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Guidelines for developing formal harvest strategies for data-poor species and fisheries

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ABSTRACT

There has been extensive literature discussion regarding data-poor assessments, but considerably less on harvest strategies for data-poor fisheries. There is also a large body of work around harvest strategy development for data-rich fisheries. However, there has been little discussion or specific guidance regarding the process of developing and implementing formal harvest strategies for data-poor fisheries. We outline such a process, illustrated using case studies of data-poor Australian Commonwealth fisheries. The process comprises: (1) compile and review available information; (2) identify possibly indicators; (3) identify reference points for key indicators; (4) select an appropriate harvest strategy and decision rules; (5) if possible, formally evaluate whether the harvest strategy options are likely to achieve the management objectives; and (6) implementation. While this approach is similar to that for data-rich cases, there is less statistical or estimation detail within each step. Even with minimal capacity, the guidelines outlined here, backed by even the simplest form of management strategy evaluation, provide an approach that should enable harvest strategies to be proposed and associated monitoring to be implemented. Monitoring requirements may be explicitly built into harvest strategies via trigger reference points and control rules related to data-collection. While prior formal evaluation provides the best basis for testing the efficacy of a harvest strategy, there remains disparity between the corresponding required capacity and what many agencies and institutions worldwide are capable of providing. Thus, the extent to which harvest strategies may be effectively evaluated and implemented remains an unresolved challenge for data-poor fisheries, but one whose resolution is predicated, at least in the first instance, on adequate monitoring.

1. Introduction

There is increasing interest in the development of harvest strategies (HSs) to manage fisheries (e.g., Butterworth and Punt, 2003; Sainsbury et al., 2000). A harvest strategy specifies the monitoring program, the assessment and the use of performance measures in management decisions (through decision rules) to achieve the fishery management objectives.

Harvest strategies have been developed and applied mostly to data-rich fisheries because they typically use indicators (e.g., current exploitation rate and population biomass), with target and limit reference points estimable only through data-intensive analysis and quantitative population modelling. Developing harvest strategies for data-poor and/or capacity-poor (hereafter called "data-poor") fisheries is a significant challenge that must reconcile available information and capacity (both financial and human) against the need for a robust and transparently defensible harvest strategy to achieve management objectives (Dowling et al., 2008a; Smith et al., 2009). The conundrum is that management objectives often include avoiding overfishing, rebuilding overfished stocks, and maintaining stocks at productive target levels (Bence et al., 2008; Cadrin and Pastoors, 2008), which all imply some knowledge of stock size and exploitation rate that cannot be estimated for data-poor fisheries.

Vasconcellos and Cochrane (2005) estimated that 20–30% of the world's capture fisheries are data-poor, while Costello et al. (2012) report that about only 20% of the global fishery catch comes from assessed species. There has been much discussion surrounding assessments for data-poor species (e.g., Berkson et al., 2011; Dick and MacCall, 2010; Kruse et al., 2005; Martell and Froese, 2013; Pilling et al., 2008), and harvest strategies for data-rich

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fisheries (e.g., Constable, 2004; Punt et al., 2002; Smith et al., 2008), together with some consideration of decision rules for data-poor fisheries (e.g., Dowling et al., 2008a,b). Harvest strategies for data-poor fisheries, however, have only been dealt with sporadically. Carruthers et al. (2014) used management strategy evaluation (MSE) methods to test generic harvest strategies based on a range of data-poor assessment methods. However, there has been little discussion around the actual process of developing and implementing formal harvest strategies for data-poor fisheries.

There is a recent move to examine the global state of fisheries (e.g., Branch et al., 2011; FAO, 2010; Froese et al., 2012; Halpern et al., 2008; Hutchings et al., 2010; Thorson et al., 2012). While management of data-poor fisheries and fish stocks is improving within Organization for Economic Cooperation and Development member countries (Costello et al., 2012), analysis of most fisheries in other countries is less developed. This raises concerns about the status of such fisheries, but particularly those that are data-poor. Worm and Branch (2012) argue that capability and knowledge to manage fisheries exists, and so data-poor status should not be used as a reason for not implementing appropriate fisheries management. Moreover, harvest strategies are acknowledged to be an important component of good fishery management (Sloan et al., 2013; Smith et al., 2014; Vieira et al., 2010). It follows that harvest strategies should be developed and implemented to manage data-poor fisheries.

We describe a pragmatic process for developing formal harvest strategies for data-poor fisheries, illustrated by case studies from Australian Commonwealth (federal) fisheries. Although they may be argued to be on the lower end of data-rich, these examples still highlight the tools available for data-poor fisheries. After providing relevant definitions, we provide a stepwise guide to harvest strategy development, with a focus on empirical indicators and assessments. Empirical decision rules are beginning to be accepted in a growing range of data-poor fisheries (Bentley et al., 2005; Cheung and Sadovy, 2004; Dichmont and Brown, 2010; Parma et al., 2006), and some theoretical work has been done on the relative robustness and sensitivities of these approaches (e.g., Basson and Dowling, 2008; Campbell and Dowling, 2003; Carruthers et al., 2014; Little et al., 2011; Smith et al., 2009).

2. Defining data-poor fisheries

"Data-poor" fisheries may be defined as those for which (i) a quantitative stock assessment cannot be undertaken because of limitations in the type and/or quality of available data, and/or (ii) best available information is inadequate to determine reference points, current stock status, and/or the exploitation status of targeted stocks. Fisheries for which there is at least one other source of information in addition to catch and effort data, but for which a quantitative stock assessment cannot be undertaken could be considered to be "data-limited". As such, a fishery for which there is an existing catch or catch-per-unit-effort time series with adequate temporal and spatial coverage and contrast, enabling a (production model) assessment to be undertaken, is not considered here to be data-poor or data-limited. Conversely, catch and effort data may be available for some fisheries, but the nature of the fishery and/or the life history of the species may be such that stock status is unable to be determined.

"Data-poor" is a matter of degree. Restrepo et al. (1998) and Haddon et al. (2005) describe fishery and stock assessment attributes to delineate levels of data richness. Carruthers et al. (2014) emphasise that fisheries should be classified according to data quality in addition to the amount and type, stating that "data-rich" fisheries may be "information poor".

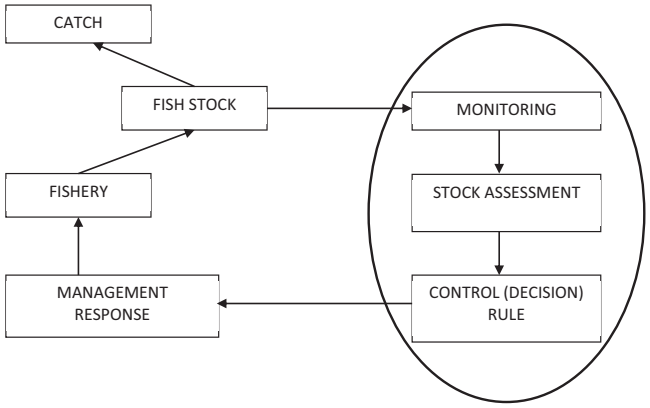

Fig. 1. The adaptive management cycle where the right hand side shows the three components of a harvest strategy. For data poor fisheries, stock assessment is usually replaced by the development and use of empirical performance measures based on direct observation.

Data-poor fisheries can include, but are not necessarily limited to:

a. new fisheries with limited observations and no time series of information;
b. those where fisheries research and management have lagged exploitation;
c. low-value fisheries or species for which comprehensive data collection is considered uneconomic or unjustified;
d. multi-gear, multi-species fisheries with many small operators and landing sites for which comprehensive monitoring is complex and resource demanding;
e. fisheries where data quality is poor or variable and difficult to verify (e.g., high levels of misreporting or non-reporting);
f. spatially-structured fisheries where data collected may not be representative of the whole stock; and
g. fisheries that retain by-catch species but do not adequately monitor by-catch.

3. Harvest strategy development

A harvest strategy is a set of specifications for managing a fishery to achieve defined management objectives (e.g., Butterworth, 2007; Rayns, 2007). Harvest strategies formalize management arrangements so that decisions are transparent to all stakeholders. A harvest strategy comprises: (a) a monitoring program, (b) an assessment that estimates status against specified management objectives, and (c) decision or control rules to determine management actions (Butterworth and Punt, 2003; Punt et al., 2002; Sainsbury et al., 2000) (Fig. 1). The decision rules explicitly link the outcomes of monitoring and assessment with the management response. Harvest strategies generally specify decision rules that invoke actions depending on the estimated status of stocks relative to target and limit reference points.

The efficacy of a harvest strategy should ideally be formally evaluated before the harvest strategy is implemented; this is often via MSE (Sainsbury et al., 2000; Smith et al., 1999). Testing is particularly important for empirical harvest strategies because the indicators on which they are based are usually indirect measures with potentially ambiguous interpretation, and management responses are often indirect (e.g., input controls). However, the capacity to undertake such testing is usually limited for data-poor fisheries.

A harvest strategy seeks to achieve management objectives despite uncertainties and data limitations. This generally entails increasing precaution with increasing uncertainty. If data