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Ecosystem-based assessment of a prawn fishery in coastal Kenya using ecological indicators

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ABSTRACT

The study aimed to describe and assess indicators that can potentially contribute to the development of Ecosystem-based Approach to Fisheries Management (EAFM) of prawn stocks in the Malindi-Ungwana Bay, the most productive coastal ecosystem in Kenya. A comprehensive EAFM is required to holistically manage fisheries resources and their associated habitats. The study assessed ecological indicators based on objectives of harvest sustainability and biodiversity conservation. Analyses were performed on data sourced from the State Department of Fisheries, and research databases. Trends in historical landings (1985–2010) of penaeid shrimps from the Malindi-Ungwana Bay were analyzed using LOWESS. Number-size spectra analysis was used to assess the exploitation status of the shrimps, while biomass-trophic level spectra (BTLS) analysis was applied as a potential tool for analyzing multifactor effects on the bay. IndiSeas-based ecosystem indicators were used to assess impact of the prawn trawl fishery on biodiversity of the bay. Results indicate long-term series with two peaks (1997 and 2000) in historical landings of penaeid shrimps and a monotonous decline in catches during 2002–2010. Slopes of number-size spectra suggested increased fishing mortality with time (2008–2012), while patterns of intercepts indicated a general increase in fisheries productivity of the bay. BTLS analysis using demersal fish survey and fish by-catch data suggested reduced levels of biomass across trophic levels and a temporal decline in trophic levels of fish species caught, however, the short time span constrains robust conclusions from the BTLS analysis. Biodiversity and conservation based indicators (e.g. fish sizes, trophic levels and proportion of predators in catches) adopted from the IndiSeas program showed the Malindi-Ungwana Bay to be ecologically degraded. There is need to initiate long-term monitoring programs to strengthen temporal scale of analysis of the datasets and to support use of ecological indicators for resource management and development of an EAFM in data-poor WIO countries.

1. Introduction

Ecosystem Approach to Fisheries Management (EAFM) refers to holistic assessment and management of fisheries resources and their associated habitats (Shin et al., 2010a; Zhang et al., 2009). It is intended to ensure that the planning, development and management of fisheries will meet ecological, social and economic needs, but without jeopardizing the options for future generations to benefit from the full range of goods and services provided by marine ecosystems (FAO, 2003). Management of fish stocks is increasingly challenging due to the failure of conventional approaches associated with model uncertainties, enforcement constraints, and poor policy frameworks which often lead to; overfishing of stocks, disruption of ocean ecosystem services and loss of biodiversity (reviews in; Cury and Christensen, 2005; Myers and Worm, 2003; Worm et al., 2006). Although the need for an EAFM has become increasingly apparent because of the multiple factors impacting on resources (FAO, 2003), the approach has hardly been implemented in most countries since the envisaged 2010 global start date (Garcia, 2000). A number of factors have contributed to this state including; difficulties in translating principles to policy actions, lack of clear recognition by stakeholders of the objectives, indicators, and performance measures of the approach (Browman and Stergiou, 2004; FAO, 2003; Pikitch et al., 2004). EAFM will nonetheless remain an important mechanism for maintaining ecosystem health and fisheries productivity and has been implemented in a few countries with varied success (Shin et al., 2010a). Widespread progress toward an EAFM will be fastest if a clear process for identifying and selecting ecosystem and management indicators is identified (FAO, 2003; ICES, 2005).

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Ecological indicators are tools which can be used to overcome problems associated with conventional fisheries management and to support EAFM initiatives, working as a link between objectives and action in management (Cury and Christensen, 2005; Rice and Rochet, 2005). They support the decision making process in resource management by (i) describing the pressures affecting the ecosystem, the state of the ecosystem and the response of managers, (ii) tracking progress toward meeting management objectives and (iii) communicating trends in complex impacts and management processes to a non-specialist audience (Garcia, 2000; Jennings, 2005). Overall, indicators provide a readily understood set of tools for describing the state of fisheries resources and for assessing trends regarding sustainable development objectives, and performance of fisheries policies and management (Rice and Rochet, 2005). To support an EAFM program, indicators need to track the state of components and attributes that may be adversely impacted by fishing and they should be easily understood by resource managers (Jennings, 2005).

The aim of this study was therefore to assess ecological and biodiversity indicators for possible use in future applications of an EAFM in the Malindi-Ungwana Bay prawn fisheries in Kenya and other data-poor fisheries in the WIO region. The Malindi-Ungwana Bay supports the only known industrial and semi-industrial prawn fishery in Kenya and is easily the richest nearshore ecosystem in coastal East Africa (Mutagyera, 1984). The Kenyan government suspended bottom trawling in the bay in 2006 when resource use conflicts between commercial trawlers and artisanal fishers escalated because of continuous encroachment on the artisanal fishing grounds by the commercial vessels (Fulanda et al., 2011; Munga et al., 2013a). Information on the status of the stocks and the biology of the species in the bay was inadequate to inform management decisions leading to an indefinite suspension of the fishery in 2006. This study therefore aimed to generate indicators that can be used to develop EAFM initiatives as an alternative to the problem-prone conventional fisheries management methods. Data were analyzed for size-based indicators (number-size spectra) of overexploitation and ecosystem-based indicators (biomass-trophic level spectra and IndiSeas-based indicators) for analyzing multi-factor effects on the bay.

2. Materials and methods

2.1. Study sites

The study was based on analyses of data collected within Malindi-Ungwana Bay on the northern coast of Kenya (Fig. 1). The bay lies between latitudes 3°30′S and 2°30′S and longitudes 40°00′N and 41°00′N. It covers an estimated 200 km of coastline and is the only known trawlable shallow (<30 m) ground in coastal Kenya. An average of 6000 million m^3 of freshwater and about 3 million tons of sediment (Tychsen, 2006) is discharged into the bay

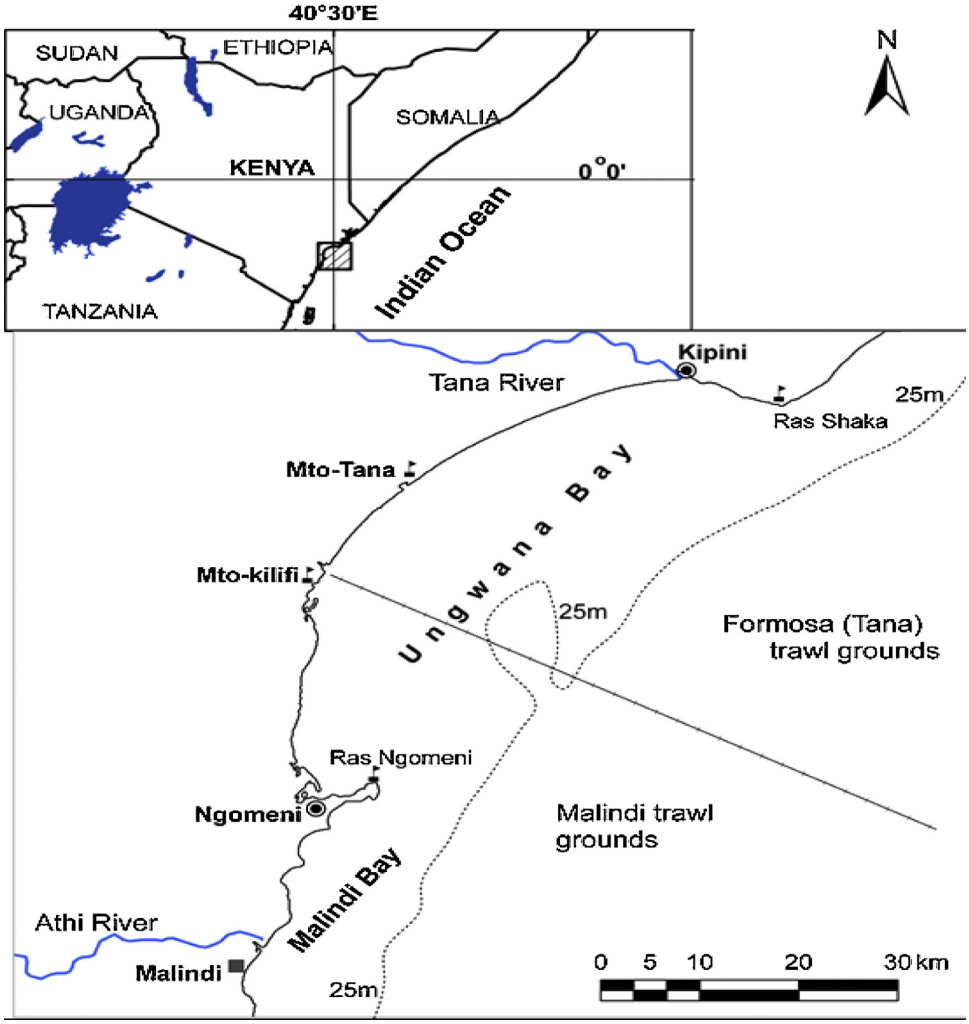

Fig. 1. A map of Kenya's coastline showing location of the Malindi-Ungwana Bay and the beaches along the bay (the flags) sampled for artisanal prawn landings. Source: Munga et al. (2012)