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INTEGRATING HAWKES PROCESS- AND BIOMASS MODELS TO CAPTURE IMPULSIVE POPULATION DYNAMICS

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Abstract. This paper presents a modeling framework that captures the impulsive biomass dynamics (bust-boom) of a fish stock. The framework is based on coupling a Hawkes-process model to a discrete-time, ages-structured population dynamics model. Simulation results are presented to demonstrate the efficacy of the framework in capturing impulsive events in the population trajectory.
The results presented in this paper are significant in three ways:

- A framework has been presented that demonstrates how premonitory information may be extracted from exogenous observations from complex environmental systems
- We have demonstrated how exogenous information may be parameterized and incorporated into the modeling process for better understanding of the link between environmental drivers and the population dynamical system
- The framework has been successfully applied in modeling and short-term prediction of the population dynamics of an empirical fish stock.

Keywords. Hawkes process, Discrete time, Delay-time model, Auto-regressive, Impulsive population dynamics, Marine population, Parameter estimation.

AMS (MOS) subject classification: 93A30, 92-08, 90C31

1 Introduction

This paper deals with a system consisting of a single prey (the Barents Sea capelin) and multiple predators in a real ecosystem, where the prey biomass is impulsive, and a period of boom is followed by a protracted period of bust. No unique theory (based on predator-prey considerations) exists currently, to explain the multiple bouts of population bust and boom that has been observed in the past three decades, see e.g., [5, 15]. The goal of this paper is to investigate a hypothesis that considers an environmental point process as an external forcing of the population biomass dynamics. The approach involves