Marine Pollution Bulletin 113 (2016) 147–155

Contents lists available at ScienceDirect

Marine Pollution Bulletin

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

Benthic surveys of the historic pearl oyster beds of Qatar reveal a dramatic ecological change

D. Smyth *, I. Al-Maslamani, M. Chatting, B. Giraldes

Environmental Studies Center (ESC), Qatar University (QA), Doha, P.O. Box 2713, Qatar

ARTICLE INFO

Article history:
Received 18 June 2016
Received in revised form 10 August 2016
Accepted 30 August 2016
Available online 7 September 2016

Keywords:
Marine biotope classification
Pearl oyster
Overfishing
Anthropogenic disturbance
Pinctada radiata
Arabian Gulf

ABSTRACT

The study aimed to confirm the presence of historic oyster banks of Qatar and code the biotopes present. The research also collated historical records and scientific publications to create a timeline of fishery activity. The oyster banks where once an extremely productive economic resource however, intense overfishing, extreme environmental conditions and anthropogenic impacts caused a fishery collapse. The timeline highlighted the vulnerability of ecosystem engineering bivalves if overexploited. The current status of the oyster banks meant only one site could be described as oyster dominant. This was unexpected as the sites were located in areas which once supported a highly productive oyster fishery. The research revealed the devastating effect that anthropogenic impacts can have on a relatively robust marine habitat like an oyster bed and it is hoped these findings will act as a driver to investigate and map other vulnerable habitats within the region before they too become compromised.

1. Introduction

The mapping and classification of marine benthic habitats into specific biotopes is now a recognised procedure for the comparative analysis of ecological data which can be used to monitor environmental change (Olenin and Ducrotoy, 2006; Costello, 2009). The concept of describing marine and terrestrial habitats in association with substratum and associated species is not novel and has been in practice since the mid 1800's (Tillin et al., 2008; Costello, 2009). Southern (1915) stated that the classification of marine habitats based on their associated flora and fauna, their intertidal/subtidal zonation, benthic/pelagic nature, substratum type and salinity were all excellent descriptive parameters when accurately defining a specific marine environment. The correct documentation of habitat characteristics is crucial when managing and monitoring the spatial and temporal changes of marine ecosystem components and the resources they provide (Connor et al., 2004; Costello, 2009). In the western Arabian Gulf one of the most recognised marine ecosystem components has been the pearl oyster assemblages (Al-Khayat and Al-Ansi, 2008; Smyth et al., 2016a).

The large oyster beds on the western Gulf have acted as bio-engineers for centuries with many of the marine habitats throughout the region formed as a result of the services provided by these assemblages (Bouma et al., 2009; Smyth et al., 2016a). These accumulations of oysters have been primary components in the stabilisation of sediments, water filtration, the provision of hard substratum for sessile species and the subsequent reef matrix complexes for mobile fauna (Bouma et al., 2009; Smyth et al., 2016a).

The oyster beds of the Gulf have been exposed to anthropogenic impacts since as far back as 1050 CE when they were harvested for food and pearls (Carter, 2005). They were fished intensely for pearls from the late 1700's up until the early 1900's (Bowen, 1951). The scale of the fishing activity was immense and Captain Durand of the East India Trading Company in 1878 estimated that over 4000 pearling boats were working the oyster banks of the Gulf (Carter, 2005; Hightower, 2012). However, concerns about the over-exploitation of the oyster beds were raised as early as 1770 by a pearl trader called Justamond who described the beds as being overfished and exhausted (Carter, 2005). Durand reinforced this concern about overfishing a century later in 1878 when he described the yield of pearls and oysters as having decreased considerably. These reductions in the pearl as a commodity lead to an almost doubling of prices which subsequently lead to an increase in exploitation (Hightower, 2012). In the early 1900's pearling boat captains were reporting a drop of 40% in landings with the catch per unit effort of the fishery considered not economically viable (Burdett, 1995). In 1905 Mr. James Hornell, an officer of the Madras Fisheries Bureau proposed a scientific survey of the beds be undertaken to establish the true status of the standing stocks, however this investigation never came to fruition with the onset of the First World War (Carter, 2005). Interest in the pearl industry within the Gulf diminished after the war with the introduction of cultured pearls from Japan in the 1930's. The discovery of oil in the western Arabian Gulf during the

* Corresponding author.
E-mail addresses: dsmyth@qu.edu.qa (D. Smyth), almaslamani@qu.edu.qa (I. Al-Maslamani), mchatting@qu.edu.qa (M. Chatting), bweltergiraldes@qu.edu.qa (B. Giraldes).

http://dx.doi.org/10.1016/j.marpolbul.2016.08.085

1940's marked the end of the commercial fishery as more economic benefit was available from employment with the oil companies than could be obtained from the harvesting of pearls (Burdett, 1995; Mohammed and YASSIEN, 2003).

During the pearl fishing epoch the offshore oyster banks within Qatari waters were considered particularly productive (Carter, 2005). Numerous research studies have been conducted on the oyster beds of Qatar in regards to topographical features, heavy metal contamination and population dynamics (Al-Madfa et al., 1998; Al-Khayat and Al-Ansi, 2008). However, these survey sites have not been investigated in relation to their environmental status and the density of the associated oyster assemblages.

Over the past decade Qatar is one of the countries within the Gulf, which has experienced unprecedented economic growth and development (Sheppard et al., 2010; Feary et al., 2011; Smyth et al., 2016a). An increase in real estate and infrastructure expansion has been accompanied by an equivalent rise in the number of people living in the country. The national residency of Qatar was recorded as being 470,000 in 1990 the estimate rose to over 2.2 million by 2014 (Kamrava, 2015). This exponential population climb has placed extreme pressure on natural resources, particularly those within the marine environment. The increase in food demands from a growing population has concentrated significant stress on the fishing sector (Price, 1993; Sheppard et al., 2010). Unfortunately, the marine habitats within the Gulf not only have to accommodate anthropogenic stressors but also the naturally occurring extremes in environmental conditions. The Arabian Gulf is a small semi-enclosed sea which experiences extreme ranges of temperature and salinity on an annual basis (Riegl and Purkis, 2012; Smyth et al., 2016a). The west coast of Qatar for example regularly has salinities recorded at >60 ppt and sea temperatures at >35 °C. When increases in fishing activity are combined with the loss of intertidal and subtidal habitats and an increased input of pollutants from a growing population the status of marine ecosystems become a matter for concern (Munawar et al., 2002; Sheppard et al., 2010).

As previously discussed the classification of biota in both the terrestrial and marine environments into easily recognisable biotopes was developed as a practical tool to assist in the preservation and management of habitats (Connor et al., 1997a, 2003; Bartsch and Tittley, 2004). The use of baseline biotope classification codes has been used successfully to monitor and evaluate the recovery and demise of marine environments which have been exposed to extreme stresses such as; oil spills, tsunami, algal blooms and fishing impact (Tyler-Walters and Jackson, 1999; Zacharias and Gregr, 2005). When marine habitat classification is combined with ecological descriptions of a biotope a very powerful monitoring device is created which can be rapidly employed to identify site specific changes (Bartsch and Tittley, 2004).

The oyster beds of Qatar have experienced centuries of overexploitation and have been exposed to a significant increase in environmental pressure and anthropogenic disturbances over the last 15 years (Carter, 2005; Al-Khayat and Al-Ansi, 2008; Smyth et al., 2016a). It was therefore considered necessary to evaluate the current environmental status of the historical oyster beds with a methodology that would be suitable for their long term ecological monitoring.

The primary aim of this study was to assess the presence of the historic offshore pearl oyster beds and identify the biotopes present at the sites by employing a coding system based on that used by the Joint Nature Conservation Committee (JNCC) as described by Connor et al. (1997a, 1997b, 2003). A secondary aim was to compare descriptive ecological data from previous studies and historical records so that a temporal perspective on the stability of the oyster bed biotopes could be obtained.

2. Materials and methods

2.1. Study area

Qatar is situated on the west coast of the Arabian Gulf 25°30′N and 51°15′E (Fig. 1A) located on the peninsula bordering Saudi Arabia and the United Arab Emirates. It has a total coastline of 563 km. The hydrodynamic regimen in Qatari waters is typified by a south easterly surface current circulation (Kampi and Sadrinasab, 2006). The average sea temperature ranges from 18.7 to 32.0 °C and salinities vary from 35.5 to 44.5 ppt (Al-Maslamani et al., 2009). The survey focused on five sites which would be representative of the historically renowned oyster banks (Fig. 1A & B) and this research was undertaken in October 2014 and all sites were located subtidally at depths of between 12 and 25 m (Fig. 1B).

2.2. Methodology

A Qatari oyster bank is recognised on a nautical chart as a raised mound known locally as a *hairãt* and is surrounded by neighboring deep water topography. A team of scientific divers were used to collect biotope data from five historical renowned pearl oyster banks and the five neighboring deep water sites. The divers employed video and digital still transect survey methodologies along four 100 m transect lines as outlined in Smyth et al. (2009) and Giraldes et al. (2015). The start and finish of each survey transect was marked by a diver deployed surface marker buoy. The longitudinal and latitudinal co-ordinates of each surface marker were recorded by topside using a Garmin ® GPS plotter. The transects ran parallel to each other separated by a 10 m band either side of each transect. At each site one diver recorded the substratum type and noted key species on a dive slate, the second recorded video footage of each transect and the third diver collected quantitative biotope data by taking 25 digital stills of randomly placed frame (1 m) mounted 0.25 m^{-2} quadrats. If oysters were recorded at any site a sample was taken to ascertain which oyster species were present and to identify age classes.

2.3. Biotope data analysis

The subtidal biotope classification of the survey sites followed the protocol developed by Foster-Smith and Sotheran (2003). The protocol allocates biotope codes to sites according to the heterogeneity of the substratum type as viewed from the video recordings and digital still images. The still imagery collected during the survey was analysed using Coral Point Count© software with an Excel extension (CPCe). The images were calibrated in CPCe to the known distance at which the photos were taken (1 m). The program randomly overlaid a pre-determined number of points on each photo and whatever was present at each point was identified. A total of 50 overlay points were used for each image a methodology recommended by Carleton and Done (1995). The software quantified the quadrat epifauna to class level as per Kohler and Gill (2006). CPCe software then calculated Shannon-Weaver and Simpson Diversity Index for each oyster bank surveyed.

2.4. Construction of biotope codes

Identification of biotopes and the allocation of lettered codes followed that described by Connor et al. (1997a and 2003) whereby the primary divisions of biotope classification concern physical features, firstly rock or sediment substratum and secondly zonation. The largest unit of biological feature is the 'habitat complex' which can contain one or more biotopes. Within the biotope sub-biotopes can also be described.

The use of a lettered coding system enables the construction of intuitive codes which can be related to their respective biotope features. The codes are defined for each level in the classification. Each unit of the classification is given a lettered code with each letter representing physical and biological features. Habitat factor codes for, higher taxa and descriptive community features are derived from the lexicon created by Connor (1997). Codes for names of genera are derived using the first three letters of a genus or higher taxon name. Codes for species names are derived using the first letter of the genus and the first three letters of the specific name. Within the code each new element of the code