The effect of artificial reefs on fish assemblage versus natural sites in the Bandar Lengeh-Iran

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Received: March 2011 Accepted: June 2011

Abstract

Artificial reefs are used to compensate the destruction of marine ecosystems. In the present study, the effects of artificial reefs were compared to natural sites. For this purpose, five treatments including four different forms (Reef ball (R), Laneh Mahi (L), used materials (U) and R+L+U) of artificial reefs and one control were established. The reefs were deployed at Bandar Lengeh, the Persian Gulf. At each site, the fish sampling were carried out every three months for one year. According to data, significant differences ($p<0.05$) were found between the artificial reefs and the control sites in terms of Catch Per Unit Effort (CPUE). Among the reef treatments, the best enhancement of CPUE was for the mixed form of reefs compared to other forms and control. The present study indicates that the artificial reefs deployed have enhanced the fish community.

Keywords: Artificial Reef, Reef attraction, Comparative fish attraction, Reef fishery, Fish assemblage, Persian Gulf

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[DOR: 20.1001.1.15622916.2012.11.1.1.7]

Introduction

A part of the world's population lives along the coastal plain comprising the coasts, the seas, oceans, rivers and estuaries. Humans deal with the coastal and aquatic ecosystems as food resources and a large proportion of the people in most countries are dependent on aquatic resources to provide their daily needs. Nevertheless, unfortunately natural ecosystems have been indiscriminately harvested or even devastated due to over fishing (Claudet and Pelletier, 2004), physical and chemical destructions arising from industrial activities (Ajdari and Ajdari, 2006), untreated sewage of nearby cities and factories, oil and gas contamination from refineries and passing vessels and oil rigs. All these factors have caused the destruction of marine ecosystems, especially decreases in the population of many kinds of aquatic biota (FAO, 2007).

The Persian Gulf (PG) has not only experienced the same fate but also the occurred wars in the region have imposed negative impacts on aquatic systems such as reducing of fish catch especially for important economical fish i.e. middle water pelagic and demersal fish. Nowadays, one of the best strategies to reform marine communities is applying Artificial Reefs (ARs).

Of course, the construction of artificial reefs is thousands of years old, although the historic usages were related to sea power rather than aquaculture. Ancient Persians blocked the mouth of the Tigris River to thwart Indian pirates by building an artificial reef, and during the First Punic War, the Romans built a reef across the mouth of the Carthaginian harbor in Sicily to trap the enemy ships within and assist in driving the Carthaginians from the island (Hess, et al., 2001; Williams, 2006).

The use of artificial reefs to increase fish yields or for algaculture also has a long history. Historically Iranian fishermen have indeed sunken artificial materials such as blocks of stones, palm trunks and broken clay pots to improve fishery. Anglers have realized through experimentation that the sunken materials have caused increased fish catches. This activity was called Hannaby (Rostamian, 1998).

In general terms, the artificial reefs are man-made habitats placed in areas of sea bottom that provide a framework for marine life to develop. Such habitats have several benefits including: providing food, shelter, protection, and spawning areas for fish and marine life, as well as, relieving natural reefs from user pressure by providing alternative recreational areas. From an aquacultural point of view, the artificial reefs can increase fish catch tremendously (Matthews, 1985; Ambrose and Swarbrick, 1989; Bayle-Sempere et al., 1994; Baine, 2001; Lance et al., 2005). The artificial reefs are now employed in over 40 countries and it is also ongoing (Baine, 2001). In this study, the different forms of artifical reefs were applied in order to examine their effects on fish yields.

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Materials and methods

The studied area was Bandar-e-Lengeh, located in latitude 26° 29. 774′ N and longitude of 54° 45. 055′ E, north of the Persian Gulf, Hormozgan province offshore. The site was selected on hard sea bottom (Fig. 1).

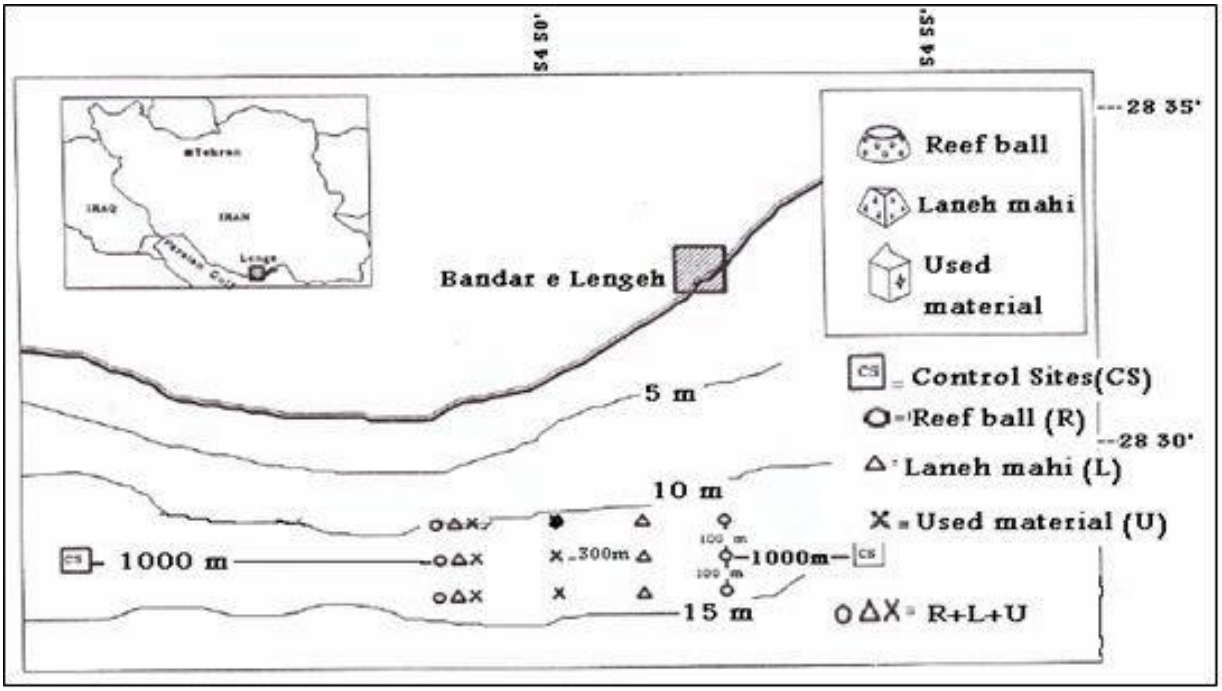

Figure 1: Location of artificial reef site

The locations of sites for the artificial reef establishments were determined through preliminary survey with GPS and buoys were used to mark these locations at sea. In this study, the artificial reefs were constructed and established in two forms - designed and non designed materials (Seaman, 2000; Sherman et al., 2002; Walker et al., 2002). The designed material included among others was Reef ball and Laneh mahi of different sizes, shapes and porosity. These were designed arithmetically, for instance, the Reef ball was 1.2m high, 1.5m wide and about 2-3 tons (Fig. 2a).

The width, height and weight of Laneh mahi were 1.5m, 1.4m and 1.5-2 tons respectively (Fig. 2b). Both artificial reefs (ARs) were made of concrete (Fitzhardinge and Bailey-Brock, 1989). Despite attempts to construct the artificial reefs in similar sizes, the reefs constructed have actually slightly different sizes. For instance, the reef balls were built in sizes ranging from 1.37 to 1.45 m (Mean ± Standard error: 1.43 ± 0.1 m) in maximum height and 1.47 to 1.51 m (Mean ± Standard error: 1.49 ± 0.02 m) in maximum diameter. For Laneh Mahi, the mean ± standard error for each triangular side was mean 1.52 ± 0.02m in maximum.

Non-designed materials were the used materials e.g. broken concrete, columns, old concrete pipes and bridges (Pickering

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and Whitmarsh, 1997). Their weights were between 0.2 to 2 tons. (Figs. 2c, 2d). A research layout (Fig. 1) was designed for this experiment comprising four treatments and a control with three replicates for each of them (Fig. 1 and Table.1).

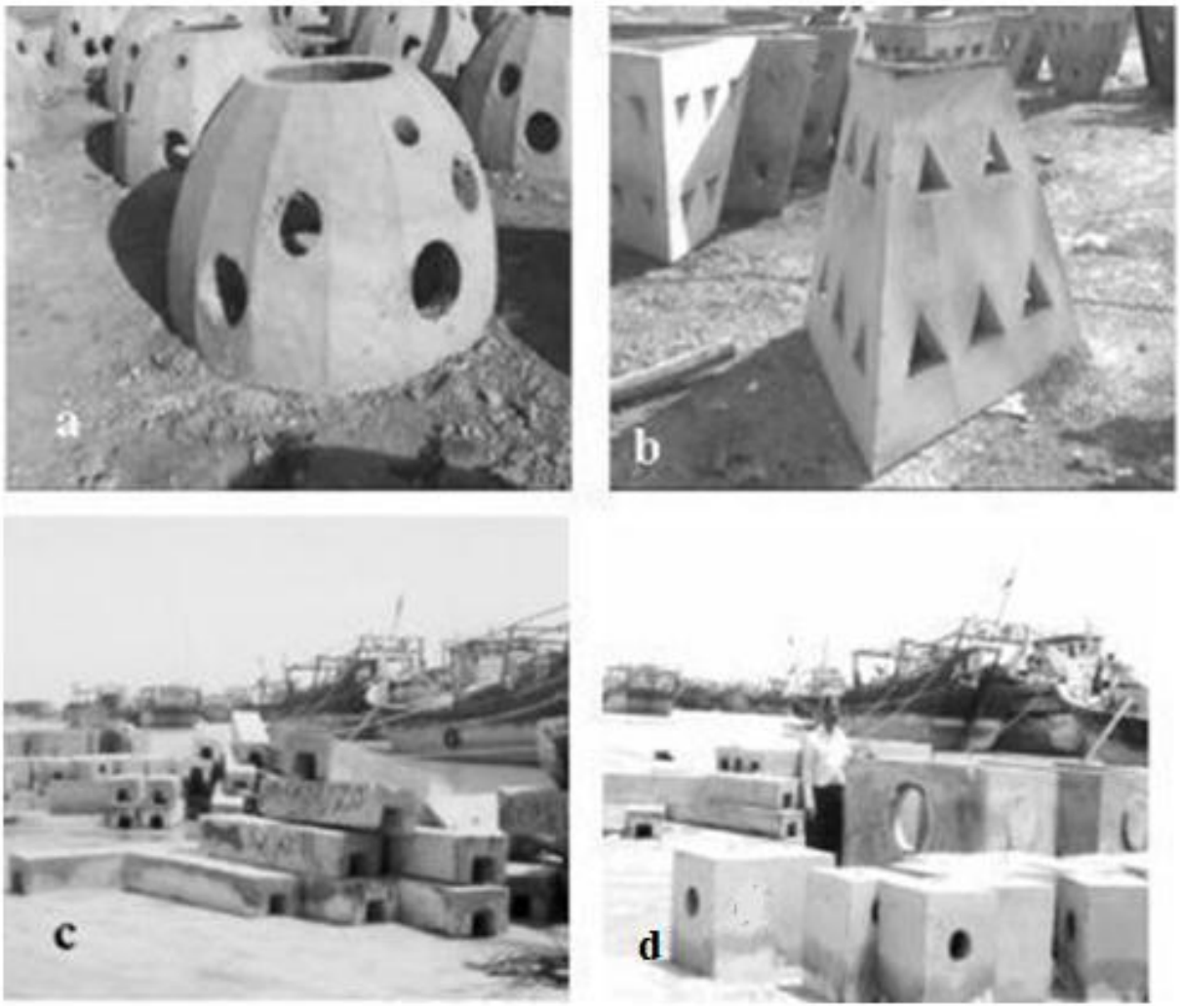

Figure 2: Materials used for constructing the artificial reefs

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Table 1: Statistical plan for deployment constructions of ARs in the sites

Treatment / Replicates	Reef ball (R)	Laneh Mahi (L)	Used material (U)	Mixed reefs (RLU)	Control Site (CS)
1	A	A	A	A	*A*
2	B	B	B	B	*B*
3	*C*	*C*	*C*	*C*	*C*

A= sites in first replicates in different treatment**, B=** sites in second replicates in different treatment**, C=** different sites in third replicates in each treatments.
R=Reef ball, L=Laneh mahi, U=Used material, RLU= mix of three kind reefs and CS=Control Site or Natural reef

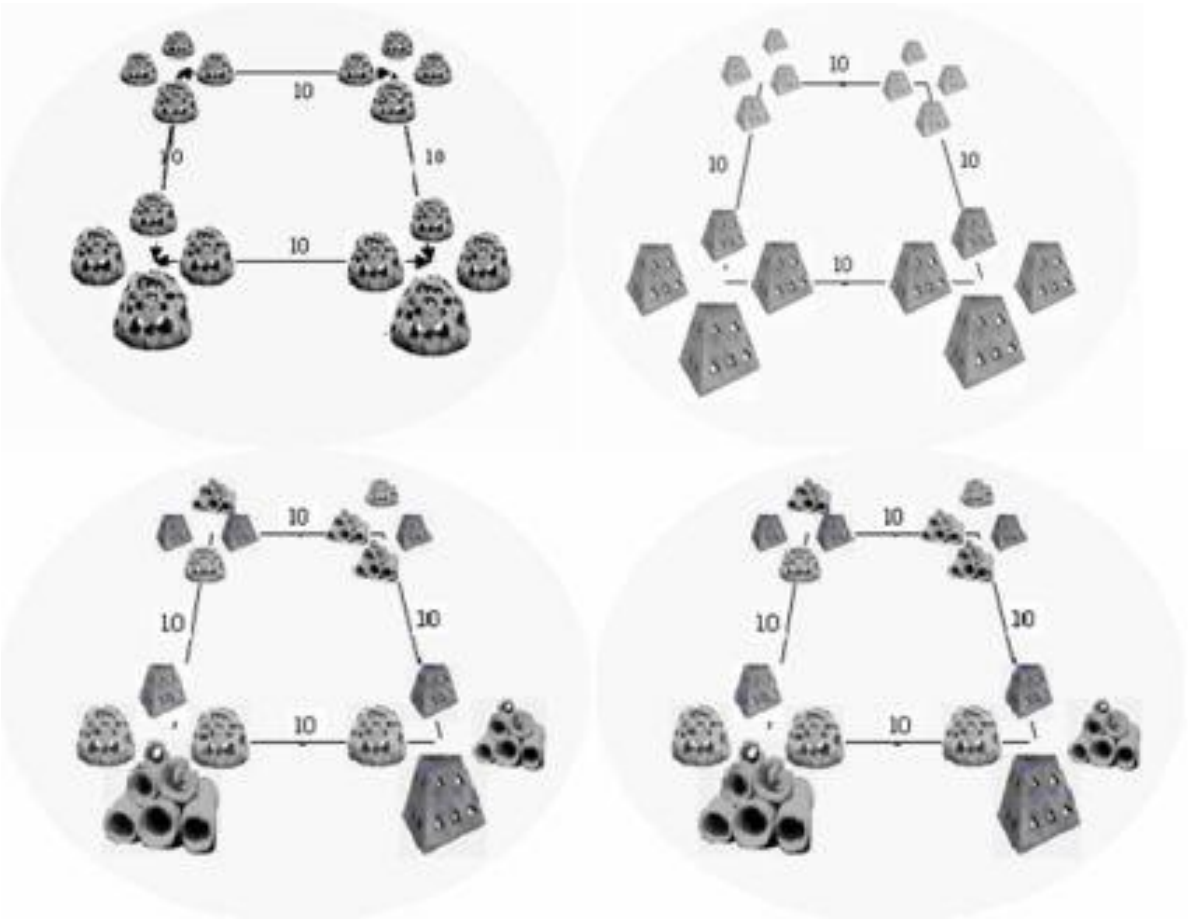

Figure 3: Artificial Reef Design, in each replicate for treatments of structures

The treatments were Reef ball (R), Laneh mahi (L), used materials (U), and mixed materials (RLU). The control site (CS) was similar to the artificial reefs deployed places with hard sea bottoms. The distance between artificial reef treatments was

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300m and replicates were 100m (Walker et al., 2002; Miguel and Carlos 1998), occupying an area of 36ha approximately, with depths ranging from 10 to 15m (Fig. 1). Each site was square shaped of 10×10m dimension. There were 4×4=16 pieces (Fig. 3) of artificial reefs depending on the condition of the site of different treatments (Figs. 2a, b, c, d).

The total number of artificial reef pieces for all 12 sites, except the 3 control sites was 192 (statistical plan, Table 1). Samplings were done once every three months during a period of one year. There was 15×3 = 45 number of trap nets used in the study. Each used trap net was of size ranging from 120cm to 150cm in diameter, meeting local requirement. As mentioned previously, the artificial reef sites were checked every three months. In each visit, the trap nets were placed in every sampled site by skilled experts and divers and then abounded for a period of 5-7 days. The catch per sample site was collected after this period. The fishes in the different reefs were grouped into families and species and their respective weights were recorded. The catches were treated with Formalin (4%) and transported by boat to the marine ecology laboratory. In the laboratory, biometric measurements (Total weight) were estimated for each fish species. The SPSS software was used for data analysis. The means of fish catch were normal according to Kolmogorov Smirnov test. One-way analysis of variance (ANOVA) was employed to compare the total means of fish catch between experimental groups (treatments and control) and also seasonal changes of CPUE (Catch Per Unit Effort= yielded weight of fish in each collection). Also, the total means of CPUE of each treatment were compared with control by independent samples t-test (Table 3).

Results

Catch composition

The status of attraction and assemblage of fishes found in this experiment were 249 fishes grouped under 10 families and 16 species of demersal fishes. The families were Serranidae, Haemulidae, Lutjanidae, Siganidae, Pomacanthidae, Carangidae, Scaridae, Chaeodontidae, Lethernidae and Sparidae. Three species were found in the families of Lutjanidae and Haemulidae while the Seranidae and Sparidae families each had two species and for other families just one species were found.

Fishing yield

Throughout the experiment, the total fish catch was higher in RLU reefs than other treatments and control sites (Fig. 4).

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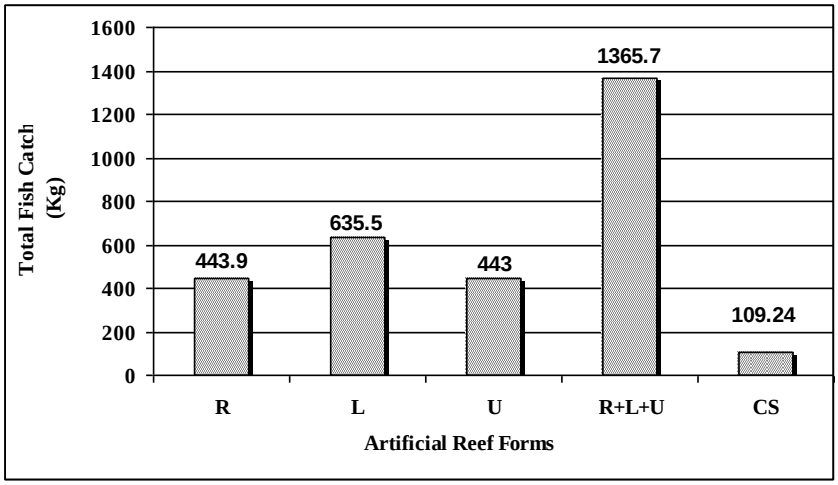

Figure 4: The total fish catch (Kg) in different forms of artificial reefs over the course of experiment

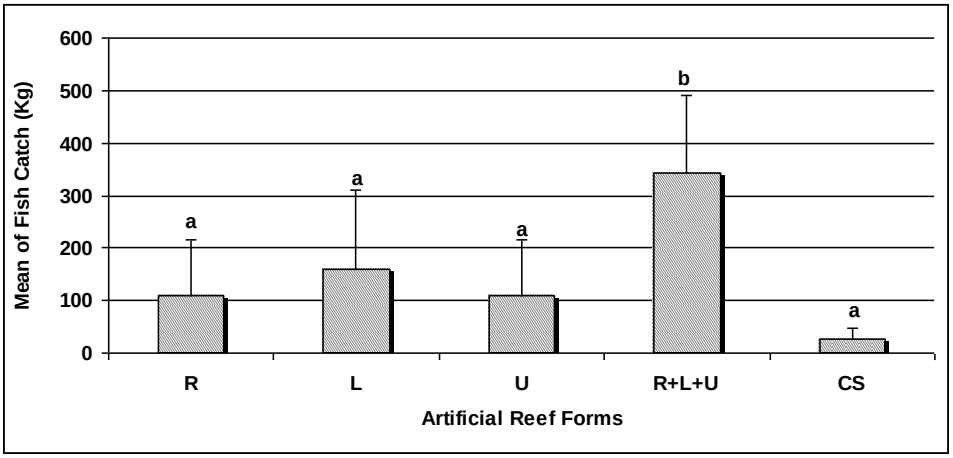

Figure 5: Comparison of mean of total fish catch (Kg) between different forms of artificial reefs over the course of experiment. The values with different letters are significantly different (P<0.05)

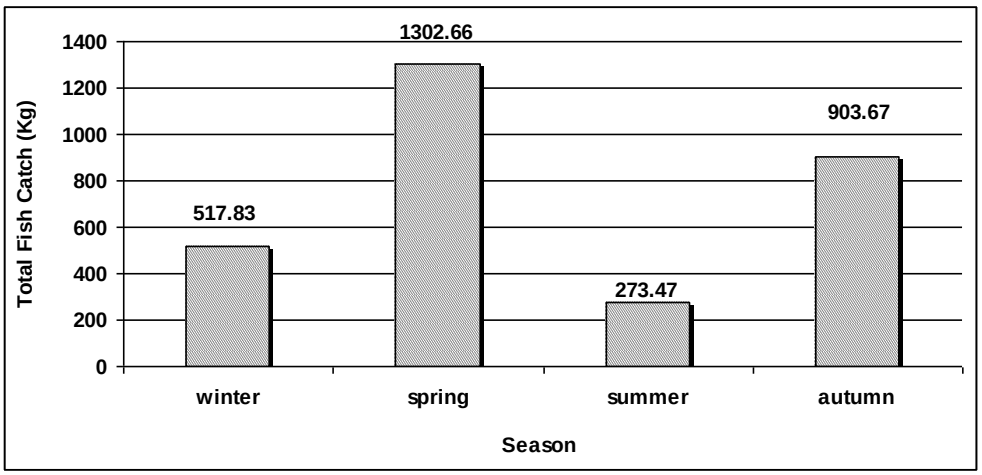

Figure 6: Total fish catch (Kg) for each season over the course of experiment

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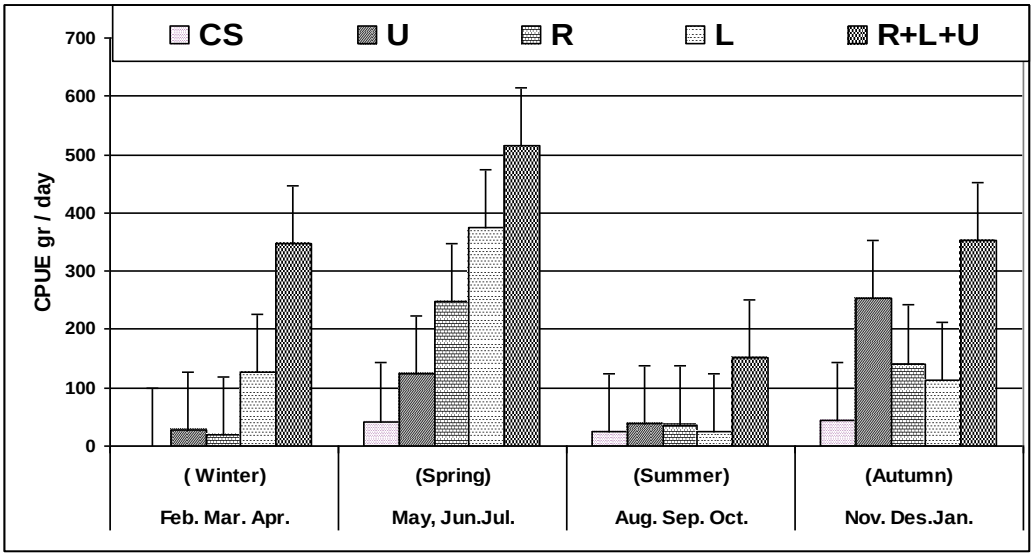

Figure 7: Seasonal changes of Catch Per Unit Effort (CPUE) for different forms of artificial

In this regard, the total weight of caught fishes in RLU and other artificial reef forms were approximately 13 and 4-6 times greater than CS (Fig. 4). The mean of fish catch was higher in RLU reefs than other forms and control sites (Fig. 5). Also, the total fish catch was higher in spring season than in other seasons (Fig. 6). The RLU reefs showed higher values of CPUE in all seasons than other artificial reef forms and the control (Fig. 7).

Discussion

Artificial structure developments have served many purposes and designs (Jensen et al., 2000, Seaman, 2000, Sayer and Wilding, 2002, Perkol-Finkel, and Benayahu, 2005). The primary purpose of artificial reefs has been attracting fishes by providing more favorable habitats than those present in the original environment (Godoy et al., 2002). The deployment of artificial reefs in the coastal zone of Bander-e-lengeh, north of the Persian Gulf has shown that artificial reefs are reliable tools to assemble, attract and enhance fish production. In fact, there was a significant difference in fish production between the artificial reefs and control sites in favor of the former. In a previous study (Kamali, 2003) in Bandar Abbas, the significant differences were found in fish abundance between the various forms of artificial reefs (Kamali, 2003). Bohnsack, 1989 observed the dramatic increases in fish richness and abundance after deployment of artificial reefs. Miguel and Carlos (1998) carried out the project on the presence of fish in artificial reefs and when compared with control sites the data demonstrated the difference between tow group as artificial reefs (protection reefs PR and exploitation reefs ER) with control sites (as control protection reefs CPR and control exploitation reefs CER). The equal numbers of fish and associated species

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were found on an artificial reef and a natural reef in Florida after only 7 months (Dean, 1983). The biomass on an artificial reef of the Maquevas Island in 1972, monitored by the University of Puerto Rico's Department of Marine Science, was found to be eight times greater than that of a nearby natural reef, although there was smaller species diversity (Dean, 1983). An enlarged biomass of some 11 times greater was also found in an artificial reef compared to the natural one in the Virgin Islands. In the present study, the mean values of fish catch were higher in all artificial reef forms than in control, although this was significant only for RLU. Also, the total weight of caught fish in RLU and other artificial reef forms were approximately 13 and 4-6 times greater than CS (fig. 4).

Most importantly, artificial reefs have been used for enhancement of fishery harvests in two ways. Firstly, almost immediately after reefs deployment, the attraction of mobile organisms to the structure was obvious as anticipated by those interested in improving catch efficiency. Secondly, there has been expectation that ecologically the artificial reefs are same or even better the natural environment, in catch efficiency in the long term. This is because assemblages including sessile organisms have adapted well with the artificial reefs surface, structure and its surrounding water column, eventually increasing the biomass at the site (Seaman, 2000). One of the mechanisms through which an artificial reef would increase environmental carrying capacity and biomass within a naturally self-sustaining stock or aid in the survival of an introduced stock is that artificial reef structures can reduce predation on the reefs' residents through the provision of shelter (Bohnsack, 1989, Eggleston et al., 1992). As a result, an artificial reef is an appropriate habitat, which plays a great role as a reliable and comfortable shelter for aquatic life. So this explains its potential to attract and assemble fishes. Many studies also concluded that the artificial reefs are suitable habitats for aquatic life providing appropriate space for complete life activity such as living, propagation, nourishment, single or group living and temporary occupancy during migration (Pickering and Whitmarsh, 1997, Seaman, 2000, Godoy et al., 2002). In this study, many groups of vertebrates have settled easily and after three months all surfaces of the reefs both inside and outside were occupied. It is likely that some characteristics of ecosystems in the Persian Gulf such as conducive depth, existence of light and profusion of nutrients have caused the mass production of invertebrates which are essentially the main part of food chain for fishes as this was reported for other sea regions previously (foster, et al., 1994; Sampaolo and Renili, 1994). In the present study, the total fish catch fluctuated in different periods of sampling (Fig. 5).

In this regard, the maximum and minimum levels of fish catch were found

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in second (spring season: March, April and May) and first sampling (winter season: December, January, February) respectively. In another study, Walker et al. (2002) mentioned that total abundance and richness of fishes fluctuated with different times in a year, increasing during in Aug., Sep. and Oct. and similarly decreasing during Feb., Mar. and Apr.. It is likely that the second sampling has been the best time because of its optimum temperature for blooming of phytoplankton and zooplankton (Kamali, 2005) that are very important as fish food in sea waters (Seaman, 2000) including the Persian Gulf. Therefore, the increased fish catch in spring could be attributed to the probable blooming of phytoplankton and zooplankton. In conclusion, in this study, our results showed that mix reef (RLU) could be the best choice for ARs development in the north Persian Gulf coastal region.

Acknowledgements

First of all, the design of this study was dependent on the guidance and experience of Prof, Dr. Todd Barber. This was funded by the Iran Fisheries Organization. Lotfeollah Saeedi and Aminollah Taghavi, and the Iranian Fisheries Research Organisation have provided technical aids in coordinating the efforts of experts within the science groups. The Institute of Ecology of Persian Gulf and Oman Sea Esa Kamali and Behzadi (IPOE) has provided assistance with fish counting, identification and diving operation. Also, the authors express their sincere appreciation to Mr. Saeed Hajirezaee for the English structural improvement of the text.

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