An Agent-based Model of the South African Offshore Hake Trawl Industry: Part II Drivers and Trade-offs in Profit and Risk

Rachel Cooper a,⁎, Astrid Jarre b

a Marine Research Institute, Department of Biological Sciences, University of Cape Town, Private Bag X3, Rondebosch, 7701 Cape Town, South Africa
b Marine Research Institute, Department of Biological Sciences, University of Cape Town, Private Bag X3, Rondebosch, 7701 Cape Town, South Africa

A R T I C L E   I N F O

Article history:
Received 27 July 2016
Received in revised form 18 June 2017
Accepted 23 June 2017
Available online xxxx

Keywords:
Fleet size
Trawl fishery
CPUE
Fuel price
Profitability in fisheries
Mean-variance analysis
Risk

A B S T R A C T

In South Africa's most valuable fishery, the offshore demersal hake trawl, participant companies differ in their rightsholdings, product streams, core business structure and their numbers and types of vessels. HakeSim, an agent-based model of this fishing industry, is used to explore these interactions, how companies could cope with increased fuel prices, and to provide insight into profit-risk trade-offs and vulnerabilities of companies. Apart from increasing catch per unit effort (CPUE), which is often detrimental to fish stocks, fuel price increases could be offset by increasing hake market value, achieved by processing fish to higher value end products with a lower catch cost per tonne. Industry's present fleet size and composition is demonstrated to result from profit-risk trade-offs: the flexibility to respond to mismatches between total allowable catch and CPUE, market demands for frozen and fresh product types, and environmental variability. Smaller companies have less risk-averse strategies and are more vulnerable to uncertainty in catches than larger companies, which may explain ongoing trends in consolidation in the industry. Increasing the proxy for environmental uncertainty increased risk to all companies without increasing profits. Incorporating more realistic environmental effects and feedbacks with industry in HakeSim could be an exciting future direction.

© 2017 Elsevier B.V. All rights reserved.

1. Introduction

In South Africa, the hake fishing industry is an important contributor to income in coastal communities, generating some 30,000 jobs (Rademeyer et al., 2008). It is also the country's most valuable fishery (Butterworth and Rademeyer, 2005; Petersen et al., 2010), generating an estimated 5 billion South African Rand (ZAR) per year at present. The costs, revenues and profits in this industry are much the same as those incurred by fisheries internationally, such as fuel and market price for fish (e.g. the target species Merluccius capensis and M. paradoxus). It is, however, a highly consolidated and vertically integrated industry with heterogeneous business models and a high level of complexity (Cooper et al., 2014). This makes the relative importance and complex interactions and trade-offs among different drivers like fuel price and environmental variability for the industry and its profits hard to estimate at a glance.

It is known that economic, ecological and social dimensions must be appropriately considered to ensure successful management for the sustainability of fisheries (Folke et al., 2007; Garcia and Charles, 2008; Pitcher and Lam, 2010). Effective policies for the sustainability of human (social and economic) and natural systems are underpinned by untangling the complexities of these systems, such as emergent properties and reciprocal effects (Liu et al., 2007). To be able to meaningfully incorporate ecological and human dimensions into management through appropriate objectives with measurable outcomes or indicators for South Africa's hake fishery, it is necessary to first have insight into the functioning of the industry and how its profits are affected by changes in some of its major drivers. Profitability is a significant incentive for commercial fishing companies (Sumaila et al., 2008).

A modelling approach can provide insight into this type of complex system and its structure, function and dynamics (Liu et al., 2007), particularly in a situation such as South Africa's where publically available economic data on the fisheries is scarce. Scenario testing provides further understanding of how changes in external drivers affect the industry's structure, function or dynamics. Achieving insight into the South African offshore demersal hake trawl fishery was the impetus behind the building of HakeSim, an agent-based model (ABM) of the fishery (Cooper, 2015; Cooper and Jarre, 2017). HakeSim captures the complex industry structure, complete with heterogeneous company, vessel and market agents, as well as important factors that affect the industry's profitability such as fuel price, total allowable catch, environmental variability (through a proxy), domestic and international market price and demand for hake.

⁎ Corresponding author.
E-mail addresses: Rachel.Cooper@protonmail.com (R. Cooper), astrid.jarre@uct.ac.za (A. Jarre).

http://dx.doi.org/10.1016/j.ecolecon.2017.06.027
0921-8009/© 2017 Elsevier B.V. All rights reserved.
Fuel price is one factor that majorly affects running costs and therefore profitability of the offshore hake trawl industry. It can account as much as 60% of running costs for fishing companies (Sumaila et al., 2008). It is well known as a core issue affecting the economics of the fishing industry, and changes to fuel prices are driven by global fuel prices (Cooper et al., 2014). The changes to and interactions among these and other variables result in observable patterns (emergent properties) at the ecosystem level, which is a form of risk. Since companies in the fishing industry have to continually adapt to changing circumstances, such as fuel prices, it was more relevant to use than population models. Moreover, as TAC is the operational variable that limits catches and different fleet compositions and sizes in the South African context; this would provide insights into why consolidation in the industry continues to happen despite governments attempting to divide up quota, as discussed in (Cooper et al., 2014), an important point in light of upcoming long term rights allocations.

2. Methods

To test a variety of scenarios for the offshore demersal hake trawl industry of South Africa, the model HakeSim was used, as described in Cooper and Jarre (2017). The core features of its design are summarised here for convenience. It is an ABM of the industry that captures the interactions and trade-offs in the absence of extensive quantitative economic data. It will also provide insights into why consolidation in the industry continues to happen despite governments attempting to divide up quota, as discussed in (Cooper et al., 2014), an important point in light of upcoming long term rights allocations.

It is not just the overall profit that is important to companies, but also variance in profit, which is a form of risk. Since companies in the South African offshore hake trawl industry differ in their risk tolerances, the composition and numbers of vessels that they own, the products that they sell and their core business structure (Cooper et al., 2014), they might make different trade-offs between profit and risk. They can also be quite differently affected by increased risk due to (environmental) variability in catches. This type of individual level variability and the collective, emergent properties at a fisheries system level that result from the interactions of these individual companies, vessels and markets are not captured in traditional economic models, but can be captured with an ABM.

Furthermore, the overall fleet size and composition of the entire hake trawl industry has changed significantly through time (Cooper et al., 2014), and this presumably reflects trade-offs between profit (i.e. vessel costs balanced against revenue under different catch and market conditions) and deviation in profits. Understanding how profit risk trade-offs affect fleet structure help to inform management and policies regarding what vessels companies can operate and how they operate them. For example, in Namibia government apportionment restrictions enforce a certain composition of wetfish to freezer trawlers (Kirchner and Leimarn, 2014), whereas the South African government has allowed companies to allocate their catch between vessels as they see fit.

The objectives of the present paper are to use HakeSim to 1) examine trade-offs and interactions among industry drivers, such as fuel price and environmental variability, for example to understand whether losses due to high fuel price or low catches could somehow be offset and 2) examine the trade-offs in risk (variation in profit) and profit that companies experience for different company sizes and structures, and different fleet compositions and sizes in the South African context; this will provide insights into their different business strategies and how these might fare under different levels of uncertainty. As an ABM HakeSim incorporates individual variability and interactions and how these result in observable patterns (emergent properties) at the fisheries system level, as well as qualitative data, it will provide a novel way of examining these interactions and trade-offs in the absence of extensive quantitative economic data. It will also provide insights into why consolidation in the industry continues to happen despite governments attempting to divide up quota, as discussed in (Cooper et al., 2014), an important point in light of upcoming long term rights allocations.
دریافت فوری متن کامل مقاله

امکان دانلود نسخه تمام متن مقالات انگلیسی
امکان دانلود نسخه ترجمه شده مقالات
پذیرش سفارش ترجمه تخصصی
امکان جستجو در آرشیو جامعی از صدها موضوع و هزاران مقاله
امکان دانلود رایگان ۲ صفحه اول هر مقاله
امکان پرداخت اینترنتی با کلیه کارت های عضو شتاب
دانلود فوری مقاله پس از پرداخت آنلاین
پشتیبانی کامل خرید با بهره مندی از سیستم هوشمند رهگیری سفارشات