Journal of

Fisheries and Aquatic Science

ISSN 1816-4927

Academic Journals Inc.

www.academicjournals.com

Journal of Fisheries and Aquatic Science 5 (2): 70-81, 2010
ISSN 1816-4927

Coral Reefs Anthropogenic Impact Bio-indicators in the Northern Part of the Persian Gulf

[1]H. Valavi, [1]A. Savari, [2]V. Yavari, [2]P. Kochanian, [1]A. Safahieh and [3]O. Sedighi
[1]Department of Marine Biology, Faculty of Marine Science,
[2]Department of Fisheries, Faculty of Natural Resources,
Khorramshahr University of Marine Science and Technology,
P.O. Box 669, Khorramshahr, Khuzestan, Iran
[3]Department of the Environment, P.O. Box 5181, Tehran, Iran

Abstract: Potential and efficiency of coral reef bio-indicators proposed by reef check for coral reef monitoring in the Persian Gulf were studied as anthropogenic impact bio-indicators. Data were collected from the coral reefs in the Northern part of the Persian Gulf in 2007 using Reef Cheek standard methodology and analyzed using Redundancy Analysis and Indicator Species Analysis. Similar data collected in 2002 and 2003 were also incorporated into our data. According to the results short-spine sea urchin (*Echinometra mathaei*) showed consistent positive correlation with commercial fishing and high indicator value for commercial fishing areas and could be pointed out as a weak bio-indicator of over-fishing, also Arabian butterfly fish (*Chaetodon melapterus*), showed negative correlation with commercial fishing and high significant indicator values for none to low fishing areas in 2003 and 2007 and could be considered as indicator of low fishing pressure in the region. None of finfishes proposed as indicators of over-fishing and also other proposed species showed consistent correlation or consistent significant indicator values for any anthropogenic impacts and are not recognized as anthropogenic impact bio-indicators. It is concluded that a much shorter and more efficient list of bio-indicators could be used for monitoring anthropogenic impacts on coral reefs in this region.

Key words: Reef check, indicator species, over-fishing, Arabian butterfly fish, short-spine sea urchin

INTRODUCTION

Coral reef communities in the Persian Gulf exist in a harsh environment with respect to salinity, sea temperature and extreme low tides (Coles and Fadlallah, 1991). These factors have a serious influence on community structure by restricting the number of species in the area and by causing recurrent mortality among the dominant species (Coles and Fadlallah, 1991; Fadlallah *et al*., 1995; Riegl, 1999). In last two decades, coral bleaching has occurred throughout the world resulting in mass mortality of corals mainly due to the elevated temperature (Wilkinson, 2000). This has also been the case in the Persian Gulf (Pilcher *et al*., 2000).

Corresponding Author: H. Valavi, Department of Marine Biology, Faculty of Marine Science, Khorramshahr University of Marine Science and Technology, P.O. Box 669, Khorramshahr, Khuzestan, Iran

However, to date, the majority of damage to coral reefs around the world including Persian Gulf and Iranian waters has been through direct anthropogenic stress (Kinsey, 1988; Pauly and Chua, 1988). The major causes of damage are: Excessive pollution from domestic, industrial and agricultural waste, poor land use practices which increase the amount of land derived sediments flowing onto coral reefs and over exploitation, particularly through damaging practices such as dynamite fishing.

Industrial projects could cause anthropogenic damage to coral reefs mainly through industrial waste pollution, poor land use practice, uncontrolled coastal construction and reclamation.

Reef Check (RC), as the largest and most widespread global organization dedicated to monitoring reefs had proposed some fish and invertebrate indicators for coral reef monitoring program in the Persian Gulf region (Hodgson *et al.*, 2004).

These indicators include: Barramundi cod (*Cromileptes altivelis*), orange-spotted grouper (*Epinephelus coioides*), other groupers, grey grunt (*Plectorhinchus sordidus*), black-spotted grunt (*Plectorhinchus gaterinus*), spotted grunt (*Plectorhinchus pictus*), dark butterfly fish (*Chaetodon nigropunctatus*), Arabian butterfly fish (*Chaetodon melapterus*), long-fin butterfly fish (*Heniochus acuminatus*), grunts/sweetlips, parrot fish, snappers, moray eel (all species), hump-head wrasse (*Cheilinus undulates*), long-spine black sea urchin (*Diadema* sp.) banded coral shrimp (*Stenopus hispidus*), lobster (all edible species), collector sea urchin (*Tripneustes* sp.), black sea urchin (*Echinothrix diadema*), cowries, pencil sea urchin (*Heterocentrotus mammilatus*), short-spine sea urchin (*Echinometra mathaei*), crown-of-thorns starfish (*Acanthaster planci*), edible sea cucumbers (e.g., teatfish *Holothuria nobilis*), Triton shells (e.g., *Charonia tritonis*).

It is very necessary to mention here that there are some serious problems in using bio-indicator-dependent monitoring programs. Firstly when management goals are indistinct and unclear wrong variables may be monitored and therefore inappropriate indicators may be selected, secondly relying on inappropriate bio-indicators fails to reflect changes in environment and leads to poor management and finally in many cases enough scientific effort is not applied to select bio-indicators and in other words there is a lack of robust procedures for selecting ecological indicators (Beyeler and Dale, 2001).

Finally each monitoring problem requires individual treatment and there is no one bio-indicator species that will suit all programmes (Linton and Warner, 2003). The complexity and variety of reef ecosystems makes it very difficult to confidently select a single indicator for a large region. Therefore, the purpose of this study is to review coral reef fishes and invertebrates indicators proposed for the Persian Gulf region by Reef Check and determine potential and effectiveness of these indicators as anthropogenic impact indicators in the Northern part of the Persian Gulf using Reef Check data or data collected using standard RC methodology (Hodgson *et al.*, 2004).

MATERIALS AND METHODS

Study Area

Data for this study were collected from the coral reefs at Khark, Kharku, Hendorabi, Kish, Farur and Farurgan Islands and Nayband bay in 2007 in the Northern part of the Persian Gulf. Similar data collected in 2002 and 2003 in some of the mentioned regions and in Lavan and Larak Islands were also used in this study (Fig. 1).

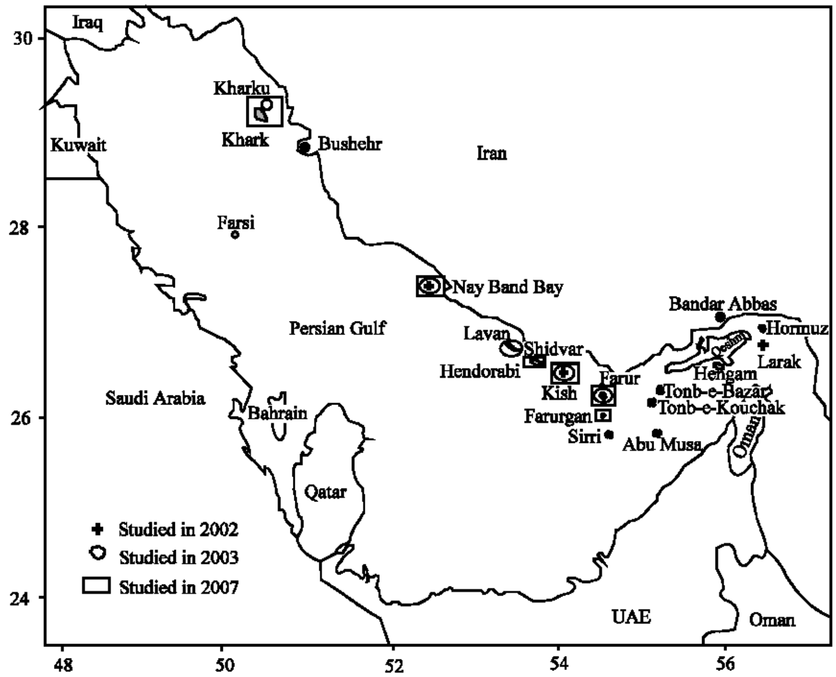

Fig. 1: Study areas in 2002, 2003 and 2007 in the Northern Persian Gulf

Table 1: Site description definitions and field guide, clarifying measurements

Impact	Low (1)	Medium (2)	High (3)
Aquarium fishing	Less than once per month	More than once per month, but less than once per week	Once a week or more
Tourist diving	1-5 individuals per day	6-20 individuals per day	More than 20 individuals per day
Sewage pollution	Sewage, irregular or rare discharge	Source of discharge >100 m but <500 m from transect	Source of discharge <100 m from any point on transect
Industrial pollution	Source > 0.5 km	Source between 0.1 and 0.5 km	Source less than 100 m
Commercial fishing	Less than once per month	Less than once a week and more than once a month	Once a week or less

Sampling Techniques

Survey sites were chosen using manta tow surveys and reconnaissance dives. Selected sites were popular diving areas, the best reefs in the area or the worst reefs in the area and they reflect a wide range of habitats.

At each site a site description sheet was completed with anecdotal, observational, historical, locational and other data. This included impacts at the site, giving values of 0 (none), 1 (low), 2 (medium) or 3 (high) for the following: tourist diving, sewage pollution, industrial pollution, commercial fishing and other impacts (Table 1).

Then data were collected along 2 depth contours at shallow (3-6 m) and intermediate (6-12 m) depths (if the reef was too shallow, the 6-12 m depth transect was not completed). Along, each depth contour a 100 m transect was placed and along it four 20 m replicate transects were surveyed. The start and end points of 20 m transects were 5 m apart.

Along each transect at each depth a belt transect (5 m wide centered on each 20 m transect line) was sampled for commercially important fish favored by fishers and aquarium and invertebrate taxa typically targeted for curios and food (Hodgson *et al.*, 2004).

Statistical Methods

Detrended Correspondence Analysis (DCA) were run on the fish and invertebrate data sets using Canoco 4.0 to determine the unimodality of the data. Detrending was done by segments, species were square-root transformed and rare species were down-weighted. Following Chi-squared measure distance and one standard deviation cutoff, outliers were identified and removed from the data set using PC-ORD 4.17.

Redundancy analysis (RDA) were run using Canoco 4.0 to determine correlations between fish and invertebrate vs. anthropogenic impact variables because all DCA axis 1 gradients were below 2.5 and RDA is useful where gradients are shorter (Palmer, 2004). Once RDA's were performed, collinear anthropogenic variables, those with Variance Inflation Factors (VIF) over 10, were deleted (Kent and Coker, 1992), also all data were checked for normality using the Anderson-Darling test in Minitab 13.20, in cases where p values were below 0.05 (Non-normal distribution), data were log transformed using x = Log(x+1).

Indicator species were identified for each habitat type using the method introduced by Dufrene and Legendre (1997) based on an indicator value index (IndVal) as follows:

$$\text{IndVal} = A_{ij} \times B_{ji} \times 100$$

where, A_{ij} is a measure of specificity (A_{ij} = $\text{Nindividual}_{ij}/\text{Nindividual}_i$) and B_{ji} is a measure of fidelity (B_{ji} = $\text{Nsites}_{ji}/\text{Nsites}_j$).

In our case Nindividual_{ij} is the mean number of species i across transects of group j and Nindividual_i is the sum of the mean numbers of individuals of species i over all groups, Nsites_{ji} is the number of transects in cluster j where species i is present and Nsites_j is the total number of transects in that cluster.

For maximum A_{ij}, species i is only present in cluster j. B_{ji} is highest when species i is present in all transects of cluster j. indicator value (IV) is thus highest (100%) when species i is present in all transects of only one habitat group. The significance of the indicator values were tested using a random reallocation of transects among transects groups using Monte Carlo randomization test (1000 permutations).

The site hierarchy component of Dufrene and Legendre's (1997) method to select site clusters was not preformed because the transects were already clustered into groups based on different levels of anthropogenic impacts with the following groups: 0(None), 1(Low), 2 (Medium) and 3 (High).

The calculations of IVs and the associated Monte Carlo (randomization) test were performed using the PC-ORD 4.17.

RESULTS

Abundance of Indicators and Levels of Anthropogenic Impacts

Levels of anthropogenic impacts in transects and average abundance of indicator fish and invertebrates within belt transects studied in 2002, 2003 and 2007 are, respectively presented in Table 2 to 4.

Correlation Between Proposed Indicators and Anthropogenic Variables

Outliers of fish and invertebrate data in 2002, were moray eel and lobster, in 2003, were black-spotted grunt and cowry shells and in 2007 were moray eel and cowry shells.

The DCA first axis gradients of fish and invertebrate data in 2002, were 2.174 and 0.782, in 2003 were 1.237 and 1.893 and in 2007 were 1.695 and 1.944, respectively. Therefore, redundancy analysis (RDA) was used for all cases.

Table 2: Levels of anthropogenic impacts and average indicator fish/invertebrate density (individuals 100 m^{-2}) in 2002 transects

Fish/invertebrate anthropogenic impact	Kish 1		Kish 2		Larak	
	3-6 m	6-12 m	3-6 m	6-12 m	3-6 m	6-12 m
Aquarium fishing	1.00	1.00	0.00	0.00	0.00	0.00
Commercial fishing	1.00	1.00	0.00	0.00	1.00	0.00
Sewage	0.00	0.00	0.00	0.00	0.00	0.00
Industrial pollution	0.00	0.00	0.00	0.00	0.00	0.00
Tourist diving	1.00	0.00	0.00	0.00	0.00	0.00
Orange-spotted grouper	0.00	0.25	0.00	0.00	0.00	0.00
Other groupers	0.00	0.00	0.25	0.00	0.50	0.25
Hump-head wrasse	1.00	0.00	0.00	0.00	0.00	0.00
Dark butterfly	0.50	1.00	0.00	0.50	14.50	0.00
Arabian butterfly	0.25	0.00	0.00	0.00	0.50	0.00
Long-fin butterfly	0.00	1.00	0.75	0.00	0.00	0.00
Parrot	0.00	0.25	1.75	0.25	2.00	0.00
Moray eel	0.00	0.00	0.00	0.25	0.00	0.00
Short-spine sea urchin	1.50	16.00	5.25	41.75	3.25	0.00
Pencil sea urchin	0.00	3.00	0.00	0.00	0.00	0.00
Sea cucumber	0.00	3.00	0.50	0.00	0.50	0.00
Lobster	0.00	0.00	0.25	0.00	0.00	0.00

Table 3: Levels of anthropogenic impacts and average indicator fish/invertebrate density (individuals 100 m^{-2}) in 2003 transects

Fish/invertebrate anthropogenic impact	Nayband 1		Kharku		Lavan		Kish 1		Kish 2	Farur		Nayband 2	
	3-6 m	6-12 m	3-6 m	6-12 m	3-6 m	6-12 m	3-6 m	6-12 m	3-6 m	3-6 m	6-12 m	3-6 m	6-12 m
Aquarium fishing	0.00	0.00	0.0	0.00	0.00	0.00	1.00	1.00	0.00	1.00	1.00	0.00	0.00
Commercial fishing	3.00	3.00	2.0	2.00	2.00	2.00	1.00	1.00	2.00	1.00	1.00	3.00	3.00
Sewage	0.00	0.00	0.0	0.00	0.00	0.00	0.00	0.00	2.00	0.00	0.00	0.00	0.00
Industrial pollution	0.00	0.00	0.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Tourist diving	0.00	0.00	0.0	0.00	0.00	0.00	2.00	0.00	0.00	0.00	0.00	0.00	0.00
Orange-spotted grouper	1.00	2.80	3.0	2.30	4.50	2.80	4.00	1.75	1.50	1.25	5.00	0.00	0.00
Other groupers	0.00	0.50	1.5	0.00	0.50	0.80	1.25	0.75	0.00	0.00	17.00	0.25	0.00
Spotted grunt	0.50	0.00	0.0	0.00	3.50	0.00	0.00	0.25	0.00	0.00	0.00	0.00	0.00
Arabian butterfly	0.00	0.00	3.0	0.50	0.50	0.00	0.50	1.25	2.00	5.25	5.25	0.00	0.00
Dark butterfly	6.50	10.75	17.0	7.30	5.50	3.00	4.50	11.25	8.50	7.50	10.25	1.00	2.50
Parrot	0.50	3.50	3.5	0.00	0.00	1.50	0.50	5.50	2.00	6.75	9.75	0.00	1.25
Snapper	28.80	1.30	57.5	7.50	13.80	2.30	10.25	4.50	58.25	39.00	10.25	0.00	0.00
Long-fin butterfly	0.00	0.00	0.0	2.80	0.0	0.00	0.00	0.00	0.00	0.00	1.25	0.00	0.00
Grey Grunt	0.00	0.00	0.0	2.50	0.00	0.00	0.00	0.00	0.00	0.00	1.50	0.00	0.00
Black-spotted grunt	0.00	0.00	0.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.25
Short-spine sea urchin	462.30	0.00	145.5	30.80	96.00	59.30	3.30	5.00	8.00	2.50	1.80	411.80	114.50
Long-spin sea urchin	0.00	123.50	38.0	75.80	2.30	0.50	12.50	8.50	3.00	3.30	1.30	0.00	0.00
Pencil sea urchin	0.00	0.00	13.3	32.00	0.00	0.00	0.50	2.30	0.00	0.00	0.00	0.00	0.00
Cowry shell	1.50	1.30	0.0	0.00	2.00	1.80	0.80	2.30	0.00	1.00	1.50	0.00	0.00
Sea cucumber	0.50	1.80	0.0	0.00	2.80	2.30	0.80	3.00	0.50	0.00	0.50	0.00	2.30
Triton shell	0.00	0.80	7.0	7.30	0.00	0.00	0.00	0.00	0.50	0.80	0.00	0.00	0.00

In redundancy analysis for fish vs. anthropogenic impacts in 2002, dark butterfly fish, Arabian butterfly fish and to some extent hump-head wrasse exhibited positive correlation and orange-spotted grouper and long-fin butterfly fish showed negative correlation with commercial fishing. Also, hump-head wrasse showed positive correlation and parrot fish and other groupers showed negative correlation with aquarium fishing and tourist diving (Fig. 2). For invertebrates vs. anthropogenic impacts short-spine sea urchin, sea cucumbers and pencil sea urchin exhibited positive correlation with commercial fishing and to lower extent with aquarium fishing and negative correlation with tourist diving (Fig. 3).

In redundancy analysis for fish vs. anthropogenic impacts in 2003, grey grunt, long-fin butterfly fish, snappers, other groupers, Arabian butterfly fish, dark butterfly fish, orange-spotted grouper and parrot fish showed negative correlation with commercial fishing. In

Table 4: Levels of anthropogenic impacts and Average indicator fish/invertebrate density (individuals 100 m^{-2}) in 2007 transects

Fish/invertebrate anthropogenic impact	Hendorabi	Nayband 1	Nayband 2	Kharku		Khark		Kish 1		Kish 2	Farur		Farurgan	
	3-6 m	3-6 m	3-6 m	3-6 m	6-12 m	3-6 m	6-12 m	3-6 m	6-12 m	3-6 m	3-6 m	6-12 m	3-6 m	6-12 m
Aquarium fishing	1.0	0.0	0.0	0.0	0.0	0.0	0.0	2.0	1.0	0.0	1.0	1.0	0.0	0.0
Commercial fishing	1.0	3.0	3.0	1.0	1.0	2.0	2.0	0.0	2.0	1.0	1.0	1.0	0.0	0.0
Sewage	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.0	0.0	0.0	0.0	0.0
Industrial pollution	0.0	0.0	0.0	0.0	0.0	3.0	2.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Tourist diving	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.0	1.0	0.0	0.0	0.0	0.0	0.0
Orange-spotted grouper	0.5	0.5	0.0	0.0	0.3	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Other groupers	1.5	0.8	0.8	0.3	0.3	0.0	0.0	0.5	0.0	0.0	0.0	0.5	0.3	0.3
Spotted grant	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.3
Arabian butterfly	0.5	0.0	0.0	0.0	0.3	0.0	0.0	5.5	0.0	0.0	2.5	0.0	0.5	0.5
Dark butterfly	5.5	6.5	5.3	13.0	4.8	5.8	6.0	7.8	0.0	0.0	10.8	0.3	2.3	2.3
Parrot	5.5	0.5	0.3	0.0	0.0	0.0	1.3	0.0	0.0	0.0	1.0	0.0	3.5	3.5
Moray	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.0	0.0
Snapper	0.8	25.8	1.8	0.0	0.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Short-spine sea urchin	1.3	0.0	700.8	270.8	155.5	60.8	0.0	0.0	0.0	65.5	0.0	22.8	1.0	0.0
Long-pine sea urchin	0.0	0.0	0.0	13.3	62.5	0.0	58.8	0.0	2.3	13.0	58.8	18.5	0.0	0.0
Pencil sea urchin	0.0	0.0	0.0	0.5	1.5	0.0	0.0	0.0	0.5	0.0	0.0	0.0	0.0	0.0
Cowry shell	0.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Sea cucumber	0.5	0.0	0.0	0.3	0.0	0.0	0.0	0.0	0.3	0.0	0.0	0.0	0.3	0.0

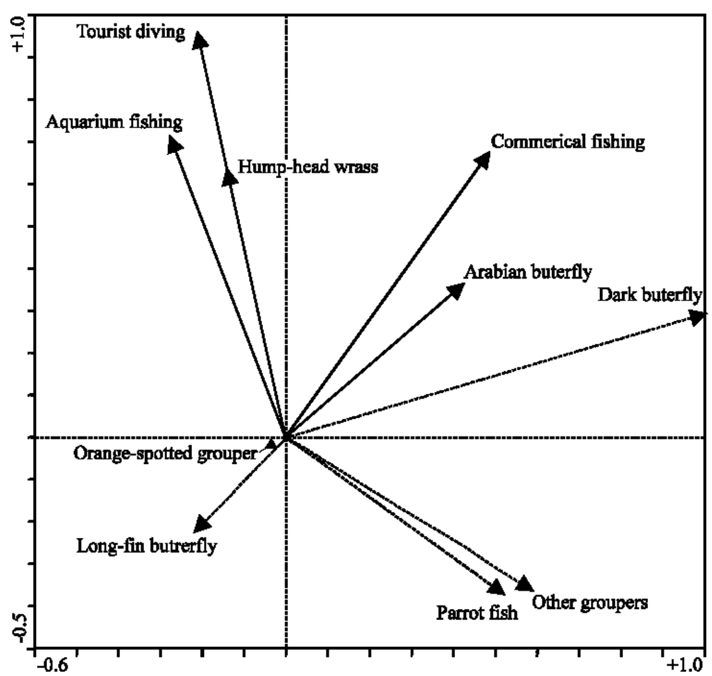

Fig. 2: Redundancy analysis for fish vs. anthropogenic impacts in 2002

addition orange-spotted grouper, other groupers and spotted grunt showed positive correlation with tourist diving and Arabian butterfly fish, snappers, grey grunt, dark butterfly fish, long-fin butterfly fish and parrot fish exhibited positive correlation with aquarium fishing and sewage pollution (Fig. 4). For invertebrates vs. anthropogenic impacts short-spine sea urchin exhibited positive correlation with commercial fishing and negative correlation with aquarium fishing, tourist diving and sewage pollution and sea cucumbers showed positive correlation with sewage pollution (Fig. 5). In addition short-spine sea urchin, Triton shells,

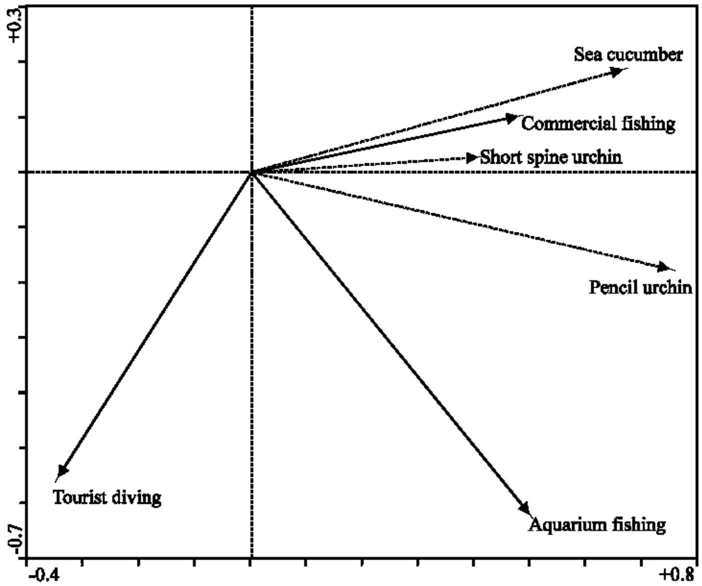

Fig. 3: Redundancy analysis for invertebrates vs. anthropogenic impacts in 2002

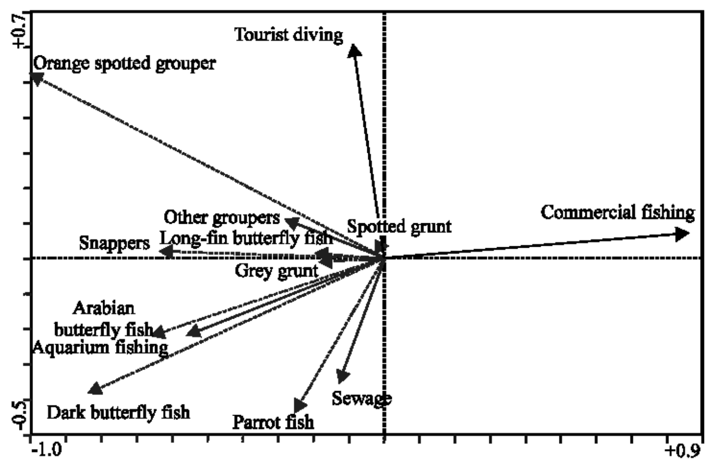

Fig. 4: Redundancy analysis for fish vs. anthropogenic impacts in 2003

pencil sea urchin and long-spine sea urchin exhibited negative correlation with sewage pollution and long-spine sea urchin exhibited positive correlation with tourist diving.

In redundancy analysis for fish vs. anthropogenic impacts in 2007, Arabian butterfly fish, parrot fish and spotted grunt showed negative correlation and snappers, orange-spotted grouper and other groupers showed more or less positive correlation with commercial fishing. Also, Arabian butterfly fish, spotted grunt and parrot fish showed positive correlation and snappers and orange-spotted grouper showed negative correlation with tourist diving, aquarium fishing and industrial pollution. In addition dark butterfly fish, orange-spotted grouper, other groupers, spotted grunt and parrot fish exhibited negative correlation with sewage pollution (Fig. 6). For invertebrates vs. anthropogenic impacts short-

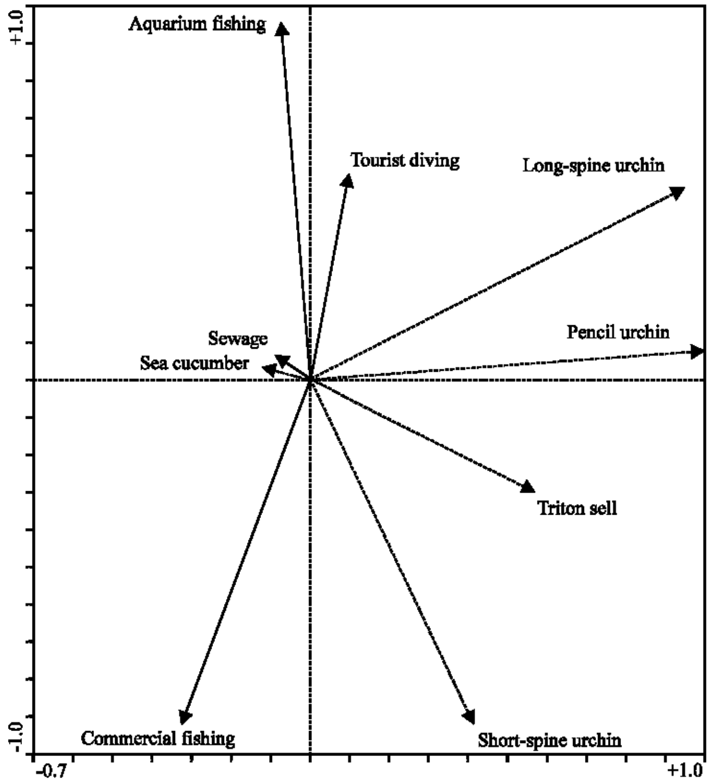

Fig. 5: Redundancy analysis for invertebrates vs. anthropogenic impacts in 2003

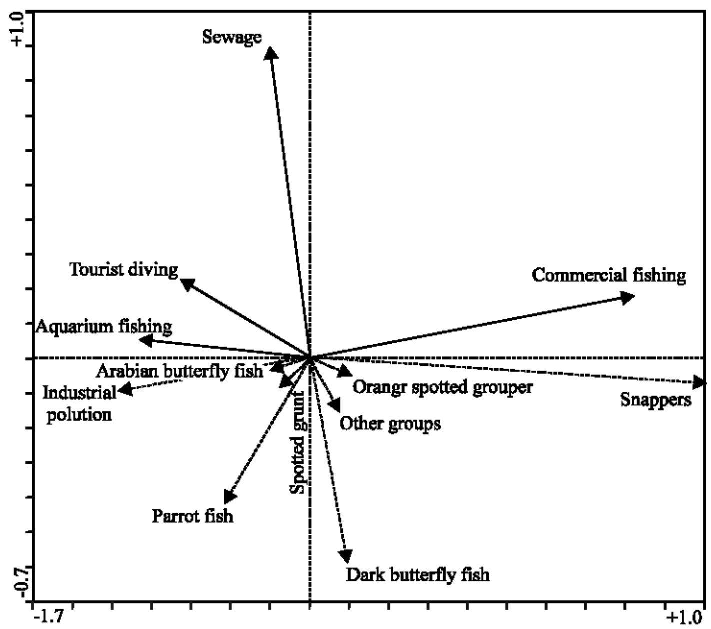

Fig. 6: Redundancy analysis for fish vs. anthropogenic impacts in 2007

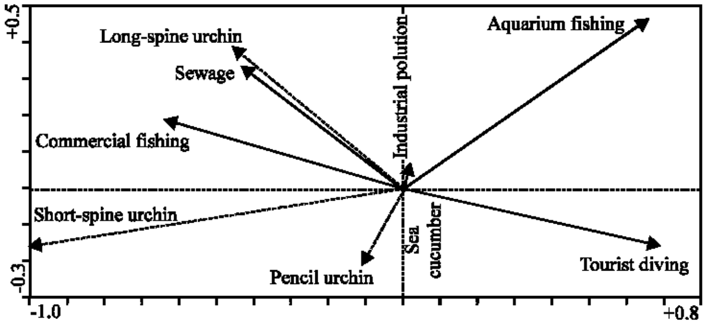

Fig. 7: Redundancy analysis for invertebrates vs. anthropogenic impacts in 2007

Table 5: Indicator values for characteristic species/taxa of different anthropogenic impact types/levels

Species/Taxa	IV	*P	Type/level of anthropogenic impact	Year
Dark butterfly	97.0	0.2000	Commercial and aquarium fishing	2002
Arabian butterfly	66.7	0.3980		
Orange-spotted grouper	60.1	0.2370	Mostly Aquarium fishing	2003
Other groupers	69.2	0.1720		
Arabian butterfly	82.1	0.0190		
Parrot fish	80.5	0.0220		
Cowries	65.6	0.0830		
Short-spine sea urchin	87.0	0.0530	Commercial fishing	
Other groupers	64.8	0.2720	Low Commercial fishing	
Arabian butterfly	71.8	0.0380		
Parrot fish	67.5	0.0310		
Spotted grunt	66.7	0.0900	No Commercial fishing	2007
Arabian butterfly	80.0	0.0420		
Snappers	98.5	0.0100	High Commercial fishing	
Short-spine sea urchin	69.0	0.1010	Commercial fishing	

*Proportion of Monte Carlo test randomized trials with indicator value equal to or exceeding the observed indicator value. p = (1 + number of runs = observed)/(1 + number of randomized runs)

spine sea urchin and long-spine sea urchin exhibited positive correlation with commercial fishing and sewage pollution and negative correlation with tourist diving and aquarium fishing. Also, pencil sea urchin showed negative correlation with industrial pollution and aquarium fishing and sea cucumbers showed positive correlation with tourist diving and negative correlation with commercial fishing and sewage pollution (Fig. 7).

Indicator Values of Indicators for Different Anthropogenic Impact Groups

Studied transects were clustered into groups based on anthropogenic impact types and levels. Calculated Indicator Values (IV)s for characteristic species/taxa of habitat groups recognized in the survey area in different years are presented in Table 5 (Only indicator values > 60% and those with p<0.25 are shown in Table 5).

DISCUSSION

Looking at anthropogenic impacts, fishes and invertebrates proposed by Reef Check as bio-indicators of coral reefs in the area are divided into five different groups:

- Barramundi cod, hump-head wrasse, long-fin butterfly fish, banded coral shrimp, lobsters (all edible species), collector sea urchin, black sea urchin and pencil sea urchin

- Sea cucumbers, triton shells, cowries (all species) and lobsters (common with the first group)
- Moray eel (all species) and banded coral shrimp (common with the first group)

Members of these three groups are not good indicators for coral reef monitoring in the region because they are rare or not common, not widely distributed in the region, are nocturnal, hide in holes during the day and can not be counted easily, or they are proposed as indicators of harvest types (such as invertebrate collection for food/for curio) which are not used in the region, also they didn't show any consistent positive or negative correlation with anthropogenic variables such as harvest types, tourist diving, etc. Also they didn't show significant indicator values for different groups of harvesting types and other anthropogenic impact levels.

- Orange-spotted grouper, other groupers, grey grunt, black-spotted grunt, spotted grunt, other grunts/sweetlips, snappers, parrot fish, dark butterfly fish and long-spine sea urchin

Members of this group exhibited more or less negative correlation with commercial fishing but didn't show consistent significant indicator values for different groups of harvesting types and other anthropogenic impacts and are not considered as reliable indicators for short term monitoring of anthropogenic impacts in the region because abundance of these fishes is affected by other factors such as food availability in different reef areas.

- Short-spine sea urchin (*Echinometra mathaei*) and Arabian butterfly fish (*Chaetodon melapterus*). Members of this group are common, easy to count and widespread in the region and showed consistent correlation with commercial fishing and consistent high indicator values for commercial fishing habitats and could be considered as indicators of fishing status in coral reef ecosystems in the region

Short-spine sea urchin exhibited positive correlations with commercial fishing in 2002, 2003 and 2007. Furthermore, Indicator Species Analysis showed them to be indicator species for commercial fishing areas, with indicator values of 87.0 ($p = 0.053$), 69.0 ($p = 0.10$), respectively in 2003 and 2007 and therefore short-spine sea urchin could be considered as bio-indicator of fishing pressure in coral reef ecosystems of this region.

Wrasses (Labridae) and emperor (Lethrinidae) also present in the study region are reported as dominant sea urchin predators in Kenyan marine protected areas by McClanahan (1995, 1998, 1999). Over-fishing and removing of these predator fishes could increase short-spine sea urchin population and high abundance of sea urchins results from reductions in sea urchin predator fishes.

Arabian butterfly fish showed high significant indicator values for none to low commercial fishing habitats in 2003 (IV = 71.8, $p<0.05$) and 2007 (IV = 80.0 , $p<0.05$) and this is further illustrated by the RDA's where they have exhibited negative correlation with commercial fishing in 2003 and 2007. However, it appears that Arabian butterfly fish is a good indicator for coral reef habitats with none to low commercial fishing impact.

Although, Reese (1981) and Crosby and Reese (1996) have suggested that corallivore butterfly fish could be used as indicator species for changing conditions of coral reefs and also relationship between temporal variation of butterfly fish population density and the corals was reported by Adjeroud *et al*. (2002), Bell and Galzin (1984) and Shokri *et al.* (2005), however it dos not seem that commercial fishing and removal of finfish is having direct impact on Arabian butterfly fish population density, because it is not target fish in this type of harvest.

Studies indicate that removal of finfish is having the largest impact on reefs and has a number of tertiary effects on other faunal groups and ecological processes (McClanahan and Shafir, 1990).

CONCLUSIONS

It is concluded that although changes in abundance of finfishes such as groupers, grunts and snappers may be useful for long term monitoring of over fishing in the coral reefs ecosystems, they can't be used as reliable indicators for short term monitoring of overfishing in the region. Furthermore over-fishing and removal of finfishes increases short-spine sea urchin population (e.g., *Echinometra mathaei*). Increased sea urchins population causes high bioerosion followed by decrease in live coral cover and finally it is associated with a decrease in corallivore butterfly fish (e.g., *Chaetodon melapterus*) population.

ACKNOWLEDGMENTS

We would like to express our appreciation to the Department of the Environment for financial support of this project and also Mr. Abolfazl Nikbakht and Mr. Mahraz Shahnazi for helping us in fieldwork and Mr. Omid Tabiei from Islamic Azad University of Arsanjan for preparing needed software. In addition, special thanks to Mr. Amir Shomali Moghaddam and Mr. Ghasem Nargesi members of the Kish Diving Centre, also Mr. Mahmood Rezaei, Mr. Mohammad Toulideh, Mr. Abdolrahman moradzadeh and members of Bushehr provincial office in Nayband National Park and Khark Island.

REFERENCES

Adjeroud, M., D. Augustin, R. Galzin and B. Salvat, 2002. Natural disturbances and interannual variability of coral reef communities on the outer slope of Tiahura (Moorea, French Polynesia): 1991 to 1997. Mar. Ecol. Prog. Ser., 237: 121-131.

Bell, J.D. and R. Galzin, 1984. Influence of live coral cover on coral reef fish communities.. Mar. Ecol. Prog. Ser., 15: 265-274.

Beyeler, S.C. and V.H. Dale, 2001. Challenges in the development and use of ecological indicators. Ecol. Indicators, 1: 3-10.

Coles, S.L. and H. Fadlallah, 1991. Reef coral survival and mortality at low temperatures in the Arabian gulf: New species specific lower temperature limits. Coral Reefs, 9: 231-237.

Crosby, M.P. and E.S. Reese, 1996. A Manual for Monitoring Coral Reefs With Indicator Species: Butterfly fishes as Indicators of Change on Indo Pacific Reefs. Office of Ocean and Coastal Resource Management, National Oceanic and Atmospheric Administration, Silver Spring, MD., pp: 45.

Dufrene, M. and P. Legendre, 1997. Species assemblages and indicator species: The need for a flexible asymmetrical approach. Ecol. Monographs, 67: 345-366.

Fadlallah, Y.H., K.W. Allen and R.A. Estudillo, 1995. Mortality of shallow reef corals in the Western Arabian Gulf following aerial exposure in winter. Coral Reefs, 14: 99-107.

Hodgson, G., M. Lena and S. Craig, 2004. Reef Check Instruction Manual: A Guide to Reef Check Coral Reef Monitoring. 1st Edn., Reef Check Institute of the Environment, University of California, Los Angeles, USA., ISBN: 0-9723051-1-4.

Kent, M. and P. Coker, 1992. Vegetation Description and Analysis. A Practical Approaches. Belhaven Press, London.

Kinsey, D.W., 1988. Coral reef system responses to some natural and anthropogenic stresses. Galaxea, 7: 113-128.

Linton, D.M. and G.F. Warner, 2003. Biological indicators in the Caribbean coastal zone and their role in integrated coastal management. Ocean Coastal Manage., 46: 261-276.

McClanahan, T.R. and S.H. Shafir, 1990. Causes and consequences of sea urchin abundance and diversity in Kenyan coral reef lagoons. Oecologia, 83: 362-370.

McClanahan, T.R., 1995. Fish predators and scavengers of the sea urchin Echinometra mathaei in Kenyan coral-reef marine parks. Environ. Biol. Fishes., 43: 187-195.

McClanahan, T.R., 1998. Predation and the distribution and abundance of tropical sea urchin populations. J. Exp. Marine Biol. Ecol., 221: 231-255.

McClanahan, T.R., 1999. Predation and the control of sea urchins and fleshy algae in the patch reefs of Glovers Reef, Belize. Ecosystems, 2: 511-523.

Palmer, M.W., 2004. Ordination methods-An overview. http://ordination.okstate.edu/overview.htm.

Pauly, D. and T.E. Chua, 1988. The overfishing of marine resources: Socioeconomic background in Southeast Asia. Ambio, 17: 200-206.

Pilcher, N.J., S. Wilson, S.H. Alhazeem and M.R. Shokri, 2000. Status of Coral Reefs in the Arabian/Persian Gulf and Arabian Sea region (Middle East). In: Status of Coral Reefs of the World: 2000, Wilkinson, C. (Ed.). Australian Institute of Marine Science: Townsville, Australia, ISBN: 0-642-32209-0, pp: 55-64.

Reese, E.S., 1981. Predation on corals by fishes of the family Chaetodontidae: Implications for conservation and management of coral reef ecosystems. Bull. Mar. Sci., 31: 594-604.

Riegl, B., 1999. Corals in a non-reef setting in the Southern Arabian Gulf (Dubai, UAE): Fauna and community structure in response to recurring mass mortality. Coral Reefs, 18: 63-73.

Shokri, M.R., S.M.R. Fatemi and M.P. Crosby, 2005. The status of butterfly fishes (Chaetodontidae) in the Northern Persian Gulf, I.R. Iran. Aquat. Conserv. Mar. Freshwater Ecosyst., 15: 91-99.

Wilkinson, C., 2000. The 1997-98 Mass Coral Bleaching and Mortality Event: 2 Years on. In: Status of Coral Reefs of the World: 2000, Wilkinson, C. (Ed.). Australian Institute of Marine Science: Townsville, Australia, ISBN: 0-642-32209-0, pp: 21-34.