Marine Policy 69 (2016) 62–72

Contents lists available at ScienceDirect

Marine Policy

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

A spatio-temporal ecosystem model to simulate fishing management plans: A case of study in the Gulf of Gabes (Tunisia)

Ghassen Halouani [a,b,*], Khaled Abdou [a,b], Tarek Hattab [c], Mohamed Salah Romdhane [a], Frida Ben Rais Lasram [a], François Le Loc'h [b]

[a] UR 03AGRO1 Ecosystèmes et Ressources Aquatiques, Institut National Agronomique de Tunisie, 43 Avenue Charles Nicolle, 1082 Tunis, Tunisia
[b] UMR 6539 Laboratoire des Sciences de l'Environnement Marin (CNRS/UBO/IRD/Ifremer), Institut Universitaire Européen de la Mer, Technopôle Brest-Iroise, Rue Dumont d'Urville, 29280 Plouzané, France
[c] UR Ecologie et Dynamique des Systèmes Anthropisés (EDYSAN, FRE 3498 CNRS-UPJV), Université de Picardie Jules Verne, Rue des Louvels, 80000 Amiens, France

ARTICLE INFO

Article history:
Received 27 February 2016
Received in revised form
30 March 2016
Accepted 1 April 2016

Keywords:
Ecospace
Fishery management
Gulf of Gabes
Fishing regulation
Ecosystem model

ABSTRACT

The Gulf of Gabes located in southern Tunisia is one of the most productive ecosystems in the Mediterranean Sea. Despite its ecological importance, it is subject to high fishing pressure affecting the different components of the ecosystem. Given the multispecies, multigear nature of the fishery, there is a need to manage trade-offs between environmental and economic objectives. In this study, an Ecospace model was developed based on the previously constructed Ecopath model of the Gulf of Gabes and calibrated for the period 1995–2008 to investigate the response of the ecosystem to a set of alternative spatial management scenarios. These scenarios were derived from the current fishery regulation owing the important interest expressed by local fishery managers to assess new management measures. The results showed for each management scenario how bottom trawling and coastal fishing impact the different trophic groups and the complexity of interaction between these two fishing activities. Furthermore, spatially explicit simulations were performed to identify regions where the management measures are effective. Results suggested that for some trophic groups, these regions are well-defined which would be interesting to propose more accurate spatial measures. Finally, several indicators were calculated to evaluate the proposed management plans and provide managers with a straightforward set of decision rules to describe the potential trade-offs and fulfill both fisheries and conservation management objectives in the context of an ecosystem approach. The decision rules were based on observed trends to reduce uncertainty relative to the model complexity and provide consistent advice to decision-makers.

1. Introduction

With the development of fishing activities during the second half of the twentieth century in the Gulf of Gabes, the Tunisian government adopted several legal texts in order to manage marine resources. The management of fisheries was essentially based on seasonal and spatial closures. The aim of these measures was to reduce the fishing pressure on species with high economic value such as the Caramote prawn (*Penaeus kerathurus*) mainly caught during shrimp campaigns. However, the focus on single-species management without considering the interactions between the different components of the ecosystem has proven ineffective. Hence the need for a more holistic management approach taking into accounts both ecosystem complexity and the different fishing activities. The Ecosystem-Based Fishery Management (EBFM) is widely acknowledged to be more effective to maintain healthy marine ecosystems and the fisheries they support [1,2].

Located south of Tunisia, the Gulf of Gabes was historically managed using single-species approaches in order to maximize the yield of target species. However, the first signs of overfishing appeared in the early 1990s [3] when a substantial decrease in total production was observed. In the late 2000s, total landings has stabilized around 40,000 t representing more than 40% of national production which gives the Gulf of Gabes a high socio-economic interest (Official statistics from "Direction Générale de la Pêche et de l'Aquaculture" (DGPA)). Given the expansion of the fishery and the increase of fishing effort an important interest has been

* Corresponding author at: Institut Universitaire Européen de la Mer, Technopôle Brest-Iroise, Rue Dumont d'Urville, 29280 Plouzané, France.
E-mail addresses: ghassen.halouani@gmail.com (G. Halouani), abdou.khaledfb@hotmail.fr (K. Abdou), hattab.tarek@gmail.com (T. Hattab), ramadhanms@gmail.com (M.S. Romdhane), frida.lasram@gmail.com (F. Ben Rais Lasram), francois.le.loch@ird.fr (F. Le Loc'h).

http://dx.doi.org/10.1016/j.marpol.2016.04.002
0308-597X/

expressed by local policy-makers to improve the current regulation. The ecosystem model Ecopath with Ecosim [4], was used as part of the EBFM to better understand the impact of fishing on target and non-target species and assess the interaction between the different fishing activities.

The Gulf of Gabes is a multispecies and multigear fishery, targeting demersal, and pelagic species using trawls, gillnet, purse seine and longlines. The most predominant fishing activities are the coastal fishery and the offshore bottom trawling [5] due to the large extent of soft bottoms.

In order to manage these activities effectively, several legal texts were adopted by the Tunisian government since the 1960s. This legislation was implemented to establish the delimitation of fishing zones, the fishing season, the characteristics of fishing gear, fishing techniques, the minimum catch size, the rest periods etc. to ensure the long-term viability of the fishery. The main legal texts which regulate the fishing sector in the Gulf of Gabes are Law No. 94-13 of 31 January 1994, the decree of September 28, 1995 and the Law No. 2009-17 of 16 March 2009. The major aspects of this regulation concern the bottom trawling activity and includes the establishment of an annual biological rest period during 3 months, the ban of bottom trawling under 50 m depth and the regulation of shrimp fishing through fishing campaign.

The aim of this study is to adjust the current measures through spatial and temporal simulations in order to: i/ examine the potential effects of several fishing management options on the different components of the ecosystem, ii/ enhance the understanding of interactions between offshore bottom trawling and coastal fishing activities and, iii/ give policy-makers evaluation elements to improve the actual legislation for an effective and sustainable fishery management. These spatial and temporal simulations are based on a previously constructed Ecopath model for the Gulf of Gabes ecosystem developed by [6]. The main advantage of this analysis is that it explores alternative management options, more relevant to deal with trade-offs by slightly modifying measures already implemented.

2. Methodology

2.1. Study area

The Gulf of Gabes, also known as “the little Sirte”, is located in the Mediterranean eastern basin and encompassed a total area of approximately 35,900 km^2 (Fig. 1). Recognized as one of the most important fishing areas in Tunisia, the Gulf of Gabes is under natural and anthropogenic threats [7,8] and is subject to great changes on its biodiversity and functioning [9,10]. This region has a large continental shelf (exclusively composed of soft sediment). The 200 m isobath is reached after a distance of 400 km from the coastline and the Gulf has the highest tidal amplitude in the Mediterranean Sea (up to 2 m height) [11]. The shallowness of the basin makes the Gulf very sensitive to atmospheric conditions. Owing to these unique oceanographic and geomorphological characteristics, the Gulf of Gabes is a highly productive ecosystem despite the oligotrophic conditions of the Mediterranean Sea [12]. The high level of productivity is also due to the presence of the ecologically-important Posidonia seagrass meadows [13]. This habitat provides an important nursery, feeding, and breeding for several marine species [14] and supports high fish productivity. The ecosystem offers an ideal shelter for 247 fish species amongst a total of 327 recorded species in Tunisia [15].

2.2. Ecopath with Ecosim model development

This work was based on the Ecopath with Ecosim (EwE) modeling approach. Principles, basic concepts and assumptions of this approach are described in detail in [4,16–20]. The EwE model

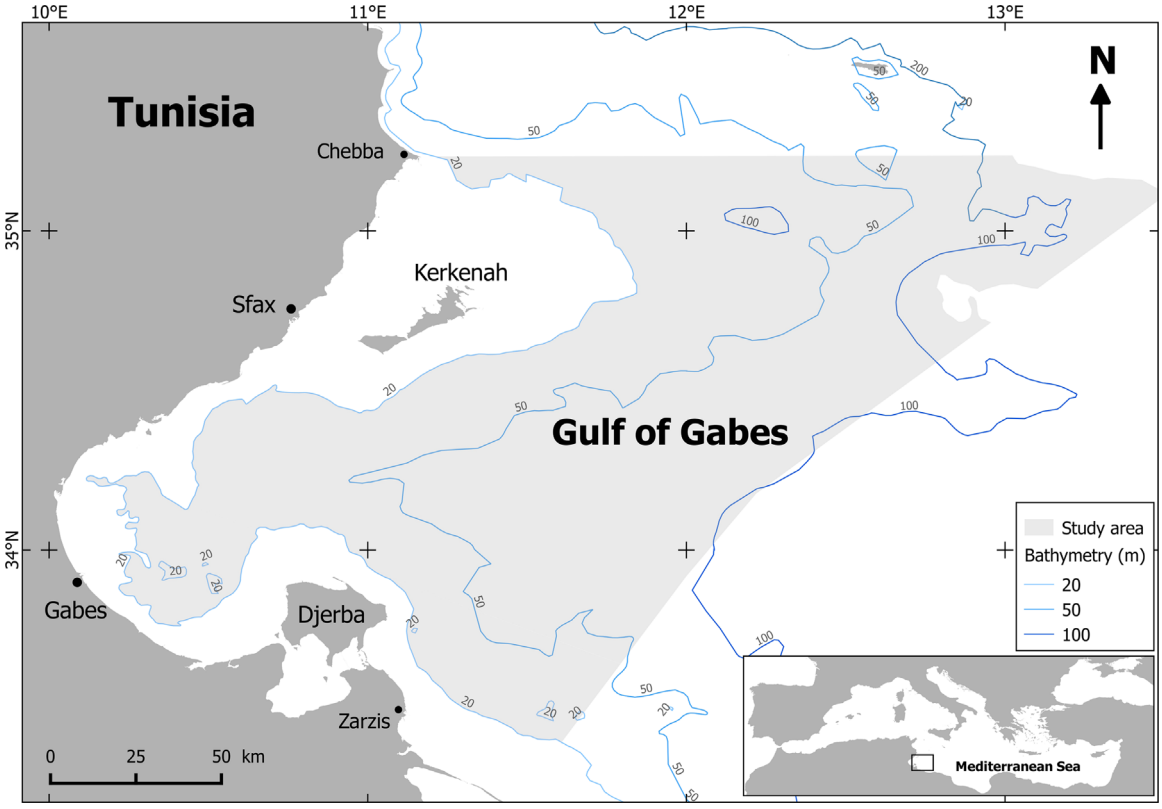

Fig. 1. The geographical situation of the Gulf of Gabes. Gray surface represent the modeled area (depth range of 20– 200 m).