Unnecessarily Complicated Research Title

John Smith

California, United States

Abstract

Keywords: Science, Publication, Complicated

1. Introduction

- Risk and uncertainty
- One rule for all?
- Impact of life histories
- Comparision of constant catch v changing catch based on trends in an empirical index.
- catch only - need good catch data if you havent got this how can you set catch limits

Sustainability and risks to non target exploited marine fish stock populations requires both estimates of current stock status, the effects of fishing pressure (catchability and fishing effort) and the effects of management measures on target populations, however these data are often lacking. Subsequently there is increasing concern and a growing need for the development of innovative approaches so that management of all marine stocks not just those of high commercial value can be included into the Common Fisheries Policy (CFP [1]) framework. Under the CFP management objectives are to recover stocks and to maintain stocks within safe biological limits to levels that can produce Maximum Sustainable Yield (MSY), including by-catch species by 2015 (Implementation Plan adopted at the World Summit on Sustainable Development, Johannesburg in 2002) and no later than 2020. These conservation objectives are currently being achieved by introducing biological target (can fluctuate around targets) and limit (i.e must not be exceeded) reference points e.g. population size (stock biomass) and/or yields (catches) and/or long–term yields and fishing mortality against which the preservation of stocks within such limits are assessed. These targets or limit reference points are often referred to as harvesting strategies which include an operational component called a harvest control rule (HCR) that are based on indicators (e.g. monitoring data or models) of stock status and to prevent overfishing.

The International Council for the Exploration of the Sea (ICES) categorises stocks in to classes *data-rich*, (categories 1 and 2) i.e those that have a quantitive assessment based on conventional mehods that require large amounts of data that include a long historical time series of catches and sound biological information [2]; or *data-limted* [3](categories 3 and 4) (often called data poor) those without assessment, forecasts and have limited funding for research. For data-rich stocks ICES uses two types of reference points for providing fisheries advice;

1. Precautionary Approach (PA) reference points (those relating to stock status and exploitation relative to precautionary objectives) and
2. MSY reference points (those relating to achieving MSY)

In contrast for data limited stocks MSY *proxy* reference points are used to estimate stock status and exploitation. Often many of the methods used to estimate MSY proxy reference points require length based inputs as they are cheap, easy to collect [4] and are related to life history paramters such as fish size, mortality and fecundity as well as fishery selectivity. For example many methods are being developed to estimate MSY, but currently only 4 are approved by ICES, these include, Surplus Production model in Continuous Time (catch based) (SPiCT; [5], Mean Length Z (MLZ; [6]), Length Based Spawner Per Recruit (LBSPR; [7]) and Length Based Indicators (LBI; e.g. [8]). The aforementoned data limited procedures have differing data requirements, intended uses and obviously have their own strengths and weaknesses.

To test the performance of candidate management procedures often requires evaluation of alternative hypothesis about the dynamics of the system e.g. population dynamics (life history dynamics such as growth parameters which are an indication of fishery exploitation levels and management) and the behaviour of the fishery (e.g range contraction and density dependence) etc.. Due to the nature of conflicting objectives, stakeholder interests and the uncertainty in the dynamics of the resource and/ or the plausibility of alternative hypotheses can lead to poor decision making and can be problematic when defining management policy.

An intense area of work being researched over the last 2 decades is Management Strategy Evaluation (MSE), which focuses on the broader aspects of fishing (the Ecosystem) whereby different management options are tested against a range of objectives (see [9]. The approach is not to come up with a definitive answer, but to lay-bare the trade offs associated with each management objective, along with identifying and incorporating uncertainties in the evaluation and communicating the results effectively to client groups and decision-makers. MSE is not intended to be complex but to provide a robust framework that account for conflicting poorly defined objectives and uncertainties that have been absent in conventional management [9].

To assess case specific harvest strategies (via simulation) within the MSE, we will implement a management procedure based on a empirical HCR that adjusts yield depending on stock status for a given range set of hypeparameters for each the harvest strategy and test their robustness to uncertainty. This approach could also help identify similar conditions across species where particular advice rules are likely to work well, and where they perform poorly for a given a set of hyper-parameters. Often empirical harvest control rules require extensive exhaustive parameter searches to tune hyper-parameters that aren't directly learnt from estimators. This requires a technique known as a grid search that extensively searches for all combinations of all parameters. In contrast and some what less time consuming alternative efficient parameter search strategies can be considered for a given range of parameter space and a known distribution. As such a random sample can be obtained and used to perform the different experiments for parameter optimisation. Assessment is made as to the performance of each HCR via a set of utilities: safety ($B/B_{MSY} > 1$), yield ($yield/MSY$), kobe proportion (proportion of years that stay in the green zone of kobe plot ($B/B_{MSY} > 1$), and Yield Annual Variation (yield changes by 10% year on year).

2. Material and Methods

2.1. Materials

Fishnets

2.2. Methods

FLife and MSE

2.2.1. Operating Model

Age based.

2.2.2. Management Procedure

The management procedure was based on an empirical MP, where an increase in an index of abundance resulted in an increase in the TAC, while a decrease in the index results in an decrease in the TAC.

2.2.3. Random Search

When running an MSE commonly a set of MP scenarios are run to tune the MP, this requires running the MSE for each OM scenario for a range of fixed values in the HCR and then choosing the rule that best meets management objectives. If there are a lot of parameters to tune then a grid search may become unfeasible. An alternative is random search [10] as randomly chosen trials are more efficient for parameter optimisation than trials based on a grid.

3. Results

Estimates of the simulated life history parameters obtained from Fishbase are presented in Fig.1. These show that for fast growing species as short lived small in size l_∞ (asymtopic length parameter) species such as sprat, the growth parameter k is high and its age-at-50%-maturity *a50* are low, in contrast to a slower growing larger l_∞ (high asymtopic length parameter) longer lived species such as rays or pollack.

Observations resulting from Fig.2 shows that maturity is related to selectivity and that the faster growing species are more susceptible to fishing, although the slower growing larger (by mass and length) species (e.g. pollack has a higher natural mortality rate at lower ages) with the most significant rate increases associated with turbot. A levelling off in the mortality rate is evident for ray just prior to age 4.5. In contrast, there have been less steep declines in natural mortality estimates for brill, but most notably for sprat.

Fig.3 displays the simulated time series resulting from the operating model in relation to reference points by species with the trends in annual stock estimates in relation to (bmsy). The relationships were compared via their statistical significance (see Table 3), using scatter plots. To highlight the changes in catchability over the 20-year period the data were divided equally into two 10-year time periods (Fig. 3, Fig. 4), and Fig. 5 reflects the mean indices over time, which is a summary of the indices presented in Fig. 3 and Fig. 4. Several spatial indices of fisher behaviour were correlated with estimates of catchability for both tuna species but, as expected, the nature and strength of these relationships differed between associated and unassociated sets and the timescales of the fishing behaviour (trip-level versus annually averaged).

[EXAMPLES TO BE UPDATED]

- Figure 3 shows the life history parameters
- Figure 2 shows the vectors
- Figure 4 shows the time series relative to reference points
- Figure **??** shows the performance statistics; points are

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    5. Figure 5 shows the utility functions for the seven study stocks points area

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4. Discussion

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- Bullet point two

5. Conclusions

- Bullet point one
- Bullet point two

6. References

References

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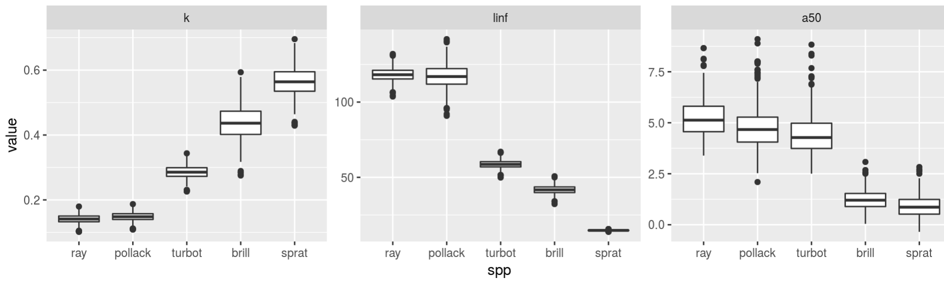

Figure 1:

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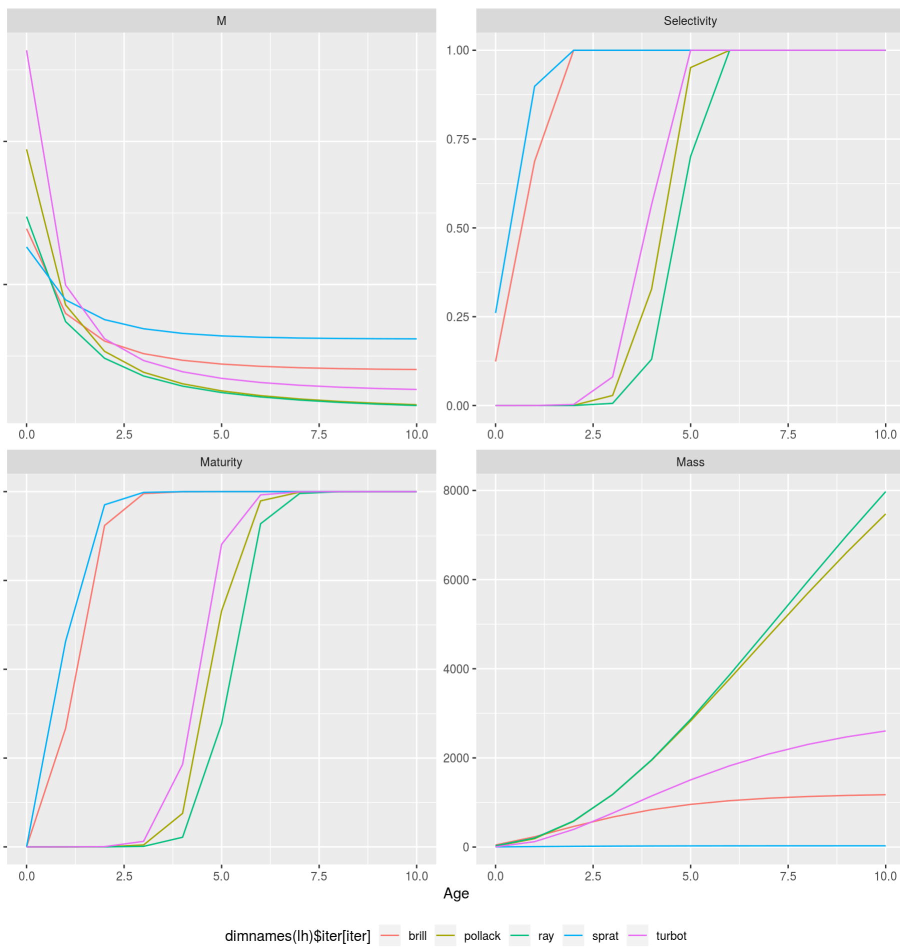
7. Figures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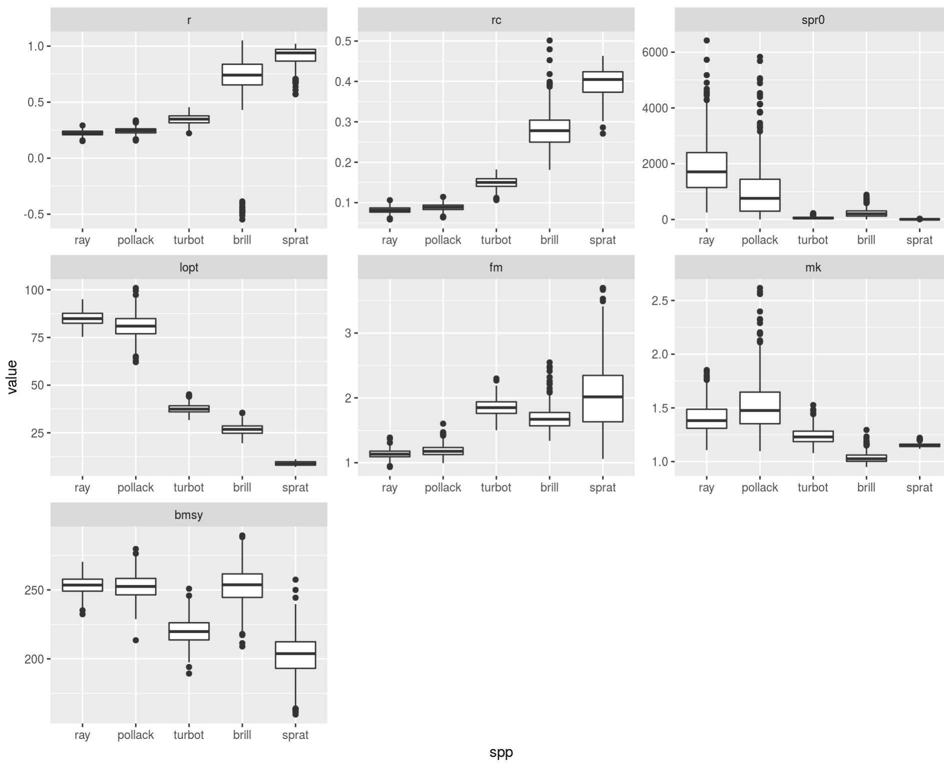

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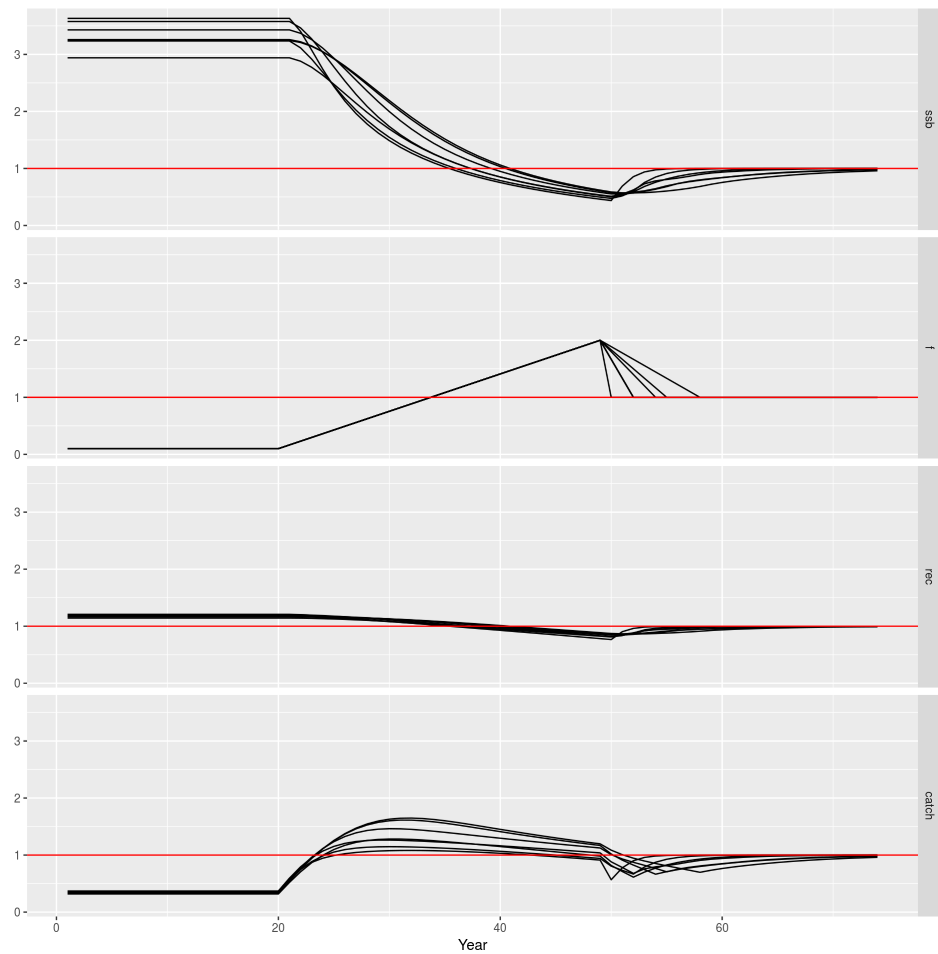

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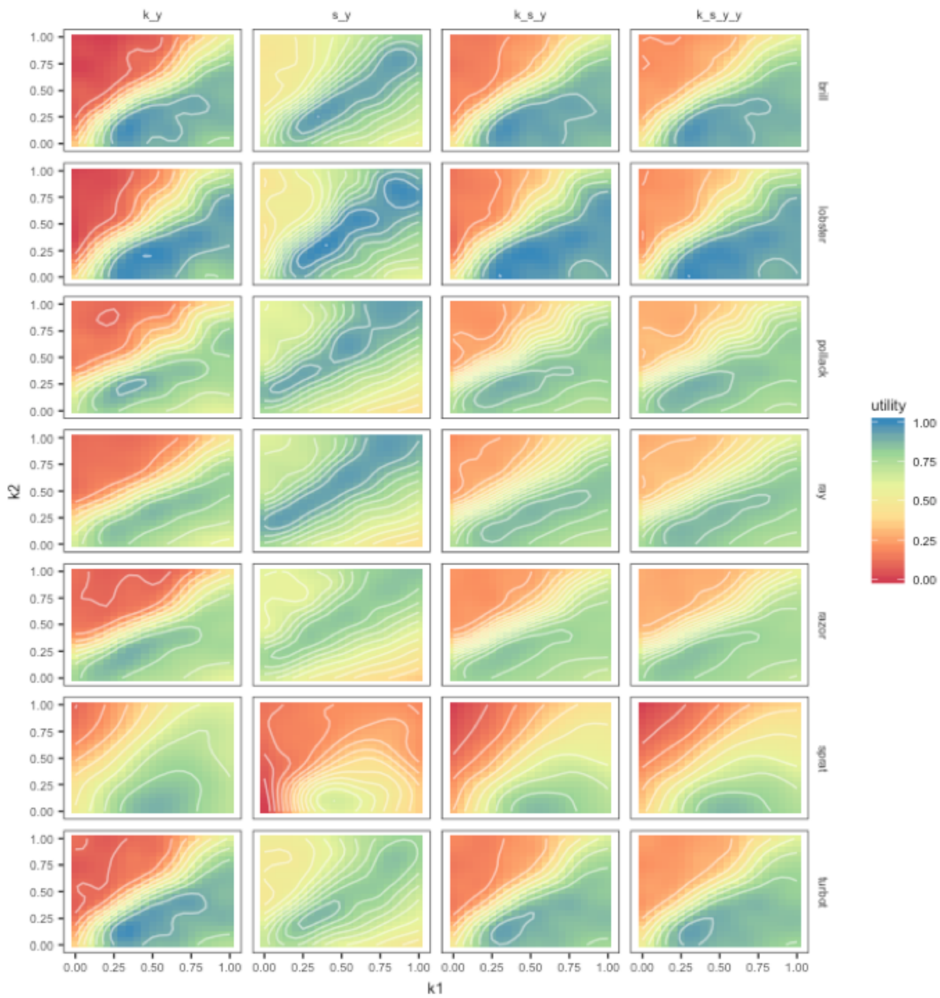
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Figure 5: