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Second-guessing uncertainty: Scenario planning for management of the Indian Ocean tuna purse seine fishery

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ABSTRACT

An important task of natural resource management is deciding amongst alternative policy options, including how interventions will affect the dynamics of resource exploitation. Yet predicting the behaviour of natural resource users in complex, changeable systems presents a significant challenge for managers. Scenario planning, which involves thinking creatively about how a socio-ecological system might develop under a set of possible futures, was used to explore uncertainties in the future of the Indian Ocean tuna purse seine fishery. This exercise stimulated thinking on how key social, economic and environmental conditions that influence fleet behaviour may change in the future, and how these changes might affect the dynamics of fishing effort. Three storylines were explored: an increase in marine protection, growing consumer preference for sustainable seafood, and depletion of tuna stocks. Comparing across several possible future scenarios, a number of critical aspects of fleet behaviour were identified that should be important considerations for fishery managers, but which are currently poorly understood. These included a switch in fishing practices, reallocation of effort in space, investment in new vessels and exit from the fishery. Recommendations for future management interventions in the Indian Ocean were offered, along with suggestions for research needed to reduce management uncertainty.

1. Introduction

An important task of fisheries management is deciding amongst alternative policy options. In doing this, policymakers must anticipate, typically using models, how key elements and dynamics of the system are likely to change in the future, and evaluate how the outcomes of management policies might be affected by this change. However, the future is loaded with uncertainty and surprise, and generating accurate, long-range biological, economic or political forecasts is a major challenge. In some regions, improved understanding of system dynamics and breakthroughs in computing power have led to the development of whole-of-system models (e.g. Atlantis, [22]), which has gone some way to improving the accuracy of forecasts. However, this depth of understanding and complexity of modelling is still beyond reach in most fishery systems, and in complex and uncertain systems the usefulness of modelled predictions of the future is limited [10].

In all fisheries systems, resource users are the key linkage between policymakers and the resource. The success of a management policy is more often than not contingent on the behaviour of fishers, and unexpected behaviours, resulting from a response to management or change in other drivers, can potentially generate unintended and undesirable outcomes (e.g. [5,25]). Despite the importance of fisher behaviour, this linkage between implementation and outcomes of management has often been downplayed or ignored in planning [23]. This is not helped by a lack of clarity on the role of fisher behaviour in management; whilst there has been considerable work directed at characterising fisher behaviour and understanding its drivers (see [40,44]), there has been little focus on the role of fishers in achieving (or undermining) management outcomes. Hence, fisher behaviour remains an important source of uncertainty in fisheries systems [23].

Scenario planning is a promising approach for aiding management decision making in complex, changeable systems. Rather than focussing on the accurate prediction of a single probable future, scenario planning involves thinking creatively about how the system might develop under a set of possible futures. In this way, policymakers can consider a range of plausible ways in which system dynamics might change, including surprise and catastrophe, and identify key uncertainties that might hinder the design and implementation of effective management policies. Scenario planning has been used extensively in business and politics

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to develop strategies for a range of possible futures [43]. More recently, scenarios have been used in the environmental sciences to improve decision making in complex ecosystems [3,46], to anticipate change in ecosystem services [36] and to explore strategies for sustainable development [39]. For instance, scenario planning was used in the Millennium Ecosystem Assessment for exploring the ways in which policy decisions may drive future ecosystem change, how ecosystem change may constrain future decision making, and ways in which ecological feedback may lead to surprise [32].

In this study, scenario planning was used to explore uncertainty in the future of the Indian Ocean tuna purse seine fishery, focussing attention on the behaviour of fishers. The aim was to stimulate thinking on how the key social, economic and environmental conditions that influence fisher behaviour, which are difficult to accurately forecast, may change in the future, and how these changes might affect the dynamics of fishing effort. A number of key aspects of fishing behaviour suggested in the scenarios as important considerations for policymakers were identified, and the current state of research on these behaviours was briefly reviewed to recommend avenues for future research.

2. Overview of scenario planning

There are many different approaches to scenario planning, which mainly differ in emphasis rather than method, depending on the goals of those who created them [37,4,43,45,46]. The scenario planning approach used here is adapted slightly from that described by Peterson et al. [36], who introduced the methodology of scenario planning to the discipline of conservation science. To the best of the authors' knowledge, there have been no scenario planning exercises published in the fisheries science literature, nor in the context of resource user behaviour. Peterson et al. describe scenario planning as consisting of six interacting stages, which, in order to incorporate a wide range of perspectives, are typically carried out in a workshop format by a diverse group of, for example, research scientists, managers, policymakers, and other stakeholders. In this case, the scenario planning exercise was the culmination of three years of detailed research on tuna purse seine fisher behaviour and was carried by the lead author (T. Davies) as a desk-based study.

2.1. Identification of the focal issue

Having a specific question in mind provides focus when examining possible futures, and therefore the identification of a clear focal issue is the first and arguably the most important stage in scenario planning. Here, the focal issue was uncertainty in dynamics of effort allocation in the Indian Ocean tuna purse seine fishery. These dynamics include two short term skipper-level behaviours; the allocation of effort in space and the allocation of effort between the two main fishing practices (fishing on free-swimming schools or floating objects), and two long term company-level behaviours; investment in fishing capacity and participation in the fishery.

2.2. Assessment of the system

This stage should determine what is known and unknown about the forces that influence the dynamics of the fishery system. The focal issue is used to organise an assessment of the actors, institutions and ecosystems that define the fishery and identify the key linkages between them. It is also important to identify engines of external change, whether they be social, economic or environmental, that drive system dynamics. Here, this assessment was based on an understanding of the system generated during the course of the research; from review of the academic and technical literature, interviews with skippers and other fishery experts, and primary research [12–14].

2.3. Identification of alternative futures

This stage involves the identification of alternative ways that the system could evolve in the future. How far into the future depends on the focal issue and the system; this study looked forward 15 years, as this was considered an appropriate length of time for both short term behaviours (e.g. patterns of effort allocation) and long term behaviours (e.g. investment in a fleet) to be influenced by the dynamics of the system. Although inherently uncertain, alternative futures should be plausible yet at the same time imaginatively push the boundaries of commonplace assumptions about the way in which the system will develop. These alternative futures should be based upon two or three uncertain or uncontrollable system drivers that have been determined in the previous assessment stage. For instance, uncertainties might arise from unknown behaviour of a group of actors, or from unknown dynamics in the natural or socio-economic components of the system.

2.4. Creating storylines

The next step is to translate alternative futures into descriptive storylines, based on the understanding of the various actors and drivers in the system accumulated during the assessment stage. Storylines should expand and challenge current thinking about the system, although they should be limited to three or four; a set of two storylines is usually too narrow, whereas more than four may complicate or confuse the scenario planning exercise [43,45]. In order to be plausible, storylines should link present events seamlessly with hypothetical future events, and the assumptions made and differences between the storylines must be easily visible. Consequently, storylines generally begin factual and become increasingly speculative at they progress. The storylines were constructed in three parts; first the changes in the fishery systems were set out, then what these changes mean in terms of fishing opportunities were outlined, and finally the storylines described the consequences for the behaviour of the fleet.

2.5. Cross-cutting behaviours

In this stage, the expected fisher behaviours under the different scenarios (a future and its associated storyline) were compared. This stage allowed opportunity for discussion on the sustainability of the fishery under alternative futures, and identification of which behaviours were common to more than one scenario and which were unique to one particular scenario. This final stage therefore served as the basis for recommendations concerning which of the fisher behaviours should be key considerations of policymakers when planning future management policies.

3. Assessment of the system

3.1. Operational, geographical and historical context

The tuna purse seine fishery exploits the surface schooling behaviour of three principal species; skipjack *Katsuwonus pelamis*, yellowfin *Thunnus albacares*, and bigeye tuna *Thunnus obesus*. In the open ocean tunas naturally aggregate in free-swimming schools (free schools) or associate with floating objects (associated schools), such as logs or branches [17]. Tuna fishers have learnt to