FINAL TECHNICAL REPORT ON THE PESUT MAHAKAM POPULATION AND WATER QUALITY MONITORING SURVEYS IN 2023



January 2024

RASI CONSERVATION FOUNDATION
(RARE AQUATIC SPECIES OF INDONESIA)

PREFACE AND ACKNOWLEDGEMENTS

This technical report presents the results of research conducted on the occurrence, population size, and threats to the Mahakam River dolphin (Pesut Mahakam) population, as well as the condition of its habitat in 2023. This research is part of the "Pesut Mahakam Conservation Program," a research and conservation program carried out by RASI Conservation Foundation since 1999. In this program, RASI collaborates with the East Kalimantan Provincial Government, particularly in the Kutai Kartanegara and Kutai Barat districts, the East Kalimantan Natural Resources Conservation Agency (BKSDA), and the Pontianak Coastal and Marine Resources Management Center (BPSPL). We express our gratitude for their support and cooperation.

This report publishes the results of the Mahakam River dolphin monitoring surveys conducted in March, June/July, and November 2023. All activities were made possible with the support of a grant from a philantrophic organization.

The surveys were conducted by a team led by senior researcher Danielle Kreb, along with assistants: Dahlia, Rendra Bayu, Emma, Henriette, Rory, Ismail (YK-RASI), Zulfa, Hera (FMIPA students), Alfin, and Kaisar (BPSPL Pontianak). We would like to express our gratitude to all observers and boat drivers, especially Mr. Darwis. We are also thankful for all the information shared with our team by the residents and fishermen along the Mahakam River.

Samarinda, 29 Januari 2024



Budiono. Ir.

Director Yayasan Konservasi RASI

Office address:

Jalan Kadrie Oening
Komplek Pandan Harum Indah
(Erlyza) Blok C, No. 52
Samarinda 75124
Kalimantan Timur, Indonesia
Office: +62.5414113510
Mobile: 081348072072
http://www.ykrasi.org
Facebook group/page:
Rare Aquatic Species of Indonesia

Citation: Kreb, D. & Budiono. 2024. Final technical report on the Pesut Mahakam population and water quality monitoring surveys in 2023. Yayasan Konservasi RASI.

CONTENTS

PREFACE & ACKNOWLEDGEMENTS i

CONTENTS ii

SUMMARY 1

1. INTRODUCTION 2

1.1. Background 2

1.2. Goal 3

2. METHODS 4

2.1.1. Monitoring of Pesut and water quality 4

2.1.2. Mark-recapture Photo-Id Analyses 5

2.2. Water quality Tests 5

3. RESULTS 6

3.1. Pesut Mahakam population 6

3.1.1. Distribution 6

3.1.2. Population size and birth rate 8

3.1.3. Mortality rate 9

3.2. Water quality in Pesut habitat 11

3.2.1. Interpretation of *in-situ* water quality test results . . 11

3.2.2. Interpretation of Laboratory Water Quality Results . . 12

3.3. Threats 13

3.4. Aquatic Conservation Area 17

4. RECOMMENDATIONS 18

5. REFERENCES 21

ACTIVITIES DOCUMENTATION 23

TABLES

1. Annual population estimation 8

2. Water quality at pesut locations 12

FIGURES

1. Pesut Mahakam sightings in March, June/July, and November 2023 . 7

2. Frequency of pesut encounters per habitat 6

3. Estimated size of the Pesut population in the Mahakam River between 2005 and 2023 with regression trend. 9

4. Probable causes of death 1995-2023. 10

5. Annual by-catch mortality 10

6. Alternative fishing gear or alternative income generation desired by fishermen if a ban on gillnets comes into effect 18

7. Alternative fishing gear desired by fishermen if a ban on gillnets comes into effect 19

APPENDICES

1. Aquatic Conservation Area in upper Mahakam of Kutai Kartanegara district 32

2. Sampling location map 33

3. Water test results of *in-situ* sampling in 2023 34

4. Water quality results at dolphin locations in 2023. 37

5. Water quality lab test results in 2023 38

SUMMARY

The purpose of monitoring the Pesut Mahakam dolphin population across the Mahakam watershed—which serves as its habitat—is to determine the number of individuals in the population, the birth and death rates over a year, and the dolphins' seasonal presence and threats. Additionally, water sampling surveys were conducted to assess the water quality in the dolphin habitat.

Survey transects, traveled twice (downstream and upstream) per survey, were conducted along the Mahakam River during three surveys in March, July, and November 2023. These surveys covered areas from Muara Kaman to Kampung Baru on the main river, including tributaries such as Kedang Rantau, Kedang Kepala, Belayan, Pela, Kedang Pahu, and Lake Semayang. The total distance covered during the search was 1,678 km over 24 days, with an average of 70 km searched per day at a speed of 12.3 km/h.

Across all three surveys, Pesut Mahakam dolphin groups were observed 28 times, with an average group size of 9 individuals (median = 8.5; min = 1; max = 20). Observations and photography were conducted for a total of 25 hours. For 95% of individuals observed in each encounter, dorsal fin photographs were successfully captured. Of these, 99.6% of the dorsal fins could be distinguished from others, resulting in a direct count of 59 individual dolphins (excluding newborns after the first survey session). Photo-identification analysis using MARK 9.0 software and full-likelihood closed capture models estimated the population at 60 individuals (min-max: 60–60; CV = 3%) in 2023. Five dolphin calves were born in 2023, and one adult male dolphin died, though the cause of death is unknown as the carcass was not recovered; another adult died as a result of a vessel strike wound and one calf died after being electrocuted. The average birth rate over the past 7 years (2017–2023) is 5 calves per year (range: 4–7).

The average mortality rate over the past 29 years (1995–2023) is 4.1 dolphins per year, with 70% of known deaths caused by entanglement in gillnets leading to drowning. However, mortality due to gillnet entanglement has significantly decreased over time (R^2 = 0,174; F (1,27) = 5.68; p < 0,05>0,01). The second most commonly-known cause of death is boat strikes (8%), followed by suspected poisoning (7%). In 26% of cases, the cause of death is unknown. Of all dolphin deaths, 72% were adults, 21% calves, and 7% juveniles. Of the deaths with known sex (35% of all cases), the male-to-female sex ratio is 1:0.9.

Laboratory water quality tests from 14 water sampling stations during the three surveys in 2023 showed improved results compared to the 2017–2019 surveys in terms of lower heavy metal concentrations. However, other parameters still exceeded water quality standards. For example, 31% of 52 samples showed high Total Suspended Solids (TSS) levels in the main river, Kedang Kepala, Belayan, and

Pela tributaries. Chemical Oxygen Demand (COD) exceeded the standard limit (<25 mg/l) in 40% of samples from the Mahakam watershed, though this marks an

improvement from 2022 (86% of samples above the standard). The highest COD levels consistently came from Sabintulung waters (Muara Kaman District). Toxic NH_3-N levels also exceeded the standard in 17% of samples.

Beyond direct mortality and chemical pollution, habitat pressure is increasing, including underwater noise pollution from coal barge traffic in narrow tributaries. Additional threats include competition for declining fish resources due to wetland conversion into palm oil plantations, illegal fishing methods (electrocution and poisoning), and monopolistic gear that blocks fish migration, reducing fish regeneration.

On December 1, 2023, the Director General of Marine and Coastal Spatial Management issued Decision No. 61 regarding the Management Plan for the Mahakam River Conservation Area in Kutai Kartanegara Regency for 2023–2042.

1. Introduction

1.1. Background

Pesut Mahakam (*Orcaella brevirostris*) is the only species of freshwater dolphin in Indonesia. It is legally protected under Indonesian law and has been chosen as the symbol of East Kalimantan. Since 2000, it has been classified as "Critically Endangered" on the IUCN Red List of Threatened Species (Hilton-Taylor, 2000).

Pesut Mahakam is a mammal that begins reproducing at the age of 9 and gives birth to a single calf every 3–5 years. The gestation period is 14 months, with nursing lasting up to 1.5 years (Stacey & Arnold, 1999). Monitoring of Pesut Mahakam has been conducted since 1997, and since 2005, population monitoring has used dorsal fin photo-identification, which works like a fingerprint to distinguish individuals. The most accurate population estimate in 2022 was 62 individuals.

Given the relatively high average mortality rate (4 dolphins/year) and average birth rate (5 calves/year), this population requires serious attention to create a stress-free environment that can increase birth rates and reduce mortality.

Key habitats identified between 1999 and 2022 are the waterways of Kutai Kartanegara (Kukar) from Muara Kaman to Batuq, including tributaries Kedang Rantau, Kedang Kepala, Belayan, Pela, and Batubumbun. In West Kutai (Kubar), the primary distribution ranges from Batuq to Muara Pahu and includes the Kedang Pahu tributary. Between Muara Pahu and Muara Benangaq (and further upstream), Pesuts are generally only seen during low water levels.

Since 2010, Pesut sightings have become increasingly rare in Kubar, especially in Muara Pahu where they used to be seen under various water conditions. The decline in the Muara Pahu area is attributed to multiple factors, including the loss of fish spawning grounds due to wetland conversion into oil palm plantations and coal transport activity in Kedang Pahu—previously a vital migration route for Pesut. With the degradation of this core habitat, preserving the Pesut population in Kukar has

become even more important to prevent extinction.

As a sign of government commitment to Pesut conservation, on January 27, 2020, the Regent of Kutai Kartanegara signed Decree No. 75/SK-BUP/HK/2020, reserving 43,117 hectares as a Conservation Area for the Pesut Mahakam Habitat. This area, agreed upon by 27 villages within it, was granted national status when the Ministry of Marine Affairs and Fisheries officially designated the Upper Mahakam Waters as a Conservation Area via Decree No. 49/KEPMEN-KP/2022. The 42,667.99-hectare area is divided into three zones; 1. Core zone (1,081.28 ha), 2. Limited use zone (30,695.74 ha), 3. Other zones (10,890.97 ha), consisting of: Rehabilitation zone (2,732.08 ha), Large vessel traffic zone (385.72 ha) and Area-specific zone (7,773.17 ha) (see Appendix 1)

On December 1, 2023, the Director General of Marine and Coastal Spatial Management issued Decision No. 61 on the Management Plan for the Mahakam Waters Conservation Area in Upper Kutai Kartanegara for 2023–2042.

1.2. Goal

The objective of this monitoring activity is to inventory the distribution and abudance the of Pesut Mahakam population, identify threats, assess annual birth and death rates, and evaluate the habitat quality conditions for the Pesut.

2. Methods

2.1.1. Monitoring of Pesut and Water Quality

Monitoring was conducted in March, July, and November 2023, with each survey lasting 8 days. The survey covered the entire Pesut Mahakam range, from the downstream area at Muara Kaman to Kampung Baru (Muara Pahu District) along the main river and its tributaries: Kedang Rantau, Kedang Kepala, Belayan, Pela, Kedang Pahu, and Lake Semayang.

The total search distance was 1,678 km over 24 days, divided into 3 survey periods: 1) March 7–14, 2023 2) June 30 – July 7, 2023 3) November 6–13, 2023.

Each route was covered at least twice. The average boat speed was 12.3 km/h, depending on whether the boat was traveling upstream or downstream, with a maximum speed of 14.5 km/h downstream. Observations were conducted between 8:00 AM and 6:00 PM. Each survey was carried out by a team of four: three observers and one recorder. The first observer was positioned on a platform at the front of the boat, around 3 meters above the water surface, using binoculars. The second and third observers scanned the front and sides up to a 90° angle with the naked eye. The recorder sat facing the rear to monitor bends in the river, ensuring no Pesut were missed, and also documented location, speed, and weather conditions. Observers rotated positions every 15 minutes.

When Pesuts were sighted, the location name and GPS coordinates were recorded. A photo session followed, focusing on dorsal fins—each having unique characteristics that allow for individual identification. These photos were compared to an existing photo-ID catalog for both right and left sides. After sufficient photos were taken (average of 40 minutes), and the number of individuals and group composition (adults, juveniles, calves, and newborns under 2 months) were estimated, in-situ water measurements began.

Parameters measured in situ included: Dissolved Oxygen (DO), pH, Electrical Conductivity (EC), Total Dissolved Solids (TDS), Water temperature, Clarity (Secchi disk), Depth (Echosounder), Current speed, River width (laser range finder).

In addition to sampling at Pesut encounter points, water sampling was also carried out at 28 predetermined locations. Of these, 14 stations had water samples sent for lab analysis (see Appendix 2).

Informal ad hoc interviews were conducted with fishermen encountered along the riverbanks. Questions covered the time and place of their most recent Pesut sightings and the condition of local fisheries under different water conditions. They were also asked whether they had any information about Pesut deaths.

2.1.2. Analyses

Photos were selected based on good image quality, considering aspects such as focus, glare, photographic angle, and completeness of the dorsal fin in the frame. They were cataloged based on identifiable features. Characteristics used to differentiate individuals included nicks and scars on the dorsal fin, as well as the distinct shape of the fin itself.

To estimate the number of individuals in the Mahakam population, two methods were used: first, by counting the total number of distinguishable dorsal fins—equivalent to individuals—that had been identified within one year (a combination of all uniquely identified individuals across four surveys). This represents the minimum population size. Second, estimation was carried out using the MARK software program, specifically selecting the "Closed captures - Full Likelihood" analysis. This analysis compared eight models and then selected the average result from several models that best fit the data (95% of the total model weight), where the delta AIC did not exceed 10. This method yielded the total annual population size. One correction was applied for the percentage of individuals that could not be identified due to lacking distinguishable features. For the Mahakam population, this percentage was minimal, ranging between only 1–4% of the population.

Birth figures were based on the presence of newborn calves under three months of age during all three surveys that covered the entire roaming range of Pesut Mahakam. Calves were identified by the presence of visible fetal folds—fat creases that remain visible for up to three months—body size, and distinctive newborn swimming patterns. Once a newborn calf was sighted, the dorsal fin of the mother was photographed so that the calf would not be counted as a new birth in subsequent surveys.

2.2. Water Quality Tests

From the 14 locations where water samples were collected and tested in the laboratory, the following parameters were examined: TSS, COD, Total Phosphate as P, NH_3-N, Cadmium (Cd), Copper (Cu), Iron (Fe), Lead (Pb), Manganese (Mn), Potassium (K), number of plankton taxa, number of individual plankton per liter, plankton diversity index (H), plankton evenness index (E), and plankton dominance index (D). Laboratory analysis was carried out at the Faculty of Fisheries Laboratory,

Mulawarman University (UNMUL), Samarinda, as an accredited laboratory. The results were then compared with the Water Quality Standards listed in the Government Regulation of the Republic of Indonesia No. 22 of 2021, Appendix VI.I, Class 2.

3. Results

3.1. Pesut Mahakam Population

3.1.1. Distribution

Across the three surveys conducted between March and November 2023, Pesut groups were encountered 28 times, with each survey recording a minimum of 7 and a maximum of 11 groups. The emergence points of Pesut can be seen in Figure 1. From the sighting locations, it is evident how important the aquatic conservation area in Kutai Kartanegara Regency is, as 89% of Pesut sightings across the three surveys occurred within that area (Figure 2).

The March and July surveys were conducted under medium water conditions, while the November survey took place as water levels began rising from dry to medium conditions. Migration of Pesut upstream toward West Kutai and Mahakam Ulu typically occurs during the dry season when kendia (*Thynnichthys vaillanti*) and repang (*Osteochilus repang*) fish also migrate upstream. However, during this survey period, water levels were not low, so the majority of Pesut remained in the Central Mahakam area.

Of the 28 Pesut encounters during the 2023 surveys, 43% occurred in tributaries, 32% in the main river, and 25% in estuary habitats (Figure 2).

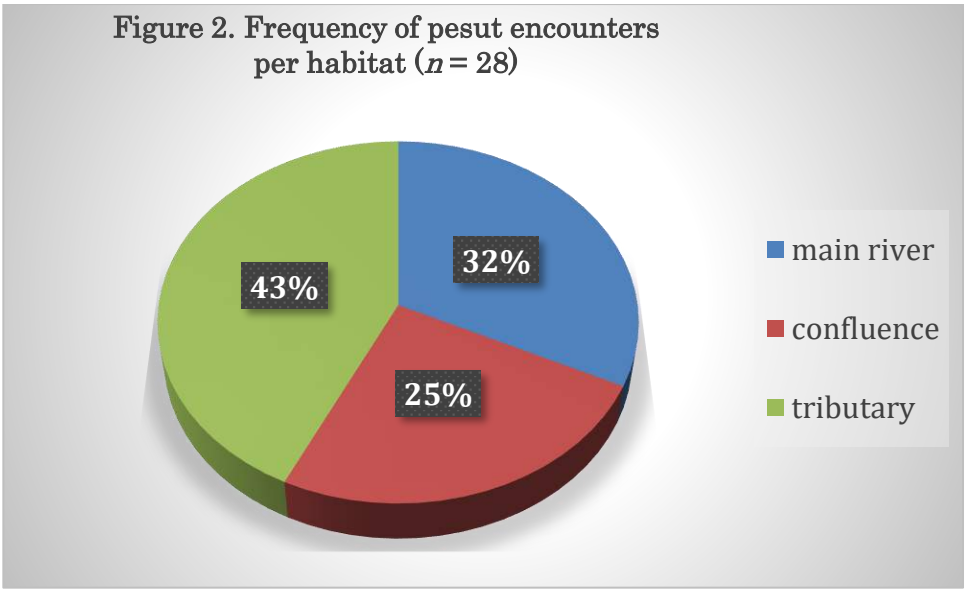
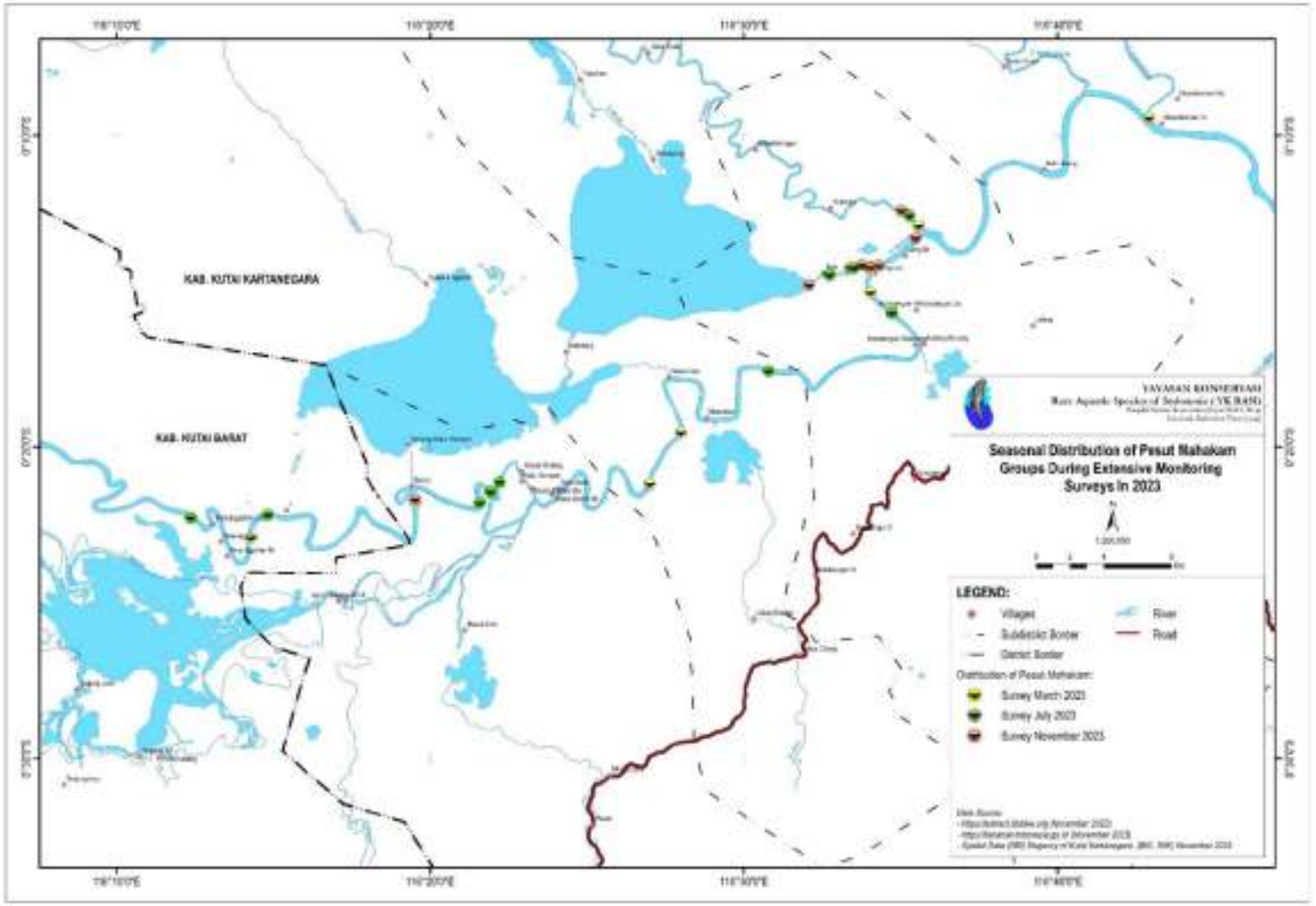


Figure 1. Pesut Mahakam sightings in March, June/July, and November 2023



3.1.2. Population Size and Birth Rate

During the three surveys, 28 Pesut groups were found, with an average group size of 9 individuals (median = 9; minimum = 1; maximum = 20). Two newborn calves (less than two months old) were observed during the March (born in February) and November (born in October) surveys. In total, including observations outside the three main surveys, five calves were known to have been born in 2023. The other three were recorded by the RASI team in June, August, and December.

The number of Pesut estimated from photo-identification and mark-recapture analysis for 2023 was most accurately calculated at 60 individuals (range 60–60; coefficient of variation = 3%). This figure includes new births and accounts for one death in 2023 (see Table 1).

Table 1. Annual population estimation (N (1/P) based on the weighted average of N from various models which has a weight of 95% & <10 Delta AICc

Year	Capture sessions	Coverage of dolphin habitat	N marked*	N best**	lower N final 95% CL	upper N final 95% CL	CV (%)
Closed Captures Full Likelihood							
2023	3	full	59	60	60	60	3
2022	3	full	56	62	61	62	5
2021	4	full	63	65	65	65	2
2020	4	full	58	63	63	63	2
2019	4	full	66	72	72	73	9
2018	4	full	67	71	71	73	9
2017	4	full	69	72	72	72	1
2016	3	full	68	69	69	69	4
2015	3	1 full + 2 partial	70	78	77	79	6
2014	3	2 full + 1 partial	71	80	79	81	6
2013	3	all partial	61	86	81	91	12
2012	4	2 full + 2 partial	78	81	81	81	2

Habitat coverage: full= entire potential distribution range (extensive surveys); partial = highest dolphin density area only (intensive surveys). N marked = total number of different distinctive fins that could be identified. N best = Mark-recapture estimate (model-averaged for multi-sample models) corrected for the proportion of identifiable individuals per year and after correcting for animals that died and calves that were born after the first capture session. CV = Coefficient of Varation.

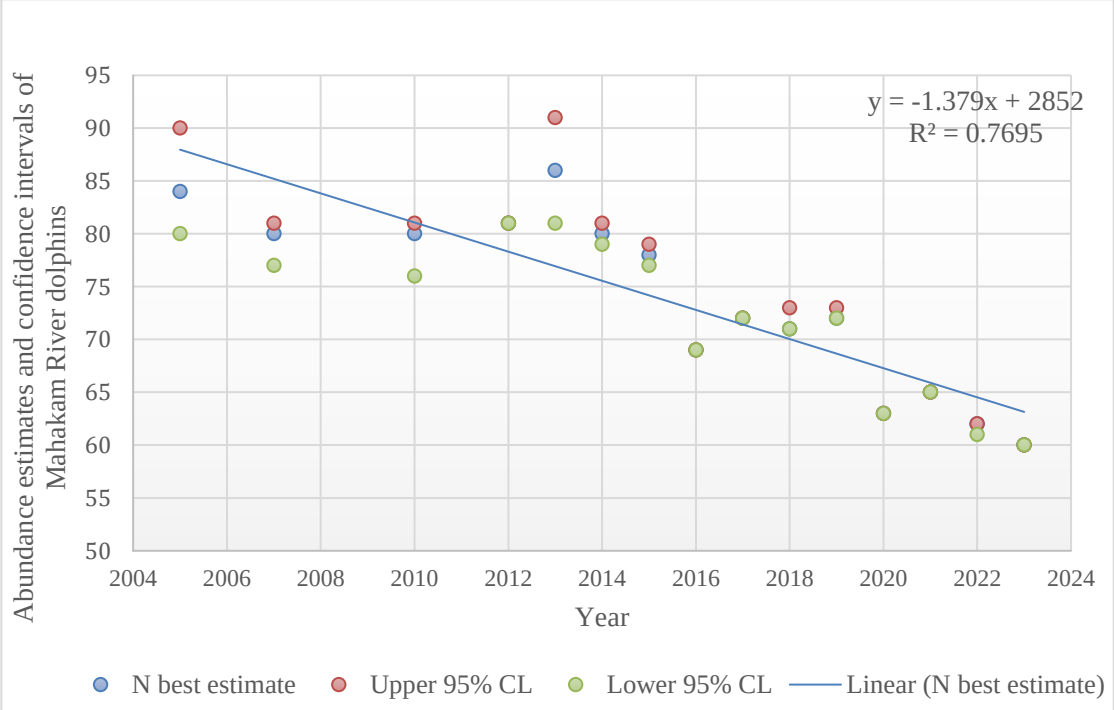


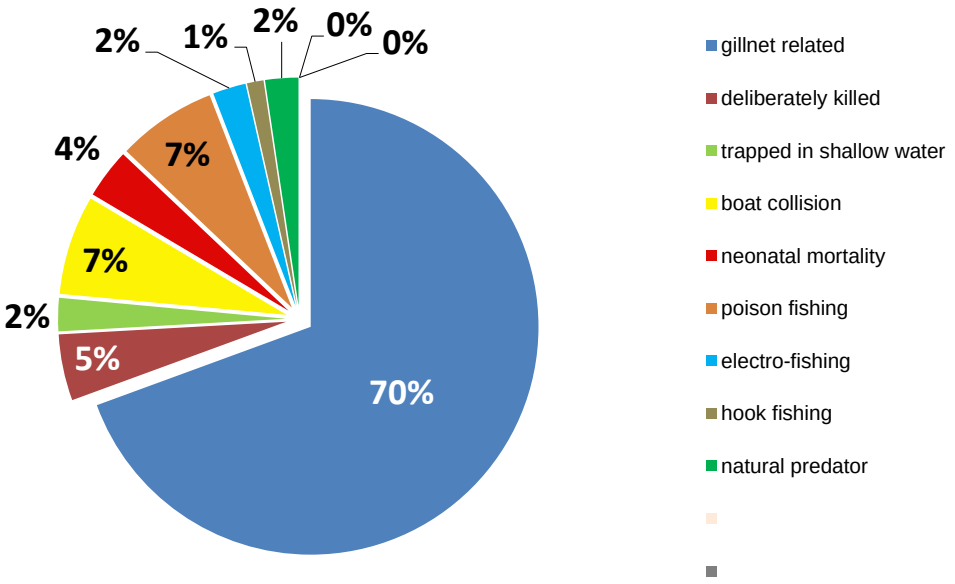
Figure 3 Estimated size of the Pesut population in the Mahakam River between 2005 and 2023 with regression trend. The population is fluctuating in size since 2005 but overall decreasing significantly (R2=.74, F (1,13) = 36.4, t = -6.03, p =<.000).

3.1.3. Mortality Rate

From 1995 until the end of 2023 (a span of 29 years), there were 119 recorded cases of Pesut Mahakam deaths, with an average of 4.1 individuals dying per year. However, when focusing on the last six years, the mortality rate slightly exceeded the average, reaching 4.8 individuals per year. Among all cases with known causes of death, 70% were due to entanglement in gillnets (locally known as *rengge*), which caused the dolphins to drown (Figure 4). The second most common cause of known mortality was collisions with pontoon and speed boats (8%), followed by suspected poisoning (7%). In 23% of cases, the cause of death could not be identified.

Age data was available for 94% of all death cases, while sex data was available for only 36%. However, over the last six years, the reporting network has improved, and sex was identified in 76% of cases. Of the deceased Pesut, 72% were adults, 21% were calves under one year old, and 7% were juveniles (Figure 4).

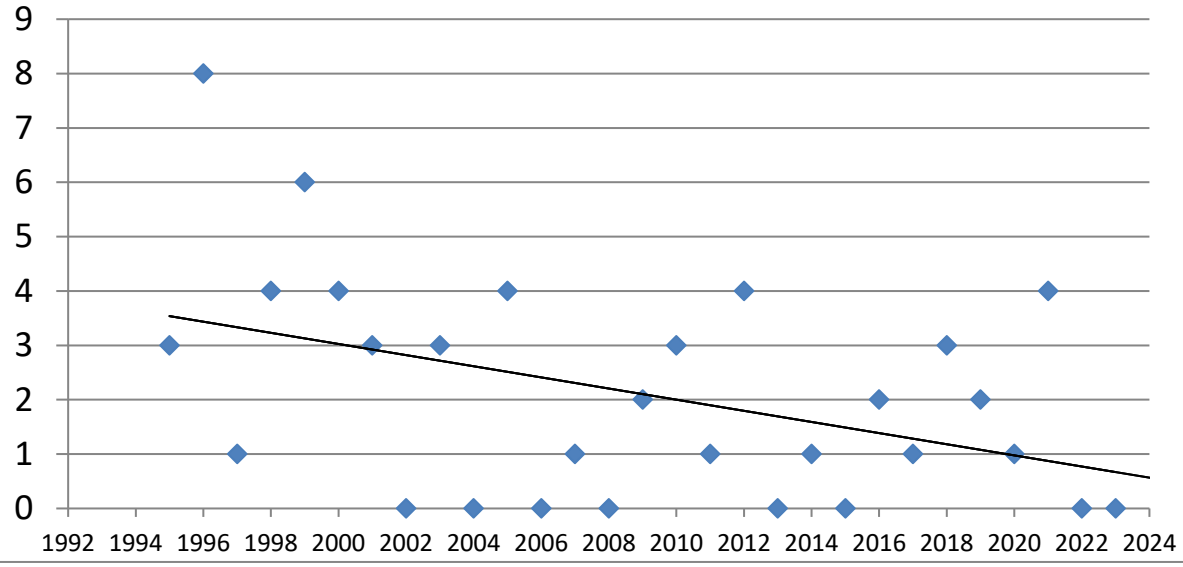
Figure 4. Probable causes of mortality 1995-2023* (n=119)



* only known mortality causes displayed. 24% of all mortalities causes are unknown

Although the overall trend in mortality has not shown a significant decline, deaths caused by entanglement in gillnets have started to decrease significantly ($R^2 = 0{,}174$; $F(1, 27) = 5{,}68$; $p < 0.05 > 0.01$) (Figure 5).

Figure 5. Annual by-catch mortality



Necropsies have been successfully conducted 14 times between 2009 and 2021, including six newborn calves. In 7 out of 8 adult death cases, gillnet fragments were found in the throat or stomach.

3.2. Water Quality in Pesut Habitat

The results of water quality analysis measured directly in the field during the three surveys in 2023 can be found in Appendix 3.

3.2.1. *Interpretation of In-Situ Water Quality Test Results*

As shown in Appendix 3, DO and pH values were low in the Kedang Rantau River across all three surveys. However, this condition is considered a natural phenomenon because the Kedang Rantau River directly connects to swamp habitat, which leads to eutrophic conditions with low dissolved oxygen and low pH. Similar conditions were observed in Muara Bolowan and the Kedang Pahu tributary during the March and November surveys, as Bolowan River also connects directly to swamplands.

Low DO levels were also recorded near the floating conveyor downstream of Muara Kedang Kepala in the Mahakam River, upstream of Muara Siran (Kedang Kepala River), and throughout the Mahakam watershed from Batuq (Muara Muntai subdistrict) to Kampung Baru (West Kutai) during the November survey. These latter cases were not due to natural swamp-related factors.

Water characteristics at Pesut encounter locations are presented in Table 2 and Appendix 4. During the surveys, Pesut were found in waters with specific ranges for several parameters measured in situ.

Tabel 2. Water quality at pesut locations (in-situ)

Water levels: M(edium); L(ow)	M-1	M-2	LM-3	M-1	M-2	LM-3	M-1	M-2	LM-3
DO- mg/l	4,8	4,6	4,2	1,8	4,3	2,1	6,8	4,8	5,7
pH	6,1	6,3	7,0	5,0	6,1	6,9	7,0	6,4	7,1
EC-mS,cm	34	29	48	16	26	42	55	31	56
TDS-mg/l	17	14	24	8	13	20	28	16	28
River Width- m	245	200	241	134	116	149	488	276	370
Clarity-cm	39	27	21	25	20	15	58	33	33
DEPTH-m	16	12	13	4	6	9	24	18	22
Current Speed-km/h	2,1	2,0	2,0	0	0,1	0	3,6	3,4	4,6
Water temp °C	28,9	27,2	27,8	26,6	26,1	26,5	32,6	28,3	29,8

3.2.2. *Interpretation of Laboratory Water Quality Results*

The results of water quality tests from 14 sampling stations across three surveys in 2023 showed improvements compared to previous reports from 2017–2019, particularly in the reduction of heavy metal concentrations in the water (Appendix

5). However, other substances were still found at relatively high levels, exceeding the water quality standards.

High Total Suspended Solids (TSS, standard <50 mg/l) were found in 13 samples (25% of 42 total samples) from the main river, Kedang Kepala River, and Belayan River. COD (Chemical Oxygen Demand) levels exceeded the standard (<25 mg/l) in 17 samples (40%) throughout the Mahakam watershed survey area. The highest COD levels were consistently recorded during all three 2023 surveys in the waters of Sabintulung (Muara Kaman subdistrict), reaching up to 54 mg/l. High COD was also recorded in Kampung Baru (Mahakam, West Kutai) in July and November, reaching 58 mg/l, and in Bolowan River (West Kutai) during the March survey at 54 mg/l. COD levels in Kedang Kepala River (upstream of Muara Siran) exceeded the standard in March and July, as did Belayan River in July.

NH_3–N (ammonia nitrogen) also exceeded the water quality standard in 6 of 42 samples (14%), indicating suboptimal organic matter decomposition. While the general standard is 0.2 mg/l, for fisheries purposes, free ammonia concentrations should ideally be ≤0.02 mg/l, especially for sensitive fish species. Higher concentrations of free ammonia may negatively impact fish diversity.

Based on the findings, at least 26 sampling points (62% of all points) exceeded optimal thresholds for sustainable fisheries.

3.3. Threats

In addition to direct mortality (as described in section 3.1), several other factors have contributed to the degradation of Pesut Mahakam habitat quality, including the following:

3.3.1. Underwater Noise Pollution

One of the main sources of underwater noise pollution is high-speed boats (40–200 HP), which cause Pesut to dive for longer durations when boats approach within 300 meters (Kreb & Rahadi, 2004). Additionally, frequent fast-moving boats (*ces*) in narrow tributaries like Pela also force Pesut to stay submerged longer.

Although coal barges emit low-frequency sounds (in kHz), their decibel levels are quite high, averaging 111 dB when passing within 50 meters of the hydrophone. Underwater noise levels above 80 dB are already enough to disrupt the sonar echoes and vocalizations that Pesut rely on to perceive their surroundings. This disorientation can be extremely dangerous, especially in narrow tributaries (Au, 1981; Gordon et al., 1996). Nedwell et al. (2003) also categorized fish avoidance responses based on underwater noise starting at 75 dB (moderate), 90 dB (significant), and 100 dB (strong).

One example of the impact of coal barge transportation in tributaries is Kedang Pahu River (West Kutai). Up to 2014, coal barges passed through this narrow river daily (average of 8.4 barges per day), which was previously a key Pesut habitat.

During the dry season, these barges occupied more than two-thirds of the river's width and more than half of its depth. Pesut routinely changed their swimming direction (especially when heading upstream) to avoid these barges. According to local fishermen, before the barges appeared, Pesut would swim deep into the tributary up to the mouth of Bolowan River (around 10 km from the mouth of Kedang Pahu) under all water conditions. Now, they no longer do so.

Since 2015, coal barges have also begun entering Kedang Kepala tributary in Kutai Kartanegara. This is alarming, given the significant underwater noise pollution generated by such vessels. On August 12, 2018, a female calf was reportedly struck by a coal barge that suddenly emerged around the first bend from the river mouth and encountered a group of Pesut. The calf was carried by the group to the shore and died shortly afterward, then was buried. Another case involved an adult female Pesut found dead on March 4, 2021, at kilometer 1. Without informing authorities, the dolphin was buried at the riverbank, preventing any necropsy.

The barge in question measured 300 feet in length and 27.4 meters in width—far exceeding the permitted dimensions for rivers less than 100 meters wide (maximum width should be 1/6 of river width, according to Ministerial Regulation No. 52, 2012). These large vessels damage riverbank ecosystems, which are important nesting and breeding grounds for fish. If coal barge traffic through tributaries like Kedang Kepala and Belayan continues unchecked, it could threaten the survival of Pesut and the fishery resources that sustain local communities.

An acoustic study conducted between 2015 and 2017 found that Pesut presence in the Kedang Kepala river mouth declined by 50%, even though the area had previously been part of the species' daily range and a core zone (RASI Foundation Report 2017 – Independent assessment of coal barge traffic impacts in Kedang Kepala tributary).

3.3.2. Chemical Pollution

Coal often falls into the river, which may have caused visible changes in the skin coloration of Pesut in the Kedang Pahu area, as observed in 2002 and 2007. This phenomenon has never been observed in Pesut from other regions. In addition, wastewater from coal washing processes flows into large tributaries and lakes during high tides. Pollution from oil palm plantations—through ditch systems that directly connect to Pesut habitat and prey zones—as well as embankment systems that eliminate swamp areas crucial for fish breeding, further worsens water quality. These effects have been observed in Muara Pahu and, according to fishermen, are increasingly felt in areas like the Kedang Rantau–Muara Sebintulung zone in Kutai Kartanegara.

The expansion of industries such as coal and oil palm in areas designated for Pesut protection has led to a drastic reduction in the prey available to Pesut in Muara Pahu and its tributaries, causing the dolphins to be seen there less frequently, despite it being one of their historical core habitats. Pesticides (including chemical fertilizers,

herbicides, and non-organic inputs) from palm oil plantations that enter the river through company drainage systems also represent a poorly monitored threat.

During water quality surveys from late 2017 to early 2018, which were discussed in previous reports, several rivers and tributaries were found to contain high concentrations of heavy metals—posing serious health risks to both humans and Pesut. Cadmium (Cd) and Lead (Pb) concentrations exceeded quality standards by up to 23 times in the worst cases. The pollution conditions in core Pesut habitats—such as Kedang Rantau and Kedang Kepala tributaries—as well as seasonal habitats like Kedang Pahu, are extremely concerning, as heavy metal contamination can severely harm both Pesut and people who consume fish from these rivers.

These metals may originate from impurities in copper-based products used in pesticides, herbicides, and fungicides applied by palm oil companies operating in the surrounding areas. Lead and cadmium, often associated with coal-related industries (particularly coal combustion), are highly toxic. For instance, lead poses a major risk to children and may cause cognitive impairments (Tiwari et al., 2013), cardiovascular problems, and cancer. These heavy metals are non-biodegradable, meaning they persist in the ecosystem and bioaccumulate in the food chain.
Water quality testing conducted in November–December 2018 also detected copper pollution in Muara Sebintulung, alongside other contaminants that have been discussed in more detail in earlier reports.

Elevated NH_3–N concentrations across all surveys also present significant toxic effects on aquatic organisms—especially benthic crustaceans and mollusks—because of ammonia's ability to diffuse across gill membranes (Cheng et al., 2019). Among various aquatic environmental problems, high ammonia concentration is one of the most dangerous factors, along with oxygen depletion

(Egnew et al., 2019). Ammonia in water can cause acute mortality in fish such as *Micropterus salmoides* (largemouth bass), and under ammonia stress, it can worsen white spot syndrome virus infections in white shrimp (*Litopenaeus vannamei*) (Lu et al., 2019). It also causes cytological damage and DNA disruption in aquatic crustaceans like *Scylla paramamosain* after 48 hours of exposure (Cheng et al., 2019). Wang et al. (2020) reported that in the Liao River, China, the acute and chronic toxic thresholds for ammonia are 0.067 mg/l and 0.017 mg/l, respectively.

3.3.3. Decline in Prey Availability

- Intensive fishing using *rengge* (gillnets), electric shock (electrofishing), trawling (especially in lakes), poisoning (using Dupon/Lamet, Deses, and *akar gadung*), and the cultivation of predatory fish fed with wild-caught small fish from lakes or rivers has likely caused a significant decline in fish resources. During surveys, the team often observed electrofishing activities during the daytime, most commonly carried out using portable generators. Equipment was also found mounted on the front of boats to transmit electricity and catch

large quantities of small fish like *kendia*, which are part of the Pesut's diet.

- Monopolistic fishing gear such as *sawaran*, *peggongan*, and others also block seasonal fish migration routes, reducing fish regeneration.
- Deforestation along riverbanks has further reduced fish resources. It causes an increase in water temperature, sedimentation, and the loss of plant debris (like fallen leaves and fruits) that serve as food sources for fish. Underwater tree roots, which function as microhabitats and spawning grounds with slow currents, are also lost. A reduction in fish populations increases the likelihood that Pesut will be attracted to gillnets, heightening the risk of entanglement.
- The conversion of swamp forests into oil palm plantations—prevalent in this region—has also eliminated important fish breeding areas. Dams constructed by companies to prevent flooding have instead blocked fish from entering swamps to spawn or prevented small fish from exiting the swamps.
- Coal barge transportation in narrow tributaries also contributes to the decline in fish resources. These large vessels canalize the riverbed, damaging fish breeding sites located along bends, and disturb riverbanks where underwater roots, critical for fish egg-laying, are located.
- The blocking of channels that connect swamps to tributaries by fishers using *hempang* traps also prevents fish from returning to river ecosystems after spawning in the swamps.
- There are still no regulations establishing a fishing season or quotas for declining fish species. Furthermore, no bans exist on catching fish during spawning periods.
- The decline in prey availability can impact the amount of time and energy Pesut need to forage. It may also increase the likelihood that Pesut will attempt to take fish from gillnets (*rengge*), placing them at greater risk of entanglement.

3.3.4. Sedimentation

High sedimentation levels and the abundance of *rengge* (gillnets) in Lakes Semayang and Melintang have restricted the movement of Pesut within these lakes. As a result, except during periods of high-water levels, the movement of Pesut is now limited to narrow boat routes between the two lakes, increasing the risk of collisions and noise disturbances. Moreover, sedimentation also reduces fish resources (look below for decline in prey availability).

3.3.5. Potential Future Threats

Future threats include continued direct mortality and ongoing habitat degradation caused by deforestation, underwater noise pollution, and chemical contamination of rivers. Underwater noise can induce stress in Pesut, which may result in lower reproductive rates. Meanwhile, chemical pollutants such as heavy metals can lead to unhealthy offspring or even death.

Another threat lies in the reduction of food sources due to unsustainable fishing techniques—especially the increasing use of electric fishing powered by high-voltage generators, as well as intensified use of seine nets (*pukat*) for feeding predatory fish in aquaculture systems. The plan to move Indonesia's capital city (IKN Nusantara) to East Kalimantan may increase demand for freshwater fish from the Mahakam River. If fishery resources are not sustainably managed, this could lead to overfishing and a further decline in fish stocks.

Additionally, there is concern about the potential pressure from inbreeding among Pesut, which could manifest in reduced calf survival beyond their first year, lower adult survival rates, decreased reproductive capacity, and reduced competitiveness in securing mates. However, current population viability analyses indicate that inbreeding rates remain low in the Mahakam population. These analyses also estimate that the population can survive if the average number of deaths does not exceed 4 individuals per year. Population growth is only possible if the annual death rate remains below 4 individuals.

Since most deaths are caused by entanglement in *rengge* (gillnets), conservation efforts should focus on identifying strategies to prevent such mortality, followed by the implementation of government regulations.

3.4. Aquatic Conservation Area

On August 8, 2022, the Minister of Marine Affairs and Fisheries designated the Upper Mahakam Waters in Kutai Kartanegara Regency as a Conservation Area in the Upper Mahakam Waters of Kutai Kartanegara Regency through Decree Number 49/KEPMEN-KP/2022. The total area of the Conservation Area is 42,667.99 hectares, divided into three zones, namely: 1) core zone (1,081.28 ha), 2) limited use zone (30,695.74 ha), 3) other zones (10,890.97 ha), which consist of a) rehabilitation zone (2,732.08 ha), b) large vessel traffic corridor (385.72 ha), c) zone according to the area's characteristics (7,773.17 ha) (Appendix I).

Then, on December 1, 2023, there was a Decree by the Director General of Marine and Coastal Spatial Management Number 61 concerning the Management Plan for the Conservation Area in the Upper Mahakam Waters of Kutai Kartanegara Regency for the period 2023–2042.

4. Recommendations

Based on the summary of issues found in the field, the following recommendations are proposed:

1) *Reducing Pesut Mortality*
   a) Formulate a regional regulation (Perda) to prohibit all gillnets (*rengge*) with a mesh size greater than 4 cm (whether made from nylon or thread), all thread-based *rengge*, and all *rengge* that stretch across the river from bank to bank.
   b) Install underwater acoustic devices (*pingers*) on *rengge* to deter Pesut from

approaching, preventing them from taking fish from the nets. A long-term effectiveness evaluation study should be conducted. As of now, 266 pingers have been installed on *rengge* gear owned by 172 fishers since July 2020. Reported benefits include a reduction in Pesut taking or damaging fish in nets, and fishers have observed that the catch remains the same or even includes larger fish (Kreb, Rosana, Paisal, Jusmaldi, 2021).

c) Provide alternatives for fishers if *rengge* are later banned. Of 146 *rengge* fishers, 97% agreed to stop using *rengge* and switch to other tools or activities if a regional regulation were enacted banning *rengge* with mesh sizes greater than 4 cm (see figures 6 & 7).

Fig. 6. Alternative fishing gear or alternative income generation desired by fishermen if ban on gillnets comes into effect (n=146)

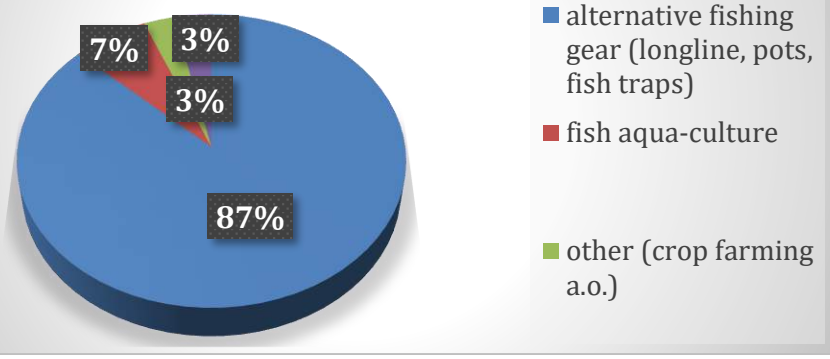
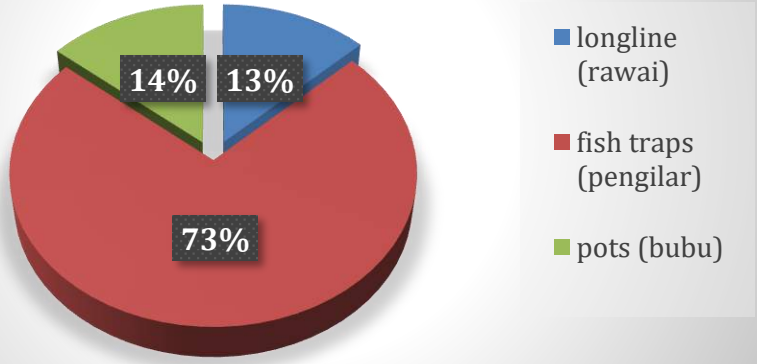


Fig. 7. Alternative fishing gear desired by fishermen if ban on gillnets comes into effect (n=101)



2) *Adressing Chemical Pollution*:

a) Continue investigations into the sources of river pollution and how to prevent it. These activities are expected to result in an appropriate action plan for Pesut conservation involving all stakeholders, both governmental and non-governmental.

b) Manage waste and sewage, and enforce a ban on dumping inorganic waste and domestic sewage into the river. One of the causes of declining water quality in Kedang Kepala and Kedang Rantau Rivers and surrounding areas is waste—particularly plastic—and household sewage. Therefore, waste and sewage management programs are needed. These should aim to reduce the volume of waste entering the river by minimizing waste production, improving waste treatment, and encouraging reuse. Activities should include public outreach, training, practical demonstrations, and follow-up assistance.
c) Heavy metal pollution must be eliminated by distancing oil palm plantations from rivers or flood-prone areas to prevent runoff from pesticides, herbicides, and fertilizers. Heavy metal contamination found near the conveyor belt site in Muara Kedang Kepala also demands urgent relocation of the conveyor downstream from the designated conservation area.

3) *Addressing the decline in fish population:*
a) Because 96% of all group sightings during the two-year survey (Nov 2019–Nov 2021) occurred in the proposed aquatic conservation area in Kutai Kartanegara Regency, it is strongly recommended that formal designation of the Aquatic Conservation Area proceed to protect Pesut habitat and ensure sustainable fishery resources.
b) Conduct regular patrols and enforce laws against the use of illegal fishing gear such as electric shock and poison.
c) Ban monopolistic fishing tools that block fish migration.
d) Carry out fishery extension services to support sustainable fisheries resource management.
e) Form fishers' groups to promote sustainable floating cage aquaculture (*keramba lestari*). This method combines pellet feed and vegetables and focuses on fish species such as *Jelawat*, *Mas*, or *Nila* bred locally to reduce pressure on wild stocks.
f) Provide training on fish breeding to reduce the cost of acquiring fingerlings from outside the zone.
g) Organize fish feed production training for women to ensure feed availability, reduce feed expenses, and increase women's participation.
h) Develop processing techniques for *Mas* or *Nila* fish (e.g., fish pressure cooking) to improve local fishers' income from sustainable cage aquaculture.

4) *Addressing underwater noise pollution*
a) Since tributaries are the primary feeding habitat for Pesut and it has been shown that their presence is disturbed by barge noise, it is recommended that no new permits be issued for coal barge transport through tributary routes within the designated conservation area. If existing permits allow such transport, it should be limited in frequency, with a minimum gap of 30 minutes

(or 3 km) between barges. Barges should not travel in opposite directions simultaneously in the following areas: from Muara Kedang Kepala to upstream of Muara Siran; in Belayan from Muara to Sebelimbingan; and in Kedang Pahu from Muara to Muara Bolowan. The size of the barges should be restricted to 180 feet.

b) Accelerate the development of land-based coal transport routes to avoid coal barges passing through tributaries. Currently, there are three tributaries traversed by barges: Kedang Kepala, Belayan, and Kedang Pahu. According to available information, PT. Bara Tabang is working on establishing a road link from its mine to a port on the Mahakam River near Kampung Baru, West Kutai. This presents an opportunity to completely eliminate barge transport through tributaries, which would significantly reduce pressure on these waterways and benefit both ecosystem health and Pesut safety.

c) Loading from small to large barges near Muara Kedang Kepala should be relocated outside the aquatic conservation area, specifically downstream of Muara Kaman. This area is part of the Pesut travel route and is currently overcrowded with barges queuing and parking, contributing to underwater noise and coal pollution.

d) Install signs indicating speed limits for boats, longboats, and speedboats (8–10 knots or max. 15 km/h) 1000 meters before entering the mouths of Pela, Semayang, Belayan, Kedang Kepala, and Kedang Rantau rivers, and along the full length of the Pela River, Kedang Rantau from the mouth to Muara Kaman Hulu village, Kedang Kepala from the mouth to Muara Siran village, and Belayan from the mouth to Sebelimbingan.

5) *Future monitoring*

It is recommended that surveys continue at least every four months per year.

5. References

Au, W.W.L. and Penner, R.H. 1981. Target detection in noise by echolocating Atlantic Bottlenose dolphins. J. Acoustic Soc Am. 70, 687-693.

Chang-Hong Cheng, Hong-Ling Ma, You-Lu Su, Yi-Qin Deng, Juan Feng, Jia-Wei Xie, Xiao-Long Chen, Zhi-Xun Guo. 2019. Ammonia toxicity in the mud crab (Scylla paramamosain): The mechanistic insight from physiology to transcriptome analysis. Ecotoxicology and Environmental Safety, Volume 179: Pages 9-16. ISSN 0147-6513, https://doi.org/10.1016/j.ecoenv.2019.04.033.

Nathan Egnew, Nilima Renukdas, Yathish Ramena, Amit K. Yadav, Anita M. Kelly, Rebecca T. Lochmann, Amit Kumar Sinha. 2019. Physiological insights into largemouth bass (Micropterus salmoides) survival during long-term exposure to high environmental ammonia. Aquatic Toxicology. Volume 207: Pages 72-82,

ISSN 0166-445X. https://doi.org/10.1016/j.aquatox.2018.11.027.

Gordon, J.& Moscrop, A. (1996) Underwater Noise Pollution and its significance for whales and dolphins. Pages 281-319 *in* Simmonds, M. P., Hutchinson, J. D., eds. University of Greenwich, UK. *The conservation of whales and dolphins*. John Wiley & Sons Ltd, Chichester, England

Hilton-Taylor, C. (2000) 2000 IUCN Red List of Threatened Species. IUCN, Gland, Switzerland and Cambridge, U.K.

Kreb, D. and Smith, B.D. (2000) *Orcaella brevirostris* (Mahakam subpopulation). In: IUCN 2004. *2004 IUCN Red List of Threatened Species.* <http://www.redlist.org/>.

Kreb, D. and Rahadi, K.D. 2004. Living under an aquatic freeway: effects of boats on Irrawaddy dolphins (*Orcaella brevirostris*) in a coastal and riverine environment in Indonesia. *Aquatic Mammals* 30, 363–375.

Kreb, D. & Budiono 2018. Laporan Teknis Monitoring Pesut Mahakam dan Kualitas Air July 2017-Mei 2018.

Kreb, D. & Budiono. 2019. Laporan Teknis Monitoring Pesut Mahakam dan Kualitas Air - Augustus 2018- Mai 2019.

Kreb, D. & Budiono. 2022. Laporan Teknis Monitoring Pesut Mahakam dan Kualitas Air – Periode November 2019- November 2021.

Kreb, D. & Budiono. 2023. Laporan Teknis Monitoring Pesut Mahakam dan Kualitas Air – Periode Maret - November 2022.

Kreb, D, Rosano, R.A., Paisal, Nainggolan, A.S., Jusmaldi. 2021. Pinger evaluation studies in the Mahakam River, Indonesia. Yayasan Konservasi RASI Technical report. July 2020-January 2021

Nedwell, Jeremy & Funnel, Red & Mill, Chase. (2003). Measurements of underwater noise during piling at the Red Funnel Terminal, Southampton, and observations of its effect on caged fish.

Stacey, P.J. & Arnold, P.W. (1999) *Orcaella brevirostris. Mammalian Species*, 616, 1-8.

Tiwari, S., Tripathi, I.P., Tiwari, H.L. 2013. Effects of lead on environment. *International Journal of Emerging Research in Management & Technology* 2 (6).

Lu Xia, Sheng Luan, Ping Dai, Kun Luo, Baolong Chen, Baoxiang Cao, Li Sun, Yunjun Yan, Jie Kong. 2019. Insights into the molecular basis of immunosuppression and increasing pathogen infection severity of ammonia toxicity by transcriptome analysis in pacific white shrimp Litopenaeus vannamei. Fish & Shellfish Immunology. Volume 88: Pages 528-539, ISSN 1050-4648, https://doi.org/10.1016/j.fsi.2019.03.026.

Xiaonan Wang, Ji Li, Jin Chen, Liang Cui, Wenwen Li, Xiangyun Gao, Zhengtao Liu. 2020. Water quality criteria of total ammonia nitrogen (TAN) and un-ionized ammonia (NH3-N) and their ecological risk in the Liao River, China. *Chemosphere*, Volume 243. 125328. ISSN 0045-6535. https://doi.org/10.1016/*j.chemosphere*.2019.125328

Documentation of activities



The research team consisted of 4–5 people, rotating positions every 15 minutes while searching for Pesut groups. Once a group was found, a photo session was carried out along with water sampling and testing.



Direct (in-situ) measurements were taken for parameters such as DO, pH, TDS, EC, and temperature.



During each photo session of a Pesut group, two DSLR cameras with zoom lenses up to 500 mm were used to capture clear images of the dorsal fins for individual photo identification. The ferry boat used was not very large, and its low engine noise made it very efficient for approaching Pesut and taking photographs.



In the November survey, a very active and playful group of Pesut was found in the Pela River



A newborn Pesut calf named Emi (under 1 month old), from a mother named "Belle," was observed in March.



Another newborn calf named Janski (under 1 month old), from a mother named "Jannah," was observed in November.



One unique behavior of Pesut, called spy-hopping or "peeking," was also observed, both in horizontal and vertical positions.



A rare moment was captured of a Pesut jumping with its body fully above the water surface.



Three Pesut surfaced in front of a coal barge tugboat. Due to loud underwater noise, the Pesut surfaced to view their surroundings, as the noise disrupts sonar reflection and causes disorientation.



Ongoing clearance of riverbanks continues to impact fish resources, which rely on riparian forests for: a) shade that helps maintain oxygen levels in the water, b) leaves and seeds that fall into the river as food for various fish species, c) underwater tree roots that serve as microhabitats and spawning areas in calmer currents, and d) biodiversity support for other species such as birds, otters, primates, reptiles, and other mammals.



The ideal Pesut habitat is one where riverbanks are still covered with tree vegetation or swamps that support fish reproduction and microhabitats.







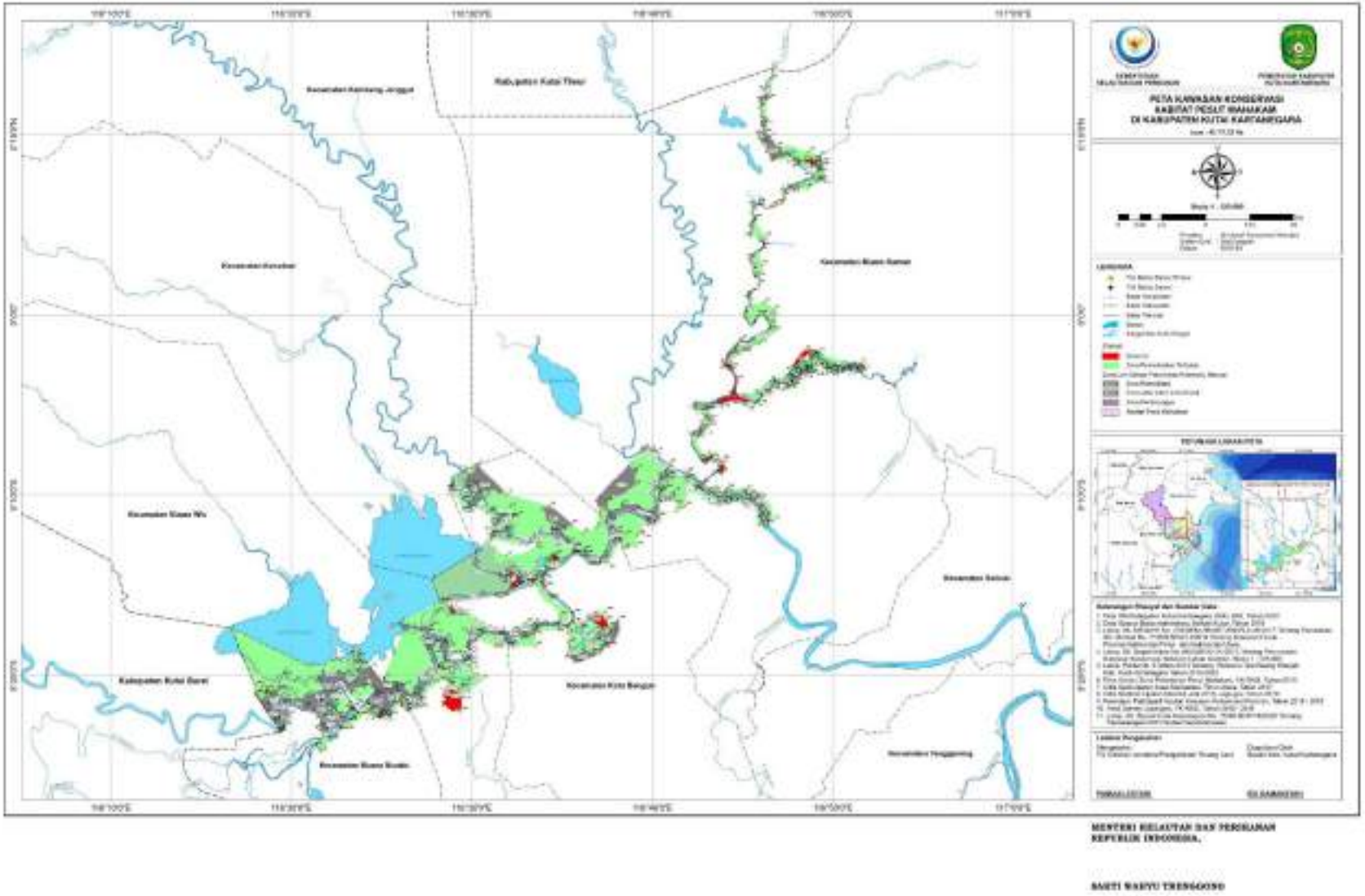
Fish traps, fish shelters (*rumpun ikan*), and nets are among the sustainable methods of fish resource utilization permitted within conservation areas.



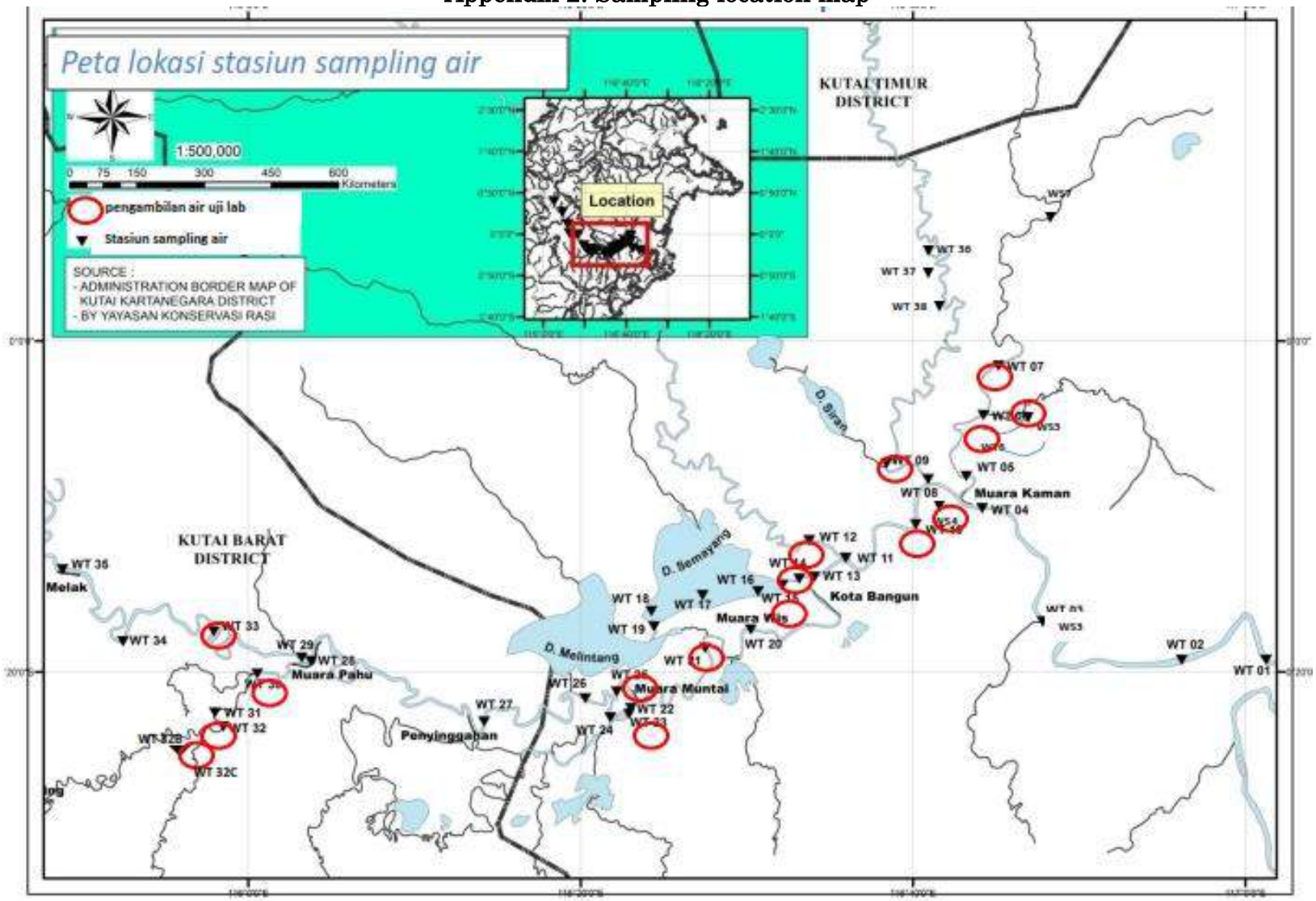



Other biodiversity observed during both the March and November surveys included: Brahminy kite, oriental pied hornbill, long-tailed macaque, proboscis monkey, smooth-coated otter, little cormorant, common kingfisher, and silvered leaf monkey.

Appendix 1. Aquatic Conservation Area in upper Mahakam of Kutai Kartanegara district



Appendix 2. Sampling location map



Appendix 3. Water test results of *in-situ* sampling during three surveys in 2023

Periode sampling (m-y)	Kondisi air: High Medium;Low	Stasiun sampling	Nama areal disusun dari hilir ke hulu	Tipe habitat	DO-mg/l	pH	EC-mS,cm	TDS-mg/l	River Width-m	Clarity-cm	DEPTH-m	Current Speed-km/h	Water temp °C
baku mutu (mg/l)-Perda Prop Kaltim No, 2, 2011 Lampiran V, Kelas 2					**>4**	**6-9'**	**<200**	**<1000**					
Mar-23	M	WT6	Hilir Muara Sabintulung	muara	1,5	5,5	39	19	114	72	14	0	28,6
Mar-23	M	WT5	Kedang Rantau	anak sungai	1,5	5,4	35	17	110	53	14	1,5	28,4
Mar-23	M	WT7	Hilir Tunjungan	anak sungai	1,6	5,5	37	18	144	75	17	2,8	28,6
Mar-23	M	WS5	Sungai Sabintulung	anak sungai	1,6	5,2	60	30	81	70	3	0	28,7
Mar-23	M	WS4	Conveyor M. Kaman	sungai utama	5,2	6,2	40	20	402	38	12	2,8	27,8
Mar-23	M	WT9	Hulu Muara Siran	anak sungai	4,8	6,3	66	33	149	33	12	2,4	28,9
Mar-23	M	WT8	Muara Kedang Kepala	anak sungai	4,1	6,3	65	32	135	37	8	2,4	27,5
Mar-23	M	WT10	Hilir Bukit jering	anak sungai	4,6	6,3	38	19	306	52	17	1,3	27,8
Mar-23	M	WT11	Muara sungai belayan	muara	5,8	6,0	35	17	481	24	10	3,8	27,2
Mar-23	M	WT12	Hilir Muhuran	anak sungai	5,2	6,4	49	25	119	45	11	3,1	27,4
Mar-23	M	WT13	Muara Pela	muara	5,5	6,0	16	8	303	36	24	2,2	28,1
Mar-23	M	WT14	Sangkuliman	anak sungai	4,2	6,0	36	18	113	37	12	0	26,4
Mar-23	M	WT15	Muara Semayang	muara	4,4	6,0	18	9	488	57	9	0	26,9
Mar-23	M	WT16	Danau Semayang	muara	5,5	7,1	29	14		62	3	1,2	28,9
Mar-23	M	WT21	Hulu sebemban	sungai utama	4,2	6,5	33	17	210	30	20	4,5	28
Mar-23	M	WT25	Hulu Muara Muntai	sungai utama	4,5	6,0	32	16	134	30	9	2,7	27
Mar-23	M	WT24	Pulau Harapan	sungai utama	4,5	6,7	39	23	235	36	8	2,8	26,1
Mar-23	M	WT23	Batu Bumbun	anak sungai	5,8	6,0	34	17	140	31	7	1,4	28,2
Mar-23	M	WT22	Muara muntai	sungai utama	4,6	5,5	35	17	236	31	22	4,2	27,6
Mar-23	M	WT26	Batuq	sungai utama	5,5	6,0	35	17	331	23	26	3,6	26,5
Mar-23	M	WT27	Hilir Tanjung Haur	sungai utama	4,7	6,5	35	15	211	49	22	3,9	26,6
Mar-23	M	WT28	Muara Pahu	sungai	4,7	6,0	35	17	262	36	35	1,8	26,8
Mar-23	M	WT30	Sungai bolowan	anak sungai	2,6	5,5	31	15	53	14	5	0	29,4
Mar-23	M	WT32	Kedang Pahu (hilir Bayan)	anak sungai	4,2	6,0	35	17	84	22	17	4,5	27,7
Mar-23	M	WT29	Hulu Tanjung Laong	anak sungai	3,6	5,8	35	17	92	25	10	0,8	27,6
Mar-23	M	WT33	Kampung Baru, Kubar	sungai	4,9	6,0	41	20	227	42	12	2,4	27,1
			random sampling maret 23	**mean**	**4,2**	**6,0**	**38**	**19**	**206**	**41**	**14**	**2,16**	**27,7**

Periode sampling (m-y)	Kondisi air: High Medium;Low	Stasiun sampling	Nama areal disusun dari hilir ke hulu	Tipe habitat	DO-mg/l	pH	EC-mS,cm	TDS-mg/l	River Width-m	Clarity-cm	DEPTH-m	Current Speed-km/h	Water temp °C
baku mutu (mg/l)-Perda Prop Kaltim No, 2, 2011 Lampiran V, Kelas 2					**>4**	**6-9'**	**<200**	**<1000**					
Jul-23	M	WT6	Hilir Muara Sabintulung	muara	1,9	5,8	39	19	153	57	14	1	29,3
Jul-23	M	WT5	Kedang Rantau	anak sungai	2,6	5,8	35	17	86	85	17	0	29,6
Jul-23	M	WT7	Hilir Tunjungan	anak sungai	2,8	5,9	37	19	95	47	11	1,1	29,1
Jul-23	M	WS5	Sungai Sabintulung	anak sungai	2,2	5,7	39	19	63	74	10	2	28,8
Jul-23	M	WS4	Conveyor M. Kaman	sungai utama	4,9	6,1	30	15	414	28	11	1,2	27,7
Jul-23	M	WT9	Hulu Muara Siran	anak sungai	4,6	6,3	39	19	141	13	27	2,7	27,5
Jul-23	M	WT8	Muara Kedang Kepala	anak sungai	4,9	6,3	41	20	152	14	9	2,2	26,7
Jul-23	M	WT10	Hilir Bukit jering	anak sungai	4,8	6,2	33	16	291	18	23	2,8	26,6
Jul-23	M	WT11	Muara sungai belayan	muara	5,0	6,2	30	16	281	21	12	1,7	27,9
Jul-23	M	WT12	Hilir Muhuran	anak sungai	4,5	6,2	26	13	108	24	10	3	27,1
Jul-23	M	WT13	Muara Pela	muara	5,7	6,5	28	14	181	57	18	1,5	28,3
Jul-23	M	WT14	Sangkuliman	anak sungai	4,2	6,3	31	15	137	31	12	1,7	27,9
Jul-23	M	WT15	Muara Semayang	muara	4,6	6,5	32	16	-----	24	8	0	27,8
Jul-23	M	WT16	Danau Semayang	muara	4,6	6,5	31	15	------	29	2	0	27,6
Jul-23	M	WT21	Hulu sebemban	sungai utama	4,9	6,4	32	16	227	18	18	4,6	27,7
Jul-23	M	WT20	hilir muara wis	sungai utama	4,8	6,4	30	15	235	28	15	3,5	26,1
Jul-23	M	WT25	Hulu Muara Muntai	sungai utama	5,2	6,3	32	16	133	24	13	3,6	26,1
Jul-23	M	WT24	Pulau Harapan	sungai utama	4,3	6,4	27	13	185	31	17	4,1	27,8
Jul-23	M	WT23	Batu Bumbun	anak sungai	4,5	6,4	32	16	164	19	5	2,4	27,1
Jul-23	M	WT22	Muara muntai	sungai utama	4,1	6,3	28	14	285	25	18	3,3	28,0
Jul-23	M	WT26	Batuq	sungai utama	5,3	6,4	28	13	209	21	24	4,5	28,4
Jul-23	M	WT27	Hilir Tanjung Haur	sungai utama	4,6	6,4	28	14	247	30	18	3,2	28,6
Jul-23	M	WT28	Muara Pahu	sungai	4,9	6,3	32	16	240	21	33	2,6	27,3
Jul-23	M	WT30	Sungai bolowan	anak sungai	4,1	5,9	41	20	48	20	7	1,6	26,1
Jul-23	M	WT32	Kedang Pahu (hilir Bayan)	anak sungai	5,0	5,9	41	21	86	18	10	2,3	26,6
Jul-23	M	WT29	Hulu Tanjung Laong	anak sungai	4,7	6,0	39	20	99	25	13	1,6	27,1
Jul-23	M	WT33	Kampung Baru, Kubar	sungai	4,5	6,5	30	15	274	23	20	4,2	27,2
			random sampling july 23	**mean**	**4,4**	**6,2**	**33**	**16**	**181**	**30**	**14**	**2,3**	**27,6**

Periode sampling (m-y)	Kondisi air: High; Medium; Low	Stasiun sampling	Nama areal disusun dari hilir ke hulu	Tipe habitat	DO-mg/l	pH	EC-mS,cm	TDS-mg/l	River Width-m	Clarity-cm	DEPTH-m	Current Speed-km/h	Water temp °C
baku mutu (mg/l)-Perda Prop Kaltim No, 2, 2011 Lampiran V, Kelas 2					**>4**	**6-9'**	**<200**	**<1000**					
Nov-23	LM	WT6	Muara Sabintulung	anak sungai	2,8	6,5	79	40	122	49	11,2	0	28,7
Nov-23	LM	WT5	Kedang Rantau	anak sungai	3	6,6	60	31	116	53	15,1	0	29,2
Nov-23	LM	WT4	Muara Kaman-Kedang Rant	sungai utama	2,7	7,1	69	35	459	37	19,3	0	29,6
Nov-23	LM	WS4	Conveyor Muara Kedang Ke	sungai utama	2,6	7,1	56	28	413	30	9,7	2,2	29,4
Nov-23	LM	WT9	Hulu Muara Siran	anak sungai	3,4	7,5	107	52	125	55	8,3	0	31
Nov-23	LM	WT8	Sungai Kedang Kepala	sungai utama	4,2	7,5	104	52		37	7,2	2,2	31
Nov-23	LM	WT10	Hilir Bukit jering	sungai utama	4,3	7,0	48	24	307	29	11,6	3,5	29,2
Nov-23	LM	WT11	Muara Sungai Belayan	sungai utama	6,7	7,0	44	22	475	26	8,2	2,3	28,5
Nov-23	LM	WT12	Hilir Muhuran	anak sungai	4,8	7,3	78	39	60	47	7,2	0	29,3
Nov-23	LM	WT13	Muara Pela	sungai	5,1	6,9	42	21	370	17	21,7	1,6	27,2
Nov-23	LM	WT14	Sangkuliman	anak sungai	2,4	7,0	56	28	130	30	9	0,0	28,5
Nov-23	LM	WT15	Muara Semayang	muara	7,9	7,5	41	21		26	4,7	0	33,9
Nov-23	LM	WT20	Hilir Muara Wis	sungai utama	3,0	7,0	49	24	279	36	11,7	8,3	30
Nov-23	LM	WT21	Hulu sebemban	anak sungai	3,2	7,0	54	27	112	20	16,7	3,6	29,3
Nov-23	LM	WT22	Muara Muntai Ilir	sungai	7	6,9	34	17	224	20	13,5	3,5	27,3
Nov-23	LM	WT23	Batu Bumbun	anak sungai	6,0	6,9	39	19	99	20	7,9	1,4	27,2
Nov-23	LM	WT24	Tanjung Harapan	sungai	4,7	6,0	35	17	262	36	35,4	1,8	26,8
Nov-23	LM	WT25	Muara muntai	sungai utama	6,3	6,9	44	22	112	20	8,5	2,6	25,9
Nov-23	LM	WT26	Batuq	sungai utama	2,8	7,2	47	23	330	19	11,9	5,8	26,5
Nov-23	LM	WT27	Tanjung Haur	sungai utama	1,8	7,1	53	27	230	26	16,8	5	27
Nov-23	LM	WT28	Muara Pahu	sungai utama	2	7,0	43	22	258	19	14,5	2,8	27,4
Nov-23	LM	WT30	Muara Pahu Sungai Boloan	anak sungai	1,7	6,9	100	6,4	38	16	5,6	0	28,3
Nov-23	LM	WT32	Kedang Pahu (hilir Bayan)	anak sungai	2,4	6,8	84	42	62	20	8,2	1,4	29
Nov-23	LM	WT32C	Muara Jelau	anak sungai	2,8	6,8	74	37	155	19	9,8	1,1	30,1
Nov-23	LM	WT29	Hulu Tanjung Laong	anak sungai	2,7	6,8	86	43	123	26	15,4	0	29,8
Nov-23	LM	WT33	Kampung Baru, Kubar	sungai utama	2,5	6,9	37	18	235	20	9,2	3,7	28,1
26			**random sampling nov 23**	**mean**	**3,9**	**7,0**	**59**	**28**	**181**	**27**	**12**	**2,2**	**28,8**

Appendix 4. Water quality at dolphin locations from three surveys in 2023

Periode sampling (m-y)	Kondisi air: High Medium; Low	Kode pesut	Nama areal disusun dari hilir ke hulu	Tipe habitat	DO-mg/l	pH	EC-mS,cm	TDS-mg/l	River Width-m	Clarity-cm	DEPTH-m	Current Speed-km/h	Water temp °C
baku mutu (mg/l)-Perda Prop Kaltim No, 2, 2011 Lampiran V, Kelas 2					**>4**	**6-9'**	**<200**	**<1000**					
Mar-23	M	PM1	Muara Kaman	muara	1,8	5,8	55	28	488	56	24	0	28,1
Mar-23	M	PM2	Sangkuliman	anak sungai	6,8	7,0	24	12	134	58	11	1	29,3
Mar-23	M	PM4	Sungai Belayan	anak sungai	5,1	6,5	44	22	139	28	8	1,9	28,6
Mar-23	M	PM5	Muara Pela	muara	5,5	6,0	16	8	303	36	24	2,2	28,1
Mar-23	M	PM6	Hilir Kuyung	sungai	4,2	5,0	33	16	225	33	4	3,4	32,6
Mar-23	M	PM7	Hulu Batuq	sungai	4,6	6,0	28	14	240	30	14	1,8	27,3
Mar-23	M	PM8	Hilir Tanjung Haur	sungai	4,7	6,5	35	15	211	49	22	3,6	26,6
Mar-23	M	PM9	Kuyung	sungai	5,4	5,5	35	17	230	33	20	2,1	29
Mar-23	M	PM11	Liang	sungai	4,9	7,0	35	17	232	25	19	3	30,4
Rata-rata					**4,8**	**6,1**	**34**	**17**	**245**	**39**	**16**	**2,1**	**28,9**
Jul-23	M	PM3	Belayan	anak sungai	4,7	6,1	26	13	138	33	14	2	27,3
Jul-23	M	PM4	Hilir Batuq	sungai	4,7	6,3	31	16	211	24	8	1,1	26,6
Jul-23	M	PM5	Penyinggahan	sungai	4,3	6,4	27	13	232	28	13	2,3	27,1
Jul-23	M	PM6	Hulu Minta	sungai	4,5	6,3	28	13	225	29	13	3,4	28,3
Jul-23	M	PM7	Pulau Harapan	muara	4,3	6,4	29	14	116	25	18	2,8	28,1
Jul-23	M	PM8	Pulau Harapan	sungai	4,6	6,3	28	13	244	26	6	1,9	27,3
Jul-23	M	PM9	Hulu Rimba Ayu	sungai	4,8	6,3	30	15	276	28	11	2,7	26,1
Jul-23	M	PM10	Sangkuliman	anak sungai	4,6	6,4	30	15	156	20	10	0,1	26,5
Rata-rata					**4,6**	**6,3**	**29**	**14**	**200**	**27**	**12**	**2,0**	**27,2**
Nov-23	LM	PM1	Liang	sungai	3,7	6,9	50	24	263	33	9	1,6	29,8
Nov-23	LM	PM2	Sangkuliman	anak sungai	2,4	7,0	56	28	130	30	9	0,0	28,5
Nov-23	LM	PM3	Batuq	sungai	2,1	6,9	40	20	247	18	11	4,6	27,1
Nov-23	LM	PM4	Sungai Belayan	anak sungai	5,7	7,1	55	28	149	15	11	1,3	28,2
Nov-23	LM	PM5	Muara Semayang	danau	5,0	6,9	50	25	156	19	9	1,6	26,5
Nov-23	LM	PM6	Muara Pela	muara	5,1	6,9	42	21	370	17	22	1,6	27,2
Nov-23	LM	PM7	Liang	sungai	5,1	6,9	42	21	370	17	22	3,3	27,2
Rata-rata					**4,2**	**7,0**	**48**	**24**	**241**	**21**	**13**	**2,0**	**27,8**

Appendix 5. Water quality lab test results from three surveys in 2023

Survei Maret 2023 air sedang																
Stasiun Sampling	**Nama Areal**	**Nama Sungai**	**TSS**	**COD**	**NH3-N 0,2 tapi lebih baik <0,02**	**Kad-mium (Cd)**	**Temba-ga (Cu)**	**Timbal (Pb) mg/l**	**Besi (Fe) mg/l**	**Manga n (Mn) mg/l**	**Pottasi um (K)**	**jumlah ind. Plankto n/ liter**	**jumlah taksa plankt on**	**indeks keanekar agaman plankton (H): 1-3 sedang-bagus; <1 kurang**	**indeks keseraga man plankton (E): 0-1: rendah-tinggi**	**indeks dominan plankton (D): 0-1: rendah-tinggi**
baku mutu (mg/l)-Perda Prop Kaltim No. 2, 2011 Lampiran V, Kelas 2			**<50**	**<25**		**<0,01**	**<0,02**	**<0,03**	**tinggi kalau >1**							
WS4	Conveyor Muara Kaman	Mahakam	25	26	0,1	<0,002	<0,002	<0,003	0,67	<0,001	1,97	1449	13	2,40	0,94	0,10
WS5	hilir Sabintulung	Sabintulung	19	54	0,1	<0,002	<0,002	<0,003	1,18	<0,001	1,77	1323	12	2,36	0,95	0,11
WT6	Hilir Muara Sabintulung	Kedang Rantau	8	34	0,1	<0,002	<0,002	<0,003	0,84	<0,001	1,20	1197	11	2,20	0,92	0,14
WT7	Hilir Tunjungan	Kedang Rantau	5	39	0,1	<0,002	<0,002	<0,003	0,72	<0,001	1,49	1260	11	2,22	0,93	0,13
WT9	Hulu Muara siran	Kedang Kepala	35	33	0,2	<0,002	<0,002	<0,003	0,88	<0,001	1,37	1449	13	2,35	0,92	0,12
WT10	Hilir Bukit Jering	Mahakam	53	28	0,1	<0,002	<0,002	<0,003	0,48	<0,001	1,95	3465	12	2,28	0,89	0,13
WT12	Hilir Muhuran	Belayan	48	23	0,2	<0,002	<0,002	<0,003	0,61	<0,001	2,36	1575	11	2,29	0,95	0,11
WT14	Rakit Sangkuliman	Pela	9	22	0,1	<0,002	<0,002	<0,003	0,66	<0,001	2,22	1764	13	2,38	0,93	0,11
WT21	Hulu Sebemban	Mahakam	55	24	0,1	<0,002	<0,002	<0,003	0,73	<0,001	1,48	819	8	1,99	0,96	0,15
WT23	Batu Bumbun	Batu Bumbum	14	36	0,3	<0,002	<0,002	<0,003	1,07	<0,001	1,72	4914	12	1,85	0,74	0,23
WT26	Batuq	Mahakam	21	23	0,1	<0,002	<0,002	<0,003	0,59	<0,001	1,17	630	10	2,30	1,00	0,10
WT30	Sungai Bolowan	Bolowan	11	35	0,1	<0,002	<0,002	<0,003	1,29	<0,001	1,04	1008	11	2,34	0,98	0,10
WT32	Kedang Pahu	Kedang Pahu	22	26	0,1	<0,002	<0,002	<0,003	0,99	<0,001	1,43	1197	8	1,94	0,93	0,16
WT33	Kampung Baru, Kubar	Mahakam	23	21	0,1	<0,002	<0,002	<0,003	0,40	<0,001	1,74	1260	9	2,09	0,95	0,14
Nilai rata-rata			**25**	**30**	**0,13**				**0,79**		**1,64**	**1665**	**11**	**2,21**	**0,93**	**0,13**

Survei July 2023 air surut-sedang																
Stasiun Sampling	**Nama Areal**	**Nama Sungai**	**TSS**	**COD**	**NH3-N 0,2 tapi lebih baik <0,02**	**Kad-mium (Cd)**	**Temba-ga (Cu)**	**Timbal (Pb) mg/l**	**Besi (Fe) mg/l**	**Manga n (Mn) mg/l**	**Pottasi um (K)**	**jumlah ind. Plankto n/ liter**	**jumlah taksa plankt on**	**indeks keanekar agaman plankton (H): 1-3 sedang-bagus; <1 kurang**	**indeks keseraga man plankton (E): 0-1: rendah-tinggi**	**indeks dominan plankton (D): 0-1: rendah-tinggi**
baku mutu (mg/l)-Perda Prop Kaltim No. 2, 2011 Lampiran V, Kelas 2			**<50**	**<25**	**baik <0,02**	**<0,01**	**<0,02**	**<0,03**	**tinggi kalau >1**							
WS4	Conveyor M,Kaman	Mahakam	31	24	0,2	<0,002	<0,002	<0,003	0,31	0,53	4,56	1197	12	2,33	0,94	0,11
WS5	Sungai Sabintulung	Sabintulung	5	27	<0,036	<0,002	<0,002	<0,003	0,28	0,08	5,44	1386	11	2,26	0,94	0,12
WT6	Hilir Muara Sabintulung	Sabintulung	6	21	<0,036	<0,002	<0,002	<0,003	0,41	0,13	4,99	1008	9	2,05	0,93	0,15
WT7	Hilir Tunjungan	Kedang Rantau	9	19	<0,036	<0,002	<0,002	<0,003	0,39	0,13	5,20	1071	10	2,18	0,95	0,13
WT9	Hulu Muara Siran	Kedang kepala	171	25	<0,036	<0,002	<0,002	<0,003	0,47	0,75	5,32	945	9	1,99	0,90	0,17
WT10	Hilir Bukit jering	Mahakam	69	22	<0,036	<0,002	<0,002	<0,003	0,39	0,31	4,26	756	8	1,98	0,95	1,5
WT12	Hilir Muhuran	Belayan	63	28	<0,036	<0,002	<0,002	<0,003	0,43	0,43	4,04	1134	9	2,12	0,96	0,96
WT14	Sangkuliman	Pela	59	18	<0,036	<0,002	<0,002	<0,003	0,43	0,41	3,49	882	10	2,21	0,96	0,12
WT21	Hulu sebemban	Mahakam	49	20	<0,036	<0,002	<0,002	<0,003	0,25	0,28	3,10	945	8	1,86	0,89	0,19
WT23	Batu Bumbun	Batu Bumbum	56	22	<0,036	<0,002	<0,002	<0,003	0,29	0,28	4,62	1008	10	2,19	0,95	0,13
WT26	Batuq	Mahakam	202	37	<0,036	<0,002	<0,002	<0,003	0,36	0,36	3,80	1071	10	2,15	0,93	0,13
WT30	Sungai bolowan	Bolowan	34	27	<0,036	<0,002	<0,002	<0,003	0,80	0,82	6,30	504	8	2,08	1,00	0,13
WT32	(Kedang Pahu)	Kedang Pahu	27	24	<0,036	<0,002	<0,002	<0,003	0,70	0,71	6,66	1008	10	2,22	0,96	0,12
WT33	Kampung Baru, Kubar	Mahakam	154	31	<0,036	<0,002	<0,002	<0,003	0,47	0,68	4,77	1701	11	2,22	0,93	0,12
Nilai rata-rata			**67**	**25**	**0,21**				**0,43**	**0,42**	**4,75**	**1044**	**10**	**2,13**	**0,94**	**0,29**

Survei November 2023 air surut-sedang																
Stasiun Sampling	**Nama Areal**	**Nama Sungai**	**TSS**	**COD**	**NH3-N 0,2 tapi lebih baik <0,02**	**Kad-mium (Cd)**	**Temba-ga (Cu)**	**Timbal (Pb) mg/l**	**Besi (Fe) mg/l**	**Manga n (Mn) mg/l**	**Pottasi um (K)**	**jumlah ind. Plankto n/ liter**	**jumlah taksa plankt on**	**indeks keanekar agaman plankton (H): 1-3 sedang-bagus; <1 kurang**	**indeks keseraga man plankton (E): 0-1: rendah-tinggi**	**indeks dominan plankton (D): 0-1: rendah-tinggi**
baku mutu (mg/l)-Perda Prop Kaltim No. 2, 2011 Lampiran V, Kelas 2			**<50**	**<25**		**<0,01**	**<0,02**	**<0,03**	**tinggi kalau >1**							
WS4	Conveyor M,Kaman	Mahakam	84	14	0,2	<0,002	<0,002	<0,003	0,65	0,08	6,81	882	6	1,73	0,97	0,18
WT6	Muara Sabintulung	Sabintulung	5	32	<0,036	<0,002	<0,002	<0,003	1,48	0,11	7,21	1575	12	2,40	0,97	0,10
WT9	Hulu Muara Siran	Kedang kepala	7	5	<0,036	<0,002	<0,002	<0,003	0,51	0,01	9,23	1260	7	1,90	0,98	0,16
WT10	Hilir Bukit jering	Mahakam	43	14	0,05	<0,002	<0,002	<0,003	0,59	0,20	6,33	1386	8	2,05	0,99	0,13
WT12	Hilir Muhuran	Belayan	8	21	<0,036	<0,002	<0,002	<0,003	0,74	0,11	8,23	693	6	1,72	0,96	0,19
WT14	Sangkuliman	Pela	31	10	0,06	<0,002	<0,002	<0,003	0,97	0,23	6,48	1008	7	1,89	0,97	0,16
WT15	Muara Semayang	Pela	7	17	0,09	<0,002	<0,002	<0,003	0,60	0,23	6,30	1512	9	2,14	0,98	0,12
WT21	Hulu sebemban	Mahakam	66	18	0,07	<0,002	<0,002	<0,003	1,33	0,01	6,39	945	7	1,86	0,96	0,16
WT23	Batu Bumbun	Batu Bumbum	23	18	0,1	<0,002	<0,002	<0,003	1,77	0,01	6,12	1197	7	1,87	0,96	0,16
WT26	Batuq	Mahakam	123	24	0,1	<0,002	<0,002	<0,003	0,97	0,01	6,21	756	7	1,70	0,95	0,19
WT30	Sungai Bolowan	Bolowan	6	19	0,2	<0,002	<0,002	<0,003	1,96	0,01	8,58	1260	10	2,25	0,98	0,11
WT32	Gunung Bayan	Kedang pahu	5	19	0,3	<0,002	<0,002	<0,003	1,99	0,01	8,23	1134	8	2,03	0,98	0,14
WT32C	Muara Jelau	Kedang Pahu	5	23	0,1	<0,002	<0,002	<0,003	1,72	0,01	7,91	1071	7	1,89	0,97	0,16
WT33	Kampung Baru, Kubar	Mahakam	165	58	0,1	<0,002	<0,002	<0,003	1,28	0,01	6,23	1008	7	1,89	0,97	0,18
Nilai rata-rata			**41**	**21**	**0,12**				**1,18**	**0,07**	**7,16**	**1121**	**8**	**1,95**	**0,97**	**0,15**