Proceedings of the 2019 Winter Simulation Conference
N. Mustafee, K.-H.G. Bae, S. Lazarova-Molnar, M. Rabe, C. Szabo, P. Haas, and Y.-J. Son, eds.

TOWARDS AN AGENT-BASED MODEL FOR MANAGING RECREATIONAL FISHERIES OF WESTERN BALTIC COD

Kevin Haase
Marc Simon Weltersbach
Wolf-Christian Lewin
Harry V. Strehlow

Thünen Institute of Baltic Sea Fisheries
Alter Hafen Süd 2
18069 Rostock, GERMANY

Oliver Reinhardt
Adelinde M. Uhrmacher

Visual and Analytic Computing
University of Rostock
Albert-Einstein-Straße 22
18059 Rostock, GERMANY

ABSTRACT

The removal of fish biomass by marine recreational fishery (MRF) for some fish species can be substantial. This makes its inclusion into stock management necessary. The impact of policy changes on angler behavior is, however, difficult to predict. Agent-based modeling and simulation appears as a promising approach, as it allows to include different types of agents with their individual decision strategies and social networks. Biomass removal by MRF was recently considered in stock assessment for western Baltic cod, but without consideration of angler behavior. Rich unexploited data sources are available, as data about anglers and catches has been collected for years, including surveys about the anglers decision making. Based on this data, we will develop an agent-based model of recreational fisheries for western Baltic cod. We will apply methods for managing the provenance of simulation models to make the foundations of the model, including assumptions and data, explicit.

1 THE IMPACT OF RECREATIONAL FISHERIES AND BALTIC COD MANAGEMENT

Marine recreational fishery (MRF) is a complex socio-ecological system, which generates significant economic and social values around the globe. About 8.7 million people participate in MRF in Europe, spending 5.9 billion € annually. Recreational fishers (anglers) target many different species with a broad range of fishing methods (Hyder et al. 2018) and it has been shown that MRF can impact fish stocks substantially through the removal of biomass. The recreational harvest has rarely been considered in stock assessment and management due to the lack of data and knowledge about the recreational fishery sector.

MRF has recently been taken into account in the stock assessments of western Baltic cod (Gadus morhua). The population has been in a poor state in the past decade with a spawning stock biomass (adult fish that can spawn, SSB) below the limit reference point and a low number of recruits (young fish that has grown into the SSB). The fishing pressure during this time exceeded the level of pressure that allows a sustainable yield. Decreased commercial fishing pressure and the introduction of a bag-limit for recreational fishery (maximum of 5 cod per fishing day and angler) in combination with one strong cohort led to an increase of the SSB in recent years (ICES 2019). The long-term biological effects as well as the social and economic costs for commercial and recreational fisheries, charter boat providers and the tourist sector remain, however, unknown.

Exploring the impacts of different regulations and understanding the mechanisms of recreational fishery, requires a model that takes current data and knowledge into account and is easily adaptable to new information.

2 MODELING OF RECREATIONAL FISHERIES

The behavior of anglers and their reactions to management decisions depend on various drivers and differs between individual anglers and angler groups. Next to resource-related aspects, joy, relaxation and to be in the nature are major drivers for the motivation and decision making of anglers. Weather and sea conditions play an additional role. Agent-based models can deal with the heterogeneity of angler populations and the complex individual decision making. Therefore, agent-based models can help to understand the processes of decision making and to predict the responses of anglers to new management regulations. Until now, only few models exist. For example, Johnston et al. (2010) analyze optimal regulation strategies to achieve a sustainable recreational fishery by considering angler diversity. The model is based on a virtual recreational fishery for a single lake and 5 types of anglers. In an agent-based model Gao and Hailu (2011) investigate recreational fishing behavior within a coral reef ecosystem based on empirical data. They include econometric sub-models of angler behavior, but leave out explicit complex decision processes and angler heterogeneity. We will use the existing models as orientation and for cross validation.

3 A NEW MODEL OF RECREATIONAL FISHERY FOR WESTERN BALTIC COD

In our study we aim to develop a novel simulation model of recreational fisheries, which helps scientists and policy makers to understand angler behavior and the impact of policy changes on anglers. For model building and validation, we can use an extensive data collection about western Baltic cod recreational fishery, collected at the Thünen-Institute for Baltic Sea Fisheries. The time-series data provides detailed information about angler demography (e.g., age, gender, place of residence, education, employment and annual expenses for fishing), fishing (e.g., fishing effort, catch, harvest and release rates, type of fishing license), but also about drivers for angling decisions such as main fishing motivation, catch satisfaction and acceptance of management tools (e.g., season closure, bag-limit, increase of minimum landing size). Especially the latter allows for a more detailed model of angler's decision processes, based firmly not only on theory of decision making, but also on empirical data. We will be able to identify different types of anglers, who react differently to policy changes. Data about cod stock development and commercial fishing pressure will also be included in our model. For validation, we plan to reproduce the effects of past policy changes, e.g., the aforementioned introduction of a bag limit in 2017. Finally, we will use the model to simulate the impact of proposed management measures for MRF in the western Baltic Sea. Our next step will be to assess model requirements, which will guide our decision for modeling methods and software. One central problem will be the quantification of decision drivers that are difficult to measure (e.g, relaxation, catch satisfaction). To some degree we will be able to adapt from the existing literature on fishing site choice (Hunt 2005). To make all assumptions, theory and data explicit, we will employ recent techniques for managing the provenance of simulation models (Ruscheinski and Uhrmacher 2017).

REFERENCES

Gao, L., and A. Hailu. 2011. "Evaluating the Effects of Area Closure for Recreational Fishing in a Coral Reef Ecosystem: The Benefits of an Integrated Economic and Biophysical Modeling". *Ecological Economics* 70(10):1735–1745.

Hunt, L. M. 2005. "Recreational Fishing Site Choice Models: Insights and Future Opportunities". *Human Dimensions of Wildlife* 10(3):153–172.

Hyder, K. et al. 2018. "Recreational Sea Fishing in Europe in a Global Context-Participation Rates, Fishing Effort, Expenditure, and Implications for Monitoring and Assessment". *Fish and Fisheries* 19:225–243.

ICES 2019. "Cod (Gadus Morhua) in Subdivisions 22-24, Western Baltic Stock (Western Baltic Sea)". *In Report of the ICES Advisory Committee, 2019, cod.27.22-24*.

Johnston, F. D., R. Arlinghaus, and U. Dieckmann. 2010. "Diversity and Complexity of Angler Behaviour Drive Socially Optimal Input and Output Regulations in a Bioeconomic Recreational-Fisheries Model". *Canadian Journal of Fisheries and Aquatic Sciences* 67(9):1507–1531.

Ruscheinski, A., and A. Uhrmacher. 2017. "Provenance in Modeling and Simulation Studies – Bridging Gaps". In *Proceedings of the 2017 Winter Simulation Conference*, edited by W. K. V. Chan, A. D'Ambrogio, G. Zacharewicz, N. Mustafee, G. Wainer, and E. Page, 872–883. Piscataway, New Jersey: Institute of Electrical and Electronics Engineers, Inc.