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Untangling a Gordian knot that must not be cut: Social-ecological systems research for management of southern Benguela fisheries

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ABSTRACT

The historical approach of sector-specific, largely top-down management in favor of highly capitalized industry sectors has seemingly left southern Benguela fisheries management in a Gordian knot. The modern systems approach to management of human activities in the oceans forbids cutting through the knot, making it necessary to develop methodology for including a wide range of stakeholders and trading off multiple, conflicting objectives under high uncertainty. Recent research in an interdisciplinary group including researchers and students from the humanities, social and natural sciences has focused on soft predictability and structured decision making in social-ecological marine systems under global change. Using three management case studies from the southern Benguela, i.e. purse-seine fisheries, conservation of the Endangered African penguin and the commercial handline fishery system in the southern Cape, we review how modelling system dynamics with stakeholders, semi-quantitative methodology for the integration of a wide variety of indicators, social learning, communication around shared issues and dedicated trust building have supported softening of boundaries between stereotyped stakeholders, and are contributing to a shared knowledge base as well as to an extended toolkit for management. We highlight promising loops of the knot with a view of generating discussion on how these can be tackled strategically.

1. Introduction

The historic approach of sector-specific, largely top-down management (Ommer et al., 2012) in favor of highly capitalized industry sectors has seemingly left fisheries management in the southern Benguela, situated around South Africa's west and south coasts, caught in a Gordian knot. The country's economically most important fishery, on Cape hakes (*Merluccius capensis* and *M. paradoxus*) is struggling with increasingly less optimistic stock outlooks (Rademeyer and Butterworth, 2016), and the country's second most important fishery, the purse-seine fishery targetting sardine (*Sardinops sagax*), has been contending with a worryingly low resource base for nine out of the past ten years (de Moor and Butterworth, 2016). Commercially important coastal resources, including the west coast rock lobster (*Jasus lalandii*) and linefish are grossly overfished (e.g., Blamey et al., 2015). Coastal fishing communities are poor (e.g., Sowman et al., 2014) and marginalized in the decision-making and management processes. Tensions in human social subsystems are high, ranging from grievances of small quota holders in the large, offshore fisheries (e.g., Hara et al., 2014), through class action court cases of fishing communities (e.g., Isaacs, 2011) and irregularities in fishing right allocations ("FRAP 2013", see, e.g., Moolla, 2014) to highly organized crime syndicates targeting high value resources such as abalone (*Haliotis midae*) (e.g., Norton, 2014; Raemaekers et al., 2011; Steinberg, 2005). Although it would have been reasonable to assume that industrialized fisheries management had learnt from the havoc wreaked by the collapse of the Newfoundland-Labrador cod fishery some 25 years ago, there continues to be an overwhelming parallel in South Africa to the structural problems in Canadian fisheries in the 1980s, caused by bureaucratic, centralist management that has failed to institute relationships that promote rural

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development with a diversified livelihood base (Ommer, 1985).

South Africa has committed to implementing an Ecosystem Approach to Fisheries (EAF) (FAO, 2003; Garcia and Cochrane, 2005), which strives to balance ecological, economic, social, and governance-related objectives in view of uncertainty and multiple drivers external to the fisheries system, such as global (including climate) change. Implementation of this approach is envisaged along three dimensions, ecological, human and "ability to achieve" which, taken together, comprise the main elements of governance and also consideration of the influence of drivers beyond the control of fisheries management institutions such as long-term climate variability and change, or pollution. The implications of this modern systems approach to management of human activities in the ocean makes it necessary to develop methodology for including a wide range of stakeholders and trading off multiple, conflicting objectives under high uncertainty. The approach seeks to implement the principles of "ecosystem justice" discussed in Coward et al. (2000), implying the need to develop ethically acceptable relationships among all competing and complementary interests of a social-ecological system. In short, it rejects cutting through the proverbial knot by pursuing solutions that may seem short-term effective but cause high collateral damage.

In practice, however, South Africa has embarked on a neoclassical economy, which continues to favor economic over ecological and social values. An improvement of well-being of the natural and the human-social subsystems in the southern Benguela requires (following on from, e.g., Jentoft, 2000) re-building overexploited coastal and offshore marine living resource bases while building sustainable fishing communities that are currently unbalanced or dysfunctional through such structural problems as poverty and low education levels, aggravated in South Africa by the atrocities of its Apartheid past (e.g., Ratner et al., 2013; Russell, 2009). Fisheries problems have been recognized as 'wicked' (Rittel and Webber, 1973 and many recent other studies) - i.e., so complex that there is disagreement on how to solve their problems and so they remain persistent or recurring, in part because there are no technical 'solutions' except those that often have distributional and procedural equity implications for stakeholder groups. Rebuilding damaged fisheries has been described as "particularly wicked" (Khan and Neis, 2010). Given this, our solution is to use available qualitative and quantitative methodology, here called "tools", to unpick the more promising loops of the Gordian knot, while also contributing new tools to the existing toolkit.

The implementation of an EAF in the southern Benguela region — which represents two of the four subsystems of the Benguela Current Large Marine Ecosystem (Blamey et al., 2015; Hutchings et al., 2009) — is based on a relatively good understanding of ecological dynamics (e.g., Moloney et al., 2004; Shannon et al., 2004) and the more recent increased focus on understanding the human social dimensions and social-ecological interrelationships of fisheries in a management context (Hara et al., 2014; Isaacs, 2013; Jarre et al., 2013; Norton, 2014; Sowman et al., 2013). Marine Spatial Planning for biodiversity conservation, as well as integrated coastal zone management, are also developing (Lombard et al., 2004; Sink and Attwood, 2008; Sink et al., 2011). Our interdisciplinary group, which includes researchers and students from anthropology, sociology, history, geography, economics, mathematics, oceanography and biology, has the requisite interdisciplinary expertise to tackle the problem. Our research has focused on soft predictability and structured decision making in the Benguela under global change, with the aim of advancing the implementation of an EAF. In other words, we have sought to generate a wider knowledge-base for management which is shared by a larger group of stakeholders, in support of inclusive, transparent and defensible management decision-making.

Using three case studies — the South African purse-seine fisheries, conservation of the Endangered African penguin and the commercial handline fishery system in the southern Cape — we here review progress and the lessons learnt for the South African but also global contexts, and suggest strategic next steps to strengthen the support for an ecosystems approach to fisheries management based on social-ecological systems research.

2. Methodology and results by case study

2.1. Case study 1: South African purse-seine fisheries

South Africa's purse seine fishery mainly targets sardine and anchovy (*Engraulis encrasicolus*), with by-catch of juvenile horse mackerel (*Trachurus capensis*) and redeye round herring (*Etrumeus whiteheadi*), as well as mesopelagic lanternfish (*Lampanyctodes hectoris*) and lightfish (*Maurolicus walvisiensis*). Sardine is mostly canned for human consumption, where South African demand exceeds the current supply, and also frozen as bait. Anchovy are reduced to fishmeal and oil which is traded globally. The fishery has undergone substantial changes over the past 70 years (e.g., Hutchings et al., 2015; Jarre et al., 2013) most recently in the wake of a regime shift that caused a shift in distribution from the west coast subsystem to the Agulhas Bank subsystem in the early 2000s (Coetzee et al., 2008; Fairweather et al., 2006; Howard et al., 2007).

The fishery is currently managed based on long-term rights (in effect an Individual Transferable Quota (ITQ) system), an Operational Management Procedure (OMP) that sets annual total allowable catches (TACs) for sardine and anchovy, as well as precautionary upper catch limits for the principal bycatch. This management system continues to favor industrial capitalism (e.g., Hara et al., 2014). The active involvement of large industry in both scientific (stock assessment) and management working groups of the Fisheries Branch of the Department of Agriculture, Forestry and Fisheries (DAFF) exerts strong influence on scholarly discourse and management decisions. Principal sources of conflict include the needs of small quota holders and new (post-1996) entrants into the fishery versus those of established, large industry, and those of balancing ecosystem services versus maximization of fisheries revenue. The power of the neoclassical economics paradigm is also manifested in the disbanding by DAFF in 2014 of the EAF Working Group in which much of the research underpinning the implementation of an EAF had been shaped and shared, including the novel frame-based (Smith and Jarre, 2011; Watermeyer, 2015) and agent-based systems modelling approaches (Cooper, 2015).

An Ecological Risk Assessment (ERA), carried out in 2005 (Nel et al., 2007), pointed to extreme risks in all three EAF dimensions, and derived a set of management objectives from these that is much wider than those considered in mainstream management. In collaboration with the departmental EAF Working Group, this initial set of wider management objectives was revised and an approach was pursued linking indicators to these management objectives and developing a simple model for their combined evaluation (Jarre et al., 2006; Paterson et al., 2007), to be used as additional tool in the management advisory process. For objectives in the human dimension, a first prototype model is currently available, pertaining to the well-being of communities in which processing factories are located, the well-being of the established industry, and the well-being of new entrants (Paterson et al., 2010). For the ecological dimension a second-prototype model is available (Astor, 2014; McGregor, 2015), based on the Pressure-State-Response Framework (OECD, 1999, 2003) which, in addition to evaluating indicators used in the current OMP, explicitly evaluates the *pressure* exerted by spatially disproportionate fishing on sardine, as well as the *state* of selected seabird populations as dependent predators (Fig. 1). Combined evaluation of the indicators through a hierarchy of weighted means for the period 1987–2009 reveals that *pressures* exerted by the sardine fishery were acceptable in the first half of the 1990s, but worsened from "Good" to "Bad" in the decade from 1998 to 2008 (Fig. 2, top panel). The *state* of the (sardine-dependent) ecosystem improved from "Acceptable" in the second half of the 1990s to "Good" in 2000, but then deteriorated from 2000 through 2008 (Fig. 2, middle