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Mortality Records of the Irrawaddy Dolphin *Orcaella brevirostris* (Artiodactyla: Delphinidae) in Sumatra and Java

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Abstract
Indonesia is a global biodiversity hotspot, yet aquatic mammals remain understudied, particularly in coastal and estuarine ecosystems. The Irrawaddy Dolphin *Orcaella brevirostris* inhabits these environments and is highly exposed to anthropogenic pressures. This study compiles mortality records of *O. brevirostris* in Sumatra and Java using published papers, media reports and citizen science data. A total of 24 records (2011–2025) were documented, with most concentrated along the eastern coast of Sumatra. Of the 24 documented mortality records of *O. brevirostris* in Sumatra and Java (2011–2025), unknown causes accounted for the majority of deaths (14 records, 58.3%). Fishing gear entanglement was the second most common cause (7 records, 29.2%), representing the primary identified anthropogenic threat. The remaining mortalities were each attributed to suspected poaching, strong monsoon currents, and extreme weather (1 record each, 4.2%). Reported body lengths ranged from 90 to 225 cm and weights from 80 to 150 kg. Both juvenile and adult individuals were affected, with adult mortality raising concerns for population viability. These findings highlight critical risk zones and the need for improved monitoring and conservation measures.

Keywords: coastal ecosystems, Endangered, Indonesia, Irrawaddy Dolphin, *Orcaella brevirostris*.

Introduction

Indonesia is widely recognized as one of the world's biodiversity hotspots, encompassing an extraordinary range of ecosystems and life forms, from microscopic organisms and diverse insect communities to large terrestrial and marine mammals (IBSAP 2016, 2024). Its tropical forests, freshwater systems, mangroves and expansive marine ecosystems sustain exceptional biodiversity and high levels of endemism (Rachman *et al.* 2024; Arifah *et al.* 2025: Iqbal *et al.* 2026). This biological richness extends across an extraordinary spectrum of life, from microscopic organisms, fungi, and plants to small insects and large, complex animals (Ali *et al.* 2024; Aprillia *et al*. 2025; Widayanti *et al*. 2025).

Despite this remarkable diversity, research and conservation efforts in Indonesia have historically been uneven, and only a limited number of new species records have been documented from the country (Windusari *et al.* 2019; Syah & Iqbal 2025). Scientific and conservation priorities have largely centered on terrestrial ecosystems and charismatic megafauna, including elephants, tigers, and primates, resulting in a disproportionate lack of research on aquatic organisms, especially aquatic mammals (Rudolph *et al.* 1997; Kreb & Budiono 2005a; Kreb *et al.* 2015, Daniel *et al*, 2025). This imbalance has resulted in limited baseline data and reduced visibility of conservation issues affecting marine mammal species inhabiting coastal environments (Sahri *et al.* 2020, 2021). Among Indonesia's

aquatic mammals, the Irrawaddy Dolphin *Orcaella brevirostris* is a distinctive and ecologically significant species inhabiting coastal, estuarine, and riverine environments (Stacey & Arnold 1999; Kreb 2004a, b; Wang *et al.* 2014; Kreb *et al.* 2020).

Most documented populations of *O. brevirostris* occur in coastal and estuarine habitats, with an estimated global abundance of approximately 6,975 individuals, including more than 5,000 in Bangladesh. In contrast, riverine populations in the Mahakam, Mekong, Ayeyarwady, and Sesayap rivers are small (<100 individuals), geographically isolated, and highly vulnerable to anthropogenic pressures, habitat degradation, and local extinction (Minton *et al.* 2017). Reflecting these threats, the Indonesian Cetacean Conservation Action Plan (2026–2029) identifies the Mahakam population as a national conservation priority and emphasizes habitat protection, threat mitigation, research and monitoring, stranding response, and stakeholder engagement (Menteri Kelautan dan Perikanan, 2026). Its occurrence within these transitional ecosystems places it in close proximity to human activities, thereby increasing its vulnerability to anthropogenic pressures (Kreb & Budiono 2005b; Kreb *et al.* 2020).

Despite its importance, information on its population dynamics, distribution, and mortality patterns in Indonesian waters, particularly in Sumatra and Java, remains limited (Minton *et al.* 2017; Khalifa *et al.* 2014). The present review was intentionally restricted to Sumatra and Java, where mortality records remin scattered and have not previously been synthesized in a single study. Although important freshwater and coastal populations of *O. brevirostris* occur in Kalimantan and mortality event have been documented there (e.g., Kreb *et al.* 2020), their inclusion would require a separate systematic assessment to avoid introducing geographic and ecological biases into regional mortality analyses.

Methods

Study Area

This study focuses on coastal, estuarine, and riverine regions of Sumatra and Java, Indonesia, where *O. brevirostris* occurrences have been reported (Rudolph *et al.* 1997; Stacey & Arnold 1999; Kreb *et al.* 2004b; Khalifa *et al.* 2014). Sumatra, the westernmost major island of Indonesia, is a large equatorial landmass known for its extensive tropical ecosystems and high biodiversity, whereas Java, located to the south of Sumatra, is smaller in size but serves as the country's most populous and socioeconomically central island (Whitten *et al.* 1996, 2000). In coastal habitats, *O. brevirostris* exhibit a preference for shallow waters (2–9 m depth), with the highest occurrence recorded at sea surface temperatures of 29–31°C. They are found across a broad salinity range (0.27–27.42 ppt), indicating tolerance to both freshwater and brackish conditions. Occurrences are most frequent at distances of 1.5–4.4 km from the coastline, suggesting a preference for nearshore and estuarine environments (Mahmud *et al.* 2018). The coastal areas included in this study are predominantly shallow, productive waters associated with estuaries, river mouths, mangrove forest, tidal creeks and sheltered bays. These environments are generally characterized by low salinity gradients, high sedimen loads and strong influences from freshwater discharge, creating suitable habitats for *O. brevirostris* (Stacey & Arnold 1999; Kreb 2004a). Most mortality records were reported from nearshore waters and estuarine systems where dolphin habitats overlap extensively with human activities, including fisheries, shipping, coastal settlement and industrial development. These areas include both natural habitats and human-influenced environments characterized by fisheries activities, coastal settlements, and industrial development (Whitten *et al.* 1996, 2000).

Data Collection

Mortality records of *O. brevirostris* were compiled from publicly available sources, including published papers, online media reports, news articles, social media platforms and citizen science contributions. Searches were conducted using relevant keywords in both Bahasa Indonesia and English (e.g., "*pesut*", "*Irrawaddy Dolphin*", "*terdampar*", "*stranding*", "*lumba-lumba mati*" and "*dead dolphin*") to identify reported incidents in Sumatra and Java. The data collection period covered all accessible records up to 2011 to 2025. Mustika *et al.* (2022) provided a synthesis of historical stranding records of *O. brevirostris* in Indonesia between 1995 and 2021, including Sumatra and Java. These records were revisited and combined with newly acquired information. Each record was screened to ensure relevance to *O. brevirostris* and to confirm that the event occurred within the defined study area.

Data Verification and Inclusion Criteria

To improve data reliability, only records supported by photographic evidence or detailed descriptions were included. Species identification was verified based on visible morphological characteristics, such as body shape, dorsal fin structure, and head profile, following established field identification guides (Jefferson *et al*. 1993; Kinze 2001; Wang *et al*. 2014). Based on our review conducted for this study, *O. brevirostris* may be misidentified as other cetaceans occurring in the region, including the Finless Porpoise *Neophocaena phocaenoides*, False Killer Whale *Pseudorca crassidens*, and Risso's Dolphin *Grampus griseus*, as well as the Dugong *Dugong dugon*. This species also commonly overlaps in habitat with the Humpback Dolphin *Sousa chinensis*, but it can be readily distinguished by its distinct morphological characteristics, particularly when the snout shape is clearly visible. This species also usually overlaps with the habitat of *S. chinensis*, but the morphological character is significant different, particularly when the beak pattern is clearly seen.

Reports lacking sufficient information or with uncertain species identification were excluded from the analysis. Gibson *et al.* (2020) highlighted that data collection via social media can serve as a cost-effective and scientifically valuable tool for the photo-identification of coastal cetaceans. This approach is particularly recommended for studies on low-density and wide-ranging coastal cetacean populations. Duplicate records from multiple sources were cross-checked and consolidated into single entries. When available, additional information was extracted by comparing multiple reports describing the same event. For each confirmed mortality record, the following variables were documented: date of occurrence, location (name of river or village, district, and province), habitat type (coastal, estuarine, riverine), condition of the animal (*e.g.*, fresh carcass, decomposed, skeletal remains), evidence of cause of death (*e.g.*, entanglement, pollution, disease, hunting, unknown), and source of information (media, citizen report, or both).

The analytical approach and classification of mortality causes in this study follow established frameworks commonly applied in cetacean stranding research.

Results and Discussion

Mortality Records Overview

A total of 24 mortality records of *O. brevirostris* were documented across Sumatra and Java between 2011 and 2025 (Table 1). These records show a clear geographical imbalance, with the majority occurring in Sumatra, particularly in Riau, Riau Islands, South Sumatra (Banyuasin), and Bangka Belitung Provinces (Fig. 1). In contrast, fewer cases were recorded in Java, including Banten, West Java, Central Java, and East Java. The concentration of records in Sumatra, especially along its eastern coastal and estuarine systems, likely reflects both the suitability of these habitats for *O. brevirostris* and the higher intensity of human activities such as fisheries and coastal development in these regions.

Table 1. Mortality records of the Irrawaddy Dolphin *Orcaella brevirostris* from 2011 to 2025 in Sumatra and Java. Note, NA is Not Available.

No.	Location	Date	Sources	Size/weight	Remarks
1	Langkat, North Sumatra Province	20 Jul 2019	Fauzi 2019; Mustika *et al.* 2022	NA	Stranded, cause unknown
2	Pematang Matik/Pantai Matik, North Sumatra Province	27 Mar 2025	Perbaungan 2025	NA	Stranded, cause unknown
3	Around Labuhan Batu, North Sumatra Province	NA	Mustika *et al.* 2022	NA	Unknown
4	Dumai, Riau Province	13 Jan 2019	Sophian 2019	NA	Stranded, unknown
5	Rokan Hilir, Riau Province	20 Apr 2017	Fajar 2017; Mustika *et al.* 2022	150 cm/?	Died after becoming entangled in a fishing net
6	Muara Sako, Riau Province	18 Aug 2015	Agustina 2015; Mustika *et al.* 2022	100 cm/?	Entangled in a local fishing net
7	Tanjung Pinang, Riau Islands Province	30 Dec 2020	Darilaut 2020; Mustika *et al.* 2022	173 cm/?	Suspected poaching
8	Bintan, Riau Islands Province	26 Feb 2013	Limahekin 2013; Mustika *et al.* 2022	*c.* 150 kg	Stranding likely due to strong monsoon

No.	Location	Date	Sources	Size/weight	Remarks
					currents
9	Bintan, Riau Islands Province	14 Mar 2023	Slamet 2023	NA	Entangled in gillnet
10	Banyuasin, South Sumatra Province	Oct-Dec 2011	Fauziyah *et al.* 2022	200 cm	Entangled in gillnet
11	Lalan River, South Sumatra Province	Oct-Dec 2012	Fauziyah *et al.* 2022	200 cm	Entangled in gillnet
12	Banyuasin, South Sumatra Province	Jan-Feb 2013	Fauziyah *et al.* 2022	200 cm	Entangled in gillnet
13	Tanjung Kalian, Bangka Belitung Province	1 Aug 2024	Wahyono 2024	180 cm/80 kg	Stranding co-occurred with extreme weather conditions
14	Puding, Bangka Belitung Province	25 Sep 2019	Nita 2019; Mustika *et al.* 2022	NA	Unknown
15	Air Jangkang, Bangka Belitung Province	8 Sep 2025	Nadaa 2025	225 cm	Unknown
16	Pangkal Pinang, Bangka Belitung Province	14 Nov 2025	Tvribangkabelitung 2025	NA	Unknown
17	South Bangka, Bangka Belitung Province	7 May 2023	Rakha 2023	90 cm	Unknown
18	Labuhan Maringgai, Lampung Province	8 Sep 2024	Ahmad 2024; TvOneNews 2024	210 cm	Unknown
19	Banten, Banten Province	June 2025	iNaturalist 2026; Mustika *et al.* 2022	NA	Unknown. Only skull remains
20	Anyer, Banten Province	26 Aug 2025	Aulia 2025	NA	Unknown
21	Bekasi, West Java Province	22 Jan 2025	Yahya & Huda 2025	150 cm	Entangled in gillnet
22	Pangandaran, West Java Province	10 Apr 2022	Mustika *et al.* 2022; Padna 2022	100 kg	Unknown
23	Wonokerto, Central Java Province	1 Jan 2025	Karyadi 2025	NA	Unknown
24	Mlandingan, East Java Province	25 Mar 2024	Pratama 2024	200 cm	Unknown

Notably, Banyuasin (South Sumatra) represents a localized hotspot, with repeated mortality events recorded between 2011 and 2013, all associated with fishing gear entanglement. Similarly, multiple records from Bangka Belitung and Riau further indicate that mortality events are not randomly distributed but tend to cluster in specific high-risk areas. These regions are characterized by shallow coastal waters, river mouths, and estuaries, which are preferred habitats for the species but also overlap extensively with human activities (Iqbal 2003; Mujiyanto *et al.* 2026).

The temporal distribution of records indicates that mortality events are sporadic yet recurrent, occurring throughout the study period. However, there is a noticeable increase in reported cases in recent years, particularly during 2023–2025 (Fig. 2). This apparent rise may be attributed to several factors. First, the expansion of digital media and citizen science platforms (*e.g.* online news, social media, and biodiversity reporting tools) has likely improved detection and reporting of stranding events. Second, the increase may also reflect growing anthropogenic pressures in coastal ecosystems, including intensified fishing activities, industrial expansion, and habitat degradation. Increased environmental variability, including extreme weather events and seasonal oceanographic changes such as sea surface temperature, currents, and wind patterns, is known to contribute to higher frequencies of cetacean stranding events through alterations in habitat distribution and prey availability (Evans *et al.* 2005; Warlick *et al.* 2022; Yang *et al.* 2023).

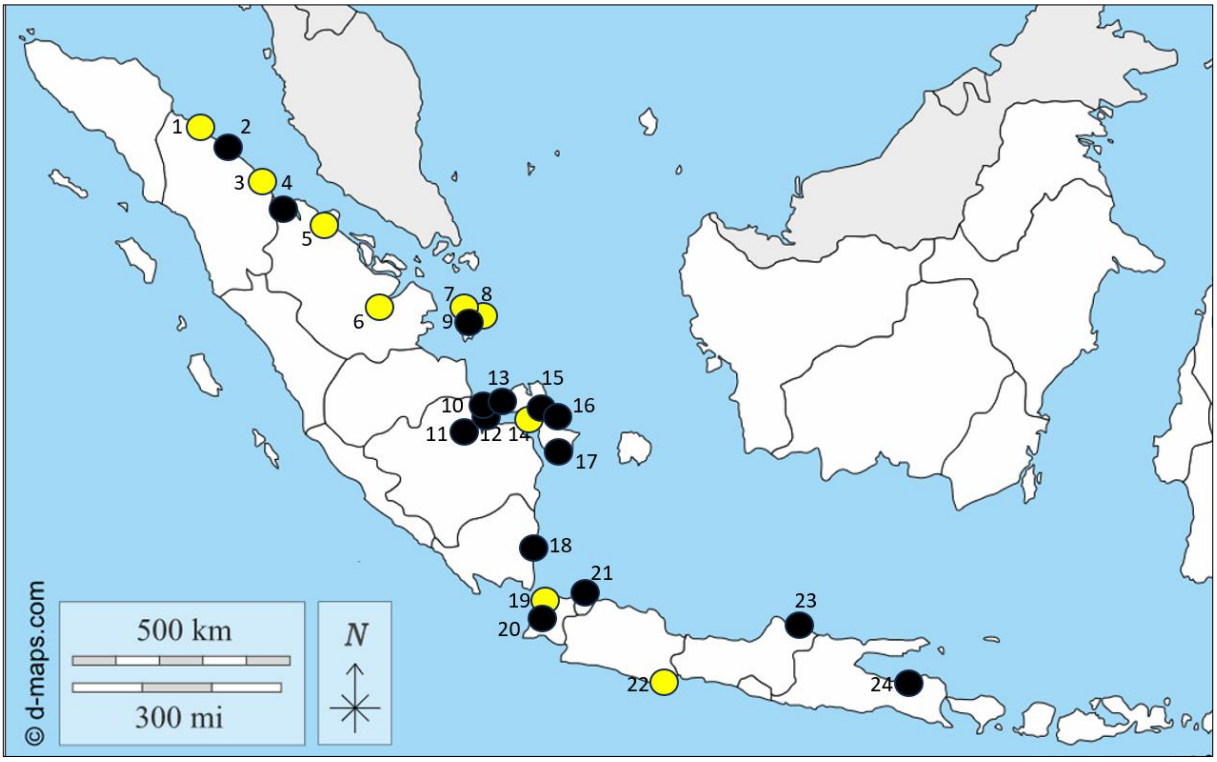


Figure 1. The map shows the spatial distribution of Irrawaddy Dolphin *Orcaella brevirostris* mortality records across Sumatra and Java, Indonesia. Yellow circles denote records reported by Mustika *et al*. (2022), whereas black circles indicate newly identified records. The numbered points on the map correspond to the entries provided in Table 1.

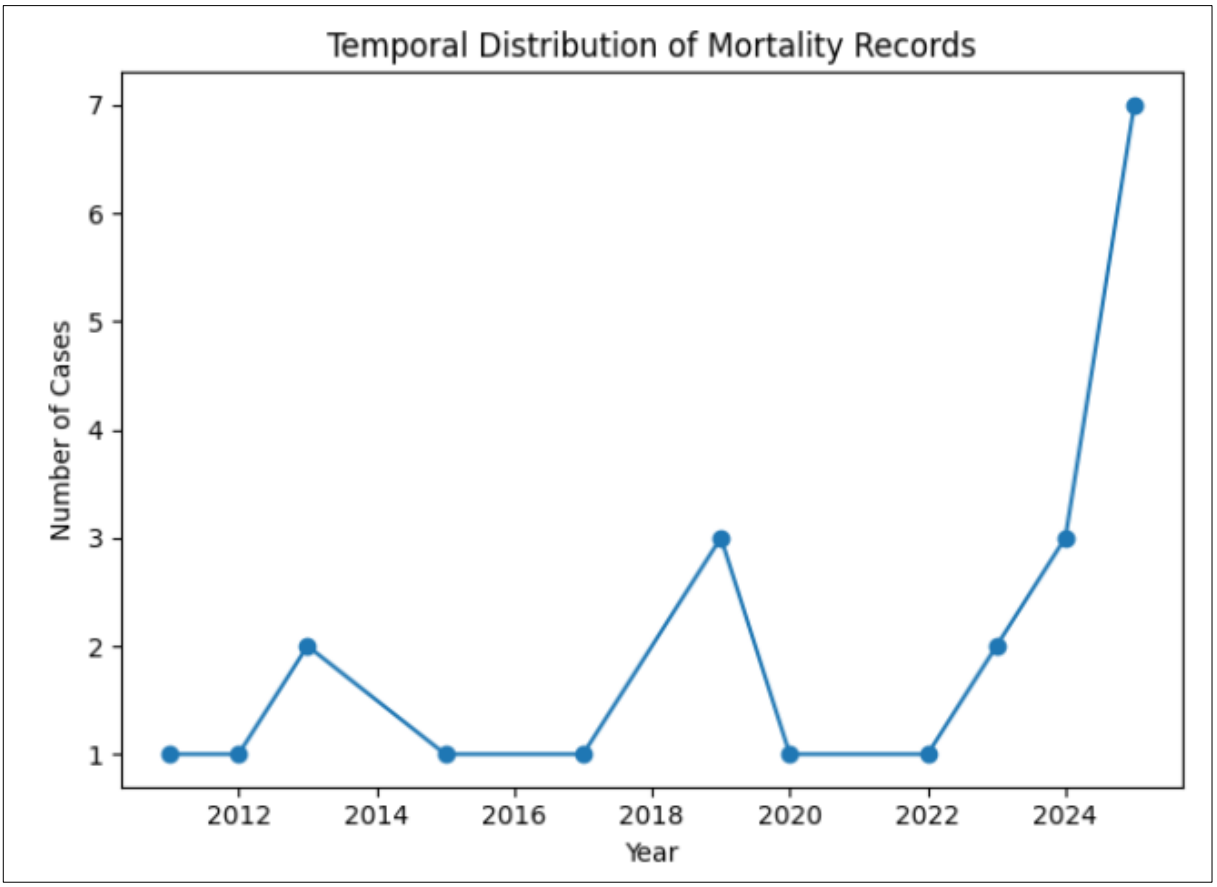


Figure 2. The temporal distribution of mortality records of the Irrawaddy Dolphin *Orcaella brevirostris* in Sumatra and Java (2011–2025).

Causes of Mortality

The analysis of 24 documented mortality records of *O. brevirostris* in Sumatra and Java between 2011 and 2025 revealed that unknown causes accounted for the majority of deaths (14 records, 58.3%; Fig. 3). Mortality associated with fishing gear entanglement, including gillnets and local fishing nets, represented the second most common cause (7 records, 29.2%), highlighting fisheries interactions as the principal identified anthropogenic threat to the species. The remaining mortality records were each attributed to suspected poaching, strong monsoon currents, and extreme weather conditions (1 record each, 4.2%). The high proportion of cases with undetermined causes reflects the limited availability of post-mortem examinations and standardized stranding investigations, which constrain accurate identification of mortality drivers. Nevertheless, the documented prevalence of fisheries-related mortality underscores the urgent need to strengthen bycatch mitigation measures, improve stranding response capacity, and implement systematic necropsy protocols to better understand and reduce threats to this vulnerable species.

Entanglement in fishing nets represents one of the most consistent threats, reflecting the overlap between dolphin habitats and small-scale fisheries. This finding is consistent with global studies indicating that bycatch is a major driver of mortality in coastal cetaceans (Reeves *et al.* 2013; Lewison *et al.* 2014; Brownell *et al*. 2019). In addition, coastal pollution, including industrial effluents, has been shown to negatively affect marine mammals through bioaccumulation and physiological stress (Kannan *et al*. 2000; Tanabe 2002). Although direct causal relationships remain difficult to establish, the co-occurrence of mortality events and industrial activity necessitates further research to determine in how far environmental contamination may contribute to mortality risk.

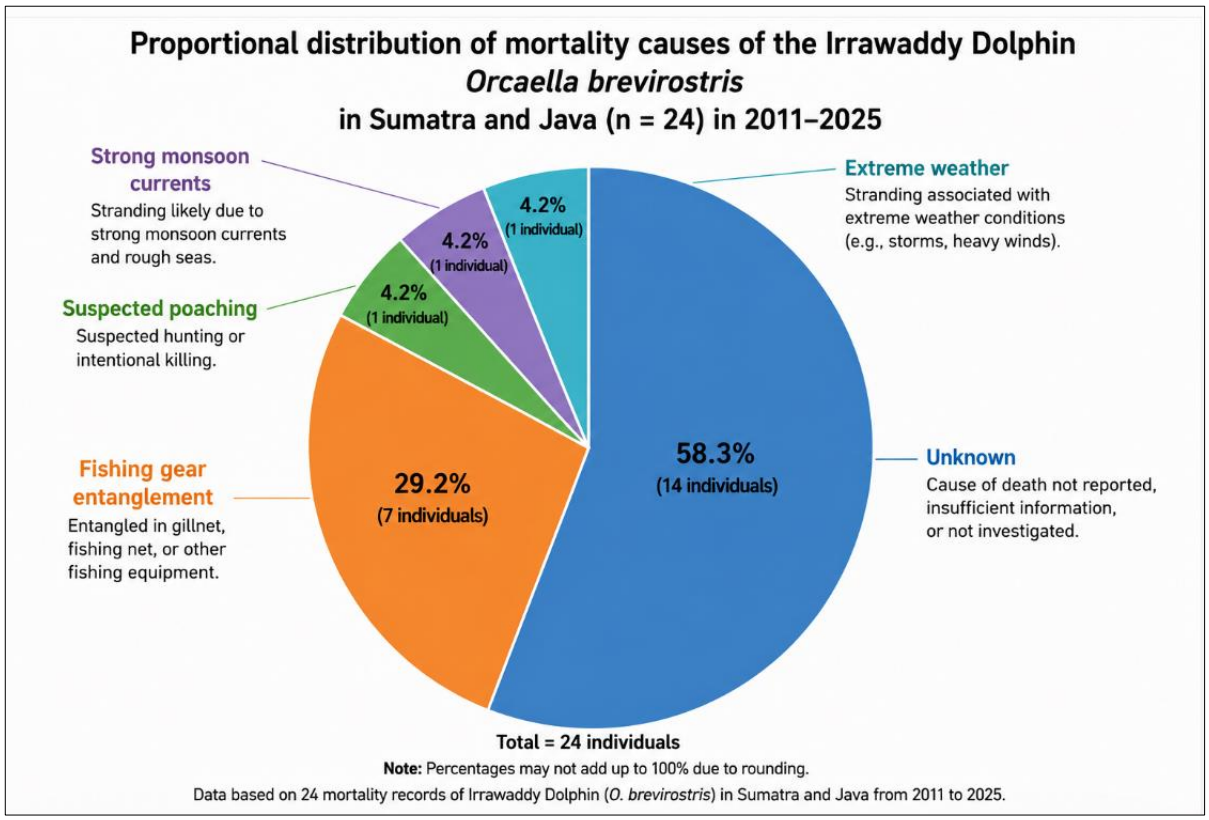


Figure 3. Proportional distribution of mortality causes of the Irrawaddy Dolphin *Orcaella brevirostris* in Sumatra and Java (n = 24) in 2011–2025. Unknown causes and fishing gear entanglement represent the largest proportions of recorded mortality.

A substantial proportion of records were categorized as unknown, including multiple cases across North Sumatra, Bangka Belitung, Lampung, Banten, Central Java, and East Java. In some instances, only skeletal remains (*e.g*. skulls) were discovered, indicating advanced decomposition that prevented determination of the cause of death. The high frequency of undetermined cases highlights a key limitation in marine mammal monitoring in Indonesia, namely the lack of systematic stranding response networks and standardized necropsy protocols. Similar challenges have been reported in Balikpapan

Bay, East Kalimantan 76% out of 29 stranding cases, were classified as unknown while globally incomplete documentation and advanced carcass decomposition often hinder accurate diagnosis of mortality causes (Geraci & Lounsbury 2005; Peltier *et al.* 2012). Without detailed post-mortem examinations, it remains difficult to assess mortality drivers and identify underlying threats to marine mammal populations (Kuiken & Hartmann 1993; Gulland & Hall 2007).

Size Structure and Implications for Population Dynamics

The observed size distribution suggests that multiple age classes, including juveniles and adults, are affected by mortality events in Sumatra and Java. Among the 12 *O. brevirostris* individuals with available body-length measurements, adults constituted the largest proportion of mortality records (6 individuals, 50.0%; Fig. 4), followed by sub-adults (4 individuals, 33.3%) and juveniles (2 individuals, 16.7%). Life stages were inferred from body length because direct age estimates were unavailable. Records lacking body-length data were excluded from the analysis. The presence of juvenile individuals (≤100 cm) is particularly concerning, as it may indicate impacts on recruitment and population sustainability. The dominance of adult-sized individuals (150–210 cm) in entanglement cases, especially in Banyuasin and other coastal fishing areas, suggests that fisheries interactions disproportionately affect mature individuals. This pattern is ecologically significant, as the loss of reproductive adults can have a greater impact on population viability compared to juvenile mortality (Owen-Smith & Mason 2005; Strem & Bouzat 2012).

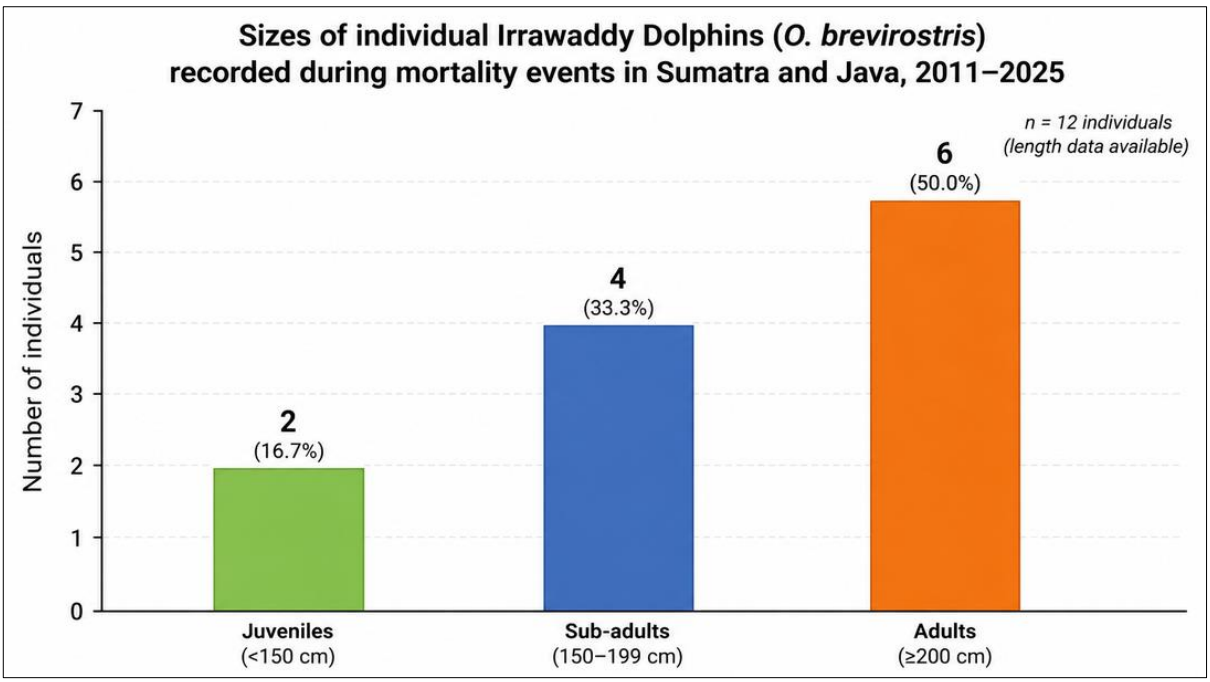


Figure 4. Sizes of individual Irrawaddy Dolphins *O. brevirostris* recorded during mortality events in Sumatra and Java, 2011–2025.

The limited availability of weight data restricts more detailed biological interpretation. However, the recorded weights (80-150 kg) fall within the expected range for *O. brevirostris*, supporting the reliability of species identification in these cases. Importantly, the large proportion of records lacking size and weight information highlights a critical gap in data collection. Standardized documentation of morphometric parameters during stranding events would greatly enhance the ability to: assess age structure of affected individuals, detect spatial variation in body size, and identify potential signs of malnutrition or health decline. The available morphometric data indicate that mortality affects both juvenile and adult *O. brevirostris*, with potential consequences for population dynamics. Improved recording of size and weight during future stranding events is essential to support more robust ecological and conservation assessments.

Spatial Patterns and Risk Areas

Spatially, mortality events of *O. brevirostris* were predominantly concentrated in coastal and estuarine environments characterized by intense human activity. These included fishing-intensive areas, industrialized coastal zones, and regions influenced by strong seasonal oceanographic processes, such as monsoon-driven currents. Fishing-intensive regions, particularly along the eastern coast of Sumatra (e.g., Riau and Banyuasin), emerged as key hotspots of mortality. These areas support extensive small-scale and artisanal fisheries, where the widespread use of gillnets and other passive fishing gear significantly increases the risk of cetacean bycatch. Similar patterns have been documented across Southeast Asia, where entanglement in fishing gear is considered one of the primary threats to small coastal cetaceans (Reeves *et al*. 2013; Lewison *et al.* 2014). The repeated occurrence of mortality events in Banyuasin further suggests that localized fisheries pressure may create persistent risk zones. Kreb et al (2020) also found that four out of seven (57%) documented strandings with known mortality cause in Balikpapan Bay, East Kalimantan were due to gillnet entanglement and that this rate surpassed the potentially biological removal rate based in its small population size.

Industrial coastal areas, such as Dumai in Riau Province, also represent important risk environments. This region is a major hub for crude palm oil (CPO) processing and export, and is usually associated with increased levels of coastal pollution and habitat modification (Nufus 2016). Although direct causal links between industrial activities and dolphin mortality remain difficult to establish, exposure to chemical contaminants and degraded water quality has been shown to negatively affect marine mammals, including through immunosuppression and increased susceptibility to disease (Kannan *et al*. 2000; Tanabe 2002; Van Bressem 2014). The co-occurrence of mortality records and industrial activity in Dumai require more research in how far environmental stressors contribute to mortality.

Environmental and oceanographic factors, in addition to anthropogenic pressures, also influence the spatial patterns of mortality. Areas such as Bintan and Bangka Belitung are subject to strong monsoonal currents, wind-driven circulation, and seasonal wave dynamics, all of which may affect dolphin movements and elevate the risk of stranding events. Previous studies have demonstrated that cetacean strandings are frequently linked to extreme weather conditions and complex coastal geomorphology, which can disorient individuals or carry weakened animals toward shore (Evans *et al*. 2005; Pyenson 2010). The observed clustering of mortality events along the eastern coast of Sumatra likely reflects a combination of ecological suitability and anthropogenic exposure. This region comprises extensive estuaries, river mouths, and shallow coastal waters, which are preferred habitats for *O. brevirostris* due to high productivity and prey availability (Stacey & Arnold 1999). However, these same environments are also heavily utilized by humans for fisheries, transportation, and industrial development, creating intensive habitat overlap between dolphins and human activities.

Overall, these findings suggest that transitional zones between natural habitats and human-dominated environments constitute critical risk areas for *O. brevirostris*. As noted by Minton *et al*. (2017), the species' fragmented distribution in coastal waters near river mouths and in deep pools of large rivers (Kreb & Budiono 2005b) increases its exposure to intensive anthropogenic pressures, as human activities are typically concentrated in these regions. These interface zones are subject to cumulative impacts, where fisheries interactions, pollution, and environmental variability operate concurrently.

In Indonesia, this pattern is evident not only in the Mahakam River, which supports a small and isolated freshwater population (Kreb & Budiono 2005a; Minton e*t al*. 2017), but also in Balikpapan Bay, East Kalimantan, where an important coastal population persists despite increasing pressures from coastal development, vessel traffic, fisheries, and industrial activities (Kreb & Budiono 2005a; Mustika *et al*. 2022). Strandings and mortality have also been documented in Kalimantan, highlighting the cumulative impacts of fisheries interactions, pollution, and habitat degradation on this species. Consequently, the identification and effective management of these high-risk areas are essential for reducing mortality and enhancing the conservation of *O. brevirostris* in Indonesian waters (Menteri Kelautan dan Perikanan 2026). It is of equal importance to determine the population sizes of this species in these high-risk areas.

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