Noname manuscript No.
(will be inserted by the editor)

Title here

Do you have a subtitle? If so, write it here

Äüthör 1 · Âuthóř 2 ·

Received: date / Accepted: date

Abstract The text of your abstract. 150 – 250 words.

Keywords key · dictionary · word ·

Mathematics Subject Classification (2000) MSC code 1 · MSC code 2 ·

1 Introduction

Your text comes here. Separate text sections with [1].

2 Background

In this section we first review two well-established techniques commonly used in sustainable fishery management. These are the maximum sustainable yield (MSY) and the constant escapement (CE) approaches. After this, deep reinforcement learning is briefly reviewed

Grants or other notes about the article that should go on the front page should be placed here. General acknowledgments should be placed at the end of the article.

Äüthör 1
Department of YYY, University of XXX
E-mail: `abc@def`

Âuthóř 2
Department of ZZZ, University of WWW
E-mail: `djf@wef`

2.1 Fishery management

2.2 Deep reinforcement learning

3 Dynamical models used

In this section we present three models of increasing complexity which plausibly describe the population dynamics of a marine ecosystem. These models will form the test beds for the comparison between classical fishery management strategies and DRL.

3.1 A one-dimensional tipping point model.

Consider a population V whose dynamics is given by

$$\frac{\mathrm{d}V}{\mathrm{d}t} = rV\left(1 - V/K\right) - \frac{\beta H V^2}{V_0^2 + V^2}. \tag{1}$$

This model has been used in [2] to describe a grazing ecosystem, where a species V of vegetation is harvested by a constant herbivore population H.

In (1), a population V grows logistically with rate r up to carrying capacity K. This is expressed by the first term in the equation,

$$L(V \mid r,\ K) := rV\left(1 - V/K\right).$$

Moreover, V is predated on by a (constant) population H, as can be seen from the negative term

$$F(V,\ H \mid \beta,\ V_0) := \frac{\beta H V^2}{V_0^2 + V^2}$$

which saturates to βH as $V \to \infty$, and whose half maximum is V_0, i.e. $F(V = V_0,\ H; \beta,\ V_0) = \beta H/2$.

Ref. [2] studies the fixed points of (1) in order to show that in certain parameter regimes, its dynamics can undergo a *catastrophe.* A catastrophe is a sudden change in the state of the system from one stable state to another—often, the final state is ecologically detrimental, possibly associated with extinction or near-extinction events.

Fig. **??** shows the stable V populations for differing values of H. Here one sees that as $H \to T_2$, the top stable state is annihilated with the unstable fixed point. This way, if, e.g. H were to slowly drift until $H = T_2$, the system would collapse to the low stable state, leading to a near extinction of V.

4 Results

5 Discussion

Paragraph headings Use paragraph headings as needed. Use paragraph headings as needed. Use paragraph headings as needed. Use paragraph headings as needed. Use paragraph headings as needed. Use paragraph headings as needed. Use paragraph headings as needed.

$$a^2 + b^2 = c^2 \tag{2}$$

References

1. R. Mislevy, in *Educational Assessment*, ed. by R.L. Brennan (American Council on Education and Praeger Publishers, 2006), chap. 8
2. R.M. May, Thresholds and breakpoints in ecosystems with a multiplicity of stable states, Nature **269**(5628), 471 (1977)