Assessment of the spatial distribution of plankton and fish resources in Bangka Island waters

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Abstract. The waters of Bangka Island are a unique ecosystem. This causes the emergence of unique aquatic resources, including plankton, zooplankton, and fish resources that are endemic to Bangka Island. The food chain in the ecosystem is influenced by producers, namely phytoplankton, followed by zooplankton functioning as the first consumers and fish resources as the next consumers. The research was conducted in the Bikang River (BK) and Pelawan Nawang River (PL) on August 29 - September 1, 2023, on Bangka Island. There are 6 stations around the waters of PL (3 stations) and 3 stations in BK. The water quality analysis method was carried out by measuring physico-chemical parameters in situ and in the laboratory, plankton were analyzed by identification and calculating abundance using a microscope, while fish were evaluated through morphological and eDNA observations. The results of the study obtained the composition and abundance of the highest classes, namely Zygnemaceae and Bacillariophyceae, while the crustacean class zooplankton increased. Water quality parameters in the form of temperature, pH, dissolved oxygen (DO), and total dissolved solids (TDS) are still in the category of being suitable for the life of aquatic biota. Fishery resources are still widely found, where the highest families are Osphronemidae and Cyprinidae. Thus, the waters of the BK and PL are still suitable for the life of organisms and the food chain process according to the stages from producer to consumer.
Key Words: Bikang, Bangka Island, fishery resources, Nawang, river, phytoplankton, zooplankton.

Introduction. The Bangka Islands, which are the location of the research, are in the Southern Sumatra region. The Bangka Belitung archipelago is famous for its fishery resources, tin mining, and fresh waters in the form of flowing rivers that are connected to other waters. Bangka Belitung Island has an area of around 81,725,06 km^2. The area consists of land and sea (Limbong 2018). Such conditions certainly cause this province to have quite diverse and large potential for fishery resources. Fishery potential is closely related to animal protein sources. The utilization of potential fisheries resources is expected to accelerate development, especially a sustainable fisheries economy, but it must pay attention to the sustainability of fish resources and the environment. The great fisheries potential cannot be separated from the existence of other biota that are sources of energy for fisheries, namely plankton (phytoplankton and zooplankton).

In aquatic ecosystems, plankton plays a very important role, phytoplankton as producers that supply energy to the food web, while zooplankton as the first chain that transfers energy to aquatic ecosystems, both marine and freshwater (Ara et al 2009; Thoha et al 2013). Phytoplankton is eaten by zooplankton, then eaten by small fish and large fish. According to Nybakken et al (2005), zooplankton play an important role as the first chain in energy transfer in the aquatic food web of aquatic ecosystems. (Yurkovskis et al 1999; Domingues et al 2005). The availability of nutrients and changes in their ratio in waters can cause changes in the abundance of phytoplankton and zooplankton, which are meroplanktonic. Meanwhile, meroplanktonic zooplankton are very rarely found, and what is often found are strong vertical migrator zooplankton, such as macroplanktonic copepods and Euphasiidae (Lenz 2000). Predation pressure from zooplankton can reduce the abundance of phytoplankton, and reduced phytoplankton can cause a decrease in the abundance of zooplankton that are their predators (Uye et al 2000; Abmus et al 2009).

Different types of waters result in plankton communities with distinct characteristics (Asriani 2014; Damara et al 2022). Studies of aquatic environmental parameters are very necessary to determine whether the environment is still suitable for the life of aquatic biota (Gaol et al 2017; Aditia et al 2020; Lista et al 2023). Several studies have been conducted on Bangka Island, related to plankton, water quality, and fish resources (Sari et al 2017; Yulianti 2018; Gulo et al 2023).

Material and Method

Description of the study sites. The research was conducted in August-September 2023 on Bangka Island. The research was carried out in two locations, namely the Kurau River Basin, Palalawan Namang Village, Central Bangka Regency, and the Bikang River Basin, South Bangka Regency. The length of the Kurau River is 60.16 km with an area of 657.69 km^2 (Sari et al 2018), and the area of the Bikang River is 199.04 km^2. The first research location is adjacent to the community tin mining area and is located in the Pelawan forest area, which is a buffer for land cover. Tin mining activities occur upstream, while the downstream area is adjacent to oil palm plantations. The second location does not have mining activities either upstream or downstream of the river, but the downstream is also adjacent to the oil palm plantation area. A total of 6 sampling points were used for sampling stations, namely in the Namang River (PL01, PL03, PL04), and the Bikang River (BK01, BK04, and BK05) (Figure 1).

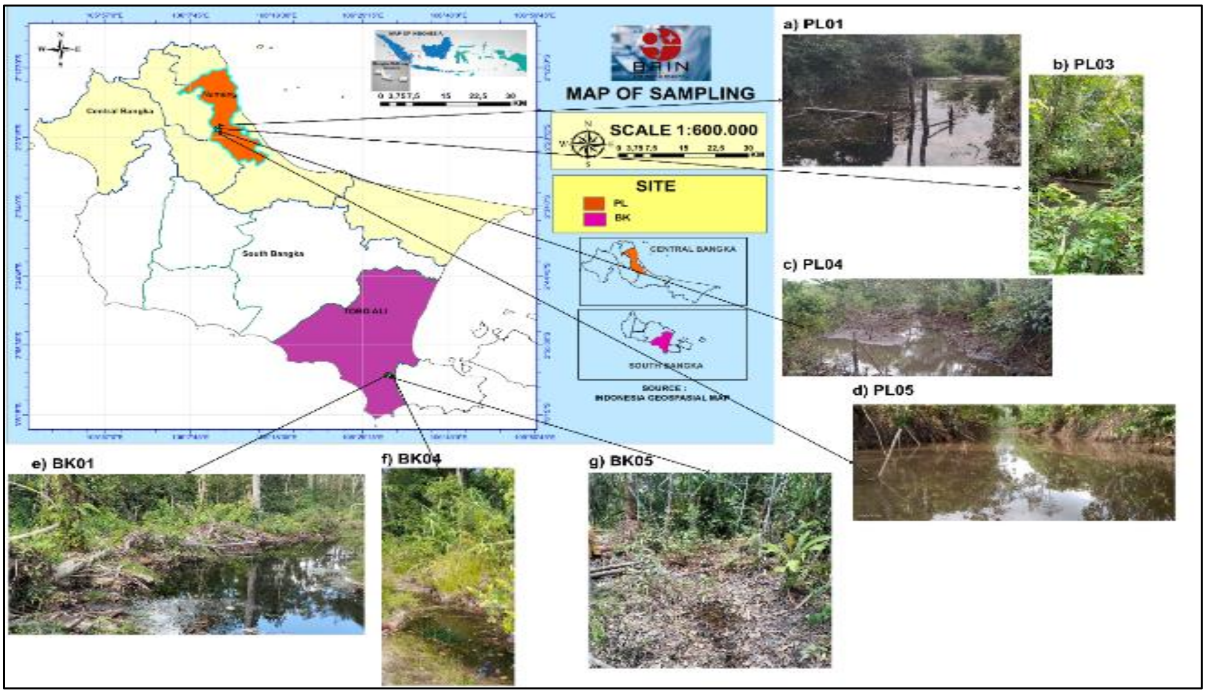


Figure 1. Sampling map in the Bangka Islands, Pelawan Namang River, and Bikang River (BK).

Plankton sampling in the Bangka Islands. Determination of sampling points was carried out using the purposive sampling method. The purposive sampling technique was carried out by determining sample points (stations) with certain considerations, namely, determining points based on different distances and locations (Sugiono 2012; Rizqina 2017). The research method used was quantitative and descriptive. Measurement of water quality parameters was carried out in situ at 6 stations, namely temperature, dissolved oxygen (DO), pH, and total dissolved solids (TDS). Identification of fish samples obtained from fishermen's catches was also carried out using the book (Kottelat 1993) for morphology and eDNA/BLAST. Plankton sampling was carried out in the morning using a 25μm plankton net. Water samples were collected using a plankton net and preserved with Lugol's solution at a 100 mL of water to 1 drop of Lugol's solution ratio. The sampling location consisted of 6 stations (Figure 1). Identification was carried out in the laboratory with reference to (Davis 1955; Yamaji 1966). The number of plankton was counted using the census method on a *Sedgewick Rafter* Cell under a microscope with a magnification of 20x. Plankton abundance is calculated using the formula (APHA 2017) :

$$N=\frac{n \, x \, vt}{Vd \, x \, Vs}$$

Description:
Vd: Volume of filtered water (mL)
Vt: Volume of water taken(mL)
Vs: Volume of observed water (mL)
N: Total number of plankton (ind L^{-1}) or (cells L^{-1})
n: Average individuals per number of fields of view

Raymont (1963) stated that the range of phytoplankton abundance (ind L^{-1}) is as follows:
Oligotrophic = 0-2,000 (Very low fertility)
Mesotrophic = 2,000-15,000 (Medium fertility)
Eutrophic = > 15,000 (Fertile waters)

Result. Based on the research conducted. The results of phytoplankton abundance (Figure 2) and zooplankton abundance (Figure 3) were obtained. The abundance of plankton per class of phytoplankton (Figure 4) and zooplankton (Figure 5) is shown.

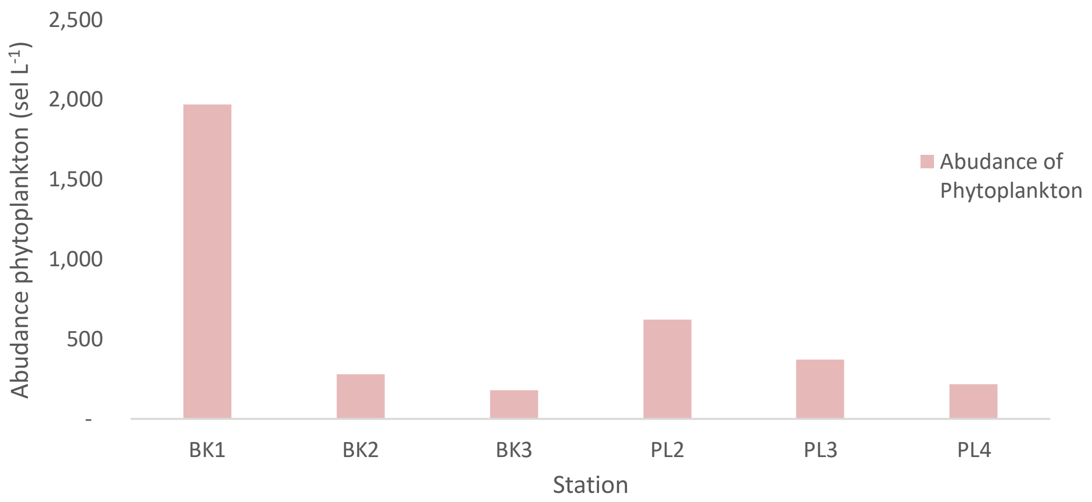


Figure 2. Total abundance of phytoplankton on Bangka Island.

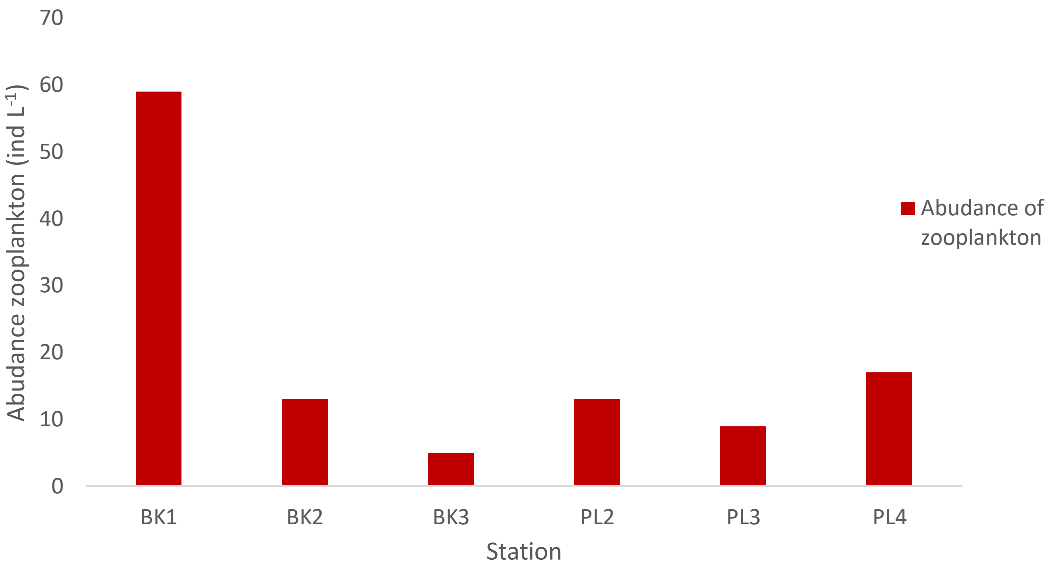


Figure 3. Total abundance of zooplankton on Bangka Island.

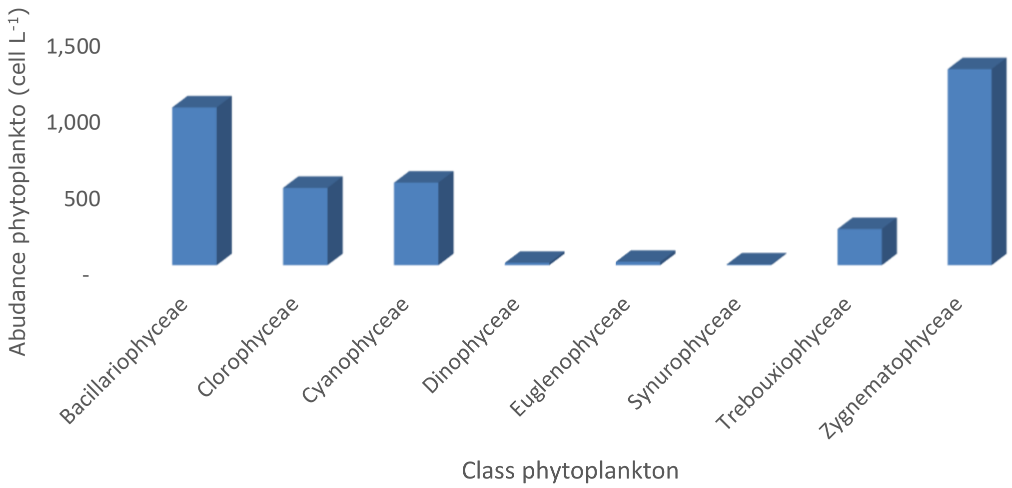


Figure 4. Abundance of phytoplankton classes on Bangka Island.

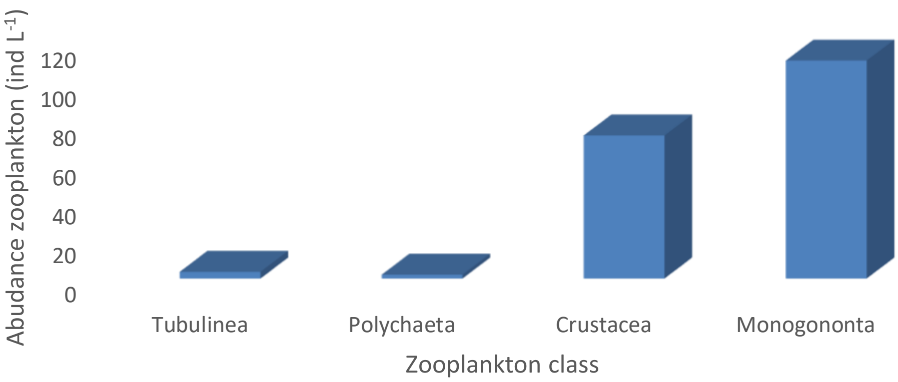
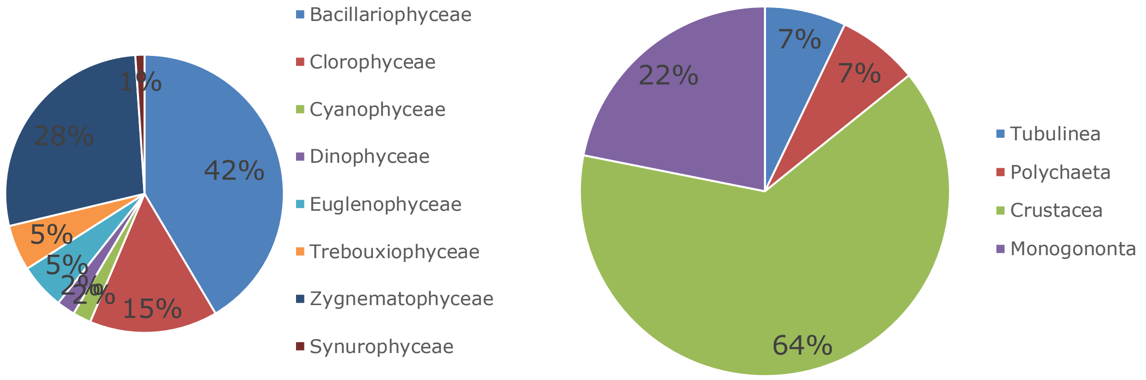


Figure 5. Abundance of zooplankton classes on Bangka Island.

Plankton composition. The composition of plankton produced by phytoplankton and zooplankton is presented in Figure 6. In phytoplankton, 7 classes were found, while in zooplankton, 5 classes were found.



a. b.

Figure 6. Plankton composition (a. Phytoplankton and b. Zooplankton) on Bangka Island.

Water quality parameters. Observation of water quality parameters as supporting data is very necessary to see whether the environmental conditions are still in a good category or have experienced disturbances. The results of the observations can be seen in Figure 7.

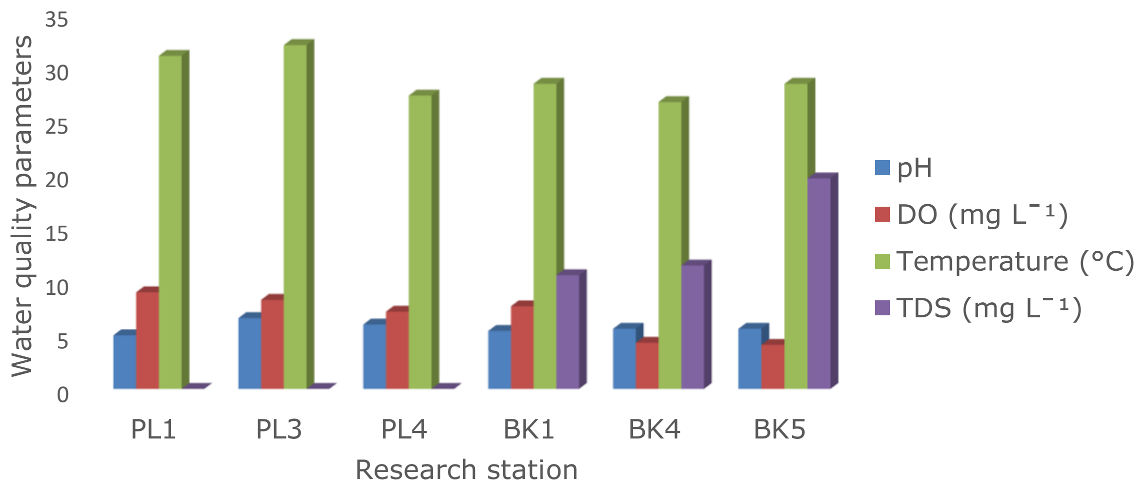


Figure 7. Results of environmental parameter analysis on Bangka Island.

Types and composition of fish. Based on morphological and eDNA identification, several fish catches were found by surrounding fishermen (Helmizuryani et al 2025) (Table 1).

Table 1

Types of fish caught using fishing gear

Family	*Species*
Bagridae	*Hemibagrus nemurus* (Valenciennes, 1840)
Clariidae	*Clarias leiacanthus* (Bleeker, 1851)
Cyprinidae	*Trigonopoma gracile* (Kottelat, 1991)
	Trigonopoma pauci perforatum(Weber & de Beaufort, 1916)
	Brevibora cheeya(Liao & Tan, 2011)
	Osteochilus spilurus (Bleeker, 1851)
	Neolissochilus (Day, 1871)
	Barbodes binotatus (Valenciennes, 1842)
	Rasbora cephalotaenia (Bleeker, 1852)
Osphronemidae	*Betta burdigala* (Kottelat & Ng, 1994)
	Betta chloroparynx (Kottelat & Ng, 1994)
	Parosphromenus deissneri (Bleeker, 1859)
	Betta schalleri (Kottelat & Ng, 1994)
	Luciocephalus pulcher (Gray, 1830)
	Sphaerichthys osphromenoides (Canestrini, 1860)
	Betta edithae (Vierke, 1984)
	Betta simorum (Tan & Ng, 1996)
	Betta coccina (Vierke, 1979)
Nandidae	*Nandus nebulosus* (Gray, 1835)
Nemacheilidae	*Nemacheilus fasciatus* (Valenciennes, 1846)
Barbinae	*Desmopuntius puntius hexazona* (Weber & de Beaufort, 1912)
Clariidae	*Encheloclarias tapeinopterus* (Bleeker, 1853)
Chanidae	*Channa bankanensis* (Bleeker, 1853)

Discussion

Plankton abundance. The abundance of phytoplankton and zooplankton was found in the BK and Pelawan Nawang River (PL) (Figure 1). Partially, the highest abundance was found in BK1 at 1968 cell $L^{-1,}$ and the lowest in BK2 at 180 cell L^{-1}. The highest abundance was found in PL 01 at 622 cells L^{-1}, and the lowest in PL4 at 218 cells L^{-1}. Meanwhile, the highest zooplankton abundance was found in BK 1 (59 ind L^{-1}, the lowest in BK 3 (5 ind L^{-1}), and the highest in PL4 (17 ind L^{-1}), and the lowest in PL 3 (9 ind L^{-1}). Partially reviewed, the highest total abundance of phytoplankton was in BK 1, namely 1968 cells L^{-1}, while the lowest was in PL4, namely 218 cells L^{-1}. While the highest zooplankton was in BK1 (59 ind L^{-1}), the lowest was in PL 3 (9 ind L^{-1}). The difference in phytoplankton and zooplankton abundance from all stations in this study is suspected to be due to the influence of sampling time and location conditions at the time of sampling. When reviewed partially, BK and PL Rivers have fewer zooplankton species than phytoplankton types. The BK River channel is very close to access to community tin mining and oil palm plantations, while PL is far from mining and oil palm plantations. This is supported by the opinion (Aisoi 2019), phytoplankton abundance is the number of individuals per unit volume of water per liter (ind L^{-1}). An environment that does not support phytoplankton causes a decline in phytoplankton species (Pambudi et al 2016; Raunsay et al 2016). Phytoplankton is closely related to water fertility (Setyowardani et al 2021).

One factor that can influence the abundance of phytoplankton and zooplankton is the availability of nutrients in a body of water. High zooplankton abundance leads to a more complex aquatic food chain. Phytoplankton abundance < 12,500 cells L^{-1} is considered low. The low abundance of phytoplankton is caused by uneven nutrient distribution and current speed (Yuliana 2012). Phytoplankton is a study material to determine the quality and fertility of waters, which are very much needed to support the utilization of coastal and marine resources (Raymont 1980). If the abundance of phytoplankton in a body of water is high, then the waters tend to have high productivity as well. In the highest abundance of phytoplankton classes, there is Zgynemaceae (*Closterium, Cosmarium, Eastrum, Micrasterias, Staurastrum, Spyrogyra,* and *Zygnema*), followed by the Bacillariophyceae class (*Bacillaria, Chaetoceros, Coscinodiscus, Fragilaria, Lauderia, Navicula, Nitzschia, Pinnularia, Pleurosigma, Skeletonema, Streptotheca,* and T*halassionema*) and the lowest class Dinophyceae (*Dynophysis* and *Peridinium*). Bacillariophyceae are widely found in waters because of their better salinity adaptation and ability to reproduce faster (Muryani et al 2018). This is supported by the opinion that the Zgynemaceae and Bacillariophyceae classes tend to be abundant in rivers and lakes and are used as bioindicators of water. Research by Madinawati (2012), Meirinawati & Mochtar (2017), and Wiyarsih et al (2019) suggests that the high abundance of Bacillariophyceae is caused by the fact that these organisms are predominantly found in open waters, where the amount of nitrate and phosphate content in these waters is high. The increase in the phytoplankton population in waters is related to the availability of nutrients and light (Tomascik et al 1997; Razai'i et al 2017). High phytoplankton abundance can produce high oxygen content and vice versa (Tiara et al 2024). Meanwhile, the abundance of zooplankton was found in the Bikang River, the highest being 59 ind L^{-1}, the lowest being 5 ind L^{-1}, while the PL was the highest at 17 ind L^{-1} and the lowest was 8 ind L^{-1}. Zooplankton conditions greatly affect the existence of phytoplankton directly. According to Basmi (1999), the zooplankton food chain process acts as the first consumer, where zooplankton plays a role at the second energy level, which connects directly with the first producer, namely phytoplankton, and is also related to the second consumer at a higher food level. The highest abundance of phytoplankton was found in the Zynematophyceae and Bacillariophyceae classes, while the lowest was in Synurophyceae, and the highest composition of zooplankton was in the Monogononta class 111 ind L^{-1} and the lowest was in Polycaheta (2 ind L^{-1}).

Plankton composition. The highest phytoplankton composition is in the Bacillariophyceae class (41%), and the lowest is Synurophyceae (1%). While the highest zooplankton composition is in the Crustacea class (64%), the lowest is Tubulinea (7%) and Polychaeta (7%). The Crustacea class is included in the Arthropoda phylum, which is supported by the opinion (Nybakken 1992; Meadows & Campbell et al 1993) that the Arthropoda phylum is the largest component of zooplankton in waters (Paramudhita et al 2018). Zooplankton is an aquatic organism that is influenced by water currents. Stated that currents river are the main factor controlling genus, distribution, and abundance (Gaol et al 2017). The large number of Crustacea genera indicates that these biota act as important secondary producers of water (Ahmad et al 2014; Faqih et al 2023). Crustacea have a higher composition because they are better able to survive with wide changes in salinity or migrate further to river estuaries (Kordi 2012; Kalor et al 2018).

Water quality. The complex conditions of the aquatic environment will affect the hydro-oceanographic conditions. Supported (Odum 1993) that changes in water conditions will cause changes in the ecosystem and community of organisms in a body of water, including phytoplankton, zooplankton, and biota in the form of fish resources. Water quality parameters observed in the study included temperature, pH, DO, and TDS. The water temperature in the Bikang River ranges from 26-28°C, and the PL ranges from 27-31°C Temperature plays a role in the aquatic environment and the existence of aquatic biota, both plankton and fish resources. At warm temperatures, a high abundance of plankton is found, and vice versa. Basically, water temperature affects the growth of plankton and other aquatic biota (Mariyati 2020). The optimal temperature for phytoplankton to grow and reproduce well is at an average water temperature of 28-30°C. The range of values is still suitable for zooplankton growth, namely 28-32°C (Tambaru et al 2014). Based on this, the temperature in the waters of the Bikang River and PL is still in the good category and suitable for plankton life and fish resources. (Yuliana et al 2015) that the optimum temperature range for plankton growth is around 20-30°C. In general, zooplankton species can grow well at a temperature of 25°C (Raymont 1963). Increasing water temperatures cause zooplankton to be more active, to a certain extent. Many factors will affect water temperature, so its value will change over time. Factors that affect changes in temperature in waters are the presence of shade (such as trees or aquatic plants) and wastewater (waste) that enters water bodies (Muarif 2016). Acidity (pH) affects the availability of carbon forms in waters. Plankton, especially phytoplankton, use HCO_3 as a source of free carbon dioxide. The pH range at the Research Location partially, the Bikang River ranges from 5.4-5.6, while the PL ranges from 5-6.6. This pH value is still a fairly good range for zooplankton life (Wadoyo 1975). If the pH is high or alkaline, it will endanger the survival of zooplankton organisms, because it will cause metabolic and respiratory disorders. This is also supported (Odum 1983), the pH of waters suitable for the growth of aquatic organisms ranges from 6-9 (Odum 1993). The range of DO values in the Bikang River is 4.1 to 7.7 mg L^{-1}, and the PL ranges from 7.2 to 9 mg L^{-1}. The DO content in the waters should not be less than 2 mg/l because it can cause death. Temperature indirectly affects the life processes of organisms, such as disrupting growth and reproduction, while indirectly affecting the solubility of oxygen (Odum 1993). The TDS value BK ranges from 10.6 to 19.6 mg L^{-1}, while the PL has a small TDS value of 0 mg L^{-1}, so this affects the growth of aquatic biota in the form of plankton (Agustin & Rijal 2024). High TDS content is caused by the presence of organic and inorganic compounds dissolved in water, including minerals and salts. The TDS value of water is influenced by several factors, such as the weathering of rocks, waste from the soil, and human influence through domestic and industrial waste. In seawater, high TDS content is caused by the presence of chemical compounds that result in high salinity and electrical conductivity.

Fish resources. *In* the food chain process, fish resources are at the secondary consumer level, starting from producers in phytoplankton, which are eaten by zooplankton and then eaten by small and large fish (Odum 1993). All phytoplankton live as supporters of primary productivity, continued by consumers in the form of zooplankton and fish resources. Phytoplankton, as primary producers, occupy the lowest level in the food pyramid. Phytoplankton occupy the lowest trophic level and play a role in transferring solar energy and distributing that energy through the food chain. It can be seen from the food pyramid that the higher the size of the individual, the greater the number of individuals. On the other hand, the number of phytoplankton is much larger than that of zooplankton and fish, but their size is much smaller. When viewed from the types of fish that are still widely found, it is indicated that the presence of plankton is sufficiently available in these waters.

Observations made found the Osphronemidae family (39%) and Cyprinidae (31%) (Helmizuryani et al 2025). One of the Osphronemidae families is the *Betta* fish (Prananda et al 2024). Betta fish belong to the Osphromidae family and are endemic fish in the waters of Bangka Island (Gulo et al 2023). In the study conducted (Kottelat & Whitten 1993; Wood et al 2017; Spikmans et al 2020; Syarif et al 2020; Thutshari & Senevirathna 2023) the diversity of native fish species are starting to be threatened due to damage to their habitat, the environment due to land conversion, pollution and climate change both due to nature and human activities, so domestication is needed to maintain sustainability by ensuring the availability of producers in the form of phytoplankton, zooplankton and other small fish for the sustainability of the life of these fish resources. However, the forest area that functions as an ecological shelter for living things is now increasingly declining due to forest encroachment, as well as the use of building materials and land conversion into plantations. This has resulted in several fish species decreasing due to environmental conditions that no longer support the life of these fish (Soetignya et al 2023). Furthermore, the introduction of foreign fish has also resulted in increasing pressure on the existence of local fish species in nature (Muchlisin et al 2011). Introduced fish entering public waters increases competition (food and habitat) (Singh & Lakra 2011). Predator-introduced fish will prey on local fish that are still small in size, increasing pressure on the existence of several local fish populations and having a greater impact on endemic fish species. This is supported by Mayu et al (2018), small pelagic fish resources during 2012-2016 in South Bangka Regency have not reached overfishing, but fishing efforts in 2014 have exceeded the optimum limit. Cyprinidae is a family with the largest number of species spread across all public waters (Nelson 2006; Purnama & Yolanda 2016), in Malaysian waters (Keat et al 2017). The dominance of the Cyprinidae family was also found in research in the Kumu River, Rokan Hulu, Riau (Sukmono et al 2020). According to Nelson (2006), Cyprinidae can be found almost everywhere except Australia, Madagascar, New Zealand, and South America. Cyprinidae has a fast regeneration phase and special sensory organs, such as feelers that can detect food sources in water. Detritus comes from leftover food, feces, and dead plankton. Stated that the percentage of fish stomach contents is higher than that of other foods (Aqil et al 2013). Stated that detritus is interpreted as dead phytoplankton, but can still be used as food for fauna (Sachlan 1982). Spatially, the Bikang River in South Bangka still has a lot of fish, which is in line with the abundance of plankton, which tends to be higher in the Bikang River compared to the PL.

Conclusions. The abundance of plankton, both phytoplankton and zooplankton, in the Bikang River is higher compared to the PL. The highest abundance of phytoplankton is found in the Zygnemaceae and Bacillariophyceae classes, while the highest zooplankton is found in the Crustacea class. The water quality in the Bikang River and PL is still in the category of being suitable for aquatic biota. Fishery resources in the waters of the Bikang River, South Bangka, are found more than in the PL; the Osphronemidae and Cyprinidae families are found more in these waters.

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Conflict of interest. The authors declare that there is no conflict of interest.

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