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Species composition and abundance of penaeid shrimps in the outer Songkhla Lake of Thailand

Samphan, P. [1*], Sukree, H.[2] and Reunchai, T.[2]

[1]Marine and Coastal Resources Institute, Faculty of Graduated school, Prince of Songkla University, Hat Yai, Songkhla, 90112, Thailand; [2] Department of Biology, Faculty of Science, Prince of Songkla University, Hat Yai, Songkhla, 90112, Thailand; [3] National Institute of Coastal Aquaculture, Coastal Natural Resources Group, Muang, Songkhla, 90000, Thailand.

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Abstract The coastal waters of Songkhla Lake in Thailand constitute an important habitat for penaeid shrimps. Despite the high economic value attached to this resource, the biological information necessary for its sustainable exploitation is scanty and fragmented. The present study was therefore designed to investigate the species diversity composition of the penaeid shrimps in Songkhla Lake. Samples were obtained monthly for (during January 2010 to Janauary, 2011) a period of thirteen month from Outer Songkhla lake, samples were identified to the species level. The samples were collected using trap nets. Twenty-two species from 6 genera of Penaeidae were reported from the present study. Six species of *Penaeus* (Farbricius, 1798) were found; *P. japonicus* (Bate, 1888), *P. latisulcatus* (Kishinouye, 1896), *P. monodon* (Fabricius, 1798), *P. semisulcatus* (De Haan, 1844), *P. merguiensis*(De Man, 1888) and *P. silasi* (Muthu and Motoh, 1979). There were two speciesof the genus *Metapenaeopsis* (Bonvier, 1909)*; M. stridulans* (Alcock, 1905) and *Metapenaeopsisbarbata* (De Haan, 1844). The only species in genus *Solenocera* (H. Milne Edwards, 1837) was *Solenocera crassicornis* (H. Milne Edwards, 1837). There were 7 species of *Metapenaeus*(Wood-Masen, Alcock, 1891); *M. lysianassa*(De Man, 1888), *M. intermedius* (Kishinouye, 1900), *M. ensis* (De Haan, 1844), *M. affinis* (H. Milne Edwards, 1837), *M. moyebi* (Kishinouye, 1896), *M. brevicornis* (H. Milne Edwards, 1837) and *M. tenuipes* (Kubo, 1949). There were 3 species of *Parapenaeopsis* (Alcock, 1901); *P. hungerfordii* (Alcock, 1905) *P. hardwickii* (Meirs, 1878) *P. sculptilis* (Heller, 1862) The genus *Trachypenaeus* (Alcock,1901) were found 3 species. There were 3 species of *Trachypenaeus* (Alcock, 1901); *T. sedili* (Hall, 1961), *T. malaiana* (Balss, 1933) and *T. pescadoreensis* (Schmitt,1931). The species composition of Penaeid shrimps were divided three seasons; rainy season, summer season and interseason. The most dominant Penaeid shrimps species were *M. moyebi*, *M. ensis*, *P. silasi* and *P. merguiensis*throughout the entire study period. In general, *Penaeus* spp. and *Metapenaeus* spp. were the most abundant species found in the Outer Songkhla Lake and season. Shrimp juveniles move out from the Songkhla Lake into the Gulf of Thailand. The species composition and population abundance in this study is a fundamental development of a management policy for modeling of a shrimp population in Outer Songkhla Lake.

Keywords: *Penaeidae*, Marine shrimp, Species composition, Abundance, outer SongkhlaLake

[*] **Corresponding author:** Samphan, P.; **Email**: nsamphan@yahoo.com

Introduction

Penaeids shrimps include the widespread tropical and subtropical shrimps of the genera Fenneropenaeus, Penaeus and Metapenaeus (Richmond, 2002). Most commercially important shrimps in tropical areas belong to a group known as penaeids. The adults of most commercially important penaeid shrimps live and spawn in deeper water away from the shore. Most species are found naturally in shallow, inshore tropical and subtropical waters and many have been artificially cultured in ponds (Holthuis, 1980).

The penaeid prawns, or shrimps as they are referred to outside the Indian and western Pacific Oceans, have a world-wide distribution in tropical and sub-tropical seas within the 20^{o}C isotherms. They are most varied in the Indo-Pacific where there are roughly five times more species than in the Atlantic. The Indo-Pacific region, which stretches from eastern Australia and the Philippines to eastern and southern Africa, supports 125 species of which 124 are endemic. The Indo-Malaysian sub-region which encompasses the area from Sri Lanka and the Bay of Bengal to the Philippines and the northern coast of Papua New Guinea supports 85 species with 25 endemics and is the centre of diversity in the Indo-Pacific region. Diversity and endemism decrease in all directions from this sub-region declining to 16 species and one endemic in the southern African region which stretches from Durban to Swakopmund (Dall *et al.,* 1990). Shallow coastal habitats are ecologically dynamic and productive areas used by larvae, juveniles and adults of many estuarine-dependent species for reproduction, foraging and shelter (Peterson & Whitfield, 2000; Harris *et al*., 2001; Schaffmeister *et al*., 2006; Hajisamae *et al*., 2013). Commercial shrimps, such as Penaeus and Metapenaeus, normally have a life cycle where they spawn offshore, and post-larvae or juveniles move to estuarine backwaters for growing out in inshore and estuarine waters (Staples & Vance, 1985; Dall *et al*., 1990).

Songkhla Lake is located in Phattahalung, Songkhla and Nakhon Si Thammarat, Province, southern Thailand. Songkhla Lake is a coastal lagoon produced by sand-bar formation includes three lakes, Thale Noi (2,800 ha), Thale Luang (78,280 ha) and Thale Sap Songkhla (17,600 ha), lying from north to south, which are inter-connected by narrow channels. A narrow strait connects Thale Sap with the Gulf of Thailand at its southeastern end (Figure 1). A gradient of salinity exists, therefore, between the brackish water of Thale Sap and the pure freshwater of Thale Noi. The middle lake, Thale Luang, approaches a freshwater condition during the rainy season (October - January), but is influenced by the invasion of seawater in other months. Songkhla Lake is influenced by run-off from the upstream, mainly forested mountains in the west and by the introgression of salt water from the sea. Water quality varies greatly

throughout the different parts of the lake; there is a spatial variation in salinity and turbidity according to seasons.

This study is aimed to to investigate the diversity of the penaeid shrimp in the Outer Songkhla Lake. These studies include species composition taxonomy and description of each species of penaeid shrimp. The study of penaeid shrimps in the Outer Songkhla Lake is important for coastal resources management planning.

Materials and methods

Study sites

The Songkhla lake is the largest natural lake in Thailand, located on the Malay peninsula in the southern part of the country. Covering an area of 1,040 km ^{2}it borders the provinces of Songkhla and Phatthalung. Despite being called a lake, this water surface is actually a lagoon complex geologically.

The lake is divided into three distinct parts. The southern part opens by a 380 m wide strait to the Gulf of Thailand at the city of Songkhla, and contains brackish water of about half the salinity of the ocean. Further north after a bottleneck of only 6 km width is the Thale Luang (782.80 km ^{2}), and finally at the northern end in between a mangrove swamp the 28 km ^{2}small Thale Noi in Phatthalung Province. The most striking feature is the long 75 km long spit which separates the lake from the sea. Unlike most spits, it is probably formed when originally existing islands became interconnected by the silting from the lake precursor.

Sampling methodology

The marine shrimps were collected monthly during January 2010 to January 2011 in the Outer Songkha Lake, Songkhla province, Thailand. The samples were collected using trap nets and preserved in 10 % formalin. The specimens were identified to species level, sexed, and measured in the laboratory. Total length (TL, to nearest 0.1 mm.) was measured from the tip of the rostrum to the end of the telson, carapace length (CL, to nearest 0.1 mm.), from the posterior margin of the orbit to the posterior margin of the carapace and total weight (TW, to nearest 0.1 g) as wet weight.

The trap nets is a small sized stationary fishing gear, combined with seine wing-like barriers used for re-directing and then trapping crab, shrimp and fish as shown in Figure 1. Trap selectivity relies on the shrimp moving actively

into the trap and catches depend on the duration of the soak, i.e. the time the trap is left on the fishing ground.

The study areas were divide in five stations and three replicates in each station. The station one (front of Ko Yo), near channel of water flow pass from Songkhla Lake. Station two (Ko Yo), the habitat lied adjacent to the station one, the habitat was a sediment of fine sand Station three at the middle of Outer Songkhla Lake (Ban Laeam Po), the habitat was mudflat. The station four was at the lower of Outer Songkhla Lake (Ban Ao Thing), the habitat was sediment of coarse sand. The station five at the end of Outer Songkhla Lake (Ban Pak Rua) the habitat was characterized by sediment and water turbulence. In general, the bottom of Outer Songkhla Lake was mudflat habitat. Additional characteristics of the sample area were different in water salinity and other environmental parameters. (Figure. 1)

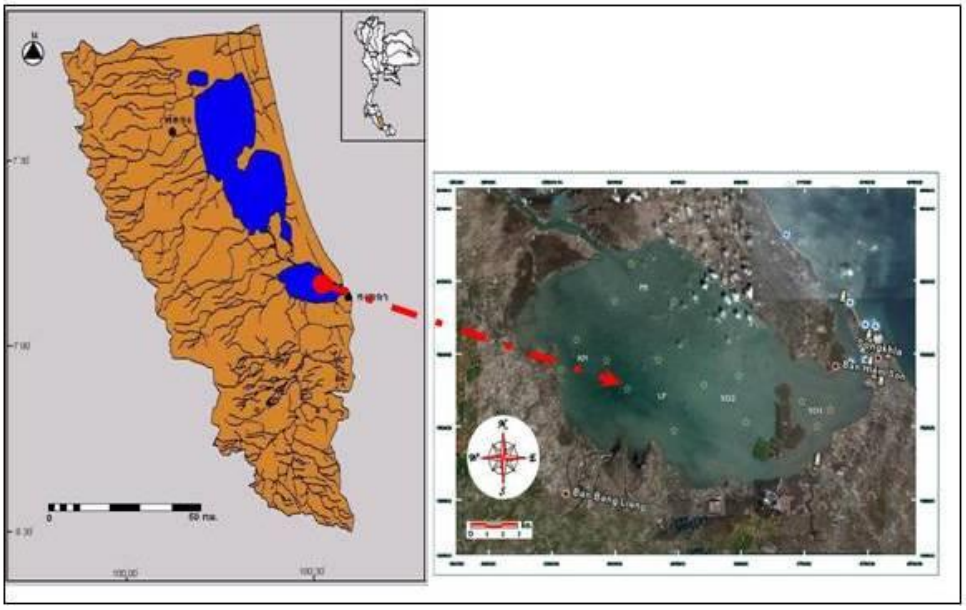


Figure 1. Show the Songkhla Lake basin and station 1, 2, 3, 4 and 5 in the Outer Songkhla Lake, for sample collections.

The shrimp catches were immediately iced and transported to the laboratory for sorting, identification and measurements of carapace length. All materials were preserved with 10% formalin solution and deposited in Faculty of Science, Prince of Songkla University, for future reference.

Water quality parameters analysis

Prior to shrimp sampling, dissolved oxygen, pH, salinity and temperature were measured *in situ* by a YSI 556 MPS meter at a depth of 0.5 m from the water surface. Salinity was measured using the Practical Salinity Scale.

Results and discussion

Species of Penaeidae were distribution in the Outer Songkhla Lake

Twenty-two species from 6 genera of Penaeidae were reported from the present study. Six species of Penaeus were found; *P. japonicus* (Bate, 1888), *P. latisulcatus* (Kishinouye, 1896), *P. monodon* (Fabricius, 1798), *P. semisulcatus* (De Haan, 1844), *P. merguiensis* (De Man, 1888) and *P. silasi* (Muthu and Motoh, 1979). There were two species of the genus Metapenaeopsis; *M. stridulans* (Alcock, 1905) and *M. barbata* (De Haan, 1844). The only species in genus Solenocera was *S. crassicornis* (H. Milne Edwards, 1837). There were 7 species of Metapenaeus; *M. lysianassa* (De Man, 1888), *M. intermedius* (Kishinouye, 1900), *M. ensis* (De Haan, 1844), *M. affinis* (H. Milne Edwards, 1837), *M. moyebi* (Kishinouye, 1896), *M. brevicornis* (H. Milne Edwards, 1837) and *M. tenuipes* (Kubo, 1949).Three pecies the genus Parapenaeopsis. There were three species of Parapenaeopsis; *P. hungerfordii* (Alcock, 1905) *P. hardwickii* (Meirs, 1878) *P. sculptilis* (Heller, 1862). There were three species of Trachypenaeus; *T. sedili* (Hall, 1961), *T. malaiana* (Balss, 1933) and *T. pescadoreensis* (Schmitt,1931) Fig. 2 .

Penaeus japonicus (Bate,1888)

Penaeus latisulcatus. (Kishinouye,1896)

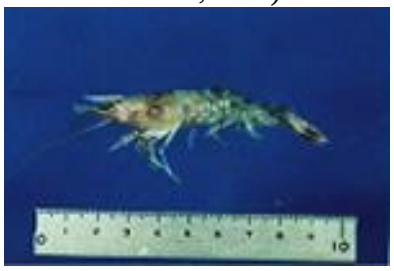
Penaeus monodon (Fabricius,1798)

Penaeus semisulcatus (De Haan,1844)

Penaeus merguiensis (De Man,1888)

Penaeus silasi (Muthu and Motoh,1979)

Metapenaeopsis stridulans (Alcock, 1905)



Metapenaeopsis barbata (De Haan, 1844)

Metapenaeus intermedius (Kishinouye, 1900)

Metapenaeus ensis (De Haan, 1844)

Metapenaeus affinis
(H. Milne Edwards, 1837)

Metapenaeus moyebi
(Kishinouye, 1896)

Metapenaeus brevicornis
(H.Milne Edwards, 1837)

Metapenaeus tenuipes
(Kubo, 1949)

Parapenaeopsis hungerfordi
(Alcock,1905)

Parapenaeopsis hardwickii
(Meirs, 1878)

Parapenaeopsis sculptilis
(Heller, 1862)

Trachypenaeus sedili
(Hall, 1961)

Trachypenaeus malaiana
(Balss, 1933)

Trachypenaeus pescadoreensis
(Schmitt,1931)

Figure 2. Show the group of penaeid shrimps in the uter Songkhla Lake.

Decapod crustaceans are typical components of estuarine systems and play an important role in their dynamics (McLusky and Elliott, 2004). Penaeid shrimp are commercially important organisms in many tropical and subtropical seas. Penaeids include the widespread tropical and sub- tropical shrimps of the genera *Penaeus* and *Metapenaeus* (Richmond, 2002). The life cycle involves several stages: (1) female adults spawn in the ocean where the eggs undergo most of their larval development (nauplii, protozoea and mysis stages) until they reach the postlarvae stage, then enter coastal and estuarine waters, (2) at the juvenile stage, they migrate to offshore waters where further growth and development occurs, and (3) after reaching reproductive maturity, spawning occurs (Garcia and Le Reste, 1981).

Penaeid shrimp may exhibit specific behaviors depending on the type of habitat they occupy. For example, *P. merguiensis* typically inhabits areas characterized by soft, muddy bottoms and high turbidity. This type of habitat may confer some protection from visual predators because of the restricted light penetration into the water. In these conditions, *P. merguiensis* does not exhibit strong burrowing behavior, and can forage at any time throughout a diel cycle. During periods of the tidal cycle when turbidity falls to a minimum, *P. merguiensis* can form dense schools and generate intense, turbid patches known as "mud boils". This schooling behavior and turbidity generation may have survival value for this non-burrowing species by reducing predation pressure at times of low turbidity (Garcia, 1984).

In general, *Penaeus* spp. and *Metapenaeus* spp. were the most abundant species found in the Outer Songkhla Lake. Songkhla Lake is one of the most productive coastal area in the southern part of Thailand. However it is also an example of the heavy utilization of coastal resources. Serious concerns have been raised about the ecological effects of industrialized fishing. Fisheries have rarely been 'sustainable'. Rather, fishing has induced serial depletions, long masked by improved technology, geographic expansion and exploitation of previously spurned species lower in the food web. With global catches

declining since the late 1980s, continuation of present trends will lead to supply shortfall, for which aquaculture cannot be expected to compensate, and may well exacerbate. Reducing fishing capacity to appropriate levels will require strong reductions of subsidies. (Myers and Worm, 2003)

Species compositon and population abundance

The composition of penaeid sepecies caught monthly from January 2010 to January 2011.

Species composition across seasons was shown in Figure 3. The seasons were separated into 3 periods, rainy season summer season and inter seasonal period. Seasonality and abundance fluctuations for the penaeid species identified in the Outer Songkhla Lake shown in Table 1. A seasonal monthly variation was found during study period. Twenty-two species from 6 genera of Penaeidae were recorded. The dominant species was *M. moyebi* and *M. ensis* in all seasons.

Salinity is one of the most important environmental factors affecting growth, survival and development of aquatic organisms. Penaeid shrimp live in saline water ranging from 15 to 50 ppt, but salinity tolerance is usually more restricted in the adults than the juveniles or larvae. Spawning adults are generally restricted to habitats where the salinity is no less than 28 ppt. Species specific salinity optima differences have been noted. *P. japonicus* are adapted to a narrow, more oceanic salinity range, and larval development is best at salinities of 27 - 32 ppt. They generally avoid salinities in excess of 65 ppt. Adults are nearly always confined to 33 - 36 ppt sea water. *P. monodon* can, as an adult, tolerate the low and variable salinity of fish ponds. Reduced salinity is rarely a problem as long as the shrimp are able to migrate to deeper, more saline water or into outer coastal regions away from river mouths. The inshore shallow water habitats of many juvenile penaeids are generally either continuously or intermittently low in salinity. Penaeids cope with this by being euryhaline which greatly increases the inshore area that can be used as nursery grounds (Dall *et al*., 1990). The term salinity refers to the total concentration of all ions in water. It is not, as many people think, the concentration of sodium chloride in water. Juvenile pink shrimp are found in water of 5 ppt during summers. They generally avoid salinities in excess of 65 ppt. Adults are nearly always confined to 33 - 36 ppt sea water (Dall *et al.*, 1990). In Day (1964), he stated that the most important physical conditions, apart from the salinity regime, are the depth and permanence of the mouth, the clarity of the water, and the nature of the bottom sediments. The importance of salinity variation in estuaries has led to biotic classification systems based on the relationship of

species with the salinity of the surrounding water. A number of classification systems based on the organisms' ability to osmoregulate and to tolerate certain salinity ranges were developed, for example, by Kinne (1963) and Day (1951, 1967). The classification system suggested by Day (1967) was based on the Venice system of approximate ranges of salinity values in coastal waters and assigns estuarine animals to five groups: a stenohaline marine component (marine species that can tolerate a slight decrease in salinity only), an euryhaline marine component (marine species having a wide tolerance range for salinity), an estuarine component (species absent from both the riverine and the marine habitats), a freshwater component (riverine species which may penetrate estuaries), and a migratory component (species that may penetrate estuaries during a part of their life-cycle). First, the influence of the river on physical and chemical processes is often greater, which results in the exclusion of many marine species. Secondly, the mouth areas particularly of the estuaries of mud-rich rivers tend to be channel-like (Cooper *et al*., 1999), which decreases the surface area available for colonisation by species associated with high salinities and sandy sediments. Most penaeid shrimps exhibit rapid growth which is correlated with the water temperature. As the penaeid shrimps are short-lived animals living in highly variable inshore areas during the juvenile phase, they are frequently subjected to strong environmentally driven variability in recruitment and stock size (Garcia, 1984).

These shrimps, like other penaeids, have an estuarine phase in their life cycle and thus they get exposed to wide fluctuations in salinity. Salinity is an important environmental variable that has significant influence on the energy budget of estuarine and marine animals, knowledge of the energy requirement of the animal under different salinity regimes will be useful in formulating improved culture practices for maximizing growth and returns (Bindu and Diwan, 2002). Presently, these assets are in danger. Many natural habitats has been increased rapidly destroyed, because of the pollution of water, air and soil, irregular structure, and faulty land use. Our biological diversity is under threat and certain species are endangered.

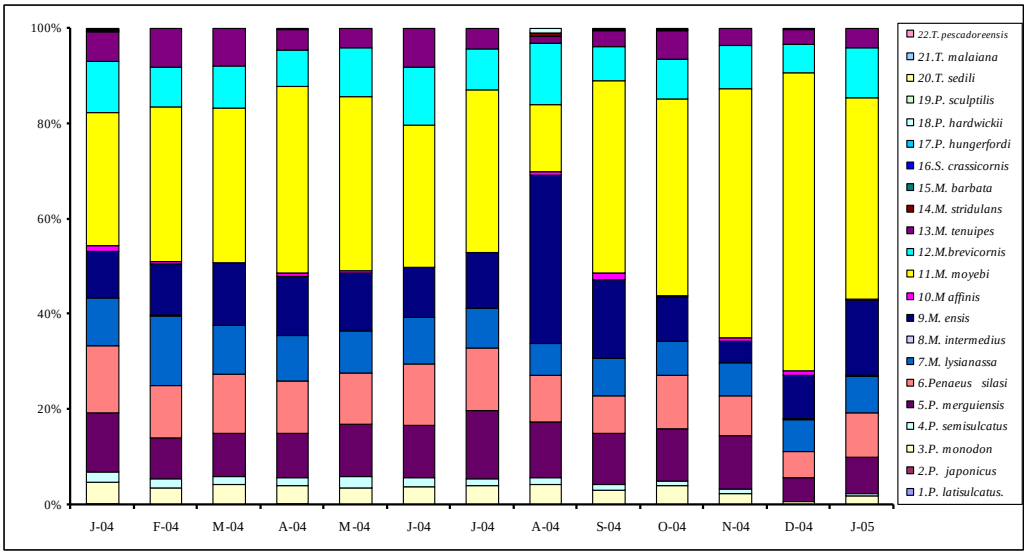


Figure 3. Percentage of penaeidae species composition during the study period (January 2010 to January 2011).

Species composition and population abundance in rainy season

The rainy season covers the period of four months in October, November, December and January. Thirteen species of penaeid shrimps were found in October 2010. The most abundance species, *M. moyebi* (41.19 %) were recorded larger than other species during rainy season. The monthly percentage of species composition; *M. moyebi* 41.19 %, *P. silasi* 11.24 %, *P. merguensis*, 11.11 % were found. Only *M. moyebi* was the most abundance in October (Table.1 and Figure. 3). In october salinity ranged from 10.1 to 26.8 ppt. and monthly averages of salinity was 18.25 ppt.

The monthly species composition in November 2010; thirteen species of penaeid shrimps were found. In November, the most abundance species, *M. moyebi* (52.16 %) were recorded more than other species during rainy season. The monthly percentage of species composition, *M. moyebi* 52.16 %, *P. merguensis*,11.26 % *M. brevicornis* 9.17 % were found. Only *M. moyebi* was the most abundance in November (Table.1 and Figure. 3). The salinity ranged from 1.1 to 2.4 ppt. and monthly averages was 1.96 ppt. In this month the salinity was low and reach to freswater. Most of area in the Outer Songkhla Lake showed low salinity.

The monthly species composition in December 2010; thirteen species of penaeid shrimp were found. In December, the most abundance species, *M. moyebi* (62.49%) were recorded more than other species during rainy season.

The monthly percentage of species composition *M. moyebi* 62.49 %, *M. ensis* 9.21 %, *M. lysianassa* 6.73 % were found. The *M. moyebi* were found in all period of raining season with a peak in December (Table.1 and Figure. 3). The salinity ranged from 1.2 to 34.1 ppt. and monthly averages of salinity 12.6 ppt.

The monthly species composition in January 2011; eleven species of penaeid shrimp were found. In January species composition of penaeid shrimp most abundance *Metapenaeus moyebi* (42.28 %) than other species during rainy season. The monthly percentage of species composition, *M. moyebi* 42.28 %, *M. ensis* 15.78 %, *M. brevicornis* 10.46 % were found. The *M. moyebi* were found in all study period (Table.1 and Figure. 3). The salinity ranged from 6.5 to 35.7 ppt. and monthly averages of salinity 20.52 ppt.

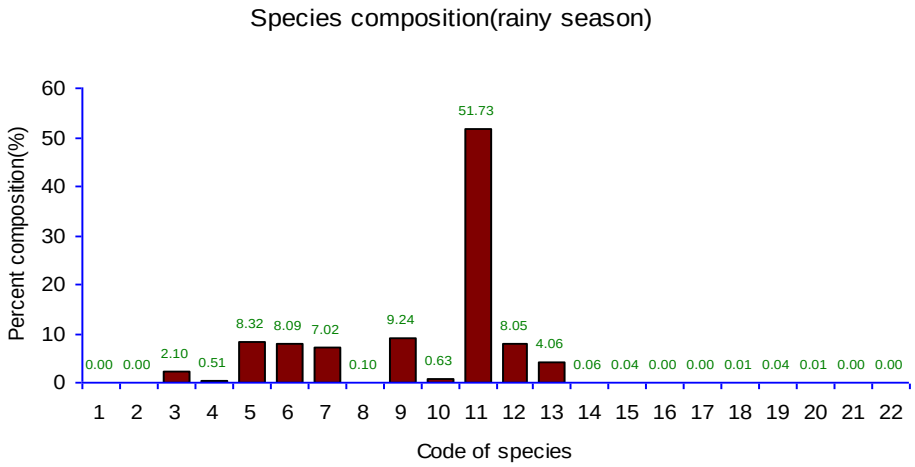


Figure 4. Percentage of penaeidae species composition in rainy season.

The composition of penaeid species caught from October 2010 to January 2011 was summarized in Table1 and Figure 3. The monthly pattern of abundance in relation to rainfall showed variations. Sixteen species of the family *Penaeidae; Penaeus monodon, P.semisulcatus, P. merguensis, P. silasi, Metapenaeus lysianassa, M. intermedius, M. ensis, M. affinis, M. moyebi, M.brevicornis, M. tenuipes, Metapenaeopsis stidulan, M. barbata, P. hardwickii, P. sculptilis and T. sedili* were found in rainy season.

M. moyebi represented the highest recording in rainy season with the species composition of 52.16 %, 62.49 %, 42.28 %, followed by *P. merguiensis* 11.26 %, 4.29 %, 7.61% and *M. ensis* 4.62 %, 9.21 %, 15.78 %. The genus *Metapenaeus* with seven species, followed by genus *Penaeus* with fourth

species were the most diverse. *M. moyebi* were caught all year round in the Outer Songkhla Lake with an abundant peak in December (Figure. 4).

The salinity in rainy season ranged from 5.75 to 24.5 ppt. with the average of 13.34 ppt. Catches of *M. moyebi* were mainly in rainy season. *M. moyebi* was most abundant in the estuarey. The *M. moyebi* was the most widespread of the species in the gulf or estuary. Generally, salinity in Songkhla Lake decreases in rainy season due to the freshwater input from rivers.

By contrast, many factors influence the migration of shrimps from estuarine systems. Increased temperature was considered to influence emigration of penaeid shrimps St Lucia estuary, Southern Africa (Joubert and Davies, 1966). The process seems to be influenced by a number of factors, including lunar phase, salinity and temperature (Subramaniam, 1990). According to Odum (1953) stated that freshwater organisms share the estuarine environment with marine organisms up to salinities of 3.5 ppt. and that it is not correct to say that marine species at these salinities. Therefore, when the environment changes, the community structure not only responds with the disappearance or recruitment of organisms on the species level, but also a much quicker response occurs in which individuals may move in or out of an area.

Species composition and population abundance in summer season

The summer season covers up to four months in February, March, April and May. The monthly species composition in February 2010; twelve species of penaeid shrimp were found. In February species composition of penaeid shrimp most abundance *M. moyebi* (32.45 %) than other species during summer season.The monthly percentage of species composition, *M. moyebi* 32.45 %, *M. lysianassa* 14.56 %, *P. silasi* 11.13 %nwere found. The genus *Metapenaeus* were found highest abundant in February. *M. moebi* was the dominant species of the genus *Metapenaeus* (Table 1 and Figure.3). The salinity ranged from 1.5 to 7.8 ppt. and monthly averages of salinity 4.18 ppt.

The monthly species composition in March 2010; eleven species of penaeid shrimp were found. In March species composition of penaeid shrimp highest abundance *M. moyebi* (32.41 %) than other species during summer season. The monthly percentage of species composition, *M. moyebi* 32.41 %, *M. ensis* 13.13 % and *P. silasi* 12.44 % were found. The genus *Metapenaeus* were found highest abundant in March. *M. moyebi* was the dominant species of the genus Metapenaeus. In March, the *M. ensis* was the predominant species (Table 1and Figure.5). The salinity ranged from 6.8 to 22.2 ppt. and monthly averages of salinity 14.49 ppt.

The monthly species composition in April 2010; fourteen species of penaeid shrimp were found. In April species composition of penaeid shrimp highest abundance *M. moyebi* (39.21 %) than other month and many species during summer season. The monthly percentage of species composition, *M. moyebi* 39.21 %, *M. ensis* 12.27 %, *P. silasi* 11.08 % were found. The genus Metapenaeus were found highest abundant in April. *M. moyebi* was the dominant species of the genus *Metapenaeus*. In April the *M. ensis* was the followed dominant species (Table 1and Figure.5). The salinity ranged from 12.8 to 30.3 ppt. and monthly averages of salinity 22.7 ppt.

The monthly species composition in May 2010; eleven species of penaeid shrimp were found. In May species composition of penaeid shrimp highest abundance *M. moyebi* (36.71 %) than other species during summer season. The monthly percentage of species composition, *M. moyebi* 36.71 %, *M. ensis* 12.18 %, , *P. merguensis* 10.82 % were found. The genus Metapenaeus six species were found for the most part abundant in May. *M. moyebi* was the dominant species of the genus *Metapenaeus*. In this month the *M. ensis* was the followed dominant species (Table 1and Figure.5). The salinity ranged from 9.4 to 26.5 ppt. and monthly averages of salinity 15.19 ppt.

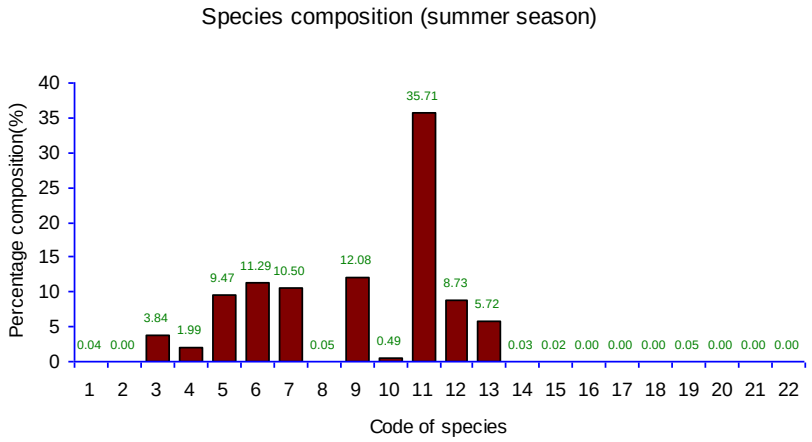


Figure 5. Percentage of penaeidae species composition in summer season.

The composition of penaeid species caught from February 2010 to May 2010 was summarized in Table1 and Figure 12. The time period in south of Thailand was summer season. Most of area in Songkhla Lake covered by dry season and the water quality reach to the brackish water or saline water. About the end of summer, depending upon weather conditions the rainfall can fill water into the Songkhla Lake which effected the aquatic animal to move to the

Songkhla Lake. The monthly pattern of the species abundance in relation to rainfall showed variations of species composition during the study period.

Fifth teen species of the family; *Penaeidae; P. latisulcatus P. monodon, P.semisulcatus, P. merguensis, P. silasi, M. lysianassa, M. intermedius, M. ensis, M. affinis, M. moyebi, M. brevicornis, M. tenuipes, M. stidulan, M. barbata and P. sculptilis* were found in summer season. *M. moyebi* represented the highest in all summer season with species composition of 32.45 %, 32.41 %, 39.21%, 36.71 % followed by *Metapenaeus ensis* 10.64 %, 13.13 %, 12.27 %, 12.18 %. The genus *Metapenaeus* with seven species and followed by genus *Penaeus* with five species were the most diverse. *M. moyebi* were trapped all year round at the Outer Songkhla Lake with an abundant peak in December and were found all year. Monthly densities of penaeid shrimp were showed variations in number of species and the number of shrimp. Seasonality and abundance fluctuations for the peneaids species were exposed in Table 1and Figure 3.

The salinity in summer season ranged from 8.88 to 21.5 ppt. with the average of 14.14 ppt. The monthly pattern of abundance in relation to salinity showed in each month. According, *M. moyebi* showed high abundance all month in summer season. In general, the Juvenile shrimps are abundantly occurring in the moderate salinity. Hence the discharge of freshwater in the estuarine system is essential for the growth of many shrimp species. Any action to change the freshwater sources may affect the shrimp distribution. According, the osmotic stress caused by low salinity waters in the lagoon during the periods of high precipitation, may stimulate emigration of shrimps, resulting in a decline in lagoon catches and an increase in stake net catches. A similar relationship between the emigration of shrimps from estuaries and the decline of salinity levels during periods with high precipitation was reported by Jayakody and Costa (1988). In general, salinity is one of the most important environmental factors affecting growth, survival and development of aquatic organisms. In nature, mature penaeid shrimps normally spawn at oceanic salinities where the newly hatched larvae also complete their larval development.

Species composition and population abundance in the interseasonal period

The interseasonal period cover up four months in June, July, August and September. The monthly species composition in June 2010; ten species of penaeid shrimp were found. In June, species composition of the penaeid shrimps, the high abundance, *M. moyebi* (29.98 %) was found more than other months and other species during the interseasonal period. The monthly

percentage of species composition *M. moyebi* 29.98 %, *P. silasi* 13.01 % and *M. brevicornis* 12.14 % were found. The genus Metapenaeus were found more abundant in June. *M. moyebi* was the dominant species of the genus *Metapenaeus* (Table 1 and Figure.6). The salinity ranged from 8.6 to 25.7 ppt. and monthly averages of salinity 15.63 ppt.

The monthly species composition in July 2010; ten species of penaeid shrimp were found. In July, species composition of penaeid shrimps towering abundance *M. moyebi* (34.12 %) than other species during the month. The monthly percentage of species composition, *M. moyebi* 34.12 %, *P. merguensis* 14.46 % and *P. silasi* 13.02 % were found. The genus Metapenaeus five species were found for the most part abundant in July. *M. moyebi* was the dominant species of the genus Metapenaeus. In this month the *P. merguensis* was the followed dominant species. Some period the *M. ensis* were raising abundance to the highest abundance (Table 1 and Figure.6). The salinity ranged from 21.1 to 33.9 ppt. and monthly averages of salinity 27.99 ppt.

The monthly species composition in August 2010; fifteen species of penaeid shrimp were found. In August, species composition of penaeid shrimp high abundance *M. ensis* (35.28 %) than other species during the month. The monthly percentage of species composition, *M. ensis* 35.28 % *M. moyebi* 14.08 % and *M. brevicornis* 12.85% were found. The genus *Metapenaeus* seven species were found for the high abundant in August. *M. ensis* was the dominant species of the genus *Metapenaeus* (Table 1 and Figure.6). The salinity ranged from 26.3 to 34.5 ppt. and monthly averages of salinity 30.32 ppt.

The monthly species composition in September 2010; seventeen species of penaeid shrimps were found. In September, species composition of penaeid shrimp high abundance *M. moyebi* (40.32 %) than other month and many species during the interseason period. The monthly percentage of species composition, *M. moyebi* 40.32 %, *M. ensis* 16.48 %, *P. merguensis* 10.84 %, were found. The genus *Metapenaeus* were found more abundant in September. *M. moyebi* was the dominant species and found all year of the genus *Metapenaeus* (Table 1 and Figure.6). The salinity ranged from 18.6 to 30.8 ppt. and monthly averages of salinity 24.71 ppt.

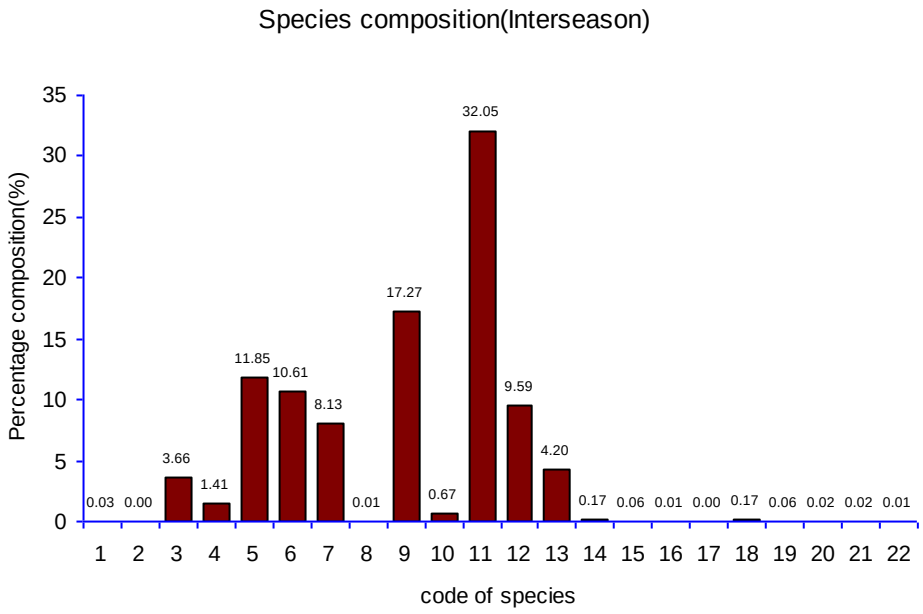


Figure 6. Percentage of penaeidea species composition in interseasonal period.

The composition of penaeid species caught from June 2010 to September 2010 was summarized in Table 1 and Figure 6. The salinity in interseasonal period ranged from 20.05 to 31.025 ppt. and season averages of salinity 24.67 ppt. The time period in south of Thailand was the interseasonal period. Most of area in Songkhla Lake covered by wet season and the water quality reach to the brackish water or saline water. At the end of interseasonal period depending upon weather conditions the rainfall can fill water into the Songkhla Lake which affected the aquatic animal move to the Songkhla Lake. The monthly pattern of abundance in relation to rainfall and the river flow showed variations of species composition during study period.

Twenty species of the family; *Penaeidae*; *P. latisulcatus P. monodon, P.semisulcatus, P. merguensis, P. silasi, M. lysianassa, M. intermedius, M. ensis, M. affinis, M. moyebi, M. brevicornis, M. tenuipes, M. stidulan, M. barbata, S. crassicornis, P. hardwickii, P. sculptilis, T. sedili, T. malaiana* and *T. pescadoreensis* were found in the interseasonal period. *M. moyebi* represented the highest in the interseasonal period, species composition of 29.98 %, 34.12 %, 14.08 %, 40.32 %. The genus *Metapenaeus* with seven species and followed by genus *Penaeus* with five species were the most diverse. *M. moyebi* were trapped all year round at the Outer Songkhla Lake with an

abundant peak in December and were found all year. Monthly densities of penaeid shrimp were showed variations in the number of species and the number of shrimp. Seasonality and abundance fluctuations for the peneaids species were exposed in Table 1 and figure.3.

Species composition and population abundance in all season

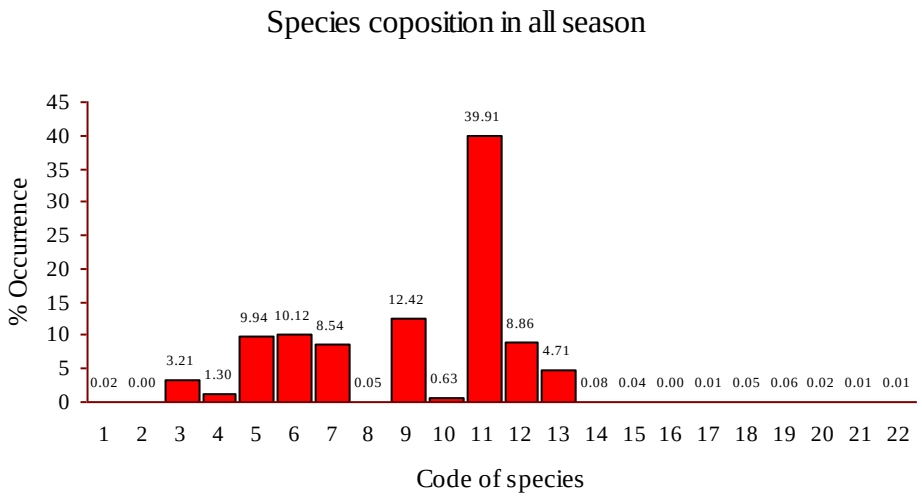


Figure 7. Percentage of penaeidea species composition in all season.

The composition of penaeid species caught from January 2010 to January 2011(13 month) was summarized in Table1and Figuer18. The Penaeid shrimps; *P. monodon, P. merguensis, P.silasi, M. lysianassa, M. ensis, M. moyebi, M. brevicornis and M. tenuipes* were caught also all year around in the Outer Songkhla Lake. A seasonal monthly variation was found for during the study period. *M. Moyebi* were significantly abundant in December, *M. ensis* increased their presence peak in August. *P. merguensis* and *M. lysianassa* abundant all year. While *P. latisulcatus, M.intermedius, M. stridulans, M. babrata, P. hardwickii, P. scultilis, T. sedili, T. malaiana* and *T.pescadoreensis* were present in some month and a few number during the study period. *P. japonicus S. crassicornis* and *P. hungrfordi* ewre found only once upon a time in all season. The genus *Metapenaeus* with seven species; *M. moyebi* (39.91%), *M. ensis* (12.42%), *M. brevicornis* (8.86 %), *M. lysianassa* (8.54 %), *M. tenuipes* (4.71 %), *M. affinis* (0.63 %) and *M. intermedius* (0.05 %) were institute the varied and representative. Only *M. Moyebi* and M. ensis occurred

in most numbers every time. Only a few individuals of *M. intermedius* were caught during the study. The genus *Penaeus* with six species; *P. silasi* (10.12%), *P. merguiensis* (9.94%), *P. monodon* (3.21 %)**,** *P. semisulcatus* (1.30%), *P. latisulcatus* (0.02%) and *P. japonicus* (0.003%) were found the follow abundance. *P. silasi* and *P. merguiensis* most abundance than other species (Figure. 7).

The salinity in all season period ranged from 5.75 to 31.025 ppt. and season averages of salinity 17.38 ppt. Penaeid shrimps were the most abundant penaeid species inside the Outer Songkhla Lake complex, spending more time inside of the lagoon than previous reports suggested. Following Dall *et al*. (1990), salinity responses are also involved in the emigration of some species of penaeids from estuaries. In nature, Penaeids spend most of their life in contact with the sea bottom. The salinity of the Outer Songkhla Lake showed a strong seasonal trend with lower salinity in the wet season when there was a dilution effect due to rain-water. This is a complex environment with many features that may be of importance to penaeids. Bottom structures such as seagrass play a significant role in defence from predation and in habitat selection. The substratum itself has several properties that may influence penaeids that burrow into it and feed on it: particle size distribution, pore space and porosity, water content, thixotropy and shear strength, as well as organic content and the presence of other organisms. In contrast, *Metapenaeus monoceros* exhibited a significant preference for sand flat habitats over mangroves. As the high tide entered the mangrove forest, this species remained on the adjacent sand flat at a ratio of almost 4:1. Another Mozambican study found M. monoceros to be widespread, occurring on seagrass, mangrove and mud flat habitats (de Freitas, 1986).

The character of habitats that supply greater numbers of recruits to adult populations has considerable implications for fisheries management. Lagoons are critical transition zones providing essential ecological functions. As its life cycle differs from the known schema, a different management strategy should be implemented. Zoning the oceans into unfished marine reserves and areas with limited levels of fishing effort would allow sustainable fisheries, based on resources embedded in functional, diverse ecosystems (Pauly, 2002). Spurring a United Nations resolution on restoring fisheries and marine ecosystems to healthy levels (United Nations, 2002). We found a migration passage between the Outer Songkhla Lake and the sea. For this reason, Songkhla Lake the represents the most important habitat area for Penaeid shrimps.

Conclusion

The community of crustacean in coastal lagoons is strongly influenced by abiotic factors. The sandbar opening, as an aperiodic phenomenon, strongly influences the composition and density of these organisms in Songkhla Lake, for the alteration in the salinity levels caused by the inflow of seawater promotes the alternation of larvae from marine and continental species.

The present study has revealed that *Metapenaeus* sp. is the most dominant shrimp species in the coastal waters of the Outer Songkhla Lake, followed by *Penaeus* sp. (Table 1).Twenty-two species from 6 genera of Penaeidae were reported from the present study. They are: large size shrimps and small size shrimps. Penaied shrimp catches and distribution among the habitats, most species captured in the study area were of economic importance. *M. moyebi* were dominant of the catches while *P. merguensis* and *M. ensis* were found in all seasons. This pattern of adult Penaeid shrimps abundance does not reflect the pattern of the abundance found for the juvenile population in the shrimp fisheries at Songkhla Lake.

Penaeid shrimps distributed among the sampled habitats. This suggests different habitat preferences between the species and that of the nursery habitat requirement for the juvenile penaeid species this is not necessarily the same as for the adults. This result also emphasises spatial partitioning among the species captured, which reduces competition for space and food. In general, the shrimps were significantly more abundant in mud flats and sand-flats compared to other habitats. However, some species appear to be more widespread, foraging over much wider areas. Nevertheless, care should be taken when comparing catches at different locations and times of sampling, which may cause differences in Penaeid shrimp abundances due to tidal height.

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References

Bindu, R. P. and Diwan, A. D. (2002). Effects of acute salinity stress on oxygen consumption and ammonia excretion rate of the marine shrimp Metapenaeus monoceros. Journal of Crustacean Biology 22:45-52.

Cooper, J. A. G., Wright, C. I. and Mason, T. R. (1999). Geomorphology and sedimentology. In. Allanson, B. R.and Baird D., (Eds.), Estuaries of South Africa. Cambridge: Cambridge University Press.

Dall, W., Hill, B. J., Rothlisberg, P. C. and Staples, D. J. (1990). The Biology of the Penaeidae. In: Blaxter J. H. S. and Southward A. J. (Eds.), Advances in Marine Biology 27:1-489.

Day, J. H. (1951). The ecology of South African estuaries. Part I. A review of estuarine conditions in general. Transactions of the Royal Society of South Africa 23:53-91.

Day, J. H. (1964). The origin and distribution of estuarine animals inSouth Africa. In Davis, D. H. S. (Ed.), Ecological studies in southern Africa. The Hague: W. Junk. pp.159-173.

Day, J. H. (1967). The biology of Knysna Estuary, South Africa. In Lauf, G. H. (Ed.), Estuaries. Washington, DC.

Freitas, A. J. (1986). Selection of nursery areas by six Southeast African Penaeidae. Estuarine, Coastal and Shelf Science 23:901-908.

Holthuis, L. B. (1980). FAO species catalogue. Vol. 1 Shrimps and prawns of the world. FAO Fisheries Synop 125:1-271.

Garcia, S. and Le Reste, L. (1981). Life cycles, dynamics, exploitation and management of coastal penaeid shrimp stocks. FAO Fisheries Technical Paper. pp. 203.

Garcia, S. (1984). A note on environmental aspects of penaeid shrimp biology and dynamics. In: Gulland, J. A. and Rothschild, B. J. (Eds.), Penaeid Shrimps Their Biology and Management. Farnham, UK: Fishing News Books Ltd.

Garcia, S. (1985). Reproduction, Stock Assessment Models and Population Parameters in Exploited Penaeid Shrimp Populations, In: P.C. Rothlisberg and H.P. Staples (Eds.), Second Australian National Prawn Seminar, Cleveland, Australia. pp. 139-158.

Jayakody, D. S. and Costa, H. H. (1988). Population dynamics of Indian shrimp (*Penaeus indicus*, Milne Edwards) on the west coast of Sri Lanka. Asian Fisheries Science 1:135-146.

Joubert, L. S. and Davies, D. H. (1966). The Penaeid Prawns of the St. Lucia Lake System. Investigation Report. Vol. 13. Oceanography Research Institute of South Africa, Association of Marine Biological Research. pp. 40.

King, M. (1995). Fisheries biology assessment and management. Blackwell Science Ltd. (Fishing News Books), Osney Mead, Oxford.

McLusky, D. S. and Elliott, M. (2004). The estuarine ecosystem: ecology, threats and management. Oxford: Oxford University Press.

Myers, R. A. and Worm, B. (2003). Rapid worldwide depletion of predatory fish communities. Nature 423:280-283.

Odum, H. T. (1953). Factors controlling marine invasion into Florida fresh waters. Bulletin of Marine Science 3:134-156.

Pauly, D. (2002). Towards sustainability in world fisheries. Nature 418:689-695.

Richmon, R. (2002). A field guide to the seashores of eastern Africa and the western Indian Ocean Islands. Second edition. Sida, Sweden and University of Dares Salaam, Tanzania. pp. 461.

Subramaniam, S. (1980). Studies on penaeid prawns with special reference to the nursery environment. (Doctor of Philosophy's Thesis). University of Dar es Salaam.

Subramaniam, S. P. (1990). Chwaka Bay (Zanzibar, East Africa) as nursery ground for penaeid prawns. Hydrobiologia 208:111-122.

United Nations (2002). World Summit on Sustainable Development: Plan of Implementation. New York.

Worm, B., Lotze, H. K., Hillebrand, H. and Sommer, U. (2002). Consumer versus resource control of species diversity and ecosystem functioning. Nature 417:848-851.

Worm, B. and Myers, R. A. (2003). Meta-analysis of cod-shrimp interactions reveals topdown control in oceanic food webs. Ecology 84:162-173.