sea trout (*Salmo trutta)*	38.5	49.8	2.6	5.2	<0.0005
Zander (*Sander lucioperca*)	24.5	51.2	2.7	4.9	<0.0005
Pike (*Esox lucius*)	23.8	47.1	2.8	5	<0.0005
Perch (*Perca fluviatilis*)	20.3	47.9	2.6	4.9	<0.0005
Flounder (*Platichthys solemdali*)	17.6	33.8	3.6	5.3	<0.0005
Plaice (*Pleuronectes*	15.5	33.2	3.6	5.3	<0.0005

platessa)					
Garfish (*Belone belone*)	15.5	30.0	3.6	5.5	<0.0005
Herring (*Clupea harengus*)	12.2	26.3	3.3	5.5	<0.0005
Cod (*Gadus morhua*) *	9.6	6.1	4.9	5.9	<0.0005
Brown trout (*Salmo trutta*)	8.6	16.4	2.8	5.7	<0.0005
Mackerel (*Scomber scombrus*)	8.4	20.0	4.4	5.6	<0.0005
Pollock (*Pollachius pollachius*)	7.5	7.5	4.4	5.9	<0.0005
Halibut (*Hippoglossus hippoglossus)*	7.0	4.7	5.1	5.9	<0.0005
European eel (*Anguilla anguill*a)	6.1	13.6	3.4	5.7	<0.0005
Rainbow trout (*Oncorhynchus mykiss*)	4.7	14.3	3.2	5.7	<0.0005
Salmon (*Salmo salar*)	4.7	3.5	4.1	6	<0.0005
Carp (*Cyprinus carpio*)	4.5	13.6	2.5	5.8	<0.0005
Dab (*Limanda limanda*)	3.9	9.4	4.9	5.8	<0.0005
Sea bass (*Dicentrarchs labrax*)	3.8	4.0	4.2	6	<0.0005
Small-bodied cyprinids (Weissfische)	2.6	8.2	3.9	5.9	<0.0005

N=426

Note. The reported percentages for the selection of perfect substitutes and targeted species are unweighted and represent only the proportion within the analysed sample (N = 426); they do not constitute population-level estimates.

Mean target ranks were calculated based on the position each participant assigned to a species within their list of the five most frequently targeted species after 2024 (rank 1 = most frequently targeted; rank 5 = least frequently targeted). Species not included in a participant's ranking were assigned a value of 6.

The p-values reported for the Mann–Whitney U tests were adjusted using Bonferroni corrections.

5. Discussion

The broad objective of this thesis was to analyze perfect substitute selection and stated substitution behaviors among German cod anglers following the 2024 cod retention ban in the western Baltic Sea. I used a range of statistical models were used to examine the relationships between angler characteristics and substitution responses. The findings and their theoretical interpretations should therefore be regarded as exploratory, as the methods used do not permit causal inference between angler characteristics and substitution preferences and behaviors.

The strength of model fit varied across models, though overall predictive power was low. In general, the models predicting broad perfect substitution preferences performed better than those predicting the selection of specific species or activity types, while the models predicting stated behavior were generally weak. This could be in a way an illustration of the difference between perfect substitutability perception and actual substitution behavior. Actual fishing behavior depends on many external factors that cannot be captured through measures of internal angler characteristics alone (Hunt et al., 2019).

The results provide preliminary evidence on how German recreational cod anglers perceive and engage in substitution alternatives following the 2024 retention ban on Atlantic cod in the German Baltic Sea. Of the seven hypotheses tested, two were fully supported, three were partially supported, and two were not supported (Table 23).

In the first part of this discussion, I addressed the results concerning perfect substitution preferences, for both non-fishing and fishing alternatives, and the corresponding stated substitution behaviours following the ban. In the second part, I examined how the different predictors analysed were, or were not, significant in predicting perceived perfect substitutability for cod fishing in the German Baltic Sea, as well as stated substitution behaviours following the ban. In the final part I discussed the relationship between perfect substitution preferences and stated behavioural substitution responses.

Table 23. *Summary of hypothesis testing results*

Hypothesis	Result
H1. Angler specialization subdimensions are negative predictors of non-fishing activity substitution.	**Partially supported.** Only psychological commitment was a significant negative predictor; behavioral commitment and skill were not significant.
H2. Angler specialization subdimensions are predictors of non-fishing activity type selection.	**Not supported.** Psychological commitment significantly predicted only outdoor non-consumptive activity selection; no subdimension was a consistent predictor across activity types.
H3. Cod-specific psychological and behavioral variables are negative predictors of perfect species substitution.	**Partially supported.** Cod attachment, and cod avidity were negative predictors for selecting some species, but not consistently across all categories.

Hypothesis	Result
H4. Anglers with lower place attachment to the German Baltic Sea are more likely to perceive sites away from the Baltic Sea as equally enjoyable.	**Supported.** Place dependence was a consistent negative predictor across all substitution alternatives located away from the German Baltic Sea.
H5. Cod catch orientation subdimensions are predictors of perfect species substitution.	**Not supported.** None of the four catch orientation subdimensions significantly predicted the selection of any species category as a perfect substitute.
H6. Anglers who identify perfect substitutes are more likely to exhibit corresponding substitution behaviors.	**Partially supported.** Strong correspondence for Baltic Sea species substitution, moderate correspondence for substitution away from the Baltic Sea, and weak or non-significant correspondence for freshwater and non-fishing substitution.
H7. Species perceived as perfect substitutes are more likely to be targeted after the ban.	**Supported.** Across all 20 species examined, perceived perfect substitutability significantly predicted post-ban targeting**.**

5.1 Perfect and stated substitution behavior

5.1.1 Activity substitution

The results of this thesis indicate that, while many cod anglers consider recreational fishing to be irreplaceable, a majority recognised alternative activities as capable of providing comparable enjoyment. These findings are similar to the frequency of non-fishing activity substitutes reported for saltwater anglers in Queensland, Australia (59% in Sutton & Oh, 2015; 60% in Gentner & Sutton, 2008), and higher than that reported for saltwater angler populations in Texas and Florida (51% in Ditton & Sutton, 2004).

Substitution theory suggests that activities are perceived as perfect substitutes when they fulfil the same experiential benefits sought in the original activity (Manfredo & Anderson, 1987; Vaske et al., 1983). Given that recreationists seek substitute activities that provide a similar temporary escape from the constraints of everyday non-leisure life (Knopf, 1976), it is not surprising that many anglers did not consider non-fishing activities equally satisfying as fishing. Specially, taking into account that German anglers have been characterised as deriving much of their fishing satisfaction from the possibility of catching fish (Arlinghaus, 2006). Among those who recognize non fishing activities as perfect substitutes, outdoor active activities were selected most frequently, likely because, similarly to fishing, they provide opportunities to engage actively with the natural outdoor environment. The most frequently selected substitutes, cycling and hiking, share with angling the possibility of being pursued along the coast, reinforcing the argument of functional similarity of perceived substitutes.

In contrast to findings from the United States, where many anglers identified hunting as a perfect substitute (Ditton & Sutton, 2004), outdoor consumptive activities were selected by only a minority of German cod anglers, and specifically hunting only by 5 %. Cultural differences in human-wildlife value orientations could explain this difference. Residents of the United States have been characterised as more broadly dominance-oriented towards wildlife, viewing it primarily as a resource to be used, in comparison, German resident tend to hold a more mutualistic orientation towards nature (Manfredo et al., 2026). These

difference in social values, and the fact that hunting is highly regulated in Germany (Bundesjagdgesetz [BJagdG], 1952/1976), may be an explanation for the lower appeal of hunting in the German context.

Only about half of anglers who reported having a perfect activity substitute also reported engaging more frequently in non-fishing activities following the 2024 cod retention ban. From an economic perspective, this gap is theoretically expected: leisure participation involves trade-offs between monetary costs and the opportunity cost of time (Becker, 1965). This means that recreationists are constrained by financial resources, time availability, and participation in other activities and therefore do not reallocate their entire leisure time a towards a single most preferred activity (Hunt et al., 2019, Gentner & Sutton, 2008). Leisure research has similarly emphasised that multiple factors intervene between the identification of an equally satisfying substitute and actual behavioural substitution, including structural, intrapersonal, and interpersonal constraints that limit the translation of preferences into participation (Brunson & Shelby, 1993; Gentner & Sutton, 2008; Crawford & Godbey,1987).

Importantly for management, the results of this thesis suggest that the 2024 cod retention ban is having an effect on the broader recreational landscape of the German Baltic coast. Approximately one third of anglers increased their participation in non-fishing recreational activities following the ban. Based on the pattern of perfect substitute selections, it is reasonable to infer that most of this increase was directed towards outdoor non-consumptive activities such as cycling or hiking. Considering that more than 60% of anglers reported reduced fishing participation in the German Baltic Sea after the cod retention ban, and that a substantial proportion of cod anglers identified a perfect non-fishing substitute, there is potential for further effort spill over towards non-fishing activities in the future.

5.1.2 Marine resource substitution

The finding that fishing for other species in the German Baltic Sea was selected, both as perfect substitute and as a behavioral response following the cod retention ban, by the majority of German cod anglers is consistent with substitution and economic theory. Fishing for other species in the German Baltic Sea is the alternative most similar to cod fishing in the same location in terms of setting, and associated costs (Manfredo & Anderson, 1987; Vaske et al., 1983; Hunt, 2005). Previous studies have identified within-location species substitution as a key coping mechanism when anglers face constraints in targeting their preferred species (Metcalf et al., 2010; Sutton & Ditton, 2005).

However, the finding that around 38% of anglers did not consider other saltwater species in the German Baltic Sea to be perfect substitutes is notable. This proportion is considerably higher than that reported in other saltwater recreational fisheries (14% in Sutton and Ditton (2005) and 32% among shark anglers in the Gulf of Mexico in Fisher & Ditton (1993)) and may indicate a comparatively stronger attachment to cod as a target species among German anglers. Strong species-specific attachment has previously been identified as a factor limiting anglers' willingness to substitute their preferred species (Gentner & Sutton, 2008; Dorow et al., 2010).

Fewer anglers considered fishing for saltwater species abroad to be a suitable alternative compared to fishing for other species within the German Baltic Sea, despite the broader range of potential target species available internationally (Hyder et al., 2018; Radford et al., 2018). This pattern was consistent across both perfect substitution preferences and stated substitution behavior. Travel costs, both financial and in terms of time investment, are a well-established determinant of where anglers choose to fish (Hunt, 2005; Hunt et al., 2019), and of their perception of alternative sites as perfect substitutes (Fisher & Ditton, 1993). Fishing in marine waters abroad represents a greater cost than targeting other species within the

German Baltic Sea and this factor probably constrains many cod anglers to make substitution decisions within the German Baltic Sea area.

An interesting finding was that fewer anglers selected fishing for cod abroad than fishing for other species abroad as a perfect substitute for cod fishing in the German Baltic Sea, despite the former being more similar to their preferred activity in terms of target species. While fishing for other marine species abroad does not necessarily imply long travel distances, as it can be pursued in bordering countries, fishing for cod specifically may require traveling to more distant destinations, for example Norway, which is a well-established cod fishing tourism destination frequently visited by German anglers (Vølstad et al., 2020; Table 13). This suggests that, for most anglers, continue fishing cod in other destinations represents a too costly a substitution alternative to be feasible, and therefore the cod fishing spillover to other countries appears to remain modest.

The German North Sea was selected as a perfect and behavioural substitution alternative only by a minority of anglers. Fishing quality is one of the primary attributes' anglers consider when selecting fishing locations (Hunt, 2005; Hunt et al., 2019), and the North Sea is generally perceived as offering lower fishing quality than the German Baltic Sea and is not regularly used by German recreational anglers (Lewin et al., 2023; Weltersbach et al., 2021).

The majority of marine fishing spillover following the ban appears to have been redirected toward other marine species within the German Baltic Sea. Indirect estimates from this thesis, comparing the selection of preferred target species in 2020 with the frequencies of preferred target species reported in 2024, suggest that the cod retention ban was associated with an approximately 10% increase in the targeting of Baltic Sea species such as sea trout, flounder, and herring. Taking the estimate of 160,000 German Baltic Sea recreational anglers reported by Weltersbach et al. (2021), this would imply an increase of approximately 16,000 anglers redirecting their effort towards other, less regulated Baltic Sea species following the ban. This could be particularly concerning in the case of sea trout, for which there is existing evidence of declining recruitment and population decline in Germany (ICES, 2025; Dębowski, 2018). The results of this thesis in this regard support the call for increased monitoring of recreational sea trout fishing recommended by the ICES Baltic Salmon and Trout Assessment Working Group (2025), as, at least in Germany, there could be the possibility of an increase in recreational targeting of this species as a direct consequence of the cod retention ban that should be accounted for in the management of sea trout populations.

5.1.3 Freshwater resource substitution

A substantial proportion of anglers recognised freshwater species as perfect substitutes for cod. Given the importance of similarity in environmental setting and fishing experience in substitution theory (Sutton & Ditton, 2005; Gentner & Sutton, 2008), this result is not immediately intuitive, as it implies the substitutability of a marine resource with a freshwater one. However, several complementary explanations can account for this finding.

First, many of the most frequently selected freshwater species are valued for harvest and consumption, particularly among East German anglers (Dorow et al., 2010; Birdsong et al., 2025). Second, the most frequently selected freshwater perfect substitutes (pike, zander, and perch) are commonly targeted in the brackish "Bodden" lagoons along the German Baltic coast (Lewin et al., 2023; Erlich et al., 2023), meaning that fishing for these species does not necessarily require a complete change in location or the additional costs associated with travel and fishing permits in other states. Supporting this interpretation, is the finding that inland fishing abroad was selected as a perfect substitute by a considerably smaller proportion of anglers than domestic inland fishing.

Beyond these reasons, a broader explanation may lie in German angling culture more generally. The majority of German anglers fish primarily in freshwater, with only 12% reporting saltwater as their main fishery in a nationwide survey conducted in 2002 (Arlinghaus, 2004; 2008). This indicates that most cod anglers are not exclusively saltwater anglers and were likely already active freshwater fishers prior to targeting cod in the Baltic Sea. This interpretation is supported by the description of the cod angling population favorite targets before the cod retention ban (Table 11). Before the ban, many cod anglers already reported freshwater predators among their top five target species, suggesting that freshwater fishing represented a common practiced activity for many.

Not all freshwater species were considered perfect substitutes with equal frequency. Freshwater predators were selected by a large proportion of anglers, while coarse fish and freshwater salmonids were chosen by a minority. A plausible explanation lies again in the distribution of species across the Bodden lagoons along the German Baltic coast. Coarse fish species such as carp and salmonid species such as brown trout are not typically present in these brackish lagoons (Lewin et al., 2023). For cod anglers residing close to the Baltic coast in particular, targeting these species would therefore require a more substantial change in setting.

Additionally, cod anglers have been characterised as deriving greater utility from capturing large individual fish than from catching large numbers of fish (Bronnmann et al., 2023). The freshwater predators most frequently selected as perfect substitutes, pike and zander, are similarly associated with trophy-oriented angling (Arlinghaus et al., 2014), particularly when targeted in the Bodden lagoons along the Baltic coast (Koemele et al., 2021). In contrast, freshwater salmonid angling is not typically characterised by trophy-seeking behaviour (Arlinghaus et al., 2014), and most coarse fish species do not hold trophy value (Beardmore et al., 2015). The comparatively lower selection of these species as perfect substitutes is therefore consistent with the catch expectations of cod anglers, for whom the capture and consumption of large fish represents an important source of angling satisfaction.

Despite that the majority of cod anglers (61%) selected inland fishing in Germany as a perfect substitute alternative, the proportion of anglers reporting an increase in freshwater fishing following the cod retention ban was considerably smaller (30%). Given that the majority of cod anglers were likely already active freshwater fishers prior to the ban (Arlinghaus, 2004), many were probably already allocating a substantial portion of their available leisure time and financial budget to freshwater fishing, and had limited capacity to further increase their participation.

In summary, although most cod anglers considered freshwater species within Germany to be perfect substitutes for cod, the effort spillover towards freshwater resources is likely to remain limited, as many anglers were probably already targeting these species regularly prior to the ban. Nevertheless, the widespread recognition of freshwater fishing as equally enjoyable to cod fishing means that targeting pressure on freshwater species could increase in the future, particularly if access to alternative marine species in the Baltic Sea becomes more restricted. This is of particular concern for freshwater predators in the Bodden lagoons along the German Baltic coast, where stocks of species such as pike are already in decline, in part due to recreational fishing pressure (Ehrlich et al., 2023).

5.2 Main predictors of perfect and stated substitution behavior

5.2.1 Specialization

Angler specialization has been commonly used in the recreational fishing literature to capture angler heterogeneity based on the degree of involvement with the activity (Bryan, 1977; Ditton et al., 1992; Scott & Shafer, 2001; Beardmore et al., 2013). Following Scott and Shafer (2001), this thesis used behavioural commitment, psychological commitment, and skill as subdimensions of angler specialization.

Psychological commitment, understood as emotional involvement with fishing, was a negative predictor of considering non-fishing activities as equally satisfying as cod fishing. These results are consistent with previous studies that have found the same negative relationship (Sutton, 2006; Sutton & Oh, 2015). Regarding specific activity types, psychological commitment was also a negative predictor of selecting outdoor non-consumptive active activities such as cycling or hiking as perfect substitutes. Given that the possibility of catching fish is a key component for satisfaction among most anglers (Arlinghaus, 2006), it follows that the most psychological committed to fishing are less likely to find equal satisfaction in outdoor activities that by definition do not provide them with this possibility.

Psychological commitment and general self-perceived fishing skill were a negative predictors of engaging more frequently in non-fishing activities following the cod retention ban. From an economic perspective, recreational substitution behaviours represent a utility maximisation response to changed conditions (Gentner & Sutton, 2008; Hunt et al., 2019). More involved recreationists are expected to identify a greater array of satisfying attributes in their fishing experience and, at the same time, to have greater financial, social, or emotional investments tied to the activity (Ditton et al., 1992). Relatedly, more committed anglers have been shown to be more willing to sustain fishing restrictions in order to continue with the activity (Koemle et al., 2024). It is therefore consistent that more psychologically committed and more skilful anglers were less likely to engage in non-fishing activities in response to the cod retention ban. The same reasoning helps explain why greater psychological commitment was negatively associated with stopping fishing altogether following the ban.

Behavioural commitment, measured as fishing avidity, was not a significant predictor of perfect activity substitution or stated substitution behaviour following the cod retention ban. Similarly, Choi et al. (1994) reported no relationship between behavioural commitment and perfect activity substitution among Texas saltwater anglers. Taken together, these results suggest that the psychological dimension of angler specialization, rather than its behavioural component, plays a more important role in shaping the acceptance of non-fishing activity substitutes among German cod anglers.

The three specialization subdimensions were not consistent predictors of resource substitution preferences, particularly regarding the selection of other species within the German Baltic Sea. This result supports Sutton and Ditton's (2005) proposition that species substitution is not a behaviour unique to the most committed anglers, but rather a coping strategy accessible to most anglers regardless of their degree of involvement. Given that fishing for other marine species in the German Baltic Sea probably represents the alternative most similar in terms of setting and costs for most anglers, it is reasonable that it is considered a satisfying substitution option across the full spectrum of angler involvement.

It is important to note that the limited explanatory power of the behavioral commitment for resource substitution is probably in part attributable to the nature of data collection in this

survey, as discussed further in the limitations section. The responses analysed are likely biased towards more avid anglers, as illustrated by the mean fishing avidity of 45 days per year among respondents, which is considerably higher than the 13 days per year reported for a broader sample of German saltwater anglers (Weltersbach et al., 2021). This sampling bias means that the results presented here may not capture the full spectrum of behavioral commitment within the German cod angling population, which could partly explain the inconsistent predictive performance of the subdimensions across resource substitution models.

Nevertheless, behavioural commitment was a useful predictor of certain substitution choices away from the German Baltic Sea coast. More avid anglers were more likely to consider fishing in other locations within Germany as perfect substitutes alternatives, but less likely to consider fishing abroad es as an equal satisfying substitute. This pattern suggests that more behavioural committed anglers consider a greater range of potential targets within Germany than less avid anglers, and probably this availability of suitable local alternatives makes them less likely to consider as viable more costly international fishing locations.

Consistent with findings from other studies (Birdsong et al., 2025; Slaton et al., 2023), the results of this thesis underscore the importance of measuring all three specialization subdimensions proposed by Scott and Shafer (2001) separately, as each predicts different angler preferences and responses to fisheries management decisions.

5.2.2 Cod attachment, cod avidity and cod fishing skill

Strong attachment to a specific species has previously been identified as a factor limiting anglers' ability to cope with restrictive management policies and to identify substitution alternatives (Dorow et al., 2010; Gentner & Sutton, 2008). A contribution of this thesis was to empirically examine this proposition by operationalising cod attachment as a construct capturing both the functional and emotional value cod anglers assign to the species.

The results provide evidence that anglers attachment to cod negatively predicted the recognition of the resource substitution options selected by the majority of anglers: targeting alternative species within the German Baltic Sea, fishing in inland waters, and targeting freshwater predatory species as perfect substitutes. This finding empirically supports the proposition that strong attachment to a target species acts as a barrier to the identification of satisfying substitute resources.

Substitution theory predicts that a perfect substitute must provide an equally satisfying experience to the activity being replaced (Shelby & Vaske, 1991). It follows those anglers who are more emotionally attached to cod, are less likely to find targeting alternative species equally enjoyable. Consistent with the importance placed on the specific species, attachment to cod was a positive predictor of considering cod fishing abroad as an equally satisfying alternative to cod fishing in the German Baltic Sea.

As opposite to the effect of angler’s psychological commitment to fishing, anglers cod attachment was a positive predictor of sated behaviors related to a reduction in fishing participation following the cod retention ban. Strict management policies can result in anglers reducing or ceasing their fishing participation as a consequence of a loss in satisfaction (Abbott & Fenichel, 2013; Beardmore et al., 2015). It is reasonable that anglers most strongly attached to cod cannot compensate for the utility loss imposed by the cod harvest restriction by targeting other species, and therefore prefer to withdraw from the activity altogether.

A decline in recreational fishing trips to the German Baltic Sea coast had already been documented in response to the bag limits imposed prior to the total cod harvest ban (Lewin et al., 2021). This thesis suggest that anglers most strongly attached to cod were the most likely to abandon fishing following the restrictions, and that this decline in fishing participation along the German Baltic Sea coast has potentially intensified following the introduction of the total harvest ban in 2024.

Anglers' cod-specific fishing skill and cod specific avidity showed an opposite prediction pattern to general fishing skill and general fishing avidity (behavioural commitment). Anglers with high general fishing skill and avidity may adapt to the retention ban by targeting other species within the region, whereas anglers highly specialised in cod fishing appear to be restricted to substitution alternatives that involve targeting cod abroad or other demersal species (e.g., pollock) not commonly found along the German coast.

More broadly, these results highlight the importance of distinguishing between behavioural and psychological specialization in general, and attachment to a specific species when predicting anglers' responses to management policies that restrict the targeting of a specific species. Commitment to fishing in general predicts openness to resource substitution and continued participation in fishing (Ditton et al., 1992), whereas commitment to cod specifically, whether expressed through attachment, avidity, or skill, appears to predict a narrower recognition of acceptable substitutes, in this case confined to cod itself or similar demersal species, and a greater likelihood of reducing fishing activity altogether.

5.2.3 Cod catch orientation

Anglers' catch orientation subdimensions have been used to predict the selection of perfect substitution species as alternatives to a preferred target species (Sutton & Ditton, 2005; Fisher & Ditton, 1993) and to explain anglers' preferences regarding different catch management regulations (Carlin et al., 2012; Beard et al., 2003; Robinson & Rash, 2023; Slaton et al., 2023). The majority of German cod anglers have been characterised as deriving a large share of their fishing satisfaction from the possibility of catching and retaining fish for consumption (Arlinghaus, 2006; Dorow et al., 2010; Birdsong et al., 2025), and German cod anglers in particular have been characterised as highly retention-oriented (Bronnmann et al., 2023; Birdsong et al., 2025). For this reason, it was expected that the cod retention subdimension of anglers' catch orientation would be a consistent significant predictor of resource substitution.

Retention orientation towards cod was a negative predictor of having a non-fishing perfect activity substitute. This finding is reasonable, as anglers motivated by retaining and consuming cod likely do not find non-fishing activities as equally satisfying that do not permit the retention and consumption of fish. Interestingly, among anglers who did identify a non-fishing perfect substitute activity, the motivation to catch a greater number of cod was positively related to selecting another consumptive activity as a perfect substitute. This suggests that the motivation to catch many fish may translate into a broader motivation to harvest natural resources through other activities.

Unexpectedly, most cod catch orientation subdimensions were not significant predictors of the selection of perfect resource substitution alternatives. The only exceptions were the subdimensions related to catching something and cod retention orientation. Anglers with higher scores on these catch motivations were less likely to consider fishing for other species abroad as equally satisfying alternatives. One possible explanation is the additional cost associated with travelling to distant fishing locations (Pokki et al., 2020). Because cod and other species have been historically targeted and harvested within the German Baltic Sea and German inland waters (Weltersbach et al., 2021; Birdsong et al., 2025), anglers

primarily motivated by catching and retaining fish may perceive travelling abroad to fish as offering limited additional satisfaction relative to the greater investment of time and money required.

An important consideration when interpreting these results is that this thesis did not use the full validated catch orientation item list (Anderson et al., 2007), and all subdimensions except trophy orientation were measured with single survey items. It is therefore possible that a more precise measure of these constructs would have revealed a greater influence of catch orientation on substitution selection among cod anglers. In addition, other studies have found a relationship between general catch orientation and perfect substitution (Sutton & Ditton, 2005; Fisher & Ditton, 1993), whereas this study measured catch orientation specifically towards cod. It seems that least for German cod anglers, cod-specific catch orientation does not translate into motivations for catching other species, and therefore does not predict perfect species substitution selection.

Some cod catch orientation subdimensions were significant predictors of certain stated substitution behaviours. Anglers motivated by catching trophy-sized cod were more likely to report fishing more often in inland waters and targeting freshwater predators following the ban. The targeting of freshwater predators such as pike and zander is often motivated by the opportunity to catch trophy-sized individuals (Arlinghaus et al., 2014). In contrast, cod retention orientation was a negative predictor of both fishing in the Bodden brackish lagoons along the German Baltic coast and targeting freshwater predators. Birdsong et al. (2025) found that German anglers tend to retain marine species more frequently than freshwater species and hypothesised that this may reflect the higher culinary value of marine fish.

These findings suggest that, although cod catch orientation dimensions did not predicted perfect resource substitute selection, some catch motivations were associated with specific stated substitution behaviours. In particular, the subdimensions related to trophy catches and fish retention appear to influence whether anglers shift towards or away from certain freshwater fisheries following the cod retention ban.

Anglers with a higher retention orientation towards cod were more likely to engage in non-fishing activities after the ban and to stop fishing altogether. This may seem contradictory to the earlier result that retention orientation was negatively related to having a non-fishing perfect activity substitute. This apparent contradiction highlights a fundamental distinction between perceived perfect substitutability and actual behavior. Perfect substitutes are defined as activities providing equivalent satisfaction (Shelby & Vaske, 1991), whereas actual behavior reflects a broader evaluation of total utility (Hunt, 2005). It has been shown that in consumptive recreational fisheries, management decisions that restrict the number of fish that can be harvested reduce the attractiveness of participation (Carlin et al., 2012; Beard et al., 2003). For the most retention-oriented anglers, the loss of utility caused by the 2024 cod retention ban probably made them more likely to abandon fishing as a recreational activity altogether and, as a consequence, to engage more frequently in non-fishing recreational alternatives.

5.2.4 Place attachment to the German Baltic Sea

Anglers' attachment to a specific site has been used to explain the selection of perfect substitution options (Oh et al., 2013), the fidelity of anglers towards fishing sites (Hunt, 2008), and anglers' attitudes towards management actions (Slaton et al., 2023). Cod anglers' dependence on the German Baltic Sea, and the degree to which their identity was tied to this location, were the most consistent predictors of perfect resource substitute selection among all the variables tested.

Cod aanglers with a greater place dependence on the German Baltic Sea were less likely to consider fishing resources alternatives away from the German Baltic Sea, marine or freshwater, as equally satisfying substitutes. Hunt (2008) found that anglers with greater place dependence were more site-constrained than less place-dependent anglers. Place dependence has been linked to a view of the natural environment as a resource serving to satisfy recreational needs (Lee and Oh, 2018; Kunchamboo et al., 2017). It follows that angler who regard the German Baltic Sea as functionally essential to their fishing satisfaction are less able to recognise fishing in other locations as equally satisfying.

Slaton et al. (2023), using a general place attachment construct that incorporated both place dependence and place identity, found that more place-attached pike anglers were more likely to accept stricter pike harvest regulations but less likely to endorse marine protected areas that would prohibit targeting pike altogether. The authors interpreted this as indicating that anglers with greater place dependence have an interest in the conservation of the resource at a specific site, provided this allows continued targeting of their preferred species. The 2024 cod harvest ban does not permit in practice a continuation of cod fishing in the German Baltic Sea, and relatedly, because of the lower value perceived for other locations in comparison, cod anglers with higher place dependence were more likely to report stopping fishing altogether as a resulting behaviour.

Beyond resource substitution, anglers place dependence was positively associated with the selection of outdoors non-consumptive activities as perfect substitutes for cod fishing. Most of the selected outdoor activities can be done along the Baltic Sea coast, so this result could suggest that the dependence of the Baltic Sea for fishing could also predict a setting dependence for other outdoor recreational activities.

Anglers' place identity towards the German Baltic Sea predicted different substitution choices and behaviours than the place dependence subdimension. Place identity has been described as a psychological characteristic that develops later than place dependence (Moore and Graefe, 1994), entailing a transformation from a functional dependence on a place to a broader psychological attachment that links a place with self-expression (Kunchamboo et al., 2017). This conceptualisation helps explain the finding that place identity positively predicted both continuing to fish in the German Baltic Sea and selecting other German Baltic Sea species as perfect substitutes for cod. Cod anglers who feel more emotionally connected to the Baltic Sea may be more likely to consider targeting other species in the same location as equally enjoyable, as opposed to anglers who perceive the Baltic Sea primarily as a functional resource for catching cod and who may not necessarily find other species in the same location equally satisfying.

In contrast to place dependence, anglers' place identity was a positive predictor of continuing to fish in the German Baltic Sea following the cod retention ban, and a negative predictor of stopping fishing as a reaction. It is reasonable to expect that anglers emotionally attached to the German Baltic Sea would lose less utility from substituting target species within the region than from fishing elsewhere. Moreover, angler general fishing specialization has been linked to place attachment and to lower willingness to substitute fishing sites (Oh et al., 2013; Oh et al.,2012). Similarly, the attraction and self-expression dimensions of activity involvement have been linked to increased place identity (Kyle et al., 2003). Anglers with a stronger place identity towards the German Baltic Sea are also likely to be highly involved in fishing, and are consequently less likely to abandon the activity following the cod retention ban, particularly given the possibility of targeting other species within the same location.

In summary, anglers' place attachment towards the German Baltic Sea was not a consistent predictor for non-fishing activity substitution, but it was the most consistent predictor for

resource substitution. Importantly, the two subdimensions of place attachment predicted different choices and behaviors, reinforcing the importance of treating them as separate constructs when assessing recreationists' behaviors or preferences, as they can have opposing predictive effects (Kyle et al., 2004).

5.2.5 Distance to preferred fishing site

Anglers' residential distance to their preferred fishing site on the German coast was a consistent predictor of both perfect substitution preferences and stated substitution behaviors among German cod anglers. Anglers living further away from their preferred fishing site on the German coast were less likely to select passive non-fishing activities as perfect substitutes. It can be argued that anglers who are willing to travel longer distances to go fishing are likely more invested in active outdoor recreation than anglers who travel less, and were therefore less likely to consider passive activities as equally enjoyable as fishing, compared to anglers living closer to the coast.

Cod anglers living further from the German Baltic coast were less likely to consider targeting other species within the German Baltic Sea and more likely to regard targeting cod abroad or marine predatory species as equally satisfying alternatives. This pattern may be explained by differences in travel costs. Anglers travelling longer distances to fish in the German Baltic Sea likely already spend several days fishing in the region (Lewin et al., 2021), meaning their trips involve substantial investments of both time and money (Pokki et al., 2020; Becker, 1965). For these anglers, travelling to another country may therefore not represent a substantially greater additional cost. In contrast, such an increase in cost would likely be more significant for anglers living closer to the German Baltic coast. A similar pattern was observed for stated substitution behavior: anglers living further away were less likely to continue fishing in the German Baltic Sea after the ban and less likely to target common Baltic Sea species such as small pelagic and flatfish species.

Probably anglers willing to travel greater distances have a higher financial investment in the activity, which may also reflect a stronger level of commitment (Ditton et al., 1992). Consistent with this interpretation, anglers living further from the Baltic coast were less likely to abandon fishing altogether following the cod retention ban. Instead, these anglers may be more likely to redirect their investment towards alternative fishing locations.

Overall, the results suggest that although non-resident anglers in the German Baltic Sea are less likely to stop fishing entirely following the cod retention ban, they are more likely to reduce the frequency of their visits to the region as a fishing tourism destination. A decline in the number of visiting anglers has already been reported following earlier cod retention restrictions, suggesting that the total harvest ban may represent a continuation of this trend, with potential implications for income generated through recreational fishing tourism (Lewin et al., 2021).

5.3 Additional predictors of perfect and stated substitution behavior

5.3.1 Fishing experience

Similarly to behavioural commitment, fishing experience did not predict perfect or stated non-fishing activity substitution, but was a positive predictor of perfect resource substitution selection within Germany (e.g., freshwater fishing in inland waters and fishing in the North

Sea), suggesting that fishing experience has a similar influence on substitution preferences to fishing avidity. Indeed, the two variables have been used in some studies as part of the behavioural commitment construct (e.g., Slaton et al., 2023).

Nevertheless, fishing experience predicted different stated substitution behaviours following the cod retention ban than fishing avidity. In particular, more experienced anglers were less likely to report fishing less frequently along the German Baltic Sea coast following the ban. Anglers who have committed more time to fishing have been characterised as more dependent on, and committed to, a given resource because of the value placed on the social relationships tied to participation in the activity (Ditton et al., 1992).

Interestingly, more experienced anglers also showed a preference for flatfish species, both in perfect substitute selection and in stated post-ban targeting behaviour, suggesting that experience could be a predictor of the selection of certain species as substitutes. Nevertheless, an explanation for the preference for flatfish specifically is not straightforward, and this result should be treated with caution.

5.3.2 Cod fishing constraints

Constraints are well established as key determinants of continued participation in recreational activities (Jackson, 1988; Sutton, 2007), and substitution has been conceptualised as a response to the inability to negotiate such constraints (Ditton & Sutton, 2004).

It is therefore surprising that cod fishing constraints were not a consistent predictor of perfect substitute choices and substitution behaviours among German cod anglers. A possible explanation lies in the limited nature of the constraint variable used in this thesis, as the survey only asked anglers about constraints if they had already reported fishing less frequently for cod following the implementation of bag limits in 2017. However, it is well established that constraints do not only reduce participation but can also prevent recreationists from increasing it (Crawford & Godbey, 1987; Sutton, 2007). As a result, the influence of constraints on substitution behaviour was likely underestimated in this study, as anglers who maintained their fishing frequency despite facing constraints were captured as constraint-free by this measure.

Nevertheless, a relevant result of this thesis is that anglers already facing constraints before the cod retention ban were more likely to decrease their fishing participation in the German Baltic Sea and to shift towards non-fishing activities after the ban. Fishing participation constrains have been negatively associated with the continuation of fishing (Joffe-Nelson et al., 2026). Notably, constraints did not predict the recognition of non fishing perfect substitutes activities, reinforcing the distinction between perceived enjoyment equivalence and actual behavioural responses. While previous constraints may matter less for evaluating whether an activity could be equally enjoyable as fishing, they appear to play an important role in determining what individuals actually do when faced with limitations (Sutton, 2007).

5.3.3 Anglers age

Angler’s age was positively related to having a perfect non fishing activity substitute. This result contradicts Ditton and Sutton (2004) that found the opposite relation. Suggesting that the influence of age in the recognition of perfect activity substitutes is not universal across different population of anglers.

Older age has been associated with increased leisure time due to the additional free time available following retirement (de Paula et al., 2022). At the same time, older age has also been linked to a preference for more passive forms of recreation, potentially because of increasing physical limitations (Garrido et al., 2021). These broader patterns in leisure participation help explain why older cod anglers were more likely to identify a non-fishing perfect activity substitute for cod fishing, while being less likely to prefer physically active outdoor activities. Instead, they tended to favour indoor passive alternatives or consumptive activities, that included relatively passive options such as mushroom picking or gardening. Age was not, however, a useful predictor for perfect resource substitution

Regarding stated behaviour following the cod retention ban, older cod anglers were less likely to report continuing to fish in the German Baltic Sea and more likely to report reducing their fishing participation in the area. Previous research has shown that older German anglers tend to be more consumption-oriented than younger anglers and less supportive of harvest restrictions (Birdsong et al., 2025; Slaton et al., 2023). One possible explanation is that older anglers may adhere more strongly to the social norm of retaining fish, which has traditionally been prominent in the German context (Birdsong et al., 2025). Consequently, older cod anglers may experience a greater loss of utility from being unable to harvest cod than younger anglers, making them more likely to reduce their fishing activity in the Baltic Sea following the ban.

5.3.4 Anglers Income

Anglers' household income was not a significant predictor of most perfect substitution choices or stated substitution behaviors. However, income was significant for the recognition of certain species categories as perfect substitutes for cod. Lower-income anglers were more likely to select freshwater coarse species as perfect substitutes and less likely to select salmonid species. It is interesting to compare this finding with the English context, where coarse fishing developed within working-class angling clubs, in contrast to game fishing, commonly targeting salmonids, which developed as an activity associated with the upper classes (Locker, 2014). Coarse fishing in Germany has similarly been associated with social fishing events focused on catch quantity in eutrophic waters (Meinelt et al., 2008). The results of this thesis may suggest a comparable pattern of socioeconomic determinants of species preferences in the German context, that could influence the selection of perfect substitutes target alternatives.

5.4 Comparison of perfect substitution and stated substitution behaviour

The relationship between recreationists' selection of perfect substitutes and their actual substitution behaviour has long been a question in leisure research (Brunson and Shelby, 1993; Sutton and Ditton, 2005). Although this thesis does not incorporate direct behavioral data, surveying both the perceived substitutability of alternatives and the stated behavioural responses of cod anglers facing a retention ban provides a rare opportunity to compare these two dimensions within the same context.

A key finding of this thesis is that the degree of correspondence between perfect substitute selection and stated substitution behaviour varies considerably depending on the type of substitution considered. The strongest association was observed between identifying other Baltic Sea species as perfect substitutes and continuing to fish in the same area following the ban. As discussed earlier, this can likely be explained by the importance of perceived cost in recreational decisions (Hunt et al., 2019). For German Baltic cod anglers, targeting

other species within the same region was probably the substitution path of least constraint and most similar in cost to cod fishing.

The association was moderately consistent for fishing away from the German Baltic Sea, whether in the North Sea or abroad, reflecting the greater practical constraints already discussed for these alternatives. Nevertheless, the presence of significant associations suggests that a subset of anglers could to act on these preferences, probably the ones who already fished as tourists along the German Baltic coast.

By contrast, the selection of freshwater predator species and of non-fishing activities as perfect substitutes showed the weakest correspondence with stated behaviour, consistent with the limited capacity argument developed earlier in this thesis. Anglers already engaged in these activities prior to the ban likely had little room to increase their participation further.

A more consistent significant relationship between perceived suitability and stated behaviour was also found at the species level. Across all 20 species most frequently selected as perfect substitutes for cod, anglers who considered a species equally enjoyable were significantly more likely to target it after the 2024 retention ban, confirming that perceived enjoyment equivalence is a meaningful predictor of substitution behaviour.

For almost all species, however, the proportion of anglers targeting them after the ban exceeded the proportion who had identified them as perfect substitutes. This was most evident for freshwater predator species such as pike, zander, and perch, which showed high targeting proportions regardless of whether anglers considered them perfect substitutes for cod. This result reflects the broad prevalence of freshwater fishing in Germany (Arlinghaus, 2004) and suggests that targeting these species after the ban was common largely independent of perceived equivalence to cod fishing. The pattern reversed for cod targeted outside the German Baltic Sea, where more anglers considered it a perfect substitute than actually reported targeting it, consistent with the time and monetary cost-related constraints on international fishing already discussed.

Taken together, these results reinforce the broader conclusion that identifying a perfect substitute does not necessarily predict actual substitution behaviour. This supports Gentner and Sutton's (2008) argument that the psychological approach to perfect substitution and the economic approach to actual substitution behaviour should be treated not as interchangeable, but as complementary, each capturing a distinct dimension of how recreationists relate to their preferred activity and respond to constraints.

6. Limitations

This thesis presents several limitations.First, the survey data were collected across two waves using electronic recruitment methods, including email distribution and social media advertising. Previous studies of recreational fisheries have reported that such methods tend to oversample anglers who are more committed to fishing relative to the broader angling population (Connelly et al., 2000; Griffiths et al., 2013). Survey weights based on population estimates were applied to correct for this bias in the descriptive results (Kuluppuarachchi et al., 2026). However, as already noted, the avidity levels reported in this sample were substantially higher than those reported in a broader survey of German marine anglers (Weltersbach et al., 2021). Moreover, the decision to conduct the statistical analyses on unweighted data means that the relationships identified in this thesis more likely reflect the characteristics and responses of highly committed cod anglers than those of the broader German Baltic cod angling population.

A second limitation is that the large number of statistical models tested in this thesis increases the probability of false positive results. Associations involving predictors that were not consistently significant across models should therefore be interpreted with caution. This is particularly relevant for models constructed using a post hoc backward AIC selection procedure, as this method has been shown to increase the likelihood of Type I errors (Forstmeier & Schielzeth, 2011).

A third limitation, already noted in the discussion, concerns the measurement of fishing constraints. The constraint variable used in this thesis was particularly limited, and as a result, the influence of constraints on substitution behaviour was likely underestimated. Future research should employ broader and more comprehensive constraint measures to support stronger conclusions regarding their role in substitution behaviour. A further limitation concerns the operationalisation of catch orientation and place attachment, which were measured using abbreviated versions of its original validated scales (Anderson et al., 2007; Kyle et al.,2003). While this abbreviation was necessary given the length of the survey, it is possible that relevant dimensions of these constructs were not fully captured, which may have limited the explanatory power of the models and could partly account for some non-significant results, particularly in the case of anglers catch orientation.

Finally, a limitation worth noting is that this thesis measured stated behaviour as a proxy for actual substitution behaviour. Self-reported behaviour, however, does not necessarily reflect actual behaviour (Baumeister et al., 2007). For this reason, the stated behavioural results of this thesis should not be treated as precise predictions of fishing effort spillover.

7. Conclusion and management implications

In this thesis, I explored how German recreational cod anglers perceived and responded to substitution alternatives following the complete 2024 harvest ban on Atlantic cod in the western German Baltic Sea.

Most anglers identified equally satisfying alternatives, particularly fishing for other species within the German Baltic Sea, freshwater fishing in Germany, and outdoor active non-fishing activities such as cycling and hiking. However, actual substitution behaviour corresponded only partially with these stated preferences. Nonetheless the results reveal potential spillover effects of fishing participation directed towards other activities, marine and inland waters in Germany and abroad.

Most of the fishing participation spillover arising from the retention ban appears directed towards other marine species within the German Baltic Sea, especially sea trout. This is of particular concern, because existing evidence already points to population decline in the Baltic region (Dębowski, 2018), and represents an important consideration for future management of this species.

The results revealed a widespread participation and appreciation for freshwater fishing among German cod anglers, as freshwater species were considered perfect substitutes for cod by a substantial proportion of the population. However, it appears that the targeting of these species did not increase substantially following the retention ban. Nevertheless, their widespread recognition as equally enjoyable alternatives suggests that pressure on these species could increase in the future, particularly if access to alternative marine species in the Baltic Sea becomes more restricted.

Beyond substitution, it seems that the 2024 cod retention ban was successful in reducing recreational fishing pressure on cod by German anglers. Even among anglers who

perceived cod fishing abroad as an equally enjoyable substitute, it appears that many did not substantially increase their fishing for cod in other countries, suggesting that spillover of cod-targeting effort towards destinations such as Norway has remained limited.

A concerning consequence of the ban, however, is the likely reduction in overall recreational fishing participation in the German Baltic Sea region. This is particularly relevant given that recreational fishing is an important economic activity for the German Baltic region (Strehlow et al., 2025). Of particular concern is the finding that anglers living further from their preferred fishing sites were less likely to continue targeting alternative species in the German Baltic Sea following the ban. Given that non-resident anglers have been found to contribute disproportionately to the economic activity generated by recreational fishing (Strehlow et al., 2025; Lewin et al., 2021), a reduction in tourist angling participation may have meaningful consequences for the economic value generated by recreational fishing. Some of the lost fishing participation could potentially be redirected towards other outdoor recreational activities along the coast, and efforts to attract visitors for non-fishing leisure activities could help to mitigate some of the economic losses.

A contribution of this thesis is the identification of measurable angler characteristics that can help predict substitution behaviour following a strict retention ban for a highly targeted species. Psychological commitment to fishing in general, age and retention orientation towards cod, were useful predictors of non-fishing activity substitution. Cod attachment, place identity and residence distance to the coast were useful for predicting anglers' preferences and behaviours regarding remaining in the Baltic Sea to target other species, or travelling abroad to continue targeting cod. Place attachment, particularly place dependence, was the most consistent predictor for substitution away from the German Baltic Sea.

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Annex I Questionnaire Survey Wave_1 (2020)

Fragebogen DORSCH 2. Welle mar marEEshift

Survey items used for this research are presented in German and a translation in English.

Fragebogen zum Dorschangeln auf den westlichen Ostseedorsch in Deutschland

(Questionnaire on recreational cod fishing in the western Baltic Sea, Germany)

Screening Questions Used for determination of admissibility

S1. In welchem Jahr sind Sie geboren? *(What year were you born?)*

S2. Haben Sie schon einmal auf Dorsch geangelt, egal ob im In- oder im Ausland? *(Have you ever been cod fishing, whether in Germany or abroad?)*

☐ Ja (Yes) ☐ Nein (No) ☐ Weiß ich nicht (Don't know)

S3. Haben Sie seit Beginn des Jahres 2017 mindestens einmal an der deutschen Ostseeküste geangelt? *(Have you been fishing on the German Baltic coast at least once since the start of 2017?)*

☐ Ja (Yes) ☐ Nein (No) ☐ Weiß ich nicht (Don't know)

S4. Haben Sie vor dem Jahr 2017, also in den Jahren 2016 und früher, mindestens einmal an der deutschen Ostseeküste geangelt? *(Did you go fishing on the German Baltic Sea coast at least once before 2017 — that is, in 2016 or earlier?)*

☐ Ja (Yes) ☐ Nein (No) ☐ Weiß ich nicht (Don't know)

S5. Planen Sie innerhalb der nächsten 3 Jahre an der deutschen Ostseeküste zu angeln? *(Do you plan to go fishing on the German Baltic Sea coast within the next 3 years?)*

☐ Ja (Yes) ☐ Nein (No) ☐ Weiß ich nicht (Don't know)

Used for calculation of fishing experience:

A1. Ich habe im Jahr _____ zum ersten Mal geangelt. / *Used for calculation of fishing experience*
(I went fishing for the first time in _____.)

Used for determination of preferred target species before the cod retention ban:

A3. Nennen Sie uns bitte in absteigender Reihenfolge bis zu fünf Fischarten, die Sie bevorzugt gezielt beangeln, egal ob im Süßwasser oder im Salzwasser.*(Please list, in descending order, up to five fish species that you prefer to target, whether in freshwater or saltwater.)*

1. Wichtigste Zielfischart (Most important target species)	
2. Zweitwichtigste Zielfischart (Second most important)	
3. Drittwichtigste Zielfischart (Third most important)	
4. Viertwichtigste Zielfischart (Fourth most important)	
5. Fünfwichtigste Zielfischart (Fifth most important)	

Used for Determination of fishing experience:

A4. Ich habe im Jahr ____ zum ersten Mal gezielt auf Dorsch geangelt. /

(I went cod fishing for the first time in the year ____.)

Used for assessing general fishing specialization.

A5. Bitte geben Sie nachfolgend an, inwieweit Sie den folgenden Aussagen zur Bedeutung des Angelns in Ihrem Leben zustimmen oder nicht zustimmen. /
(Please indicate below to what extent you agree or disagree with the following statements regarding the importance of fishing in your life.)

	Stimme überhaupt nicht zu (Strongly disagree)	**Stimme eher nicht zu** (Rather disagree)	**Weder noch** (Neither)	**Stimme eher zu** (Rather agree)	**Stimme voll und ganz zu** (Fully agree)
Ein Großteil meines Lebens dreht sich um das Angeln. *(A large part of my life revolves around fishing.)*	☐	☐	☐	☐	☐
Ich gehe lieber angeln, als irgendetwas anderes zu tun. *(I would rather go fishing than do anything else.)*	☐	☐	☐	☐	☐
Andere Hobbies interessieren mich nicht so sehr wie das Angeln. *(I am not as interested in other hobbies as I am in fishing.)*	☐	☐	☐	☐	☐
Wenn ich nicht angeln könnte, wüsste ich nicht, was ich stattdessen tun sollte. *(If I couldn't go fishing, I wouldn't know what to do instead.)*	☐	☐	☐	☐	☐
Ich würde mich selber als einen Angelexperten bezeichnen. *(I would describe myself as an expert angler.)*	☐	☐	☐	☐	☐
Meine Angelfertigkeiten sind besser als die des Durchschnittsanglers. *(My fishing skills are better than those of the average angler.)*	☐	☐	☐	☐	☐
Meine Angelfertigkeiten beim gezielten Dorschangeln sind besser als die des Durchschnittsdorschanglers. *(My fishing skills when targeting cod are better than those of the average cod angler.)*	☐	☐	☐	☐	☐

Used for determination of anglers' catch orientation towards cod

A6. Bitte geben Sie an, ob Sie den folgenden Aussagen zum Dorschangeln zustimmen oder nicht zustimmen./ *(Please indicate whether you agree or disagree with the following statements about cod fishing.)*

	Stimme überhaupt nicht zu (Strongly disagree)	**Stimme eher nicht zu** (Rather disagree)	**Weder noch** (Neither)	**Stimme eher zu** (Rather agree)	**Stimme voll und ganz zu** (Fully agree)
Ein Angeltag kann auch dann erfolgreich sein, wenn ich keinen Dorsch gefangen habe. *(A day of fishing can still be successful even if I haven't caught any cod.)*	☐	☐	☐	☐	☐
Ich möchte alle meine gefangenen maßigen Dorsche mitnehmen.	☐	☐	☐	☐	☐

(I want to take home all the cod I catch that are of legal size.)					
Je mehr Dorsch ich fange, desto zufriedener bin ich. *(The more cod I catch, the happier I am.)*	☐	☐	☐	☐	☐
Ich bevorzuge es, dort zu angeln, wo ich zumindest die Chance auf den Fang eines kapitalen Dorsches habe. *(I prefer to fish where I at least have a chance of catching a trophy-sized cod.)*	☐	☐	☐	☐	☐
Je größer der gefangene Dorsch, desto besser ist der Angeltag. *(The bigger the cod I catch, the better the day of fishing.)*	☐	☐	☐	☐	☐
An meiner Zufriedenheit mit einem Angeltag ändert sich nichts, wenn ich meine gefangenen Dorsche zurücksetze (z.B. zu klein). *(My satisfaction with a day of fishing remains unchanged if I release the cod I have caught (e.g., because they are too small).)*	☐	☐	☐	☐	☐
Ich bin rundum mit dem Angeltag zufrieden, wenn ich mindestens meine Fangbegrenzung (z.B. 5 Dorsche) erbeutet habe. *(I am completely satisfied with the day of fishing if I have caught at least my bag limit (e.g., 5 cod).)*	☐	☐	☐	☐	☐

Used for determination of anglers' general fishing avidity

A7. An wie vielen Tagen haben Sie im vergangenen Jahr 2019 ungefähr insgesamt in Deutschland oder im Ausland geangelt? (*Approximately how many days did you spend fishing in Germany or abroad in total in 2019?)*

Anzahl Tage / Number of days: _____

Used for determination of anglers' cod fishing avidity

A7a. Und wie viele Tage davon haben Sie im Jahr 2019 ungefähr gezielt auf Dorsch geangelt, egal ob in Deutschland oder im Ausland? *(And roughly how many of those days in 2019 did you spend specifically fishing for cod, whether in Germany or abroad?)*

Anzahl Tage / Number of days: _____

Used for determination of anglers' general fishing avidity

A8. An wie vielen Tagen haben Sie im Jahr 2019 ungefähr nur in Deutschland geangelt, egal ob auf Dorsch oder auf andere Arten?/

(Approximately how many days did you go fishing in Germany alone in 2019, whether for cod or other species?)

Anzahl Tage / Number of days: _____

Used for determination of anglers' cod fishing avidity

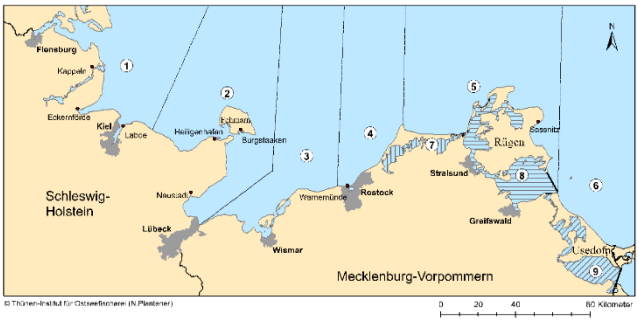
A8a. Und wie viele Tage davon haben Sie im Jahr 2019 ungefähr gezielt auf Dorsch an der deutschen Ost- oder Nordseeküste geangelt?/ *(And approximately how many of those days in 2019 did you spend specifically fishing for cod along the German Baltic or North Sea coast?)*

Anzahl Tage / Number of days: _____

Used for determination of anglers preferred fishing site in the German coast

A11. Geben Sie bitte an, an welchen Küstenabschnitten in der Nord- bzw. Ostsee Sie in Deutschland innerhalb der letzten 3 Jahre (2017, 2018 oder 2019) auf Dorsch geangelt haben. Klicken Sie die verschiedenen beangelten Gebiete einfach an, diese färben sich rot./ *Please indicate the coastal areas in the North Sea or the Baltic Sea in Germany where you have fished for cod within the last 3 years (2017, 2018 or 2019). Simply click on the different areas where you have fished; they will turn red.*

A11a. Welches davon ist Ihr Hauptangelgebiet, d.h. das Gebiet, wo Sie persönlich am häufigsten gezielt auf Dorsch angeln? (nur eine Antwort)
(Which of these is your main fishing ground, i.e. the area where you personally fish for cod most frequently? (Please select only one answer.)



Used for determination of anglers fishing preferences abroad Germany

A12. In welchen Ländern außerhalb Deutschlands haben Sie schon auf Dorsch geangelt und wie regelmäßig haben Sie dies in den letzten 3 Jahren (2017–2019) getan? / *In which countries outside Germany have you fished for cod, and how regularly have you done so over the last 3 years (2017–2019)?*

	War ich noch nie angeln, möchte ich auch zukünftig nicht. (I've never been fishing, and I don't want to go in future either.)	**War ich noch nie, plane aber, dort künftig hinzufahren.** (I've never been there, but I'm planning to go there in the future)	**Fahre ich alle paar Jahre zum Angeln hin.** (I go there for fishing every few years.)	**Fahre ich jedes Jahr einmal zum Angeln hin.** (I go there once a year to go fishing.)	**Fahre ich jedes Jahr mehr als einmal zum Angeln hin.** (I go there to fish more than once a year.)
Norwegen Norway					
Dänemark Denmark					
Schweden Sweeden					
Polen Poland					
Anderes Land, und zwar: Other country:					

Used for determination of anglers fishing constraints

D3. Angeln Sie seit der Einführung der Tagesentnahmebeschränkung (Bag Limit) von 5 Dorschen (bzw. 2 Dorschen zur Laichzeit) im Jahre 2017 weniger, genauso oft oder öfter auf Dorsch in der westlichen Ostsee?
(Since the introduction of the daily bag limit of 5 cod (or 2 cod during the spawning season) in 2017, have you been fishing for cod in the western Baltic Sea less often, just as often, or more often?)

☐ Weniger (Less often) ☐ Genauso oft (Just as often) ☐ Öfter (More often)

D3a. Es gibt verschiedene Gründe, die dazu geführt haben könnten, dass Sie seit 2017 weniger oft als früher zum Angeln auf Dorsch an die deutsche Küste gefahren sind. Bitte geben Sie an, inwieweit die folgenden Gründe auf Sie zutreffen oder nicht zutreffen.
(There are various reasons why you may have been fishing for cod off the German coast less often since 2017. Please indicate to what extent the following reasons apply to you.) / (Asked only of respondents who reported fishing less often at D3)

	Trifft überhaupt nicht zu (Does not apply at all)	**Trifft eher nicht zu** (Rather does not apply)	**Weder noch** (Neither)	**Trifft eher zu** (Rather applies)	**Trifft voll und ganz zu** (Fully applies)
Weil es sich vom Fang nicht mehr lohnt. *(Because it is no longer worth the effort in terms of catch.)*	☐	☐	☐	☐	☐
Weil es sich von der Entnahme her nicht mehr lohnt. *(Because it is no longer worth the effort in terms of harvest.)*	☐	☐	☐	☐	☐
Weil die Dorsche mir zu klein geworden sind. *(Because the cod have become too small for me.)*	☐	☐	☐	☐	☐
Weil ich es nicht verantworten kann, einen stark dezimierten Bestand zu beangeln. *(Because I cannot bring myself to fish for a severely depleted stock.)*	☐	☐	☐	☐	☐
Weil meine Angelfreunde jetzt nicht mehr so gerne an die Ostsee zum Dorschangeln fahren. *(Because my fishing friends are no longer keen on going to the Baltic Sea for cod fishing.)*	☐	☐	☐	☐	☐
Weil ich jetzt mehr auf Süßwasserfischarten angele. *(Because I now fish more for freshwater species.)*	☐	☐	☐	☐	☐
Weil ich jetzt mehr auf andere Meerwasserfischarten angele. *(Because I now fish more for other saltwater species.)*	☐	☐	☐	☐	☐
Weil ich jetzt mehr im Ausland auf Dorsch angele. *(Because I now fish for cod abroad more often.)*	☐	☐	☐	☐	☐
Weil ich meinen reduzierten Jahresfang nicht durch Mehrangeln ausgleichen kann. *(Because I cannot compensate for my reduced annual catch by fishing more.)*	☐	☐	☐	☐	☐
Weil es nicht mehr genügend Angelkutter vor Ort gibt. *(Because there are no longer enough charter fishing boats locally.)*	☐	☐	☐	☐	☐
Weil es nicht mehr genügend Mietboote gibt. *(Because there are no longer enough boats for hire.)*	☐	☐	☐	☐	☐
Weil ich nicht weiß, wo ich noch Dorsche fangen kann. *(Because I do not know where I can still catch cod.)*	☐	☐	☐	☐	☐

Weil der Angeldruck an der Küste zu hoch ist. *(Because recreational fishing pressure on the coast is too high.)*	☐	☐	☐	☐	☐
Weil der Fischereidruck an der Küste zu hoch ist. *(Because commercial fishing pressure on the coast is too high.)*	☐	☐	☐	☐	☐
Sonstiges / Other:	☐	☐	☐	☐	☐

Used for determination of gender

E3. Bitte geben Sie Ihr Geschlecht an. (Please state your gender.)

☐ Männlich (Male) ☐ Weiblich (Female) ☐ Divers (Other)

Used for determination of place of residence

E4. Bitte geben Sie zur räumlichen Zuordnung Ihren Wohnort und Ihre Postleitzahl an. *(Please state your place of residence and postcode for geographical allocation purposes.)*

Wohnort / Place of residence: _____

Postleitzahl / Postcode: _____

Used for determination of anglers' household income

E5. Wie viele Personen leben insgesamt in Ihrem Haushalt (zählen Sie sich bitte mit)? / *(How many people live in your household in total (please include yourself)?)*

Anzahl / Number: _____

Used for determination of anglers' level of education

E7. Welchen höchsten allgemeinbildenden Schulabschluss haben Sie? *(What is the highest level of general education you have completed?)*

☐ Keinen (None)

☐ Hauptschulabschluss (Lower secondary school leaving certificate)

☐ Mittlere Reife/Realschulabschluss (General secondary school leaving certificate)

☐ Polytechnische Oberschule 10. Klasse (Polytechnic secondary school certificate)

☐ Fachhochschulreife (Technical college entrance qualification)

☐ Allgemeine oder fachgebundene Hochschulreife/Abitur (General or subject-specific university entrance qualification)

☐ Sonstiges / Other: _____

Used for determination of anglers' household income

E11. Wie hoch war Ihr persönliches Nettoeinkommen (Summe aller Einkünfte) im letzten Monat? *(What was your personal net income (total of all earnings) last month?)*

☐ Kein eigenes Einkommen (No personal income)

☐ unter 500 € ☐ 500–999 € ☐ 1000–1499 € ☐ 1500–1999 € ☐ 2000–2499 € ☐ 2500–2999 €

☐ 3000–3499 € ☐ 3500–3999 € ☐ 4000–4499 € ☐ 4500–4999 € ☐ 5000–5499 € ☐ 5500–5999 €

☐ 6000–6499 € ☐ 6500–6999 € ☐ 7000–7499 € ☐ 7500–7999 € ☐ ≥ 8000 €

Annex II Questionnaire Survey Wave_2 (2024)

Fragebogen DORSCH 2. Welle marEEchange

(Follow-up questionnaire on recreational cod fishing — western Baltic Sea, Germany)

Survey items used for this research are presented in German and a translation in English.

Used for admissibility

Q1. Sind Sie dieselbe Person, die an der letzten Dorschanglerbefragung im Winter 2020 teilgenommen und die Fragen beantwortet hatte? (*Are you the same person who took part in the last cod anglers' survey in the winter of 2020 and answered the questions?)*

☐ **Ja, ich habe die Umfrage alleine beantwortet** (Yes, I completed the survey on my own)

☐ **Ja, ich habe die Umfrage zusammen mit anderen beantwortet** (Yes, I completed the survey together with others)

☐ **Nein, das war ich nicht** (No, that was not me)

☐ **Weiß nicht / kann mich nicht mehr erinnern** (Don't know / can no longer remember)

Used for determination of age

Q2. Wie alt sind Sie? / Ich bin .... Jahre alt. *(How old are you? I am … years old.)*

Used for determination of cod attachment and place attachment to the German Baltic Sea coast.

Q4. Geben Sie bitte an, inwiefern Sie den folgenden Aussagen zur deutschen Ostseeküste und zum Dorschangeln zustimmen bzw. nicht zustimmen *(Please indicate to what extent you agree or disagree with the following statements about the German Baltic Sea coast and cod fishing.)*

	Stimme überhaupt nicht zu (Strongly disagree)	**Stimme eher nicht zu** (Rather disagree)	**Weder noch** (Neither)	**Stimme eher zu** (Rather agree)	**Stimme voll und ganz zu** (Fully agree)
Ich würde mich als Spezialisten für Ostseedorsch bezeichnen. *(I would consider myself a specialist in Baltic Sea cod.)*	☐	☐	☐	☐	☐
Ostseedorsch ist für mich eine Fischart unter vielen. *(Baltic Sea cod is just one fish species among many for me.)*	☐	☐	☐	☐	☐
Zum Dorsch habe ich eine ganz tiefe, persönliche Beziehung. *(I have a very deep, personal connection to cod.)*	☐	☐	☐	☐	☐
Keine andere Fischart ist für mich anglerisch mit dem Dorsch vergleichbar. *(No other fish species is comparable to cod for me in terms of angling.)*	☐	☐	☐	☐	☐
Die deutsche Ostseeküste ist mit anderen Gewässern nicht vergleichbar. *(The German Baltic Sea coast is incomparable to other waters.)*	☐	☐	☐	☐	☐
Die deutsche Ostseeküste ist für mich das beste Gewässer zum Dorschangeln. *(The German Baltic Sea coast is the best fishing water for cod for me.)*	☐	☐	☐	☐	☐
Ich würde die deutsche Ostseeküste nur sehr ungern durch ein anderes Gewässer zum Dorschangeln austauschen. *(I would be very reluctant to replace the German Baltic Sea coast with another water for cod fishing.)*	☐	☐	☐	☐	☐

An der deutschen Ostseeküste zu angeln bedeutet mir viel. *(Fishing on the German Baltic Sea coast means a lot to me.)*	☐	☐	☐	☐	☐
Ich fühle mich der deutschen Ostseeküste sehr verbunden. *(I feel very connected to the German Baltic Sea coast.)*	☐	☐	☐	☐	☐

Used for determination of attachment to cod

Q5. Geben Sie bitte auch an, wie sehr Sie den folgenden Aussagen zum Dorschangeln an der Ostsee zustimmen oder nicht zustimmen. Es gibt keine richtigen oder falschen Antworten. *(Please also indicate how much you agree or disagree with the following statements about cod fishing in the Baltic Sea. There are no right or wrong answers.)*

Das Dorschangeln in der Ostsee ist für mich wichtig, …

(Cod fishing in the Baltic Sea is important to me …)

	Stimme überhaupt nicht zu (Strongly disagree)	**Stimme eher nicht zu** (Rather disagree)	**Weder noch** (Neither)	**Stimme eher zu** (Rather agree)	**Stimme voll und ganz zu** (Fully agree)
… weil Dorsch für mich ein geschätztes Lebensmittel ist. *(… because cod is a valued source of food for me.)*	☐	☐	☐	☐	☐
… weil das Dorschangeln besonders reizvoll für mich ist. *(… because cod fishing is especially appealing to me.)*	☐	☐	☐	☐	☐
… weil ich mich als Meeresangler sehe. *(… because I see myself as a sea angler.)*	☐	☐	☐	☐	☐
… weil es uns hilft, unsere Angelkultur heute und in Zukunft zu erhalten. *(… because it helps us preserve our angling culture today and in the future.)*	☐	☐	☐	☐	☐
… weil es mir die Möglichkeit gibt, Beziehungen zu Freunden / Familie / Anderen zu stärken. *(… because it gives me the opportunity to strengthen relationships with friends, family, or others.)*	☐	☐	☐	☐	☐
… weil ich mich mit der Ostsee verbunden fühle. *(… because I feel connected to the Baltic Sea.)*	☐	☐	☐	☐	☐
… weil es mein Leben bereichert. *(… because it enriches my life.)*	☐	☐	☐	☐	☐
… weil ich von und durch das Angeln lerne. *(… because I learn from and through fishing.)*	☐	☐	☐	☐	☐
… weil mich die Natur fasziniert und zum Staunen bringt. *(… because nature fascinates and fills me with wonder.)*	☐	☐	☐	☐	☐
… weil ich die Landschaften und Angelplätze besonders schön finde. *(… because I find the landscapes and fishing spots particularly beautiful.)*	☐	☐	☐	☐	☐
… weil es mich beruhigt und ich so Stress abbauen kann. *(… because it calms me and helps me reduce stress.)*	☐	☐	☐	☐	☐

Used for determination of stated substitution behaviour following the 2024 cod retention ban

Q15. Nennen Sie uns in absteigender Reihenfolge bis zu fünf Fischarten, die Sie seit Januar 2024, also seit Einführung des Entnahmeverbots für Dorsch, bevorzugt gezielt beangelt haben, egal ob im Süßwasser oder im Salzwasser. Schließen Sie auch die Arten ein, die Sie bis zum Jahresende eventuell noch beangeln werden.

(Please list, in descending order, up to five fish species that you have preferentially targeted since January 2024 — that is, since the introduction of the cod retention ban — whether in freshwater or saltwater. Please also include species you may still target by the end of the year.) / Used for determination of stated substitution behaviour following the 2024 cod retention ban

Falls Ihre Lieblingsart nicht auftaucht, bitte frei den Artnamen eintragen. Wenn Sie weniger als fünf Zielarten hatten, lassen Sie die entsprechenden Kategorien einfach frei.

(If your preferred species does not appear, please enter the species name manually. If you had fewer than five target species, simply leave the remaining fields empty.)

Ich habe keine Fischart gezielt beangelt (I did not target any species)	Bachforelle, keine Meerforelle (Brown trout, not sea trout)
Aal (Eel)	Barsch (Perch)
Dorsch (Cod)	Brasse/Blei (Bream)
Flunder (Flounder)	Döbel (Chub)
Hering (Herring)	Güster (White bream)
Heilbutt (Halibut)	Hecht (Pike)
Hornhecht (Garfish)	Karpfen (Carp)
Kliesche (Dab)	Rapfen (Asp)
Lachs (Salmon)	Regenbogenforelle (Rainbow trout)
Makrele (Mackerel)	Rotauge/Plötze (Roach)
Meeräsche (Mullet)	Rotfeder (Rudd)
Meerforelle (Sea trout)	Schleie (Tench)
Seelachs (Pollock)	Weissfische allgemein (Coarse fish, general)
Scholle (Plaice)	Wels (Catfish)
Steinbutt (Turbot)	Zander (Pike-perch)
Wolfsbarsch (Sea bass)	Andere Fischart (Other species): .....
Aland (Ide)	Andere Fischart (Other species): .....
Äsche (Grayling)	Andere Fischart (Other species): .....

Used for perfect resource substitution for cod fishing in the German Baltic Sea

Q17.1. Gibt es eine Art und Weise des Angelns, bei der Sie genauso viel Freude empfinden wie beim Dorschangeln an der deutschen Ostseeküste?*(Is there a form of fishing that gives you just as much enjoyment as cod fishing on the German Baltic Sea coast?)*

☐ Ja (Yes) ☐ Nein (No) ☐ Unsicher / weiß nicht (Unsure / don't know)

Q17.2. Was genau macht ihnen anglerisch ebenso viel Freude wie das Dorschangeln an der deutschen Ostseeküste? Markieren Sie bitte alles, was auf Sie zutrifft. *(What exactly gives you as much angling enjoyment as cod fishing on the German Baltic Sea coast? Please mark everything that applies to you.) (Asked only if respondent answered 'Yes' at Q17.1)*

☐ Angeln auf Dorsch an der Nordseeküste (Cod fishing on the North Sea coast)

☐ Angeln auf Dorsch im Ausland (Cod fishing abroad)

☐ Angeln auf andere Fischarten an der deutschen Ostseeküste (Fishing for other species on the German Baltic Sea coast)

☐ Angeln auf andere Fischarten an der deutschen Nordseeküste (Fishing for other species on the German North Sea coast)

☐ Angeln auf Süßwasserfischarten in Deutschland (Fishing for freshwater species in Germany)

☐ Angeln auf Süßwasserfischarten im Ausland (Fishing for freshwater species abroad)

☐ Angeln auf andere Meeresfischarten im Ausland (Fishing for other marine species abroad)

☐ Eine andere Art und Weise des Angelns, nämlich: …… (Another form of fishing, namely: ……)

☐ Nichts davon (None of the above)

Q17.3. Welche Fischarten sind es, bei deren Beangelung Sie ebenso viel Freude empfinden wie beim Dorschangeln an der deutschen Ostseeküste? Bitte wählen Sie bis zu fünf Fischarten aus. *(Which fish species give you as much enjoyment to fish for as cod fishing on the German Baltic Sea coast? Please select up to five species.)*

(Asked only if respondent selected a species-based substitute at Q17.2)

Aal (Eel)	Barsch (Perch)
Dorsch (Cod)	Brasse/Blei (Bream)
Flunder (Flounder)	Döbel (Chub)
Hering (Herring)	Güster (White bream)
Heilbutt (Halibut)	Hecht (Pike)
Hornhecht (Garfish)	Karpfen (Carp)
Kliesche (Dab)	Rapfen (Asp)
Lachs (Salmon)	Regenbogenforelle (Rainbow trout)
Makrele (Mackerel)	Rotauge/Plötze (Roach)
Meeräsche (Mullet)	Rotfeder (Rudd)
Meerforelle (Sea trout)	Schleie (Tench)
Seelachs (Pollock)	Weissfische allgemein (Coarse fish, general)
Scholle (Plaice)	Wels (Catfish)
Steinbutt (Turbot)	Zander (Pike-perch)
Wolfsbarsch (Sea bass)	Andere Fischart (Other species): .....
Aland (Ide)	Andere Fischart (Other species): .....
Äsche (Grayling)	Andere Fischart (Other species): .....
Bachforelle, keine Meerforelle (Brown trout, not sea trout)	Unsicher / weiß nicht (Unsure / don't know)

Used for determination of perfect non-fishing activity substitution

Q18.1. Gibt es andere Freizeitaktivitäten außer Angeln, bei denen Sie genauso viel Freude empfinden wie beim Dorschangeln an der deutschen Ostseeküste? *(Are there leisure activities other than fishing that give you just as much enjoyment as cod fishing on the German Baltic Sea coast?)*

☐ Ja (Yes) ☐ Nein (No) ☐ Unsicher / weiß nicht (Unsure / don't know)

Q18.2. Welche Freizeitaktivitäten sind das, die Ihnen genauso viel Freude bereiten wie das Dorschangeln? Bitte geben Sie uns ein paar Stichworte. *(What are these leisure activities that give you as much enjoyment as cod fishing? Please give us a few keywords.)*

(Asked only if respondent answered 'Yes' at Q18.1. Open-ended response.)

Antwort / Answer: _____

Used for determination of federal state of residency

Q31. In welchem Bundesland leben Sie? *(In which German federal state do you live?)*

Annex III -Backward stepwise AIC selection procedures for logistic and linear regression models

The following tables present the results of the backward stepwise AIC (Akaike Information Criterion) selection procedure applied to each regression model estimated in this study. Starting from a full model including all predictor variables, the procedure iteratively removes the variable whose elimination yields the greatest reduction in AIC, continuing until no further removal improves model fit. Each table displays the sequence of elimination steps, the variable removed at each step, the set of variables retained after removal, and the corresponding AIC value. The final model, highlighted in green, is the one with the lowest AIC.Models for which the final selected model did not achieve a lower AIC than the null model were not retained for further analysis.

Table 1. Backward stepwise AIC selection for logistic regression model predicting the selection of 'Outdoor non-consumptive active activities' as a perfect substitute for cod fishing in the German Baltic Sea.

Step	Variable removed	Remaining variables	AIC
0	None (full model)	Age, Income, Distance, Constraints, Place identity, Place dependence, Trophy cod, Catch cod, Quantity cod, Cod attachment, Retention cod, Fishing centrality, Fishing experience, Cod avidity, Fishing avidity, Skill (general), Skill (cod)	346.86
1	Quantity cod	Age, Income, Distance, Constraints, Place identity, Place dependence, Trophy cod, Cod attachment, Fishing centrality, Catch cod, Retention cod, Fishing experience, Cod avidity, Fishing avidity, Skill (general), Skill (cod)	344.91
2	Cod avidity	Age, Income, Distance, Constraints, Place identity, Place dependence, Trophy cod, Cod attachment, Fishing centrality, Catch cod, Retention cod, Fishing experience, Fishing avidity, Skill (general), Skill (cod)	343.04
3	Cod attachment	Age, Income, Distance, Constraints, Place identity, Place dependence, Trophy cod, Fishing centrality, Catch cod, Retention cod, Fishing experience, Fishing avidity, Skill (general), Skill (cod)	341.14
4	Constraints	Age, Income, Distance, Place identity, Place dependence, Trophy cod, Fishing centrality, Catch cod, Retention cod, Fishing experience, Fishing avidity, Skill (general), Skill (cod)	339.23
5	Retention cod	Age, Income, Distance, Place identity, Place dependence, Trophy cod, Fishing centrality, Catch cod, Fishing experience, Fishing avidity, Skill (general), Skill (cod)	337.36
6	Catch cod	Age, Income, Distance, Place identity, Place dependence, Trophy cod, Fishing centrality, Fishing experience, Fishing avidity, Skill (general), Skill (cod)	335.5
7	Skill (cod)	Age, Income, Distance, Place identity, Place dependence, Trophy cod, Fishing centrality, Fishing experience, Fishing avidity, Skill (general)	333.7
8	Skill (general)	Age, Income, Distance, Place identity, Place dependence, Trophy cod, Fishing centrality, Fishing experience, Fishing avidity	331.84
9	Distance	Age, Income, Place identity, Place dependence, Trophy cod, Fishing centrality, Fishing experience, Fishing avidity	330.46
10	Place identity	Age, Income, Place dependence, Trophy cod, Fishing centrality, Fishing experience, Fishing avidity	329.13
11	Trophy cod	Age, Income, Place dependence, Fishing centrality, Fishing experience, Fishing avidity	328.29
Final	—	Age, Income, Place dependence, Fishing centrality, Fishing experience, Fishing avidity	**328.29**
Null	—	(no predictors)	336.23

Table 2. Backward stepwise AIC selection for logistic regression model predicting the selection of 'Outdoor passive activities' as a perfect substitute for cod fishing in the German Baltic Sea.

Step	Variable removed	Remaining variables	AIC
0	None (full model)	Age, Income, Distance, Constraints, Place identity, Place dependence, Trophy cod, Catch cod, Quantity cod, Cod attachment, Retention cod, Fishing centrality, Fishing experience, Cod avidity, Fishing avidity, Skill (general), Skill (cod)	131.04
1	Retention cod	Age, Income, Distance, Constraints, Place identity, Place dependence, Trophy cod, Catch cod, Quantity cod, Cod attachment, Fishing centrality, Fishing experience, Cod avidity, Fishing avidity, Skill (general), Skill (cod)	129.04
2	Age	Income, Distance, Constraints, Place identity, Place dependence, Trophy cod, Catch cod, Quantity cod, Cod attachment, Fishing centrality, Fishing experience, Cod avidity, Fishing avidity, Skill (general), Skill (cod)	127.05
3	Fishing avidity	Income, Distance, Constraints, Place identity, Place dependence, Trophy cod, Catch cod, Quantity cod, Cod attachment, Fishing centrality, Fishing experience, Cod avidity, Skill (general), Skill (cod)	125.06
4	Place dependence	Income, Distance, Constraints, Place identity, Trophy cod, Catch cod, Quantity cod, Cod attachment, Fishing centrality, Fishing experience, Cod avidity, Skill (general), Skill (cod)	123.2
5	Cod attachment	Income, Distance, Constraints, Place identity, Trophy cod, Catch cod, Quantity cod, Fishing centrality, Fishing experience, Cod avidity, Skill (general), Skill (cod)	121.29
6	Fishing experience	Income, Distance, Constraints, Place identity, Trophy cod, Catch cod, Quantity cod, Fishing centrality, Cod avidity, Skill (general), Skill (cod)	119.41
7	Cod avidity	Income, Distance, Constraints, Place identity, Trophy cod, Catch cod, Quantity cod, Fishing centrality, Skill (general), Skill (cod)	117.7
8	Fishing centrality	Income, Distance, Constraints, Place identity, Trophy cod, Catch cod, Quantity cod, Skill (general), Skill (cod)	115.99
9	Income	Distance, Constraints, Place identity, Trophy cod, Catch cod, Quantity cod, Skill (general), Skill (cod)	114.68
10	Trophy cod	Distance, Constraints, Place identity, Catch cod, Quantity cod, Skill (general), Skill (cod)	113.33
11	Quantity cod	Distance, Constraints, Place identity, Catch cod, Skill (general), Skill (cod)	112.32
12	Place identity	Distance, Constraints, Catch cod, Skill (general), Skill (cod)	111.81
13	Catch cod	Distance, Constraints, Skill (general), Skill (cod)	111.08
14	Skill (general)	Distance, Constraints, Skill (cod)	110.92
15	Skill (cod)	Distance, Constraints	**110.52**
Null	—	(no predictors)	114.27

Table 3. Backward stepwise AIC selection for logistic regression model predicting the selection of 'Indoor active activities' as a perfect substitute for cod fishing in the German Baltic Sea. Note: the final selected model did not outperform the null model and was therefore not retained for analysis.

Step	Variable removed	Remaining variables	AIC
0	None (full model)	Age, Income, Distance, Constraints, Place identity, Place dependence, Trophy cod, Catch cod, Quantity cod, Cod attachment, Retention cod, Fishing centrality, Fishing experience, Cod avidity, Fishing avidity, Skill (general), Skill (cod)	302.9
1	Fishing avidity	Age, Income, Distance, Constraints, Place identity, Place dependence, Trophy cod, Catch cod, Quantity cod, Cod attachment, Retention cod, Fishing centrality, Fishing experience, Cod avidity, Skill (general), Skill (cod)	300.9

2	Skill (cod)	Age, Income, Distance, Constraints, Place identity, Place dependence, Trophy cod, Catch cod, Quantity cod, Cod attachment, Retention cod, Fishing centrality, Fishing experience, Cod avidity, Skill (general)	298.92
3	Place identity	Age, Income, Distance, Constraints, Place dependence, Trophy cod, Catch cod, Quantity cod, Cod attachment, Retention cod, Fishing centrality, Fishing experience, Cod avidity, Skill (general)	296.93
4	Catch cod	Age, Income, Distance, Constraints, Place dependence, Trophy cod, Quantity cod, Cod attachment, Retention cod, Fishing centrality, Fishing experience, Cod avidity, Skill (general)	294.96
5	Retention cod	Age, Income, Distance, Constraints, Place dependence, Trophy cod, Quantity cod, Cod attachment, Fishing centrality, Fishing experience, Cod avidity, Skill (general)	293.02
6	Place dependence	Age, Income, Distance, Constraints, Trophy cod, Quantity cod, Cod attachment, Fishing centrality, Fishing experience, Cod avidity, Skill (general)	291.27
7	Fishing centrality	Age, Income, Distance, Constraints, Trophy cod, Quantity cod, Cod attachment, Fishing experience, Cod avidity, Skill (general)	289.56
8	Age	Income, Distance, Constraints, Trophy cod, Quantity cod, Cod attachment, Fishing experience, Cod avidity, Skill (general)	287.76
9	Distance	Income, Constraints, Trophy cod, Quantity cod, Cod attachment, Fishing experience, Cod avidity, Skill (general)	286.05
10	Trophy cod	Income, Constraints, Quantity cod, Cod attachment, Fishing experience, Cod avidity, Skill (general)	284.5
11	Quantity cod	Income, Constraints, Cod attachment, Fishing experience, Cod avidity, Skill (general)	283.1
12	Fishing experience	Income, Constraints, Cod attachment, Cod avidity, Skill (general)	282.45
13	Skill (general)	Income, Constraints, Cod attachment, Cod avidity	281.7
14	Income	Constraints, Cod attachment, Cod avidity	**281.48**
Null	—	(no predictors)	281.2

Table 4. Backward stepwise AIC selection for logistic regression model predicting the selection of 'Indoor passive activities' as a perfect substitute for cod fishing in the German Baltic Sea.

Step	Variable removed	Remaining variables	AIC
0	None (full model)	Age, Income, Distance, Constraints, Place identity, Place dependence, Trophy cod, Catch cod, Quantity cod, Cod attachment, Retention cod, Fishing centrality, Fishing experience, Cod avidity, Fishing avidity, Skill (general), Skill (cod)	163.92
1	Constraints	Age, Income, Distance, Place identity, Place dependence, Trophy cod, Catch cod, Quantity cod, Cod attachment, Retention cod, Fishing centrality, Fishing experience, Cod avidity, Fishing avidity, Skill (general), Skill (cod)	161.94
2	Skill (cod)	Age, Income, Distance, Place identity, Place dependence, Trophy cod, Catch cod, Quantity cod, Cod attachment, Retention cod, Fishing centrality, Fishing experience, Cod avidity, Fishing avidity, Skill (general)	160.06
3	Cod avidity	Age, Income, Distance, Place identity, Place dependence, Trophy cod, Catch cod, Quantity cod, Cod attachment, Retention cod, Fishing centrality, Fishing experience, Fishing avidity, Skill (general)	158.17
4	Trophy cod	Age, Income, Distance, Place identity, Place dependence, Catch cod, Quantity cod, Cod attachment, Retention cod, Fishing centrality, Fishing experience, Fishing avidity, Skill (general)	156.41
5	Fishing experience	Age, Income, Distance, Place identity, Place dependence, Catch cod, Quantity cod, Cod attachment, Retention cod, Fishing centrality, Fishing avidity, Skill (general)	154.69

6	Skill (general)	Age, Income, Distance, Place identity, Place dependence, Catch cod, Quantity cod, Cod attachment, Retention cod, Fishing centrality, Fishing avidity	152.92
7	Fishing centrality	Age, Income, Distance, Place identity, Place dependence, Catch cod, Quantity cod, Cod attachment, Retention cod, Fishing avidity	151.12
8	Place identity	Age, Income, Distance, Place dependence, Catch cod, Quantity cod, Cod attachment, Retention cod, Fishing avidity	149.4
9	Catch cod	Age, Income, Distance, Place dependence, Quantity cod, Cod attachment, Retention cod, Fishing avidity	147.7
10	Fishing avidity	Age, Income, Distance, Place dependence, Quantity cod, Cod attachment, Retention cod	146.04
11	Place dependence	Age, Income, Distance, Quantity cod, Cod attachment, Retention cod	144.52
12	Cod attachment	Age, Income, Distance, Quantity cod, Retention cod	142.8
13	Retention cod	Age, Income, Distance, Quantity cod	**142.15**
Null	—	(no predictors)	147.7

Table 5. Backward stepwise AIC selection for logistic regression model predicting the selection of 'Outdoor consumptive activities' as a perfect substitute for cod fishing in the German Baltic Sea.

Step	Variable removed	Remaining variables	AIC
0	None (full model)	Age, Income, Distance, Constraints, Place identity, Place dependence, Trophy cod, Catch cod, Quantity cod, Cod attachment, Retention cod, Fishing centrality, Fishing experience, Cod avidity, Fishing avidity, Skill (general), Skill (cod)	296.71
1	Fishing avidity	Age, Income, Distance, Constraints, Place identity, Place dependence, Trophy cod, Catch cod, Quantity cod, Cod attachment, Retention cod, Fishing centrality, Fishing experience, Cod avidity, Skill (general), Skill (cod)	294.72
2	Place dependence	Age, Income, Distance, Constraints, Place identity, Trophy cod, Catch cod, Quantity cod, Cod attachment, Retention cod, Fishing centrality, Fishing experience, Cod avidity, Skill (general), Skill (cod)	292.73
3	Cod avidity	Age, Income, Distance, Constraints, Place identity, Trophy cod, Catch cod, Quantity cod, Cod attachment, Retention cod, Fishing centrality, Fishing experience, Skill (general), Skill (cod)	290.8
4	Retention cod	Age, Income, Distance, Constraints, Place identity, Trophy cod, Catch cod, Quantity cod, Cod attachment, Fishing centrality, Fishing experience, Skill (general), Skill (cod)	288.93
5	Skill (cod)	Age, Income, Distance, Constraints, Place identity, Trophy cod, Catch cod, Quantity cod, Cod attachment, Fishing centrality, Fishing experience, Skill (general)	287.16
6	Constraints	Age, Income, Distance, Place identity, Trophy cod, Catch cod, Quantity cod, Cod attachment, Fishing centrality, Fishing experience, Skill (general)	285.55
7	Catch cod	Age, Income, Distance, Place identity, Trophy cod, Quantity cod, Cod attachment, Fishing centrality, Fishing experience, Skill (general)	284.03
8	Fishing centrality	Age, Income, Distance, Place identity, Trophy cod, Quantity cod, Cod attachment, Fishing experience, Skill (general)	282.84
9	Skill (general)	Age, Income, Distance, Place identity, Trophy cod, Quantity cod, Cod attachment, Fishing experience	281.76
10	Cod attachment	Age, Income, Distance, Place identity, Trophy cod, Quantity cod, Fishing experience	280.69
11	Distance	Age, Income, Place identity, Trophy cod, Quantity cod, Fishing experience	279.92
12	Fishing experience	Age, Income, Place identity, Trophy cod, Quantity cod	279.3

13	Place identity	Age, Income, Trophy cod, Quantity cod	**278.21**
Null	—	(no predictors)	284.14

Table 6. Backward stepwise AIC selection for logistic regression model predicting the selection of 'Cod fishing in the German North Sea' as a perfect substitute for cod fishing in the German Baltic Sea.

Step	Variable removed	Remaining variables	AIC
0	None (full model)	Age, Income, Distance, Constraints, Place identity, Place dependence, Trophy cod, Catch cod, Quantity cod, Cod attachment, Retention cod, Fishing centrality, Fishing experience, Cod avidity, Fishing avidity, Skill (general), Skill (cod)	263.4
1	Catch cod	Age, Income, Distance, Constraints, Place identity, Place dependence, Trophy cod, Quantity cod, Cod attachment, Retention cod, Fishing centrality, Fishing experience, Cod avidity, Fishing avidity, Skill (general), Skill (cod)	261.4
2	Age	Income, Distance, Constraints, Place identity, Place dependence, Trophy cod, Quantity cod, Cod attachment, Retention cod, Fishing centrality, Fishing experience, Cod avidity, Fishing avidity, Skill (general), Skill (cod)	259.42
3	Fishing avidity	Income, Distance, Constraints, Place identity, Place dependence, Trophy cod, Quantity cod, Cod attachment, Retention cod, Fishing centrality, Fishing experience, Cod avidity, Skill (general), Skill (cod)	257.44
4	Trophy cod	Income, Distance, Constraints, Place identity, Place dependence, Quantity cod, Cod attachment, Retention cod, Fishing centrality, Fishing experience, Cod avidity, Skill (general), Skill (cod)	255.51
5	Constraints	Income, Distance, Place identity, Place dependence, Quantity cod, Cod attachment, Retention cod, Fishing centrality, Fishing experience, Cod avidity, Skill (general), Skill (cod)	253.68
6	Skill (cod)	Income, Distance, Place identity, Place dependence, Quantity cod, Cod attachment, Retention cod, Fishing centrality, Fishing experience, Cod avidity, Skill (general)	251.9
7	Quantity cod	Income, Distance, Place identity, Place dependence, Cod attachment, Retention cod, Fishing centrality, Fishing experience, Cod avidity, Skill (general)	250.43
8	Retention cod	Income, Distance, Place identity, Place dependence, Cod attachment, Fishing centrality, Fishing experience, Cod avidity, Skill (general)	248.7
9	Income	Distance, Place identity, Place dependence, Cod attachment, Fishing centrality, Fishing experience, Cod avidity, Skill (general)	247.24
10	Skill (general)	Distance, Place identity, Place dependence, Cod attachment, Fishing centrality, Fishing experience, Cod avidity	245.86
11	Cod avidity	Distance, Place identity, Place dependence, Cod attachment, Fishing centrality, Fishing experience	244.45
12	Fishing centrality	Distance, Place identity, Place dependence, Cod attachment, Fishing experience	243.33
13	Distance	Place identity, Place dependence, Cod attachment, Fishing experience	**242.85**
Null	—	(no predictors)	253.6

Table 7. Backward stepwise AIC selection for logistic regression model predicting the selection of 'Fishing for other species in the German North Sea' as a perfect substitute for cod fishing in the German Baltic Sea.

Step	Variable removed	Remaining variables	AIC
0	None (full model)	Age, Income, Distance, Constraints, Place identity, Place dependence, Trophy cod, Catch cod, Quantity cod, Cod attachment, Retention cod, Fishing centrality, Fishing experience, Cod avidity, Fishing avidity, Skill (general), Skill (cod)	309.14
1	Cod attachment	Age, Income, Distance, Constraints, Place identity, Place dependence, Trophy cod, Catch cod, Quantity cod, Retention cod, Fishing centrality, Fishing experience, Cod avidity, Fishing avidity, Skill (general), Skill (cod)	307.14
2	Retention cod	Age, Income, Distance, Constraints, Place identity, Place dependence, Trophy cod, Catch cod, Quantity cod, Fishing centrality, Fishing experience, Cod avidity, Fishing avidity, Skill (general), Skill (cod)	305.23
3	Catch cod	Age, Income, Distance, Constraints, Place identity, Place dependence, Trophy cod, Quantity cod, Fishing centrality, Fishing experience, Cod avidity, Fishing avidity, Skill (general), Skill (cod)	303.32
4	Age	Income, Distance, Constraints, Place identity, Place dependence, Trophy cod, Quantity cod, Fishing centrality, Fishing experience, Cod avidity, Fishing avidity, Skill (general), Skill (cod)	301.41
5	Income	Distance, Constraints, Place identity, Place dependence, Trophy cod, Quantity cod, Fishing centrality, Fishing experience, Cod avidity, Fishing avidity, Skill (general), Skill (cod)	299.82
6	Place identity	Distance, Constraints, Place dependence, Trophy cod, Quantity cod, Fishing centrality, Fishing experience, Cod avidity, Fishing avidity, Skill (general), Skill (cod)	298.56
7	Distance	Constraints, Place dependence, Trophy cod, Quantity cod, Fishing centrality, Fishing experience, Cod avidity, Fishing avidity, Skill (general), Skill (cod)	297.55
8	Cod avidity	Constraints, Place dependence, Trophy cod, Quantity cod, Fishing centrality, Fishing experience, Fishing avidity, Skill (general), Skill (cod)	296.46
9	Skill (cod)	Constraints, Place dependence, Trophy cod, Quantity cod, Fishing centrality, Fishing experience, Fishing avidity, Skill (general)	295.36
10	Skill (general)	Constraints, Place dependence, Trophy cod, Quantity cod, Fishing centrality, Fishing experience, Fishing avidity	294.5
11	Fishing centrality	Constraints, Place dependence, Trophy cod, Quantity cod, Fishing experience, Fishing avidity	293.76
12	Place dependence	Constraints, Trophy cod, Quantity cod, Fishing experience, Fishing avidity	293.06
13	Constraints	Trophy cod, Quantity cod, Fishing experience, Fishing avidity	292.8
14	Quantity cod	Trophy cod, Fishing experience, Fishing avidity	292.7
15	Trophy cod	Fishing experience, Fishing avidity	**292.4**
Null	—	(no predictors)	299.22

Table 8. Backward stepwise AIC selection for logistic regression model predicting the selection of 'Marine predator species' as a perfect substitute for cod fishing in the German Baltic Sea.

Step	Variable removed	Remaining variables	AIC
0	None (full model)	Age, Income, Distance, Constraints, Place identity, Place dependence, Trophy cod, Catch cod, Quantity cod, Cod attachment, Retention cod, Fishing centrality, Fishing experience, Cod avidity, Fishing avidity, Skill (general), Skill (cod)	150.27
1	Cod avidity	Age, Income, Distance, Constraints, Place identity, Place dependence, Trophy cod, Catch cod, Quantity cod, Cod attachment, Retention cod, Fishing centrality, Fishing experience, Fishing avidity, Skill (general), Skill (cod)	148.33
2	Constraints	Age, Income, Distance, Place identity, Place dependence, Trophy cod, Catch cod, Quantity cod, Cod attachment, Retention cod, Fishing centrality, Fishing experience, Fishing avidity, Skill (general), Skill (cod)	146.4
3	Skill (cod)	Age, Income, Distance, Place identity, Place dependence, Trophy cod, Catch cod, Quantity cod, Cod attachment, Retention cod, Fishing centrality, Fishing experience, Fishing avidity, Skill (general)	144.54
4	Skill (general)	Age, Income, Distance, Place identity, Place dependence, Trophy cod, Catch cod, Quantity cod, Cod attachment, Retention cod, Fishing centrality, Fishing experience, Fishing avidity	142.68
5	Fishing avidity	Age, Income, Distance, Place identity, Place dependence, Trophy cod, Catch cod, Quantity cod, Cod attachment, Retention cod, Fishing centrality, Fishing experience	140.91
6	Place identity	Age, Income, Distance, Place dependence, Trophy cod, Catch cod, Quantity cod, Cod attachment, Retention cod, Fishing centrality, Fishing experience	139.53
7	Fishing experience	Age, Income, Distance, Place dependence, Trophy cod, Catch cod, Quantity cod, Cod attachment, Retention cod, Fishing centrality	138.21
8	Age	Income, Distance, Place dependence, Trophy cod, Catch cod, Quantity cod, Cod attachment, Retention cod, Fishing centrality	136.86
9	Place dependence	Income, Distance, Trophy cod, Catch cod, Quantity cod, Cod attachment, Retention cod, Fishing centrality	135.95
10	Retention cod	Income, Distance, Trophy cod, Catch cod, Quantity cod, Cod attachment, Fishing centrality	135.15
11	Income	Distance, Trophy cod, Catch cod, Quantity cod, Cod attachment, Fishing centrality	**135.11**
Null	—	(no predictors)	138.4

Table 9. Backward stepwise AIC selection for logistic regression model predicting the selection of 'Flatfish species' as a perfect substitute for cod fishing in the German Baltic Sea.

Step	Variable removed	Remaining variables	AIC
0	None (full model)	Age, Income, Distance, Constraints, Place identity, Place dependence, Trophy cod, Catch cod, Quantity cod, Cod attachment, Retention cod, Fishing centrality, Fishing experience, Cod avidity, Fishing avidity, Skill (general), Skill (cod)	550.73
1	Quantity cod	Age, Income, Distance, Constraints, Place identity, Place dependence, Trophy cod, Catch cod, Cod attachment, Retention cod, Fishing centrality, Fishing experience, Cod avidity, Fishing avidity, Skill (general), Skill (cod)	548.73
2	Distance	Age, Income, Constraints, Place identity, Place dependence, Trophy cod, Catch cod, Cod attachment, Retention cod, Fishing centrality, Fishing experience, Cod avidity, Fishing avidity, Skill (general), Skill (cod)	546.76
3	Cod attachment	Age, Income, Constraints, Place identity, Place dependence, Trophy cod, Catch cod, Retention cod, Fishing centrality, Fishing experience, Cod avidity, Fishing avidity, Skill (general), Skill (cod)	544.82

4	Retention cod	Age, Income, Constraints, Place identity, Place dependence, Trophy cod, Catch cod, Fishing centrality, Fishing experience, Cod avidity, Fishing avidity, Skill (general), Skill (cod)	542.9
5	Age	Income, Constraints, Place identity, Place dependence, Trophy cod, Catch cod, Fishing centrality, Fishing experience, Cod avidity, Fishing avidity, Skill (general), Skill (cod)	541.02
6	Skill (cod)	Income, Constraints, Place identity, Place dependence, Trophy cod, Catch cod, Fishing centrality, Fishing experience, Cod avidity, Fishing avidity, Skill (general)	539.34
7	Cod avidity	Income, Constraints, Place identity, Place dependence, Trophy cod, Catch cod, Fishing centrality, Fishing experience, Fishing avidity, Skill (general)	537.79
8	Fishing centrality	Income, Constraints, Place identity, Place dependence, Trophy cod, Catch cod, Fishing experience, Fishing avidity, Skill (general)	536.41
9	Constraints	Income, Place identity, Place dependence, Trophy cod, Catch cod, Fishing experience, Fishing avidity, Skill (general)	535.09
10	Income	Place identity, Place dependence, Trophy cod, Catch cod, Fishing experience, Fishing avidity, Skill (general)	534.54
11	Place dependence	Place identity, Trophy cod, Catch cod, Fishing experience, Fishing avidity, Skill (general)	533.9
12	Trophy cod	Place identity, Catch cod, Fishing experience, Fishing avidity, Skill (general)	533.22
13	Skill (general)	Place identity, Catch cod, Fishing experience, Fishing avidity	533.07
14	Fishing avidity	Place identity, Catch cod, Fishing experience	**532.55**
Null	—	(no predictors)	541.5

Table 10. Backward stepwise AIC selection for logistic regression model predicting the selection of 'Small pelagic marine species' as a perfect substitute for cod fishing in the German Baltic Sea. Note: the final selected model did not outperform the null model and was therefore not retained for analysis.

Step	Variable removed	Remaining variables	AIC
0	None (full model)	Age, Income, Distance, Constraints, Place identity, Place dependence, Trophy cod, Catch cod, Quantity cod, Cod attachment, Retention cod, Fishing centrality, Fishing experience, Cod avidity, Fishing avidity, Skill (general), Skill (cod)	518.19
1	Place dependence	Age, Income, Distance, Constraints, Place identity, Trophy cod, Catch cod, Quantity cod, Cod attachment, Retention cod, Fishing centrality, Fishing experience, Cod avidity, Fishing avidity, Skill (general), Skill (cod)	516.19
2	Age	Income, Distance, Constraints, Place identity, Trophy cod, Catch cod, Quantity cod, Cod attachment, Retention cod, Fishing centrality, Fishing experience, Cod avidity, Fishing avidity, Skill (general), Skill (cod)	514.26
3	Skill (general)	Income, Distance, Constraints, Place identity, Trophy cod, Catch cod, Quantity cod, Cod attachment, Retention cod, Fishing centrality, Fishing experience, Cod avidity, Fishing avidity, Skill (cod)	512.37
4	Fishing centrality	Income, Distance, Constraints, Place identity, Trophy cod, Catch cod, Quantity cod, Cod attachment, Retention cod, Fishing experience, Cod avidity, Fishing avidity, Skill (cod)	510.46
5	Cod attachment	Income, Distance, Constraints, Place identity, Trophy cod, Catch cod, Quantity cod, Retention cod, Fishing experience, Cod avidity, Fishing avidity, Skill (cod)	508.57
6	Income	Distance, Constraints, Place identity, Trophy cod, Catch cod, Quantity cod, Retention cod, Fishing experience, Cod avidity, Fishing avidity, Skill (cod)	506.73
7	Quantity cod	Distance, Constraints, Place identity, Trophy cod, Catch cod, Retention cod, Fishing experience, Cod avidity, Fishing avidity, Skill (cod)	505.02

8	Skill (cod)	Distance, Constraints, Place identity, Trophy cod, Catch cod, Retention cod, Fishing experience, Cod avidity, Fishing avidity	503.57
9	Distance	Constraints, Place identity, Trophy cod, Catch cod, Retention cod, Fishing experience, Cod avidity, Fishing avidity	502.14
10	Cod avidity	Constraints, Place identity, Trophy cod, Catch cod, Retention cod, Fishing experience, Fishing avidity	500.93
11	Trophy cod	Constraints, Place identity, Catch cod, Retention cod, Fishing experience, Fishing avidity	499.77
12	Retention cod	Constraints, Place identity, Catch cod, Fishing experience, Fishing avidity	498.9
13	Fishing experience	Constraints, Place identity, Catch cod, Fishing avidity	498.4
14	Constraints	Place identity, Catch cod, Fishing avidity	497.81
15	Place identity	Catch cod, Fishing avidity	497.76
Null	—	(no predictors)	496.9

Table 11. Backward stepwise AIC selection for linear regression model predicting agreement with the stated behaviour 'Fishing for freshwater species abroad' in response to the 2024 cod retention ban in the German Baltic Sea.

Step	Variable removed	Remaining variables	AIC
0	None (full model)	Age, Income, Distance, Constraints, Place identity, Place dependence, Trophy cod, Catch cod, Quantity cod, Cod attachment, Retention cod, Fishing centrality, Fishing experience, Cod avidity, Fishing avidity, Skill (general), Skill (cod)	1719.7
1	Skill (general)	Age, Income, Distance, Constraints, Place identity, Place dependence, Trophy cod, Catch cod, Quantity cod, Cod attachment, Retention cod, Fishing centrality, Fishing experience, Cod avidity, Fishing avidity, Skill (cod)	1717.7
2	Quantity cod	Age, Income, Distance, Constraints, Place identity, Place dependence, Trophy cod, Catch cod, Cod attachment, Retention cod, Fishing centrality, Fishing experience, Cod avidity, Fishing avidity, Skill (cod)	1715.72
3	Catch cod	Age, Income, Distance, Constraints, Place identity, Place dependence, Trophy cod, Cod attachment, Retention cod, Fishing centrality, Fishing experience, Cod avidity, Fishing avidity, Skill (cod)	1713.74
4	Fishing avidity	Age, Income, Distance, Constraints, Place identity, Place dependence, Trophy cod, Cod attachment, Retention cod, Fishing centrality, Fishing experience, Cod avidity, Skill (cod)	1711.78
5	Fishing centrality	Age, Income, Distance, Constraints, Place identity, Place dependence, Trophy cod, Cod attachment, Retention cod, Fishing experience, Cod avidity, Skill (cod)	1709.99
6	Trophy cod	Age, Income, Distance, Constraints, Place identity, Place dependence, Cod attachment, Retention cod, Fishing experience, Cod avidity, Skill (cod)	1708.32
7	Fishing experience	Age, Income, Distance, Constraints, Place identity, Place dependence, Cod attachment, Retention cod, Cod avidity, Skill (cod)	1706.6
8	Constraints	Age, Income, Distance, Place identity, Place dependence, Cod attachment, Retention cod, Cod avidity, Skill (cod)	1705
9	Cod avidity	Age, Income, Distance, Place identity, Place dependence, Cod attachment, Retention cod, Skill (cod)	1703.39
10	Distance	Age, Income, Place identity, Place dependence, Cod attachment, Retention cod, Skill (cod)	1701.72
11	Age	Income, Place identity, Place dependence, Cod attachment, Retention cod, Skill (cod)	1700.36
12	Skill (cod)	Income, Place identity, Place dependence, Cod attachment, Retention cod	1699.13

13	Place dependence	Income, Place identity, Cod attachment, Retention cod	1698.23
14	Income	Place identity, Cod attachment, Retention cod	1697.47
15	Retention cod	Place identity, Cod attachment	**1697.3**
Null	—	(no predictors)	1699.9

Table 12. Backward stepwise AIC selection for logistic regression model predicting whether anglers included 'Marine predator species' among their top five most targeted species since January 2024.

Step	Variable removed	Remaining variables	AIC
0	None (full model)	Age, Income, Distance, Constraints, Place identity, Place dependence, Trophy cod, Catch cod, Quantity cod, Cod attachment, Retention cod, Fishing centrality, Fishing experience, Cod avidity, Fishing avidity, Skill (general), Skill (cod)	199.51
1	Cod avidity	Age, Income, Distance, Constraints, Place identity, Place dependence, Trophy cod, Catch cod, Quantity cod, Cod attachment, Retention cod, Fishing centrality, Fishing experience, Fishing avidity, Skill (general), Skill (cod)	197.52
2	Skill (cod)	Age, Income, Distance, Constraints, Place identity, Place dependence, Trophy cod, Catch cod, Quantity cod, Cod attachment, Retention cod, Fishing centrality, Fishing experience, Fishing avidity, Skill (general)	195.57
3	Place identity	Age, Income, Distance, Constraints, Place dependence, Trophy cod, Catch cod, Quantity cod, Cod attachment, Retention cod, Fishing centrality, Fishing experience, Fishing avidity, Skill (general)	193.69
4	Fishing centrality	Age, Income, Distance, Constraints, Place dependence, Trophy cod, Catch cod, Quantity cod, Cod attachment, Retention cod, Fishing experience, Fishing avidity, Skill (general)	191.94
5	Fishing avidity	Age, Income, Distance, Constraints, Place dependence, Trophy cod, Catch cod, Quantity cod, Cod attachment, Retention cod, Fishing experience, Skill (general)	190.2
6	Trophy cod	Age, Income, Distance, Constraints, Place dependence, Catch cod, Quantity cod, Cod attachment, Retention cod, Fishing experience, Skill (general)	188.65
7	Constraints	Age, Income, Distance, Place dependence, Catch cod, Quantity cod, Cod attachment, Retention cod, Fishing experience, Skill (general)	187.05
8	Catch cod	Age, Income, Distance, Place dependence, Quantity cod, Cod attachment, Retention cod, Fishing experience, Skill (general)	185.55
9	Income	Age, Distance, Place dependence, Quantity cod, Cod attachment, Retention cod, Fishing experience, Skill (general)	184.06
10	Age	Distance, Place dependence, Quantity cod, Cod attachment, Retention cod, Fishing experience, Skill (general)	182.56
11	Cod attachment	Distance, Place dependence, Quantity cod, Retention cod, Fishing experience, Skill (general)	181.1
12	Fishing experience	Distance, Place dependence, Quantity cod, Retention cod, Skill (general)	179.83
13	Quantity cod	Distance, Place dependence, Retention cod, Skill (general)	179.39
14	Retention cod	Distance, Place dependence, Skill (general)	178.44
15	Skill (general)	Distance, Place dependence	**178.04**
Null	—	(no predictors)	179.8

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I certify that I have written this thesis independently and have not used any sources or aids other than those specified, that all statements taken verbatim or in spirit from other writings have been identified and that the thesis has not been used in the same or a similar form for other examinations and has not been submitted to any other examination authority.

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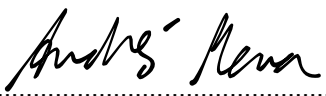
Berlin, 24.06.2026 

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