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Hyperbenthic community and its trophic significance to *Silago sihama* and *Toxotes chatareus* in Palian mangrove estuary, Trang Province, Thailand

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ABSTRACT

Aims: Hyperbenthos is a small animal living in water column above the bottom surface. They play an important role in the trophodynamics of coastal environments, as predator and prey. However, study of hyperbenthos in Palian mangrove estuary was scare. The aims of present study are to determine the diversity and abundance of hyperbenthos in the Palian mangrove estuary, to investigate the feeding ecology of *Silago sihama* and *Toxotes chatareus* in the Palian mangrove estuary, and to elucidate the trophic role of hyperbenthos for benthic fish, *S. sihama* and *T. chatareus*, in the Palian mangrove estuary.
Methodology and results: Hyperbenthos and fishes were collected on 19-20 February 2015 using a sledge net (500 µm) and fish trap, respectively. A total of 19 hyperbenthos groups, belonging to seven phyla were found. Cumaceans were the major compartment of hyperbenthos community followed by prawns, mysid shrimps, polychaetes and crabs. Stomach content analysis revealed that both *S. sihama* and *T. chatareus* were carnivorous which fed mainly on polychaetes, prawns, crabs and other benthic organisms.
Conclusion, significance and impact of study: It can be concluded that hyperbenthos in Palian mangrove estuary are in high diversity and they are importance food source to *S. sihama* and *T. chatareus* in Palian mangrove estuary, Trang Province, Thailand.

Keywords: Hyperbenthos, mangrove estuary, *Silago sihama*, stomach content, *Toxotes chatareus*

INTRODUCTION

Mangroves are important ecosystems along the coastal areas of tropical and subtropical regions. The mangrove ecosystems support a variety of living organisms (Chong, 2007), including the valuable fisheries resources. In other words, the mangroves serve as habitat and feeding ground for many living organisms. From the previous study, Ramarn *et al.* (2015b) reported that zooplankton including the larval stages of fish, crabs and prawns were abundant and diverse in the Palian mangrove estuary. Ramarn *et al.* (2017) reported that there were more than 30 species of fish found in the Palian mangrove estuary and most of them are commercially important. Thus, the mangrove ecosystems are very important as a nursery habitat especially for juvenile fish.

Hyperbenthos are also called as suprabenthic fauna or demersal benthic zooplankton, includes small swimming animals, mainly crustaceans, is the faunal element of the benthic boundary layer, which living in the lowest strata of the water column and dependent on the proximity of the bottom (Mees an Jones, 1997). Hyperbenthos plays an important role in the trophodynamics of coastal environments (Mees and Hamerlynck, 1992). They are shaping the benthopelagic community as predator, e.g. feeding on zooplankton (Ramarn *et al*., 2015a). In turn, they serve as prey food for demersal fishes (Mauchline, 1980), thus providing a trophic link between primary producers and secondary consumers.

In spite of their important role in the coastal ecosystem, hyperbenthos are poorly studied. This is because of their small size, non-economic value, and difficult to identify. Published works on hyperbenthos in Thailand are markedly lacking. Soawapa *et al*. (2005a) reported seasonal variations of hyperbenthos in mangrove and sandy beach, Tanyong Po, Satun Province. In addition, Saowapa *et al*. (2005b) reported diel distribution of the dominant hyperbenthos in Rai Canal, Satun mangrove area. There is no study of hyperbenthos in Palian estuary, Trang province. Therefore, the aims of the present study are to determine diversity and abundance of hyperbenthos in Palian Estuary; to investigate feeding ecology of *Silago sihama* and *Toxotes chatareus* in Palian mangrove estuary and to study the role of hyperbenthos as food source for *S. sihama* and *T. chatareus* in Palian mangrove estuary, Trang province, Thailand. These two species of fishes are common species in Palian mangrove estuary. *Silago sihama* was commercial fish for food while *Toxotes chatareus* is important as an ornamental fish.

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MATERIALS AND METHODS

Sampling area

Palian mangrove estuary is located in coastal of Andaman Sea, Kantang District, Trang Province, southern of Thailand. The southwest monsoon and the northeast monsoon were influenced on seasonal period in this area. The dry season extended from December to April and rainy season from May to November (Tanyaros and Tongnunui, 2011). This mangrove estuary is an important ecosystem in Thailand. Three sample stations were established from station 1 (S1), located at river mouth, through station 2 at the middle estuary and station 3 (S3) at the upper river in the main channel of the Palian river (Figure 1).

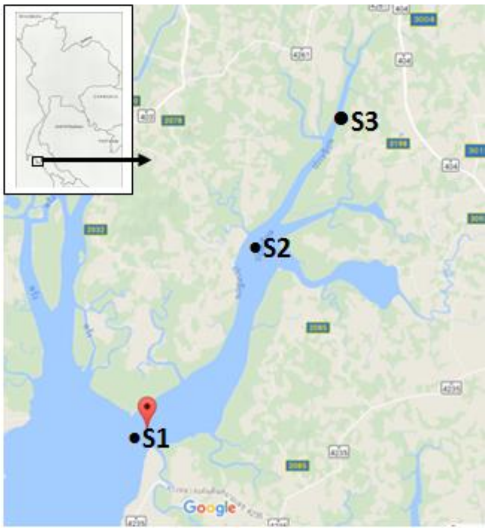

Figure 1: Map showing the sampling area and stations during study period in the Palian Estuary, Tang province, Thailand. S1 = river mouth, S2 middle estuary, and S3 = upper estuary.

Hyperbenthos and fish collections

Hyperbenthos was sampled on 19-20 February 2015, during low tide (spring, new moon) using a sledge net with a 0.53 × 0.16 m mouth area and a 2.35 m long net of 500 µm mesh size. Samplings were carried out during daytime when hyperbenthic animal are known to be concentrated near the bottom (Verslycke and Janssen, 2002). It was pulled over the mud bottom by first paying out a fixed 30 m length of a tow line from the moving boat, stopping the boat, and then pulling in the net by hand onto the desk. The collected sample was completely emptied into the pail before large mangroves and debris were removed, and the entire contents were then washed into 1L sample bottle containing a borax-buffered 4% seawater-formalin solution (Ramarn *et al*., 2012).

Two more replicate samples following the same sampling procedure were also taken. In addition, water quality data such as temperature, salinity, pH, and dissolved oxygen (DO) concentration were measured just above the mud bottom with mutiprobe water quality equipment (YSI Company).

Fish samples were collected using fish trap (Figure 2) at the same site that the hyperbenthos was collected. Fish trap is considered the most appropriate for fishes by local fishermen. Fish traps were set during night-time and in the morning fishes were collected. Then, fish samples were immediately preserved in ice box and transported to the laboratory of Department of Biology, Faculty of Science, Thaksin University.

Figure 2: Fish trap for fish collection using in southern of Thailand. (http://www.kohyaotravel.com/thai/sai.htm).

Laboratory analysis

In the laboratory, hyperbenthos was sorted out and counted under a stereo and compound microscope. All identification was based on external morphological characteristics. Hyperbenthos abundance was expressed as number of individuals per m^2 using equation 1.

Abundance = number of hyperbenthos (individuals)/swept area (m^2) (1)

Where swept area is the sledge net mouth width (0.53 m) x towed distance (30 m) (Ramarn *et al*., 2012).

Fish species were identified and standard length (SL) for each fish individual was measured. Fishes were group in 3 size classes; *Silago sihama* were grouped as small (<13 cm) medium (13-15 cm) and large size (>15 cm) (Tongnunui *et al*., 2005) while *Toxotes chatareus* group as small (<10 cm.) medium (10-15 cm.) and large size (>15 cm.) (Simon and Mazlan, 2006). After that, stomach was removed and preserved in 4% formalin solution. The stomach contents were analyzed under the microscope and quantified according to Hyslop (1980). Stomach contents were sorted taxonomically and counted using light microscope (400×) after the food items settle down on the slide. Two transects (about 100 fields) were examined on a slide. The frequency of occurrence was determined by recording the number of stomachs containing each food item divided by the total fish stomachs examined (%Frequency of Occurrence) (Lin *et al*., 2007). The weight

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of a consumed item was then measured by using an electronic balance (Sartorius, BSA2245-CW).

Data analysis

The weight of a consumed item taken by a fish population was given as a percentage of the total weight of the stomach content (%W). Using both frequency of occurrence and weight percentage for a consumed item can provide an indication of the homogeneity of feeding within a fish population (Hyslop, 1980). Empty stomachs of fishes were excluded from analysis. However, percentage of empty stomach was calculated using equation 2.

% empty stomach = (empty stomach/No. of stomach) x 100 (2)

Analysis of Variance (ANOVA) was conducted to compare the differences in water parameters and hyperbenthos abundance among sampling stations at p<0.05. All data sets were first tested for normality and homogeneity as a required for parametric analysis (Sokal and Rohlf, 1998).

RESULTS AND DISCUSSION

Water parameters

Results of water parameters were presented in Table 1. Water temperatures were stable for all sampling station (27.01±0.03 °C). Salinity showed a clear horizontal gradient along the river with the lowest mean recorded at the upper estuary (15.17±0.90 ppt) and the highest mean at the river mouth (25.45±0.10 ppt). Mean DO was significantly lowest at the upper estuary (3.55±0.85 mg/L) compared to mid- and lower estuaries (p < 0.05). There was no significant difference in mean DO between S1 and S2 (p > 0.05).

Table 1: Water parameters during 19-20 February 2015 at Palian estuary, Tang Province. S1 = river mouth, S2 = middle estuary, and S3 = upper estuary.

Water quality	S1	S2	S3
Temp. (°C)	29.50±0.09	29.78±0.04	29.03±0.06
pH	7.54±0.02^a	7.24±0.02^a	6.89±0.02^b
Salinity (ppt)	25.45±0.10^a	23.59±0.08^b	15.17±0.90^c
DO (mg/L)	8.90±0.28^a	7.80±0.30^a	3.55±0.85^b

Values (a, b, c,) on the same row with different superscript are significantly different (p < 0.05) while those with same superscript are not significantly different (p > 0.05).

Hyperbenthos abundance and composition

A total of 19 hyperbenthos taxa belonging to seven phyla were found: Nematoda, Annelida (polychates), Mollusca (gastropod and bivalve larvae), Arthropoda (ostracods, cumaceans, isopods, amphipods, sergestids, mysids (chiefly *Notacanthomysis hodgarti*), caridean prawns (*Palemonetes* sp.), branchyuran (both zoea and megalopa stages), Chaetognatha (*Sagitta* sp.), Echinodermata (brittle star larvae) and Chordata (fish larvae).

Percentage composition of the hyperbenthos is presented in Figure 3. The Phylum Arthropoda was numerically dominant (76% of hyperbenthos composition) followed by Phylum Annelida (7%), Nematoda (6%), and Chaetognatha (5%). Phylum Mollusca, Echinodermata and Chrodata altogether represented <6% of the overall hyperbenthos composition.

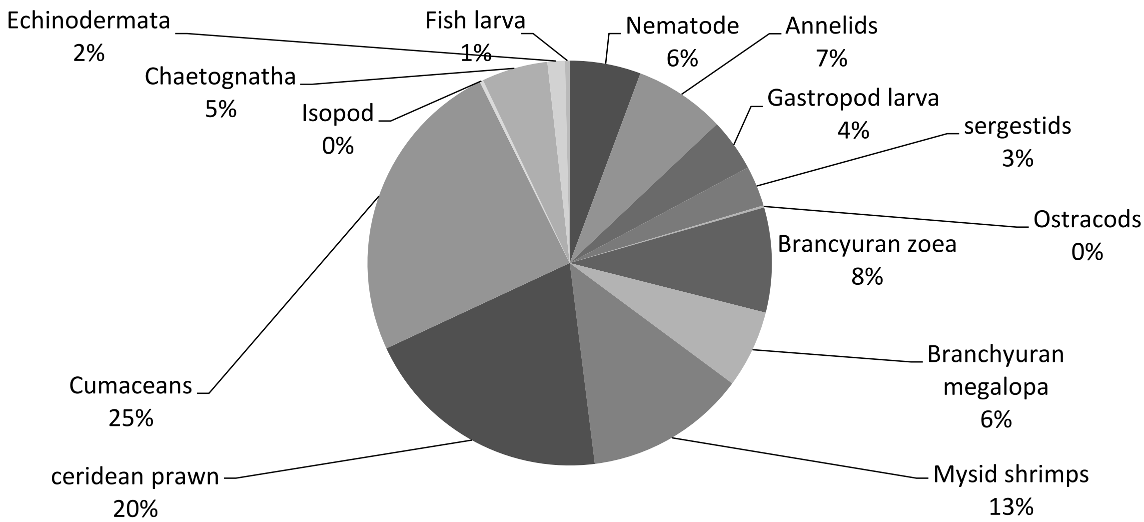

Figure 3: Overall percentage composition of hyperbenthos in the Palian estuary, Trang Province, during study period.

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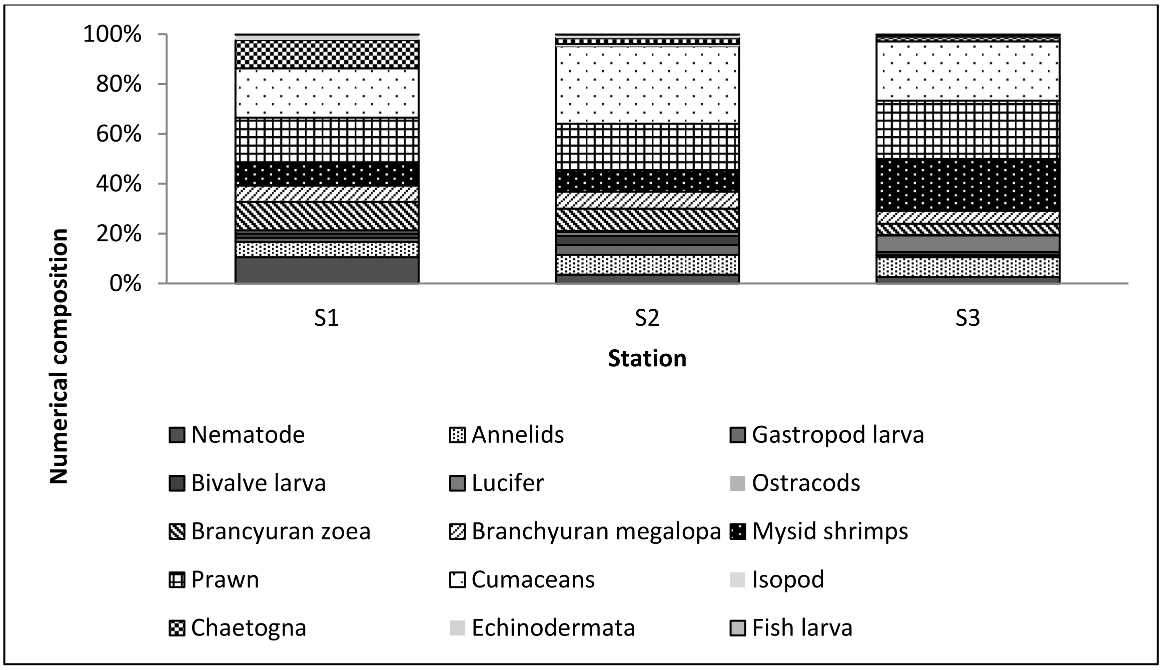

Figure 4: Hyperbenthos composition based on sampling stations at Palian Estuary, Trang Province, during February 2015. Station S1= river mouth, station S2 = middle estuary and station S3 = upper estuary.

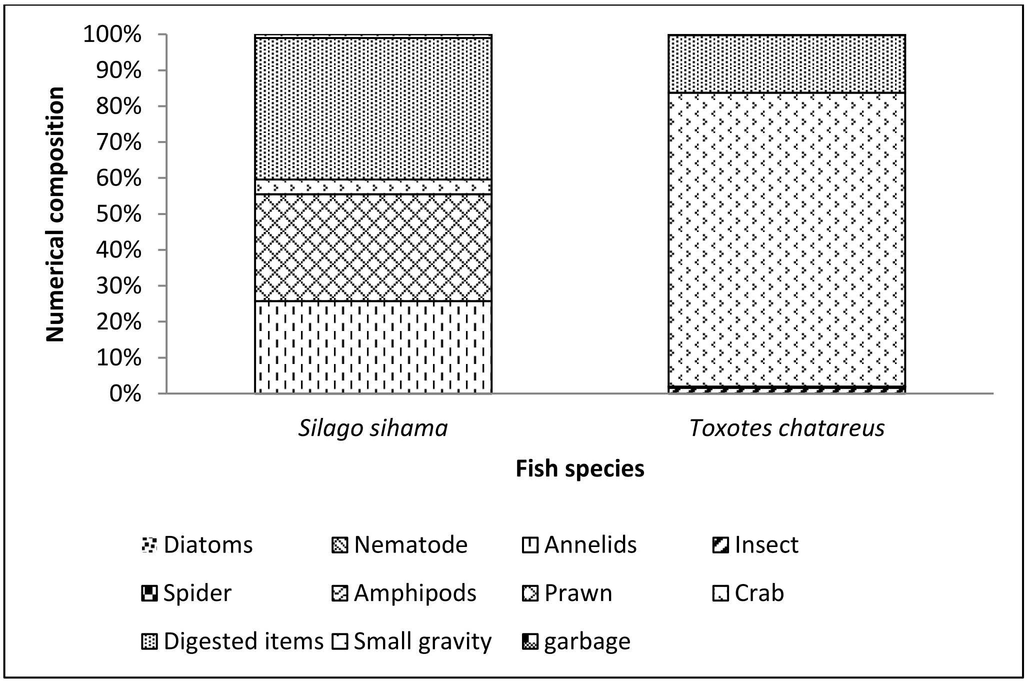

Figure 5: Weight composition (%W) of food items for *Silago sihama* and *Toxotes chatareus* (combined size classes) in the Palian estuary.

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Table 2: Frequency of occurrence (%FO) and weigh composition (%W) of food items in stomach contents of *Silago sihama* and *Toxotes chatareus* according to different size classes.

Food items	*Silago sihama*				*Toxotes chatareus*					
	small		medium		small		medium		large	
	%FO	%W	%FO	%W	%FO	%W	%FO	%W	%FO	%W
Diatoms	16.0	<0.01	0.0	0.00	0.0	0.00	8.0	<0.01	0.0	0.00
Nematode	0.0	0.00	11.1	0.00	4.0	<0.01	8.0	<0.01	0.0	0.00
Polychaetes	72.0	31.66	33.3	18.30	0.0	0.00	0.0	0.00	0.0	0.00
Insect	0.0	0.00	0.0	0.00	60.0	3.20	52.0	1.54	66.0	1.54
Arachnida	0.0	0.00	0.0	0.00	4.0	1.14	0.0	0.00	0.0	0.00
Amphipods	0.0	0.00	0.0	0.00	4.0	0.14	0.0	0.00	0.0	0.00
Caridean prawns	28.0	26.45	51.8	33.81	0.0	0.00	4.0	0.20	0.0	0.00
Crabs	12.0	1.92	7.4	6.88	72.0	75.85	76.0	81.41	33.0	50.30
Digested materials	100	38.03	100	41.01	56.0	19.6	88.0	16.37	66.0	48.10
Non-living materials	8.0	1.94	0.00	0.00	0.0	0.00	4.0	0.42	0.0	0.00

The composition of hyperbenthos varied among stations (Figure 4). Cumaceans were the most dominant group at all sampling station (20-31% of heperbenthos composition) followed by caridean prawns (18-23%), and mysid shrimps (8-21%)***.***

ANOVA results showed that there was no significant difference (*p*>0.05) in total abundance of hyperbenthos among stations. Mean density of hyperbenthos was 13.10±5.42 (S1), 11.51±4.69 (S2) and 12.44±4.85 (S3), respectively. However, the species-specific abundance of hyperbenthos showed a great spatial variation in the Palian estuary. Nematodes, branchyuran zoea and chaetognatha were more abundant at the more saline water of river mouth (S1). Molluscs and cumaceans were more abundant at the mid-estuary, while sergestid shrimp, caridean prawns and mysids preferred less saline water at the upper estuary (S3).

Dietary composition of *Silago sihama* and *Toxotes chatareus*

Stomach contents of 75 *Silago sihama* and 54 *Toxotes chatareus* were examined, respectively. Out of all fish stomachs examined, 30.67% of *S. sihama* and 28% of *T. chatareus* were empty. A broad range of food items were found in fish stomachs, including diatoms, nematodes, polychaetes, caridean prawns, insects, amphipods, crabs and unidentified digested materials. A small proportion of non-living materials (foam and plastics) were also found in fish stomach (Table 2).

In general, both fish were carnivores, feeding mainly on animal preys. However, the animal food items differed between both species. *Silago sihama* (combined all size classes) preferred polychaetes (~25%W) and caridean prawns (~30%W), while *Toxotes chatareus* preferred crabs (up to 81.74%W) and insects (~2%W) (Figure 5).

Dietary composition among size classes was also determined. With the exception of the large size class, *Silago sihama* were found only two size class; small and medium size. *Silago sihama* showed an ontogenetic shift in diet composition while *Toxotes chatareus* was not. For *S. sihama*, the most common stomach content in small size were Annelids, prawn and crab while prawn was the most common food items followed by Annelids and crab. On the other hand, crab was the highest percentage composition in *T. chatareus* for all size classes (Table 2).

DISCUSSION

The hyperbenthos in the Palian mangrove estuary show distinctive spatial distributional pattern, with some specie clearly separated by specific habitats in the mangrove**.** Isopods and *Sagitta* sp. were found only at the river mouth where mean salinity of 25.45±0.10 ppt. Spatial distribution pattern has previously been reported in other estuaries (Azeiterio and Marques, 1999; Grabe *et al*., 2004)***.*** Salinity controlling hyperbenthos spatial distribution has been reported from Matang mangrove, Malaysia (Ramarn, 2015)***.*** In Matang mangrove, *Gangeomysis assimilis* and *Rhopalothalmus hastatus* were found in upstream, while *Mesopodophsis orientalis* and *R. orientalis* were found at the river mouth.

The results from present study indicated that *Silago sihama* in Palian mangrove estuary is carnivorous feeding mainly on the polychaetes, caridean prawn and other benthic organisms. Most food items reported for *S***.** *sihama* from Kwazulu-Natal, South Africa (Weerts *et al*., 1997), Karachi, India (Khan *et al*., 2014), Persian Gulf (Motlagh *et al*., 2012) and Sikao Bay, Tang Province, Thailand (Tongnunui *et al*., 2005) were also reported as carnivorous (consumed on animal preys)***.*** However, diet composition for *S. sihama* showed variation among regions. Motlagh *et al*. (2012), Tongnunui *et al*. (2005) and Hajisamae *et al*. (2006) found high number of diatoms and copepods in the stomach of *S. sihama* (SL= 0-10 cm), however, these food items were not found from present study.

In the present study, *Toxotes chatareus* fed on a variety of food items such as crabs (81.74%W) and terrestrial arthropods (e.g. insects and arachnid, ~2%W). Our results for *T. chatareus* agreed well with the archer fish from Malaysian (Simon and Mazlan, 2006) estuary. Apart from living organisms, *T. chatareus* also consumed non-living material for example small piece of foam and plastics. This non-living material may be accidentally ingested by fish. In recent years, increasing plastic pieces are found in several fish such as *Xiphias gladius*, *Thynnus thunnus* and *T. alalunga* collected from Mediterranean Sea (Romeo *et al*., 2015).

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Results of stomach contents of *Silago sihama* and *Toxotes chatareus* in the present study showed that both fish species preferred animal preys which are not the most abundant group in the Palian estuary. Although cumacean is numerically dominant, both of the fish species preferred the decapods and mysids. This result may be suggested that both fish species, *S. sihama* and *T. chatareus*, are selective feeder instead of opportunistic feeders in the Palian mangrove estuary. Both fish were selective feeder because they selected the prey item which not most abundant in water column. These size classes of fish may be select only the large prey size. Weerts *et al*. (1996) reported juvenile *S. sihama* feed on diatoms and copepod. Ontogenetic shift in diet composition of *S. sihama* may be results from changing in digestive system organ e.g. increase in mouth gap size that has been found in other fish (Weerts *et al*, 1996; Wongchinawit and Paphavasit, 2009).

CONCLUSION

Nineteen taxa of hyperbenthos were found during present study. Phylum Arthropoda was the main component of hyperbenthos composition. *Silago sihama* and *Toxotes chatareus* are carnivorous feeders, feeding mainly on benthic organisms, especially polychaetes, caridean prawn and crabs. These results confirmed the importance of hyperbenthos as food source for fish in the Palian mangrove estuary.

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