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SPECIES DIVERSITY INDICES IN MARINE BENTHIC COMMUNITIES AS A POLLUTION INDICATOR IN THE UPPER GULF OF THAILAND

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Summary

Comparative studies of species diversity indices in marine benthic communities were made from pollution survey data in the Upper Gulf of Thailand from 1974-1976. The areas compared were the northwestern coastline from Samut Sakhon Province to Petchaburi Province (Area A), the northeastern coastline from Samut Prakan Province, Ko Sichang to Laem Chabang in Chonburi Province (Area B), the western coastline from Area A on down to Hua Hin in Prachuap Kiri Khan Province (Area C) and the eastern coastline from Area B to Ko Juang in Rayong Province (Area D). The average species diversity index in the northwestern coastline was found to be lowest at 0.379. The highest species diversity of 0.702 was found in the northeastern coastline area. Low diversity in the northwestern area might indicate pollution stresses in that area. The remaining areas still show species richness and no serious indication of effects from pollution.

Introduction

The Upper Gulf Thailand contributes a great deal to the national economy. It is also the zone most heavily prone to pollution due to growing population and industry, especially in the metropolitan Bangkok region. Several studies on the environmental aspects of this part of the Gulf of Thailand have been carried out[1-4]. The National Marine Science Committee have set up the Subcommittee for Pollution Study in the Upper Part of the Gulf of Thailand to carry out pollution survey of the area since 1974. Later on this interdisciplinary project has expanded to cover the entire Gulf area and the Andaman coastline.

It has been proposed that community structure of aquatic organisms may aid in the interpretation of water quality other than the standard physical and chemical analysis or toxiciy studies[4-6]. Benthic fauna have been used in many studies to show relationship between community structure and environmental stress, both natural and man-made. Their habitat preference and low motility cause the benthic fauna to be directly affected by changes such as pollution within their environment. The use of diversity indices as associations or populations of benthic organisms is found

to be more reliable than single indicator species[7-9]. Species diversity is inversely related to environmental stress levels; the greater the stresses, the lower the diversity and vice versa[10]. Diversity is usually increased with offshore depth and decreases with naturally stressed and polluted estuarine areas[11].

The objective of this study was to ascertain water quality or pollution stress in the Upper Gulf of Thailand through the investigation of benthic community structure by using species diversity indices.

Methods and Materials

Comparative studies of species diversity indices in marine benthic communities were calculated from pollution survey data in the Upper Gulf of Thailand from 1974-1976. The benthos samples were collected by the grab modified by Assist. Prof. Suthichai Tamiyavanich[12]. The grab was designed to collect sediment within an area of 0.1 m^2 and with the sediment volume of 1,000 cm^3 at a time. The grab could penetrate to about 7-15 cm depth. Three samples were collected per each station. The samples were washed carefully through a series of sieves. Specimens were sorted out and preserved in 10% formalin. Identification and determination of biomass were carried out in this laboratory. The areas of 18 stations compared were the northwestern coastline from Samut Sakhon Province to Petchaburi Province (Area A), the northeastern coastline from Samut Prakan Province, Ko Sichang to Laem Chabang in Chonburi Province (Area B), the western coastline from Area A on down to Hua Hin in Prachuap Kiri Khan Province (Area C) and the eastern coastline from Area B to Ko Juang in Rayong Province (Area D). These areas are shown in Fig. 1.

Shannon index of general diversity ($\overline{H}$) and index of dominance (C) were used in data analysis[13]. Shannon index of general diversity ($\overline{H}$) is defined by

$$\overline{H} = \sum_{i=1}^{s} (n_i/N) \log (n_i/N)$$

where n_i is the importance value for each species (number of individuals or biomass). In this analysis due to the difficulty of identification of species, the organisms were grouped into taxa such as polychaetes, nematodes, etc., instead of by species. Biomass in terms of wet weight per square metre for individual groups was used as the importance value. The number of taxa summed is s and N is the sum of the importance values for a given sample location.

The index of dominance is

$$C = \sum_{i=1}^{s} (n_i/N)^2$$

Analysis of variance (F–test) was applied to determine whether there were variations in species diversity indices among the four areas and whether there were variations due to the seasonal aspect. Student's t–test was used to determine the differences in the species diversity indices of the estuarine area and the offshore area. Both the Student's t–test and the F–test calculations were according to Snedecor[14].

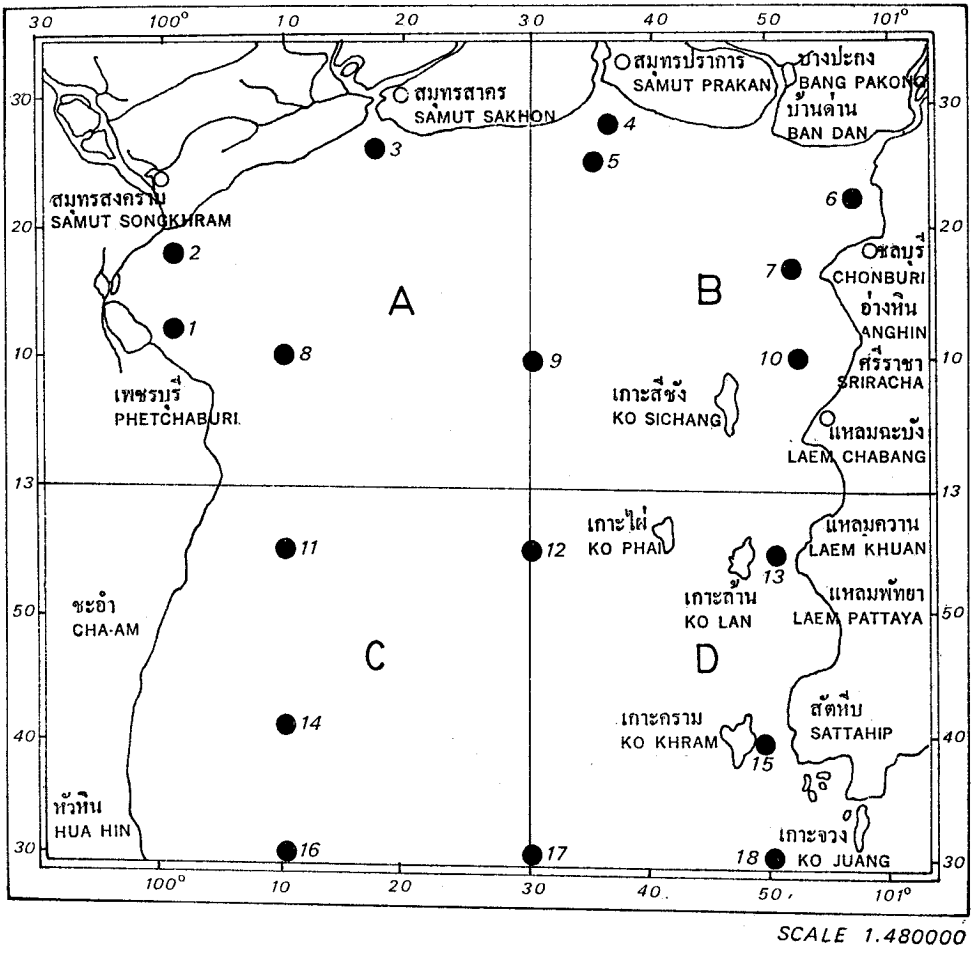

Fig. 1. Map showing the four areas (A, B, C, D) and the stations in the study (numbers)

Results

Complete taxa list of benthic organisms found in the four areas is shown in Table I.

TABLE I: COMPLETE TAXA GROUPINGS OF BENTHIC ORGANISMS IN THE UPPER GULF OF THAILAND.

- Phylum Porifera
- Phylum Coelentarata
  - Class Scyphozoa
    - Order Rhizostomeae
  - Class Anthozoa
    - Order Actinaria
- Phylum Platyhelminthes
- Phylum Nemertinea
- Phylum Nematoda
- Phylum Sipunculida
- Phylum Annelida
  - Class Oligochaeta
  - Class Polychaeta
- Phylum Mollusca
  - Class Gastropoda
  - Class Pelecypoda
  - Class Scaphopoda
- Phylum Arthropoda
  - Class Crustacea
    - Subclass Cirripedia
    - Subclass Ostracoda
    - Subclass Malacostraca
      - Order Stomatopoda
      - Order Isopoda
      - Order Amphipoda
      - Order Decapoda
        - Section Penaeidae
        - Section Caridea
        - Section Anomura
        - Section Brachyura
- Phylum Echinodermata
  - Class Holothuroidea
  - Class Echinoidea
    - Subclass Regularia
    - Subclass Irragularia
  - Class Ophiuroidae
- Phylum Brachiopoda
- Phylum Bryozoa
- Phylum Hemichordata
- Phylum Chordata
  - Subphylum Urochordata
    - Class Ascidiacea
  - Subphylum Cephalochordata
    - *Amphioxus*

Table II shows the species diversity indices calculated for the four areas. On the average, the northwestern coastline benthic communities (Area A) showed the lowest species diversity index. The other three areas showed relatively high indices. Species diversity indices in the four areas showed variations at the 5% level of significance according to the analysis of variance test in Table II. The data of 1975 and 1976 were used separately to determine seasonal variations in species diversity indices by F–test. The results show that seasonal variations did not occur.

The species diversity indices of the estuarine area (Area A & B) is compared with the offshore area (Area C & D) in Table III. We found that species diversity indices for the estuarine areas (A & B) were lower than those of the offshore areas C & D. The Student's t–test showed that there was significant variation between the two areas.

TABLE II: SPECIES DIVERSITY INDICES IN MARINE BENTHIC COMMUNITIES IN THE UPPER GULF OF THAILAND.

Data from trip	Area A	Area B	Area C	Area D
October, 1974	0.280	0.902	0.528	0.968
January, 1975	0.465	0.642	0.698	0.352
April, 1975	0.679	0.849	0.614	0.842
July, 1975	0.397	0.565	0.598	0.598
October, 1975	0.488	0.701	0.764	0.650
March, 1976	0.431	0.753	0.479	0.742
May, 1976	0.537	0.506	0.553	0.705
September, 1976	0.218	0.640	0.344	0.762
Average	0.379	0.695	0.572	0.702
Analysis of variance (F–test)	F–calculated between areas (A, B, C, D) 5.89		F–calculated seasonal aspect (1975) 2.54	
	F [0.05 (3, 28)] = 2.95		F [0.05 (2, 12)] = 3.49	
			F–calculated seasonal aspect (1976) 0.39	
			F [0.05 (2, 9)] = 4.26	

TABLE III: SPECIES DIVERSITY INDICES IN MARINE BENTHIC COMMUNITIES IN THE ESTUARINE AREAS AND THE OFFSHORE AREAS IN THE UPPER GULF OF THAILAND.

Data from trip	Areas A & B	Areas C & D
October, 1974	0.591	0.748
January, 1975	0.554	0.525
April, 1975	0.764	0.728
July, 1975	0.481	0.598
October, 1975	0.595	0.707
March, 1976	0.592	0.610
May, 1976	0.522	0.629
September, 1976	0.429	0.554
Average	0.566	0.637
Student's t–test	t–calculated − 3.24	t–table (0.05, 7) 2.31

In contrast, the index of dominance showed the highest values in areas of lowest species diversity indices. This strongly shows an inverse relationship between the index of dominance and the species diversity index. Table IV shows the calculated indices of dominance.

TABLE IV: INDICES OF DOMINANCE IN MARINE BENTHIC COMMUNITIES IN THE UPPER GULF OF THAILAND.

Data from trip	Area A	Area B	Area C	Area D
October, 1974	0.704	0.168	0.380	0.132
January, 1975	0.445	0.317	0.370	0.591
April, 1975	0.244	0.189	0.303	0.165
July, 1975	0.533	0.355	0.368	0.350
October, 1975	0.421	0.249	0.258	0.307
March, 1976	0.468	0.208	0.450	0.281
May, 1976	0.400	0.428	0.334	0.250
September, 1976	0.773	0.287	0.595	0.251
Average	0.499	0.275	0.382	0.291

Discussion

The results show that low diversity in the northwestern area might indicate pollution stresses in that area. This area receives freshwater runoff from several large rivers, namely the Mae Klong, the Tha Chin and the Chao Phraya. Several studies indicated that water quality in the northwestern area showed high pollution stress resulting from the runoff from the Mae Klong, the Tha Chin and the Chao Phraya as compared to the other area along the northeastern coastline receiving runoff from Bang Pakong River only. This also correlated with the low fisheries yield from this area. The Chao Phraya River provides the major contribution to coastal water pollution. Pollutants come primarily from domestic and solid wastes discharged in the Bangkok metropolis and from industrial sources in Samut Prakan Province. Pollution in Mae Klong is somewhat different from that of other rivers in Thailand. In most rivers, the major sources of pollution are from domestic and solid wase discharges and the degree of pollution is relatively constant throughout the year. The major sources in the Mae Klong are industries and the degree of pollution varies considerably during the year. Sugar mills and pulp and paper mills are the most important pollution sources. Pollution in the Tha Chin River is considered a minor contributor to coastal water pollution as compared to those of Chao Phraya and Mae Klong Rivers. But it should be noted that the conditions of the river have become worse in the past few years, as the population grows and industries expand rapidly in the region[1, 10, 15].

This study agrees with that of Carriker[10] that the greater the environmental pollution, the lower the diversity indices. This is in contrast to the index of dominance. When the stresses occurred in the environment, only few species were able to tolerate the conditions, and the diversity was reduced. The species that could thrive in such condition would then reproduce and expand its population quickly.

Comparative results between the estuarine area and the offshore area (Table III) show that diversity of the former is less than the latter, which is less polluted, in agreement with Boesch's observation[11]. However, it should be noted that estuarine area B has comparable diversity with offshore areas C and D.

The seasonal aspects of the species diversity indices of marine benthic communities was less pronounced as shown in this study. Several studies indicated seasonal variations of pollution parameters[1-4] in the Gulf of Thailand. During the Southwest monsoon period or in the rainy season, the pollution problems in the Gulf of Thailand are less pronounced[3]. Moreover there appear to be variations in the total estimated BOD load reaching the river in area such as the Mae Klong River during the cane sugar processing season and the off-season. It has been reported that the total estimated BOD load reaching the Mae Klong River from all sources is about 104.6 tons per day in the cane sugar processing season. During the off-season period, the BOD load reaching the river will be equal to the total load produced in the processing season minus the load produced by all sugar mills[2] which is approximately 20.6 tons/day.

It should be noted that this study is a preliminary study on introducing the use of species diversity indices in marine benthic communities as one of the pollution indicators in Thailand. Due to the difficulty in identification of organisms, the calculations of species diversity indices were based or rough taxonomic groupings. In the future if the identification of the organisms is more complete, more accurate species diversity indices can be calculated. It is also important to look into the relationship of the species diversity with various parameters in the sediment such as type of sediment, grain sizes and organic content. These parameters may cause differences in the species diversity other than the pollution stresses.

Conclusion

Low diversity in the marine benthic communities in the northwestern area of the Upper Gulf of Thailand correlates with the stresses caused by pollution in the area. The remaining areas still show species richness and no serious indication of effects from pollution.

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บทคัดย่อ

ในการศึกษาเปรียบเทียบค่า species diversity ในกลุ่มประชากร สัตว์ทะเลหน้าดินในบริเวณอ่าวไทยตอนบน จากข้อมูลการสำรวจน้ำเสียอ่าวไทยปี 2517-2519 โดยแบ่งออกเป็น 4 บริเวณ คือ บริเวณฝั่งตะวันตกเฉียงเหนือ จากสมุทรสาครถึงเพชรบุรี (เขต A) บริเวณฝั่งตะวันออกเฉียงเหนือ นับแต่สมุทรปราการ เกาะสีชังจนถึง แหลมฉะบัง (เขต B) บริเวณฝั่งตะวันตก นับแต่เขต A จนถึงหัวหิน (เขต C) และบริเวณฝั่งตะวันออกนับแต่บริเวณใต้แหลมฉะบังลงมาถึงเกาะจวง ในจังหวัดระยอง และรวมบริเวณเกาะไผ่ด้วย (เขต D) พบค่า species diversity โดยเฉลี่ยที่ต่ำสุดอยู่บริเวณฝั่งตะวันตกเฉียงเหนือ จากสมุทรสาครถึงเพชรบุรี มีค่าเท่ากับ 0.379 ส่วนค่าที่สูงที่สุดพบที่บริเวณฝั่งตะวันออกเฉียงเหนือเท่ากับ 0.702 การที่บริเวณฝั่งตะวันตกเฉียงเหนือของอ่าวไทยมีจำนวนชนิดของสัตว์ทะเลน้อยมากนั้น อาจแสดงถึงมลภาวะในทะเลที่เกิดขึ้นในบริเวณนั้นได้ บริเวณตอนอื่นของอ่าวไทยตอนบนยังแสดงถึงความอุดมสมบูรณ์พอควรและไม่แสดงถึงผลกระทบที่ได้รับจากมลภาวะดังกล่าว