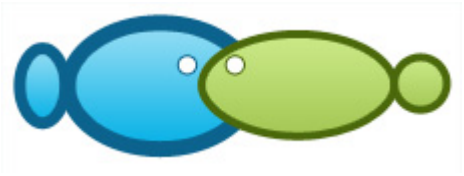

Bioaccumulation of lead (Pb) in muscle, skin, and gills of threadfin bream (*Nemipterus* sp.) in Banten Bay, Indonesia

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Abstract. Industrial areas located around the waters of Banten Bay affect the water quality and also the biota. The use of materials containing Pb as an industrial material will result in waste that can pollute the waters and impact on the biota. Pb is typically used in industry as an additive in mineral processing, battery charger material, paint material as well as textile dyes. This study was aimed to analyze the accumulation of Pb in threadfin bream, *Nemipterus* sp. (meat (muscle), skin and gills) in Banten Bay waters, thus it can be taken into consideration in making aquatic environmental management policy especially in Banten Bay. Sample collection was conducted in July-August 2016 and later analyzed using atomic absorption spectrophotometry (AAS). Based on the research result, Pb accumulation in threadfin bream contained in muscles, skin, and gills was at high concentration and already exceeded the quality standard set by BPOM, that is 0.3 mg kg^{-1}. The highest concentration was found in the gills (22.02-70.56 mg kg^{-1}) with the average concentration of 43.54±21.58 mg kg^{-1}. Moreover, the lowest concentration was found in muscles (11.08-31.59 mg kg^{-1}) with the average of 17.24±7.95 mg kg^{-1}. Industrial, residential, and fisheries activities produce waste that generates pollutants one of which is Pb in the environment around the waters of Banten Bay. Establishment of regulation by the government concerning the threshold of waste disposal is needed to reduce the level of pollution.
Key Words: industry, Banten Bay, heavy metal, *Nemipterus* sp., fish organ.

Introduction. Banten Bay is one of waters area located in Banten Province, North of Cilegon City, ±65 km East of Jakarta Bay and is the northern coast of Java. This bay has an area of ±150 km^2 and relatively shallow waters (Wisha et al 2015; Suwandana et al 2011). Banten Bay is under pressure of surrounding environment in term of rapid population growth and settlement development in the coastal area, the establishment of several industries and large scale sand mining (Hoekstra et al 2002). Community activities around the waters of Banten Bay generate organic and inorganic waste, one of inorganic waste is in the form of heavy metal. One heavy metal contained in Banten Bay waters is lead (Pb). In the study of Setyobudiandi (2004) in this area, the Pb concentration was 0.153 mg L^{-1}, and in the study of Irnawati et al (2014) in the same area, the Pb concentration was 0.0660 mg L^{-1}, both values exceeding the official quality standard.

Pb is often used as raw material in some industries in Indonesia such as an additive in mineral processing, battery charger material, paint material, and textile dyes (Setyawan et al 2004). Pb in the environment can be derived from a natural source or artificial source/anthropogenic activities. The anthropogenic sources include mining waste, industrial waste (disposal of sewage sludge), domestic waste, agriculture waste (application of pesticide and inorganic fertilizer), waste of transportation, and atmospheric deposition (Setyawan et al 2004; Asante et al 2014). Contamination from anthropogenic sources continues to rise due to the increasing exploitation of mining and industrialization (Setyawan et al 2004). Waste entering the water environment will

spread and accumulate in sediment and biota which later disrupt the food chain. The entry of Pb into aquatic organisms occurs through three main processes namely through breathing organ (gills), body surface, and from food or water through the digestive system which later will accumulate in the body over the exposure period (Purnomo & Muchyiddin 2007; Asante et al 2014).

The consequences of Pb exposure on the organisms range from sublethal to lethal effects (death). Research conducted by Natalia (2007) showed that sublethal impact caused by continuous exposure includes necrosis in area connecting the gill filaments and hypertrophy of secondary lamella during 24 hours observation and hemorrhagic (bleeding) that is a condition marked by blood release from vascular blood vessels as a result of damaged vascular wall during 48 hours observation. Authman et al (2015) also conducted a research concerning the effect of exposure of Pb on liver condition of *Clarias batrachus.* The effect includes hepatocyte vacuolation, liver cirrhosis, necrosis, shrinkage, and parenchymatous degeneration. Other impacts are the occurrence of hyperplasia caused by blockage due to exposure to Pb at low concentration yet it has been contaminated the fish body for a long time (Tresnati et al 2007). Fish is one of accumulator organisms of both organic and inorganic pollutants. Age of fish, fat content in tissue and how fish eat are factors significantly affecting the accumulation of heavy metals in fish (Asante et al 2014).

Threadfin bream (*Nemipterus* sp.) is one of superior local fish commodities in Banten Bay waters. Threadfin bream is classified as demersal fish which has relatively low motion activity and short-distance migration habit, found in mud or sand base, and usually in groups (Triharyuni et al 2013; Diana & Manjulatha 2013). All these reasons make threadfin bream suitable to be the sample in the study of heavy metal bioaccumulation. Fluctuated number of catches with an increasing trend each year also makes threadfin bream as a commodity (Nugraha et al 2012). The main food of this fish is small fish, crustacean, mollusk (mainly squid), polychaetes and echinoderms (Diana & Manjulatha 2013).

The purpose of this study was to analyze the accumulation of Pb in meat (muscle), skin and gills of threadfin bream in Banten Bay waters, thus it can be taken as consideration in making aquatic environmental management policy, especially in Banten Bay.

Material and Method

Collected samples. Samples of threadfin bream were collected from five stations located in Banten Bay (Figure 1) consisting in residential areas and fishing port, industrial center, until area closed to Panjang Island. Fish were caught using fishing-rod techniques on each station. The analysis of Pb content was conducted in the Laboratory of PROLING Study Program of Aquatic Resources Management, Faculty of Fisheries and Marine Science, Bogor Agricultural University. The supporting parameter of water quality was measured *in situ*. Research was carried out in July 2016.

Determination of Pb concentration in fish. Determination of heavy metal concentration was carried through the AAS (Atomic Absorption Spectrophotometric) method (APHA 2012). Samples of muscle, skin, and gills were dried and smoothed until homogeneous. As much as ±5 gram (dry weight) of each sample was taken, added with 5 mL HNO_3 and heated on a hot plate until the volume reached ±1 mL. Later, distilled water was added until the volume became 100 mL then the sample was homogenized. Further, the sample was filtered using 0.45 µm filter paper and was measured for its heavy metal concentration using the AAS.

Statistical analysis. The results were analyzed using one-way ANOVA and descriptive analysis by comparing the value obtained with the quality standard (National Agency of Drug and Food Control 1989).

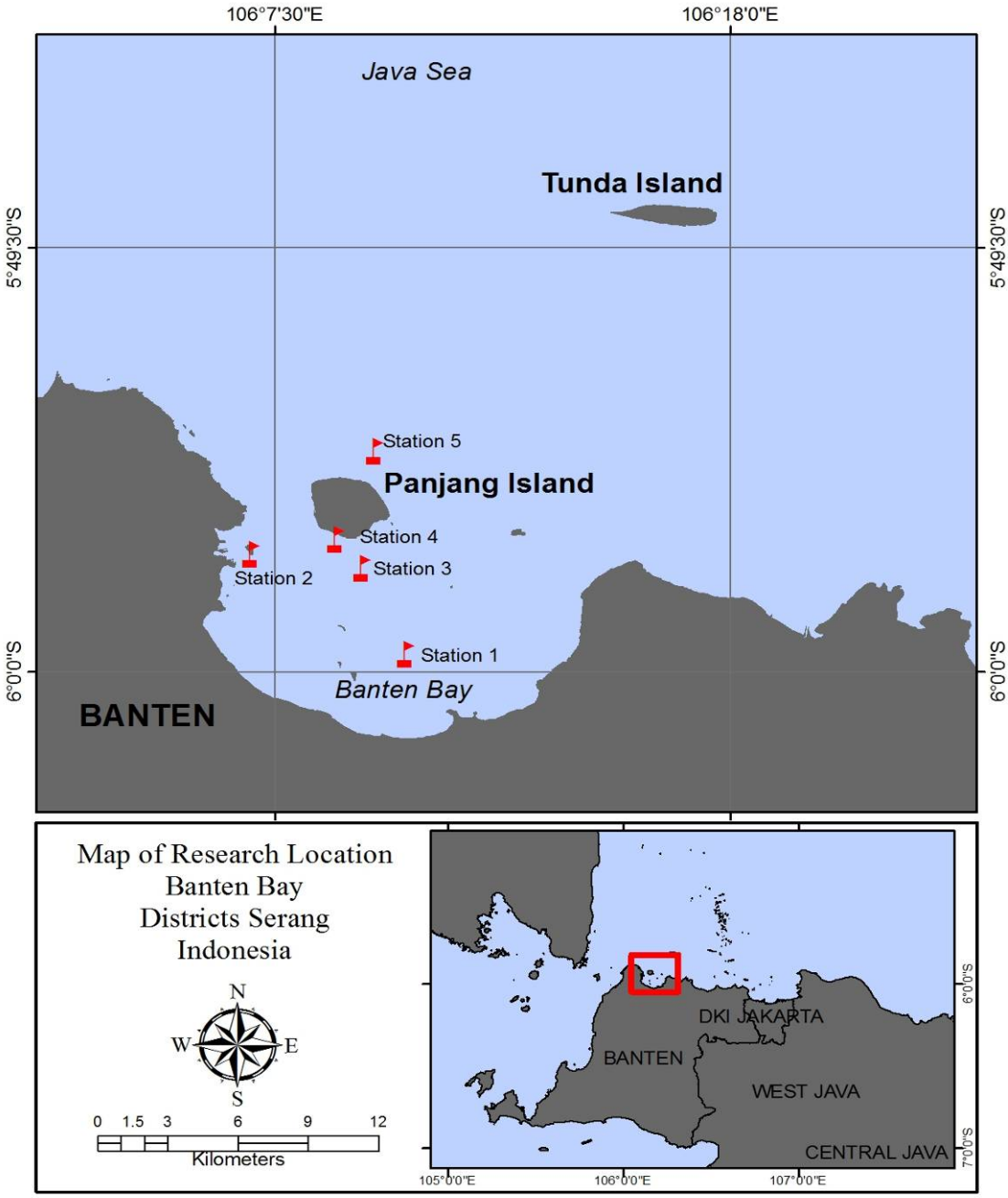

Figure 1. Map of research location.

Results. Based on the result of research conducted in the waters of Banten Bay, Pb accumulation in the muscles, skin, and gills of threadfin bream were at high concentration and have already exceeded the permissible quality standards (Table 1). The highest concentration was found in the gills, that was 22.02-70.56 mg kg^{-1} with the average concentration of 43.54±21.58 mg kg^{-1}. Moreover, the lowest metal concentration of 11.08-31.59 mg kg^{-1} was found in muscles with an average of 17.24±7.95 mg kg^{-1}. These results can be seen in Figure 2.

Table 1

Concentration of Pb in waters of Banten Bay in each organ of threadfin bream (*Nemipterus* sp.)

Organ	Unit	Station					Mean±SD	Quality standard*
		1	2	3	4	5		
Meat (muscle)	mg kg^{-1}	11.08	14.16	17.34	21.32	31.59	19.098±7.949058	0.3
Skin	mg kg^{-1}	19.27	25.81	25.54	35.16	60.5	33.256±16.25153	0.3
Gills	mg kg^{-1}	22.02	23.19	59.51	70.56	42.44	43.544±21.58451	0.3

* National Agency of Drug and Food Control (1989).

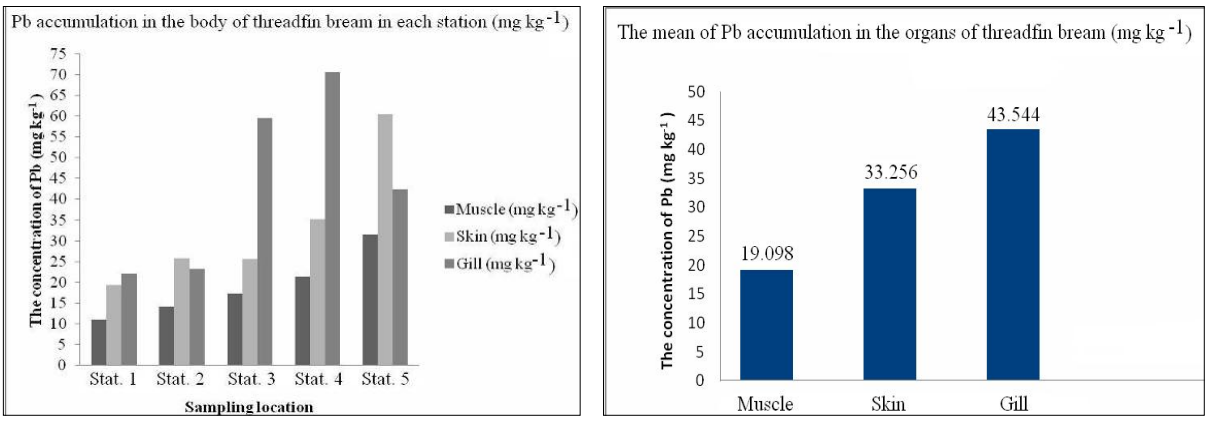

Figure 2. Accumulation of Pb in the body of threadfin bream (*Nemipterus* sp.).

Discussion. Basically, heavy metals in small amounts are available in nature through natural processes. However, if the concentrations have exceeded the permissible limit, environmental pollution which adversely affects the biota will occur. Pb is a primarily heavy metal and is considered to be the most toxic metal in the environment especially in waters and causes a lot of physiological disturbances on the biota, one of which is fish (Rolli et al 2016). Fish accumulate xenobiotic chemicals including heavy metals, especially those that dissolve in water since fish take the oxygen from the water through the gills (Javed & Usmani 2011). Indirectly, heavy metals dissolved in the water would enter the body of the biota through the gills. The results of this study indicated that the concentration of Pb in the body of *Nemipterus* sp., both in the skin, muscle, and gills were above the permissible quality standards (Table 1). The gill of threadfin bream is the accumulator organ which obtained the highest Pb concentration with average value of 43.544±21.58451 mg kg^{-1}, followed by skin with the concentration of 33.256±16.25153 mg kg^{-1} and meat (muscle) amounted to 19.098±7.949058 mg kg^{-1} (Table 1). This result was due to the reason that gill is the main entry of the dissolved metal ions from the water and has a very large surface area to facilitate diffusion of metal (El-Moselhy et al 2014; Olgunoglu et al 2015). Gill also has function to perform gas exchange, ion regulation, acid balance and waste excretion (Murtala et al 2012). According to Akan et al (2012), gill on all fish tends to be more significant in accumulating the metal than any other organ. Gill tissue can separate the blood from water and is highly vulnerable to changes in variables (heavy metals, pH, temperature, etc.) in the environment. These variables affect the structural integrity of the gill and cause morphological changes. For this reason, the gill is a good indicator of water pollution (Javed & Usmani 2011) because the gill filaments and lamellae provide a large surface area for continuous direct contact with contaminants in the water (Olgunoglu et al 2015). Therefore, the heavy metal concentration in gill reflects the heavy metal concentration in the waters where the fish live (Olgunoglu et al 2015).

In fish, other than gills, skin and digestive tract are potential organs to absorb a load of chemical material contained in waters (Javed & Usmani 2011). When fish are exposed to heavy metals, they will absorb and accumulate these metals in gills and skin

(Weber et al 2013). In this study, the concentration of metal in the skin was higher than the concentration of metal in muscles. It is also shown in studies conducted by Al-Weher (2008) and Yasmeen et al (2016) that the concentration of metals in the skin of three different species was higher than that in the muscle. High metal concentration in the skin was due to the pattern between metal and mucus which is not possible to be removed from the tissue. These results showed that the lowest concentration of heavy metals is usually stored in the muscles rather than in the skin, while higher values were recorded to be in the gills and sometimes in the bones and scales (Weber et al 2013).

The meat (muscle) has the lowest metal concentration compared to the gills and the skin. However, a concentration of Pb in muscles has exceeded the permissible quality standards. Muscle is an important part of fish because this part is consumed by people and has lipophilic nature. The concentration of heavy metal in the muscle that exceeds the value of the quality standard impacts on serious health effects (Malik et al 2014). Lower metal concentration in the muscle than that in the gills and skin proved that the muscle is not an active organ to accumulate heavy metals (Asante et al 2014). Murtala et al (2012) also stated that the metal concentration in meat which was lower than that in the gill was caused by the reason that gill is an organ that directly interfaces with the environment, on the other hand muscle is not a bioaccumulated active issue. Metabolic rate and the amount of food intake vary among organisms. Moreover, organisms that have more food intake tend to accumulate more metal (Asante et al 2014). Bioaccumulation of heavy metals in fish will impact on the biological and biochemical growth status (Ibrahim et al 2013).

Conclusions. Based on the result and discussion above, it can be concluded that the accumulation of heavy metals in threadfin bream body (*Nemipterus* sp.) in the waters of Banten Bay namely the meat tissue (muscle), skin and gills has exceeded the quality standard set by BPOM. Industrial, residential, and fisheries activities generate waste that produce pollutants in the environment around the waters of Banten Bay. One of the waste is in the form of Pb which further will be accumulated in the body of organisms. Establishment of regulation by the government concerning the threshold of waste disposal is required to reduce the level of pollution.

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