Journal of Agricultural Technology 2015 Vol. 11(8): 1767-1780
Available online http://www.ijat-aatsea.com
ISSN 1686-9141

Species diversity of benthic macrofauna on the intertidal zone of seacoasts in Krabi, Trang and Satun Provinces, Thailand

Suwit Jitpukdee[1*], Khwanta Tantikamton [2], Nathawut Thanee [2], and Watcharaporn Tantipanatip [3]

[1] Faculty of Science and Fisheries Technology, Rajamangala University of Technology, Trang, 92150, Thailand
[2] School of Biology, Institute of Science, Suranaree University of Technology, Nakhon Ratchasima, 30000, Thailand
[3] Faculty of Science and Technology, Phranakhon Si Ayutthaya Rajabhat University, Phranakhon Si Ayutthaya, 13000, Thailand

Jitpukdee S., Tantikamton K., Thanee N., and Tantipanatip W. (2015). Species diversity of benthic macrofauna in the intertidal zone of Krabi, Trang and Satun Coasts, Thailand. Journal of Agricultural Technology 11(8):1767-1780.

The objectives of this study were to assess species diversity of benthic macrofauna on the intertidal zone of seacoasts in Krabi, Trang and Satun provinces, Thailand. The survey included 30 sampling stations of 8 beaches. It was carried out in Nopparatthara, Ao-nang and Nam Mao beaches along Krabi coast, Pak Meng, Chao Mai and Yong Ling beaches in Trang coast and Pak Bara and Pak Bang beaches in Satun coast. Benthic macrofauna were collected by quadrate sampling technique at the intertidal zones. The results showed that, overall, 116 species were accounted belonging to 51 families, 20 orders, 5 classes of 4 phyla. The phyla were Polychaeta, Mollusca, Arthropoda and Brachiopoda in order of species number. Of these, the numbers of benthic macrofauna species found in Krabi, Trang and Satun provinces were 65, 72 and 64 species, respectively. Cluster analysis and multidimensional scaling (MDS) were used to compare similarity of all sampling stations based on benthic macrofauna species. The results exhibited moderate similarity at 21% and the sampling stations were separated into 3 groups at 35% similarity. The benthic macrofauna communities of sampling stations in Satun province were homogeneity whereas in Krabi and Trang provinces were clustered into the same group. All sampled stations from Yong Ling beach and a station from Pak Meng beach were separated from those 2 groups. Sampling stations in Satun province had different types of species to Krabi and Trang sampling stations. Satun province had 41 benthic macrofauna species that also found in Krabi or Trang provinces whereas the species found in both Krabi and Trang provinces were 58 species. The 26 species of benthic macrofauna were found in all three provinces including 11 species of polychaetes, 9 species of mollusks and 6 species of crustaceans.

Keywords: Benthic macrofauna, species diversity, intertidal zone

[*]**Coressponding** Author: Suwit Jitpukdee**; E-mail :** suwitjit@hotmail.com

Introduction

The southern Andaman Sea coast of Thailand has particular oceanographic characteristics. The coastal is characterized by geologic nature of landforms. Krabi, Trang and Satun provinces are sandy to sandy/muddy beaches and dunes. Rocky coast, cliff coast and islands occurred in Trang and Krabi provinces, whereas Satun province has a long sandy/muddy intertidal flat but on the landward side is sandy. The coastline length of each province is 160 km in Krabi, 119 km in Trang and 144.8 km in Satun (Office of the Strategy Management of Andaman, 2011). The sea of Krabi, Trang and Satun provinces is influenced by semi-diurnal tides of approximately 3 m in spring and 1 m in neap tide (Pornpinatepong, 2005). Beaches in provide habitats and support a great variety of living organisms. They are key ecosystems of beaches which are important nursery and recruitment areas for fish that rely on the smaller invertebrates as a supply of food. For example, prey organisms (e.g. invertebrates) that live in the intertidal zone support fish populations. These areas are considerable biological diversity which plays a major role in the life cycles of economic important species. However, during recent decades, these habitats in the Andaman Sea present in a critical state (Janekarn and Chullasorn, 1997). Although benthic macrofauna are important to the coasts, a few studies on benthic macrofauna in the intertidal zone of the 8 beaches had never been reported.This knowledge will provide preliminary data regarding benthic macrofana assemblages of the areas.

Materials and methods

Sampling areas

Krabi, Trang and Satun provinces were selected which have tourism areas and provide many attractive beaches where there are increasing population and coastal development. The selected provinces are shown in Fig. 1. Selected beaches and length of each beach (in parenthesis) were as follows:

1) Krabi province: Nopparatthara beach (1.6 km), Ao-nang beach (1.3 km), and Nam Mao beach (2.7 km)

2) Trang province: Pak Meng beach (6.0 km), Chao Mai beach (3.6 km), and Yong Ling beach (2.7 km)

3) Satun province: Pak Bara beach (3.2 km), and Pak Bang beach (6.1 km)

Benthic macrofauna were collected from 30 stations of the 3 provinces that were 3 stations from Nopparatthara beach (KB-NT st1, KB-NT st2 and

KB-NT st3) , 3 stations from Ao-nang beach (KB-AN st1, KB-AN st2 and KB-AN st3), 3 stations from Nam Mao beach (KB-NM st1, KB-NM st2 and KB-NM st3) , 6 stations from Pak Meng beach (TR-PM st1, TR-PM st2, TR-PM st3, TR-PM st4, TR-PM st5 and TR-PM st6), 3 stations from Chao Mai beach (TR-CM st1, TR-CM st2 and TR-CM st3), 3 stations from Yong Ling beach (TR-YL st1, TR-YL st2 and TR-YL st3), 3 stations from Pak Bara beach (ST-PR st1, ST-PR st2 and ST-PR st3) and 6 stations from Pak Bang beach (ST-BB st1, ST-BB st2, ST-BB st3, ST-BB st4, ST-BB st5 and ST-BB st6).

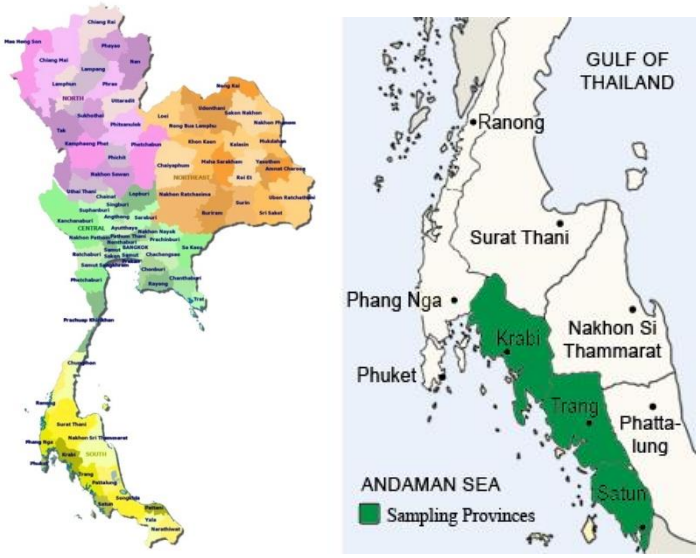

Fig. 1 The study sites (modified from Map of Thailand, 2010)

Sampling methods

Benthic macrofauna samples were collected once every season during the Northeast monsoon (mid October to mid February), in the dry season (mid February to mid May) and during the Southwest monsoon (mid May to mid October). Quadrate sampling (Rodil and Lastra, 2004) was used during low tide range at the intertidal zone. The quadrate sampling area in each station accounted 2.25 m^2. The area of quadrat sampling is necessary to obtain >95% of macrofauna species living on the beaches (Jaramillo, McLanchlan, and Dugan, 1995). At each sampling point, a 0.5x0.5 m^2 quadrate was used. Sampling positions were estimated by global positioning system (GPS). Each sample was sieved in the field using a 1000 μm mesh. The materials retained on the sieve were fixed in 4% buffer formalin according to Worsfold and Hall

(2010) method and the samples were brought back to a laboratory for sorting and taxonomic identification.

The benthic macrofauna samples were studied under a stereo microscope (Olympus SZX7) and a compound microscope (Olympus BX50) with the DP27 camera and the Cellsens Dimension program to magnify the details of the specimens based on the keys to marine invertebrates and previous identification reports (Environmental Monitoring and Support Laboratory Office of Research and Development, 1986; Fauchald, 1977; Poutiers, 1998; Swennen, 2001; Allen, 2010; McLaughlin, 1998).

Data analyses

The similarity analysis between stations was explored by cluster analysis and Multi-dimensional scaling (MDS). The nearest-neighbor approach was used for hierarchical clustering, prior to MDS analysis. The Bray-Curtis dissimilarity measure was used for cluster analysis (Bray and Curtis, 1957 as cited in Somerfield, 2008). Benthic macrofauna data were root transformed prior to statistical analysis by the PRIMER 6.

Results and discussion

Taxonomic classification of benthic macrofauna

The 30 sampling stations were selected to evaluate the biodiversity of benthic macrofauna. The result found that a total of 116 species of benthic macrofauna were collected from the 30 sampling stations representing 4 phyla, 5 classes, 20 orders, and 51 families. The numbers of benthic macrofauna found in Krabi, Trang and Satun provinces were 65, 72 and 64 species, respectively. Of theses, the phylum Polychaeta had the highest number of species. They composed of 11 orders, 22 families and 65 species. Phylum Mollusca was the second highest number of species. Mollusks composed of 2 classes which were Bivalvia and Gastropoda. The class Bivalvia consisted of 3 orders, 11 families and 22 species whereas the class Gastropoda accounted for 4 orders, 9 families and 15 species. Phylum Arthopoda was found only in class Malacostraca (subphylum Crustacea). The class was found only in the order Decapoda which consisted of infraorder Anomura (hermit crabs) and infraorder Brachyura (crabs). The infraorder Anomura had 3 species belonging to the family Diogenidae and the Brachyura had 10 species of 5 families. The lowest species number was found in the phylum Brachiopoda. It was found only a single species (*Lingula* sp.) in Satun province.

Previous study on beaches and coastal areas reported that the abundance of benthic macrofauna on the coastal seabed of the Andaman Sea ranged from 200 to 1,000 individuals/m^2 (Chantananthawej and Bussarawit, 1987; Jantharakhantee and Aryuthaka, 2007). In this study, the mean densities of benthic macrofauna in the sampling stations were in the range of 23-935 individuals/2.25 m^2. The highest abundance was at KB-AN st2 during the summer (935 individuals/2.25 m^2) and the lowest abundance was at TR-YL st3 during the summer (23 individuals/2.25 m^2). The highest number of species was at TR-PM st1 which was 26 species during the Southwest monsoon whereas the lowest species number was 3 species at TR-YL st1, TR-YL st2, TR-YL st3 and ST-BB st6 in different collecting seasons. Taxonomic classification of benthic macrofauna collected from study areas are shown in Table 1.

Table 1 Taxonomic classification of benthic macrofauna found in study areas

Taxa	Family	No.	Species
Phylum Annelida			
Class Polychaeta			
Orbinida	Orbiniidae	1	*Scoloplos* (*Leodamas*) *gracilis*
		2	*Scoloplos* (*Scoloplos*) *marsupialis*
		3	*Scoloplos* (*Scoloplos*) *tumidus*
		4	*Scoloplos* (*Scoloplos*) sp. 1
		5	*Scoloplos* (*Scoloplos*) sp. 2
		6	*Scoloplos* (*Scoloplos*) sp. 3
Spionida	Spionidae	7	*Scolelepis* (*Scolelepis*) sp.
		8	*Paraprionospio* cf. *oceanensis*
		9	*Paraprionospio* sp.
		10	*Prionospio* (*Prionospio*) *steenstrupi*
		11	*Dispio latilamella*
	Magellonidae	12	*Magelona* cf. *cincta*
		13	*Magelona conversa*
		14	*Magelona sacculata*
	Cirratulidae	15	*Aphelochaeta* sp.
		16	*Timarete* sp.
		17	*Chaetozone* sp. 1
		18	*Chaetozone* sp. 2
		19	*Monticellina* sp.
Capitellida	Capitellidae	20	*Mediomastus* sp.
		21	*Heteromastus filiformis*
		22	*Heteromastus* sp. 1

Taxa	Family	No.	Species
		23	*Heteromastus* sp. 2
		24	*Heteromastus* sp. 3
		25	*Heteromastus* sp. 4
		26	*Capitellus branchiferus*
	Maldanidae	27	*Euclymene annandalei*
		28	*Axiothella obockensis*
Opheliida	Opheliidae	29	*Ophelina* sp. 1
		30	*Ophelina* sp. 2
		31	*Armandia* sp.
	Scalibregmatidae	32	*Asclerocheilus* sp.
Phyllodocida	Phyllodocidae	33	*Anaitides* sp.
		34	*Phyllodoce* sp.
		35	*Eteone* sp.
	Polynoidae	36	*Lepidonotus* sp.
	Eulepethidae	37	*Grubeulepis geayi*
	Pisionidae	38	*Pisione* sp.
	Pilargidae	39	*Sigambra pettiboneae*
	Nereididae	40	*Neanthes caudata*
		41	*Neanthes* sp.
		42	*Dendronereis arborifera*
		43	*Tylonereis heterochaeta*
	Glyceridae	44	*Glycera alba*
		45	*Glycera natalensis*
		46	*Glycera* sp.
	Goniadidae	47	*Goniadopsis incerta*
Amphinomida	Amphinomidae	48	*Linopherus canariensis*
Eunicida	Onuphidae	49	*Diopatra amboinensis*
		50	*Diopatra semperi*
		51	*Diopatra sugokai*
		52	*Diopatra* sp. 1
		53	*Diopatra* sp. 2
	Eunicidae	54	*Marphysa macintoshi*
	Lumbrineridae	55	*Lumbrineris heteropoda*
		56	*Lumbrineris* sp. 1
		57	*Lumbrineris* sp. 2
		58	*Scoletoma* sp. 1
		59	*Scoletoma* sp. 2
		60	*Scoletoma* sp. 3

Taxa	Family	No.	Species
Sternaspida	Sternaspidae	61	*Sternaspis andamanensis*
		62	*Peternaspis* sp.
Oweniida	Oweniidae	63	*Owenia fusiformis*
Terebellida	Terebellidae	64	*Lanice conchilega*
Sabellida	Sabellidae	65	*Chone* sp.
Phylum Mollusca			
Class Bivalvia			
Arcoida	Arcidae	1	*Anadora granosa*
Ostreoida	Propeamussiidae	2	*Chlamys* sp.
Veneroida	Lucinidae	3	*Pillucina* sp.
	Mactridae	4	*Mactra olorina*
		5	*Mactra cuneata*
	Pharidae	6	*Siliqua fasciata*
		7	*Siliqua radiata*
	Tellinidae	8	*Tellina* sp. 1
		9	*Tellina* sp. 2
	Donacidae	10	*Donax cuneatus*
		11	*Donax incarnatus*
		12	*Donax faba*
		13	*Donax scortum*
	Psammobiidae	14	*Gari* (*Psammotaea*) *elongata*
	Corbiculidae	15	*Meretrix* sp.
	Veneridae	16	*Pitar* sp.
		17	*Anomalocardia squamosa*
		18	*Paphia gallus*
		19	*Timoclea scabra*
		20	*Timoclea imbricata*
		21	*Circe scripta*
	Cardiidae	22	*Fragum fragum*
Class Gastropoda			
Vestigastropoda	Trochidae	23	*Umbonium vestiarium*
	Neritidae	24	*Clithon oualaniensis*
Sorbeoconcha	Cerithiidae	25	*Cerithium coralium*
	Naticidae	26	*Natica tigrina*
		27	*Natica vitellus*
		28	*Polinices mammilla*
	Nassaridae	29	*Nassarius pullus*
		30	*Nassarius livescens*

Taxa	Family	No.	Species
		31	*Nassarius jacksonianus*
		32	*Nassarius stolatus*
		33	*Nassarius globosus*
	Costellariidae	34	*Vexillum* sp.
	Turridae	35	*Turricula javana*
	Vitrinellidae	36	*Lodderia novemcarinata*
Cephalaspidae	Bullidae	37	*Atys cylindricus*
Phylum Arthropoda			
Subphylum Crustacea			
Class Malacostraca			
Order Decapoda			
Infraorder Anomura	Diogenidae	1	*Diogenes klassi*
		2	*Diogenes dubius*
		3	*Diogenes planimanus*
Infrorder Brachyura	Leucosiidae	4	*Philyra olivacea*
		5	*Philyra platycheira*
	Matutidae	6	*Matuta victor*
	Ocypodidae	7	*Dotilla intermedia*
		8	*Dotilla myctiroides*
		9	*Ocypode macrocera*
		10	*Ocypode ceratopthalma*
		11	*Scopimera proxima*
	Macrothalmidae	12	*Macrophthalmus convexus*
	Camtandriidae	13	*Camptandrium sexdentatum*
Phylum Brachiopoda			
Class Lingulata			
Order Lingulida	Lingulidae	1	*Lingula* sp.

Composition of benthic macrofauna communities

The faunal composition of the benthic samples that were analysed in the period 2012-2013 showed a poorly structured community with a relatively small number of species in some stations which were TR-YL st1, TR-YL st2 and TR-YL st3 and a moderate number of species in most stations. In addition, there was no particularly seasonal pattern in total macrofaunal abundance. For overall results, polychaetes had the highest percent abundant representation

followed by mollusks and crustaceans. Most sampling stations of Krabi, Trang and Satun provinces, polychaetes showed the highest abundance but in some stations were exceptional. The mollusks groups presented highest total abundance at 5 stations comprising KB-AN st1, ST-BB st1, ST-BB st2, ST-BB st3, ST-BB st5 and ST-BB st6. The crustaceans groups displayed highest total abundance at TR-PM st4, TR-YL st1, TR-YL st3, ST-PR st2 and ST-PR st3. In case of percent composition of number species, almost all stations manifested that the polychaetes had the highest species numbers. In exception, at KB-AN st3 and ST-PR st3 exhibited the highest species number composition of mollusks. The distribution of species by groups is shown in Fig. 2.

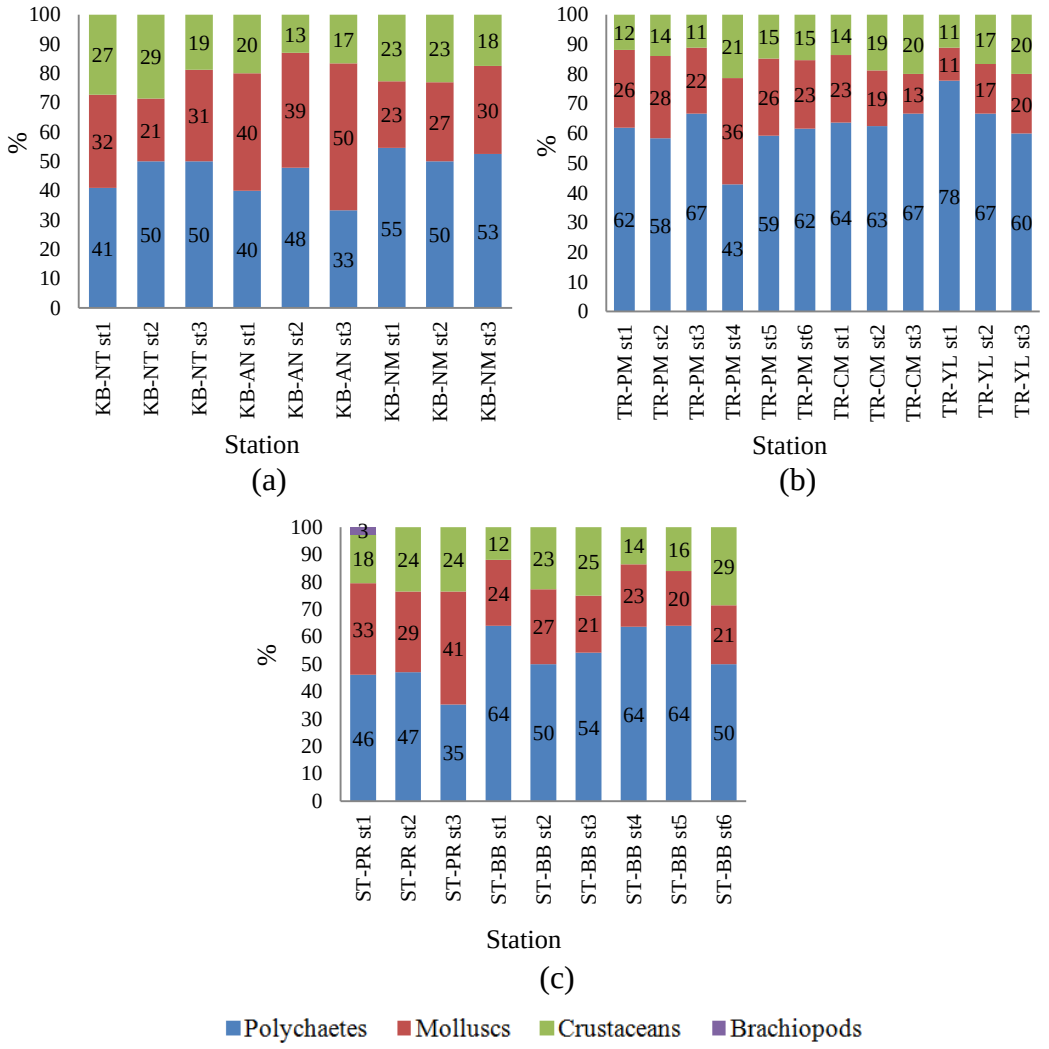

Fig. 2 Species composition of benthic macrofauna of sampling stations in (a) Krabi, (b) Trang, and (c) Satun provinces

Benthic macrofauna community similarities of sampling stations

The resultant similarity matrix of sampling stations based on benthic macrofauna communities was subjected to cluster analysis and nonmetric multidimensional scaling (MDS).

Benthic macrofauna abundance data was forth root transformed to reduce the effect of dominant species on the analysis. A ranked similarity matrix was conducted on abundance data (individual/2.25 m^2) of each species at all stations. The similarity was conducted by using Bray and Curtis similarity.

Similarity of species found among sampling stations was related to its abundance and number of species. When sampling stations were compared by Bray and Curtis similarity, it generated a grouping of the sampling stations into three groups. The three distinct groups were identified with 35% similarity between the clusters. Cluster 1 consisted of all 9 sampling stations in Satun province and cluster 2 consisted of 17 sampling stations from Krabi and Trang provinces. Cluster 3 was consisted of TR-PM st4, TR-YL st1, TR-YL st2 and TR-YL st3 in Trang province. These results showed that overall benthic macrofauna communities of sampling stations in Satun province were homogeneity whereas in Krabi and Trang provinces were clustered into the same group. These results showed the distinction of benthic macrofauna communities in Satun province, that is, sampling stations in Satun province had different types of species or number of species to Krabi and Trang sampling stations. Satun province had 41 benthic macrofauna species that also found in Krabi or Trang provinces whereas the species found in both Krabi and Trang provinces were 58 species. The 26 species of benthic macrofauna were found in all three provinces including 11 species of polychaetes, 9 species of mollusks and 6 species of crustaceans. These polychaetes were *Scoloplos* (*Scoloplos*) *tumidus*, *Scolelepis* (*Scolelepis*) sp., *Prionospio* (*Prionospio*) *steenstrupi*, *Phyllodoce* sp., *Neanthes caudata*, *Glycera alba*, *Glycera natalensis*, *Glycera* sp., *Goniadopsis incerta*, *Scoletoma* sp. 2, and *Scoletoma* sp. 3. The mollusks included *Donax incarnatus*, *Donax faba*, *Umbonium vestiarium*, *Natica vitellus*, *Nassarius pullus*, *Nassarius livescens*, *Nassarius jacksonianus*, *Nassarius stolatus* and *Turricula javana*. The crustaceans consisted of *Diogenes klassi*, *Matuta victor*, *Dotilla intermedia*, *Ocypode macrocera*, *Scopimera proxima* and *Macrophthalmus convexus*. Furthermore, in the case of all station similarity, the results exhibited moderate similarity (21% similarity). The dendrogram in Fig. 3 shows the results of the cluster analysis from the different stations.

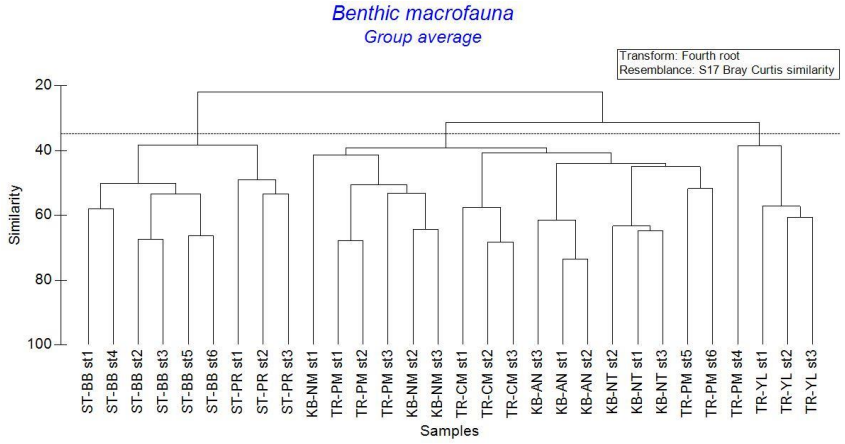

Fig. 3 A dendrogram of cluster analysis illustrated species abundance similarity among 30 stations.

The groups of sampling stations subjected by multidimensional scaling (MDS) showed that the results of cluster analysis coincided results with MDS at 35% similarity. A stress value was calculated for the MDS procedure. It is a useable measure of the relationship among the sampling stations that was represented by the MDS. A value < 0.10-0.20 is considered to provide a good representation (Clarke and Warwick, 2001). Two-dimensional ordination plot from multidimensional scaling analysis of the 30 sampling stations examining species similarity among stations is shown in Fig. 4.

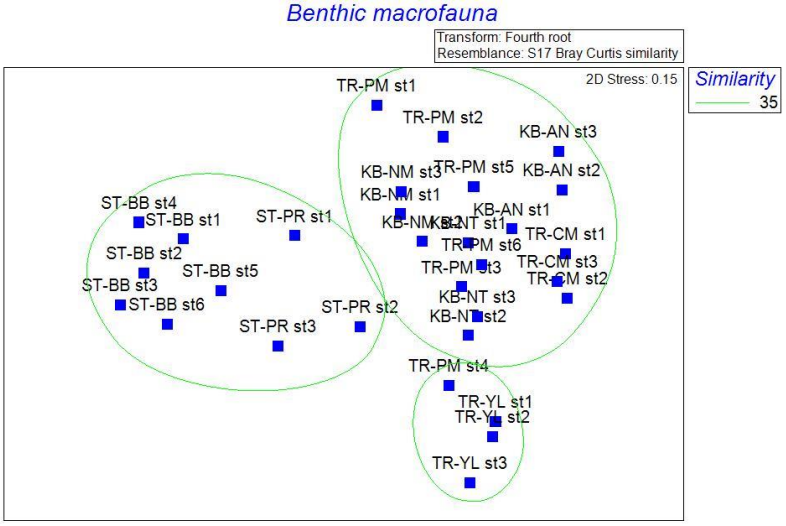

Fig. 4 Two-dimensional MDS configuration for forth root transformed benthic macrofauna assemblages of 30 stations using sum seasonal data (stress value = 0.15).

The species and the number of individuals of TR-PM st4, TR-YL st1, TR-YL st2 and TR-YL st3 that were collected during the Southwest monsoon, the Northeast monsoon and the summer season were separated from other stations. In general, differences between sampling stations of Krabi, Trang and Satun provinces seemed to be due to the differences between types of presented species. Meanwhile, the differences of those 4 sampling stations were due to the difference in the number of species that were only represented by a few numbers. Moreover, the abundances of crustaceans were higher than other benthic macrofauna groups presenting in those sampling stations. These lower number of benthic macrofauna found in TR-PM st4, TR-YL st1, TR-YL st2 and TR-YL st3 compared to the other sampling stations. However, unpolluted and unanoxic conditions were observed in the analysed water and sediment during the sampled seasons, therefore, the depletion of faunal communities by the reducing conditions in the areas could not be explained by pollution. This result may be influenced by the other beach physical characteristics. Its open areas and the moderate slope could potentially be an artifact of low taxonomic resolution of the taxa found here (Jaramillo et al., 1995).

Conclusion

A total of 116 species of benthic macrofauna from 8 beaches were sampled during the 3 seasons. They were accounted belonging to 51 families, 20 orders, 5 classes of 4 phyla (Polychaeta, Mollusca, Arthropoda and Brachiopoda). The highest number of species was polychaetes followed by mollusks, crustaceans and brachiopods, respectively. The similarity based on benthic macrofauna communities grouped sampling stations in Krabi and Trang provinces into the same group and it revealed the homogeneity of these sampling stations whereas sampling stations in Satun province were separated from those stations. The percentage of similarity was moderate at 21%. The highest species richness in each province was at Pak Meng beach station 1 in Trang, Nam Mao beach station 3 in Krabi and Pak Bara beach station 1 in Satun which the highest species richness of all sampling stations was at Pak Meng beach station 1. The lowest species richness in each province was at Yong Ling beach station 3 in Trang, Nopparatthara beach station 2 in Krabi and Pak Bang beach station 6 in Satun and the least species richness was at Yong Ling beach station 3.

Acknowledgement

The authors wish to acknowledge funding support from Suranaree University of Technology, Rajamangala University of Technology Srivijaya and the National Research Council of Thailand, fiscal year 2012-2013.

References

Allen, CJ. (2010). Ecology of the intertidal crab *Dotilla intermedia* from tsunami impacted beaches in Thailand. Ph.D. thesis: University of Southampton, UK.

Chantananthawej, B. and Bussarawit, S. (1987). Quantitative survey of the macrobenthic fauna along the west coast of Thailand in the Andaman Sea. Phuket Marine Biological Center Research Bulletin 47: 1-23.

Clark, KR. and Warwick, RM. (2001). Change in marine communities: An approach to statistical analysis and interpretation. 2nd edition. PRIMER-E, Plymouth, UK.

Environmental Monitoring and Support Laboratory Office of Research and Development. (1986). Manual for identification of marine invertebrates: A guide to some common estuarine macroinvertebrates of the big bend region, Tampa bay, Florida. United States Environmental Protection Agency, Ohio, USA.

Fauchald, K. (1977). The polychaete worms: Definitions and keys to the orders, families and genera, Science Series vol. 28. Natural History Museum of Los Angeles County, Los Angeles, USA.

Janekarn, V. and Chullasorn, S. (1997). Environmental impacts on coastal fisheries along the West Coast of Thailand. In: Environmental Aspects of Responsible Fisheries Proceeding of the APFIC Symposium October 1996. Asia-Pacific Fishery Commission, Seoul, the Republic of Korea, 222-233.

Jantharakhantee, C. and Aryuthaka, C. (2007). Macrobenthic communities in the Kuraburi seagrass bed, Phang-nga Province. Kasetsart University, Bangkok, Thailand.

Jaramillo, E., McLanchlan, A. and Dugan, J. (1995). Total sample area and estimates of species richness in exposed sandy beaches. Marine Ecology Progress Series 119: 311-314.

Map of Thailand. (2010). Travel map of Thailand [On-line]. Available: http://www. map of thailand.org/.

McLaughlin, PA. (1998). A review of the hermit-crab (Decapoda: Anomura: Paguridea) fauna of southern Thailand, with particular emphasis on the Andaman Sea, and descriptions of three new species. In: Proceedings of the International Workshop on the Crustacea of the Andaman Sea, Phuket, 385-460.

Office of the Strategy Management of Andaman. (2011). Andaman development plan year 2010-2013 [On-line]. Available: http://www.osmsouth-w.moi. go.th /submenu.php page=37.

Pornpinatepong, S. (2005). Tidal circulation in Andaman Sea. Songklanakarin Journal of Science and Technology 27(2): 425-431.

Poutiers, JM. (1998). The living marine resources of the Western Central Pacific. Volume I Seaweeds, corals, bivalves and gastropods. In: FAO species identification guide for fisheries purposes (Eds Carpenter KE, Niem VH) FAO, Rome, Italy. 1-686.

Rodil, IF. and Lastra, M. (2004). Environmental factors affecting benthic macrofauna along a gradient of intermediate sandy beaches in northern Spain. Estuarine, Coastal and Shelf Science 61: 37-44.

Somerfield, PJ. (2008). Identification of the Bray-Curtis similarity index: Comment on Yoshika (2008). Marine Ecology Progress Series 372: 303-306.

Swennen, C., Moolenbeek, RG., Ruttanadakul N., Hobbelink H., Dekker H. and Hajisamae S. (2001). The mollusks of the Sothern Gulf of Thailand. The Biodiversity Research and Training Program, Bangkok.

Worsfold, T. and Hall, D. (2010). Guidelines for processing marine macrobenthic invertebrate sample: A processing requirements protocol. National Marine Biological Quality Control Science, England.