Community structure of nekton in the waters around Dongtou Island in Autumn of 2019

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Abstract. Resource distribution characteristics of nekton in estuarine waters are related to hydrology, ecological environment changes and anthropogenic factors. A total of 49 species of nekton was found from 10 sites in the estuarine waters around Dongtou Island (DTI), with which the species of fish were in the highest proportion, followed by shrimp and crab. Average nekton biomass and abundance were 522.61 kg/km² and 28.60×10³ ind./km², significantly higher than that of previous studies. The distribution pattern was highest in the eastern part of DTI, lower in the ORE area, and lowest in the northern part of DTI. The intersection of water currents was an important hydrological factor in forming the high resource density area of nekton. Changes in the number of nekton were driven by the contribution of the two economically valuable dominant species of fish Harpodon nehereus and crab Portunus trituberculatus. The mean value of $H'$ of nekton abundance was higher than that of nekton biomass. The species diversity of nekton in the sea near DTI was relatively low and community structure was in a relatively unstable state. The impact of human development activities on the nekton resources cannot be ignored, further research is essential.

1. Introduction
The waters near estuaries and bays are common areas of baiting, spawning and breeding for anadromous nekton, and a large number of juveniles appeared in estuaries, harbors and shallows in summer and autumn for baiting and fattening and other activities (Day et al., 2012). Some species with large individuals and numbers and high economic value often become the target of coastal fishermen, which has a certain impact on the community structure of nekton in nearby waters. In addition, the community structure of nekton is also closely related to the hydrological environment and climatic conditions of the investigated sea area (Day et al., 2012).

Dongtou Island (DTI) is located in the estuarine area in the southwestern part of the East China Sea, which is rich in islands and marine resources. The runoff of the Oujiang River Estuary (ORE) brings rich nutrients and forms a rich local bait environment, making the Oujiang River estuary fishery in which Dongtou has located a good place for nekton to grow and rich in fishery resources, which also has an important influence on the resource dynamics of the Wentai fishery, the second largest fishery in the offshore East China Sea. Although, Xu (2008a, 2008b, 2009a, 2009b) studied the fish, shrimp and crab species in ORE earlier and mainly focused on the influence of topography and hydrology on quantitative analysis. Yan et al (2018, 2019) studied the fish, shrimp and crab communities in ORE with relatively small scope and limitations. In recent years, various marine engineering constructions and large area of beach reclamation on the islands have led to a certain threat to the ecological environment and fishery resources in the sea area of Dongtou. Therefore, by studying the current status of the nekton community...
2. Materials and methods

2.1. Study area
DTI is located in the offshore subtropical monsoon area in the south of the East China Sea, and the numerous islands' distribution characteristics make the waters have many bays and capes. The nearby Oujiang River is the second largest river in Zhejiang Province of China. Under the influence of runoff, the waters are characterized by many turbulent currents, the nutrients brought by it enable the bait organisms to grow and reproduce in large numbers.

2.2. Sample collection and data analysis
We proceeded a survey cruise with 10 sites in Autumn (October) of 2019 in the waters around DTI, (Fig. 1). An 8-m wide, mouth-opening bottom trawl, with 20 mm cod-end mesh, was towed in mean speed of 3.7 kn for 25 min on average in stepped tows to collect nekton. Nekton in catches were frozen after towing and brought back to home laboratory for biological identification, classification and quantification. Nekton sampling and analysis were in accordance with the National Standard of the People’s Republic of China (GB/T 12763.6-2007). Fish names and classification were based on the classification system of Nelson (2006). The name and classification of crustaceans were based on the book of Checklist of Marine Biota of China Seas (Liu, 2008).

The original survey data of nekton were standardized before data analysis. Squillidae was classified as shrimp for computational statistical analysis. The density of nekton resources was estimated by sweeping sea area method as follows (Zhan, 1995): 
\[ D = \frac{C}{aq} \]

\( D \) stands for resource density (kg/km\(^2\) or ind/km\(^2\)), \( C \) represents average trawl catch per hour (kg/h or ind/h), \( a \) is the area swept by a trawl per hour (km\(^2\)/h) (i.e., the horizontal width of the trawl net (km) × drag distance (km)), in which the width of the trawl net in this study was 0.8×10^{-2} km; the drag distance was calculated by multiplying the average trawl speed (km/h) with the actual trawl time (h)), \( q \) is the capture rate of trawl net, which was selected as 0.5 in this study.

The dominant species was determined by the Index of Relative Importance (IRI): 
\[ IRI = (W + N) \times F \]

\( W \) is the percentage of a species’ biomass in the total biomass, \( N \) is the percentage of a species’ abundance in the total abundance, \( F \) is the frequency of a species’ occurrence in all sites.

We explored the diversity of nekton using parameters of Shannon-wiener diversity index \( H' \), Pielou evenness index \( J' \) and Margalef richness index \( d \), which are defined as the follows (Shannon et al., 1963; Pielou, 1966; Margalef, 1968): 
\[ H' = -\sum_{i=1}^{S} P_i \log_2 P_i \]
\[ J' = H'/\ln S \]
\[ d = (S-1)/\ln N \]

Here, \( P_i \) means the ratio of individual number or weight of species \( i \) in the total number of individuals or total biomass of nekton; \( S \) stands for the species number per site at each sampling period, \( N \) and \( G \) refers to the total nekton number of individuals or biomass of each sampling period.

3. Results & discussion
We found a total of 49 species of nekton (30 fishes, 12 shrimps, and 7 crabs) from 10 sites in the waters around DTI, with which the species of fish were in the highest proportion, followed by shrimp and crab (Table 1). Compared with Xu (2008a, 2008b, 2009a, 2009b, Table 2), the proportion of nekton was consistent, except that there are more species of fish than that of this study. Average nekton biomass was 522.61 kg/km\(^2\), which significantly higher in fish (328.98 kg/km\(^2\)) than in shrimp (48.08 kg/km\(^2\)) (Table 1). Average nekton abundance was significantly higher in fish (13.51×10\(^3\) ind./km\(^2\)) than in crab (6.23×10\(^3\) ind./km\(^2\)). The mean abundance of nekton was 28.60×10\(^3\) ind./km\(^2\) (Table 1). Average nekton biomass in this study was significantly higher than Xu (2008, 2009, Table 2). It maybe associated with inconsistencies in survey timing or the long-term self-repair of fishing grounds after the completion of
marine engineering. The highest ratio of juveniles was crab, followed by fish and lowest in shrimp (Table 1). The high proportion of juvenile crabs may be due to the migration of adult crabs to offshore coastal and estuarine areas for spawning and fattening in autumn (Chao et al., 2015).

For the resource density distribution of nekton in the waters around DTI, the distribution characteristics of biomass were generally consistent with the distribution trend of abundance. The distribution pattern was highest in the eastern part of DTI, lower in the ORE area, and lowest in the northern part of DTI (Fig. 2). The distribution characteristics of nekton are closely related to the ecological habits of nekton and changes in the hydrological environment Xu (2008a, 2008b). In the sea area around Dongtou, there are high temperature and saline water from the warm current of Taiwan in the southeast; coastal water of the East China Sea from the coast of Zhejiang in the northeast; and freshwater runoff from the northern mouth of the Oujiang River in the west (Yao et al, 1998). The high density areas of nektomic resources in the surveyed waters were overlapped with area where water masses intersected, so we believed that the intersection of water currents was an important hydrological factor in forming the high density area of nekton in the eastern part of DTI. Further, the diversity of seafloor topography (shoals, reefs and deep troughs), substrate quality (sandy, silty) and current environment (eddies, turbulence and upwelling) among the islands near Dongtou provided a suitable habitat for most of the nekton, the number of nekton was significantly higher than other areas (Fig. 2).

The species of nekton with \( IRI \geq 500 \) (dominant species) were regarded as the main species of the community. The mean biomass and abundance of fish \( Harpodon nehereus \) were 104.17 kg/km\(^2\) and 8.51×10\(^3\) ind./km\(^2\), and the \( IRI \) was as high as 4970.16 (Table 3), which became the most important dominant species. As a warm-water coastal species, \( Harpodon nehereus \) entered offshore for baiting in autumn, and thus appeared in the waters around Dongtou at high resource density values. Another more important dominant species was crab \( Portunus trituberculatus \), with the average biomass and abundance were 100.82 kg/km\(^2\) and 5.36×10\(^3\) ind./km\(^2\), and the \( IRI \) was highly of 3803.04 (Table 3). \( Portunus trituberculatus \) has the habit of reproductive and overwintering migration for being a warm-temperate offshore species. In autumn, the water mass intersection affects the Dongtou waters with the \( Portunus trituberculatus \) consisting mainly of newly born juvenile crabs and overwintering adult crabs. Changes in the community structure of nekton were driven by the contribution of these two economically valuable dominant species (Xu, 2008b).

We use the Shannon-Wiener diversity index (\( H' \)), Pielou evenness index (\( J' \)) and Margalef richness index (\( d \)) to analyze the diversity characteristics of nekton community in the waters around DTI, which integrated the richness and evenness of nekton and could measure the ecological diversity and heterogeneity of nekton community. The indices of \( H' \) of nekton biomass were ranged from 1.18 to 3.35, with an average value of 2.56. The mean value of \( H' \) of nekton abundance was 2.87 (2.07-3.86), higher than that of nekton biomass (Fig. 3). On the contrary, the mean value of \( d \) of nekton abundance was significantly lower than that of biomass. The \( H' \) values of nekton in waters outside the island group were much lower than those in waters between and inside the island group, which may be related to the uneven distribution of the dominant species density, resulting in the relatively low diversity of nekton in the waters off DTI, consistent with Xu (2008b). In general, the waters with small area are conducive to the dispersal of residential nekton, but migratory economic nekton tend to seek bait in a wider offshore waters (Blaber & Blaber, 1980). So we could inferred that the aggregation of the absolutely dominant species of \( Harpodon nehereus \) formed a low diversity of nekton in the outer waters of the island group, for it being a migratory economic fish. As a result, the species diversity of nekton in the sea near DTI was relatively low and the community was in a relatively unstable state.

4. Conclusions
A total of 49 species of nekton was found from 10 sites in the estuarine waters around DTI, and the species of fish were in the highest proportion. Average nekton biomass and abundance were 522.61 kg/km\(^2\) and 28.60×10\(^3\) ind./km\(^2\), significantly higher than that of previous studies. The distribution pattern was highest in the eastern part of DTI, lower in the ORE area, and lowest in the northern part of DTI. The intersection of water currents was an important hydrological factor in forming the high density
area of nekton. Changes in the number of nekton were driven by the contribution of the two economically valuable dominant species of fish *Harpodon nehereus* and crab *Portunus trituberculatus*. The mean value of $H'$ of nekton abundance was higher than that of nekton biomass. In general, the species diversity of nekton in the sea near DTI is relatively low and the community is in a relatively unstable state. Even though the resource density has increased compared with historical studies, the impact of human pollution and development activities on the dynamics of nekton resources still cannot be ignored, and a long time-scale follow-up survey study is necessary.

![Study area and sampling sites in DTI, China.](image)

![Spatial distribution of nekton biomass (kg/km²) and abundance ($\times 10^3$ind./km²) in DTI.](image)

### Table 1  
Species composition, biomass and abundance of nekton in DTI. (Mean biomass: kg/km²; Mean abundance: $\times 10^3$ind./km²).

| Group               | Fish | Shrimp | Crab | Total |
|---------------------|------|--------|------|-------|
| Species number      | 30   | 12     | 7    | 49    |
| Proportion (%)      | 61.22| 24.49  | 14.29| 100.00|
| Biomass             | 328.98±256.05 | 48.08±63.46 | 145.55±169.15 | 522.61±432.48 |
| Proportion (%)      | 62.95| 9.20   | 27.85| 100.00|
| Abundance           | 13.51±9.73 | 8.85±10.61 | 6.23±10.34 | 28.60±29.21 |
| Proportion (%)      | 47.25| 30.96  | 21.80| 100.00|
| Ratio of juveniles  | 41.41| 22.85  | 51.30| -     |
Table 2  Historical survey results of species composition, biomass and abundance of nekton in DTI. (Mean biomass: kg/km²; Mean abundance: ×10³ind./km²).

| Group          | Fish (Xu, 2008a, 2008b) | Shrimp (Xu, 2009b) | Crab (Xu, 2009a) |
|----------------|-------------------------|-------------------|------------------|
| Species number | 39                      | 13                | 9                |
| Biomass        | 271.53                  | 32.36             | 73.48            |
| Abundance      | 14.99                   | 10.66             | 3.80             |

Table 3  Characteristics of dominant species in DTI. (Mean biomass: kg/km²; Mean abundance: ×10³ind./km²).

| Group | Species               | IRI   | Biomass   | Abundance |
|-------|-----------------------|-------|-----------|-----------|
| Fish  | Harpodon nehereus     | 4970.16 | 104.17±146.89 | 8.51±6.82 |
| Crab  | Portunus trituberculatus | 3803.04 | 100.82±154.8     | 5.36±9.56 |
| Shrimp| Oratosquilla oratoria | 1984.02 | 47.98±59.63    | 6.24±9.49 |
| Fish  | Collichthys lucidus   | 550.33  | 41.15±46.76   | 2.12±2.92 |

Fig.3  Diversity indexes ($H'$, $J'$ and $d$) in DTI. (a)~(b): diversity index ($H'$), evenness index ($J'$) and richness index ($d$) of nekton biomass and abundance.

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