FINAL TECHNICAL REPORT OF MAHAKAM RIVER DOLPHIN POPULATION AND WATER QUALITY MONITORING SURVEYS IN 2025

February 2026

YAYASAN KONSERVASI RASI
(RARE AQUATIC SPECIES OF INDONESIA)

FOREWORD

This technical report presents the results of research conducted on the presence, population size, and threats to the Mahakam Irrawaddy dolphin (Pesut Mahakam), as well as the condition of its habitat in 2025. This research forms part of the Mahakam Dolphin Conservation Program, a long-term research and conservation initiative implemented by Yayasan Konservasi RASI since 2000. Through this program, RASI collaborates with the Provincial Government of Kalimantan Timur, particularly in Kutai Kartanegara and Kutai Barat Regencies, the Natural Resources Conservation Agency of East Kalimantan (BKSDA Kalimantan Timur), and the Coastal and Marine Resources Management Center (BPSPL Pontianak). We sincerely acknowledge and thank all partner institutions for their continued support and collaboration.

This report presents the results of Mahakam dolphin monitoring surveys conducted in April, July, and November 2025. These activities were made possible through philanthropic grant funding, and we express our sincere appreciation for this valuable support.

The surveys were conducted by teams of varying composition, including senior researcher Danielle Kreb and research assistants Ismail, Nadila, Nur, and Sadikin (YK-RASI), as well as Alfin Pranata and Dedi (partners from BPSPL Pontianak). Additional support was provided by volunteers Jannah Kreb, Chanchon Trancharoen, Kent Truog, and Isna. We would like to extend our sincere appreciation to all observers and to the boat operator, Mr. Darwis, for their essential contributions to the fieldwork. We are also grateful to the local communities and fishers along the Sungai Mahakam for generously sharing their knowledge and information with our team.

Samarinda, 5 February 2026

Budiono S.Hut

Direktur 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: Danielle Kreb & Budiono. 2026. Final Technical Report on the Monitoring Survey of the Mahakam Irrawaddy Dolphin and Water Quality in 2025. Yayasan Konservasi RASI.

TABLE OF CONTENTS

TABLES

FIGURES

APPENDICES

EXECUTIVE SUMMARY

The objective of the Mahakam River dolphin or pesut population monitoring conducted throughout the Mahakam watershed, which represents the species' primary habitat, is to determine the total number of individuals within the population, as well as annual birth and mortality rates. In addition, the surveys aim to assess the seasonal presence of dolphins and identify potential threats to the population. Water sampling surveys were also conducted to evaluate water quality within the dolphin's habitat.

The survey transect was covered twice during each survey (downstream to upstream and vice versa) along the Mahakam River during three survey periods in April, July, and November 2025. The survey area extended from Muara Kaman (180 km from the river mouth) to Muara Benangaq along the main river channel, and included several tributaries: Kedang Rantau (up to Tunjungan), Kedang Kepala (up to Muara Siran), Belayan (up to Sebelimbingan), Pela, Kedang Pahu (up to Desak), and Lake Semayang. The total survey effort covered 1,831 km over 27 survey days, with an average daily survey distance of 66 km and an average survey speed of 11.8 km/h.

Across the three surveys, dolphin groups were encountered on 24 occasions, with an average group size of 8 individuals (median = 5; min = 1; max = 33), based on photo-identification data. Analysis of dorsal fin photo-identification using MARK 9.0 software and full-likelihood closed capture models estimated the population size at 66 individuals (min–max: 65–67; CV = 9%) in 2025. Population trends since 2005 have fluctuated but show a significant overall decline ($R^2 = 0.79$, $F(1, 15) = 57.7$, $t = -7.6$, $p < 0.000$) and a 88% reduction in by-catch was noted since 2022. A total of 10 calves were born in 2025. The average annual birth rate over the past eight years (2017–2025) was 6 calves per year (minimum = 4; maximum = 10). Three dolphin mortalities were recorded in 2025, consisting of two calves (found drifting deceased and not reported at the time of death) and one juvenile male aged 3 years and 4 months, whose death was attributed to poisoning from contaminated prey.

The average annual mortality rate over the past 31 years (1995–2025) was 4.1 individuals. Of the known mortality cases, 67% were caused by entanglement in gillnets, leading to drowning. However, mortality caused by gillnets has declined significantly over time ($R^2 = 0.19$; $F(1, 29) = 6.87$; $p = 0.014$). The second leading causes of mortality among known cases were poisoning (9%) and vessel strikes (9%). In 27% of cases, the cause of death could not be determined.

Laboratory analysis of water quality from 14 sampling stations across the three surveys in 2025 revealed concerning results. A total of 56 samples (35% of 210 samples for parameters including TSS, COD, NH_3-N, Cd, and Cu) exceeded national water quality standards. Additionally, 73 samples, although within national limits, exceeded more conservative international standards for NH_3-N, Cu, Fe, and Mn (25% of 294 samples). Notably, Fe and Mn standards are not established in Indonesia for Class II water quality (designated for aquatic ecosystems and fisheries), but are regulated internationally, highlighting additional concerns regarding habitat quality of the pesut.

In addition to mortality and chemical pollution, threats to the Mahakam Irrawaddy dolphin habitat continue to increase, particularly from underwater noise pollution. This is mainly caused by coal barge transportation using pontoons in narrow tributaries, as well as the increasing volume of barge traffic along the main river. Furthermore, competition for declining fish resources has intensified due to the conversion of wetland spawning habitats into oil palm plantations. Illegal fishing practices, including electrofishing and the use of poison, as well as the use of monopolistic fishing gear that blocks fish migration routes, have further reduced fish recruitment and availability, thereby affecting the sustainability of the dolphin's prey base.

1. Introduction

1.1 Background

The Mahakam River dolphin is the only freshwater dolphin population of *Orcaella brevirostris* in Indonesia. This species is legally protected under Indonesian law and has been designated as a provincial symbol of Kalimantan Timur. It was classified as Critically Endangered on the IUCN Red List by the International Union for Conservation of Nature in 2000 (Hilton-Taylor, 2000). As a mammal, the species reaches reproductive maturity at approximately 9 years of age and produces a maximum of one calf every 3–5 years. The gestation period is approximately 14 months, followed by a nursing period of up to 1.5 years (Stacey & Arnold, 1999). Monitoring surveys of the Mahakam dolphin population began in 1997, and since 2005, population estimates have been conducted using dorsal fin photo-identification analysis, which functions similarly to a fingerprint and allows individual dolphins to be distinguished. The most recent and reliable population estimate in 2024 was 60 individuals.

Due to relatively high mortality rates, averaging 4 individuals per year (1995–2024), compared to an average annual birth rate of 5 calves, this population requires urgent conservation attention. Creating a low-stress and safe habitat is essential to support increased reproductive success and reduce mortality rates.

Key habitat areas identified between 1999 and 2024 include aquatic regions in Kutai Kartanegara, ranging from Muara Kaman to Batuq, including the tributaries Kedang Rantau, Kedang Kepala, Belayan, Pela, and Batubumbun. In Kutai Barat, the main distribution extends from Batuq to Muara Pahu and the Kedang Pahu tributary. Upstream areas from Muara Pahu to Muara Benangaq and beyond typically support dolphin presence only during low-water conditions. Since 2010, dolphin occurrence in Kutai Barat has declined, whereas previously dolphins could be observed in Muara Pahu under all water conditions. This decline is attributed to multiple factors, including the loss of fish spawning habitats due to wetland conversion for oil palm plantations and coal transportation activities along the Kedang Pahu tributary, which was historically an important migration corridor for the species. As a result of these habitat changes within the former core area of Muara Pahu, the conservation of dolphin habitat in Kutai Kartanegara has become increasingly critical to prevent further population decline and reduce the risk of extinction in the near future.

As part of the government's commitment to dolphin conservation, on 27 January 2020, the Regent of Kutai Kartanegara issued Decree No. 75/SK-BUP/HK/2020, establishing a reserved Mahakam Dolphin Habitat Aquatic Conservation Area covering 43,117 hectares. This designation was supported by agreements from 27 villages located within the conservation area. The site was later granted national conservation status when the Minister of Marine Affairs and Fisheries formally designated the Upper Mahakam Waters in Kutai Kartanegara as a protected aquatic conservation area under Decree No. 49/KEPMEN-KP/2022. The total conservation area covers 42,667.99 hectares and is divided into three management zones: (1) core zone (1,081.28 ha), (2) limited-use zone (30,695.74 ha), and (3) other designated zones (10,890.97 ha), consisting of (a) rehabilitation zone (2,732.08 ha), (b) major vessel traffic lane zone (385.72 ha), and (c) special management zone based on area characteristics (7,773.17 ha) (Appendix 1).

Furthermore, on 1 December 2023, the Director General of Marine Spatial Management issued Decree No. 61 concerning the Management Plan for the Upper Mahakam Aquatic Conservation Area in Kutai Kartanegara for the period 2023–2042, providing a long-term framework for the protection and sustainable management of the Mahakam Irrawaddy dolphin and its habitat.

1.2 Objectives

The objective of this monitoring activity is to assess the distribution and population size of the Mahakam Irrawaddy dolphin, as well as to identify threats, determine annual birth and mortality rates, and evaluate the habitat quality within the dolphin's range.

2. Methods

2.1 Monitoring of Dolphin Occurrence and Water Quality

The survey covered the entire known range of the Mahakam Irrawaddy dolphin, extending from the downstream area of Muara Kaman to Muara Benangaq (Melak District) along the main river channel, and including the tributaries Kedang Rantau, Kedang Kepala, Belayan, Pela, Kedang Pahu, as well as Lake Semayang. The total survey effort covered 1,787 km over 27 survey days, divided into three survey periods of nine days each: (1) 8–16 April 2025; (2) 14–22 July 2025; and (3) 4–12 November 2025 (Figure 1). During each survey, the route was covered at least twice. The average vessel speed was 11.8 km/h, depending on whether the vessel was traveling upstream or downstream, with a maximum downstream speed of 14.5 km/h. Surveys were conducted between 08:00 and 18:00.

Each survey was conducted by a core team of four members, consisting of three observers and one data recorder. The primary observer was positioned on a forward observation platform with an eye height of approximately 3 m above the water surface and used binoculars for scanning. The second and third observers visually scanned the area ahead and to the sides up to a 90° angle using the naked eye. The data recorder was positioned facing backward to monitor river bends and ensure that dolphins were not missed, while recording positional data, vessel speed, and weather conditions. Team members rotated positions every 15 minutes to reduce observer fatigue and maintain detection efficiency.

Upon sighting dolphins, the location name and GPS coordinates were recorded. Dedicated photo-identification sessions were then conducted, focusing on the dorsal fin, which has unique individual characteristics. Photographs were taken from both the left and right sides and later compared with the existing photo-identification catalog.

Once sufficient photographic documentation had been obtained (averaging 47 minutes per encounter) and the number of individuals and group composition had been determined—including adults, juveniles, calves, and neonates (≤ 3 months)—in-situ water quality measurements were conducted. Parameters measured included dissolved oxygen (DO), pH, electrical conductivity (EC), total dissolved solids (TDS), temperature, water transparency (Secchi disk), depth (echosounder), current velocity, and river width (laser range finder).

In addition to measurements taken at dolphin encounter locations, water quality sampling was conducted at a minimum of 28 predetermined sampling stations. Of these, water samples from 14 stations were collected and analyzed in the laboratory (Appendix 2).

Ad hoc and informal interviews were conducted with fishers encountered along the riverbanks. Information was collected regarding the most recent sightings of dolphins, their seasonal presence in relation to water conditions, local fisheries conditions, and any known dolphin mortality events.

2.2 Data Analysis

Photographs were selected based on high image quality, taking into account focus, glare, photographic angle, and the completeness of the dorsal fin within the frame. Selected photographs were cataloged according to identifiable features. Distinguishing characteristics used to differentiate individuals included nicks and scars on the dorsal fin, as well as the unique shape of the fin itself.

Two methods were used to estimate the number of individuals in the Mahakam population:

(1) Direct count of distinct dorsal fins, representing the total number of uniquely identified individuals recorded within a given year (combined from all surveys), which provides the minimum population estimate; and

(2) Capture–recapture analysis using the computer software MARK, applying the "Closed Captures – Full Likelihood" model. This analysis compared eight candidate models, and the average estimate was calculated from the models that collectively accounted for 95% of the total model weight, with

delta AIC values not exceeding 10. This method provides an estimate of the total annual population size.

A correction factor was applied to account for the proportion of individuals that could not be identified due to the absence of distinctive markings. In the Mahakam population, this proportion has remained minimal, ranging between 0–4% since 2005. In 2025, all individuals observed were identifiable, resulting in no unidentified proportion.

Birth rates were determined based on the presence of neonates (≤ 3 months old) recorded during surveys covering the entire Mahakam dolphin range. Neonates were identified by the presence of visible fetal folds, which remain detectable for up to three months after birth. In addition to body size, neonates could also be distinguished by their characteristic surfacing and swimming behavior. Once a neonate was observed, photographs of the mother's dorsal fin were taken to establish maternal identity, ensuring that the same calf would not be counted again as a newborn in subsequent surveys.

2.3 Water Quality Assessment

Water samples were collected from 14 predetermined sampling locations for laboratory analysis. The following parameters were examined: total suspended solids (TSS), chemical oxygen demand (COD), total phosphate (as P), ammonia nitrogen (NH_3-N), cadmium (Cd), copper (Cu), iron (Fe), lead (Pb), manganese (Mn), potassium (K), plankton taxa abundance, plankton density (individuals per liter), plankton diversity index (H), plankton evenness index (E), and plankton dominance index (D).

Laboratory analyses were conducted at the accredited laboratory of the Faculty of Fisheries, Universitas Mulawarman, located in Samarinda. The analytical results were then compared against national water quality standards as defined in Government Regulation of the Republic of Indonesia No. 22 of 2021, Appendix VI.I, Class II water quality criteria.

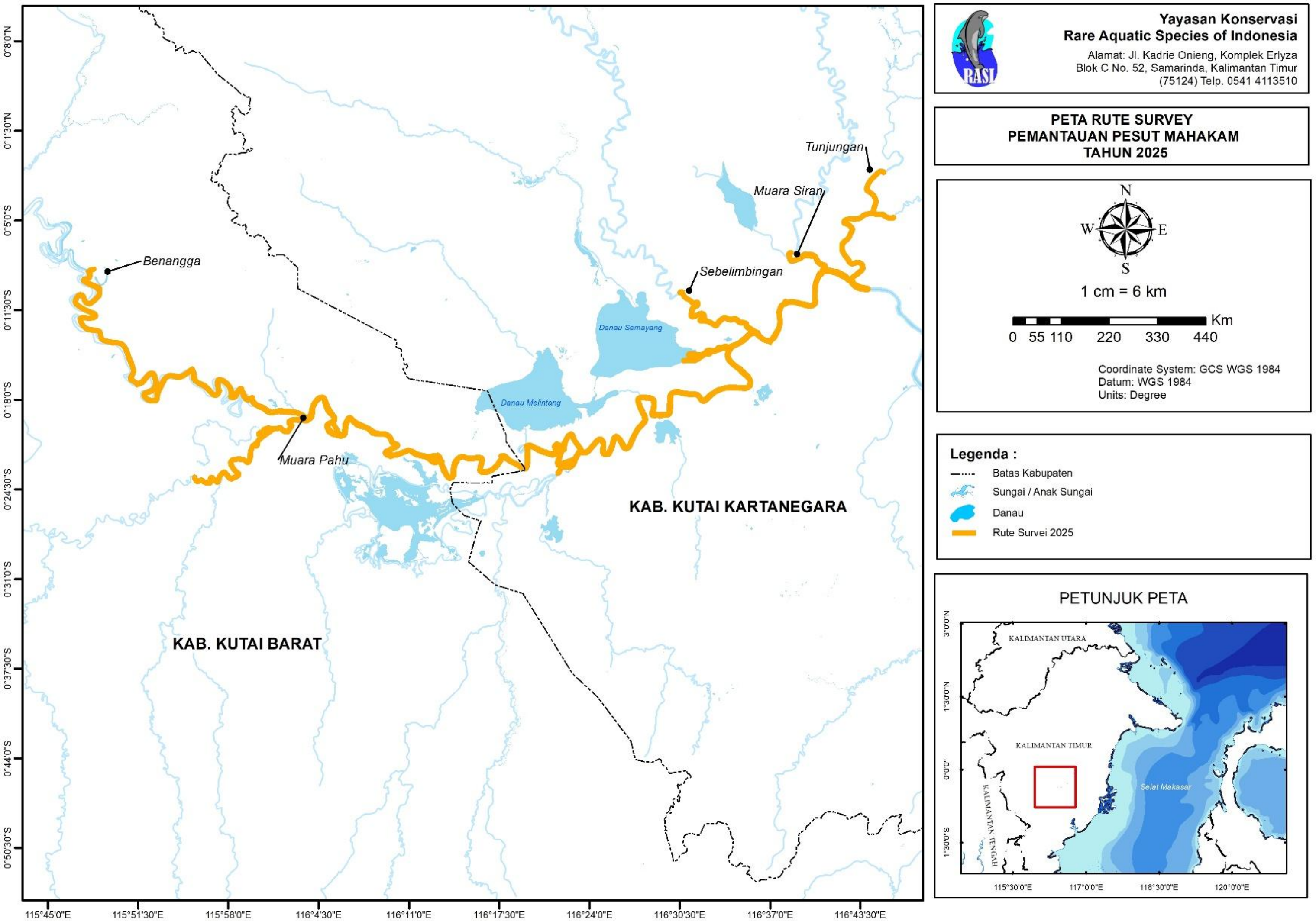


Figure 1. Map showing survey routes conducted in 2025.

3. Results

3.1 Mahakam River Dolphin Population

3.1.1 Distribution

The April survey was conducted during high water conditions, the July survey during moderate water levels, and the November survey when water levels had begun rising following the low-water period. Typically, during the dry season, dolphins migrate upstream along the Sungai Mahakam into Kutai Barat and Mahakam Ulu, following the migration of key fish prey species such as kendia (*Thynnichthys vaillanti*) and repang (*Osteochilus repang*). However, during the November survey, water levels had already begun to rise from low-water conditions, which may explain why most of the population remained within Kutai Kartanegara.

Of the 24 dolphin encounter locations recorded during the 2025 surveys, dolphins were observed slightly more frequently in tributary habitats and tributary confluences (54%) than in the main river channel (46%) (Figure 2).

During the three surveys conducted in 2025, dolphin groups were encountered on 24 occasions, with a minimum of 7 and a maximum of 9 groups recorded per survey. The locations of dolphin sightings are presented in Figure 3. These sighting locations highlight the importance of the aquatic conservation area in Kutai Kartanegara, as 100% of dolphin encounters during all three surveys occurred within this conservation area.

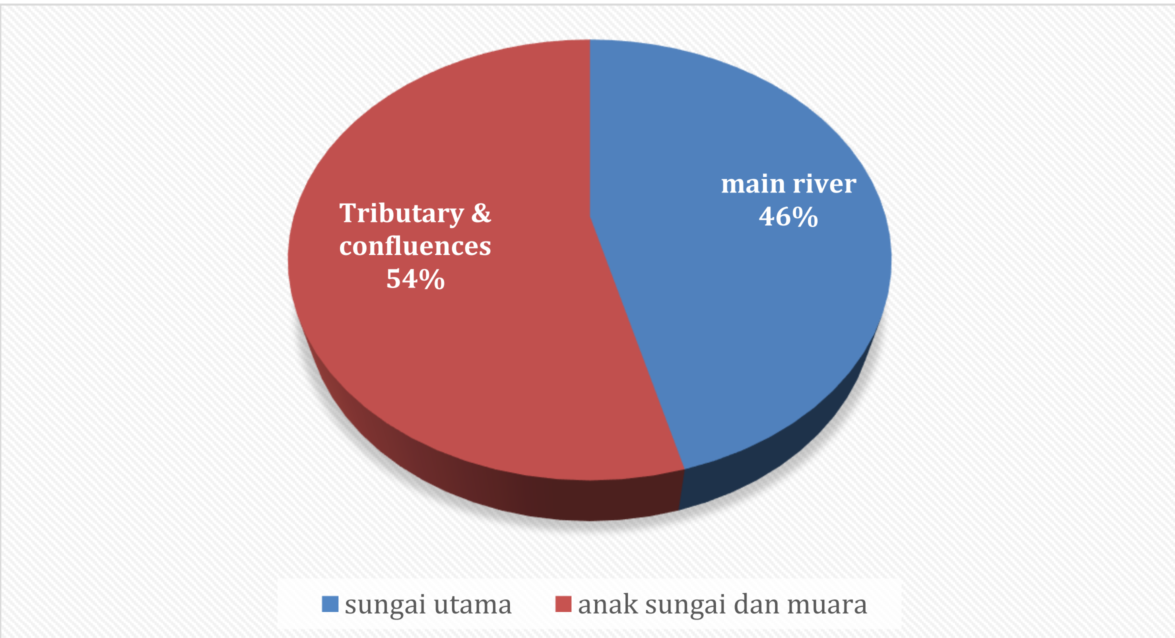


Figure 2. Frequency of Mahakam River dolphin encounters by habitat type in 2005 (n = 24).

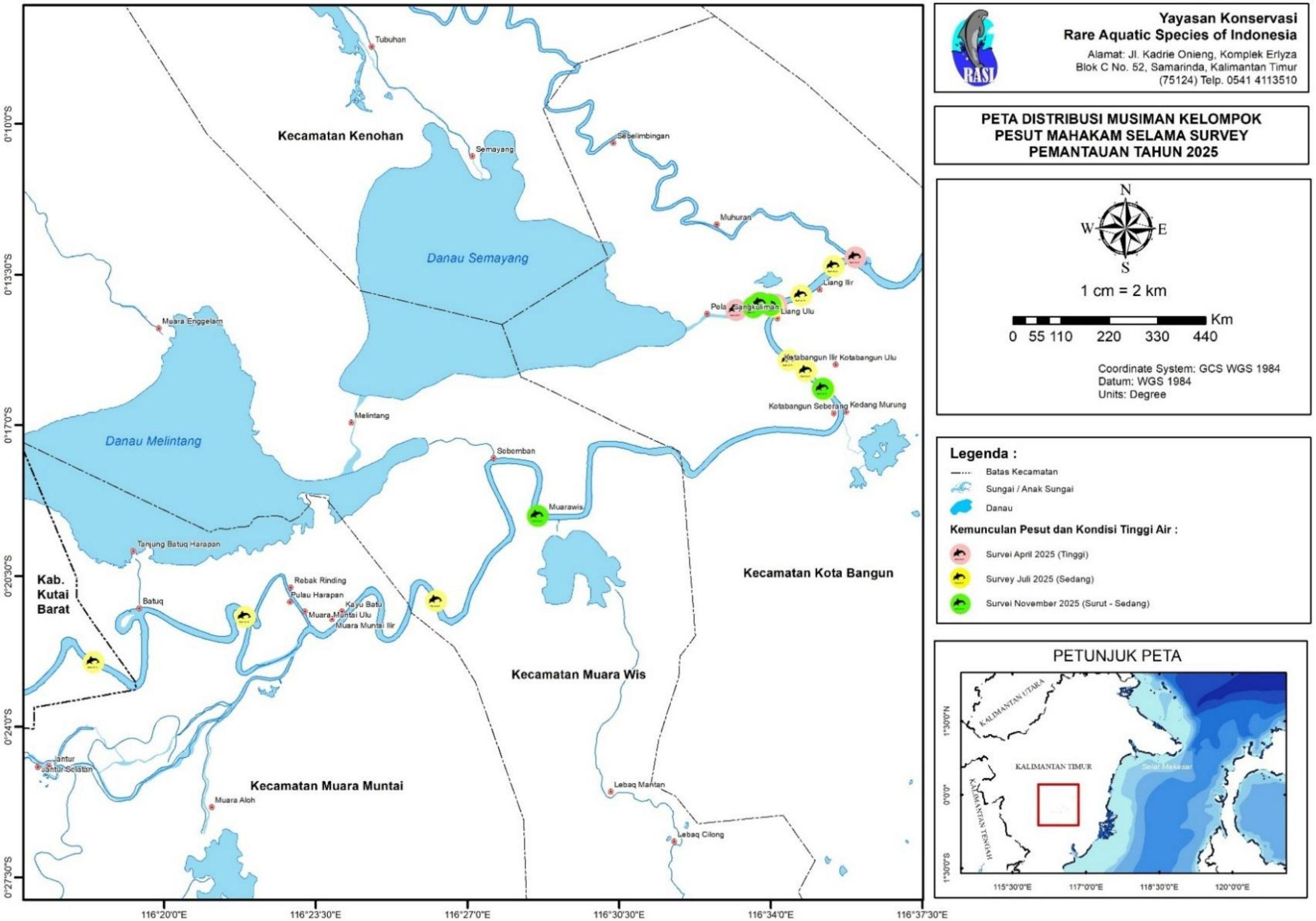


Figure 3. Map of Mahakam River dolphin sightings during surveys conducted in April, July, and November 2025.

3.1.2 Population Size and Birth Rate

During the three surveys conducted in 2025, a total of 24 dolphin groups were encountered, with an average group size of 8 individuals (median = 5; min = 1; max = 33), based on individual photo-identification analysis. Nearly all individuals observed during the 24 encounters were successfully photographed, and photo-identification analysis often revealed more individuals than were detected through direct visual observation alone. As a result, the average group size based solely on direct observation was lower (5 individuals) compared to the estimate based on photo-identification. In two encounters involving single individuals, no photographs were obtained.

During the three surveys in 2025, seven neonates (< 3 months old) were observed. However, based on the full monitoring dataset, including observations outside the formal survey periods, a total of 10 calves were born in 2025. Of these, two calves (approximately 1 m in length) were found dead by fishers on 7 January and 21 February 2025 near Muara Kedang Kepala in the Sungai Mahakam channel. No necropsies were conducted, as the carcasses were left drifting by the fishers, and the monitoring team was only informed later. One additional neonate was observed outside the survey period in December 2025 by the Pela community tourism group (POKDARWIS Pela), who safely witnessed a birth event near Tanjung Halat, located within the core zone of the conservation area.

The most reliable population estimate for 2025, based on photo-identification mark–recapture analysis, was 66 individuals (range: 65–67; CV = 9%), including the addition of newborn calves and accounting for mortality recorded during 2025 (Table 1; Appendix 3). Since 2005, the population has fluctuated but shows a significant declining trend ($R^2 = 0.78$; $F(1,14) = 49.0$; $t = -7.0$; $p < 0.000$).

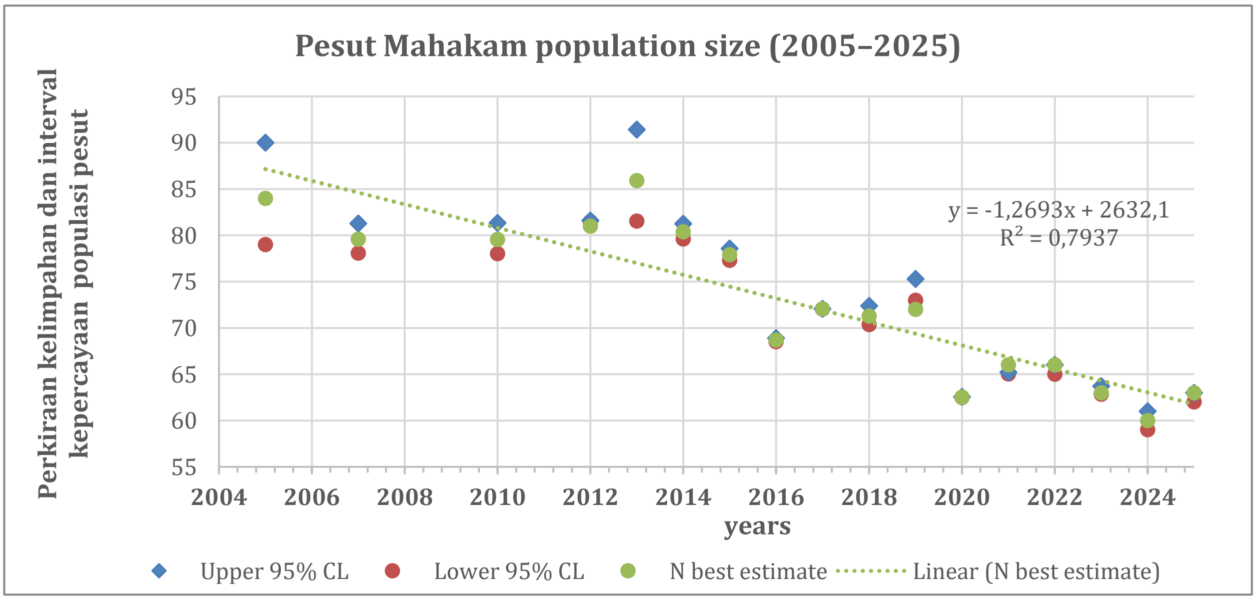


Figure 4. Estimated population size from 2005–2025 with regression trend.

Table 1. Estimated population size per year (N (1/P)) based on the weighted average N from models contributing to 95% of the total model weight and with ΔAICc < 10.

Year	Photo-identification session	Dolphin habitat coverage	Identified N*	Best population estimate (N) **	lower N final 95% CI	upper N final 95% CI	CV %
Closed Captures Full Likelihood							
2025	3	full	52	66	65	67	9
2024	3	full	59	60	59	61	7
2023	3	full	61	62	62	63	4
2022	3	full	61	66	65	66	5
2021	4	full	66	66	66	66	2
2020	4	full	59	63	63	63	2
2019	4	full	71	72	72	73	9
2018	4	full	73	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

CV = Coefficient of variation;
*Identified N = Total number of dolphins identified during combined encounter sessions,
*Best population estimate (N) = Population estimate derived from the weighted mean of models accounting for 95% of total AICc weight, corrected for individuals that could not be identified because
they were never successfully photographed, and adjusted by subtracting mortalities and adding newborn calves observed after the first capture session;
**Lower 95% CL = Minimum population size;
****Upper 95% CL = Maximum population size.

3.1.3 Mortality Rates and Causes

In 2025, three dolphin mortalities were documented, consisting of two calves and one juvenile male. The two calves were found dead and drifting, and their deaths were not reported immediately at the time of discovery. The juvenile male, aged 3 years and 4 months and known as Upin, died due to toxic food exposure, as determined through histopathological analysis (Appendix 2).

Histopathological examination revealed that Upin's heart experienced cardiac arrest associated with elevated potassium levels. Both the left and right lungs showed evidence indicating that the dolphin had died prior to submergence and subsequent resurfacing. The kidneys exhibited severe pathological damage, including partial autolysis, coagulative necrosis, and lesions consistent with exposure to toxic irritants, likely pesticide-related compounds, as well as potassium-related physiological disturbances.

The liver showed swelling and cellular hypertrophy associated with elevated copper concentrations. This finding may be linked to elevated copper levels also detected in surface water samples collected during the 2025 survey (Table 3). The copper concentration measured in the liver was 20.1 mg/kg. Copper concentrations in dolphin liver tissue typically range from 4.92 to 16.5 mg/kg. Therefore, the measured concentration of approximately 20 µg/g exceeds the normal range and may indicate adverse health effects related to copper accumulation.

Fragments and fibers of microplastics were found in the stomach and intestines. Histopathological examination of the stomach also showed thickening of the stomach wall and the presence of ulcers accompanied by hemorrhage. These ulcers were caused by the ingestion of foreign materials or objects that irritated the stomach lining. In the previous year, 2024, microplastics were also found in three adult individuals, specifically in the stomach and intestines, causing hemorrhage, inflammation, and necrosis of the intestinal villi. In one 7-year-old male, coal debris was found, which caused edema of the mucus cells and interfered with the absorption of nutrients through the intestinal wall.

The average annual mortality rate over the 31-year period (1995–2025) was 4.1 individuals, with 67% of known-cause mortalities resulting from entanglement in gillnets, followed by drowning (Figure 5). However, mortality caused by gillnet fisheries has declined significantly over time ($R^2 = 0.19$; $F(1, 29) = 6.87$; $p = 0.014$). The second most common, known causes of mortality were poisoning (9%) and vessel collisions (9%) (Figure 5). In 27% of cases, the cause of death remained unknown.

Of all mortality cases recorded between 1995 and 2025 (n = 128), the age class (calves < 1 year; juveniles and adults) was determined in 97% of cases, while sex was identified in only 38% of cases. However, in the most recent six-year period (2020–2025), this proportion increased to 82% due to improvements in the dolphin mortality reporting network.

Of the recorded mortalities, 69% were adults, 24% were calves under one year of age, and 6% were juveniles. Among individuals whose sex was determined, 46% were female and 54% were male.

Necropsies were conducted in 21 cases between 2009 and 2025. Among the 11 adult dolphins examined, fragments of fishing nets were found in the throat or stomach in nine cases, indicating ingestion or entanglement associated with fishing gear.

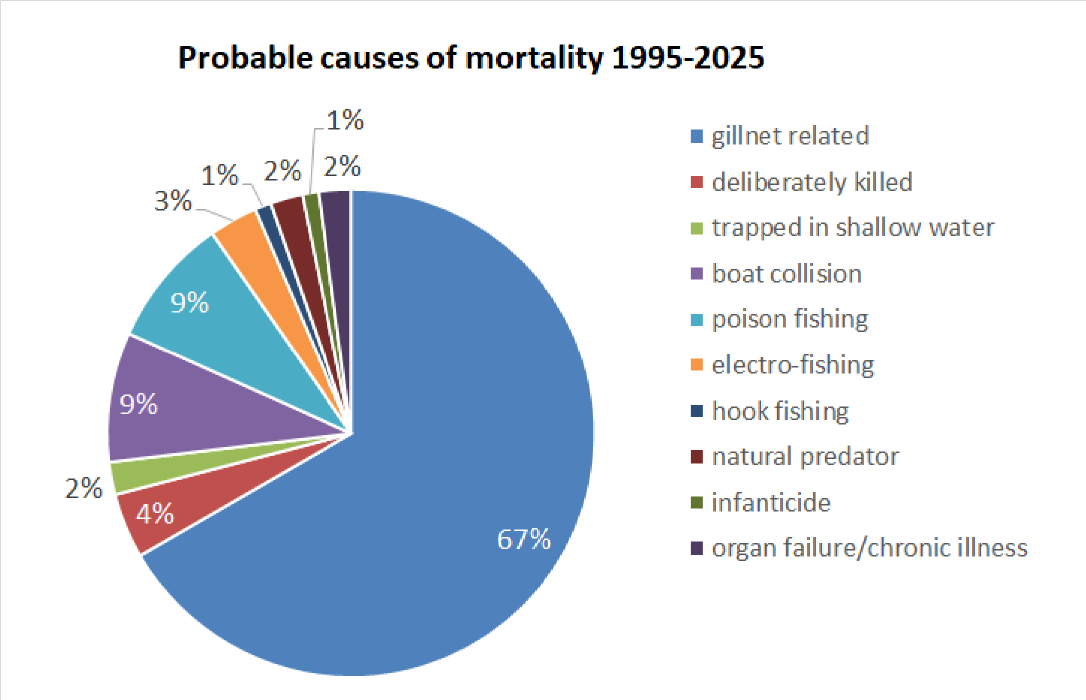


Figure 5. Suspected causes of Mahakam River Dolphin mortality, 1995–2025

* Based on mortality cases with known causes (n = 93 (73%) out of 128 total deaths)

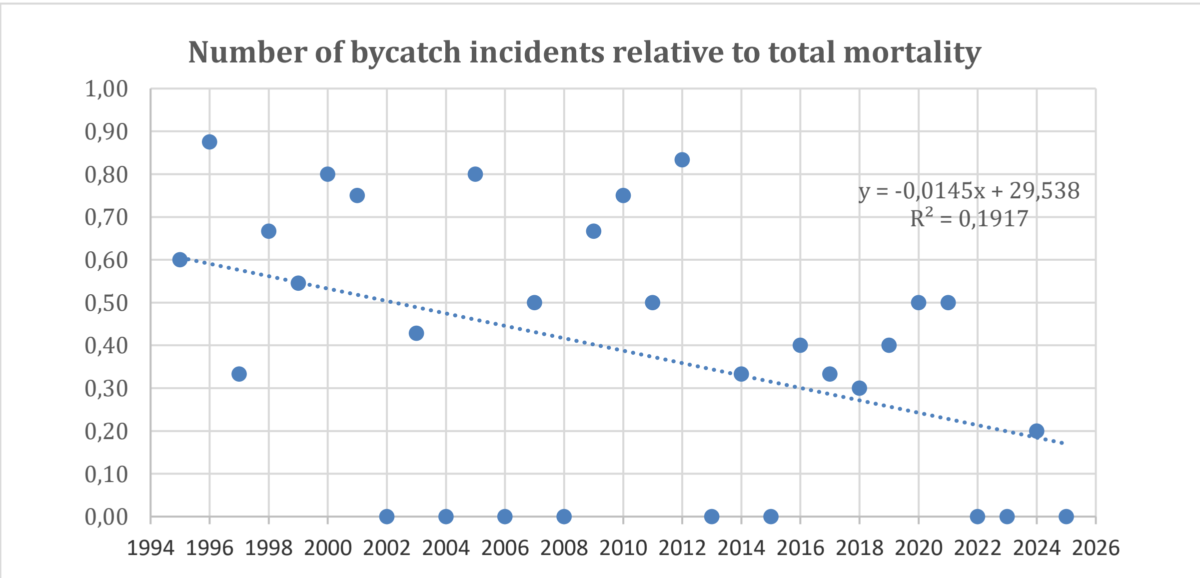


Figure 6. Trend in bycatch relative to total mortality over time (1995–2025).

3.2 River Water Quality in the Mahakam River Dolphin Habitat

The results of water quality analyses measured directly in the field during the three surveys conducted in 2025 are presented in Appendix 3.

3.2.1 Interpretation of In-situ Water Quality Results

Appendix 3 shows that dissolved oxygen (DO) levels in 13% (12 samples) of the 94 in-situ measurements fell below the national water quality standard, with values lower than 4 mg/L. However, these conditions were for 50% observed in samples collected from locations connected to swamp or lake systems, such as the Kedang Rantau River and the Pela River. These environments are characterized by eutrophic conditions, which can result in naturally low dissolved oxygen levels at certain locations and times. The in-situ water quality characteristics measured at dolphin sighting locations are presented in Table 2 and Appendix 3.

Table 2. Water characteristics at Mahakam River Dolphin encounter locations in 2025.

	Mean value			Minimum Value			Maximum Value		
Water Level	H	M	LM	H	M	LM	H	M	LM
DO- mg/l	5.3	4.2	5.0	4.9	3.3	4.2	5.8	5.0	5.7
pH	6.4	7.0	6.4	5.7	6.3	6.3	7.1	7.6	6.4
EC-µS/cm	43	42	37	18	24	28	128	46	45
TDS-mg/l	21	22	19	9	11	14	60	25	22
River Width- m	217	156	165	128	156	117	467	350	224
Clarity-cm	54	31	29	7	22	23	91	47	35
DEPTH-m	13	17	14	5	6.5	11	23	25	19
Current Speed-km/h	1.2	2.7	2.3	0	1.7	1.1	2.4	4.5	4.6
Water temp °C	29.2	27.8	28.1	28	26.6	27.3	32.1	30.5	28.6

H= High M = Medium; LM= Low to medium

3.2.2 Interpretation of Laboratory Water Quality Results

Laboratory water quality analysis from 14 sampling stations during the three surveys in 2025 showed that 56 samples (35% of all 210 samples for TSS, COD, NH_3-N, Cd, and Cu) exceeded Indonesian national water quality standards (Table 3). In addition, 73 samples exceeded international guideline values for NH_3-N, Cu, Fe, and Mn, which are generally more conservative. As noted above, Indonesia does not specify Class 2 water quality standards for Fe and Mn, although international guidelines do.

For Total Suspended Solids (TSS), eight samples (19% of all 42 samples) collected in April and July exceeded the national standard of 50 mg/L, with the highest concentration recorded downstream of Muhuran in July at 344 mg/L.

For Chemical Oxygen Demand (COD), 28 samples (67% of all 42 samples) exceeded the national standard of 25 mg/L. Elevated COD values were detected in all tributaries during April, July, and November, and also in the main Mahakam River during April and July, particularly near ship-to-ship conveyor locations downstream of Muara Kedang Kepala.

Cadmium (Cd), a toxic heavy metal, was detected above national standards (>0.01 mg/L) in

12 samples (29% of all 42 samples across the three surveys), including 86% of samples collected in April. In April, copper (Cu) concentrations also exceeded national standards (>0.02 mg/L) in five of 14 samples. An additional two samples showed Cu concentrations approaching the national threshold (0.016–0.018 mg/L).

For ammonium nitrogen (NH_3-N), three samples exceeded the national standard (0.2 mg/L) in November, including locations downstream of Tunjungan and Muara Sabintulung (Kedang Rantau River), and in the Bolowan River (Kedang Pahu). Although the national threshold is 0.2 mg/L, free ammonia concentrations suitable for sensitive fish species should not exceed 0.02 mg/L. Elevated ammonia levels can negatively affect fish diversity and aquatic ecosystem health. A total of 24 samples (57% of all 42 samples) exceeded optimal ammonia thresholds for fisheries and also exceeded international guideline values, such as those established for rivers in China (0.017 mg/L; Wang et al., 2020).

Iron (Fe) concentrations exceeded international guideline values in 98% of all samples, with an average concentration of 1.9 mg/L, approximately six times higher than the internationally recommended threshold of 0.3 mg/L for aquatic life, such as those applied in Brazilian river systems (Viana et al., 2021). Indonesia does not currently establish Class 2 freshwater standards for Fe.

For manganese (Mn), six samples (14% of all 42 samples) exceeded international guideline values. Similar to Fe, no Class 2 freshwater standard exists for Mn in Indonesia. However, international guidelines recommend a threshold of 0.073 mg/L to protect 99% of tropical freshwater species (Australia; Harford et al., 2015), and an even lower threshold of 0.033 mg/L for naturally acidic waters, such as swamp-connected tributaries. In Russia, an even more conservative standard of 0.01 mg/L is applied for river ecosystems (Matveeva et al., 2022).

Table 3. Water quality parameters from laboratory analyses exceeding national (WQC) and/or international (IWQC) standards.

Parameter	WQC or IWQC	n sampel < WQC or IWQC		Percentage (of n = 42 samples per parameter)	
		2024	2025	2024	2025
TSS	WQC	10	8	24%	19%
COD	WQC	9	28	21%	67%
Cd	WQC	6	12	14%	29%
Cu	WQC	2	5	5%	12%
NH3-N	WQC	2	3	5%	7%
Sub-total		29	56		
NH3-N	IWQC	28	24	67%	57%
Cu	≈WQC	3	2	7%	5%
Fe	IWQC	21	41	88%	98%
Mn	IWQC	14	6	33%	14%
Sub-total		66	73		
Total		95	129		

3.3 Threats

Ancaman-ancaman lain disamping kematian langsung (3.1.) adalah beberapa faktor yang menyebabkan penurunan kualitas habitat Pesut di antara lain:

3.3.1 Underwater Noise Pollution

Underwater noise pollution is primarily caused by high-speed vessels (40–200 HP), which induce longer dive durations in Mahakam River Dolphins when vessels approach within distances of 300–0 m from their position (Kreb & Rahadi, 2004). In addition, the increasing number of small motorized boats ("ces") traveling at high speeds in tributaries such as the Pela River also causes dolphins to remain submerged for extended periods.

Although coal barges produce relatively low frequencies (kHz), their sound intensity is high, with average levels of 111 dB recorded at a distance of 50 m from the hydrophone. Underwater sound levels exceeding 80 dB are sufficient to interfere with sonar reflections and dolphin echolocation, impairing their ability to estimate distances between themselves and surrounding objects such as barges. This condition poses significant risks, particularly in narrow tributaries (Au, 1981; Gordon et al., 1996).

Acoustic monitoring conducted between 2015 and 2017 revealed a 50% decline in dolphin presence within the Kedang Kepala tributary estuary, an area that was previously traversed daily by dolphins and designated as a core habitat zone (Yayasan Konservasi, 2017).

A clear example of the impact of coal barge transportation on dolphin habitat occurred in the Kedang Pahu tributary (West Kutai). Until 2014, coal barges were towed through the Kedang Pahu River daily (average = 8.4 vessels/day), which is a narrow tributary that was considered a primary dolphin habitat prior to 2009. During the dry season, these vessels occupied more than two-thirds of the river width and more than half of its depth. Observations indicated that dolphins consistently altered their swimming direction, particularly when moving upstream, upon encountering coal barges.

According to local fishermen, prior to the introduction of coal barge traffic, dolphins regularly entered tributaries up to the Bolowan tributary estuary (approximately 10 km from the Kedang Pahu estuary) under high, medium, and low water level conditions. However, such occurrences are no longer observed.

Since 2015, coal barges have also begun operating in the Kedang Kepala tributary in Kutai Kartanegara Regency, raising serious conservation concerns due to the magnitude of underwater noise generated. On August 12, 2018, a female calf was struck by a barge that suddenly appeared around a river bend and encountered a group of dolphins. The injured calf was carried to the riverbank by the group and later died. Additionally, an adult female dolphin was found dead on March 4, 2021, at kilometer 1 of the tributary. The carcass was buried by local residents without coordination with authorities, preventing necropsy and proper investigation.

Coal barges measuring approximately 300 feet in length and 27.4 m in width exceed the maximum permitted vessel width for rivers less than 100 m wide (maximum vessel width should not exceed 1/6 of the river width; Ministry of Transportation Regulation No. 52, 2012). Such vessels can damage riverbank ecosystems, which serve as critical spawning and nursery habitats for fish.

If coal barge transportation continues to operate in narrow tributaries such as Kedang Kepala and Belayan, it may severely impact the survival of the Mahakam River Dolphin. This situation is particularly concerning, as the potential loss of this endangered species would also affect fisheries resources that serve as an important livelihood for local communities (Yayasan Konservasi RASI, 2025).

Studies on dolphin behavioral responses to vessel disturbance have shown that an increase from seven vessel interactions to ten interactions (e.g., tourism vessels), with an average interaction duration of 57 minutes within a 300 m radius—even at minimal speed and noise levels (wake speed)—resulted in a reduction of resting behavior (Constantine et al., 2004). Resting is a vital behavior necessary for maintaining dolphin health.

Currently, there are no regulations in the Mahakam River governing the minimum distance between barges or the maximum allowable vessel traffic frequency during day or night. Therefore, it is necessary to establish limits on vessel traffic within Mahakam River Dolphin habitats. Observations indicate that dolphins alter both behavioral and acoustic patterns each time a coal barge passes, with disturbance effects lasting approximately five minutes.

To minimize behavioral disruption, it is recommended that a minimum distance of 3 km be maintained between coal barges. This measure would effectively limit vessel traffic in both upstream and downstream directions to a maximum of approximately three barges per hour (combined two-way traffic), thereby reducing the cumulative disturbance that could negatively impact dolphin survival.

In addition, the total number of large vessels and high-speed boats (including barges and speedboats) passing through dolphin habitats should be limited to a maximum of 36 vessels per day. Exceeding this threshold would significantly disrupt resting and feeding activities, which constitute approximately 20% of the dolphins' daily behavior and are essential for their survival. Furthermore, because sonar disturbance and collision risks are significantly higher at night, vessel traffic during nighttime should be strictly minimized or suspended.

3.3.2 Chemical Pollution

Coal spillage into the river has been observed and may contribute to skin discoloration in Mahakam River Dolphins in the Kedang Pahu River area, as documented in 2002 and 2007. Such conditions have not been observed in dolphins inhabiting other areas.

In addition, wastewater from coal washing processes enters tributaries and lakes during high water levels, further degrading water quality.

Pollution originating from oil palm plantations also contributes significantly to habitat degradation. Drainage canal systems that directly connect plantation areas to dolphin habitats and their prey, as well as embankment systems that eliminate swamp areas critical for fish spawning and nursery grounds, have severely affected water quality. These impacts have been documented in Muara Pahu and have also been reported by local fishermen in the Kedang Rantau–Muara Sebintulung area in Kutai Kartanegara.

Industrial expansion, particularly coal mining and oil palm plantations within designated Mahakam River Dolphin protected areas, has resulted in a significant decline in prey availability, especially in Muara Pahu and its tributaries. As a result, dolphin sightings in these areas have become increasingly rare, despite their historical importance as core habitats.

Additionally, pesticide contamination—including non-organic fertilizers and herbicides—from oil palm plantations enters river systems through drainage channels constructed by plantation operators. This form of pollution remains insufficiently monitored and poses a continued threat to the Mahakam River Dolphin and its habitat.

Heavy metal contamination, particularly cadmium (Cd) and copper (Cu), in the core habitat of the Mahakam River Dolphin is highly concerning, as these pollutants pose serious risks to both dolphin health and human communities consuming fish from the river. These metals may originate from active ingredients or impurities in copper-based products used in pesticides, herbicides, fungicides, and phosphate-based fertilizers applied by oil palm plantations operating in the surrounding areas. Cadmium is also strongly associated with coal-related activities, especially coal burning. Importantly, these heavy metals are non-biodegradable, meaning they persist in the ecosystem and accumulate within the food chain.

Elevated copper concentrations in natural waters exceeding environmental thresholds can cause sublethal effects in aquatic organisms, including histological and morphological tissue changes, suppressed growth and development, impaired swimming performance, biochemical alterations, behavioral changes, and reproductive impairment (Hossain et al., 1999). Cadmium is highly toxic to both humans and aquatic life, causing liver and kidney damage and acting as a genotoxic carcinogen (Nguyen et al., 2005).

Meanwhile, elevated ammonia (NH_3–N) concentrations observed throughout the surveys present significant toxicity risks to aquatic organisms, particularly benthic crustaceans and mollusks, due to ammonia's ability to diffuse across gill membranes (Cheng et al., 2019). Among environmental stressors affecting aquatic organism health in freshwater ecosystems, high ammonia concentrations are considered one of the most dangerous threats, alongside oxygen depletion (Egnew et al., 2019).

Ammonia exposure can cause acute mortality in fish species such as Micropterus salmoides (Egnew et al., 2019) and increase the severity of white spot syndrome virus infections in white shrimp Litopenaeus vannamei under ammonia stress (Lu et al., 2019). Additionally, ammonia exposure for 48 hours has been shown to cause cytological damage and DNA damage in aquatic crustaceans such as Scylla paramamosain (Cheng et al., 2019). Wang et al. (2020) reported that acute and chronic toxic thresholds in the Laio River, China, were 0.067 mg/L and 0.017 mg/L, respectively. In contrast, Indonesia's national water quality standard for ammonia in Class II waters is set at 0.2 mg/L, a level considered relatively high and insufficiently protective for sustaining healthy fisheries and aquatic biodiversity.

3.3.3 Decline in Prey Availability

- Intensive fishing using gillnets, electrofishing, trawls (especially in lakes), poison (Dupon/Lamet, Deses, Gadong root), and aquaculture of predatory fish fed with small wild-caught fish from lakes and rivers has likely caused a significant decline in fish resources. During surveys, the team frequently observed electrofishing activities during the daytime, mostly using generators. Devices consisting of electrically charged metal frames mounted at the front of boats were also observed, allowing fishers to capture large quantities of small fish (kendia), which are an important prey species for the Mahakam River Dolphin.
- Monopolistic fishing gear such as sawaran, peggongan, and similar barrier systems obstruct seasonal fish migration, thereby reducing fish regeneration and population recovery.
- Deforestation along riverbanks reduces fish resources by increasing water temperature, sedimentation, and reducing organic inputs such as leaves and fruits that fall into the water, which serve as important food sources for fish. Declining fish availability increases the likelihood that dolphins will approach gillnets, thereby increasing the risk of entanglement.
- Conversion of swamp forests into oil palm plantations, which is widespread in the region, reduces critical fish breeding habitats. Dams constructed by companies to prevent flooding block spawning migrations of adult fish and prevent juvenile fish from dispersing from swamp habitats into rivers.
- Coal barge transportation in narrow tributaries can also reduce prey availability because:
  a) Vessel movement alters riverbed structure (canalization), particularly in river bends, damaging fish spawning grounds. Due to the narrow width of tributaries, barges are unable to travel in the center of the river and often move along riverbanks, colliding with banks and damaging submerged roots that serve as fish spawning and nursery habitats. This also causes bank erosion, tree collapse, and destruction of riparian ecosystems essential for fish reproduction and survival. Field observations indicate that repeated navigation along riverbanks accelerates river canalization, increasing current velocity and making

conditions less suitable for fish, negatively affecting fisheries. These impacts conflict with Government Regulation of the Republic of Indonesia No. 38 of 2011 concerning Rivers and Minister of Transportation Regulation No. PM. 52 of 2012, Article 51.7b, which states that river vessels being towed must be properly controlled by the towing vessel.

b) Nedwell et al. (2003) classified fish avoidance responses to underwater sound beginning at 75 dB (moderate), 90 dB (significant), and 100 dB (strong), indicating that underwater noise negatively affects not only dolphins but also fish populations.

- Closure of swamp–tributary connecting canals by fishers using hempang barriers prevents fish from returning to river ecosystems after spawning in swamp habitats, thereby limiting natural recruitment.
- There are currently no established fishing seasons or catch quotas for fish species experiencing population decline. There are also no regulations prohibiting the capture of spawning fish.
- The decline in prey availability increases the time and energy dolphins must expend to find food and may cause dolphins to target fish caught in gillnets (rengge), significantly increasing the risk of entanglement and mortality.

3.3.4 Sedimentation

High sedimentation levels and the extensive use of gillnets in Lakes Semayang and Melintang restrict the movement of the Mahakam River Dolphin within these lakes. As a result, except during periods of high-water levels, dolphin movements are limited to narrow boat transportation channels between the two lakes, increasing the risk of vessel collisions and exposure to underwater noise disturbance. In addition, sedimentation also reduces fish resources (see section on prey decline above).

3.3.5 Potential Future Threats

Future threats include ongoing direct mortality and continued habitat degradation caused by deforestation, underwater noise pollution, and chemical contamination of rivers. Noise pollution can cause chronic stress, which may reduce reproductive success, while chemical pollutants such as heavy metals can result in unhealthy offspring or even death.

Another major threat is the continued decline in food availability due to unsustainable fishing practices, particularly the increasing use of high-voltage electrofishing generators and intensified net fishing to support aquaculture of predatory fish species.

The planned relocation of Indonesia's new capital city, Nusantara, to East Kalimantan may increase demand for freshwater fish from the Mahakam River. If fish resources are not managed sustainably, this could lead to overfishing and further depletion of fish populations.

Additional concern exists regarding potential inbreeding within the small dolphin population, which could lead to reduced calf survival during the first year of life, lower adult survival rates, decreased reproductive success, and reduced ability to compete for mates. However, population viability analysis indicates that the current level of inbreeding remains low.

Based on population survival analysis, the Mahakam River Dolphin population is expected to persist if the average mortality rate does not exceed four individuals per year, and the population may increase if annual mortality remains below this threshold. Since most deaths are caused by entanglement in gillnets, conservation efforts must prioritize preventing entanglement-related mortality, supported by the establishment and enforcement of effective government regulations.

4. Recommendations

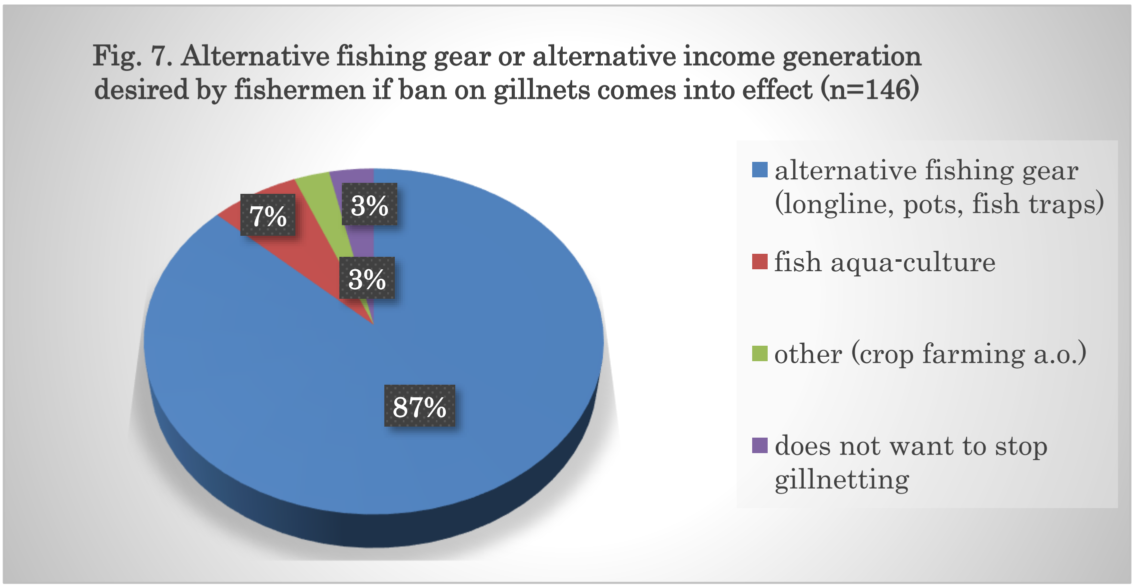
Based on the summary of issues identified in the field, the following recommendations are proposed:

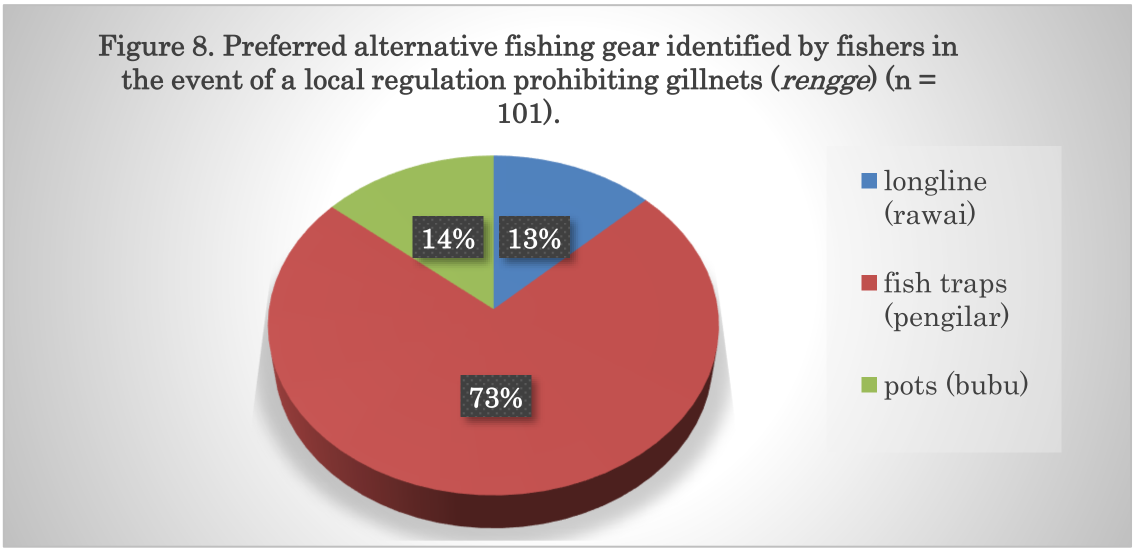
1) *Reducing Mahakam River Dolphin Mortality*

   a) Include a prohibition in the revision of Kutai Kartanegara Regency Regulation No. 13 of 2017 on fisheries management to ban:All gillnets with mesh sizes greater than 4 cm (single side), whether made of nylon or thread, All gillnets made of thread material, and All gillnets installed across the full width of the river from one bank to the other.

   b) Install underwater acoustic deterrent devices (*pingers*) on gillnets to deter dolphins from approaching nets and prevent them from attempting to feed on trapped fish. Long-term effectiveness monitoring should also be conducted. Currently, 251 pingers have been installed on gillnets belonging to 158 fishers, distributed gradually since July 2020 (Kreb, Rosana, Paisal, Jusmaldi, 2021). Fishers have reported positive outcomes, including:Dolphins no longer or rarely damaging nets or taking fish from nets, and Fish catches remaining stable or even consisting of larger fish sizes.

   c) Provide alternative fishing gear or livelihood options for fishers in the event that gillnets are fully prohibited. Of 146 gillnet fishers surveyed, 97% agreed to stop using gillnets and switch to alternative gear or activities if regulations banning gillnets with mesh sizes greater than 4 cm are implemented (Figures 6 & 7). In 2025, a total of 2,438 meters of gillnets (≤ 5 cm mesh size, single side) owned by 46 fishers from 9 villages were successfully exchanged, benefiting 1,509 households. This gear exchange program will continue until 2027.





2) Addressing Chemical Pollution

a) Continue investigating the sources of river pollution and identify effective prevention measures. This effort is expected to support the development of appropriate conservation action plans for the Mahakam River Dolphin and involve all stakeholders, including government and non-government institutions.

b) Improve waste and wastewater management and prohibit the disposal of inorganic waste and garbage into rivers. One of the major causes of declining water quality in the Kedang Kepala River, Kedang Rantau River, and surrounding areas is plastic waste and domestic wastewater. Therefore, comprehensive waste and domestic wastewater management programs are needed. These programs should aim to reduce the volume of waste entering rivers through waste reduction, treatment, and reuse. Activities should include outreach, training, practical implementation, mentoring, and post-processing support.

c) Eliminate heavy metal pollution by ensuring oil palm plantations are located away from rivers and flood-prone areas to prevent runoff containing pesticides, herbicides, and fertilizers. Additionally, the conveyor facility located near Muara Kedang Kepala, where heavy metals have been detected, should be relocated downstream outside the proposed aquatic conservation area.

3) *Addressing the Decline in Fish Populations*

a) Establish buffer zones around the Mahakam River Conservation Area in the Upper Kutai Kartanegara region through the OECM (Other Effective Conservation Measures) mechanism, including areas in West Kutai. This will help accommodate the seasonal presence of Mahakam River Dolphins while protecting water quality and fish resources upstream of the conservation area.
b) Conduct regular patrols and enforce laws against illegal fishing methods, including electrofishing and poisoning.
c) Prohibit monopolistic fishing gear that blocks fish migration routes.
d) Conduct fisheries outreach programs to promote sustainable fisheries resource management.
e) Establish fisher groups focused on sustainable floating cage aquaculture. Sustainable aquaculture involves feeding fish with a combination of pellets and plant-based materials. Suitable species include Jelawat, Common Carp, and Nile Tilapia sourced from hatcheries, reducing pressure on wild fish populations.
f) Provide fish hatchery training to reduce dependence on external seed supplies.
g) Provide fish feed production training for women to ensure feed availability, reduce costs, and strengthen women's participation in sustainable fisheries.
h) Develop value-added fish products, such as pressure-cooked carp or tilapia (*presto fish*), to increase local fisher income from sustainable aquaculture.
i) Prohibit large vessels with widths exceeding one-sixth of the river width and/or vessel drafts that leave less than 15 meters of clearance beneath structures above the river surface.
j) Prohibit coal barges from tying to riverside trees and require barges to park in a single line rather than side-by-side.
k) Require companies that clear riverbanks (within 100 meters inland) to restore vegetation in areas not used for industrial infrastructure, such as ports or conveyors.
l) Conduct outreach and collaboration with communities engaged in riverside deforestation to promote reforestation within 100 meters of riverbanks. This will help prevent erosion and sedimentation, provide fish microhabitats, and support broader biodiversity.

4) *Addressing Underwater Noise Pollution*

Enforce existing regulations outlined in Director General of Marine Spatial Management Decree No. 61 of 2023 and Indonesian Ministry of Transportation Regulation No. PM. 52 of 2012, including:

a) Prohibit all barge traffic in tributaries classified as Class II waterways where river width is less than 250 meters (and Class III waterways less than 100 meters wide). Maximum vessel specifications for Class II waterways include a maximum length of 9.48 meters, maximum width of 2.8 meters, minimum clearance of 10 meters, and a maximum of 20 transport trips per day.
b) Require barges operating in Class I waterways (such as the Mahakam River, average width ~250 meters) to maintain a clearance greater than 15 meters beneath overhead structures and prohibit navigation near riverbanks. Vessel drafts should be minimized due to average river depth of approximately 15 meters.
c) Require vessels larger than 8 GT to navigate only in the center of the river within conservation areas and prohibit travel near riverbanks.
d) Prohibit 300-foot vessels from overtaking, operating side-by-side, or passing vessels sized 180–300 feet. Vessels measuring 180 feet may only pass vessels of the same size.

5. Additional Proposed Regulations

a) Prohibit the use of active sonar.
b) Maintain a minimum distance of 3 km between barges traveling in the same direction.
c) Prohibit barges from parking along riverbanks within conservation areas.
d) Prohibit coal loading and transfer operations using floating conveyors (ship-to-ship transfer) within Mahakam River Dolphin habitat and relocate floating conveyor operations downstream outside conservation areas, such as downstream of Muara Kaman. This area is an important dolphin migration corridor currently impacted by barge congestion, underwater noise, and coal pollution.
e) Limit vessel traffic within conservation areas to a maximum of 3 vessels per hour (combined two directions) and no more than 36 vessels per day.
f) Prioritize land-based coal transportation routes downstream of the conservation area.
g) Limit vessel speeds (speedboats, longboats, and similar vessels) to a maximum of 15 km/h (8–10 knots). Install speed limit signage at least 1,000 meters before key dolphin habitats, including the mouths of the Pela, Semayang, Belayan, Kedang Kepala, and Kedang Rantau rivers, as well as along critical river sections.

5) *Monitoring the Future Status of the Mahakam River Dolphin*

It is recommended that population and habitat monitoring surveys be conducted at least once every four months each year to track population trends, habitat quality, and conservation effectiveness.

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

Harford AJ, Mooney TJ, Trenfield MA, Van Dam RA (2015) Manganese toxicity to tropical freshwater species in low hardness water. Environ Toxicol Chem. Dec; 34(12):2856-63. doi: 10.1002/etc.3135. Epub 2015 Oct 30. PMID: 26118763.

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

Hossain, Mahmood & Forestry, Rakkibu. (1999). EFFECTS OF COPPER ON AQUATIC ECOSYSTEMS -A REVIEW. Khulna University Studies. 1. 259-266. 10.53808/KUS.1999.1.2.259-266-Ls.

Kreb, D. and Smith, B.D. (2000) *Orcaella brevirostris* (Mahakam subpopulation). In: IUCN 2004. *2004 IUCN Red List of Threatened Species.* <4 >.

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

Matveeva, VA, Alekseenko, AV, Karthe, D & Puzanov, AV. 2022. Manganese pollution in mining-influenced rivers and lakes: current state and forecast under climate change in the Russian Artic. *Water* **14:** 1091.

Nguyen, HL, M. Leermakers, J. Osán, S. Török, W. Baeyens. 2005. Heavy metals in Lake Balaton: water column, suspended matter, sediment and biota, *Science of The Total Environment*: 340, Issues 1–3, Pages 213-230, ISSN 0048-9697, https://doi.org/10.1016/j.scitotenv.2004.07.032.

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.

Viana LF, Crispim BDA, Spositio JCV, Melo MP, Franciso LFV, Nascimento VAD, Barufatti A (2021) High iron content in river waters: environmental risks for aquatic biota and human health. Ambiente & Agua. doi:10.4136/ambi-agua.2751.

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

Yayasan Konservasi RASI. 2017. Kajian independen terkait dampak pengangkutan ponton batu-bara di anak sungai Kedang Kepala.

Yayasan Konservasi RASI. 2025. Laporan kajian ringkas dampak lalu lintas tongkang pengangkut batubara terhadap kualitas air dan (habitat) pesut Mahakam.

Documentation of Activities

The research team consisted of 4–5 members who rotated observation positions every 15 minutes while searching for Mahakam River Dolphin groups. Once a group was located, photo documentation was conducted along with water sample collection and analysis.

Interviews with fishers regarding dolphin presence and fisheries conditions provided valuable supporting data during each monitoring survey.

Newborn calves (< 3 months old) were recorded during every survey, with a total of seven different calves identified directly by the research team.

The female dolphin "Sakira" gave birth to a calf named "Hanif" in early September 2025.

*Dolphins were observed hunting gagok fish (*Mystus wolffii*) by forcing fish to the water surface, a hunting strategy that makes escape more difficult.*

One unique hunting behavior observed was water spraying, where dolphins spray water to disorient fish, making them easier to capture.

Dolphins were most commonly observed in groups of 7–8 individuals, although solitary individuals were occasionally found far from other groups. Larger aggregations of up to 33 individuals were recorded, such as in Muara Wis during the November 2025 survey.

Dorsal fin photo-identification, unique to each individual, is the primary method used for population estimation. The mark-recapture method estimates population size by comparing dorsal fin photographs collected during three survey periods and can also estimate individuals not directly observed in a given survey year. This photo shows Nadila (left) and Bolang (right).

A rare observation captured a male dolphin rolling its body, displaying mating readiness behavior.

A female dolphin was observed rotating her body and displaying playful behavior, commonly associated with mating readiness.

Threats

A dolphin surfaced in front of an upstream-moving coal barge. Due to intense underwater noise, dolphins often surface to visually assess their surroundings because excessive noise interferes with their sonar, causing disorientation.

Plastic waste was frequently observed in the river, posing risks of microplastic ingestion and digestive disruption in dolphins.

On November 5, 2025, a juvenile dolphin aged 3 years and 4 months named "Upin" was found dead in Kuyung Village (Muara Wis District). Cause of death: [to be completed if known].

The dolphin "Darwis" was previously entangled in an abandoned ghost net in Lake Melintang in 2019. After local communities contacted RASI for guidance, the dolphin was successfully released by cutting the net, although some net fragments remained on the tail as a reminder of the incident.

Uut

Jannah

Po

Linda

Fiona

shakira

A dolphin with visibly poor body condition was observed during the July 2025 survey.

Riverbank clearing continues despite protection under Government Regulation No. 38 of 2011 on Rivers. This activity negatively impacts fisheries resources that depend on riparian forests for: shade that maintains oxygen levels, leaf and fruit litter as food sources, submerged roots as fish spawning microhabitats, and habitat support for broader biodiversity including birds, otters, primates, reptiles, and other mammals.

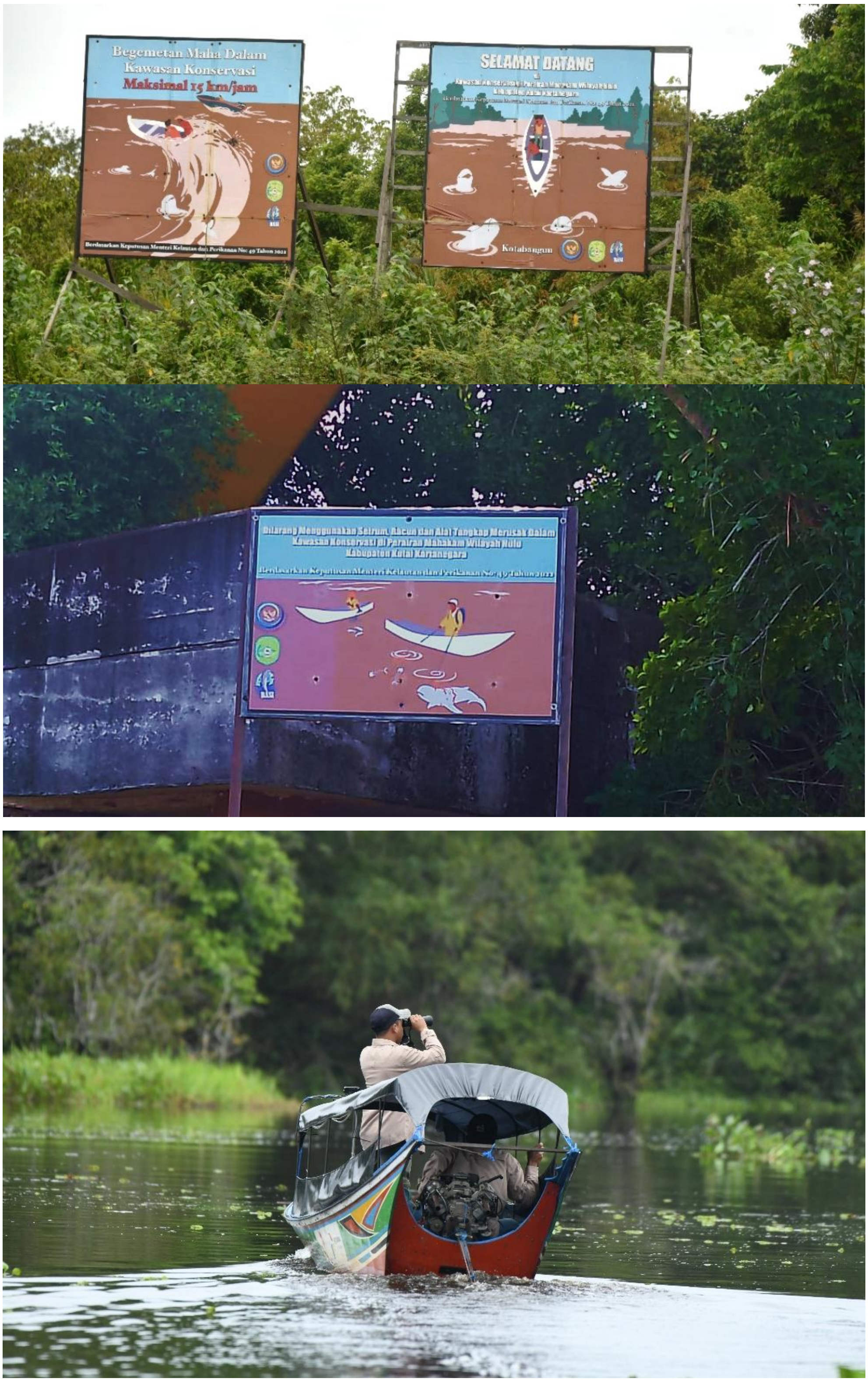
Monopolistic fishing barriers such as sawaran, peggongan, and hempang obstruct fish migration routes, preventing natural regeneration.

Conservation

Ideal dolphin habitat consists of riverbanks with intact vegetation or wetlands that support fish reproduction and provide essential microhabitats.

Sustainable fishing methods permitted within conservation areas include fish traps, fish shelters, and cast nets.

Gillnets are permitted only if mesh size does not exceed 4 cm (one side) and are installed along riverbanks. Most dolphin entanglements have occurred in gillnets with mesh sizes ≥ 7 cm installed across rivers with weights. Dolphins have also been documented feeding from smaller mesh nets and accidentally ingesting net fragments. To prevent this, acoustic deterrent devices ("pingers") are installed to repel dolphins from nets at approximately 10 meters distance. Currently, 251 pingers have been installed in collaboration with 158 fishers and have proven effective.



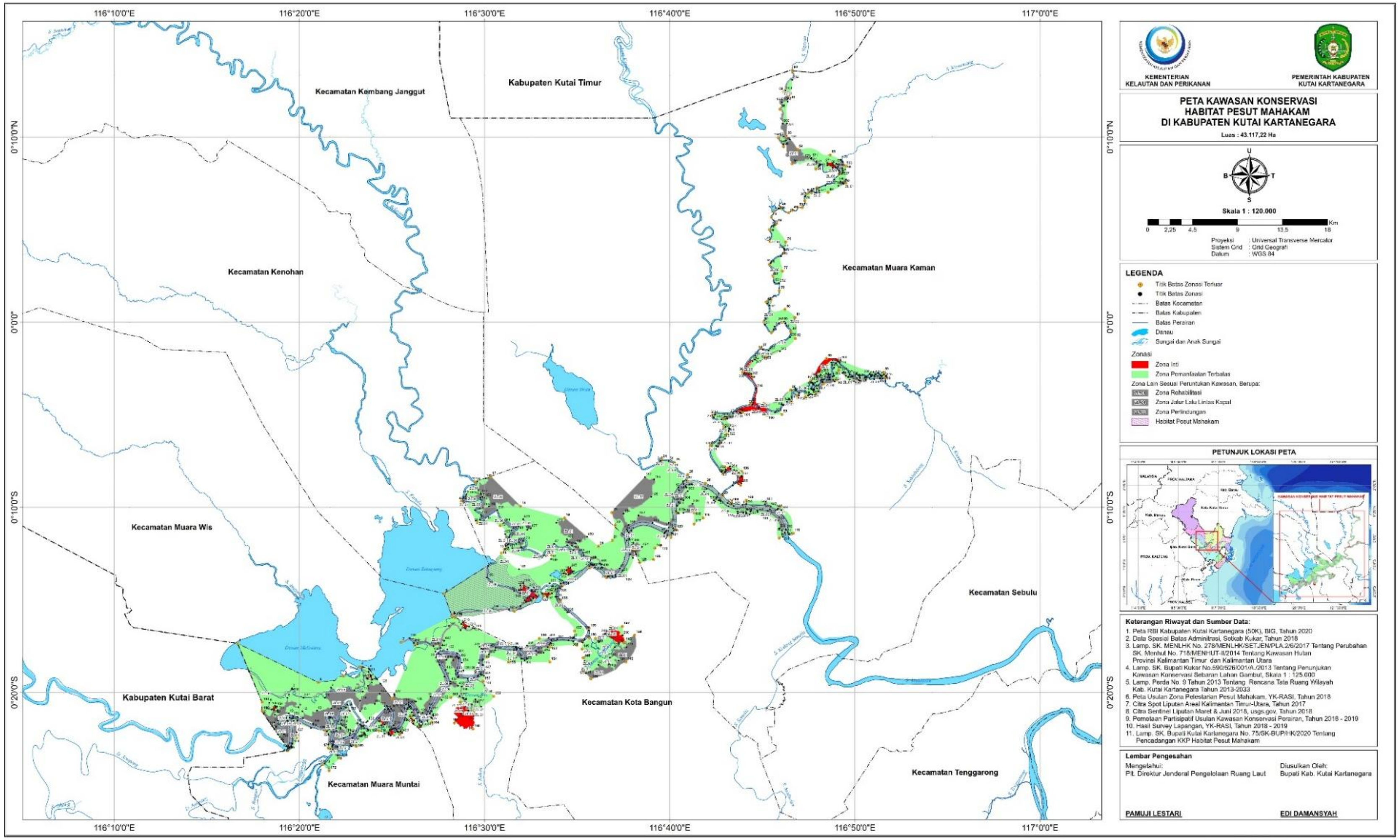
Conservation efforts include community outreach and monitoring to detect and report illegal activities. Three patrol teams regularly monitor river and lake areas within the conservation zone.

Other Biodiversity Potential

Surveys also documented other biodiversity species that depend heavily on riparian forests and fish resources.

*Upper photo: Lesser Adjutant (*Leptoptilos javanicus*) – protected species, Near Threatened (NT) on the IUCN Red List.*
*Lower photo: Storm's Stork (*Ciconia stormi*) – protected species, Endangered (EN) on the IUCN Red List.*

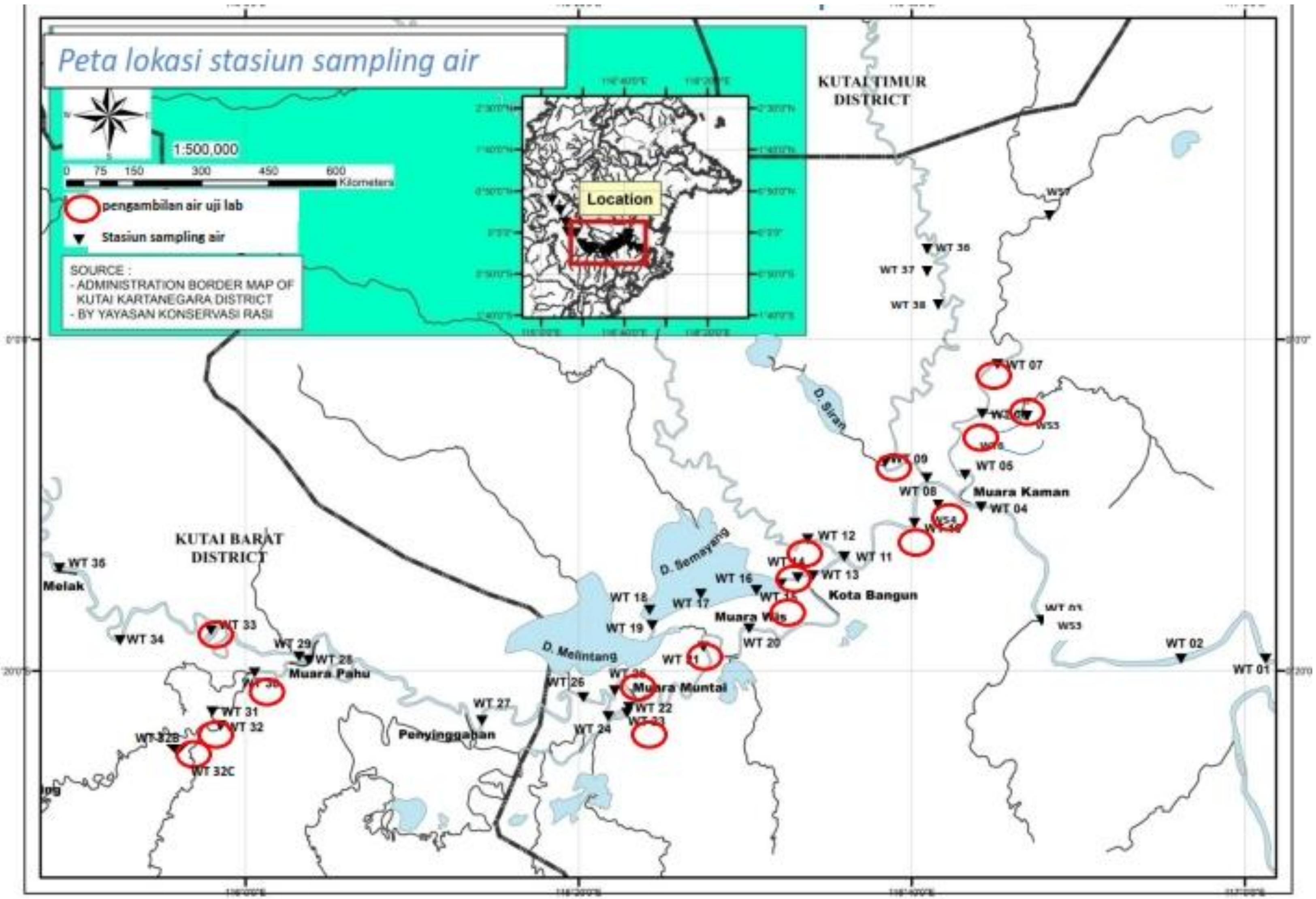
Appendix 1. Mahakam River Conservation Area in Upper Kutai Kartanegara Regency



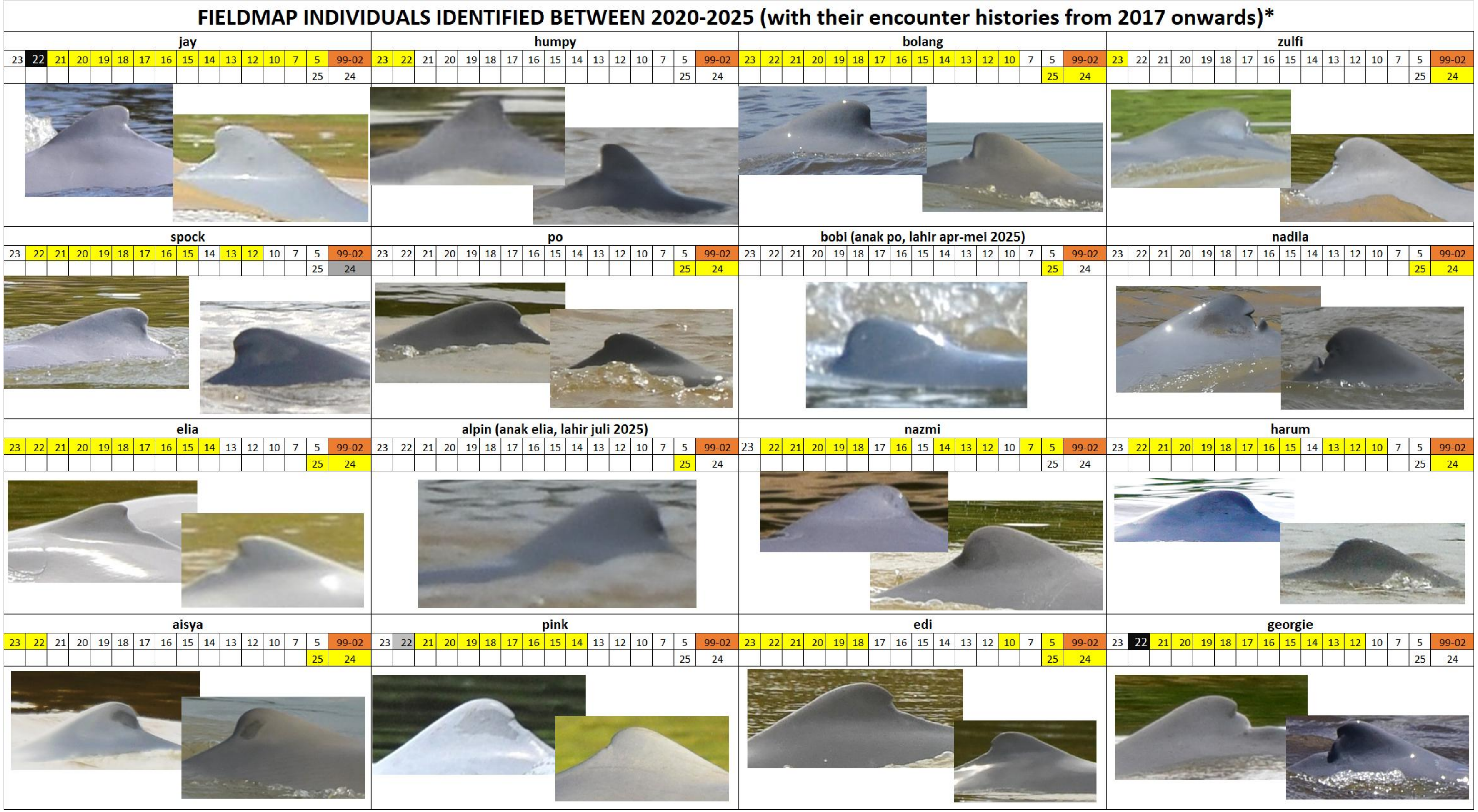
MENTERI KELAUTAN DAN PERIKANAN REPUBLIK INDONESIA,

SAKTI WAHYU TRENGGONO

Appendix 2. Map of water sampling stations within Mahakam River Dolphin distribution areas



Appendix 3. Photo-identification map of individual dolphins identified between 2020–2025 (including historical observations*)

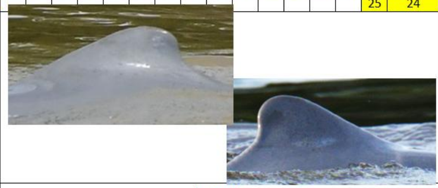


hepi

23	22	21	20	19	18	17	16	15	14	13	12	10	7	5	99-02
														25	24

budi

23	22	21	20	19	18	17	16	15	14	13	12	10	7	5	99-02
														25	24

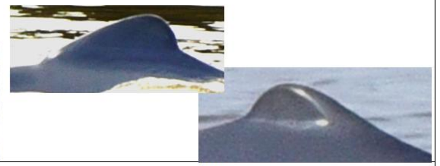


najwa

	22	21	20	19	18	17	16	15	14	13	12	10	7	5	99-02
														25	24

moon

23	22	21	20	19	18	17	16	15	14	13	12	10	7	5	99-02
														25	24

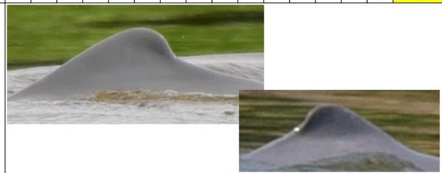


elmo

23	22	21	20	19	18	17	16	15	14	13	12	10	7	5	99-02
														25	24

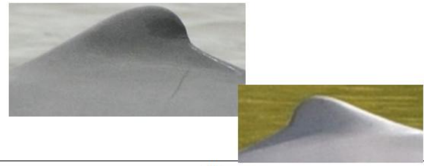
britney

23	22	21	20	19	18	17	16	15	14	13	12	10	7	5	99-02
														25	24



bulat

	22	21	20	19	18	17	16	15	14	13	12	10	7	5	99-02
														25	24

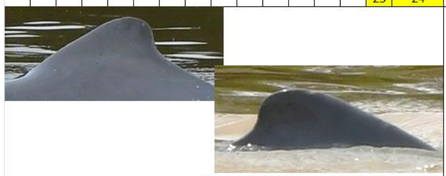


uut

23	22	21	20	19	18	17	16	15	14	13	12	10	7	5	99-02
														25	24

dobi

23	22	21	20	19	18	17	16	15	14	13	12	10	7	5	99-02
														25	24



meli

23	22	21	20	19	18	17	16	15	14	13	12	10	7	5	99-02
														25	24

olli

23	22	21	20	19	18	17	16	15	14	13	12	10	7	5	99-02
														25	24

kadir

23	22	21	20	19	18	17	16	15	14	13	12	10	7	5	99-02
														25	24

bayu

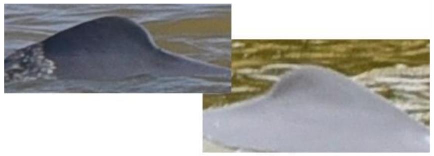
	22	21	20	19	18	17	16	15	14	13	12	10	7	5	99-02
														25	24

dumbledore

23	22	21	20	19	18	17	16	15	14	13	12	10	7	5	99-02
														25	24

four

23	22	21	20	19	18	17	16	15	14	13	12	10	7	5	99-02
														25	24



kerawin

23	22	21	20	19	18	17	16	15	14	13	12	10	7	5	99-02
														25	24

syani

23	22	21	20	19	18	17	16	15	14	13	12	10	7	5	99-02
														25	24

Lilith

23	22	21	20	19	18	17	16	15	14	13	12	10	7	5	99-02
														25	2024

Tita

23	22	21	20	19	18	17	16	15	14	13	12	10	7	5	99-02
														25	24

reza

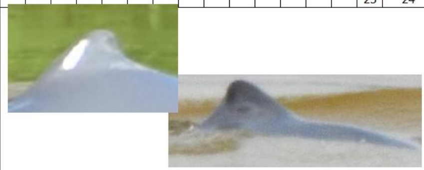
23	22	21	20	19	18	17	16	15	14	13	12	10	7	5	99-02
														25	24

pace

23	22	21	20	19	18	17	16	15	14	13	12	10	7	5	99-02
														25	24

ipung

23	22	21	20	19	18	17	16	15	14	13	12	10	7	5	99-02
														25	24

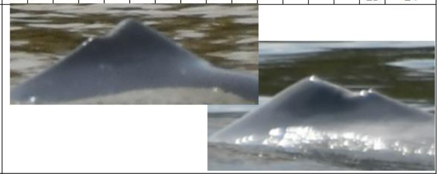


alun

23	22	21	20	19	18	17	16	15	14	13	12	10	7	5	99-02
														25	24

mutia

23	22	21	20	19	18	17	16	15	14	13	12	10	7	5	99-02
														25	24



thamrin

23	22	21	20	19	18	17	16	15	14	13	12	10	7	5	99-02
														25	24

paman

23	22	21	20	19	18	17	16	15	14	13	12	10	7	5	99-02
														25	24

padma

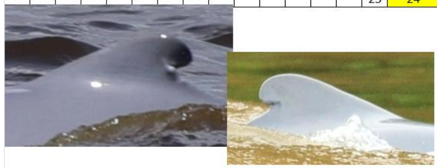
23	22	21	20	19	18	17	16	15	14	13	12	10	7	5	99-02
														25	24

nur

23	22	21	20	19	18	17	16	15	14	13	12	10	7	5	99-02
														25	24

twister

23	22	21	20	19	18	17	16	15	14	13	12	10	7	5	99-02
														25	24



eyang

	22	21	20	19	18	17	16	15	14	13	12	10	7	5	99-02
														25	24

lars

	22	21	20	19	18	17	16	15	14	13	12	10	7	5	99-02
														25	24

nosy

	22	21	20	19	18	17	16	15	14	13	12	10	7	5	99-02
														25	24

Susan

23	22	21	20	19	18	17	16	15	14	13	12	10	7	5	99-02
														25	24

kaisar

23	22	21	20	19	18	17	16	15	14	13	12	10	7	5	99-02
														25	24

Musmus

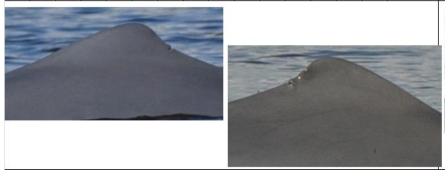
	22	21	20	19	18	17	16	15	14	13	12	10	7	5	99-02
														25	24

hook

23	22	21	20	19	18	17	16	15	14	13	12	10	7	5	99-02
														25	24

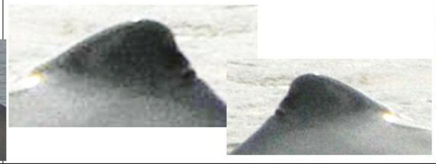
epok

23	22	21	20	19	18	17	16	15	14	13	12	10	7	5	99-02
														25	24



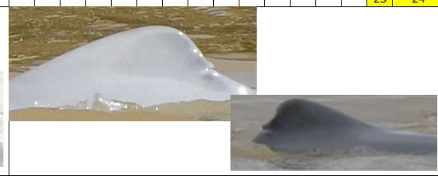
piet

23	22	21	20	19	18	17	16	15	14	13	12	10	7	5	99-02
														25	24



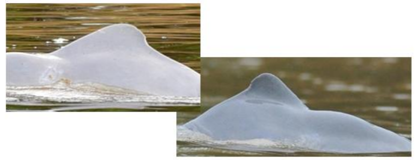
rahma

23	22	21	20	19	18	17	16	15	14	13	12	10	7	5	99-02
														25	24



fiona

23	22	21	20	19	18	17	16	15	14	13	12	10	7	5	99-02
														25	24



Akbal

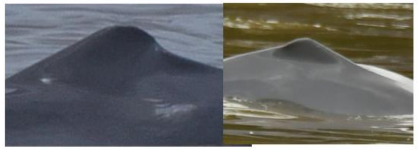
23	22	21	20	19	18	17	16	15	14	13	12	10	7	5	99-02
														25	24

alimin

23	22	21	20	19	18	17	16	15	14	13	12	10	7	5	99-02
														25	24

darwis

23	22	21	20	19	18	17	16	15	14	13	12	10	7	5	99-02
														25	24



laila

23	22	21	20	19	18	17	16	15	14	13	12	10	7	5	99-02
														25	24

miu

23	22	21	20	19	18	17	16	15	14	13	12	10	7	5	99-02
														25	24

dahlia

23	22	21	20	19	18	17	16	15	14	13	12	10	7	5	99-02
														25	24

joko

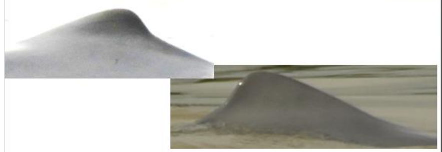
23	22	21	20	19	18	17	16	15	14	13	12	10	7	5	99-02
														25	24

boy

23	22	21	20	19	18	17	16	15	14	13	12	10	7	5	99-02
														25	24

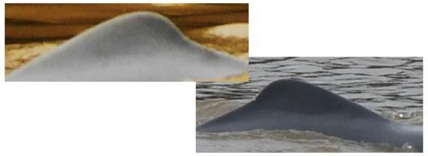
pong

23	22	21	20	19	18	17	16	15	14	13	12	10	7	5	99-02
														25	24



belle

23	22	21	20	19	18	17	16	15	14	13	12	10	7	5	99-02
														25	24

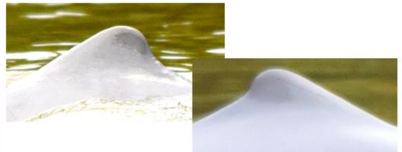


faiz

	22	21	20	19	18	17	16	15	14	13	12	10	7	5	99-02
														25	24

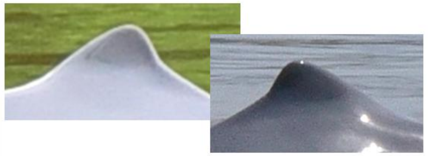
purnama

23	22	21	20	19	18	17	16	15	14	13	12	10	7	5	99-02
														25	24



nick

23	22	21	20	19	18	17	16	15	14	13	12	10	7	5	99-02
														25	24



merry

23	22	21	20	19	18	17	16	15	14	13	12	10	7	5	99-02
														25	24

lusi

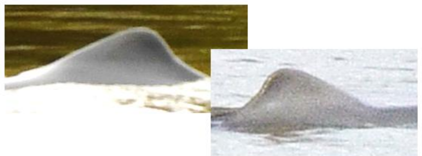
23	22	21	20	19	18	17	16	15	14	13	12	10	7	5	99-02
														25	24

naga

	22	21	20	19	18	17	16	15	14	13	12	10	7	5	99-02
														25	24

maulana

23	22	21	20	19	18	17	16	15	14	13	12	10	7	5	99-02
														25	24



rio

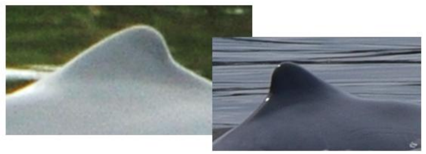
	22	21	20	19	18	17	16	15	14	13	12	10	7	5	99-02
														25	24

ivan

23	22	21	20	19	18	17	16	15	14	13	12	10	7	5	99-02
														25	24

zani

	22	21	20	19	18	17	16	15	14	13	12	10	7	5	99-02
														25	24



zunia

23	22	21	20	19	18	17	16	15	14	13	12	10	7	5	99-02
														25	24

rexy

23	22	21	20	19	18	17	16	15	14	13	12	10	7	5	99-02
														25	24

amehr

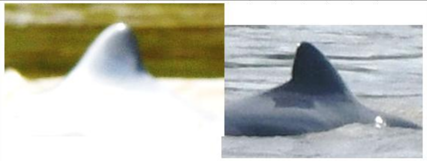
23	22	21	20	19	18	17	16	15	14	13	12	10	7	5	99-02
														25	24

elok

	22	21	20	19	18	17	16	15	14	13	12	10	7	5	99-02
														25	24

dilla

23	22	21	20	19	18	17	16	15	14	13	12	10	7	5	99-02
														25	24



keris

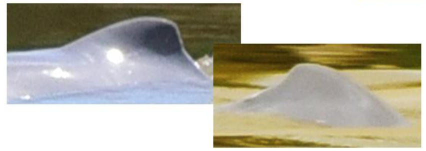
23	22	21	20	19	18	17	16	15	14	13	12	10	7	5	99-02
														25	24

ilham

23	22	21	20	19	18	17	16	15	14	13	12	10	7	5	99-02
														25	24

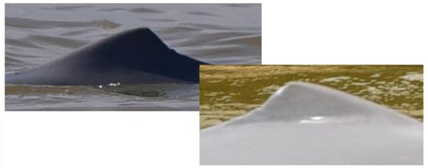
linda

23	22	21	20	19	18	17	16	15	14	13	12	10	7	5	99-02
														25	24



setia

23	22	21	20	19	18	17	16	15	14	13	12	10	7	5	99-02
														25	24



sakira

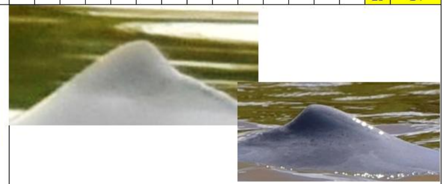
23	22	21	20	19	18	17	16	15	14	13	12	10	7	5	99-02
														25	24

dea

23	22	21	20	19	18	17	16	15	14	13	12	10	7	5	99-02
														25	24

luna

23	22	21	20	19	18	17	16	15	14	13	12	10	7	5	99-02
														25	24

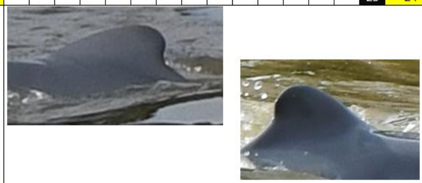


jannah

23	22	21	20	19	18	17	16	15	14	13	12	10	7	5	99-02
														25	24

upin (anak jannah 23/7/22)

23	22	21	20	19	18	17	16	15	14	13	12	10	7	5	99-02
														25	24



novi

23	22	21	20	19	18	17	16	15	14	13	12	10	7	5	99-02
														25	24

kanci

23	22	21	20	19	18	17	16	15	14	13	12	10	7	5	99-02
														25	24

janski (anak jannah-lahir nov 23)

23	22	21	20	19	18	17	16	15	14	13	12	10	7	5	99-02
														25	24

ocha

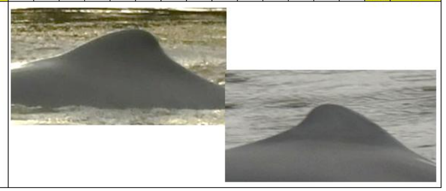
23	22	21	20	19	18	17	16	15	14	13	12	10	7	5	99-02
														25	24

hera

23	22	21	20	19	18	17	16	15	14	13	12	10	7	5	99-02
														25	24

sipong (anak edi march24)

23	22	21	20	19	18	17	16	15	14	13	12	10	7	5	99-02
														25	24

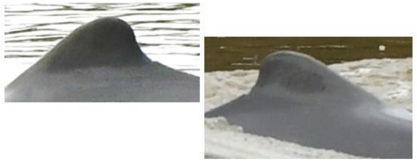


emi (anak belle)-Maret 23

23	22	21	20	19	18	17	16	15	14	13	12	10	7	5	99-02
														25	24

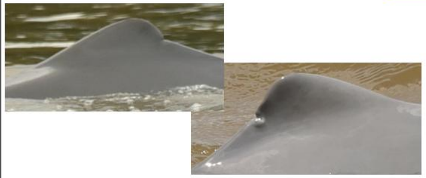
toto

23	22	21	20	19	18	17	16	15	14	13	12	10	7	5	99-02
														25	24



jeli

23	22	21	20	19	18	17	16	15	14	13	12	10	7	5	99-02
															24



vito

23	22	21	20	19	18	17	16	15	14	13	12	10	7	5	99-02
															24

Mira (anak jeli lahir okt 2025)

23	22	21	20	19	18	17	16	15	14	13	12	10	7	5	99-02
														25	24

Inge (anak nadila lahir okt 2025)

23	22	21	20	19	18	17	16	15	14	13	12	10	7	5	99-02
														25	24

Hanif (anak sakira lahir okt 2025)

23	22	21	20	19	18	17	16	15	14	13	12	10	7	5	99-02
														25	24

Fin (anak mutia lahir jan-feb 2025)

23	22	21	20	19	18	17	16	15	14	13	12	10	7	5	99-02
														25	24

romi

23	22	21	20	19	18	17	16	15	14	13	12	10	7	5	99-02
														25	24

dikin

23	22	21	20	19	18	17	16	15	14	13	12	10	7	5	99-02
														25	24

sorang (anak- lahir akhir april-awal mai25)

23	22	21	20	19	18	17	16	15	14	13	12	10	7	5	99-02
														25	24

(orange)	belum periksa
(black)	mati
(grey)	kemungkingan besar mati
*	Hanya individu yang ditemukan antara tahun 2020-2025 dimasukin dalam tabel dengan sejarah observasi sebelumnya; tahun 1999-2002 belum dilakukan analisa karena belum selesai discan semua slide (non-digital format)

Appendix 4. In-situ water quality results from three surveys conducted in 2025

Periode sampling (bulan-tahun)	Kondisi air H=High; M=medium;L=low	Stasiun sampling (WT=random sampling; PM = lokasi pesut)	Nama areal disusun dari hilir ke hulu	Tipe habitat	DO- mg/l	pH	EC-µS,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					
Lokasi random sampling													
Apr-25	H	WT 7	Hilir tunjungan	anak sungai	3,7	5,9	72	35	125	43	17,9	0,8	28,2
Apr-25	H	WT 13	Muara pela	anak sungai									
Apr-25	H	WT 6	Muara Sabintulung	anak sungai	4,2	5,9	84	46	119	37	16	1,0	28,4
Apr-25	H	WT 5	Kedang Rantau	anak sungai	4,1	6,0	62	34	117	33	14,8	2,0	28,5
Apr-25	H	WS 4	konveyor Muara Kama Ilir	sungai	5,2	6,5	52	26	393	23	14,3	5,0	27
Apr-25	H	WT8	Muara Kedang Kepala	anak sungai	6,1	6,4	76	47	139	19	12,9	4,9	27,4
Apr-25	H	WT10	Hilir Bukit jering	sungai	4,4	6,6	86	42	330	19	19,4	4,3	27,9
Apr-25	H	WS 5	Sabintulung	anak sungai	4,5	6,0	122	55	454	53	23,3	1,3	28
Apr-25	H	WT 14	sangkuliman	anak sungai	4,3	5,6	24	11	128	54	13,2	28,6	2,1
Apr-25	H	WT 9	Muara Siran	anak sungai	4,7	6,5	68	32	150	15	11,7	3,8	28,5
Apr-25	H	WT 15	pela	anak sungai		5,5	22	9		83	10,6	2,1	30,3
Apr-25	H	WT 12	Hilir Muhuran	anak sungai	4,7	6,7	80	44	127	20	11,8	4,4	28,9
Apr-25	H	WT 11 / PM 2	Muara sungai belayan	anak sungai	4,9	6,3	56	29	467	19	14,2	2,4	28,5
Apr-25	H	WT 16	Tanjung Halat	anak sungai	6,0	7,7	46	22		61	5,7	0,8	37,4
Apr-25	H	WT 20	Hilir muara wis	sungai			32	17	262	17	21	4,9	77
Apr-25	H	WT 21	Hulu sebemban	sungai	5,0	6,8	70	31	235	24	19	3,9	26,0
Apr-25	H	WT 30	Sungai bolowan	anak sungai	4,9	5,9	60	30	42	21	8,6	0,8	26,9
Apr-25	H	WT 32	Hilir gunung bayan	anak sungai	5,0	6,2	55	28	68	28	10,8	3,1	27,5
Apr-25	H	WT 32b	Muara Jelau	anak sungai	5,6	5,7	54	27	95	21	11,4	3,4	26,9
Apr-25	H	WT 29	Hilir Muara Pahu	anak sungai	5,4	6,2	82	40	94	17	11,2	1,3	26,8
Apr-25	H	WT 33	Kampung Baru, Kubar	sungai	5,2	6,4	58	27	270	27	14,5	3,3	25
Apr-25	H	WT 28	Muara pahu	sungai	5,0	6,0	60	28	278	22	16,1	5,6	26,4
Apr-25	H	WT 22	Muara muntai ilir	sungai utama			30	15	230	18	21	4,1	26,8
Apr-25	H	WT 27	hilir tanjung haur	sungai utama	5,6	7,1	62	31	226	20	17,8	3,6	27,8
Apr-25	H	WT 26	batuq	sungai utama	4,4	7,0	76	37	214	16	20,5	4,8	27,9
Apr-25	H	WT 24	Tanjung Harapan	sungai utama		6,8	40	20	230	18	13,8	4,5	26,9
Apr-25	H	WT 25	muara muntai hulu	sungai utama	4,8	7,0	52	25	159	22	10,5	2,4	27,9
Apr-25	H	WT 23	batu bumbun	anak sungai	4,7	7,0	62	28	170	54	7,3	1,7	28,4
Nilai rata-rata random sampling April 2025					**4,9**	**6,4**	**60,9**	**30,2**	**204,9**	**29,8**	**14,4**	**4,0**	**28,9**
Kualitas air di lokasi Pesut													
Apr-25	H	PM1	Muara Pela	anak sungai	5,2	6,1	128	60	258	18	22,7		28
Apr-25	H	PM2	Muara Belayan	anak sungai	4,9	6,3	56	29	467	19	14,2	2,4	28,5
Apr-25	H	PM3	Muara Pela	anak sungai	5,8	7,1	50	25	142	77	7	1,8	32,1
Apr-25	H	PM4	Muara pela	anak sungai	5,2	7,1	18	9	146	75	7,9	1,8	28
Apr-25	H	PM5	Muara pela	anak sungai	5,2	7,1	18	9	159	7	16,4	1,3	28
Apr-25	H	PM6	Muara pela	anak sungai			20	9	128	56	8,5	0,9	29,4
Apr-25	H	PM7	Pela - Danau Semayang	anak sungai		5,7	28	14	lake	91	4,8	0	29,9
Apr-25	H	PM8	Pela	anak sungai		5,7	28	14		91	19,6	0	29,9
Nilai rata-rata sampling di lokasi pesut April 2025					**5,3**	**6,4**	**43,3**	**21,1**	**216,7**	**54,3**	**12,6**	**1,2**	**29,2**

Periode sampling (bulan-tahun)	Kondisi air H=High; M=medium;L=low	Stasiun sampling (WT=random sampling; PM = lokasi pesut)	Nama areal disusun dari hilir ke hulu	Tipe habitat	DO- mg/l	pH	EC-µS,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					
Lokasi random sampling													
Jul-25	M	WS 5	Sungai Sabintulung	anak sungai	3,1	5,2	78	39	77	57	8,2	0	28,6
Jul-25	M	WT 7	Hilir tunjungan	anak sungai	3,6	5,8	56	25	81	52	15,8	0,8	28,9
Jul-25	M	WT 6	Muara Sabintulung	anak sungai	3,7	5,6	80	40	176	41	20,1	1,1	28,5
Jul-25	M	WT 5	Kedang Rantau	anak sungai	3,5	5,3	52	27	100	43	16,7	0,0	29,9
Jul-25	M	WS 4	konveyor Muara Kama Ilir	sungai	4,2	5,7	58	28	419	21	11,8	2,4	28,5
Jul-25	M	WT8	Muara Kedang Kepala	anak sungai	3,0	6,9	60	30	141	26	8,5	2,6	28,4
Jul-25	M	WT10	Hilir Bukit jering	sungai	3,4	6,4	50	23	311	26	15,6	2,6	27,5
Jul-25	M	WT 14	sangkuliman	anak sungai	5,4	6,4	20	11	130	51	11,1	1,7	29,4
Jul-25	M	WT 9	Muara Siran	anak sungai	4,5	6,6	70	35	116	27	13,2	2,5	26,7
Jul-25	M	WT 13	Muara pela	anak sungai	5,4	7,0	20	10	300	53	16,3	2,5	30,9
Jul-25	M	WT 15	Muara Semayang	anak sungai	4,9	6,6	14	8	419	53	7,6	0	30,4
Jul-25	M	WT 12	Hilir Muhuran	anak sungai	3,4	7,4	62	31	111	19	8,3	3,7	26,6
Jul-25	M	WT 11	Muara sungai belayan	anak sungai	4,0	7,2	78	39	523	22	21	4,5	27
Jul-25	M	WT 16	Tanjung Halat	anak sungai	4,3	6,7	24	12		48	4,1	0	29
Jul-25	M	WT 20	Hilir muara wis	sungai	5,3	7,1	44	22	238	28	13,9	3,4	28,6
Jul-25	M	WT 21	Hulu sebemban	sungai	5,3	7,3	50	24	228	38	16,8	2,3	27,9
Jul-25	M	WT 30	Sungai bolowan	anak sungai	4,5	5,5	62	30	48	23	5,1	0	27,4
Jul-25	M	WT 32	Hilir gunung bayan	anak sungai	5,2	7,5	55	27	80	17	9,5	3	26,5
Jul-25	M	WT 29	Hulu Tanjung Laong	anak sungai	5,4	7,7	60	30	133	17	8,2	1,5	26
Jul-25	M	WT 33	Kampung Baru, Kubar	sungai	4,9	7,0	26	13	218	27	14	3,5	25,9
Jul-25	M	WT 36	Muara (Sungai Kelumpang	sungai	5,3	7,3	42	21	320	34	10,2	3,8	26,0
Jul-25	M	WT 28	Muara pahu	sungai	5,3	6,5	48	24	225	28	21,2	2,4	27,4
Jul-25	M	WT 22	Muara muntai ilir	sungai utama	5,3	7,3	50	24	27,9	228	38	16,8	2,3
Jul-25	M	WT 27	hilir tanjung haur	sungai utama	5,0	5,9	46	23	217	30	16,5	4,3	27,5
Jul-25	M	WT 26	batuq	sungai utama	4,9	7,8	54	26	230	37	17,1	4,3	27,5
Jul-25	M	WT 24	Tanjung Harapan	sungai utama	5,6	6,2	44	22	195	32	11,2	1,6	28,4
Jul-25	M	WT 25	muara muntai hulu	sungai utama	5,1	7,8	40	21	140	35	8,1	1,8	
Jul-25	M	WT 23	batu bumbun	anak sungai	3,5	7,5	52	26	150	39	5,3	0	28,3
Nilai rata-rata random sampling Juli 2025					**4,5**	**6,7**	**49,8**	**24,7**	**198,3**	**41,1**	**13,3**	**2,6**	**27,0**
Kualitas air di lokasi Pesut													
Jul-25	M	PM1	Liang ilir - Kota Bangun	anak sungai	3,3	6,3	46	23	310	32	11,4	2,7	27,6
Jul-25	M	PM2	Sungai Mahakam	anak sungai									
Jul-25	M	PM3	Kota Bangun Ilir	anak sungai	3,8	7,6	44	23	324	22	14,8	1,7	27,5
Jul-25	M	PM4	Kota Bangun Ilir	anak sungai	3,8	7,6	44	23	324	22	14,8	1,7	27,5
Jul-25	M	PM5	Kuyung	anak sungai	3,9	7,7		24		33	23	4,5	26,6
Jul-25	M	PM6	Loah Deras	anak sungai	5,0	6,4	46	23	350	29	25	3,9	27,5
Jul-25	M	PM7	Muara Muntai Ulu	anak sungai	5,0	6,5	46	25	242	31	24,5	2,8	27,5
Jul-25	M	PM8	Kota Bangun	anak sungai									
Jul-25	M	PM9	Muara Pela	anak sungai	5,0	6,8	24	11	155,6	47	6,5	1,9	30,5
Nilai rata-rata sampling di lokasi pesut Juli 2025					**4,2**	**7,0**	**41,7**	**21,7**	**284,3**	**30,9**	**17,1**	**2,7**	**27,8**

Periode sampling (bulan-tahun)	Kondisi air H=High; M=medium;L=low	Stasiun sampling (WT=random sampling; PM = lokasi pesut)	Nama areal disusun dari hilir ke hulu	Tipe habitat	DO- mg/l	pH	EC-µS,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					
Lokasi random sampling													
Nov-25	L-M	WS 5	Sungai Sabintulung	anak sungai	4,4	5,3	73	36	57	32	7	1,4	27,7
Nov-25	L-M	WT 7	Hilir tunjungan	anak sungai	4,7	6,1	47	24	82	39	14,4	2,1	28
Nov-25	L-M	WT 6	Muara Sabintulung	anak sungai	5,2	5,9	55	27	125	38	12,9	2,1	27,7
Nov-25	L-M	WT 5	Kedang Rantau	anak sungai	5,4	5,7	55	28	115	37	18,7	1,0	28,8
Nov-25	L-M	WS 4	konveyor Muara Kama Ilir	sungai	6,1	6,4	47	23	396	32	9,2	2,1	27,9
Nov-25	L-M	WT8	Muara Kedang Kepala	anak sungai	6,4	6,7	67	33	138	32	8,9	1,5	28,1
Nov-25	L-M	WT10	Hilir Bukit jering	sungai	5,4	6,6	64	32	324	29	15,2	2,4	28,9
Nov-25	L-M	WT4	Sabintulung										
Nov-25	L-M	WT 14	sangkuliman	anak sungai	5,2	6,2	37	19	105	29	10,3	2,7	27,9
Nov-25	L-M	WT 9	Muara Siran	anak sungai	4,4	6,9	72	36	124	24	9,5	1,8	29,7
Nov-25	L-M	WT 13	Muara pela	anak sungai	4,2	6,3	44	22	-	23	18,7	1,4	27,9
Nov-25	L-M	WT 15	Muara Semayang	anak sungai	4,9	6,4	24	12	150	28	69	2,5	27,9
Nov-25	L-M	WT 12	Hilir Muhuran	anak sungai	5,4	6,5	45	23	126	13	11,3	2,5	27,4
Nov-25	L-M	WT 11	Muara sungai belayan	anak sungai	5,6	6,5	45	22	488	14	8,6	3,7	27,5
Nov-25	L-M	WT 16	Tanjung Halat	anak sungai	4,5	6,6	25	12	-	32	2,7	1,8	27,5
Nov-25	L-M	WT 20	Hilir muara wis	sungai	5,3	6,4	44	22	133	23	18	3,7	28,8
Nov-25	L-M	WT 21	Hulu sebemban	sungai	5,0	6,4	46	23	216	24	16,8	4,3	28,3
Nov-25	L-M	WT 30	Sungai bolowan	anak sungai	5,4	5,6	26	13	42	38	4,5	0	31,5
Nov-25	L-M	WT 32	Hilir gunung bayan	anak sungai	4,6	6,1	65	32	79	19	7,2	2,6	27,6
Nov-25	L-M	WT 29	Hilir Muara Pahu	anak sungai	4,9	6,1	60	31	89	25	5,7	3,2	27,7
Nov-25	L-M	WT 33	Kampung Baru, Kubar	sungai	5,0	6,6	40	20	216	31	9,8	1,2	27,5
Nov-25	L-M	WT 28	Muara pahu	sungai	4,5	6,6	43	22	273	33	10,1	3,2	26,9
Nov-25	L-M	WT 22	Muara muntai ilir	sungai utama	4,6	6,5	43	22	230	34	21,5	2	27,5
Nov-25	L-M	WT 27	hilir tanjung haur	sungai utama	5,2	6,5	46	23	216	32	20,4	2	27,8
Nov-25	L-M	WT 26	Batuq	sungai utama	4,9	6,6	42	21	239	31	13,5	1	27,7
Nov-25	L-M	WT 24	Tanjung Harapan	sungai utama	5,0	6,4	43	22	232	34	7,8	1,4	27,6
Nov-25	L-M	WT 25	muara muntai hulu	sungai utama	4,7	6,5	43	21	11	32	12	2,6	27,4
Nov-25	L-M	WT 23	Batu Bumbun	anak sungai	4,8	6,0	55	27	103	21	8,7	1,6	27,7
Nilai rata-rata random sampling November 2025					**5,0**	**6,3**	**48,0**	**24,0**	**172,4**	**28,9**	**13,8**	**2,1**	**28,0**
Kualitas air di lokasi Pesut													
Nov-25	L-M	PM1	Muara Pela	anak sungai									
Nov-25	L-M	PM2	Liang	sungai utama	5,5	6,6	31	16	153	24	10,6	1,1	27,3
Nov-25	L-M	PM3	Sungai Pela	anak sungai	5,7	6,4	28	14	117	32	10,6	2,1	28,4
Nov-25	L-M	PM4	Muara Wis	sungai utama	4,7	6,4	45	22	224	35	17,4	4,6	28,6
Nov-25	L-M	PM5	Kota Bangun Ulu	sungai utama									
Nov-25	L-M	PM6	Muara Pela	anak sungai	4,2	6,3	44	22	-	23	18,7	1,4	27,9
Nov-25	L-M	PM7	Muara Pela	anak sungai									
Nilai rata-rata sampling di lokasi pesut November 2025					**5,0**	**6,4**	**37,0**	**18,5**	**164,7**	**28,5**	**14,3**	**2,3**	**28,1**

Appendix 5. Laboratory water quality analysis results from three surveys conducted in 2025

Periode sampling (bulan-tahun)	Kondisi air H=High; M=medium; L=low	Stasiun Sampling	Nama Areal	Nama Sungai	TSS	COD	NH3-N	Kad-mium (Cd)	Temba-ga (Cu)	Timbal (Pb) mg/l	Mangan (Mn) mg/l	Besi (Fe) mg/l	Pottasium (K)	jumlah ind. Plankton / liter	jumlah taksa plankton	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)-PP-RI No. 22, 2021 Lampiran VI, Kelas 2					<50	<25	0,2 tapi lebih baik <0.02	<0,01	<0,02	<0,03	0,4 (danau) (0,073 - sungai Australia)	0,3*						
Survei air tinggi- April 2025																		
Apr-25	H	WS 4	Konveyor ilir M. K. Kepala	sungai utama	32	28	0,13	0,089	0,036	<0,016	0,11	1,6	8	1449	11	2,33	0,97	0,1
Apr-25	H	WS 5	Sungai Sabintulung	anak sungai	13	78	<0,036	0,092	0,033	<0,016	0,15	2,1	17	1701	15	2,61	0,96	0,08
Apr-25	H	WT 6	Muara Sabintulung	anak sungai	11	60	0,07	0,101	<0,014	<0,016	0,028	1,8	14	1197	11	2,26	0,94	0,12
Apr-25	H	WT 9	Muara Siran	anak sungai	52	30	0,08	0,082	<0,014	<0,016	0,016	1,9	9	2205	15	2,52	0,93	0,1
Apr-25	H	WT10	Hilir Bukit jering	sungai utama	76	38	0,05	<0,008	<0,014	<0,016	<0,009	1,4	8	2898	18	2,75	0,95	0,07
Apr-25	H	WT 12	Hilir Muhuran	anak sungai	41	36	<0,036	0,099	0,016	<0,016	0,011	1,8	8	1827	14	2,43	0,92	0,11
Apr-25	H	WT 14	Sangkuliman	anak sungai	10	31	0,07	0,112	0,034	<0,016	0,02	1,1	8	2520	19	2,77	0,94	0,08
Apr-25	H	WT 16	Tanjung Halat	anak sungai	5	25	0,07	0,103	0,029	<0,016	0,013	1,2	7	3024	13	2,24	0,87	0,14
Apr-25	H	WT 21	Hulu sebemban	sungai utama	17	21	0,07	0,086	0,018	<0,016	<0,009	1,2	7	1701	17	2,69	0,95	0,08
Apr-25	H	WT 23	Batu bumbun	anak sungai	3	39	0,16	0,084	0,023	<0,016	0,289	1,9	7	2961	14	2,4	0,91	0,12
Apr-25	H	WT 26	Batuq	sungai utama	21	38	0,07	0,079	0,014	<0,016	0,289	1,5	8	2079	16	2,65	0,96	0,08
Apr-25	H	WT 30	Sungai bolowan	anak sungai	5	27	0,07	<0,008	<0,014	<0,016	0,023	2,1	7	1575	13	2,42	0,94	0,1
Apr-25	H	WT 32	Hilir gunung bayan	anak sungai	23	32	0,08	0,081	<0,014	<0,016	<0,009	2,3	9	1638	13	2,41	0,94	0,1
Apr-25	H	WT 33	Kampung Baru, Kubar	sungai utama	55	34	<0,036	0,096	0,026	<0,016	<0,009	0,9	8	2457	16	2,58	0,93	0,09
Survei air sedang- Juli 2025																		
Jul-25	M	WS 4	Konveyor ilir M. K. Kepala	sungai utama	83	30,4	<0,036	<0,008	<0,014	<0,016	<0,015	1,2		3402	14	2,41	0,91	0,11
Jul-25	M	WS 5	Sungai Sabintulung	anak sungai	16	84,5	0,12	<0,008	<0,014	<0,016	<0,015	2,7		5544	17	2,23	0,79	0,17
Jul-25	M	WT 6	Muara Sabintulung	anak sungai	9	38,6	0,12	<0,008	<0,014	<0,016	0,027	1,9		3843	19	2,75	0,93	0,08
Jul-25	M	WT 7	hilir Tunjungan	anak sungai				<0,008	<0,014									
Jul-25	M	WT 9	Muara Siran	anak sungai	67	22,2	<0,036	<0,008	<0,014	<0,016	0,034	1,4		4221	17	2,64	0,93	0,08
Jul-25	M	WT10	Hilir Bukit jering	sungai utama	15	24,4	<0,036	<0,008	<0,014	<0,016	<0,015	1,2		4095	16	2,2	0,79	0,16
Jul-25	M	WT 12	Hilir Muhuran	anak sungai	344	33,6	<0,036	<0,008	<0,014	<0,016	<0,015	1,5		3654	18	2,73	0,94	0,08
Jul-25	M	WT 14	Sangkuliman	anak sungai	7	29,4	<0,036	<0,008	<0,014	<0,016	<0,015	2,1		4977	24	3,01	0,95	0,06
Jul-25	M	WT 16	Tanjung Halat	danau	2	31,2	<0,036	<0,008	<0,014	<0,016	<0,015	2,1		5040	18	2,54	0,88	0,1
Jul-25	M	WT 21	Hulu sebemban	sungai utama	64	17,6	<0,036	<0,008	<0,014	<0,016	<0,015	1,3		2457	15	2,51	0,93	0,1
Jul-25	M	WT 23	Batu bumbun	anak sungai	11	26,2	0,09	<0,008	<0,014	<0,016	<0,015	2,3		7686	21	2,32	0,76	0,19
Jul-25	M	WT 26	Batuq	sungai utama	45	14,4	<0,036	<0,008	<0,014	<0,016	<0,015	0,4		4284	20	2,76	0,92	0,08
Jul-25	M	WT 30	Sungai bolowan	anak sungai	34	47,6	<0,036	<0,008	<0,014	<0,016	<0,015	2,1		1512	11	2,24	0,94	0,12
Jul-25	M	WT 32	Hilir gunung bayan	anak sungai	60	21,2	0,05	<0,008	<0,014	<0,016	<0,015	2,2		1953	12	2,38	0,96	0,1
Jul-25	M	WT 33	Kampung Baru, Kubar	sungai utama	44	20,4	<0,036	<0,008	<0,014	<0,016	<0,015	2,2		3087	17	2,69	0,95	0,08
Jul-25	M	WT 36	Muara (Sungai Kelumpang - N	sungai utama				<0,008	<0,014									

Survei air rendah-sedang- November 2025

Periode sampling (bulan-tahun)	Kondisi air H=High; M=medium; L=low	Stasiun Sampling	Nama Areal	Nama Sungai	TSS	COD	NH3-N	Kad-mium (Cd)	Temba-ga (Cu)	Timbal (Pb) mg/l	Mangan (Mn) mg/l	Besi (Fe) mg/l	Pottasium (K)	jumlah ind. Plankton / liter	jumlah taksa plankton	indeks keanekaragaman plankton (H): 1-3 sedang-bagus; <1 kurang	indeks keseragaman plankton (E): 0-1: rendah-tinggi	indeks dominan plankton (D): 0-1: rendah-tinggi
Baku mutu (mg/l)-PP-RI No. 22, 2021 Lampiran VI, Kelas 2					<50	<25	0,2 tapi lebih baik <0.02	<0,01	<0,02	<0,03	0,4 (danau) (0,073 - sungai Australia)	0,3*						
Nov-25	L-M	WS 4	Konveyor ilir M. K. Kepala	sungai utama	30	10,7	<0,036	<0,008	<0,014	0,031	<0,01	2,3		9009	22	2,15	0,69	0,24
Nov-25	L-M	WS 5	Sungai Sabintulung	anak sungai	38	52,2	0,16	<0,008	<0,014	0,019	0,09	3,7		1890	14	2,55	0,97	0,08
Nov-25	L-M	WT 6	Muara Sabintulung	anak sungai	31	46,0	0,25	<0,008	<0,014	0,032	0,052	2,4		5355	25	2,91	0,90	0,07
Nov-25	L-M	WT 7	hilir Tunjungan	anak sungai	8	34,5	0,24	<0,008	<0,014	<0,016	0,04	2,6		2331	18	2,82	0,98	0,06
Nov-25	L-M	WT 9	Muara Siran	anak sungai	21	17,7	<0,036	<0,008	<0,014	<0,016	<0,01	1,4		2709	16	2,68	0,97	0,08
Nov-25	L-M	WT10	Hilir Bukit jering	sungai utama	33	24,8	<0,0036	<0,008	<0,014	0,019	<0,01	1,4		3024	11	1,74	0,73	0,28
Nov-25	L-M	WT 12	Hilir Muhuran	anak sungai	36	16,4	0,13	<0,008	<0,014	<0,016	0,038	4,3		2397	13	2,40	0,93	0,11
Nov-25	L-M	WT 14	Sangkuliman	anak sungai	26	15,9	0,15	<0,008	<0,014	<0,016	<0,01	2,0		9327	14	1,92	0,73	0,22
Nov-25	L-M	WT 16	Tanjung Halat	danau	21	32,8	0,05	<0,008	<0,014	<0,016	<0,01	2,5		4725	9	1,57	0,72	0,29
Nov-25	L-M	WT 21	Hulu sebemban	sungai utama	19	19,5	0,05	<0,008	<0,014	<0,016	<0,01	1,6		2079	8	1,88	0,90	0,18
Nov-25	L-M	WT 23	Batu bumbun	anak sungai	26	34,9	0,07	<0,008	<0,014	<0,016	0,053	1,2		5544	12	1,74	0,70	0,28
Nov-25	L-M	WT 26	Batuq	sungai utama	20	12,4	0,05	<0,008	<0,014	<0,016	<0,01	1,8		3843	11	1,91	0,80	0,22
Nov-25	L-M	WT 30	Sungai bolowan	anak sungai	18	33,6	0,28	<0,008	<0,014	<0,016	<0,01	4,7		3465	14	2,46	0,93	0,10
Nov-25	L-M	WT 32	Hilir gunung bayan	anak sungai	36	29,7	0,04	<0,008	<0,014	<0,016	0,125	0,9		2772	15	2,55	0,94	0,09
Nov-25	L-M	WT 33	Kampung Baru, Kubar	sungai utama	20	10,7	0,10	<0,008	<0,014	<0,016	<0,01	0,2		2079	12	2,25	0,91	0,13

*Nilai ambang batas yang dianggap secara internasional untuk biota akuatik di sungai-sungai Brasil (Viana et al., 2021), tetapi hanya ditetapkan sebagai WQC di Indonesia untuk perairan kelas I; Catatan: > 1 dianggap tinggi. # Nilai pedoman internasional untuk melindungi 99% biota air tawar tropis di Australia (tidak ditetapkan sebagai WQC di Indonesia) (Harford et al., 2015), sementara 0,033 mg/L disarankan sebagai pedoman ambang batas untuk sungai dengan keasaman alami yang lebih tinggi, seperti anak sungai yang terhubung dengan rawa dan danau.