

Heavy metal contents of Hg, Cd, Pb, and Cu in splendid ponyfish *Eubleekeria splendens* (Cuvier, 1829) meat in Banten Bay, Indonesia

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Abstract. Banten Bay is an area affected by industrial, shipping, and domestic activities. These have the potential to produce wastes in the form of heavy metals and can accumulate in the body of aquatic organisms such as the splendid ponyfish *Eubleekeria splendens* (Cuvier, 1829). This study aimed to determine the accumulation of heavy metals Hg, Cd, Pb, and Cu in splendid ponyfish *Eubleekeria splendens* (Cuvier, 1829) meat in Banten Bay, Serang Regency, Banten Province. Sampling was carried out for three months, from August to October 2020. Analysis of heavy metal content was carried out using AAS (Atomic Absorption Spectrophotometer). The content of heavy metals Hg, Cd, Pb, and Cu in splendid ponyfish meat were <0.030 mg/kg, <0.001 mg/kg, <0.005 mg/kg, and 0.224-0.437 mg/kg. Bioaccumulation of heavy metals Hg, Cd, Pb, and Cu in small and big splendid ponyfish meat has a low accumulation rate. During the observation period, the heavy metal content of Hg, Cd, Pb, and Cu in small and big splendid ponyfish meat was not significantly different.

1 Introduction

Banten Bay is a relatively shallow water area with an area of $\pm 150 \text{ km}^2$ [1]. Industrial activities around Banten Bay include the Suralaya Steam Power Plant, the plastic raw material industry, the chemicals industry, the steel industry, the sugar industry, and shipping activities that can contribute to heavy metal pollution in the waters [2]. Heavy metals are harmful contaminants in the aquatic environment because they have complex degradation properties, are readily soluble in water, settle in sediments, and accumulate in marine organisms [3]. Sources of heavy metal waste in Banten Bays' waters, especially Bojonegara, are dominated by anthropogenic activities or human activities in the environment. The pollution of heavy metals in waters can affect the biota in the seas [4,5].

The presence of heavy metals in waters can cause pollution through bioaccumulation and biomagnification. It will then settle to the bottom of the water and become sediments through the process of gravity. Heavy metals can accumulate mainly in the river and marine sediments [6] because metals can be bound to organic and inorganic compounds through the adsorption process and the formation of complex mixtures. Metal contaminants in the

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sediment will then be absorbed by benthic organisms, which will then be transferred to higher food chains.

Splendid ponyfish *Eubleekeria splendens* (Cuvier, 1829) is one of the economically important fish caught by fishermen in the waters of Banten Bay. Splendid ponyfish is one type of demersal fish caught in the waters of Banten, the north coast of West Java, Central Java, East Java, and the east coast of Lampung using *Cantrang* (mini trawl) fishing gear [7]. Organisms that live at the bottom of the waters, such as splendid ponyfish, are organisms that can accumulate heavy metals effectively [8]. Splendid ponyfish bodies will be contaminated with heavy metal compounds gradually through the food chain process. Over time, the number of heavy metals in the body of fish will increase, and at specific concentrations, it is suspected that it can cause damage to fish body tissues and cause poisoning.

The type of food for splendid ponyfish is generally benthic organisms consisting of invertebrate animals and plants. These organisms include *foraminifera*, *polychaetes*, *ostracods*, small decapods, diatoms, zooplankton (copepods, and fish eggs) [9]. The leading food of splendid ponyfish is Polychaeta, small crustaceans, and small fish [10]. In the larval stage, splendid ponyfish feed on zooplankton and invertebrate animals that live on the bottom of the water, as for other feeds from splendid ponyfish in the form of mollusks and crustaceans. In contrast, the additional feed is Polychaeta, bivalve larvae, and gastropod larvae [7,11]. *Eubleekeria splendens* (Cuvier, 1829) is a fish with a relatively low trophic level, but it is suspected to accumulate heavy metals effectively with its characteristics as demersal fish.

Heavy metals that enter the waters can accumulate in the water, sediment, and the fish that live in it, such as splendid ponyfish. Heavy metals have the potential to be absorbed into the fish body through the food channel (diet exposure) and the gill surface (water exposure) [12]. Heavy metal concentrations that exceed the allowed quality standard can cause various diseases and can even cause death. This research aims to determine the accumulation of heavy metals Hg, Cd, Pb, and Cu in the meat of splendid ponyfish *Eubleekeria splendens* (Cuvier, 1829) in the waters of Banten Bay, Serang Regency, Banten Province. The reason is that Banten Bay receives much garbage that is carried by the river. The flow that has organic and inorganic materials from anthropogenic waste disposal can affect the condition of Banten Bay waters and the biota in them. The input of waste in the form of heavy metal waste significantly affects the accumulation and concentration of heavy metals in the fish body, which results in a decrease in fish quality. This is because fish resources, especially splendid ponyfish, are fish with an economic value that is generally processed into salted fish and is widely consumed by the community. The study's advantage is the accumulation of heavy metals Hg, Cd, Pb, and Cu in the meat of small and big splendid ponyfish caught in Banten Bay. This study is believed to preserve splendid ponyfish resources and the Banten Bay aquatic environment, allowing them to be exploited in the future.

2 Materials and methods

2.1 On-site research

The research was conducted in Banten Bay waters, District of Bojonegara, Regency of Serang, Province of Banten (Fig. 1). The research location is divided into 2 (two) stations representing the distribution of pollutants. The process of dissection and extraction of *Eubleekeria splendens* (Cuvier, 1829) was carried out at the Macro Biology Laboratory I, Department of Aquatic Resources Management, Faculty of Fisheries and Marine Resources

Management, IPB University. The destruction and analysis of heavy metals in splendid ponyfish meat were conducted in the testing laboratory, Department of Agricultural Industrial Technology, Faculty of Agricultural Technology, IPB University. The study was conducted from August to October 2020.

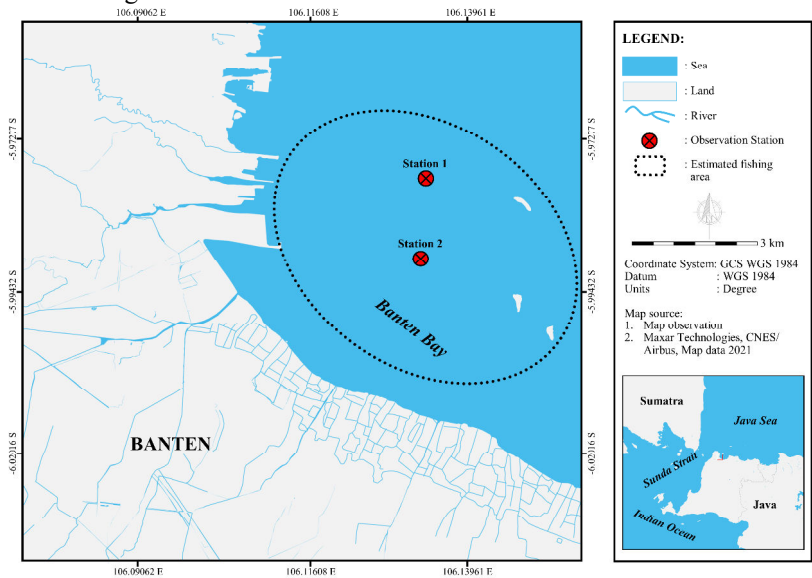


Fig. 1. Map of research location in Banten Bay, Banten Province.

2.2 Data collection

Direct collecting of data includes a sampling of splendid ponyfish in the waters of Banten Bay using boats and fishing gear in the form of *Rampus* fishing gear. Sampling using a purposive sampling method. Each catch is sorted, and only splendid ponyfish are taken. The sampled fish are then put in a plastic clip and labeled so that the fish sample is not mixed when it is put into the cool box. The number of fish caught each month ranges from 19 to 41 fish. The number of fish caught each month ranges from 19 to 41 fish. The weight of the fish also needs to be weighed using a digital scale with an accuracy of 0.01 grams. The sampled fish were dissected using sterile surgical instruments. Surgery was performed to remove fish flesh for further analysis. Heavy metals Hg, Cd, Pb, and Cu in splendid ponyfish meat were analyzed through the wet digestion and heavy metal concentration measurements with AAS (*Atomic Absorption Spectrophotometer*). The sample destruction stage uses the Nitric Acid-Perchloric Acid method. Heavy metal concentrations of Hg, Cd, Pb, and Cu were observed using the Flame Atomic Absorption Spectrophotometry method.

2.3 Data analysis

2.3.1 Descriptive

Results of water quality and heavy metal content in water are compared with Government Regulation no. 22 of 2021 concerning the Implementation of Environmental Protection and Management. Comparison of heavy metal content in splendid ponyfish meat with heavy metal content in seawater can show the effect of the environment on heavy metal accumulation in splendid ponyfish.

2.3.2 Bioconcentration factor (BCF)

The bioconcentration factor is the ratio between the concentration of chemicals in aquatic organisms' bodies and the concentration of chemicals in the water. According to [13], the BCF formula is as follows:

$$BCF = \frac{\text{Concentration of pollutants in the body of organisms (mg/kg)}}{\text{Concentration of pollutants in water (mg/L)}} \quad (1)$$

Values are divided into three categories: Values >1000 are included in the high accumulation classification; The BCF value from 100-1000 is called moderate accumulative, and the BCF value < 100 is categorized in the low accumulative group.

2.3.3 Maximum Weekly Intake (MWI)

The maximum concentration limit for heavy metals concentrates the foods consumed per week (maximum weekly intake) using thresholds published by international food organizations and institutions [14]. Calculation of the maximum weekly intake based on the formula:

$$MWI \text{ (mg/kg)} = \text{body weight a)} \times PTWI \text{ b)} \quad (2)$$

Average adult weight of 50 kg and children's weight of an average of 15 kg per week (a), PTWI (Provisional Tolerable Weekly Intake) or the maximum tolerance limit per week issued by the food agency in units of g/kg body weight (b).

2.3.4 Tolerable Maximum Intake (MTI)

The maximum weight of splendid ponyfish meat that can be tolerated for consumption in one week of MTI is calculated using the following formula [15].

$$MTI = MWI/Ct \quad (3)$$

Maximum weekly intake ($\mu\text{g}/\text{mg}$ assuming an average adult weight) an average of 50 kg and children weigh an average of 15 kg per week), Ct: Concentration of heavy metals found in the body being analyzed (mg/kg).

3 Results

3.1 Water quality and heavy metal concentrations in the aquatic environment

The Physico-chemical characteristics and the presence of heavy metals in the aquatic environment can describe the habitat conditions of the splendid ponyfish *Eubleekeria splendens* (Cuvier, 1829). The Physico-chemical conditions of the marine environment in Banten Bay based on the time of observation at stations 1 and 2 are presented in Table 1. Based on the analysis results, the heavy metal content of Hg, Pb, and Cu during the observation and Cd metal based on [16] has a relatively low value. Heavy metal concentrations in Banten Bay waters from August-October from stations 1 and 2 are presented in Table 2.

Table 1. Physico-chemical conditions of the aquatic environment in Banten Bay.

No.	Parameters	Period			Quality standards
		August	September	October	
1	Temperature (°C)	43 ± 16.26	32.5 ± 0.71	32.75 ± 0.35	28-30
2	Visibility (m)	3.75 ± 0.00	3.975 ± 1.03	1.875 ± 1.45	>5
3	Turbidity (NTU)	1.2 ± 0.28	1.3 ± 0.28	1.65 ± 0.64	5
4	TSS (mg/L)	7 ± 0.71	8.5 ± 2.83	6.8 ± 1.84	20
5	Salinity (PSU)	29.5 ± 0.71	30.5 ± 0.71	36.5 ± 2.12	33-34
6	DO (mg/L)	3.85 ± 0.78	5.8 ± 0.99	5.1 ± 0.71	>5
7	pH	7 ± 0.00	7 ± 0.00	7.85 ± 0.07	7-8.5

^aBased on Government Regulation of the Republic of Indonesia Number 22 of 2021

Table 2. Heavy metal concentrations in water in Banten Bay.

No.	Parameter	Period			Quality standards
		August	September	October	
1	Mercury (Hg) (mg/L)	<0.0002	<0.0002	<0.0002	0.001
2	Cadmium (Cd) (mg/L) ^b	<0.001	<0.001	<0.001	0.001
3	Lead (Pb) (mg/L)	<0.002	<0.002	<0.002	0.008
4	Copper (Cu) (mg/L)	0.005-0.007	<0.002	<0.002	0.008

^aBased on Government Regulation of the Republic of Indonesia Number 22 of 2021

^bBased on research, Surbakti (2020)

The physical and chemical parameters of water for stations 1 and 2 in Banten Bay waters vary widely. Parameters of temperature, brightness, salinity, and dissolved oxygen are not following the quality standards of Government Regulation of the Republic of Indonesia No.22 of 2021. The result is different from the turbidity, TSS, and pH parameters, following quality standards. If seen from Table 2, the concentration of heavy metals in the waters of Banten Bay is below the quality standard. This phenomenon indicates that the water quality at stations 1 and 2 is not suitable for splendid ponyfish habitat.

3.2 The content of Mercury (Hg) in splendid ponyfish meat

Heavy metal content analysis results for Mercury (Hg) in splendid ponyfish meat are presented in Fig. 2.

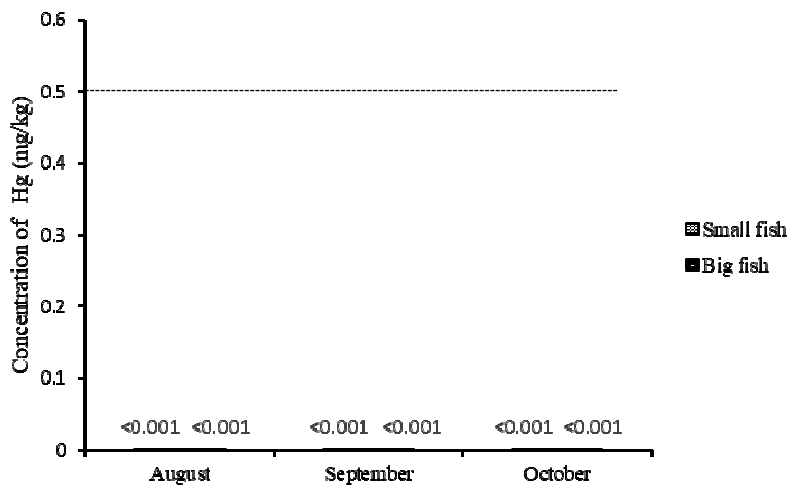


Fig. 2. The concentration of Hg in splendid ponyfish in Banten Bay.

The heavy metal mercury (Hg) concentration in splendid ponyfish meat was below the AAS detection limit, <0.001 mg/kg. This value is also below the limit for heavy metal contamination in fish, according to the National Drug and Food Control Agency [17], which is 0.50 mg/kg.

3.3 The content of Cadmium (Cd) in splendid ponyfish meat

The results of the analysis of the heavy metal content of Cadmium (Cd) in splendid ponyfish meat are presented in Fig. 3.

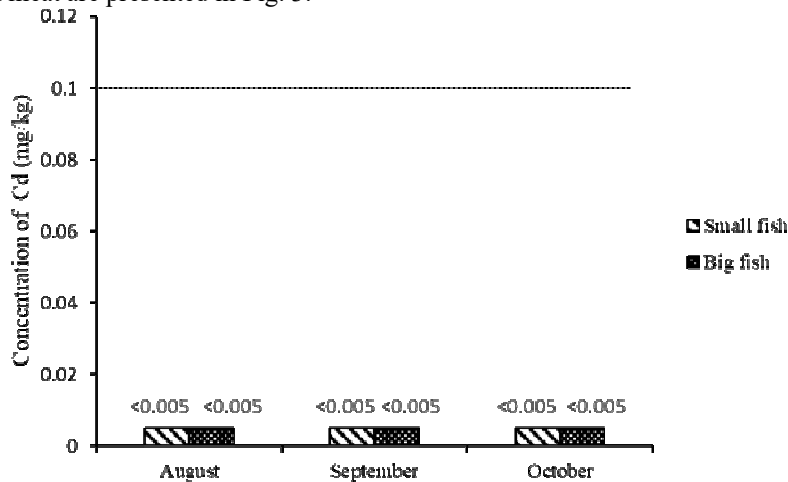


Fig. 3. The concentration of Cd in splendid ponyfish in Banten Bay.

The Cd content in splendid ponyfish meat caught in Banten Bay has a value below the AAS detection limit used, which is <0.005 mg/kg. This value is below the limit for heavy metal contamination in fish, according to the National Drug and Food Control Agency [17], which is 0.10 mg/kg.

3.4 The content of lead (Pb) in splendid ponyfish meat

Results of heavy metal content analysis for Pb in splendid ponyfish meat are presented in Fig. 4.

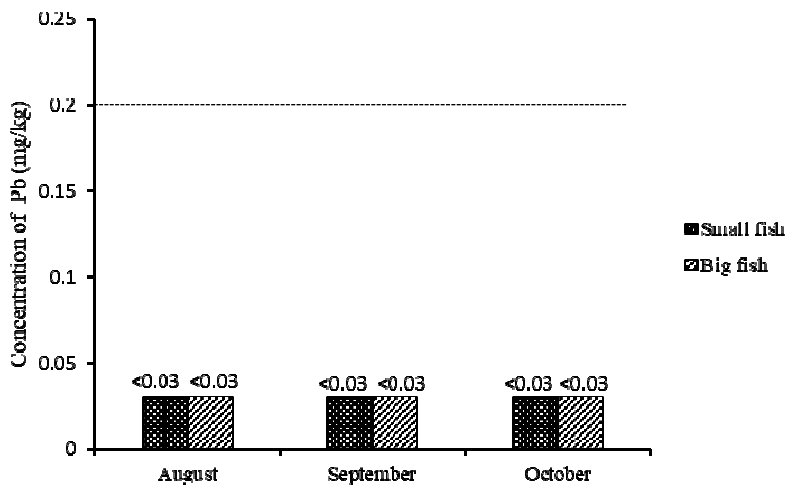


Fig. 4. The concentration of Pb in splendid ponyfish in Banten Bay.

The Lead concentration in splendid ponyfish meat caught in Banten Bay has a value below the AAS detection limit, which is <0.030 mg/kg. This value is below the limit for heavy metal contamination in fish, according to the National Drug and Food Control Agency [17], which is 0.20 mg/kg.

3.5 The content of Copper (Cu) in splendid ponyfish meat

The results of the analysis of the heavy metal content of Copper (Cu) in splendid ponyfish meat are presented in Fig. 5.

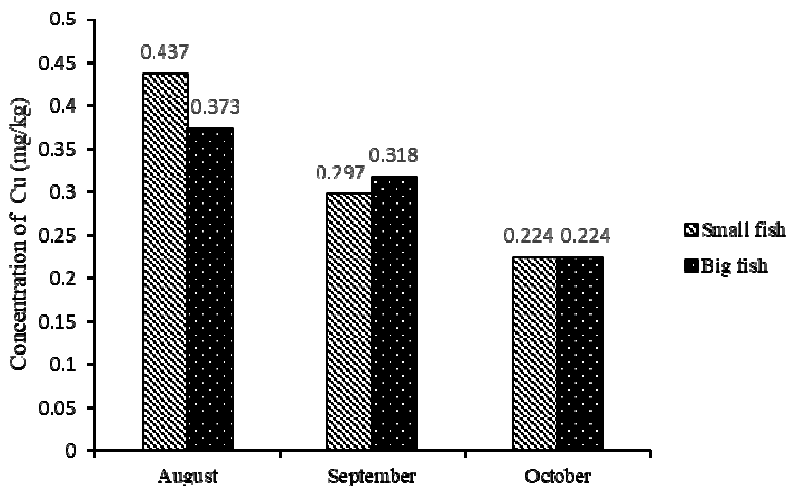


Fig. 5. The concentration of Cu in splendid ponyfish in Banten Bay.

The concentration of Cu in splendid ponyfish meat has a range of values between 0.224-0.437 for small fish and 0.224-0.373 for big fish. According to the Decree of the Director-General of Drug and Food Control, the concentration of Cu is still below the quality standard1989, which is 20 mg/kg.

3.6 Bioconcentration factor (BCF)

Table 3. Bioconcentration factors of Splendid ponyfish

Heavy metals/Period	Small splendid ponyfish (<9cm)				Big splendid ponyfish (≥9cm)			
	Hg	Cd	Pb	Cu	Hg	Cd	Pb	Cu
August	0	0	0	73	0	0	0	62
September	0	0	0	0	0	0	0	0
October	0	0	0	0	0	0	0	0

The bioconcentration factor based on table 3 is only found in Cu metal in August and is dominated by the number 0 (zero). The BCF value of Cu heavy metal in August has a value of less than 100.

3.7 Safety level

The results of the analysis of the safety level of *Eubleekeria splendens* (Cuvier, 1829) per adult weight (50 kg) are presented in Table 4, and for children (15 kg) are shown in Table 5.

Table 4. Safety level for splendid ponyfish meat consumption per adult weight (50 kg)

Size	Maximum Tolerable intake for a child (kg meat/week)			
	Hg	Cd	Pb	Cu
MWI	0.08	0.35	1.25	175
Small fish (< 9 cm)	80	70	41.67	400.46
Big fish (≥ 9 cm)	80	70	41.67	469.17

Table 5. Safety level for splendid ponyfish meat consumption per child weight (15 kg)

Size	Maximum Tolerable intake for a child (kg meat/week)			
	Hg	Cd	Pb	Cu
MWI	0.024	0.105	0.375	52.5
Small fish (< 9 cm)	24	21	13	120
Big fish (≥ 9 cm)	24	21	12.5	140.751

The safety level value for splendid ponyfish meat consumption is only found in Cu because the concentration of heavy metals Hg, Cd, and Pb cannot be detected. This value is

the Maximum Tolerable Intake (MTI) to consume splendid ponyfish meat caught in Banten Bay.

4 Discussion

Banten Bay is a water area with rapidly growing industrial activity. Industries developed around Banten Bay, precisely in Bojonegara Regency, include oil refineries, petrochemical industry, fuel storage, petrochemical products, Liquefied Petroleum Gas (LPG), base metal industry, and electronics industry [18]. Industrial activities, shipping activities, and surrounding settlements can affect the condition of the waters in Banten Bay. Fishing activities and other shipping activities such as painting and ship maintenance will impact the form of the entry of pollutants into the waters [19].

Changes in the Physico-chemical conditions of the waters may impact the concentration of heavy metals in water. Over the observation period, the resulting water temperature ranged from 31.5°-54.5° C. These temperatures are high, which may be caused by high industrial and shipping activities in the vicinity. This value was above the quality standard according to Government Regulation of the Republic of Indonesia No. 22 of 2021 with a range of 28°-30° C. High temperatures can increase the formation of heavy metal ions, so that the deposition process in sediments will increase due to heavy metal absorption. The pH parameter obtained in the observation period has a standard range between 7-7.9 which follows the quality standard of the Government Regulation of the Republic of Indonesia No 22 of 2021, which is 7-8.5; a low pH value can cause metals to be more soluble [20,21].

The range of water salinity obtained during the study was between 29-38 PSU. This value is not following the quality standards of the Government Regulation of the Republic of Indonesia No. 22 of 2021, with a range of 33-34 PSU. Low salinity will increase accumulation because high salinity can reduce heavy metal concentrations, and High salinity can increase the formation of chloride ions, which then react with metal ions. This is reflected in a decrease in the concentration of heavy metal ions in water [22,23].

Heavy metal concentration in the meat of splendid ponyfish caught from Banten Bay is deficient. This value is dominated by numbers below the AAS detection limit in the range of 0.005-0.007 mg/L for Cu metal in August. The heavy metal content is still below the quality standard of the Government Regulation of the Republic of Indonesia No 22 of 2021. The concentration of heavy metals in the water of East Segara Anakan was quite varied but tended to be low [24]. Those results might be due to the low quantity of heavy metals in the water, preventing AAS from detecting them. Heavy metal concentrations in water are generally modest because it is influenced by currents and waves that cause heavy metals to spread throughout the waters [25]. In addition, water quality parameters and the type of effluent input may also impact heavy metal concentrations in water [26].

The content of heavy metals in water can accumulate in the body of the biota. One dominant fish caught in Banten Bay waters is the splendid ponyfish *Eubleekeria splendens* (Cuvier, 1829). Based on the economic aspect, splendid ponyfish is included in the category of trash fish and is commonly consumed by people on the North Coast of Java [7].

The low Pb content can be caused by the low input of pollutants containing lead into the waters. The water's low Pb content can occur due to dilution due to tides and ocean currents [27]. The low concentrations of the heavy metal Lead (Pb) in the waters resulting from currents that generate unsafe water and sediment conditions [28].

The content of heavy metal mercury (Hg) in splendid ponyfish meat for August-October in Banten Bay waters has a value below the tool detection limit, which is <0.001 mg/kg. Low levels of Hg can be caused by insufficient input of pollutants or pollutants containing Mercury into the waters. The low levels of Hg in the seas are caused by the entry of heavy metals into the body of biota due to bacterial activity and deposition in sediments [29].

The content of heavy metal Cadmium (Cd) obtained in the study has a value below the detection limit of the tool, which is < 0.005 mg/kg. In general, the heavy metal content of cadmium in muscle tissue will be lower [30]. Metal concentrations in the tissues of organisms depend on water concentration, fish species, and bioavailability.

The heavy metal copper (Cu) content in splendid ponyfish has a relatively variable value between 0.224-0.437 for small fish and 0.224-0.373 for big fish. Copper (Cu) concentration is still below the quality standard set by the Decree of the Director-General of Drug and Food Control of 1989, 20 mg/kg.

The highest Cu levels occurred in August and decreased in September and October. This phenomenon can be caused by seasonal changes that occur during the sampling period. Seasonal changes can cause variations in the heavy metal concentration of water, sediments, and aquatic biota [31]. Heavy metal concentrations in water will be more significant in the dry season than in the rainy season because heavy metals will be concentrated in the dry season and dissolve in the rainy season [32].

Chemical compounds that enter the body of living biota will be broken down and released through the liver's metabolic processes and enzymatic mechanisms [33]. In September, the Cu metal content was higher in the larger body of splendid ponyfish. This may be due to the longer duration of heavy metal exposure in big fish. Exposure to heavy metals for a long time can increase the accumulation of these heavy metals in aquatic biota [34]. The heavy metals in the water will accumulate in the fish body, and biomagnification occurs [35]. The concentration of Cu metal in big and small splendid ponyfish in October had the same value.

Copper (Cu) can naturally enter the aquatic environment by erasing mineral rocks from land, dust particles from the air carried by rainwater, or from the waters themselves. Generally, Copper (Cu) is obtained from mining and industrial wastes such as paints, antifouling, industrial insecticides, fungicides, and others. Copper is one of the essential metals needed by organisms at certain levels. However, if it exceeds the tolerance limit, it can endanger the life of the biota [21].

The ability of fish to accumulate heavy metals can be described by the Bioconcentration Factor (BCF). The BCF value in splendid ponyfish was only found in copper in August and was dominated by 0 (zero). The BCF value of copper has a value of less than 100, which indicates that splendid ponyfish are included in the group of fish with low accumulative properties in absorbing pollutants in the form of heavy metals. This can happen because splendid ponyfish are a group of demersal fish with a low trophic level to minimize the bioaccumulation process. The low accumulation of fish still has to be watched out for due to the collection of heavy metals if consumed continuously for a long time, causing chronic poisoning [36].

The safety level of splendid ponyfish obtained during the study was only found in Copper (Cu) because the concentrations of Hg, Cd, and Pb metals were below the detection limit of the AAS. The lowest safe limit for heavy metal consumption is Cu, 400.46 kg of meat/week for adults and 120 kg of meat/week for children. The maximum limit for fish consumption is determined based on the smallest value. Even though it is low if consumed continuously, food that already contains heavy metals will accumulate in the human body and be toxic [36]. The safety level for Copper (Cu) consumption tends to be high due to its low concentration in splendid ponyfish meat and its low toxicity level compared to Hg, Cd, and Pb metals. The order of heavy metal toxicity levels to humans starting from the most toxic is Hg, Cd, Ni, Pb, Cr, Sn, and Zn [37]. Meanwhile, Cu is an essential metal that is still needed by organisms in specific concentrations.

Consumption of splendid ponyfish meat contaminated with heavy metals in the waters needs to be limited. The accumulation of heavy metals in the human body can cause various health problems such as kidney disease, hypertension, disorders of the liver and

lungs, and other diseases [38]. Therefore, management needs to be carried out in maintaining the presence and quality of splendid ponyfish in Banten Bay's waters. Leadership can be done by evaluating and monitoring various heavy metal production activities in Banten Bay Waters. The establishment of appropriate regulations and programs to increase awareness in protecting the aquatic environment is very important. Systematic research also needs to be carried out sustainably as the basis for the management of splendid ponyfish and the environment around the waters of Banten Bay.

5 Conclusion

The concentration of Mercury (Hg), Cadmium (Cd), and Lead (Pb) in splendid ponyfish meat from Banten Bay were not detected. Only Copper (Cu) was detected. However, it is a deficient level and still below the BPOM quality standard (2018) and the Directorate General of Drug and Food Control of the Indonesian Ministry of Health (1989). The bioconcentration factor was in the category of low accumulation. During the observation period, the content of heavy metals Hg, Cd, Pb, and Cu in the meat of small and big splendid ponyfish did not differ significantly.

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