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Ecosystem change in the southern Benguela and the underlying processes

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ABSTRACT

Overfishing and human-induced climate change are putting severe pressure on marine ecosystems. In the southern Benguela, most of South Africa's commercial fisheries have a long history of exploitation and this, coupled with spatio-temporal changes in key species over the last three decades has severely impacted some of South Africa's fisheries and ecosystems. This review summarizes these spatio-temporal changes and investigates possible drivers thereof. It incorporates both past and current research, with a large portion of the latter having formed part of the University of Cape Town's Ma-Re BASICS (Marine Research in the Benguela and Agulhas Systems for supporting Interdisciplinary Climate-change Science) 2010–2013 program. Almost all described changes involve a temporal decline or a spatial shift in species. Fishing seems to have played a role in many of the observed stock declines, for example through geographically disproportionate catches in relation to stock distribution. In some cases, changes in the physical environment seem to have played an additional role, e.g., rock lobsters on the west coast have been affected by fishing as well as changes in the physical environment. In almost all cases these changes have taken place since the 1980s/1990s, except for one or two resources, which have experienced declines since at least the mid 20th century. Spatial shifts in species have either involved an eastward expansion of cool-water species, including kelps, rock lobster and pelagic fish, or a retraction of warm-water species such as the brown mussel, suggesting a cooling of inshore waters along the south-west coast since the 1980s. This suggested cooling is revealed in ocean temperature (SST Pathfinder), wind and upwelling data for the Cape Peninsula and south-west coast region during the same period. The absence or inconsistency of long-term data is problematic when trying to identify drivers of ecosystem change, and actual ecosystem change itself. We discuss this using ocean temperature in the southern Benguela as an example. In addition, the complex interplay between climate and anthropogenic (notably fishing) drivers makes identification of drivers difficult and disentangling these combined effects will require interdisciplinary collaboration, co-ordinated ecosystem projects, increased modelling effort and the continuation, but also establishment, of new, long-term monitoring studies.

Contents

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1. Introduction

Over-exploitation of marine species, coupled with human-induced climate change, is putting severe pressure on marine ecosystems on a global scale. Even the most remote parts of the ocean are reported to have experienced some form of human impact, with fishing and anthropogenic climate change undoubtedly the major culprits (Halpern et al., 2008). The ecosystem effects of overfishing have been well documented (Daskalov et al., 2007; Jackson et al., 2001; Möllmann et al., 2008; Scheffer et al., 2005; Tegner and Dayton, 2000) and there is compelling evidence for the impacts of climate change on marine systems (Hoegh-Guldberg and Bruno, 2010; Poloczanska et al., 2013). In the marine environment, most climate-related research focuses on temperature change (Harley et al., 2006), and its impacts on species distribution, abundance patterns and community structure (Barry et al., 1995; Holbrook et al., 1997; Ling et al., 2009; Lloyd et al., 2012; McGowan et al., 1998; Perry et al., 2005; Sagarin et al., 1999). In general, oceans across the globe are thought to be warming at a slow to rapid rate, particularly over the last 30 years (Belkin, 2009). However, some major upwelling systems appear to show either opposite trends, or mixed signals (Belkin, 2009; Gutiérrez et al., 2011; Leduc et al., 2010; McGregor et al., 2007).

The Benguela ecosystem, located off the west coast of southern Africa, is one of four major eastern boundary upwelling systems and is divided into northern and southern sections (Shannon, 1985). The northern Benguela ecosystem, situated off Angola/Namibia, is decidedly different, in terms of both physico-chemical characteristics and biota, from the southern Benguela, off the west and south coasts of South Africa (Fig. 1). Only the latter is considered in this review. The cold, upwelled waters of the southern Benguela fuel most of South Africa's major commercial fisheries, including large-scale offshore pelagic and demersal fisheries, as well as the commercially valuable inshore linefish, rock lobster and abalone fisheries. Most of these fisheries have a long history, described, e.g., by Griffiths et al. (2004), and this, coupled with spatio-temporal changes in key species over the last three decades has severely impacted some of South Africa's fisheries and ecosystems (Blamey et al., 2014; Cockcroft et al., 2008; Coetzee et al., 2008a; Jarre et al., 2013; Plagányi and Butterworth, 2010).

Changes in marine ecosystems can be driven by natural and/or anthropogenic processes (deYoung et al., 2008) with key drivers including biotic processes, changes in structural habitat, climate change and fishing (Daskalov et al., 2007; Polovina, 2005; Scheffer and Carpenter, 2003). Ecosystem indicators help monitor these changes and can be defined as ecological, environmental and/or socio-economic variables or indices that provide information on the state of an ecosystem, the extent or intensity of exploitation of the ecosystem and progress of ecosystem management in relation to specified objectives (Garcia et al., 2000; Jennings, 2005). Frameworks for the selection and evaluation of ecosystem indicators are already in place (Livingston et al., 2005; Rice and Rochet, 2005), with numerous indicators having been developed in international collaborative projects (Rochet and Trenkel, 2003; Cury et al. 2005; Shin et al., 2005, 2010; Shin and Shannon, 2010). In the Benguela, there has been a focused effort on the development of ecosystem indicators and identification of regime shifts (Atkinson et al., 2011a, 2012; Blamey et al., 2012; Drapeau et al., 2004; Howard et al., 2007; Jarre et al., 2008; Moloney et al., 2005; Paterson et al., 2007; Shannon and Cury, 2004; Shannon et al., 2010, 2014a,b; Watermeyer, 2014), although almost all of this work has focused on offshore communities and ecosystems.

In this synthesis paper we (1) provide a summary of spatial and temporal changes that have taken place in the southern Benguela ecosystem since the mid 20th century, (2) present ecological indicators that have already been developed to assess these changes, (3) investigate potential drivers of these changes, (4) use ecological and environmental indicators to provide an overall summary and current understanding of ecosystem changes that have been observed in the Southern Benguela, and the processes underlying these changes and (5) discuss directions for future interdisciplinary research. Our paper incorporates both past and current research, with a large portion of the latter having formed part of the University of Cape Town's Ma-Re BASICS (Marine Research in the Benguela and Agulhas Systems for supporting Interdisciplinary Climate-change Science) 2010–2013 program.