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Article

Water Surface Behaviour of Irrawaddy Dolphin *Orcaella brevirostris* (Owen in Gray, 1866) and Influencing Factors in the Bay of Brunei, Brunei Darussalam

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Abstract: There is limited information on Irrawaddy dolphins (*Orcaella brevirostris*) in the Bay of Brunei, Brunei Darussalam. This research was carried out from 2016 to 2018 to determine the water surface behaviour of Irrawaddy dolphins in the bay, the relationship between behaviour and abiotic factors and the number of individuals displaying the behaviour. Behavioural categories, i.e., feeding, socializing, and travelling in groups or individually, and water parameters were documented during boat-based line transect surveys. "Feeding" (n = 188) behaviour was the dominant activity exhibited by the dolphins. The chi-square test (χ^2) shows that the frequency of feeding, socializing, and travelling to the water depth range is significantly high (p-value = 0.03). Forty-six percent (46%) of all behavioural categories occurred at depths 1.00–5.99 m. The number of individuals displaying "feeding" behaviour has a weak positive relationship with depth (p-value = 0.07), turbidity (p-value = 0.7), sea surface temperature (p-value = 0.9) and salinity (p-value = 0.9). This study may serve as a baseline for future research. It can help in planning conservation projects and management for Irrawaddy dolphins in the Bay of Brunei, Brunei Darussalam.

Keywords: Irrawaddy dolphin; behaviour; Bay of Brunei; Brunei Darussalam; parameters

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1. Introduction

1.1. Study Site

Comprehensive data on dolphins' habitat preferences and surrounding factors are crucial for more efficient management and preservation plans for the habitat area [1]. Additionally, the behavioural ecology studies of dolphins will offer a grasp of their exploration of natural environments, interspecific and intraspecific social behaviours, food web dynamics, and strategies for living in small and large groups [2]. In performing daily habits, the Irrawaddy dolphin needs a protected area such as the Bay of Brunei, where its south and east shores are almost entirely covered by mangrove beds [3]. The Bay of Brunei is divided into two sides. About 30% of the bay belongs to Brunei Darussalam, while 70% is within Malaysia, shared among the Federal Territory of Labuan, Sarawak and Sabah [2] (Figure 1). The study was carried out on Brunei's side of the bay (4°55′46.0″ N 115°04′52.3″ E). The bay's temperature varies yearly from 20 °C to 36 °C due to climate changes between the northeast and southwest monsoon [4]. It is bounded by mangroves, mountains and rainforests; the bay receives its water input from the South China Sea [5]. The area forms a vital mechanism for local hydrological systems, carbon storage and water

resources while benefiting the ecological importance with a high reproductive capacity of the mangrove forest and peat swamps [6]. The fringed mangrove bay is where the prawn, shrimp and seasonal mackerel fishery happen [7]. This is because the bay's water depth and tides variations established a complex zone where it acts as a brilliant territory for marine species [8]. It is reported that 104 freshwater fish species inhabit the bay, with 22 brackish and saltwater fish species [9]. The Bay of Brunei has been known as home to other wildlife varieties, including turtles, crocodiles, dugongs, proboscis monkeys and many more [4]. The bay also provides a suitable condition for six species of seagrasses even though with an enclosed space and faces higher inputs from river waters than Malaysia's side of the bay [10]. The major river inputs are from Limbang in the south and Padas in the north, which contribute a high amount of sediment that covers the seabed, causing turbidity of the bay water [11].

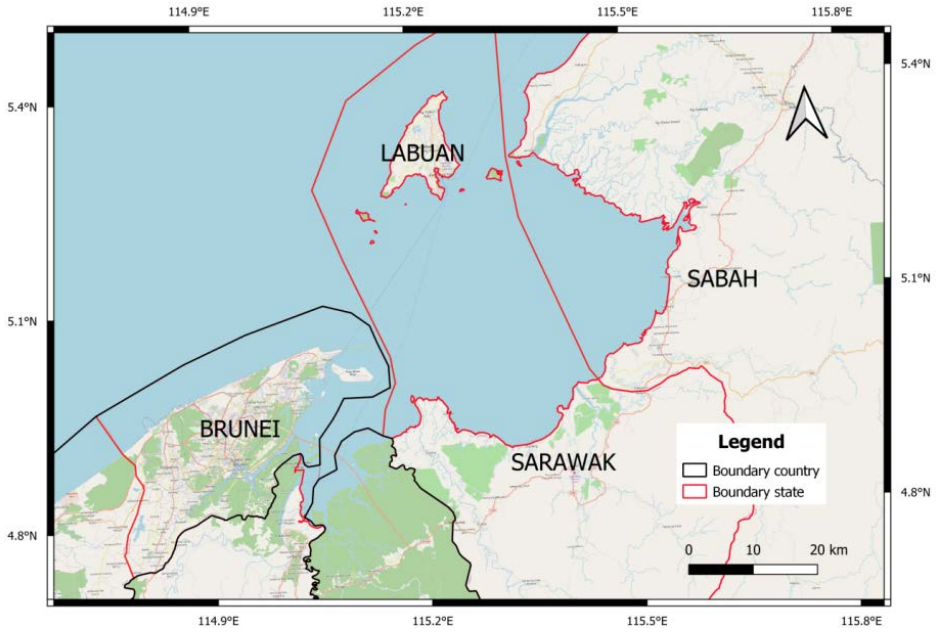


Figure 1. The map of the Bay of Brunei is shared among four Federal Territory of Labuan, Sabah and Sarawak and Brunei Darussalam.

1.2. Irrawaddy Dolphin (Orcaella brevirostris)

Irrawaddy dolphins come from the Order Cetacea, Suborder Odontoceti, Superfamily Delphinoidea and Family Delphinidae [12]. Its common name is Irrawaddy, also known in Indonesia as *Pesut Mahakam* [13]. While in Malaysia, it is known as Lumba lumba, Pa kha in Laos; Pla loma (generic word for dolphin); Hooa baht (monk's bowl, which shares a resemblance with the dolphin's head) in Thailand; and Labai in Myanmar [14]. Smith (2009) described Irrawaddy as having a round head with an overhanging mouth at the front dorsal angle to the eye and a crescent-shaped blowhole at the left midline of his body. They have a small triangular dorsal fin with a blunted tip on their back. They also have a pair of flippers about one-sixth the length of their body, which is quite large for an adult dolphin. The flukes on the leading side have a middle indentation and are curved. Adult Irrawaddy's whole body is light grey in colour and dark grey when they are young. Female Irrawaddy dolphins have been measured to reach up to 2.1–2.2 m for sexually mature adults, and males can go up to 2.8 m.

1.3. Water Surface Behaviour and Influencing Factors

Generally, animal behaviour is differentiated into two types, where the first type is actions where individuals of any species perform it without being guided or instructed. The other type of behaviour consists of acts that seem to be affected by an animal's specific

preferences, and we see striking distinctions in characters of similar species [15]. Cetacean behaviour usually changes according to age, sex and activity states, and ecological factors such as the area, season and time of day. Long-duration behaviour of an animal is considered a state, while the short ones are called events [16]. In this case, water surface behaviour is behavioural events displayed by the Irrawaddy dolphin while surfacing from the water. The behavioural categories that were recorded are feeding, travelling and socializing. The factors that potentially affect the behavioural events were also recorded, i.e., water depth, turbidity, sea surface temperature, salinity and time of day. A study [17] stated that fluctuations in abiotic factors such as salinity and temperature might significantly impact the mammals' distribution. Another study [18] suggests that sea surface temperature and prey availability control the dolphin's seasonal movements and distribution. However, the relations between different factors might vary according to the geographical area [19].

1.4. Objectives of the Study

Previous studies have been conducted on Malaysia's side of the bay, witnessing marine mammals (Irrawaddy dolphin, *Orcaella brevirostris*; Indo-Pacific Humpback dolphin, *Sousa chinensis*; and Dugong, *Dugong dugon*) residing and some even involved in socialising activities together [2,20–26]. This study is the first behavioural study of Irrawaddy dolphins on Brunei's side of the bay, and the results are a reference point for future research. The research was conducted to achieve the objectives below:

(a) To determine the behavioural categories (feeding, socializing and travelling) that will be displayed by Irrawaddy dolphins.
(b) To determine how the behavioural categories displayed by Irrawaddy dolphin are affected by the abiotic factors (depth, turbidity, sea surface temperature and salinity).
(c) To determine whether the number of individuals in a group of Irrawaddy dolphins is affected by the measured abiotic factors (depth, turbidity, sea surface temperature and salinity).

2. Materials and Methods

2.1. Boat-Based Survey

The data were collected from 2016 to 2018 using a boat-based survey with designated routes to search for Irrawaddy dolphins. The boat-based survey is a prevalent method for marine mammal studies used by researchers, for example, [23,27–29] and many others. Track lines were mapped out for all 4 routes: Sungai Temburong, Pulau Selirong, Lighthouse and Pulau Pelumpong. The routes allow us to survey the whole Bay of Brunei, Brunei's side, without bias (Figure 2). Limiting factors were included, such as tides, depth, security, size and endurance of the survey vessel during route mapping. These limitations prompted the route not to be placed randomly. The sampling was conducted throughout the monsoon seasons in January (northeast, NEM), April (inter-monsoon, IM), July (southwest, SWM) and October (inter-monsoon, IM).

The surveys were conducted only during the day, starting at 8.00 am and ending at 4.00 pm. Four observers were on a 10 m long wooden speedboat with an average speed of 12 kmh^{-1}. The boat was handled by a local boatman equipped with a handheld GARMIN GPSMAP 78 s Global Positioning System (GPS) receiver. One of the four observers sat at the front of the boat for dolphins sighting ahead of the vessel; two observers sat on the left and right of the boat, while the other observer sat at the back of the boat near the boatman. The observers were aided with NIKON© marine binoculars 7 × 50 WP compass for a clearer view of the dolphins. Once the dolphins were sighted, the survey halted, and the boat's position was marked in the GPS and recorded on a datasheet. An expert then determined the species on the boat with the naked eye.

On the first encounter, the water parameters, water depth and turbidity were taken using Speedtech© Portable Depth Sounder and Portable HANNA HI 93703 Microprocessor 112 Turbidity Meter correspondingly. At the same time, the sea surface temperature (SST) and salinity were taken by the YSI Multiprobe meter (556 MPS, Yellow Springs, OH,

USA). The readings were recorded before recording the dolphin's behavioural activities. Subsequently, the vessel continued pursuing the dolphin within a safe distance of 20 m to 50 m to avoid them startling until they disappeared. Two observers captured photos and videos using a DSLR camera and a video camera. The route abandoned was taken back, and the survey continued unless the Beaufort scale exceeded $\geq$3 or rough rain and waves occurred. The seasonal distribution maps were generated using the GPS points transferred into QGIS 3.16 Hannover Software, while the recorded navigational and sighting data were transferred and saved in a Microsoft® Excel database. The survey effort is measured by multiplying the survey distance by the survey time, as shown below:

$$\text{Survey distance (km)} \times \text{survey time (h)} = \text{survey effort (km·h)}$$

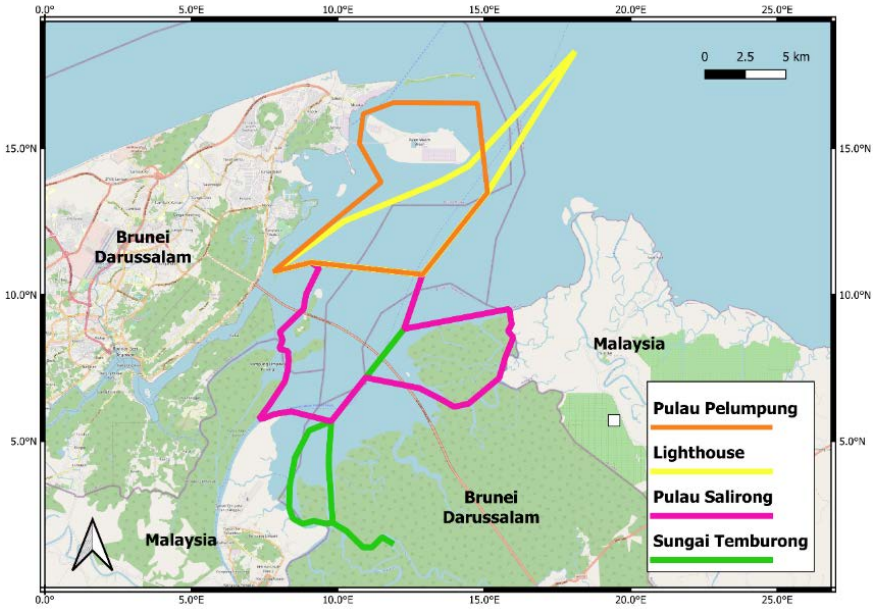


Figure 2. The planned routes for boat survey in the Bay of Brunei, Brunei Darussalam.

While sighting rate is measured as below:

$$\text{Sighting rate} = \frac{Total\ number\ of\ sighting}{Total\ survey\ effort\ (km.h)} \times 100$$

2.2. Behavioural Events

Small behavioural events are included in grouping the behavioural categories exhibited by the Irrawaddy dolphin. The behaviours were not recorded according to age, sex or number of individuals in a group. It was randomly noted to justify the behavioural category performed at a certain area and time. The method used was a 5 min interval where categories were noted as n = 1 (yes/occur) or n = 0 (no/not occur). Every 5 min, the data were marked, and when the dolphins disappeared, we waited for 10 to 20 min. In rare cases, they resurfaced, and the observation resumed. Below are the categories grouped by small behavioural events:

(a) Feeding: surfacing many times, raising flukes and long diving for fish capturing, sometimes pausing (snorkelling) for a while. Fish capturing and tossing fish and prey are often seen in dolphins' mouths. Following trawlers and preying fish near trawling net. Water spitting.

(b) Socializing: prolonged body contact with other individuals. Leaping or surfacing out of the water. Fighting and chasing between individuals. Bow riding in front of boats or survey vessels. Spy-hopping to observe around. Overlapping swim between individuals.

(c) Travelling: swimming, diving and surfacing synchronously. Grouping and moving in the same direction simultaneously.

Upon categorizing the dolphin behaviours, the size of dolphin groups was solitary (1 individual), small (2–5 individuals), medium (6–10 individuals) and large (11–15 individuals).

3. Results

3.1. Survey Effort and Sightings

From 2016 to 2018, there were 44 days of boat surveys with 64 sightings of Irrawaddy dolphins in the Bay of Brunei, Brunei Darussalam. The total survey effort was 15,844.86 km (total survey tracks; Figure 3) with a sighting rate of 0.40 per 100 km·h (Table 1) covering the whole Bay of Brunei. The highest sighting is in July, with 19 sightings, while the lowest is in January, with a total of only 9. April recorded the lowest survey effort but had the highest sighting rate of 0.59 per 100 km·h compared to other months. The total group size range is 1–15 individuals, and the total number of groups with calf sighted is 14 (Table 2). The total mean is 4.1 individuals in a group of Irrawaddy dolphins.

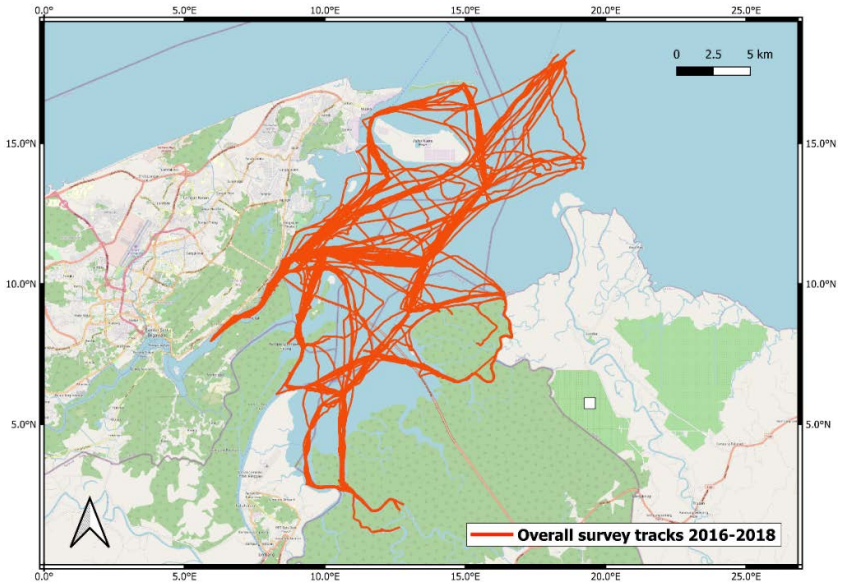


Figure 3. The overall survey tracks in the Bay of Brunei, Brunei Darussalam 2016–2018.

Table 1. Cumulative data collection from the boat surveys conducted in the Bay of Brunei, Brunei Darussalam, between 2016 and 2018 according to months (sea states Beaufort 0–3).

Year	Month	Days Surveyed	No of Sighting	Distance (km)	Time (Hour)	Survey Effort (km·h)	Sighting Rate (per 100 km·h)
2016	January (NEM)	2	1	133.8	6.57	486.083	0.21
	April (IM)	2	2	105.5	4.45	236.155	0.85
	July (SWM)	3	4	223.6	16.91	1270.17	0.32
	October (IM)	5	6	323.5	30.78	2009.58	0.30
2017	January (NEM)	4	3	281.1	22.65	1591.66	0.19
	April (IM)	4	5	277.1	20.42	1414.70	0.35
	July (SWM)	4	7	280.8	24.15	1720.41	0.41
	October (IM)	4	5	263.2	21.06	1435.15	0.35
2018	January (NEM)	4	5	277	21.91	1532.64	0.33
	April (IM)	4	11	273.6	20.23	1385.39	0.79
	July (SWM)	4	8	274.3	18.94	1303.95	0.61
	October (IM)	4	7	285.3	20.39	1458.98	0.48
TOTAL		44	64	2998.8	228.46	15,844.9	0.40

Table 2. The group size of Irrawaddy dolphins and the number of calves sighted during the sampling years of 2016 to 2018.

Months	Number of Sightingse (% of Total)	Sighting Rate (Per 100 km·h)	Number of Groups with Calf	Group Size			
				Mean	SD	Median	Range
January (NEM)	9 (14%)	0.25	6	6.9	4.2	7.0	1–15
April (IM)	18 (28%)	0.59	3	4.9	14.7	4.0	1–15
July (SWM)	19 (30%)	0.44	4	3.4	2.7	2.0	1–10
October (IM)	18 (28%)	0.37	1	2.7	1.5	2.0	1–6
TOTAL	64	0.40	14	4.1	3.3	3.0	1–15

The total survey tracks covered the whole Bay of Brunei, Brunei Darussalam, using four different routes (Pulau Pelumpong, Sungai Temburong, Lighthouse and Pulau Selirong) (Figure 3). In Figure 4, seven dolphin sightings, shown in yellow boxes, occurred at river inlets known as Temburong River and Aloh Besar River. Two of the sightings happened during the northeast monsoon, which is the wet season [30] that started around October to January, with December being the wettest month. The other five sightings occurred in the inter-monsoon that began in February to April, the first dry season. During the fishing season, which happened around December to February [31], more than 20 small boats could be seen in the middle of the bay. The dolphins were spotted feeding and socializing near the boats (red circle) (Figure 4). Additionally, dolphins (blue circle) were sighted near a small island known as Pulau Cermin, 1 km away from the land (Figure 4).

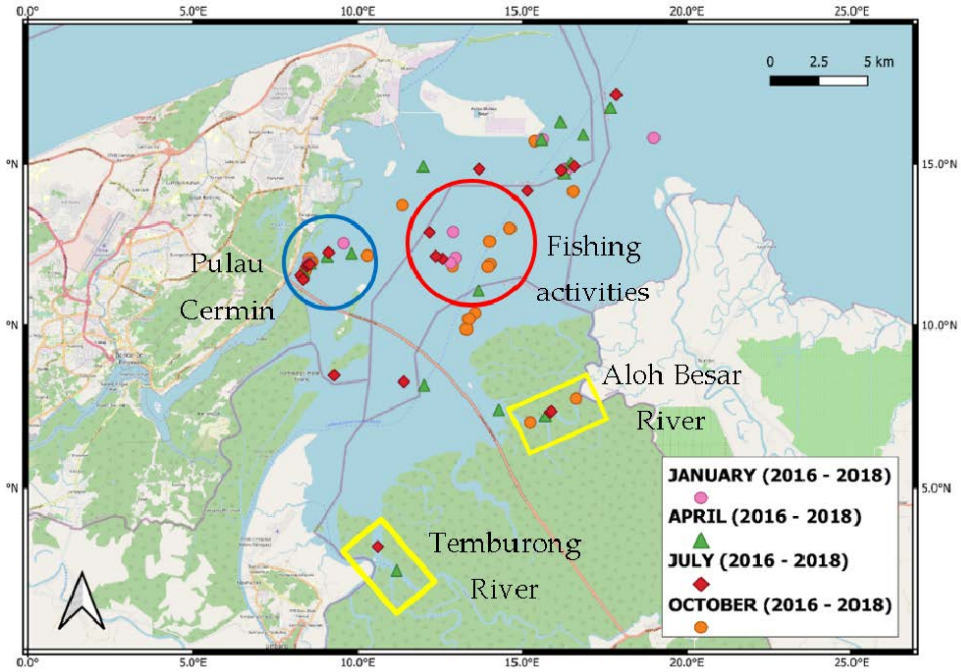


Figure 4. Overall sightings of Irrawaddy dolphins in the Bay of Brunei, Brunei Darussalam, according to months from 2016 to 2018.

3.2. Behavioural Activities of Irrawaddy Dolphin

Irrawaddy dolphins in the Bay of Brunei displayed more "feeding" (n = 188) activity during the survey, while travelling (n = 108) was recorded as the second most seen activity, and the third was socializing (n = 106) (Figure 5).

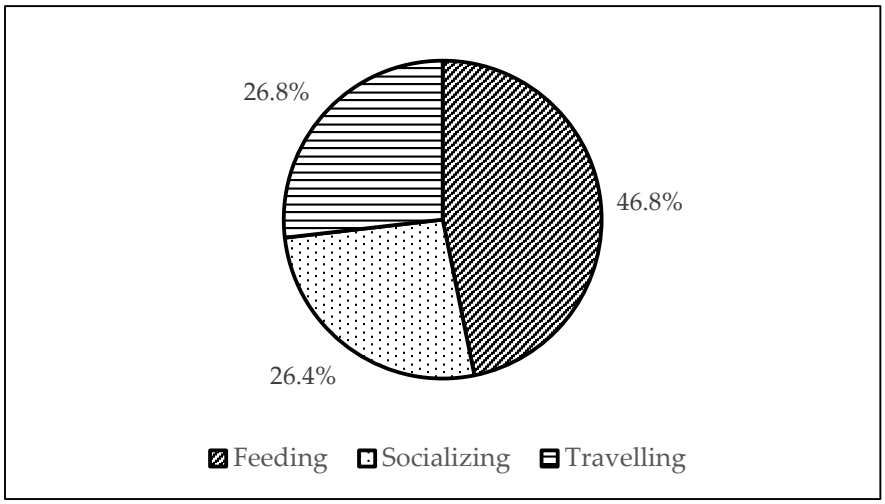
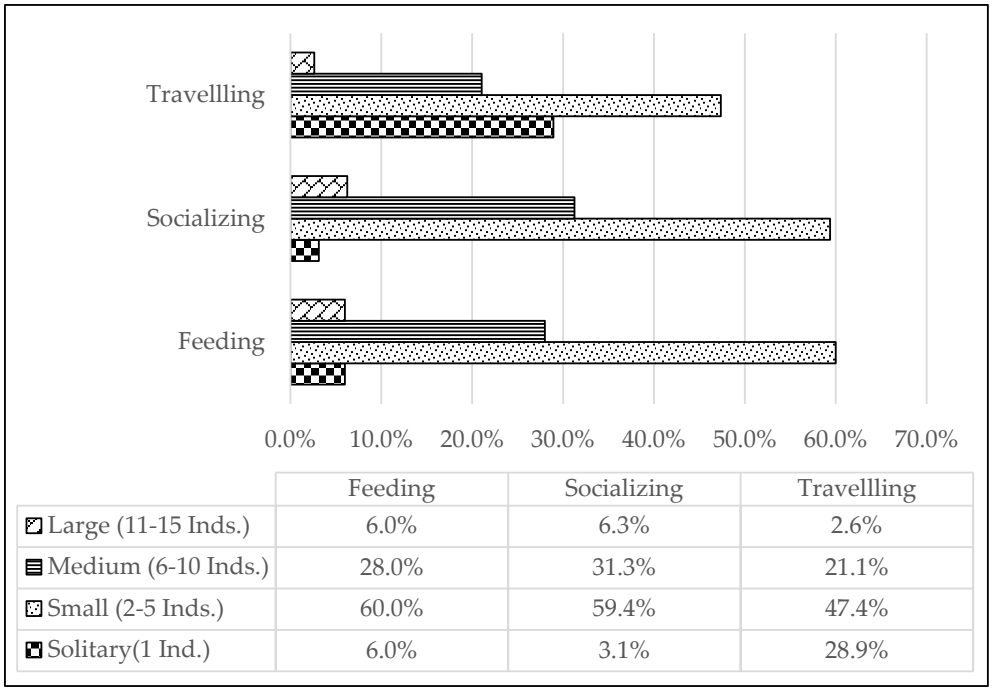


Figure 5. The behavioural events frequency percentage displayed by Irrawaddy dolphins in the bay.

3.3. Behavioural Activities in Relation to the Number of Individuals in a Group

There were 12 groups of solitary (1 ind.), 35 groups of small (2–5 inds.), 14 groups of medium (6–10 inds.) and 3 groups of large (11–15 inds.) out of 64 sightings/groups recorded. 11 out of 12 groups of solitary displayed travelling behaviour. Only 3 out of 12 solitary groups displayed socializing behaviour. 30 out of 36 small groups displayed feeding behaviour. In addition, all 14 medium and 3 large groups displayed feeding behaviour. In total, 50 groups out of 64 sightings/groups displayed feeding, 32 groups displayed socializing and 38 groups displayed travelling (Figure 6). The observed number of groups of solitary, small, medium and large groups displayed feeding (X^2 (3) = 39.12, *p*-value =< 0.00001), socializing (X^2 (3) = 26.25, *p*-value =< 0.00001) and travelling (X^2 (3) = 15.68, *p*-value=< 0.00001) behaviours are significantly higher than the expected values at $p < 0.05$.

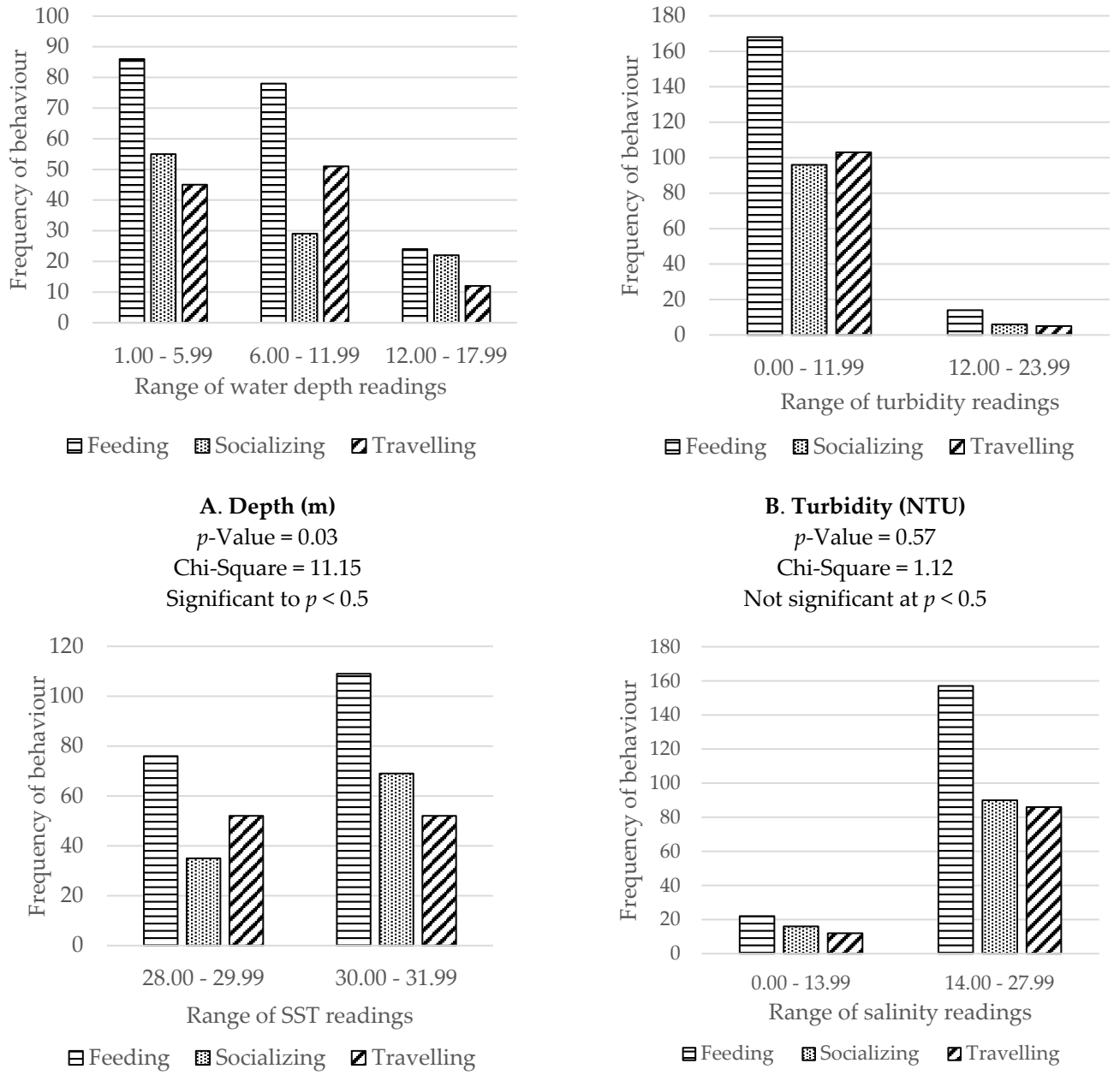


	Feeding	Socializing	Travellling
Large (11-15 Inds.)	6.0%	6.3%	2.6%
Medium (6-10 Inds.)	28.0%	31.3%	21.1%
Small (2-5 Inds.)	60.0%	59.4%	47.4%
Solitary(1 Ind.)	6.0%	3.1%	28.9%

Figure 6. The percentage of the number of solitary (n = 12), small (n = 35), medium (n = 14) and large (n = 3) groups displaying feeding, socializing and travelling behaviours.

3.4. Behavioural Categories in Relation to Abiotic Factors

The chi-square test revealed that the frequency of behavioural categories to the ranges of water depth is highly significant (X^2 (2) = 11.15, p-value = 0.03) at $p < 0.05$ (Figure 7A–D. However, the test shows no significant differences between the frequency of behavioural categories to the ranges of turbidity, sea surface temperature and salinity readings. Behavioural events occurred the highest (46.3%) at a depth of 1.00–5.99 m, with "feeding" scoring the highest frequency.



A. Depth (m)
p-Value = 0.03
Chi-Square = 11.15
Significant to $p < 0.5$

B. Turbidity (NTU)
p-Value = 0.57
Chi-Square = 1.12
Not significant at $p < 0.5$

C. Sea Surface Temperature (SST) (C°)
p-Value = 0.06
Chi-Square = 5.75
Not significant at $p < 0.5$

D. Salinity (ppt)
p-Value = 0.76
Chi-Square = 0.54
Not significant at $p < 0.5$

Figure 7. The frequency of behavioural categories (feeding, travelling and socializing) versus the ranges of abiotic factors (depth (**A**), turbidity (**B**), sea surface temperature (**C**) and salinity (**D**)).

Figures 8A–D, 9A–D and 10A–D show the analysis of the number of individuals in a group displaying different behaviour categories versus the readings of the abiotic factors. There was a positive relationship between the number of individuals displaying feeding and depth (p-value = 0.07) in Figure 8A. Then, in Figures 9A and 10A, the number of individuals socializing and travelling showed positive trends with depth with p-value = 0.53 and p-value = 0.55, respectively. Figure 8B shows a weak positive trend with turbidity with a p-value = 0.87, while the number of individuals socializing (p-value = 0.37) and travelling (p-value = 0.40), show negative trends with turbidity (Figures 9B and 10B). Figures 8C, 9C and 10C display negative relationships between all behavioural categories with sea surface temperature but are considered weak relationships as the r-value is closer to 0, and the relationship gets weaker.

(Feeding) Pearson's Correlation Coefficient at p<0.05

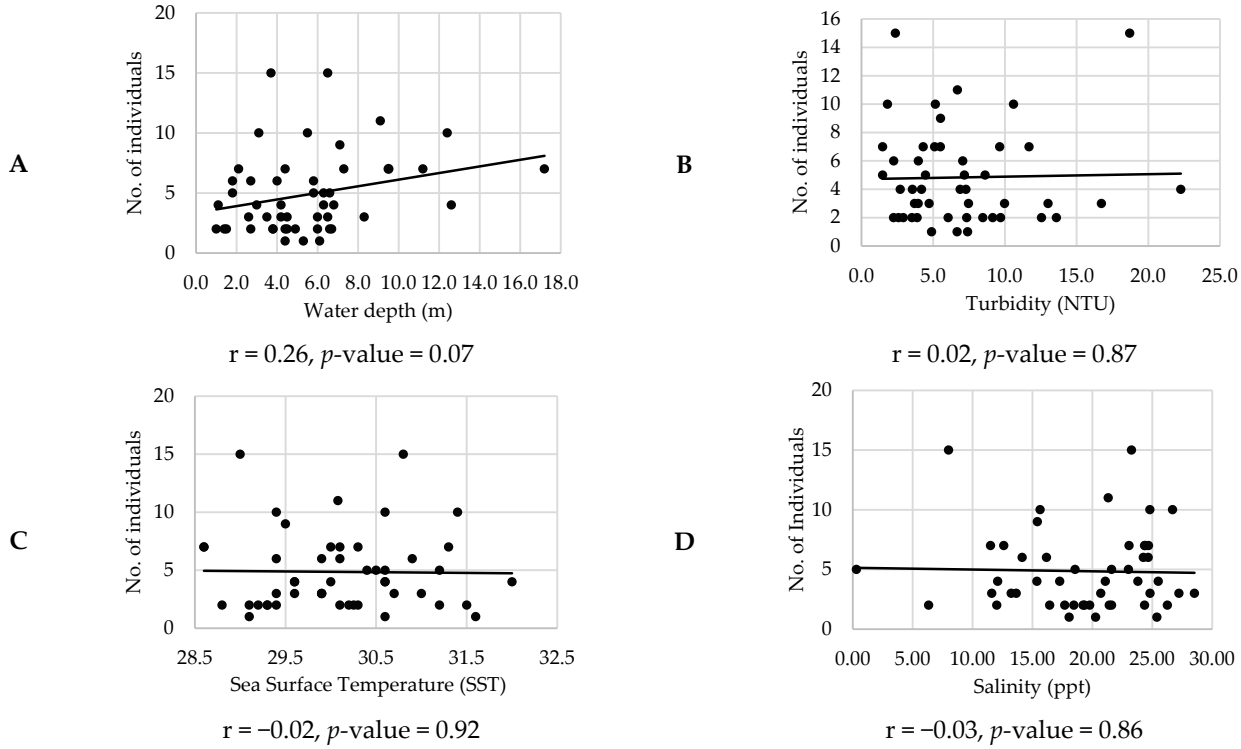


Figure 8. The number of individuals in a group of Irrawaddy dolphins displaying feeding behaviour versus abiotic factors (depth (**A**), turbidity (**B**), SST (**C**) and salinity (**D**)).

(Socializing) Pearson's Correlation Coefficient at p<0.05

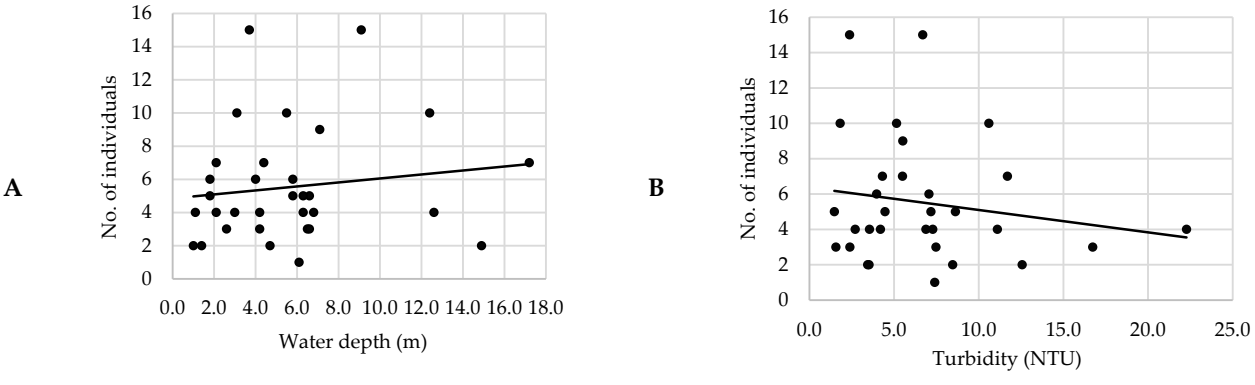


Figure 9. *Cont.*

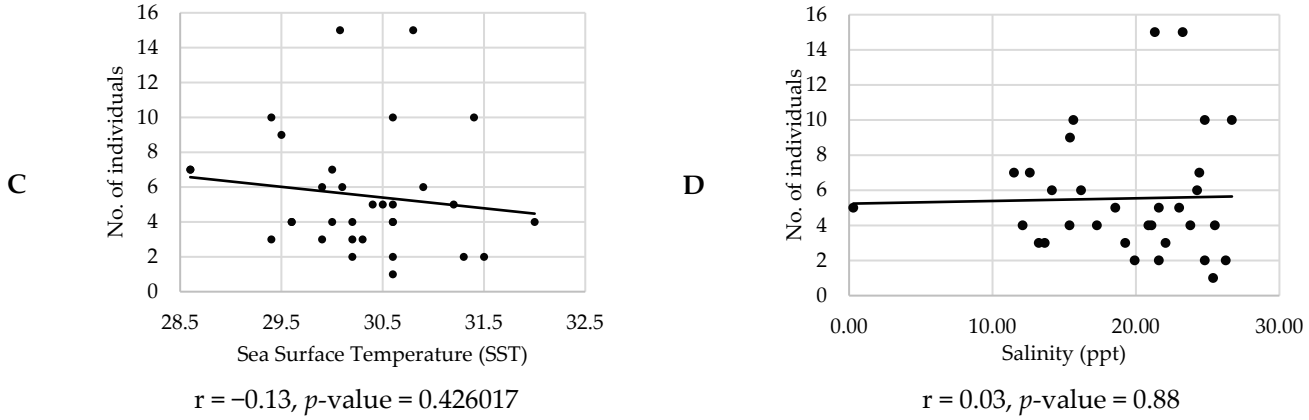


Figure 9. The number of individuals in a group of Irrawaddy dolphins displaying socializing behaviour versus abiotic factors (depth (**A**), turbidity (**B**), SST (**C**) and salinity (**D**)).

(Travelling) Pearson's Correlation Coefficient at $p<0.05$

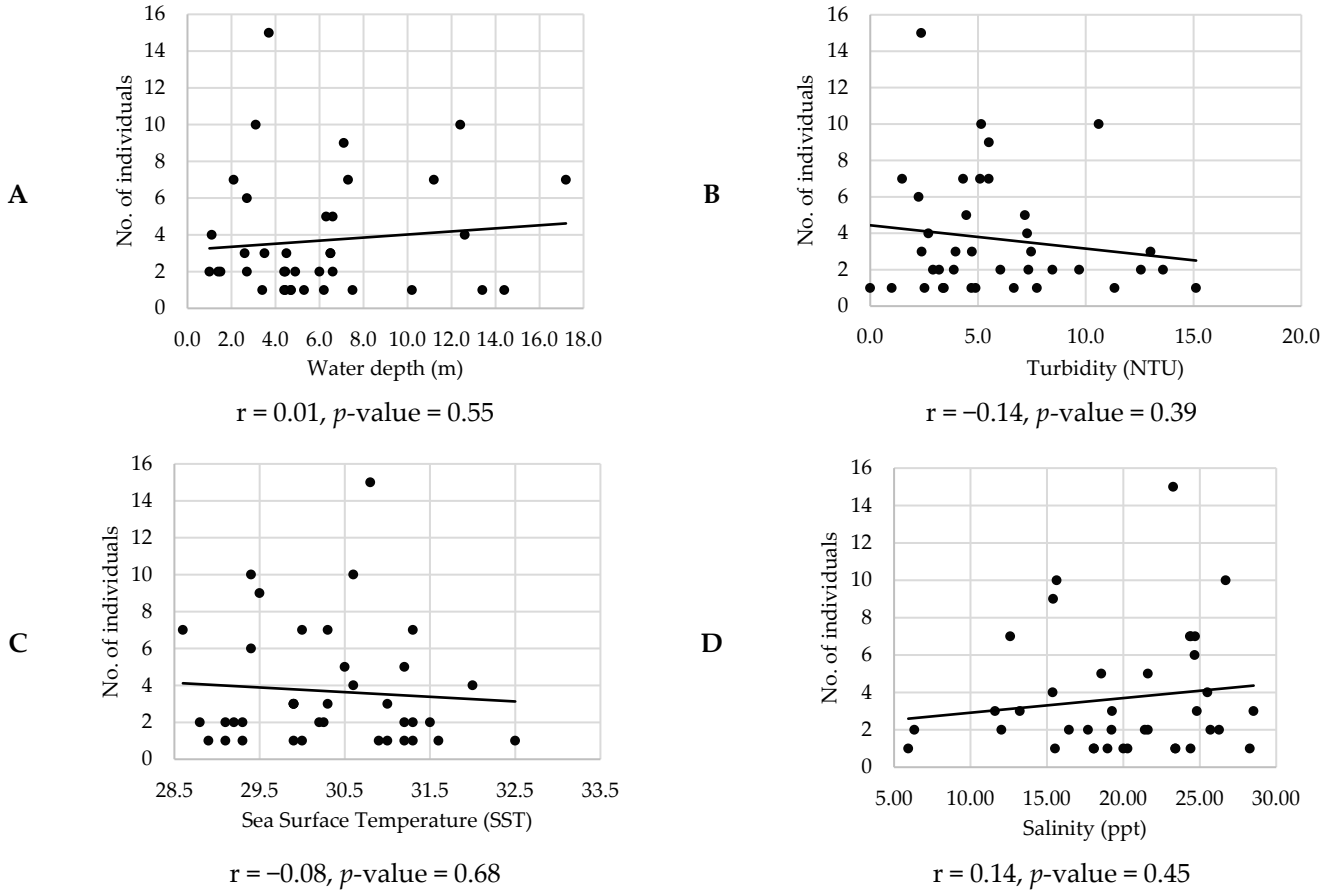


Figure 10. The number of individuals in a group of Irrawaddy dolphins displaying travelling behaviour versus abiotic factors (depth (**A**), turbidity (**B**), SST (**C**) and salinity (**D**)).

4. Discussion

4.1. Survey Effort and Sightings

No historical data were available for the Irrawaddy dolphin study in the Bay of Brunei, Brunei Darussalam. The same goes for Malaysia's side of the bay. However, between 2013 to 2015, one of the first research projects was conducted by Jaaman et al. (2016) [32] in the Bay of Brunei, Malaysia. The survey effort was 19,575.2 km·h with 36 sightings. The sighting rate was 0.18 per 100 km·h but relatively lower than the survey conducted on

Brunei's side (0.40 per 100 km·h). A total of 19 sightings were recorded during the month of July throughout the three years of surveys; still, the month of April had the highest sighting rate (100 km·h) of 0.59 per 100 km·h. However, statistically, when comparing the number of sightings per 100 km·h, there was no significant difference between survey months (Table 2). Therefore, this indicates that the sightings can occur throughout the year. The same results were for Malaysia's side [2,32], Kep Archipelago, Cambodia [33], Indonesia [29], and Malampaya Sound, Philippines [34]. Irrawaddy dolphins were seen in three regions of Malaysia's side of the Bay of Brunei: Labuan, Lawas and Weston [32]. Presumably, the dolphins travel back and forth between the bay area. The mean group size on Malaysia's side is 7.1 (min = 1, max = 35), larger than Brunei's side, which recorded only a mean of 4.1 (min = 1, max = 15). This study documented the highest sighting in April (n = 19) during inter-monsoon. Malaysia's side noted that the southwest monsoon has the highest number of sightings (n = 36), but it is not statistically significant [32]. The same case happened in Cowie Bay, Sabah, where Irrawaddy was sighted most during the southwest monsoon (n = 53), but there was no significant difference in sightings mean between seasons [35]. This signifies the occurrence of the dolphin all year round. The sighting rate is significant during the morning (8.00 a.m. to 11.59 a.m.) compared to the evening (12.00 p.m. to 4.00 p.m.). This may be a result of weather conditions and geographic distribution. The morning was generally calm between Beaufort 0 and 1, with elevated visibility. Usually, when it is late, around 3.00 p.m., the weather begins to change. The sky turned cloudy and strong winds started blowing towards the bay. That could range from Beaufort 2 to 4. Malaysia's side had significant differences between morning and afternoon by comparing the mean number of sightings per hour of survey effort [36].

The bay is predominantly surrounded by mangrove forests and receives freshwater inputs from rivers, providing a suitable spawning ground for the fish. Changes in season affect prey availability. In Xiamen Bay, China, the fish probably accumulated closer to the river during the southwest monsoon, whereas during the northeast monsoon, they scattered away from coastal waters [37]. Ismail et al. (2021) [38] reported that the movement of their preferred food might induce the dolphin's movements. Prey aggregations could be the cause of Irrawaddy dolphins being found in areas where salt and fresh water are mixed. During fishing season, the sightings for this study accumulated in the middle of the bay where the fish and shrimp catching generally took place (Figure 4). Dolphins usually follow trawlers and fishing boats into the ocean. They will hunt the fish that the fishermen discard or the fish that are caught but have escaped the nets. Irrawaddy has been seen feeding on certain demersal and estuarine fish [39]. Throughout the sampling years (2016–2018), the 30 km Sultan Haji Omar Ali Saifuddien bridge was constructed. It was built from Mengkubau and Sungai Besar in Brunei–Muara District to Labu Estate in Temburong District. It was expected that the construction would significantly impact the dolphin sightings. However, 2018 showed an increase in the number of Irrawaddy sightings.

4.2. Behavioural Activities

The dolphins on Brunei's side of the bay are timid compared to dolphins on Malaysia's side. Ninety percent of the time, they can be seen travelling individually but feeding and socialising in a group. During feeding, the dolphins can be seen diving and surfacing within seconds. It is also possible to hear the dolphin chuffing, which is the act of exhaling air from its blowhole. Tail slapping and water spitting are also techniques they use while feeding. They also swam in circles at times. For travelling, the dolphins displayed continuous surface swimming most of the time and moved in the same direction. However, they deep dived whenever the survey boat approached them. They can be solo or travel in a group. During feeding and travelling, socialising can take place. They socialised by showing body contact between individuals. This includes aggressive fighting and chasing each other while leaping out of the water. However, they can also be aggressive in response to their surroundings. Twenty-five percent of the feeding events occurred near fishing boats, while 75% happened randomly within the bay. During net pulling, the dolphins followed the

small boats and fed on fish that escaped from the net or were tossed out by the fishermen. They trailed one boat to another, and separated groups can be seen swimming around the fishing area (Figure 11).

Figure 11. Sighting of Irrawaddy dolphin feeding near a fishing boat.

Feeding activity recorded the highest event frequency with 188 times. Similar observations were in Cowie Bay, Sabah, where the most dominant activity of the Irrawaddy and Humpback dolphins was feeding [35]. Mahmud [36] also described that the dolphins on Malaysia's side of the bay feed mainly during the day. The same happened in Penang Island, Malaysia [40] and Cleveland Bay, Australia [27], where feeding activity is the main daylight activity. It is proposed that feeding activity will likely increase with a richer habitat, and more time will be spent hunting for food due to prey insufficiency [41]. Feeding activity was dominant, possibly due to a shortage of food resources, and also, the bay offers the same resources for humans and dolphins. This forces the dolphin to compete by spending more time hunting for food. Then again, Burgess [42] suggested that increased feeding behaviour may result from an increasing abundance or species of prey.

4.3. Behavioural Activities in Relation to the Number of Individuals in a Group

In the bay, small groups (2–5 individuals) of Irrawaddy dolphins were seen engaging in all behavioural categories. While [2] noted that on Malaysia's side of the bay, the dolphins seemed to engage in milling and socialising within a larger group of 11–20 individuals. This suggests that Brunei's side of the bay offers a more shielded environment making it safe to perform daily habits in a small group. On the other hand, the dolphins on Malaysia's side of the bay perform activities in a larger group as they face more offshore, where rough winds, waves, and large predators can harm the dolphins.

4.4. Behavioural Categories and Abiotic Factors

Figure 8A–D shows travelling as the lowest frequency of all abiotic factors, suggesting that depth does not influence travelling behaviour. Rationally, dolphins will not evade any particular water depth for travelling except if the path is impassable by fixed nets, fishing structures, boats, or constructions, or if they feel threatened. Figure 9A shows that the number of individuals displaying feeding and depth has a positive relationship signifying that the deeper the water goes, the higher number of individuals will engage in feeding activities. The vertical space in deep water offers a convenient way for dolphins to strategize feeding tactics as more individuals are involved.

Irrawaddy dolphins were sighted in a habitat with many abiotic factors. A study [1] recorded to have seen Irrawaddy in shallow water with high turbidity and low salinity in Kuching Bay, Sarawak. While in the Mekong River, Irrawaddy preferred to be in the water more than 8 m in depth with a mainstream flow countered by streams or secondary

currents [43] Furthermore, in the estuarine area of Banten Bay, the dolphins were observed in water with high turbidity at 1–9 m of water depth [44]. Kreb and Budiono [45] reported that in depths of 5 m to 14 m of water, the dolphins were scatteringly found in East Kalimantan. Thus, this proves that Irrawaddy dolphins can be observed inhabiting different water depths [16]. Overall, the accessibility of food in the bay might be the main factor in the reported results. In contrast, abiotic factors could act as a secondary part of affecting Irrawaddy's distribution patterns [46].

5. Conclusions

This study represents the first base information on the Irrawaddy dolphin's water surface behaviour in the Bay of Brunei, Brunei Darussalam. There were 64 sightings during the line transect surveys (January 2016–October 2018) with an average group size of 4.1 ± 3.3. The minimum number of individuals in a group was one, and the maximum was fifteen. Out of 64 groups, only 14 groups were sighted with mother and calf. "Feeding" (n = 188) behaviour is the most dominant activity displayed by the dolphins. Their behaviours may not be influenced much by the abiotic factors but might be greatly associated with prey availability, abundance and movements. Future research can be completed to test the hypothesis. In summary, the bay is an ideal area for the dolphins to act as a foraging and socializing ground. Therefore, awareness and rules should be enforced among the local community, fishermen and tourists, which can be one way to plan conservation and management to decrease anthropogenic threats on the dolphins.

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