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Article

Characteristics of Marine Mammal Habitat in Bintuni Bay

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Abstract: Bintuni Bay is one of the most important areas in Eastern Indonesia with high ecological potential, especially for marine mammals. This study aims to observe the presence of marine mammals and analyse water quality characteristics in Bintuni Bay to understand the environmental dynamics that affect the presence of marine mammals. Marine mammal observations were conducted along a predetermined pathway and seawater quality sampling was conducted at 16 points. Environmental parameters analysed included temperature, salinity, turbidity, dissolved oxygen (DO), chlorophyll-a and depth. Parameter determination was based on previous studies of key environmental parameters for marine mammal habitat and available data. Results showed that marine mammals in Bintuni Bay were found in the turbidity interval of 0.2 -16.7 NTU, temperature 24.7-27.4 ^{0}C, salinity 21.9 - 29.3 ppt, dissolved oxygen 4.10 - 6.30 mg/L, chlorophyll-a 5.38-49.10 μg/L and depth 10-51 m. This data can be utilized to conduct better environmental management for marine mammals as economic activities in Bintuni Bay increase in the future.

Keywords: Bintuni Bay; marine mammal; habitat; environmental key parameter

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1. Introduction

Marine mammals are a group of fauna that play a crucial ecological role in maintaining the balance of aquatic ecosystems. Their role in top-down population control of some prey species (Putra *et al.*, 2025), nutrient cycling (Gilbert *et al*., 2023), and carbon sequestration (Sheehy et al., 2022; Pearson *et al*., 2023) is critical for the stability of these ecosystems.

Bintuni Bay in Papua is one location where marine mammals have been encountered. Surveys by BP Berau Ltd. and PKSPL-IPB (2017, 2019, 2023, 2025) documented species including the Indo-Pacific Bottlenose Dolphin, Indo-Pacific Humpback Dolphin, Spinner Dolphin, Australian Humpback Dolphin, and Melon-headed Whale. Earlier surveys by BP Berau Ltd. and LPPM IPB in 2013 recorded similar dolphin species along with Humpback Whales. This diversity of marine mammal species indicates that Bintuni Bay provides suitable habitat for them.

The existence of marine mammals is highly dependent on stable ecosystem conditions, including water quality, food availability, and adequate living space free from disturbance. However, until now information on the mapping and habitat characteristics of marine mammals in Bintuni Bay has been limited. Sahri *et al*. (2021) revealed that the current knowledge of cetacean spatial distribution, its protection coverage and anthropogenic threats in Indonesia is still very limited though crucial for effective conservation management. At the same time, Bintuni Bay is facing increasing pressure from human activities such as territorial expansion, capture fisheries, shipping, oial and gas exploration and exploitation, mining, and other infrastructure development, which can increase threats to the natural habitat of marine mammals. Without a clear understanding of marine mammal habitat mapping and characteristics, spatial utilisation management in the region could pose a direct threat to marine mammal conservation.

This study aims to map marine mammal sightings in Bintuni Bay, and determine habitat characteristics by estimating key environmental parameters at marine mammal sighting locations. Data analysis uses interpolation methods in a Geographic Information System (GIS). The expected results are information maps that can show marine mammal sightings locations, and key environmental parameter ranges suitable for marine mammal life.

2. Materials and Methods

2.1. Study Area

The study site was situated in Bintuni Bay, West Papua Province. Marine mammal observations were carried out along a fixed boat transect in the bay, with species identification, individual counts, and coordinates recorded for each encounter. Seawater quality sampling occurred at 16 distinct points distributed throughout Bintuni Bay. The spatial configuration of both the March 2025 observation transects and the sampling points is depicted in Figure 1.

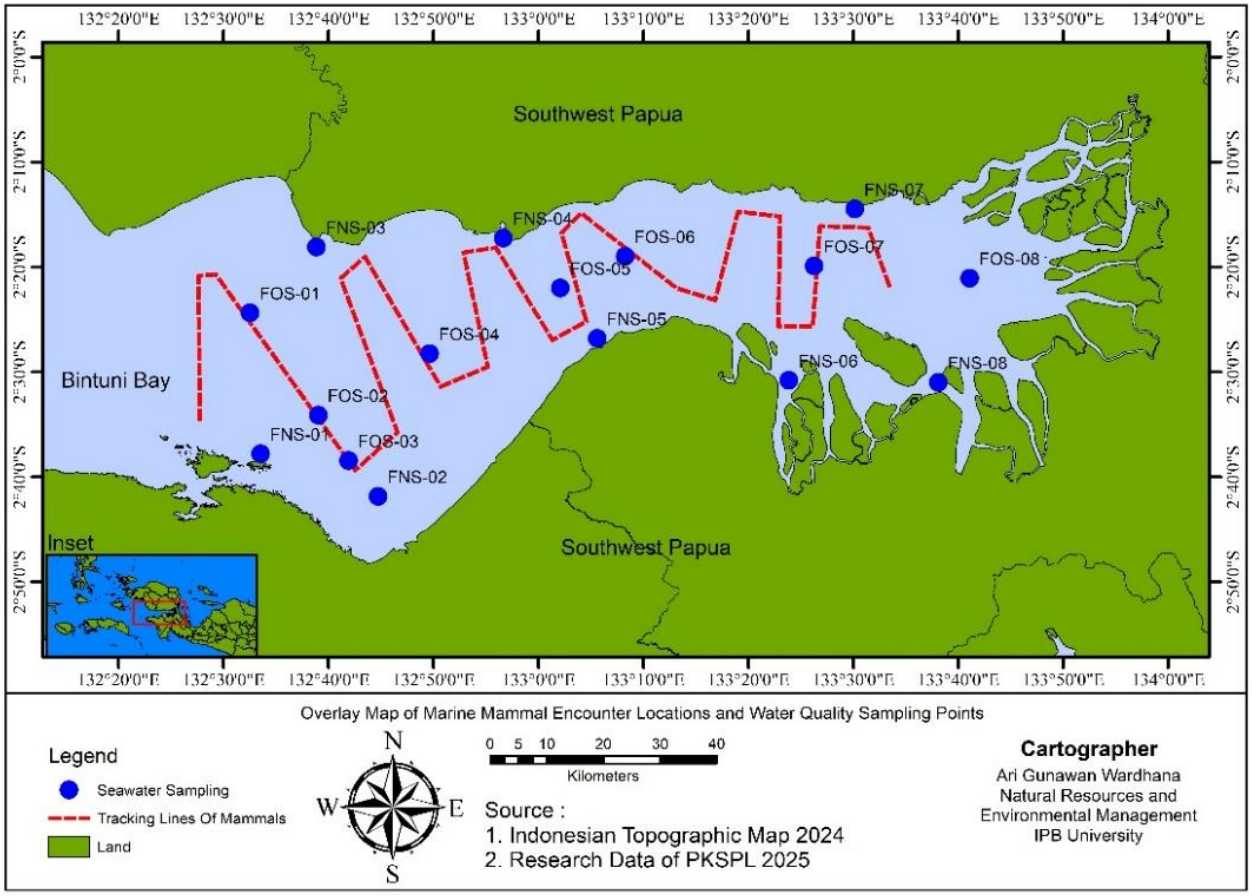

Figure 1. Spatial distribution of marine mammal observation tracks and seawater sampling points along the fixed boat transects conducted in Bintuni Bay, West Papua Province

2.2. Data Collection Method

Environmental data for Bintuni Bay were collected during a survey conducted in March 2025. Marine mammal observations were carried out visually by following predefined boat transects. Marine mammal sightings along the transects were recorded with the date and time of each sighting, geographic coordinates, species identification, and the number of individuals observed. Water quality data were obtained through in situ measurements and laboratory analyses, following standard analytical methods for each parameter.

For the analysis of marine mammal spatial distribution, key environmental parameters were selected based on established research (e.g., Sahri *et al*., 2021; Dai *et al*., 2025; Reisinger *et al*., 2025; Ingrosso *et al*., 2024; Maglietta *et al*., 2023; Levati *et al*., 2025) and data availability. These parameters included sea surface temperature, sea surface salinity, chlorophyll concentration, dissolved oxygen (DO), turbidity, and bathymetry. Bathymetric data were sourced from the Geospatial Information Agency's 2024 National Bathymetry Dataset.

2.3. Data Analysis Method

The spatial distribution of marine mammal encounters in Bintuni Bay was determined by plotting GPS coordinates within a Geographic Information System (GIS) to generate thematic distribution maps. Furthermore, key environmental parameters for the bay were analyzed using the GIS-based Inverse Distance Weighted (IDW) interpolation technique. Interpolation is a mathematical method for predicting values at unsampled locations. Interpolation is often called *resampling* or a method where the imaging method to increase and decrease the number of pixels used to produce a more detailed image. In this method, points closer to the target location have a greater influence, or weight, on the estimated value, while this weight decreases as the distance from the target point increase (Putri and Fauzan, 2024). However, IDW also has weaknesses. According to Benmoshe (2025) its accuracy decreases when there is a cluster of measurement stations or when some measuring stations are hidden behind others.

The IDW method takes distance into account as a weight. The distance in question is the (flat) distance from the data point (sample) to the block to be estimated. IDW calculates values for unknown points by weighting the influence of nearby points inversely proportional to their distance (Cahyani *et al*. 2015).

$$Z_o = \frac{\sum_{i=1}^{s} Zi \, \frac{1}{d_i^k}}{\sum_{i=1}^{s} \frac{1}{d_i^k}}$$

Description:
Z_0 = Approximate value at point 0
Z_i = The z value at control point i
d_i = Distance between point i and point 0
k = Constant
S = Number of S points used

GIS analysis using the IDW method reveals the environmental parameter values at marine mammal sighting locations. These key values are compiled into a table, and their ranges (minimum and maximum) are established.

3. Results

3.1. Spatial Distribution of Marine Mammals in Bintuni Bay

During March 2025 marine mammal surveys, encounters occurred at 19 observation points, involving 90 adults and 5 juveniles. Identified species were primarily dolphins: Bottlenose Dolphin, Spinner Dolphin, and Humpback Dolphin. Additionally, Melon-headed Whales (*Peponocephala electra*) were observed, a species known to inhabit tropical and sub-tropical waters (Kiszka and Jefferson, 2025). The spatial distribution map of marine mammal sightings in Bintuni Bay in March 2025 is presented in Figure 3.

Table 1. Geographic coordinates, species composition, and number of individuals recorded during marine mammal sightings in Bintuni Bay in March 2025

No Sighting	Coordinates		Water Depth (m)	Cetacean Type	Number of Individuals	
	S	E			Adults	Children
1	02° 33′ 30″	132° 27′ 40″	50	*Unidentified Dolphin*	5	0
2	02° 26′ 40″	132° 27′ 35″	39	*Melon Headed Whale*	3	0
3	02° 29′ 23″	132° 35′ 52″	31	*Bottlenose Dolphin*	3	0
4	02° 30′ 03″	132° 36′ 18″	31	*Bottlenose Dolphin*	2	0
5	02° 30′ 19″	132° 36′ 28″	46	*Spinner Dolphin*	3	0
6	02° 33′ 52″	132° 38′ 55″	32	*Unidentified Dolphin*	2	0
7	02° 37′ 55″	132° 41′ 90″	24	*Unidentified Dolphin*	2	0
8	02° 19′ 52″	132° 42′ 36″	31	*Unidentified Dolphin*	1	0
9	02° 16′ 10″	133° 02′ 50″	25	*Humpback Dolphin*	4	0
10	02° 15′ 13″	133° 03′ 30″	19	*Humpback Dolphin*	1	0
11	02° 15′ 20″	133° 05′ 02″	19	*Unidentified Dolphin*	2	0
12	02° 15′ 26″	133° 05′ 07″	19	*Spinner Dolphin*	19	4
13	02° 17′ 16″	133° 18′ 30″	41	*Humpback Dolphin*	2	0
14	02° 19′ 02″	133° 23′ 02″	51	*Humpback Dolphin*	2	0
15	02° 19′ 28″	133° 23′ 00″	49	*Humpback Dolphin*	3	0
16	02° 24′ 44″	133° 21′ 59″	-	*Humpback Dolphin, Spinner Dolphin, Bottlenose Dolphin*	30	1
17	02° 26′ 21″	133° 21′ 30″	10	*Humpback Dolphin*	2	0
18	02° 18′ 42″	133° 26′ 26″	46	*Humpback Dolphin*	2	0
19	02° 16′ 14″	133° 31′ 28″	23	*Humpback Dolphin*	2	0
				Total	**90**	**5**

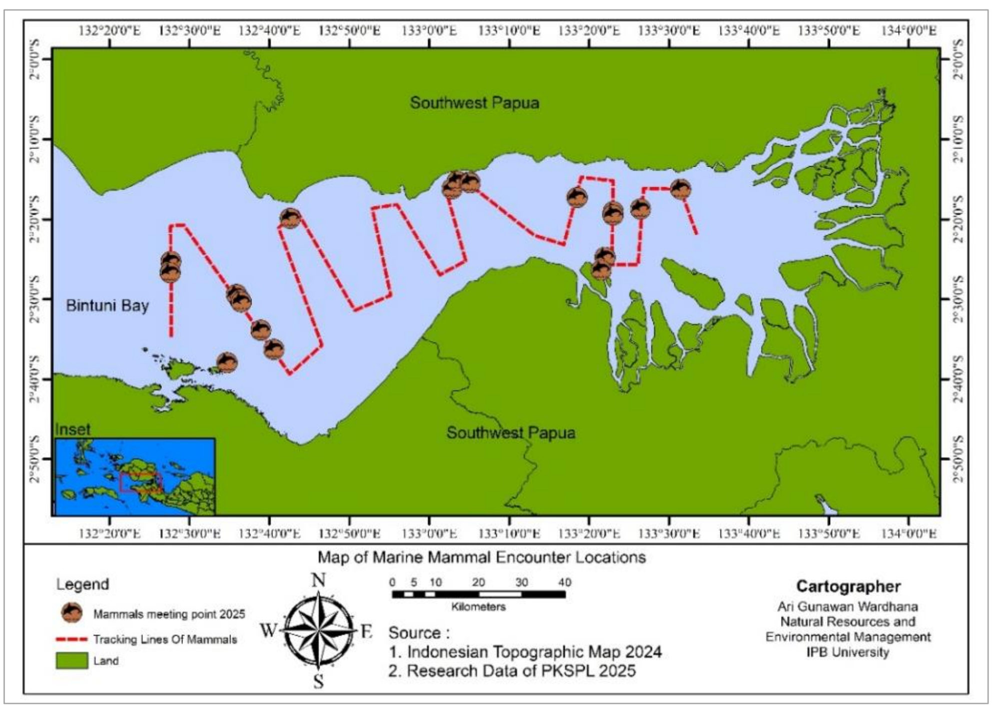

Figure 3. Spatial distribution of marine mammal observation tracks and encounter points in Bintuni Bay, West Papua Province

3.2. Marine Mammals Distribution and Key Environmental Parameter Conditions

The results of interpolating key environmental parameter values using IDW are presented in the figures below:

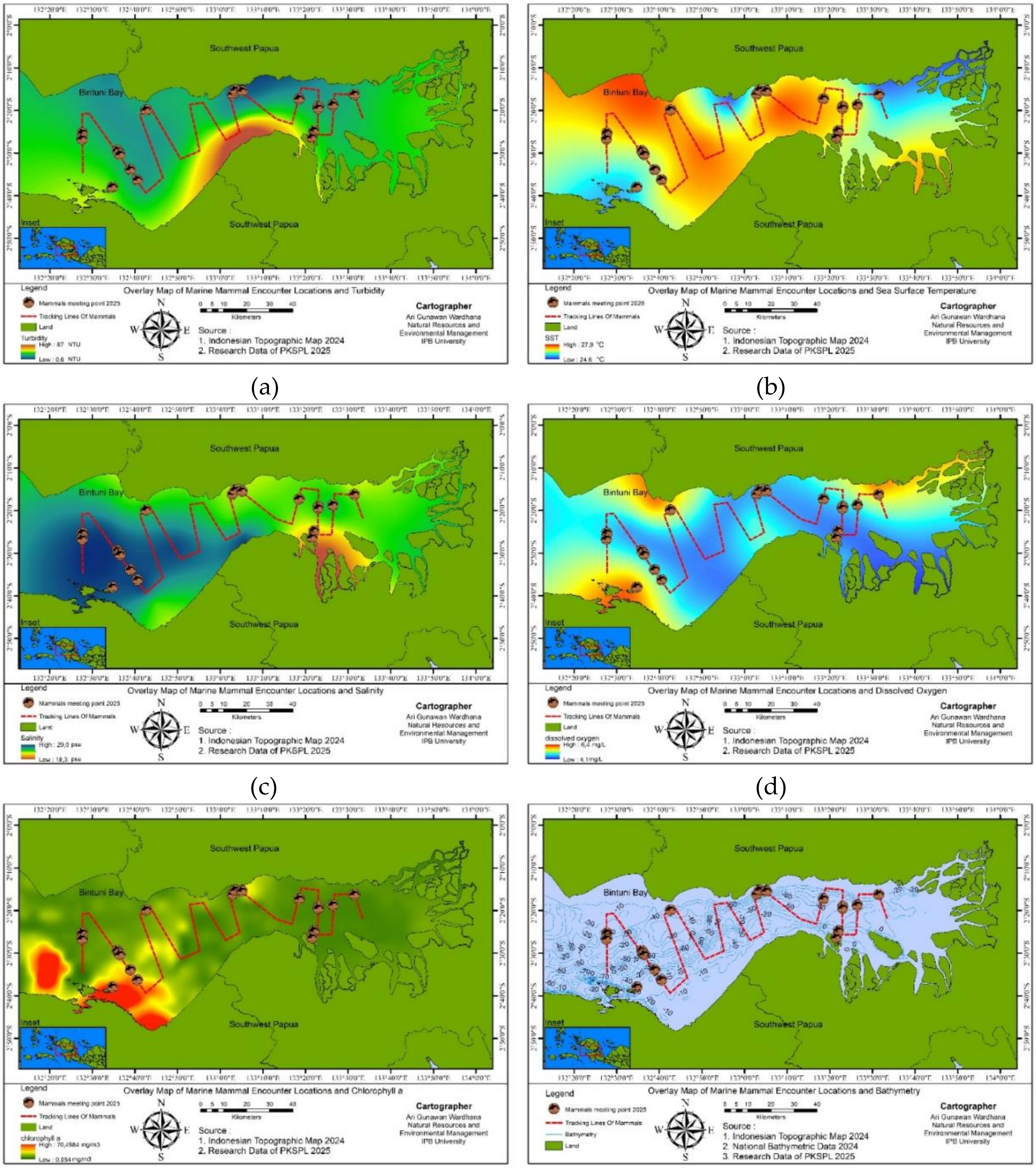

Figure 4. Overlay Map of the Distribution of Marine Mammal Sightings and the Parameters of Turbidity (**a**), Temperature (**b**), Salinity (**c**), Dissolved Oxygen (**d**), Chlorophyll-a (**e**) and Depth (**f**) in Bintuni Bay

GIS analysis revealed marine mammals in Bintuni Bay inhabit waters with turbidity levels between 0.2 and 16.7 NTU. Most individuals occurred in clearer waters (low turbidity), while a minority were found in cloudier areas (Figure 4.a). Low turbidity enhances visibility for foraging. Although Government Regulation No. 22/2021 (Appendix VIII) sets a maximum turbidity standard of 5 NTU for biota survival, these mammals persist in waters exceeding this limit. This tolerance may stem from their reliance on food sources (small fish) found specifically in these higher-turbidity zones.

Marine mammals in Bintuni Bay were primarily encountered at sea surface temperatures of 26-27°C. Out of 19 recorded encounter points, two occurred at lower temperatures. Based on geographic information system (GIS) analysis, the temperature range associated with marine mammal presence in the bay was 24.7°C to 27.4°C (Figure 4.b).

Marine mammals in Bintuni Bay inhabit waters with a relatively high salinity range (21.9 - 29.3 ppt; Figure 4.c), showing a preference for salinities around 26-27 ppt. This salinity is low compared to the typical Indonesian marine range of 32-35 ppt, likely due to significant freshwater input from surrounding rivers.

Dissolved oxygen in Bintuni Bay waters varied from 4.10 to 6.30 mg/L (Figure 4.d). This range encompasses the 4-5 mg/L levels preferred by marine mammals. According to Indonesian water quality standards (Gov. Reg. No. 22/2021, Appendix VIII; >5 mg/L), the oxygen content in the bay is sufficient to support aquatic biota.

In Bintuni Bay, chlorophyll-a levels where marine mammals occur range from 5.38 to 49.10 μg/l (Figure 4.e), classifying these waters as mesotrophic to eutrophic. This indicates a food chain supported by high productivity: elevated chlorophyll signifies abundant phytoplankton, which sustain zooplankton and small fish, the primary prey for marine mammals. The high chlorophyll-a levels in Bintuni Bay likely result from significant nutrient inputs from rivers discharging into the bay and extensive tidal transport of mangrove leaf litter.

Marine mammals in Bintuni Bay occur across a broad depth range of 10-51 m (Figure 4.f), with the highest concentrations found between 20-40 m. Their presence in shallow waters (~10 m) is likely driven by the need to pursue small fish for food.

Applying Inverse Distance Weighted (IDW) interpolation within a Geographic Information System (GIS) revealed characteristic ranges for key environmental parameters at marine mammal encounter sites (Table 2).

Table 2. Characteristic of Marine Mammal Habitat in Bintuni Bay

No	Key Parameters	Unit	Value Range
1	Turbidity	NTU	0.2 - 16.7
2	Temperature	^{0}C	24.7 - 27.4
3	Salinity	ppt	21.9 - 29.3
4	Oxygen Content (DO)	mg/L	4.10 - 6.30
5	Chlorophyll-a	μg/L	5.38 - 49.10
6	Depth	m	10 - 51

4. Discussion

Research on the distribution of marine mammal habitats in Bintuni Bay has been conducted previously by Sahri *et al*. in 2021. The key parameters used consisted of bathymetry, slope, distance to shore, sea surface temperature, and sea surface salinity. The marine mammal species modelled was the Australian humpback dolphin (*Sousa sahulensis*). Species distribution modelling was performed using Maxent software version 3.4.1. This software is capable of analysing the parameters most influential on species distribution in a given area. The modelling results indicate that *Sousa sahulensis* primarily utilises estuarine areas. Areas further from the coast appear less suitable for this species. The distribution of *S. sahulensis* is determined by distance from the coast and sea depth. The preferred habitat of *S. sahulensis* is closer to the coast in areas with a depth of around 23 metres.

The results of Sahri *et al*.'s research are similar to the species found in Bintuni Bay, namely the Australian humpback dolphin (*Sousa sahulensis*). In terms of environmental parameters, the research by Sahri *et al*. shows that *S. sahulensis* is only found near the coast at a depth of 23 metres. Meanwhile, the observations in this study show that the same species is found from near the coast to the middle of the bay at a depth of 51 metres.

The results of this study can be used as input for modelling the distribution of marine mammal species in Bintuni Bay. The model results can then be overlaid with spatial planning or conservation area plans to identify any discrepancies between the allocated space and the location of marine mammal habitats. The zonation review and evaluation took into account habitat protection areas and categorised migration routes (Mujiyanto *et al*. 2017). Management and mitigation efforts need to be developed for spatial allocations of activities that may impact marine mammals, including reducing vessel speeds, implementing procedures for handling marine mammals during oil and gas seismic activities, and using environmentally friendly fishing gear for fishing activities.

5. Conclusions

Based on the results of geographic information system analysis using the interpolation method, namely IDW or Inverse Distance Weighted, a range of key environmental parameter values can be made from the meeting point with marine mammals (Table 2). These value ranges serve as indicators: when water conditions exhibit similar parameter concentrations, there is a high likelihood of finding marine mammals in Bintuni Bay.

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