Journal of Environmental Management 203 (2017) 448–456

Contents lists available at ScienceDirect

Journal of Environmental Management

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

Research article

Evaluating the attractiveness and effectiveness of artificial coral reefs as a recreational ecosystem service

Yaniv Belhassen [a, *], Meghan Rousseau [b], Jenny Tynyakov [c, d], Nadav Shashar [b]

[a] Department of Hotel & Tourism Management, Eilat Campus, Ben-Gurion University of the Negev, Israel
[b] Department of Life Science, Eilat Campus, Ben-Gurion University of the Negev, Israel
[c] Inter-University Institute for Marine Sciences in Eilat, Tel Aviv University, Israel
[d] Department of Zoology, Tel Aviv University, Israel

ARTICLE INFO

Article history:
Received 22 March 2017
Received in revised form
31 July 2017
Accepted 9 August 2017

Keywords:
Recreational diving
Sustainable tourism development
Ecological aesthetic
Ecosystem services
Human ecology

ABSTRACT

Artificial reefs are increasingly being used around the globe to attract recreational divers, for both environmental and commercial reasons. This paper examines artificial coral reefs as recreational ecosystem services (RES) by evaluating their attractiveness and effectiveness and by examining divers' attitudes toward them. An online survey targeted at divers in Israel (n = 263) indicated that 35% of the dives in Eilat (a resort city on the shore of the Red Sea) take place at artificial reefs. A second study monitored divers' behavior around the Tamar artificial reef, one of the most popular submerged artificial reefs in Eilat, and juxtaposed it with divers' activities around two adjacent natural reefs. Findings show that the average diver density at the artificial reef was higher than at the two nearby natural knolls and that the artificial reef effectively diverts divers from natural knolls. A third study that examined the attitudes towards natural vs. artificial reefs found that the artificial reefs are considered more appropriate for training, but that divers feel less relaxed around them. By utilizing the RES approach as a framework, the study offers a comprehensive methodology that brings together the aesthetic, behavioral, and attitudinal aspects in terms of which artificial reefs can be evaluated.

1. Introduction

As a popular sport (Miller, 1993; Orams, 1999; PADI, 2015), recreational scuba (self-contained breathing apparatus) diving is characterized by the search for novel, rewarding, and adventure-filled experiences. A random examination of the widespread lists of recommended diving destinations (Cole et al., 2016; Porter, 2016; Taylor, 2011; Wuest, 2013) indicates that divers are attracted both to sites where rich natural marine life can be observed and to sites that have artificial reefs, such as shipwrecks, artistic sculptures, subway cars, tanks, and man-made submerged structures. Companies that specialize in the production of artificial reefs often use limestone, steel, and concrete. Accordingly, artificial reefs can generally be defined as man-made structures placed underwater to mimic some characteristics of natural reefs (Baine, 2001; Seaman and Jensen, 2000; Svane and Petersen, 2001). Artificial coral reefs fulfill many purposes, including distracting divers from natural reefs in the surrounding area, increasing the number of fish in the area, and enhancing and diversifying the diving experience for recreational divers (Baine, 2001; Zakai and Chadwick-Furman, 2002). In recent years, many scuba diving destinations intentionally use artificial reefs to add attractiveness and to reduce pressure from divers on natural reefs (Leeworthy et al., 2006; Stolk et al., 2007).

Despite their multiple functions, artificial coral reefs have mostly been evaluated in ecological terms (e.g. biodiversity around the reef), while ignoring divers' behavior and attitudes around and towards them. Their contributions are described in the light of the growing recognition of the worldwide decline of coral reefs caused by overfishing, sediment runoff, recreational diving and climate change (Doiron and Weissenberger, 2014; Harriott et al., 1997; Hasler and Ott, 2008; Hawkins and Roberts, 1992; Hoegh-Guldberg et al., 2007; Ravindran, 2016). However, focusing on divers' behavior and attitudes is a worthwhile research pursuit because one of the biggest challenges associated with artificial coral reef maintenance as successful recreational services is ensuring their ongoing popularity. Indeed, some studies have focused on the

* Corresponding author. Eilat Campus, Ben-Gurion University of the Negev, P.O. Box 653, Beer Sheva 84105, Israel.
E-mail address: yanivbel@bgu.ac.il (Y. Belhassen).

http://dx.doi.org/10.1016/j.jenvman.2017.08.020
0301-4797/

motivation to dive at artificial coral reefs and found it to be related to the likelihood of seeing a profusion of interesting marine life around them (Kirkbride-Smith et al., 2013).

The RES approach highlights the recreational opportunity and benefits generated from a given landscape or object, and can therefore serve as a useful research framework which focuses on divers. This approach proposes a more nuanced understanding of artificial reefs, which is sensitive to interconnections between physical environments, social meanings, and human activities around them. By extrapolating from the Eilat diving scene, this study highlights the dynamic aspects through which artificial reefs can be designed, understood and maintained, along with their sustainable role. To achieve this goal, this manuscript combines three related studies. The first study seeks to examine the popularity of artificial reefs in Eilat. The second study seeks to examine divers' behaviors around one artificial reef by juxtaposing it to their behavior around two nearby natural knolls. The third study seeks to examine divers' attitudes towards artificial reefs compared to natural reefs. All three studies provide an inclusive perspective for evaluating the recreational benefits of artificial coral reefs for divers.

1.1. Study site

Eilat's unique underwater habitat is one of its major attractions and a key feature in the city's image as a tourist destination. It would, therefore, be reasonable to assume that many of its divers are domestic and international tourists who come to the city specifically to dive, or to learn how to dive, especially since the city boasts unique natural characteristics as a diving site (Chadwick-Furman, 1995; Cole et al., 2016; Wilhelmsson et al., 1998). Diving activity around coral reefs in Eilat is high. A diving guide book for the coasts of Israel describes 14 individual dive sites in Eilat, four of which are artificial (Gur, 2004). In the *2016 Eilat Tourism Guide & Discounts* circulated at the local airport and tourism centers, two of nine sites recommended for diving in the city are artificial (both are military ships that were intentionally sunk to create diving attractions). It has been reported that more than 250,000 dives per year take place on this short 13 km stretch of coastline, with the majority of these dives taking place within the confines of the Coral Beach Nature Reserve, which is less than 5 km in length (Wilhelmsson et al., 1998; Zakai and Chadwick-Furman, 2002).

The current study examines the site that may have the highest diving density in Israel, with an estimated more than 120,000 dives per year, most of them introductory and course dives (Zakai and Chadwick-Furman, 2002). The Tamar Reef was positioned near the entrance to the nearby Marine Protected Area (MPA), between a natural coral knoll of a similar size about 10 m to its south and a smaller natural knoll 10 m to its northwest (see Fig. 1). Polak and Shashar (2012) examined whether this addition decreased diving density at the nearby natural reefs. It was found that the Tamar Reef had a small, yet significant, effect on the amount of time instructional divers spent in the MPA, but mostly changed the distribution of the dives in the MPA, with novice divers spending a smaller portion of their dive time in it (see Fig. 2).

The impact of scuba diving on coral reefs is highly variable, depending on the individual divers (Rouphael and Inglis, 1997, 2001). This suggests that divers' behavior and perceptions of the environment play an important role in the impact each diver may have on the reef. Ong and Musa (2012) found that the extent of the actual impact on coral reefs is highly influenced by the diver's experience and skill level. The diver's attitude also influences the relationship between the diving experience and underwater behavior. Fortunately, even a short environmental awareness briefing significantly improves diver's behavior and to lead to a reduction in contact with the reef, especially with live corals, which are severely harmed by such contact (Medio et al., 1997; Shani et al., 2012). In Eilat, the dive clubs have pre-dive briefings for all introductory diving courses and guided dives. These pre-dive briefings generally include a small amount of instruction on the local marine life and how to treat organisms underwater. Some also refer to the Tamar Reef as a sustainable method of reducing the pressure on the natural reefs. However, independent divers rent air tanks and/or other equipment from the clubs, but do not participate in a pre-dive briefing. It is rare that dive clubs brief independent divers; generally, this would only occur if the independent divers asked for information about sites.

The Tamar Reef, which is the focus of the second study, was submerged in October 2006 in the area with the highest diving density in Israel, as well as the highest number of instructional dives (Rouphael and Inglis, 1997). It was developed by the Israel Nature and Parks Authority, Ocean Bricks Systems, and academics from Ben-Gurion University at Eilat, the Inter-University Institute for Marine Sciences, the Hebrew University of Jerusalem, and the Marine Science Station in Aqaba, Jordan. Made from special concrete, suitable for the settlement of marine invertebrates, and studded with drilled holes in which nursery-grown corals were planted, the Tamar Reef was carefully designed to appeal both to divers and to marine animals in the area. Since 2012, there has been no active coral planting on it, yet it still demonstrates a high amount of natural coral settlement. The proximity of this site to the Coral Beach Nature Reserve, a MPA, was also a critical consideration in selecting the location. Initial examination of the effectiveness of the Tamar Reef indicates that it had a small yet significant effect on the amount of time instructional divers spent in the marine reserve, and on the distribution of dives in the marine reserve (Medio et al., 1997; Polak and Shashar, 2012; Schleyer and Tomalin, 2000). From a pragmatic point of view, the conceptualization of authenticity suggested here is an important step towards using artificial reefs as a conservation tool in other scuba diving destinations (Shani et al., 2012).

2. Theoretical framework

The premise of this study is that artificial coral reefs should be examined as RES. Ecosystem services have become an important conceptual framework in the examination of the links between the functioning of the environment and human welfare (Costanza et al., 2014). Fisher, Turner and Morling define ecosystem services as “the aspects of ecosystems utilized (actively or passively) to produce human well-being” (2009, p.645). Accordingly, ecosystem services are often conceptualized and measured in terms of their economic and cultural benefits for specific and non-specific potential contributions to human well-being. The aesthetic quality, for example, is usually examined as one of the primary non-specific recreation contributions of RES, because it arguably determines the users' satisfaction (Sikorska et al., 2017).

The evaluation of ecosystem services is a topic that has drawn much attention from the academic community. Many scholars attempt to quantify ecosystem services and even ecological attributes in terms of their economic values (e.g., Costanza et al., 2014; Polak and Shashar, 2013) and this approach is also adopted by policy makers, including the United Nations, in an attempt to quantify the overall economic value of ecosystem services globally. Other scholars focus their evaluation on classifying and mapping the various components of ecosystems. It is important to note that in the context of this research there is no agreement whether to classify the recreational function of ecosystem services as intermediate or final services provided by the ecosystems, or only as indirect benefits (see Fisher et al., 2009). Regardless of the approach