Environmental Development 22 (2017) 84–96

Contents lists available at ScienceDirect

Environmental Development

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

Linking oceanographic processes and marine resources in the western Caribbean Sea Large Marine Ecosystem Subarea

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ARTICLE INFO

Keywords:
Marine resources
Oceanographic processes
Mesoscale
Large marine ecosystem
Mesoamerican reef
Caribbean

ABSTRACT

The western Caribbean, a subarea of the Caribbean Sea Large Marine Ecosystem, includes the Mesoamerican Barrier Reef System, the Yucatan Basin, the Cayman Basin and the Yucatan Channel. Here we discuss the main oceanographic features of the western Caribbean Sea and present some examples of marine resources distributed throughout the western Caribbean Sea LME subarea along different spatial scales. Particular attention is given to their planktonic stages when physical oceanographic features (such as eddies and gyres, or current systems) can operate either as forces that promote larval dispersal or as barriers enhancing larval retention, as this determines their connectivity. Bluefin tuna, the early life stages (eggs and larvae) of reef fish, the Caribbean Spiny lobster, and the Queen conch are presented as examples. Dispersal distances depend on the oceanographic phenomena, with larger dispersals expected where intense currents occur, such as in the Yucatan Current. Conversely, retention can be expected in the presence of gyres such as the Honduras Gyre and Yucatan Basin eddies. There is a growing body of evidence supporting the need for a multi-scale approach in order to understand the complexity of LMEs. Moreover, the connectivity between regions in the western Caribbean Sea LME subarea, as shown by the exchange of marine resources and physical oceanographic processes, requires an international policy that supports collaborative efforts to monitor the dynamics of coastal and oceanic habitats together with marine resources.

1. Introduction

Within the Caribbean Sea Large Marine Ecosystem (LME) (Richards and Bohnsack, 1990; Fanning et al., 2011), there is the western Caribbean, a dynamic subarea that includes the Mesoamerican Barrier Reef System, the Yucatan Basin, the Cayman Basin and the Yucatan Channel (Fig. 1). This is the region where the Caribbean circulation system connects to the Gulf of Mexico through the Yucatan Channel. The western Caribbean holds a large variety of habitats, a high marine biodiversity, and several fishery resources. These biotic components and inherent biological processes are strongly influenced by oceanographic processes.

In some circumstances, oceanographic processes and marine resources are clearly related, for instance with physical processes

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http://dx.doi.org/10.1016/j.envdev.2017.01.004
Received 8 November 2016; Received in revised form 8 January 2017; Accepted 23 January 2017

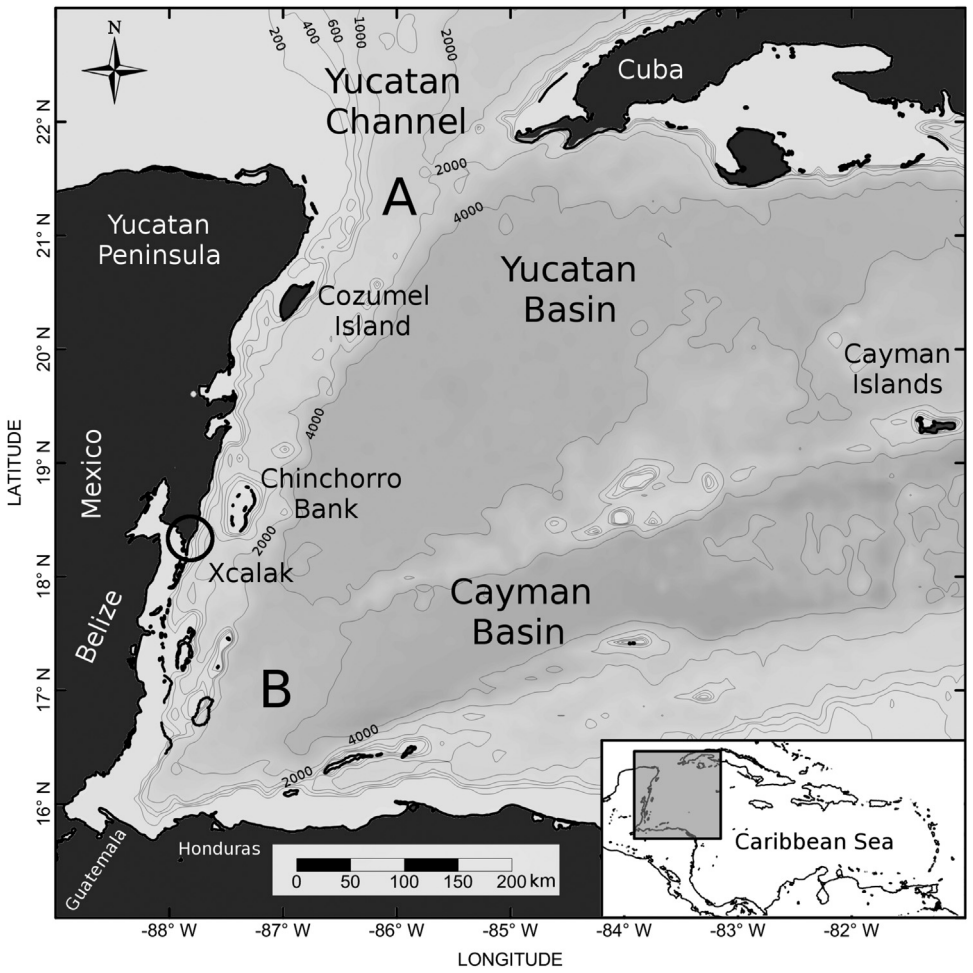

Fig. 1. Western Caribbean Large Marine Ecosystem subarea of the Caribbean Sea LME. Circle shows the position of a current meter located at Xcalak, Mexico. A and B show the position used to calculate dispersal distances referred in Section 3.3.

driving the dispersion of marine planktonic larval stages. Research on marine resources tends to be focused on the adult and juvenile stages of species, leaving aside the planktonic stages that are present in the majority of marine resources (Sale, 2002; Richards, 2006; Hixon, 2011). Since the early years of fisheries research, it has been hypothesized that planktonic stages (eggs and larvae) represent a "critical period" due to the fragility of these life stages that determine the strength of the year class (Hjort, 1914). During the 1970s, a new perspective on marine research was proposed, dealing with the recruitment processes of marine resources as they relate to early life stages (Lasker, 1975; Houde, 2008). More recently, with a new millennium approach, the interest has shifted to marine metapopulations (Kritzer and Sale, 2004) and connectivity (Hixon, 2011; Cowen et al., 2006; Kough et al., 2013, 2016). At present, the role of planktonic life stages has been widely accepted as one of the most important stages, allowing the flow of genes and enhancing population connectivity through dispersal by oceanic and coastal currents (Botsford et al., 2009; Planes et al., 2009; Cowen et al., 2006; Cowen and Sponaugle, 2009; Salas et al., 2010). Thus, physical oceanographic features (such as eddies and gyres, or predominant current systems) can operate either as forces that promote larval dispersal or as barriers enhancing larval retention. Hence, the challenging problem is to ascertain the physical mechanisms and interaction between the oceanographic processes and the reproductive strategies of the marine resources which allow enhanced survival of larval stages by reducing predation and allowing them to reach nursery habitats for shelter and sufficient food supply (Levin, 2006; D'Alessandro et al., 2007; Houde, 2008). Oceanographic processes on multiple scales lead to large variability in the main oceanic current systems influencing the larval distribution of marine resources. Therefore, the understanding of physical oceanographic processes and their relationship with early life history is key to the effective and sustainable management of marine resources in the western Caribbean LME (Fogarty and Botsford, 2007; Kough et al., 2013).

The underlying premise of this article is that the major oceanographic processes that occur in the western Caribbean Sea LME subarea define the connectivity between habitats, by either promoting dispersal or acting as barriers that restrict the propagules of the marine resources. Here we will present some examples of the most representative marine resources distributed throughout the Caribbean and their link with oceanographic processes. Particular attention will be given to the early life stages (eggs and larvae) of reef fish and two economically important benthonic marine resources, namely the Caribbean Spiny lobster and the Queen conch.