Marine Policy 94 (2018) 264–274

Contents lists available at ScienceDirect

Marine Policy

journal homepage: www.elsevier.com/locate/marpol

Ecosystem-based fisheries management (or 'triple bottom line') assessments of the western rock lobster resource: Is there an optimal target for fishing?

Nick Caputi*, Simon de Lestang, Jason How, Fabian Trinnie, Warrick (Rick) Fletcher

Science and Resource Assessment Branch, Division of Fisheries, Department of Primary Industries and Regional Development, PO Box 20, North Beach, WA 6920, Australia

ARTICLE INFO

Keywords:
Sustainability
Economic
Social
Maximum sustainable yield
Maximum economic yield
Quadruple bottom line

ABSTRACT

Ecosystem-based fisheries management (EBFM) is often termed triple bottom line because it takes into account ecological, economic and social criteria. Effective implementation of EBFM requires development of appropriate governance structures for decision-making processes and management, so governance effectiveness and efficiency can be regarded as the fourth element in a 'quadruple bottom line.' Few fisheries have explicitly considered all four criteria within their resource assessments and harvest strategies. Furthermore, as some of these objectives may be in competition (e.g. employment levels, profit), a simultaneous evaluation of these criteria is required to identify the optimal level of fishing to deliver the best overall community outcome.

The western rock lobster, *Panulirus cygnus*, resource in Western Australia is used as an EBFM case study by evaluating: sustainability of target species and effects on ecosystem and protected species; economics of the fishery; effect on employment, coastal communities and quality of recreational fishing; and governance effectiveness including explicit sectoral catch allocations, and the efficiency of monitoring and compliance systems.

In 2010 the fishery moved from effort-controlled maximum sustainable yield (MSY) to a quota-controlled, maximum economic yield (MEY) system. This study explicitly examined how different levels of harvesting across the MSY to MEY range affected each of ten EBFM criteria. We confirmed that these individual objectives were maximised at different total allowable commercial catches. However an example is provided for weighting of objectives from a possible management perspective that identified the upper end of the MEY range as likely to generate the optimum outcome for this fishery.

1. Introduction

Development of more holistic forms of natural resource management based on the principles of sustainable development that consider ecological, social and economic outcomes (the triple bottom line) have increased greatly over the past few decades (e.g. [26,28,53,14,30]). For fisheries, these more 'ecosystem-based' concepts have already shifted the focus of management in many jurisdictions from just ensuring the sustainability of the target species to also covering the broader effects of fishing on the ecosystem [25,45]. Within Australia this transition was facilitated by the adoption of ecologically sustainable development (ESD) by all levels of government [15] but more tangibly by the enactment of federal environment legislation that imposed specific environmental requirements on fisheries [16,24]. To address these, a national fisheries ESD subprogram was established which developed a framework and risk-based tools to assist individual fisheries to assess their impacts on target species, bycatch species, habitats and the broader ecosystem (e.g. [31,32,33,27,29]).

The ESD-based assessment and management of the ecological components of individual fisheries in Australia has been routine for over a decade [4], but the formal inclusion of economic and especially social components has been much slower both in Australia [60] and elsewhere (e.g. [39]). Thus, economic concepts such as maximum economic yield (MEY) have only been specifically included within the harvest strategies of some fisheries [20,22,35]. The formal consideration of social objectives has, however, rarely been explicit and these can vary widely between fisheries [39] and may even differ between sectors within a fishery [2]. This situation is replicated in many other countries [2] despite the concept of 'social licence to fish' being identified as one of the key challenges facing the fishing industry worldwide (e.g. [1,43]).

The limited formal inclusion of social and economic components into management systems is due, at least in part, to the lack of clear legislative/regulatory drivers compared to those that are imposed for the ecological components. Furthermore, their incorporation has also been hindered because most individual fishery management plans

* Corresponding author.
E-mail address: Nick.Caputi@dpird.wa.gov.au (N. Caputi).

https://doi.org/10.1016/j.marpol.2018.05.015
Received 4 September 2017; Received in revised form 29 March 2018; Accepted 8 May 2018

could not address the combined effects of multiple sectors or fisheries operating on a resource and therefore deal effectively with conflicting objectives and sectoral allocation issues [50]. The incorporation of social components is further limited by difficulties in quantifying certain aspects of this component e.g. work-life balance, ability to enter the fishery, the value of the fishery to the surrounding community [42].

While some management objectives (e.g. MEY and ecosystems) can be 'maximised' at the same time, some cannot (e.g. employment and profit), with the optimal level of fishing depending on what weight is placed on the various management objectives [39]. Similarly, Pascoe et al. [51] found that the weighting placed on multiple management objectives varied both between and within the different stakeholders, reflecting the differing importance placed on objectives by each stakeholder group. Therefore, it was recognised that a more comprehensive approach was required with changes to the structure and scope of governance to ensure that the decision-making processes and management arrangements operated at an appropriate level (see [34]). Consequently, the effectiveness and efficiency of the governance systems used for natural resource management can be described as the fourth element in what could be referred to as the quadruple bottom line.

Within Western Australia (WA), a series of ESD-related governance policies have been developed over the past two decades culminating with the development and full adoption of Ecosystem-Based Fisheries Management [26,28,33,34] through the passing of the new aquatic resource management legislation [3]. EBFM is resource-based, not activity-based, and it explicitly recognises that we manage ecological resources to generate economic and social benefits for the community. Importantly, the new act will now require Government, on behalf of the community, to set explicit objectives and associated sector allocations at the whole of resource level. These objectives and sectoral allocations will then be translated into appropriate management actions for all sectors through the development of a single comprehensive multi-objective, multi-sectoral harvest strategy for each resource [23,35]. As all of the necessary policy and legislative instruments are now in place within WA, it is therefore timely to examine how to make the best utilisation of this approach using the western rock lobster as an ideal case study to assess the full implementation of EBFM as the fishery has considered many of the issues associated with EBFM.

2. Western rock lobster case study

2.1. Background

The western rock lobster, *Panulirus cygnus*, resource in WA (Fig. 1) has a long history of management with the adoption of limited-entry for the commercial sector in the early 1960s and was the first to obtain Marine Stewardship Council (MSC) certification in 2000 [45]. It has formal sectoral harvest shares allocated to the commercial, recreational and indigenous sectors [21]. Following a significant decline in post-larval (puerulus) settlement and significant economic pressures [12], in 2010 the fishery transitioned from an effort-controlled commercial fishery based on achieving maximum sustainable yield (MSY) to an output-controlled "MEY-based" fishery with a total allowable commercial (TACC) and recreational catch (TARC) [22].

The western rock lobster resource has a harvest strategy in place that covers commercial and recreational sectors and includes explicit stock sustainability and sector-level economic and social objectives [22]. As this resource is scheduled to be one of the first to move under the new Act, this will require the articulation by Government of the explicit objectives for the 'use' of this resource [3]. Consequently, before this occurs it would be valuable to examine how the significant changes in management that have occurred over the past decade have affected each of the ESD/EBFM related components to inform future development of the governance for the rock lobster and other resources.

This study therefore examines the full EBFM-based performance of the western rock lobster fishery over the past 10 years by assessing the:

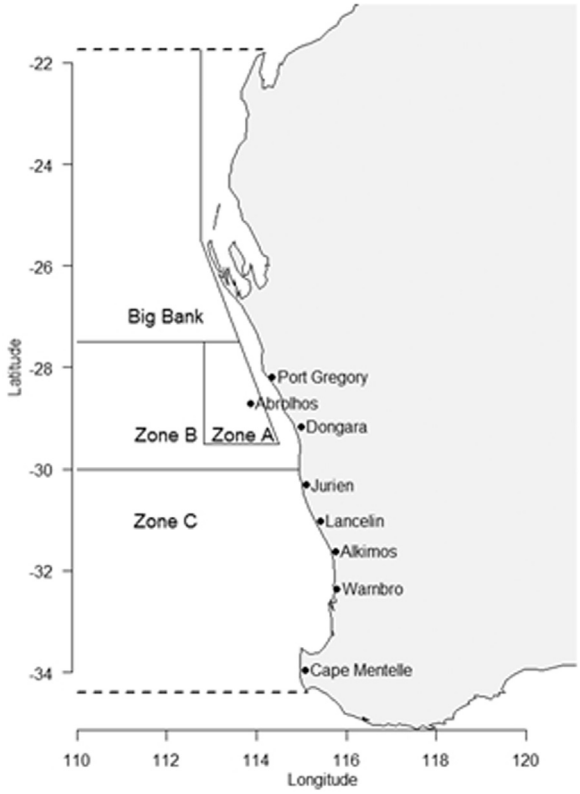

Fig. 1. Map of the western rock lobster fishery (boundaries; dotted lines), indicating the fishing zones (solid lines) and locations of puerulus settlement monitoring (dots).

(a) ecological performance of the target stock based on the egg production; (b) ecological performance relating to its effect on protected species, habitat and ecosystems; (c) economic performance based on MEY, the value of licences and the GVP generated for the State; (d) social performance based on recreational catches and catch rates, the number of commercial vessels operating and other social benefits and impacts associated with commercial fishery moving to individual transferable quota (ITQ) including local access by consumers to this resource; and (e) governance efficiency and effectiveness through the number of annual regulatory interventions plus ongoing monitoring and compliance costs. This paper represents a review article that provides a synthesis of work of many scientists and managers who have contributed to the various components of EBFM over many year. Noting that multiple objectives need to be accommodated, the paper specifically examines where, within the range of harvest levels of fishing, an optimum level for the fishery may occur, by collectively considering 10 ecological, economic, social and governance issues which are weighted from a fisheries management perspective.

2.2. Sustainability assessment

Sustainability is the primary objective for the management of all fisheries in WA [23]. For the WRL fishery, the harvest strategy measures are based on the current level of rock lobster egg production as well as that projected over the next 5 years [22]. The puerulus settlement 49-year time series (Fig. 2) has been a major driver in the management of the western rock lobster fishery as it has been demonstrated to be a reliable predictor of recruitment to the fishery 3–4 years later since the 1980s [17,54,8,9].

The record-low puerulus settlement in 2008/09 and 2009/10 [18] was the impetus in the major management changes that occurred during 2008–2010. Initially the changes involved effort reductions of