A simulation framework for exploring spatio-temporal dynamics in mixed fisheries

Paul J. Dolder[a,b,*], Cóilín Minto[a], Jean-Marc Guarini[c], Jan-Jaap Poos[d]

[a] *Galway-Mayo Institute of Technology (GMIT), Dublin Road, Galway, Ireland*
[b] *Centre for Environment, Fisheries and Aquaculture Science (Cefas), Pakefield Road, Lowestoft, UK*
[c] *UPMC*
[d] *Wageningen Marine*

Abstract

[A concise and factual abstract is required. The abstract should state briefly the purpose of the research, the principal results and major conclusions. An abstract is often presented separately from the article, so it must be able to stand alone. For this reason, References should be avoided, but if essential, then cite the author(s) and year(s). Also, non-standard or uncommon abbreviations should be avoided, but if essential they must be defined at their first mention in the abstract itself. Graphical abstract: Although a graphical abstract is optional, its use is encouraged as it draws more attention to the online article. The graphical abstract should summarize the contents of the article in a concise, pictorial form designed to capture the attention of a wide readership. Graphical abstracts should be submitted as a separate file in the online submission system. Image size: Please provide an image with a minimum of 531 X 1328 pixels (h X w) or proportionally more. The image should be readable at a size of 5 x 13 cm using a regular screen resolution of 96 dpi. Preferred file types: TIFF, EPS, PDF or MS Office files.]

Keywords: Some, keywords, here. Max 6, American "spelling"

2010 MSC: 00-01, 99-00

*Corresponding author
Email address: `paul.dolder@gmit.ie` (Paul J. Dolder)

1. Introduction

Fishers exploit fish populations that are heterogenously distributed without prior knowledge of species distributions and non-selective fishing gear. Fisheries are managed by single-species quotas, leading to discarding of overquota catch. Increasing interest in technical solutions such as gear, spatial closures as a way of managing "fisheries" instead of fish stocks.

Provide some examples here of where this is the case..focus on spatial management and the increasing sophistication / resolution of data dervied from VMS and logbooks; refs: Geritsen et al, Mateo et al.

Use of spatial management as a tool is hampered by lack of knowledge of fish and fishery spatiotemporal dyanmics and the scale at which processes are important for management. Need to understand these to implement effective management measures for species avoidance / targeting. Use Dunn et al as a ref.

We develop a simulation model where underlying population dynamics are known rather than inferred from sampling or commercial catches. It includes population movement and a number of different fisheries exploiting four fish populations with different demographics.

Using the model, we simulation 20 years of exploitation of the fish populations and use the results to draw inference on the underlying population structures - as done in species modelling approaches.

We simulate a fishery closure to protect one species based on the fishery-dependent inferred distributions at a spatial and temporal scale typical in fisheries management, and assess a theoretical "benefit" to the population, and effect on the other three populations. Further, we extend our analysis to a range of spatial and temporal scales to assess the impact of these processes on the success of the management measure.

[State the objectives of the work and provide an adequate background, avoiding a detailed literature survey or a summary of the results.]

2. Materials and Methods

[Provide sufficient details to allow the work to be reproduced by an independent researcher. Methods that are already published should be summarized, and indicated by a reference. If quoting directly from a previously published method, use quotation marks and also cite the source. Any modifications to existing methods should also be described.]

2.1. Population dynamics

The basic population level processes are simulated using a modified two-stage Deriso-Schnute delay difference model [1, 2] occurring at the weekly time-step [3]. Here, population biomass growth and depletion for pre-recruits and fish recruited to the fishery are modelled separately as a function of previous recruited biomass, intrinsic population growth and recruitment:

$$
\begin{aligned}
B_{y,w+1} = \\
& (1+\rho)B_{y,w} \cdot e^{-Z_{y,w}} - \rho \cdot e^{-Z_{y,w}} \quad \times \\
& (B_{y,w-1} \cdot e^{-Z_{y,w-1}} + Wt_{R-1} \cdot \alpha_{w-1} \cdot R_{\tilde{y}(y,w-1)}) \quad + \\
& Wt_R \cdot \alpha_w \cdot R_{\tilde{y}(y,w)}
\end{aligned}
$$

ρ is Brody's coefficient, shown to be approximately equal to $exp(-K)$, where K is the growth rate from a von bertalanffy logistic growth model [2]. Wt_{R-1} is the weight of fish prior to recruitment, while Wt_R is the recruited weight. α_w represents the proportion of fish recruited during the week, while $R_{\tilde{y}}$ is the annual recruits.

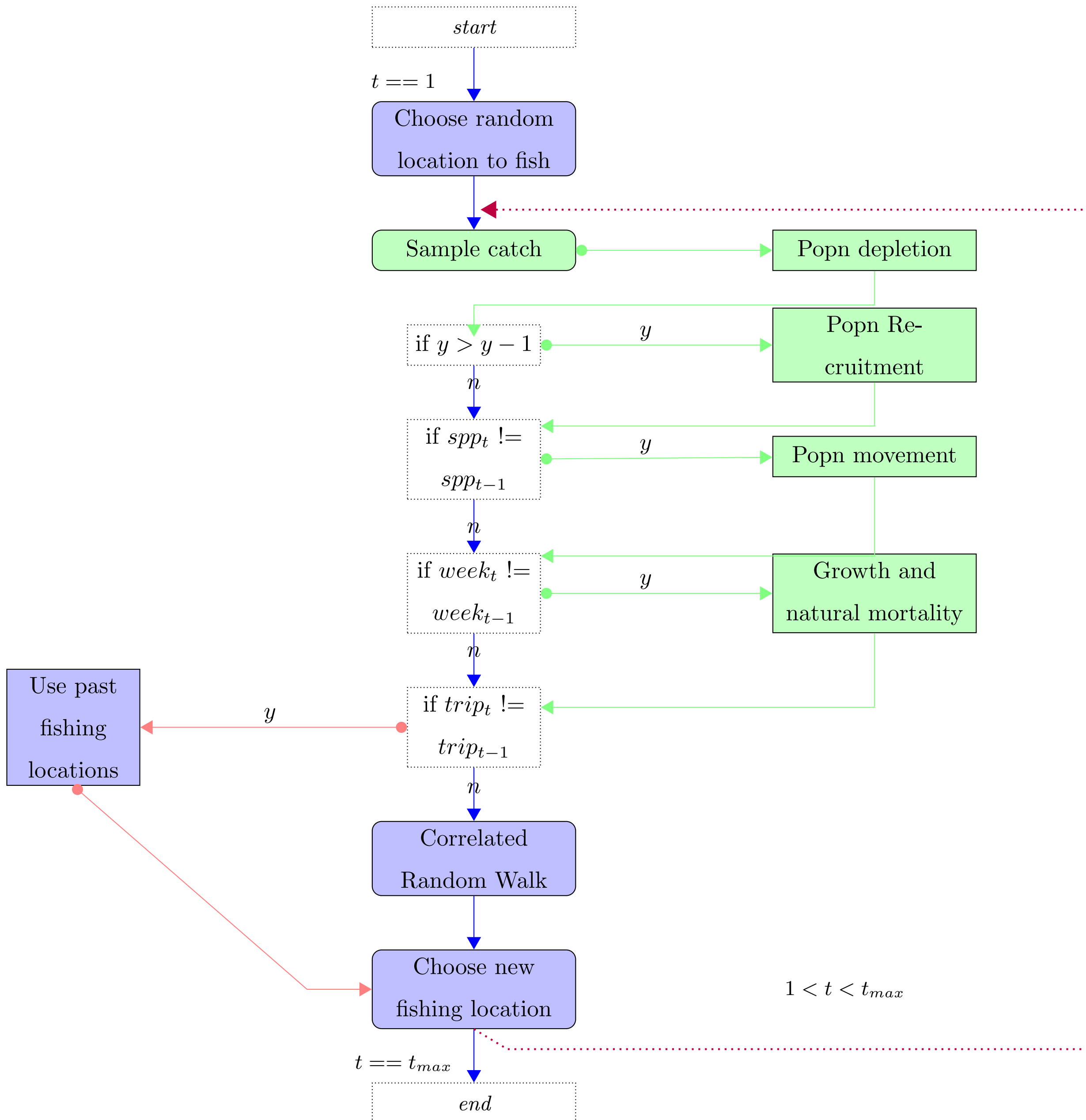

Figure 1: Overview Schematic of simulation model

Mortality Z can be decomposed to natural mortality, M, and fishing mortality, F, where both M and F are instantaneous rates with M fixed and F calculated by solving the Baranov catch equation [4] for F:

$$C_w = \frac{F_w}{F_w + M_w} * (1 - e^{-(F_w+M_w)}) * B$$

where C is the summed catch from the fishing model across all fleets and vessels for the species, year and week respectively, and B the weekly biomass for the species.

2.2. Recruitment dynamics

Recruitment is modelled through a function relating the biomass at time of recruitment to recruits, either as a stochastic Beverton-Holt stock-recruit form ([5]):

$$\bar{R} = \frac{(\alpha * B)}{(\beta + B)}$$
$$R \sim N[(\bar{R}, \sigma^2)]$$

Where α is the maximum recruitment rate, β the spawning stock biomass (SSB) required to produce half the maximum, and B current SSB;

or a stochastic Ricker form [6]

$$\bar{R} = B * e^{(\alpha - \beta * B)}$$
$$R \sim N[(\bar{R}, \sigma^2)]$$

where α is the maximum productivity per spawner and β the density dependent reduction in productivity as the SSB increases.

2.3. Population movement

2.4. Fleet dynamics

3. Theory/calculation

[A Theory section should extend, not repeat, the background to the article already dealt with in the Introduction and lay the foundation for further work. In contrast, a Calculation section represents a practical development from a theoretical basis.]

HERE DESCRIBE THE PARAMETERISATION, AND ANY COMPARISON AGAINST 'REAL' DATA

4. Results

Present simulated closures in terms of % change in population biomass and fishery.

[Results should be clear and concise.]

5. Discussion

This should explore the significance of the results of the work, not repeat them. A combined Results and Discussion section is often appropriate. Avoid extensive citations and discussion of published literature.

6. Conclusions

The main conclusions of the study may be presented in a short Conclusions section, which may stand alone or form a subsection of a Discussion or Results and Discussion section.

Appendices

If there is more than one appendix, they should be identified as A, B, etc. Formulae and equations in appendices should be given separate numbering: Eq. (A.1), Eq. (A.2), etc.; in a subsequent appendix, Eq. (B.1) and so on. Similarly for tables and figures: Table A.1; Fig. A.1, etc.

Abbreviations

Detail any unusual ones used.

Acknowledgements

those providing help during the research..

Funding

This work was supported by the MARES doctoral training program; and the Centre for Environment, Fisheries and Aquaculture Science seedcorn program.

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