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Types of Dietary Planktons of *Sardinella lemuru* at Pengambengan Nusantara Fishing Port, Bali, Indonesia

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ABSTRACT

Bali sardinella (*Sardinella lemuru)* is a type of fish that significantly contributes to the Pengambengan Nusantara Fishing Port (NFP). However, there has been a decline in lemuru production. This decline in production is closely related to its food sources, namely phytoplankton and zooplankton. Plankton plays a crucial role in the ecosystem as it forms the foundational link in the food chain. This research aimed to identify types of plankton the dietary preferences of *S. lemuru* in Pengambengan NFP. Samples were taken from the *S. lemuru* size groups 'lemuru' (sized 15–18cm) and 'lemuru kucing' (sized >18cm), during May and June 2023. The research method employed was descriptive qualitative. Plankton identification was carried out at the Aquaculture Laboratory, Marine and Fisheries Polytechnic of Jembrana. The result of *S. lemuru* stomach contents revealed a higher presence of zooplankton compared to phytoplankton. The identified plankton composition includes five orders of zooplankton (Calanoida, Harpacticoida, Euphausiacea, Amphipoda, and Cyclopoida), fish eggs, one genus of phytoplankton (*Ceratium* sp.), and one family of Bacillariaceae.

INTRODUCTION

The waters around Bali have significant marine fisheries potential, encompassing the North, East, and West Bali waters. The potential for marine fisheries in the West Bali region can be monitored through activities at the Pengambengan Nusantara Fishing Port (NFP). Based on the Pengambengan NFP annual report in 2022, *Sardinella lemuru* is the most dominant type of fish, contributing a catch of 11,010 tons, or around 90% of the total catch. However, there has been a decrease in production compared to 2021. Lemuru is a fish commodity with high economic value **(Sihombing *et al.*, 2018; Hendiari *et al.*, 2020; Laia *et al.*, 2021)**. Moreover. It has an important role for marine ecosystems **(Wujdi & Wudianto, 2015)**.

The stock status of *S. lemuru* has reached overexploitation **(Wujdi & Wudianto, 2015)**. This is in line with information of data on the decline in production of lemuru catches since 2020 in the Pengambengan NFP. The decline in *S. lemuru* has been addressed in the studies of **Puspasari *et al.* (2019, 2020)** and **Laia *et al.* (2021)**.

One of the determining factors for fish population, growth, and condition is food. *S. lemuru* fish are classified as planktivorous fish, namely zooplankton and phytoplankton eaters **(Pradini *et al.*, 2001; Pertami *et al.*, 2018; Hendiari *et al.*, 2020)** and are referred to as filter feeders. **Pertami *et al.* (2018)** reported that the results of an analysis of the stomach contents of *S. lemuru* contained the main food in the form of phytoplankton from the Cyanophyceae and Bacillariophyceae classes. This differs from data reported in the study of **Khasanah *et al.* (2014)**, where *Rhizosolenia stolterfothii* was the dominant type of phytoplankton during transition season II, while *Pareuchaeta norvegica* was the dominant zooplankton during the wet season.

Plankton is an important organism in an ecosystem because it is the most basic link in the food chain **(Setyadji & Priatna, 2011)**. **Sihombing *et al.* (2018)** stated that there was a decrease in plankton abundance that occurred from March to May. The decreasing abundance of phytoplankton is due to the absence of upwelling and grazing processes. This is different from the low abundance of zooplankton due to slow zooplankton production in nature and predation by *S. lemuru*. Research that analyzes lemuru fish food by considering catchable size has never been carried out, thus information is required. Moreover, the amount of food consumed is one of the most significant elements required for ecosystem trophic **(Palomares *et al.*, 1998)**. This study can be used to forecast ecosystem productivity as basic knowledge. This research aimed to identify the food type of *S. lemuru* at Pengambengan Nusantara Fishing Port, Bali.

MATERIALS AND METHODS

The *S. lemuru* samples in this study were taken in May and June 2023. *S. lemuru* were obtained from fishermen on small pelagic purse seiners with two vessels based at Pengambengan NFP, Bali (Fig. 1). The materials used were *S. lemuru* intestines, 5% formaldehyde, and distilled water. The research method applied was descriptive qualitative. Plankton identification was carried out at the Aquaculture Laboratory, Marine and Fisheries Polytechnic of Jembrana.

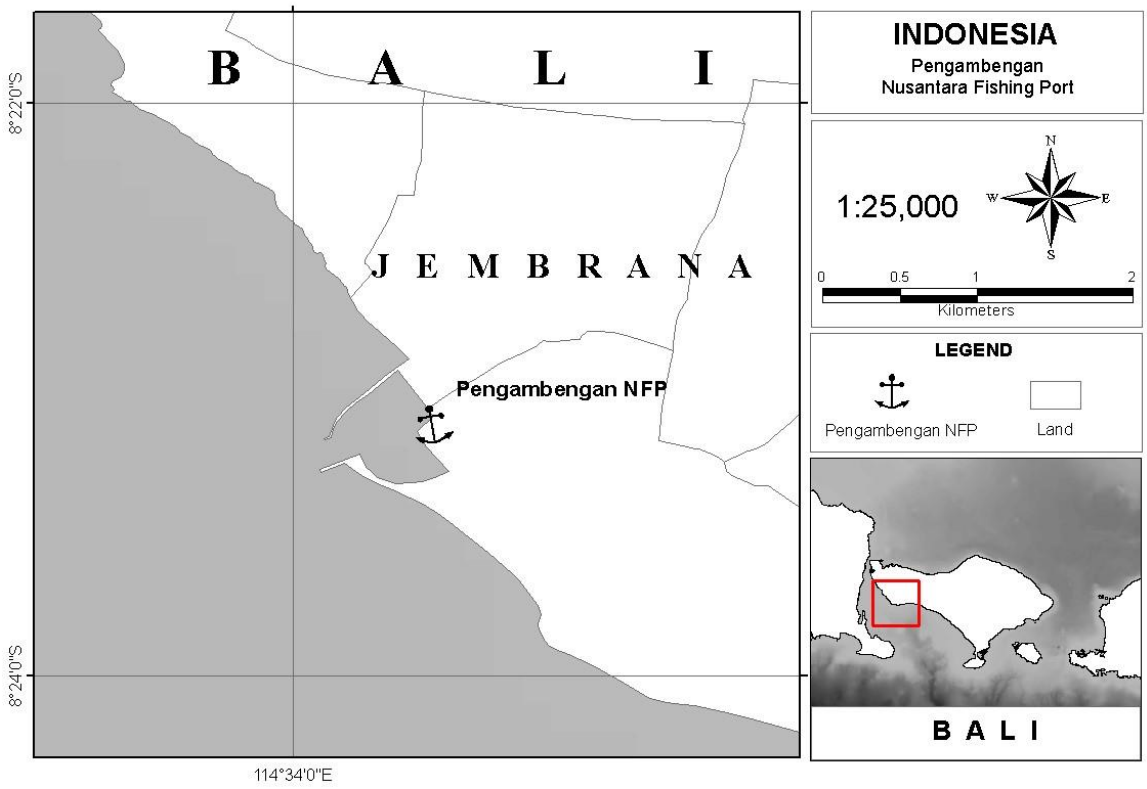

Fig. 1. Map of the sampling site

Parts of the stomach that have been preserved in formalin were then diluted with 10ml of aquadest. Next, an intestinal sample was taken using a dropper. Intestinal samples were dropped on the Sedgwick rafter and then covered with a cover glass. Then, the intestinal samples were observed under a light microscope. Observations of phytoplankton and zooplankton were repeated three times. Plankton identification is limited to the order level, but there are also family and genus levels. This was done because it was related to the limitations of the light microscope used to observe plankton. Identification of phytoplankton and zooplankton refers to the identification books of **Newell and Newell (1963)**, **Al-Yamani *et al.* (2011)** and **Slotwinski *et al.* (2014)**. The fish sampled were the *S. lemuru* size groups with categories 'lemuru' (sized 15–18cm) and 'lemuru kucing' groups (sized > 18cm) **(Merta, 1992)**.

RESULTS

Based on the results of the observations that have been made, it was found that several types of individuals were ingested by the *S. lemuru*. The types of food identified can be seen in Table (1).

Table 1. Types of plankton as *S. lemuru* food

No.	Total length fish (mm)	Weight (gram)	Size group	Food	
				Phytoplankton	Zooplankton
1	185-195	56-66	Lemuru kucing	*Ceratium* sp. Family Bacillariaceae	Order Calanoida Order Harpacticoida Order Euphausiacea Order Amphipoda Order Cyclopoida Fish egg
2	175-180	47-59	Lemuru		

1. Order Calanoida (Fig. 2)

1.1. Classification

- Phylum : Arthropoda
- Subphylum : Crustacea
- Class : Maxillopoda
- Subclass : Copepoda
- Order : Calanoida

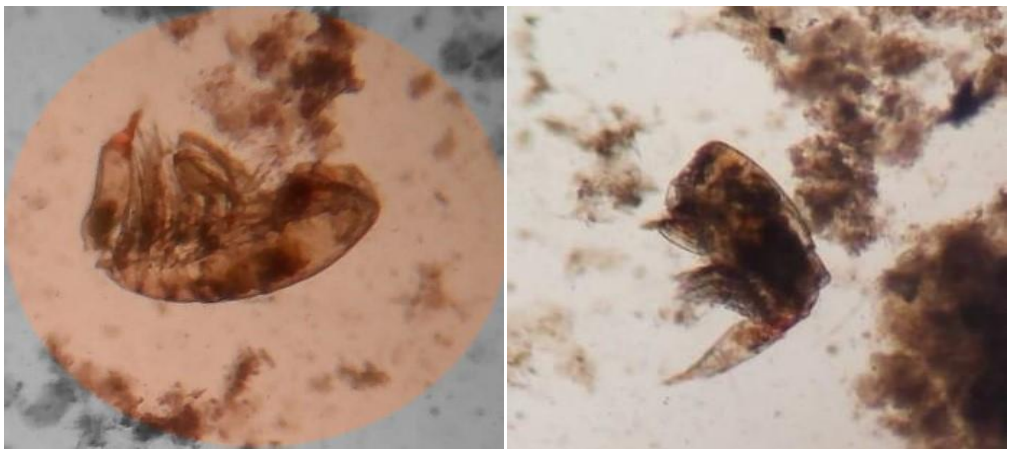

Fig. 2. Order Calanoida

Calanoids often have a bullet-like shape, a body that is much wider than its tail and that is typically longer than it, and antennae that are roughly the same length as the body. The most numerous and diverse group of copepods is the Calanoida, an order of pelagic copepods. They frequently exert forceful control over the zooplankton. The fifth limbs and body type are typically diagnostic, and there are various families. The main antennae are usually very long. The fifth pair of swimming legs in females is often much smaller and less complex than the other four pairs, and they frequently have five pairs altogether. Males always have five pairs of legs, with the fifth pair usually modified and asymmetrical to help them capture females during mating. Females lay their eggs either on their bodies or directly into the ocean.

2. Order Harpacticoida (Fig. 3)

1.2. Classification

- Phylum : Arthropoda
- Subphylum : Crustacea
- Class : Maxillopoda
- Subclass : Copepoda
- Order : Harpacticoida

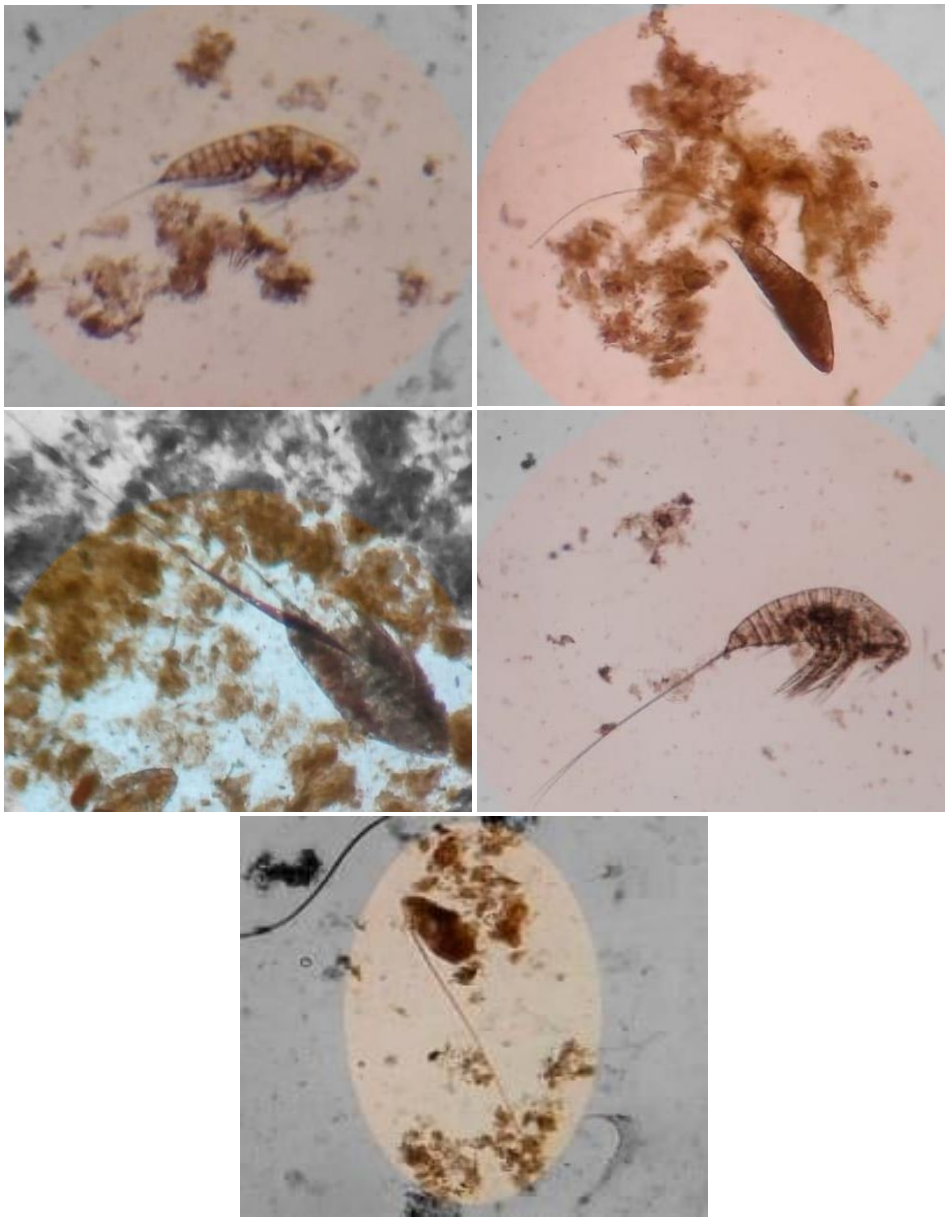

Fig. 3. Order Harpacticoida

3. Order Amphipoda (Fig. 4)

1.3. Classification

- Phylum : Arthropoda
- Subphylum : Crustacea
- Class : Malacostraca
- Superorder : Peracarida
- Order : Amphipoda

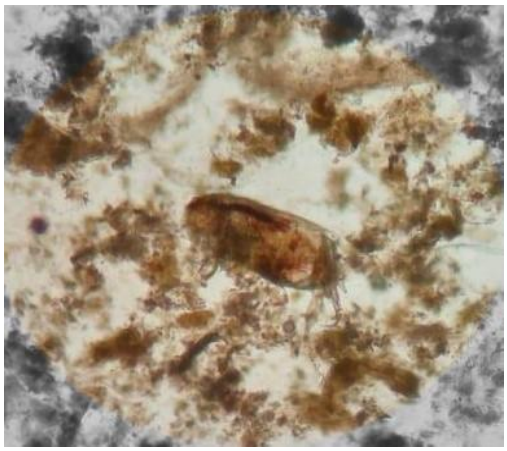

Fig. 4. Order Amphipoda

Amphipods occasionally have chelae and frequently have enormous eyes. They are lateral compressed and rather large (> 5mm). Amphipods frequently lack a carapace and exhibit lateral body compression. The body is divided into 13 segments, with the head attached to the thorax. Although there are 400 pelagic species that live in all ocean depths and latitudes, the bulk of amphipods are benthic. Many of them have large claws. All hyperiid amphipods are pelagic, have enormous eyes, and feed parasitically on zooplankton that is made of gelatin.

4. Order Euphausiacea (Fig. 5)

1.4. Classification

- Phylum : Arthropoda
- Subphylum : Crustacea
- Class : Malacostraca
- Superorder : Eucarida
- Order : Euphausiacea

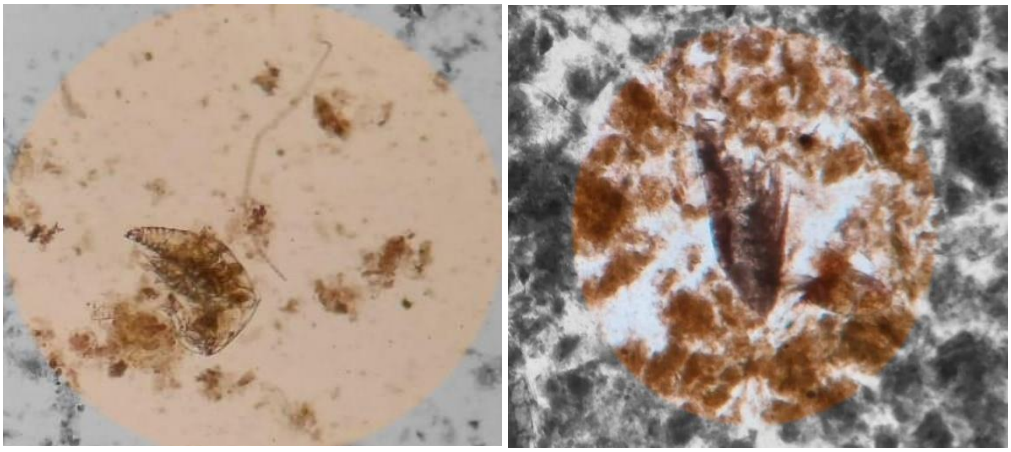

Fig. 5. Order Euphausiacea

Euphausiids are tiny holoplanktonic crustaceans that resemble shrimp. The term "euphausiid" is used to describe any member of the crab superorder Eucarida, order Euphausiacea, which is split into two families (Euphausiidae and the mono-specific Bentheuphausiidae, which includes the sole genus and species *Bentheuphausia amblyops*). According to **Baker *et al.* (1990)**, there are 11 genera and 86 identified species of Euphausiacea.

Euphausiids have a body made up of 5 cephalic, 8 thoracic, and 6 abdominal segments, just like other eucarids. The first two body parts are joined together to form a cephalothorax, which is surrounded by a carapace that extends laterally on each side of the body but does not cover the gills. The cephalothorax and the abdomen are the two primary components of the body. The carapace is located both laterally and dorsally within the cephalothorax. The length and shape of the rostrum, or frontal plate, which is located between the eyes, as well as the quantity of different lateral and post-ocular spines, are characteristics of the carapace that are helpful in identification. Some species may have a mid-dorsal keel and corresponding cervical groove **(Guglielmo *et al.*, 2015)**.

5. Order Cyclopoida (Fig. 6)

1.5. Classification

- Phylum : Arthropoda
- Subphylum : Crustacea
- Class : Maxillopoda
- Subclass : Copepoda
- Order : Cyclopoida

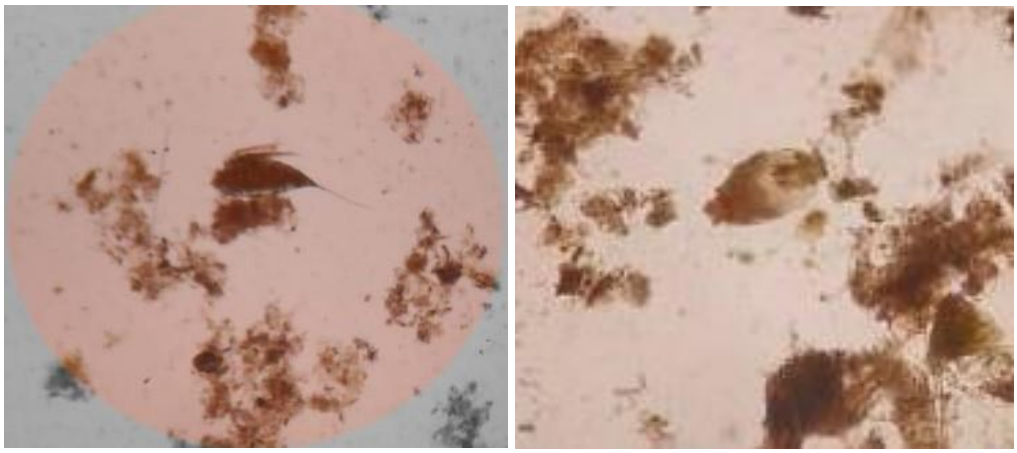

Fig. 6. Order Cyclopoida

Cyclopoids (1.3mm) are typically smaller than calanoids, having a longer urosome (approximately the same length as the prosome), a broader body (prosome) than the 'tail' (urosome), and antennae that are shorter than the body. Cyclopoida is an order of small crustaceans from the subclass Copepoda. Like most other copepods, its members are small, planktonic animals that live both in sea and freshwater habitats. They are able to move quickly. Larval development is metamorphosis, and the embryo is carried in paired or single sacs attached to the first abdominal somite **(Lowry, 1999)**. Cyclopoids are distinguished from other copepods by having a first antenna that is shorter than the length of the head and thorax and a second antenna that is uniramous. The thorax is larger than the stomach. It has mandibles, which are used for biting and chewing. The main joint is located between the fourth and fifth body segments.

6. Fish egg (Fig. 7)

1.6. Classification

- Phylum : Chordata
- Subphylum : Vertebrata
- Superclass : Osteichthyes

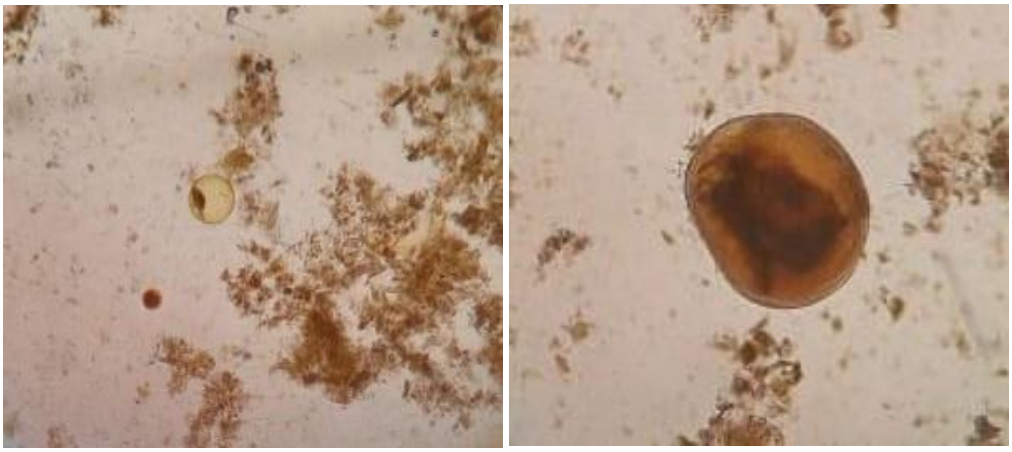

Fig. 7. Fish egg

Fish larvae are elongate with characteristic eyes, jaws, and fins, and their eggs are typically spherical and larger (by around ~1mm) than other planktonic eggs. Most marine fish, both demersal and pelagic, lay pelagic eggs and larvae that dwell in the water's surface layer. Accurately identifying eggs and larvae is difficult. A variety of physical traits, such as head spination, myomere/vertebral counts, the shape, number, and placement of melanophores, meristic traits, relative fin position, and the size and shape of fin rays, are used to identify different species. Larvae are about 3mm long when they first hatch, and it takes them 10–30mm to metamorphose. Since morphological traits change swiftly during this brief larval growth phase, it is difficult to build keys for larval identification.

7. Family Bacillariaceae (Fig. 8)

1.7. Classification

- Phylum : Bacillariophyta
- Class : Bacillariophyceae
- Order : Bacillariales
- Family : Bacillariaceae

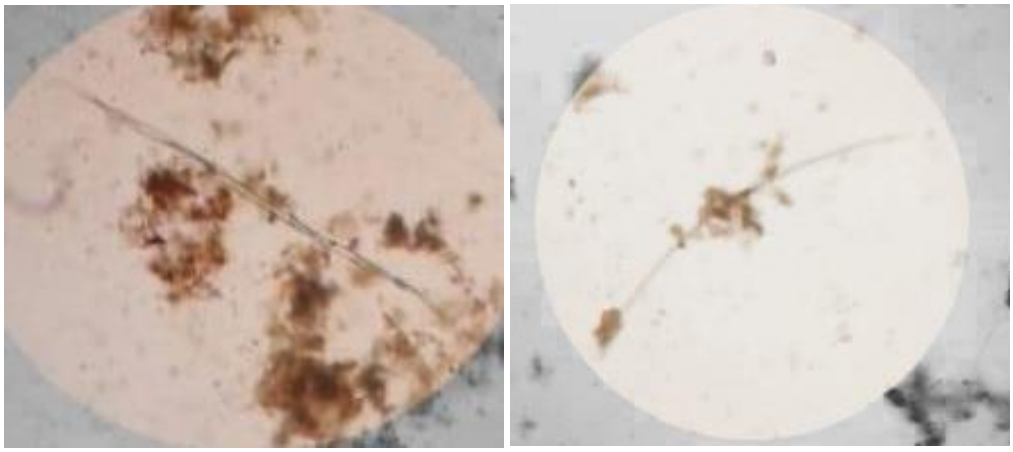

Fig. 8. Family Bacillariaceae

The family Bacillariaceae includes diversely populated **(Mann *et al.*, 2021)** and environmentally varied motile diatoms. It is widely distributed and lives in sediments, periphyton, and the water column. Some species can thrive sub aerobically on moist rocks and soil. From the arctic to the tropics, it can be found in fresh, brackish, marine, and hypersaline aquatic habitats. When viewed from the girdle, cells are either long, fusiform, or rectangular. Chains are created by overlapping cell ends. 20 or more cell chains are not unusual. Cell Size: Width = 2 – 8um, Length = 40 – 175um.

8. Genus *Ceratium* sp. (Fig. 9)

1.8. Classification

- Phylum : Dinoflagellata
- Class : Dinophyceae
- Order : Gonyaulacales
- Family : Ceratiaceae
- Genus : *Ceratium*

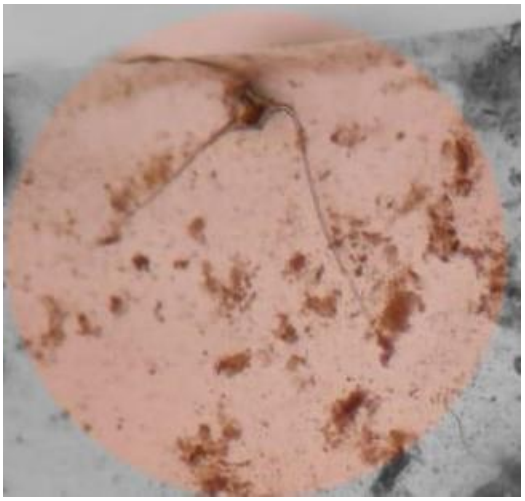

Fig. 9. Genus *Ceratium* sp.

Ceratium is a brown phytoplankton belonging to the dynoflagellate class. *Ceratium* comes from the order Gonyaulacales and the family Ceratiaceae. From the arctic to the tropics, freshwater and saltwater settings are home to the single-celled aquatic dinoflagellates of the genus *Ceratium*. Although the animals' taxonomic classification as algae is disputed, it is accepted that they are dinoflagellates because they have two different flagella and both plant and animal characteristics. Numerous species in the genus are known to cause red tides and water blooms, and they account for a sizeable amount of the plankton in temperate zone oceans.

DISCUSSION

Lemuru production in the Bali Strait has been confirmed to fluctuate from year to year. Based on the results of interviews with fishermen, captains, and owners of small pelagic purse seine vessels or 'slerek' at Pengambengan NFP, fishermen did not dare to go to sea due to bad weather conditions and strong winds. Apart from that, *S. lemuru* is a seasonal fish that occurs during the transition between seasons, namely April and September to December **(Suhery *et al.*, 2023)**.

The *S. lemuru* used as research samples, measured between 175-195mm (Table 1), are classified as *S. lemuru* that are suitable to be caught, namely from the 'lemuru' and 'lemuru kucing' groups. **Merta (1992)** grouped *S. lemuru* based on their size, including 'lemuru' (15–18cm) and 'lemuru kucing' (>18cm). This is supported by the results of **Wudianto and Wujdi (2014)**, which stated that the 'lemuru' and 'lemuru kucing' groups are relatively large fish, with an average size of 15.5–19.5cm. **Aprianti *et al.* (2022)** also categorized *S. lemuru* measuring >15cm as adult fish.

Based on the results of the analysis of the stomach contents of *S. lemuru*, more zooplankton were identified than phytoplankton. However, there are types that are not identified. The plankton composition that was identified during research at Pengambengan NFP consisted of five orders of

zooplankton and fish eggs, one phytoplankton genus, and the Bacillariaceae family. The results of this study are the same as those of **Pertamini *et al.* (2018)**, namely that zooplankton is found more often than phytoplankton because at that time of sampling in May until June, there was an absence of the upwelling phenomenom. This is different from **Sihombing *et al.* (2018)**, who identified more phytoplankton than zooplankton, this condition occurred due to the upwelling phenomenom that made the high abudance of phytoplankton. The Bacillariophyceae class and the Copepoda subclass were often found in this study. This statement is supported by the results of research by **Sihombing *et al.* (2018)**, who found that the highest abundance of plankton in the waters of the Bali Strait is phytoplankton in the Bacillariophyceae class (transitional season II) and zooplankton in the Copepoda subclass (west season). **Suprakto *et al.* (2022)** added that the diversity of plankton in both seasons showed community stability Bali Strait waters biota is in moderate condition. The high abundance of the Bacillariophyceae class and the Copepoda subclass is because they can adapt well to the environment, have strong resistance to extreme conditions, are resistant to changes in salinity, and have a high production capacity **(Aliah *et al.*, 2010; Baytut, 2013)**. **Icas *et al.* (2019)** stated that Bacillariophyceae are preyed upon by herbivorous fish such as *S. lemuru*.

Period March to May, it was reported by **Sihombing *et al.* (2018)** that the abundance of phytoplankton and zooplankton in the waters of the Bali Strait formed a sinusoidal pattern. The abundance of plankton in these months is included in transition season 1, which is classified as low abundance when compared to other seasons. This is assumed to be due to the absence of an upwelling phenomenon and the grazing process, while the low abundance of zooplankton is thought to be caused by relatively slow zooplankton production and predation by *S. lemuru*. Variability in zooplankton abundance cannot be separated from variability in ocean conditions **(Susilo *et al.*, 2021)**. The food organisms selected vary according to the size of the *S. lemuru* **(Pertami *et al.*, 2018)**.

The research results show that the 'lemuru' and 'lemuru kucing' categories tend to eat zooplankton, with crustaceans as their main food. This is supported by **Himelda *et al.* (2011)**, who stated that larger *S. lemuru* ('lemuru' and 'lemuru kucing' size groups) primarily consume zooplankton, while smaller individuals tend to feed on phytoplankton. In the research of **Aprianti *et al.* (2022)**, it was also found that the main type of food in adult *S. lemuru* fish is crustaceans, and one of the complementary foods is *Ceratium* sp.

CONCLUSION

The types of planktons as food for *Sardinella lemuru* at Pengambengan Nusantara Fishing Port were found to be more zooplankton than phytoplankton. The identified plankton composition included five zooplankton orders (Calanoida, Harpacticoida, Euphausiacea, Amphipoda, and Cyclopoida), fish eggs, one phytoplankton genus (*Ceratium* sp.), and one family Bacillariaceae.

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