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Impacts of Trawling on Distribution and Diversity of Gastropods in the Persian Gulf: the Bahrakan Fishing Area

Shirmohammadi, Mehrnaz[1*]; Doustshenas, Babak[1]; Dehghan Mediseh, Simin[2]; Savari, Ahmad[1]; Sakhaei, Nasrin[1]

1- Dept. of Marine Biology, Faculty of Marine Science and Oceanography, Khorramshahr Marine Science and Technology University, Khorramshahr, Iran
2- South Aquaculture Research Center, Ahwaz, Ahwaz, Iran

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Abstract

This study was undertaken to survey impacts of bottom trawling on distribution and diversity of gastropods of the Bahrakan Fishing Area (BFA), of the northwestern coasts of the Persian Gulf. Gastropod samples were collected from depths of 6m and 10m at 18 randomly selected stations in three occasions, right before the opening of shrimp trawling season and two weeks and 3 months after the fishing season ended. Majority of sediments displayed silt-clay texture. Abundance, diversity, richness and evenness indices of gastropods decreased but conversely, Simpson dominant index increased in all post–season samplings compared to pre-season samplings in both depths ($P<0.05$). Biomass of gastropods declined after trawling and no recovery occurred after three months. However, the abundance of smaller gastropods increased after trawling. In both depths, *Acteocina involuta* was found abundantly in two weeks after trawling. Impacts of trawling were higher in shallow areas (6m depth) than that in the deeper areas (10m depth).

Keywords: *Gastropoda, Diversity, Bottom trawl, Bahrakan, Persian Gulf*

1. Introduction

Impacts of fishing gears on the marine environment have been a matter of great concern to the sustainable management of oceanic resources (Smith et al., 2000). Despite these concerns, the intensity and extent of bottom trawling have continued to increase throughout the world, particularly over the last few decades (Hannah et al., 2010). Bottom trawl nets have been considered as one of gears that cause the most serious disturbances on benthic communities (Kaiser, 2003). Some studies have showed that areas affected by bottom trawling favor certain predator species by exposition or damage to buried animals. These injured or dead animals, not caught by trawling, might be turned into an important food resource for scavenger species (Drabsch et al., 2001; Simpson and Watling, 2006). According to Engel and Kvitek (1998), intense trawling significantly reduced the heterogeneity of bottom habitats. Thus, the possibilities of adaptative success of organisms are reduced, therefore increasing the potential environmental biodiversity. Trawling is believed to

* *E-mail: shirmohammadim@yahoo.com*

affect stock abundances directly by removing or killing individuals and indirectly by affecting structures and organisms that serve as habitat and food for demersal fish species (Kumar and Deepthi, 2006). Trawling intensity depended on size and weight of trawl, rapidity trawling, type of seabed, power of water flow and tide and natural confusion in the zone (Dellapenna et al., 2006). A number of studies have investigated the impacts of trawling on the marine ecosystem (Hall, 1999; Collie et al., 2000; Duplisea et al., 2001; Queiros et al., 2006; Hannah et al., 2010). The macrobenthos are exposed to anthropogenic disturbances as well as natural changes in their habitats which cause them to react in different ways. Therefore, macrobenthos have an important role in bioassessment (Mooraki et al., 2009). Previous studies suggested that gastropods assemblages were good indicators of impacts trawling, because of their sensitivity to habitat alterations (Morton, 1996) also, gastropods recorded as most groups of macrofauna in Bahrekan area (Shokat et al., 2010).

The Bahrakan is one of the most important sites for fishing activities (ROPME, 2004). The area is suitable habitats for many fish species because it has a high capacity of biota potential. Many studies have focused on benthic community responses to environmental stresses in the northwestern Persian Gulf and Bahrakan Fishing Area (BFA). (Nabavi, 1992; Dehghan, 2007; Havizavi, 2009; Roozbahani et al., 2010; Shokat et al., 2010) but, periodic reports reflecting impacts of trawling on the benthic communities is lacking. This study was undertaken to survey impacts of bottom trawling on distribution and diversity of gastropods of the BFA.

2. Materials and Methods

Impacts of bottom trawling were investigated at 18 stations, nine in each of 6m and 10m depths, in the northwestern Persian Gulf inshore waters (Figure 1), along the coast of Bahrakan (49° 43' – 49° 46' E, 30° 03' - 30° 06' N). Trawling started in late July and lasted until late August (30 days). Samplings were carried out in three occasions, pre-season, right before the start of the trawling season (15 May) and post-season, two weeks (5 September) and 3 months (14 November) after the end of the trawling season in 2010. Triplicate samples were collected by Van Veen grab (0.025 m^2) for studying the macrobenthos of each station. Samples of macrofauna were sieved through 0.5 mm mesh size sieve; Animals were preserved in 4 % formalin solution (Joice et al., 2006) and were transferred into Rose Bengal solution (1g/l) for identification. In addition, biomass was obtained using ash-free dry weight method. Evaluation of length of specimen was done by the micrometer optic method (Eleftheriou and McIntyre, 2005).

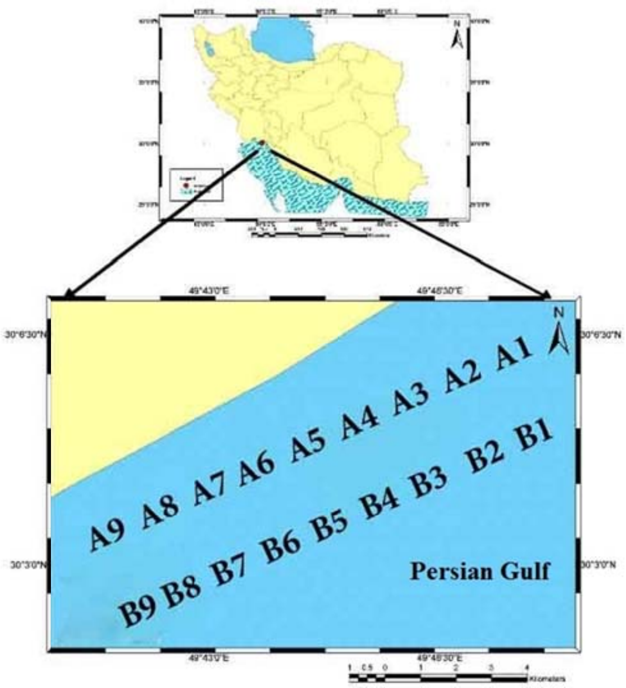

Fig. 1: Map of the study area and approximate location of the sampling stations in coasts of the Bahrakan, 6m depth (A1 to A9) and 10m depth (B1 to B9)

Total organic matter (TOM) of sediment was determined using the ignition method (Buchanan, 1984). Sediment grain size was determined using the wet sieve method (Buchanan, 1984). Furthermore, Shannon diversity, Margalef species richness, Simpson dominant and Pielou evenness indices were calculated for different periods of sampling (Ludwig and Reynolds, 1988). Normality data were examined with Shapiro-Wilk test. Differences in parameter of sediments between different times of sampling were investigated by one-way analyses of variance (ANOVA). Slight differences were determined using Tukey test, at 95% confidence limits. Differences in density, mean abundance species and indices between different times of sampling were examined using nonparametric test of Kruskal-Wallis and slight differences with Mann-Whitney test. Correlation between organic matters, density and indices were performed using Spearman correlation test. A cluster analysis, using the Bray-Curtis similarity index was performed on fourth root. All tests were done by SPSS11.5 software. Counting biology indices and cluster analysis were made using PRIMER 5.0 software.

3. Results

Results of the total organic matter and sediment analysis of BFA are shown in Table 1. More than 93% of the grain size of the sediments in all samplings were <0.063 mm, thus listed as silt-clay. There were significant differences between sediment composition of pre- and post- season samples ($P < 0.05$), but not between samples of 2 weeks and 3 months after trawling ($P>0.05$) (Table. 1). Also, there were significant differences between TOM percentage in different times of sampling ($P<0.05$).

Dissimilar words within each column are significantly different ($P<0.05$) (Mean ± Standard error).

In total, 62 specimens of gastropods were identified. The temporal change in average number of dominant species for each depth is shown in Table 2. Results showed that, *Acteocina involuta* (family Cylichnidae) displayed a higher abundance than other species in both depths at two weeks after trawling (Table. 2).

Table 1: Mean of sediments parameters in the Bahrakan zone at different times of sampling, (2010)

Time sampling	Depth(m)	Organic matter (%)	Silt-Clay (%)
Before trawling	6	21.28 ± 0.34a	95.50 ± 0.34b
	10	21.10 ± 0.36a	93.49 ± 0.55a
Two weeks after trawling	6	26.33 ± 0.20c	98.21 ± 0.03cd
	10	26.30 ± 0.19c	98.30 ± 0.08cd
3 months after trawling	6	23.82 ± 0.54b	99.08 ± 0.06d
	10	23.36 ± 0.46b	97.55 ± 0.28c

Table 2: Average abundance (No/m2) of dominant species in BFA during study period (2010)

	Before trawling	Two weeks after trawling	3 months after trawling
6m depth			
Acteocina involuta	1.48 ±0.18a	78.54±4.15b	109.62±14.72b
Scaliola arenosa	88.89±9.20b	0	2.96±0.55a
Truncatella sp.3	271.11±20.47b	0	25.18±1.81a
10m depth			
Acteocina involuta	0	80±3.53b	4.91±0.28a
Gibberula bensoni	19.25±2.03	0	19.25±2.70
Nassarius ephamillus	17.77±1.10b	2.05±0.45a	17.77±1.68b
Scaliola arenosa	66.66±10.27b	0	1.48±0.15a
Zafra comistea	17.77±1.98b	1.48±0.40a	14.81±1.55b

Dissimilar words within each row are significantly different (P<0.05) (Mean ± Standard error).

The highest mean abundance was obtained before trawling and the lowest was in two weeks after trawling (Figure. 2). Mean abundances of gastropods were 273.29/m^2 and 154.37/m^2 in 6m and 10m depths, respectively. There were significant differences between mean abundances in pre- season and post-season (P < 0.05), but not within the post-season samplings (P > 0.05).

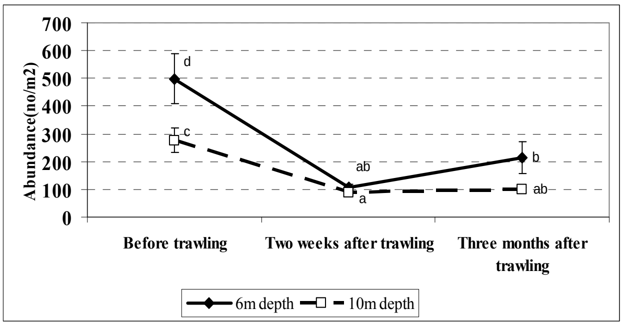

Fig. 2: Variations of mean abundance of gastropods in the Bahrakan zone at different times of sampling (2010), dissimilar words are significantly different (P<0.05)

Mean biomass were 0.16 g/m^2 and 0.13 g/m^2 in 6m and 10m depths, respectively. In both depths, the highest and the lowest biomasses of gastropods were recorded before trawling and two weeks after trawling, respectively (Figure 3).

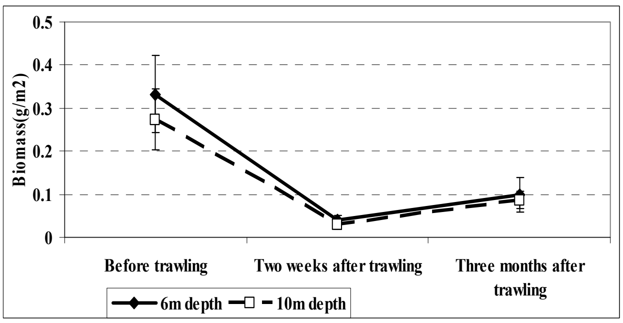

Fig. 3: Mean biomass of gastropods in the Bahrakan zone at different times of sampling (2010)

Results showed that, the highest abundance percentage obtained in size classes of 2 to 4 mm and 0 to 2 mm, before trawling and after trawling, respectively while, size class of >4mm wasn't observed in after trawling (Figures. 4 and 5).

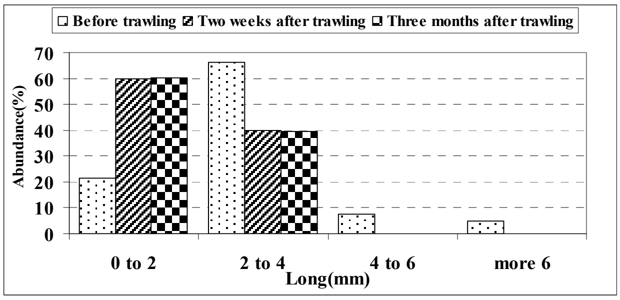

Fig. 4: Percent abundance with different size classes (mm) in 6m depth in the Bahrakan zone (2010)

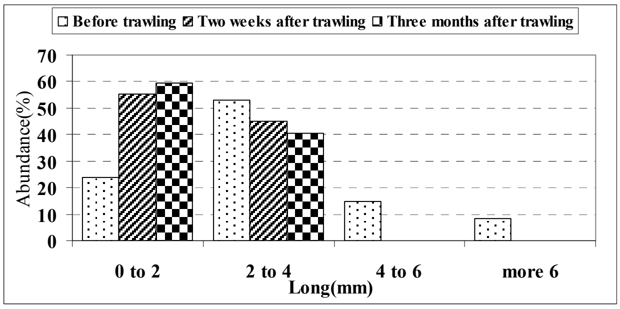

Fig. 5: Percent abundance with different size classes (mm) in 10m depth in the Bahrakan zone (2010)

The averages of ecological indices obtained in different times of sampling are shown in Table 3. According to the statistical analysis (Table. 3), there were significant differences between mean of ecological indices in all times of sampling (P < 0.05). Results showed that the highest and the lowest ecological indices were that of pre-season and two weeks after trawling while conversely, Simpson dominant index increased in post-season (two weeks and three months) after trawling.

In both depths, Shannon diversity, Margalef species richness, Pielou evenness indices and density showed significant negative correlation and Simpson dominant index showed significant positive correlation with organic matter content of sediments (P<0.05) (Table. 4).

Results of clustering based on Bray-Curtis similarities on abundance of gastropods in different times of sampling are shown in Figures 6 and 7. In both depths, three clusters based on times of sampling were determined using cluster analysis. The highest similarity were observed between stations 2, 3, 5 (100%) and 4, 8 (100%) in 6m and 10m depths in two weeks after trawling, respectively (Figures 6 and 7).

Table 3: Mean ecological indices in the Bahrakan zone in different times of sampling (2010)

Time sampling	Depth(m)	Margalef	Pielou	Shannon	Simpson
Before trawling	6	0.48 ± 0.05c	0.69± 0.09d	0.91± 0.09c	0.52 ± 0.04a
	10	0.72 ± 0.07d	0.92 ± 0.04e	1.40 ± 0.1d	0.30 ± 0.03a
Two weeks after trawling	6	0.09 ± 0.02a	0.33 ± 0.08a	0.26 ± 0.06a	0.79 ± 0.04c
	10	0.05 ± 0.01a	0.21 ± 0.07a	0.14± 0.05a	0.90 ± 0.03d
3 months after trawling	6	0.22 ± 0.04b	0.51 ± 0.09c	0.54 ± 0.1b	0.68 ± 0.05b
	10	0.17 ± 0.04b	0.47 ± 0.09b	0.46 ± 0.1b	0.71± 0.06cb

Dissimilar words within each column are significantly different (P<0.05).

Table 4: Spearman's correlation coefficient between organic matter with density and Indices

	Depth(m)	Density	Margalef	Pielou	Shannon	Simpson
	6	r = - 0.431 *	r = - 0.527 *	r = - 0.299 *	r = - 0.501 *	r = 0.434 *
Organic matter		p = 0.00	p = 0.00	p = 0.007	p = 0.00	p = 0.00
		r = - 0.382 *	r = - 0.560 *	r = - 0.438 *	r = - 0.559 *	r = 0.535 *
	10	p = 0.00	p = 0.00	p = 0.00	p = 0.00	p = 0.00

* <0.01

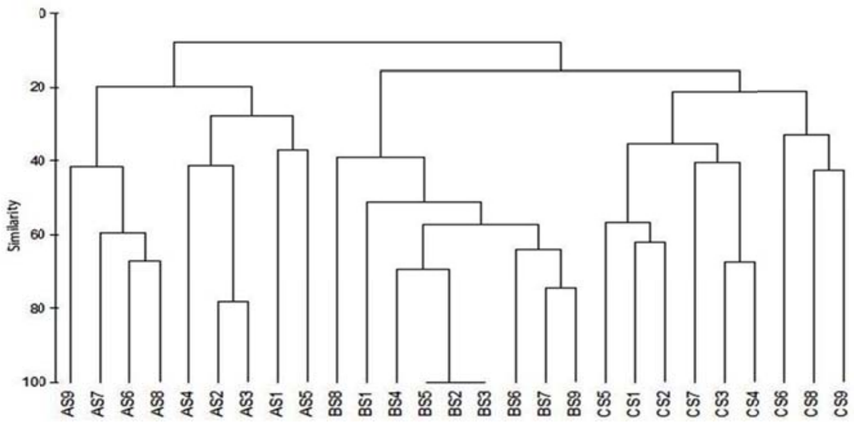

Fig. 6: Similarity of stations in 6m depth in different times of sampling, (A: Before trawling, B: Two weeks after trawling, C: 3 months after trawling, S: Station)

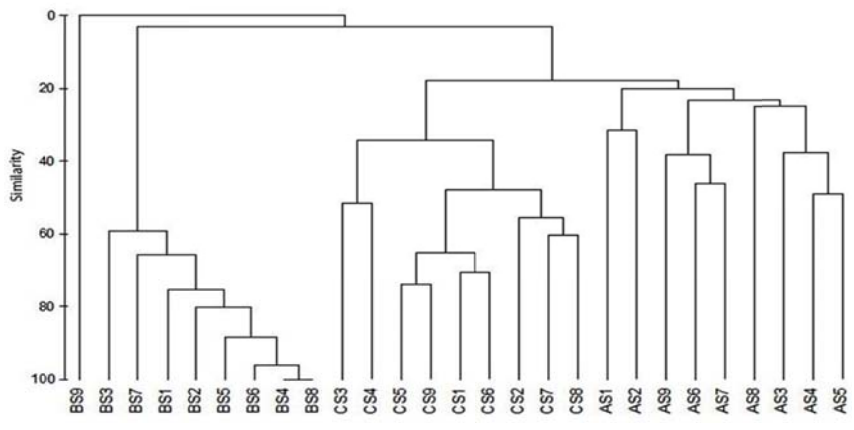

Fig. 7: Similarity of stations in 10m depth in different times of sampling, (A: Before trawling, B: Two weeks after trawling, C: 3 months after trawling, S: Station)

4. Discussion

Results of the study showed that gastropod populations were removed or damaged by passing of trawl. This finding was similar to the results reported by Morton (1996). In the present study, the abundance and biomass of gastropods decreased in the samples collected after trawling in both depths; This might be attributed to contact with the gears and exposure of animals to invertebrate and fish predators due to the removal of top sediment layer by gears (Kaiser and Spencer, 1996; Morton, 1996; Engel and Kvitek, 1998; Jenning et al., 2001; Tanner, 2003; Kumar and Deepthi, 2006).

Effects of sediment parameters, such as grain size and TOM on abundance are important and have been reported in many similar studies in the past (Pearson and Rosenberg, 1978; Joydas and Damodaran, 2009). In addition, as reported by Roozbahani et al (2010), based on the results of present study, it is concluded that TOM affected abundance of gastropods as negative correlation existed between TOM with abundance.

Results showed that recovery did not occur in three months after the trawling on organisms of soft bottom in both depths. This could be associated with high levels of turbidity and sedimentation in the area because bottom trawling caused the scraping and burrowing of the seabed and resuspension of sediments, preventing settling of veliger larvae. Therefore, trawling on muddy sediment could exert long-term effects on organisms (Engel and Kvitek, 1998; Tuck et al., 1998; Ball et al., 2000; Smith et al., 2000; Rumohr and Kujawski, 2000; Dellapeana et al., 2006).

In both depths, abundance of *A. involuta* strongly increased in two weeks after trawling. This might have been due to more resilient characteristics, such as deeper burrowing and scavenging behavior (Lokkeborg, 2005; Faucci et al., 2007). In agreement with the conclusions by Rumohr and Kujawski (2000) that trawling could create a significant food resource of moribund benthos for scavenger species. Some biological characteristics like, longevity, reproduction strategy and also trawlers activity in prohibition season influenced variation of frequency, succession and diversity of macrobenthos during study (Little, 2000). Before trawling, higher diversity, richness and evenness indices and lowest dominant index were observed than other times of sampling in both depths and this might have attributed to reducing abundance and appearance of dominant species, such as scavenger gastropods due to trawlers activity, a finding similar to other studies (Tuck et al., 1998; Thrush et al., 2001; Sparks-McConkey and Watling, 2001). Based on results, the TOM can be considered as a principal limiting factor, because of negative correlations between TOM with diversity, richness and evenness indices and positive correlations between TOM with dominant species.

Fishing activities lead to increase in the abundance of a few dominant species while, reducing diversity, richness and evenness in fishing areas (Prena et al., 1999). Results of cluster analysis showed the highest similarity of stations occurred in two weeks after trawling in both depths. It is probably due to decreasing abundance in total stations, which contributed to highest similarity between stations in two weeks after trawling (Simpson and Watling, 2006). The gastropods observed throughout the study period were smaller in size and this is a clear indication of extreme disturbance in sediment. These organisms do not get an opportunity to grow into larger size due to continuous disturbance in the sea bottom as a result of fishing activity.

It could be stated that trawling disturbance led to reductions in abundance of larger gastropods in both depths while, abundance of smaller gastropods increased after trawling because of fish predators tend to feed on larger organisms (Engel and Kvitek, 1998; Jennings et al., 2001; Lokkeborg, 2005; Kumar and Deepthi, 2006). Abundance and biomass of the gastropods in the stations located on shallow waters (6m depth) were lower than the abundance and biomass in the stations located on deeper waters

(10m depth). Also, the diversity of gastropods was the highest in shallower waters as a result of considerable fishing activities (Engel and Kvitek, 1998; Drabsch et al., 2001). Consistent with this finding, Hannah et al (2010) found that commercial trawling is considered one of the largest anthropogenic impacts on shallow waters and recorded high diversity and low abundance organism in areas with high fishing activities. Settlement of larva occurs in shallow waters and high fishing activities could prevent settling of larva (Jones, 1992). So, fisheries managers must consider the protection of ecosystems and include within its objectives the reduction of the negative consequences of trawling on organisms in shallow areas.

Reference

Ball, B.J., Fox, G. and Munday, B.W., 2000. Long- and short-term consequences of a Nephrops trawl fishery on the benthos and environment of the Irish Sea. ICES Journal of Marine Science. 57: 1315–1320.

Buchanan, J.B., 1984. Sediment analysis. In. Holme, A. and McIntyre, A.D. (Eds), Methods for the Study of Marine Benthose. NBlackwell, Oxford. 41–64 pp.

Collie, J.S., Hall, S.J., Kaiser, M.J. and Poiner, I.R., 2000. A quantitative analysis of fishing impacts on shelf-sea benthos. Journal of Animal Ecology. 69: 785–798.

Dehghan, M.S., 2007. Identification of Sensitive Regions in the Mahshahr Creeks using Ecologic and Biologic Indices. Ph.D. Thesis, Khorramshahr University of Marine Science and Technology. 144 P. (in Persian)

Dellapenna, T. M., Allison, M. A., Gill, G. A., Lehman, R. D. and Warnken, K. W., 2006. The impact of shrimp trawling and associated sediment resuspension in mud dominated, shallow estuaries. Estuarine, Coastal and Shelf Science. 69: 519–530.

Drabsch, S. L., Tanner, J. E., and Connell, S. D., 2001. Limited infaunal response to experimental rawling in previously untrawled areas. Journal of Marine Science. 58: 1261–1271.

Duplisea, D. E., Jennings, S., Malcolm, S. J., Parker, R. and Sivyer, D. B., 2001. Modelling potential impacts of bottom trawl fisheries on soft sediment biogeochemistry in the North Sea. Geochemical Transactions. 2(1): 112–117.

Eleftheriou, A. and McIntyre A., 2005. Methods for the Study of Marine Benthos. Third Edition. Blackwell Science Ltd a Blackwell. 418P.

Engel, J. and Kvitek, R., 1998. Effects of otter trawling on a benthic community in Monterey Bay National Marine Sanctuary. Conservation Biology. 12: 1204–1214.

Faucci, A., Toonen, R.J. and Hadfield, M.G., 2007. Host shift and speciation in a coral-feeding nudibranch. Proceedings of the Royal Society. 274: 111–119.

Hall, S. J., 1999. The Effects of Fishing on Marine Ecosystems and Communities. Oxford: Blackwell. 274P.

Hannah, R. W., Jones, S. A., Miller, W. and Knight, J. S., 2010. Effects of trawling for ocean shrimp (*Pandalus jordani*) on macroinvertebrate abundance and diversity at four sites near Nehalem Bank. Oregon. Fishery Bulletin. 108: 30–38.

Havizavi, S.H., 2009. Identification of Macrobenthose Secondary Production in the Regions with High Potential to Artificial Structures in Khoozestan Bay. M.Sc. Thesis, Khorramshahr University of Marine Science and Technology.78P. (in Persian)

Jenning, S., Dinmore, T. A., Duplisea, D. E., Warr, K. J. and Lancaster, J. E., 2001. Trawling disturbance can modify benthic production processes. Journal of Animal Ecology. 70: 459–475.

Joydas, T.V. and Damodaran, R., 2009. Infaunal macrobenthose along the shelf waters of the west of India. Indian Journal of Marine Sciences. 38(2): 191-204.

Joice, V. T., Sreedevi, C. and Madhusoodana Kurup, B., 2006. Variations on the infaunal polychaetes due to bottom trawling along the inshore waters of Kerala (south-west coast of India). Indian Journal of Marine Sciences. 35(3): 249–256.

Jones, J. B., 1992. Environmental impact of trawling on the seabed: a review. New Zealand Journal of Marine and Freshwater Research. 26: 59–67.

Kaiser, M. J., 2003. Detecting the effects of fishing on seabed community diversity: importance of scale and sample size. Conservation Biology. 512–520.

Kaiser, M.J. and Spencer, B., 1996. The effects of beam trawl-disturbance on infaunal communities in different habitats. Journal of Animal Ecology. 65: 348–358.

Kumar, A. B. and Deepthi, G. R., 2006. Trawling and by-catch: Implications on marine ecosystem: Review. Current Science. 90: 922–931.

Little, C., 2000. The Biology of Soft Shores and Estuaries. Oxford University Press, New York. 252P.

Lokkeborg, S., 2005. Impacts of trawling and scallop dredging on benthic habitats and communities. FAO Fisheries Technical.1–58.

Ludwig, J. A. and Reynolds, J. F., 1988. Statistical Ecology: A Primer on Methods and Computing. John Wiley and Sons, New York. 337P.

Mooraki, N., Esmaeli Sari, A., Soltani, M. and Valinassab, T., 2009. Spatial distribution and assemblage structure of macrobenthos in a tidal creek in relation to industrial activities. Environment Science Technical. 6: 651-662.

Morton, B., 1996. The subsidiary impacts of dredging (and trawling) on a subtidal benthic molluscan community in the southern. Marine Pollution Bulletin. 32(10): 701–710.

Nabavi, S.B., 1992. Identification of Macrobenthose Assemblages in Mahshahr Creeks and Their Trophic Roles in the Aquatic System. Ph.D. Thesis, Islamic Azad University, Science and Research Branch-Tehran, 130P.

Pearson, T.H. and Rosenberg, J., 1978. Macrobenthic succession in relation to organic enrichment and pollution of the marine environment. Oceanography and Marine Biology Annual Review. 16: 229-311.

Prena, J., Schwinghamer, P., Rowell, T.W., Gordon Jr., D.C., Gilkinson, K.D., Vass, W.P. and McKeown, D.L., 1999. Experimental otter trawling on a sandy bottom ecosystem of the Grand Banks of Newfoundland: analysis of trawl bycatch and effects on epifauna. Marine Ecology Progress Series. 181:107–124.

Queiros, A.M., Hiddink, J.G., Kaiser, M.J. and Hinz, H., 2006. Effects of chronic bottom trawling disturbance on benthic biomass, production and size spectra in different habitats. Experimental Marine Biology and Ecology. 335: 91–103.

Roozbahani, M.M., Nabavi, S.M., Farshchi, P. and Rasekh, A., 2010. Studies on the benthic macroinvertebrates diversity species as bio-indicators of environmental health in Bahrekan Bay (Northwest of Persian Gulf). African Journal of Biotechnology.Vol. 9(39)

ROPME, 2004. State of the Marine Environment 2003. Regional Organization for the Protection of the Marine Environment (ROPME), Kuwait. 253P.

Rumohr, H. and Kujawski, T., 2000. The impact of trawl fishery on the epifauna of the southern North Sea. ICES Journal of Marine Science. 57: 1389–1394.

Shokat, P., Nabavi, S.M.B., Savari, A. and Kochanian, P., 2010. Application of Biotic Indices in Assessing the Ecological Quality Status of Bahrekan Estuary. Pakistan Journal of Biological Sciences. 13(22): 1085–1091.

Simpson, A. W. and Watling, L., 2006. An investigation of the cumulative impacts of shrimp trawling on mud-bottom fishing grounds in the Gulf of Maine: effects on habitat and macrofaunal community structure. ICES Journal of Marine Science. 63: 1616-1630.

Smith, C. J., Papadopoulou, K. N. and Diliberto, S., 2000. Impact of otter trawling on an eastern Mediterranean commercial trawl fishing ground.

ICES Journal of Marine Science. 57: 1340– 1351.

Sparks-McConkey, P. J. and Watling, L., 2001. Effects on the ecological integrity of a soft-bottom habitat from a trawling disturbance. Hydrobiologia. 456: 73–85.

Tanner. J.E., 2003. The influence of prawn trawling on sessile benthic assemblages in Gulf St. Vincent South Australia. Canadian Journal of Fisheries and Aquatic Sciences. 60: 517–526.

Thrush, S. F., Hewitt, J. E., Funnell, G. A., Cummings, V. J., Ellis, J., Schultz, D., Talley, D. and Norkko, A., 2001. Fishing disturbance and marine biodiversity: role of habitat structure in simple soft-sediment systems. Marine Ecology Progress Series. 221: 255–264.

Tuck, I. D., Hall, S. J., Robertson, M. R., Armstrong, E. and Basford, D. J., 1998. Effects of physical trawling disturbance in a previously unfished sheltered Scottish Sea Loch. Marine Ecology Progress Series. 162: 227–242.