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Fine-scale environmental effects on Cape hake survey catch rates in the northern Benguela, using data from a trawl-mounted instrument package

Paulus Kainge[1,2,*], Kai Wieland[2]

[1]National Marine Information and Research Centre (NatMIRC), Ministry of Fisheries and Marine Resources, Swakopmund, Namibia

[2]DTU Aqua – National Institute of Aquatic Resources, Technical University of Denmark, 9850 Hirtshals, Denmark

ABSTRACT: We investigated fine-scale effects of environmental variables associated with habitat distribution for 4 size groups of Cape hakes, *Merluccius capensis* and *M. paradoxus*, using generalized additive models (GAMs) with a negative binominal error distribution. This study took place during the Namibian hake trawl survey of 2016, and was made possible for the first time in Namibia by collecting oceanographic information with a trawl-mounted instrument package concurrently with the catch data. Depth, geographical position, bottom oxygen and bottom temperature had the most pronounced effect on the catch rates of both hake species, whereas solar zenith angle representing diel effects and surface layer chlorophyll appeared to be less important. The explained deviance for the best models ranged from 71.4% for *M. capensis* to 92.7% for *M. paradoxus* between 43 and 57 cm in length. Differences in catch rates between species and size groups were most pronounced for bottom depth and bottom oxygen. The results show the potential value of trawl-mounted instrumental packages for the collection of reliable environmental data important in the study of environmental influence on abundance, catch rates and distribution, and in turn in the assessment and management of a resource.

KEY WORDS: Survey catchability · Bottom trawl catch rates · Benguela current system · Green water effect · Negative binomial GAM ·

INTRODUCTION

Useful environmental variables collected near the seabed during survey trawling are crucial for investigating environmental effects on catch rates. In the northern Benguela (off the coast of Namibia), the National Marine Information and Research Centre (NatMIRC) of the Ministry of Fisheries and Marine Resources (MFMR) conducts annual bottom trawl surveys to estimate the abundance and biomass distribution of hake populations in Namibian waters. Survey biomass, together with commercial catch per unit effort (CPUE), are part of the stock assessment model for determining management measures such as total allowable catches (TAC). Survey biomass estimations show that shallow-water Cape hake *Merluccius capensis* is more abundant in Namibian waters than deep-water Cape hake *Merluccius paradoxus*, which is predominantly found in the southern part of the survey area (Burmeister 2005, Kainge et al. 2017). The 2 species have depth-related distributions; more than 75% of *M. capensis* are found shallower than 300 m while the same proportion of *M. paradoxus* are found deeper than 300 m depth (Burmeister 2001, Kainge et al. 2015).

The northern Benguela ecosystem is very productive due to high upwelling intensity (Hutchings et al.

*Corresponding author: paulus.kainge@mfmr.gov.na