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CORELATION OF SEA SURFACE TEMPERATURE AND CHLOROPHYL CONCENTRATIONS WITH PRESENCE OF DOLPHINS IN KILUAN BAY, LAMPUNG

Hubungan Suhu Permukaan Laut dan Konsentrasi Klorofil dengan Kemunculan Lumba-Lumba di Teluk Kiluan, Lampung

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ABSTRACT

Kiluan Bay is one of the marine conservation areas in Tanggamus Regency, Province of Lampung through which dolphins migrate. This research aims to analyze the relationship between the distribution of sea surface temperature and chlorophyll with the appearance of dolphins in Kiluan Bay. This research uses an exploratory survey method. The research results show that the highest appearance of dolphins was in the Transition Season I, around 117 in the temperature range of 29,44-29,88°C with a chlorophyll concentration of 0,120-0,184 mg/m³ and the lowest in the West Season was around 31 in the temperature range of 28,56-29,34°C with a chlorophyll concentration of 0,096-0,134 mg/m³. The appearance of dolphins is more strongly related to sea surface temperature than to chlorophyll concentration because dolphins do not eat phytoplankton directly where there is a time lag where increasing the chlorophyll concentration value does not immediately have an impact on increasing the intensity value of dolphin emergence, but requires some predation time**.**

Keywords: Chlorophyl, Dolphin, Kiluan Bay, Sea Surface Temperature

ABSTRAK

Teluk Kiluan merupakan salah satu kawasan konservasi perairan yang ada di Kabupaten Tanggamus, Provinsi Lampung yang dilalui migrasi dari lumba-lumba. Penelitian ini bertujuan menganalisis hubungan sebaran suhu permukaan laut dan klorofil dengan kemunculan lumba-lumba di Teluk Kiluan. Penelitian ini menggunakan metode survei jelajah. Hasil penelitian menujukkan kemunculan lumba-lumba tertinggi pada Musim Peralihan I sekitar 117 kali pada kisaran suhu 29,44-29,88°C dengan konsentrasi klorofil 0,120-0,184 mg/m³ dan terendah pada Musim Barat sekitar 31 kali pada kisaran suhu 28,56-29,34°C dengan konsentrasi klorofil 0,096-0,134 mg/m³. Kemunculan lumba-lumba lebih berhubungan kuat dengan suhu

permukaan laut dibandingkan dengan konsentrasi klorofil dikarenakan lumba-lumba tidak memakan langsung fitoplankton dimana ada waktu sela (*time lag*) dimana naiknya nilai konsentrasi klorofil tidak langsung berdampak pada naiknya nilai intensitas kemunculan lumba-lumba, tetapi membutuhkan beberapa waktu pemangsaan.

Kata Kunci: Klorofil, Lumba-Lumba, Teluk Kiluan, Suhu Permukaan Laut

INTRODUCTION

Kiluan Bay is one of the marine conservation areas in Tanggamus Regency, Lampung Province with an area of 72,211.68 hectares (Ha) (KKP, 2019). Kiluan Bay is one of the locations through which marine mammals migrate. These marine mammals are dolphins. Dolphins are marine mammals that belong to the cetacean order that have teeth (odontoceti) (Serres & Delfour, 2019). The presence of dolphins in waters is greatly influenced by sea surface temperatures (La Manna et al., 2023). Temperature is an important factor in the life of marine organisms because it affects metabolic activity, the reproduction process and can be an indicator of climate change phenomena (Mintzer & Fazioli, 2021). In addition to temperature, the presence of biota in the sea is also influenced by other parameters such as chlorophyll (Kusuma et al., 2024). Chlorophyll describes the presence of phytoplankton content which plays a role as primary productivity in the food chain (Connor et al., 2019). High concentrations of chlorophyll in the sea indicate the presence of sufficient plankton to maintain food availability for small fish which are food for dolphins (Borja et al., 2022). Dolphins are one of the protected marine biota in accordance with Law Number 5 of 1990 concerning Conservation of Natural Resources and Ecosystems and Government Regulation Number 7 of 1999 concerning Preservation of Plant and Wild Animal Species (Rosmini et al., 2022). According to the international wildlife trade agreement Convention on International Trade in Endangered Species of World Fauna and Flora (CITES) dolphins are included in the Appendix II category while the International Union for the Conservation of Nature and Natural Resources (IUCN) where the status of the dolphin population in Indonesia is currently threatened (Sultanah et al., 2024). However, on the other hand, public knowledge about dolphins is still very minimal, so this leads to unwise utilization of marine biota (Heriyani, 2022). Illegal fishing and hunting activities, shipping and shipping, marine tourism and environmental degradation both naturally and anthropogenically result in threats to dolphins which ultimately cause the dolphin population to decrease (de Vere et al., 2018). Holistic research efforts are the basis for dolphin conservation to maintain sustainability but are still limited and have not received special attention. This is evidenced by the lack of scientific information related to dolphins in Kiluan Bay. This study aims to analyze the relationship between the distribution of sea surface temperature and chlorophyll with the emergence of dolphins in Kiluan Bay. The benefits of the research conducted are to provide information as input for the management of cetacean conservation groups, especially dolphins in Kiluan Bay.

METHODS

Time and Location of the Research

This research was conducted from June to December 2022 in the waters of Kiluan Bay, Tanggamus Regency, Lampung Province (Figure 1).

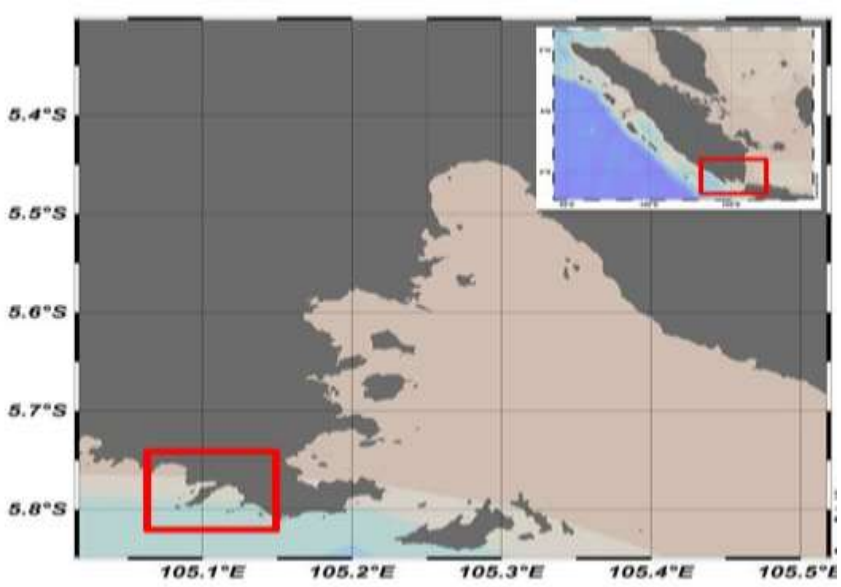


Figure 1. Map of the Research Location

Tools and Materials

The tools used in this study were outboard motorboats for marine surveys, GPS (Global Positioning System) to mark the coordinate positions of dolphin appearances, digital cameras to document dolphin appearances, watches to see the time of dolphin appearances, binoculars and dolphin identification books to identify dolphin species, Arc GIS 8.0 software and Microsoft Excel 2022 for data processing. The materials used in this study were reanalysis data of hydro-oceanographic parameters such as sea surface temperature and chlorophyll concentration.

Working Procedure

This study used the exploration survey method (Perrin et al., 2018; Diogou et al., 2019). The use of the exploration survey method is carried out in a zigzag manner which aims to obtain information on the abundance of dolphins and avoid glare from sunlight. This method consists of 4 observers placed on the front deck, on the left, middle and right of the ship. The recorded information data is the date and time of appearance, the coordinate position of the type, number, sea surface temperature and chlorophyll concentration.

Data Analysis

The coordinate data of the appearance of dolphins is plotted into using Arc GIS software through a digitization and overlay process, then correlated with sea surface temperature and chlorophyll concentration, then discussed descriptively (Dréo et al., 2019; Hartoko et al., 2019).

RESULTS

Distribution of Sea Surface Temperature with the Appearance of Dolphins

Temperature is a factor that plays a major role in the physiological processes and distribution of organisms in the sea. The distribution of sea surface temperature with the appearance of dolphins can be seen in Figure 2.

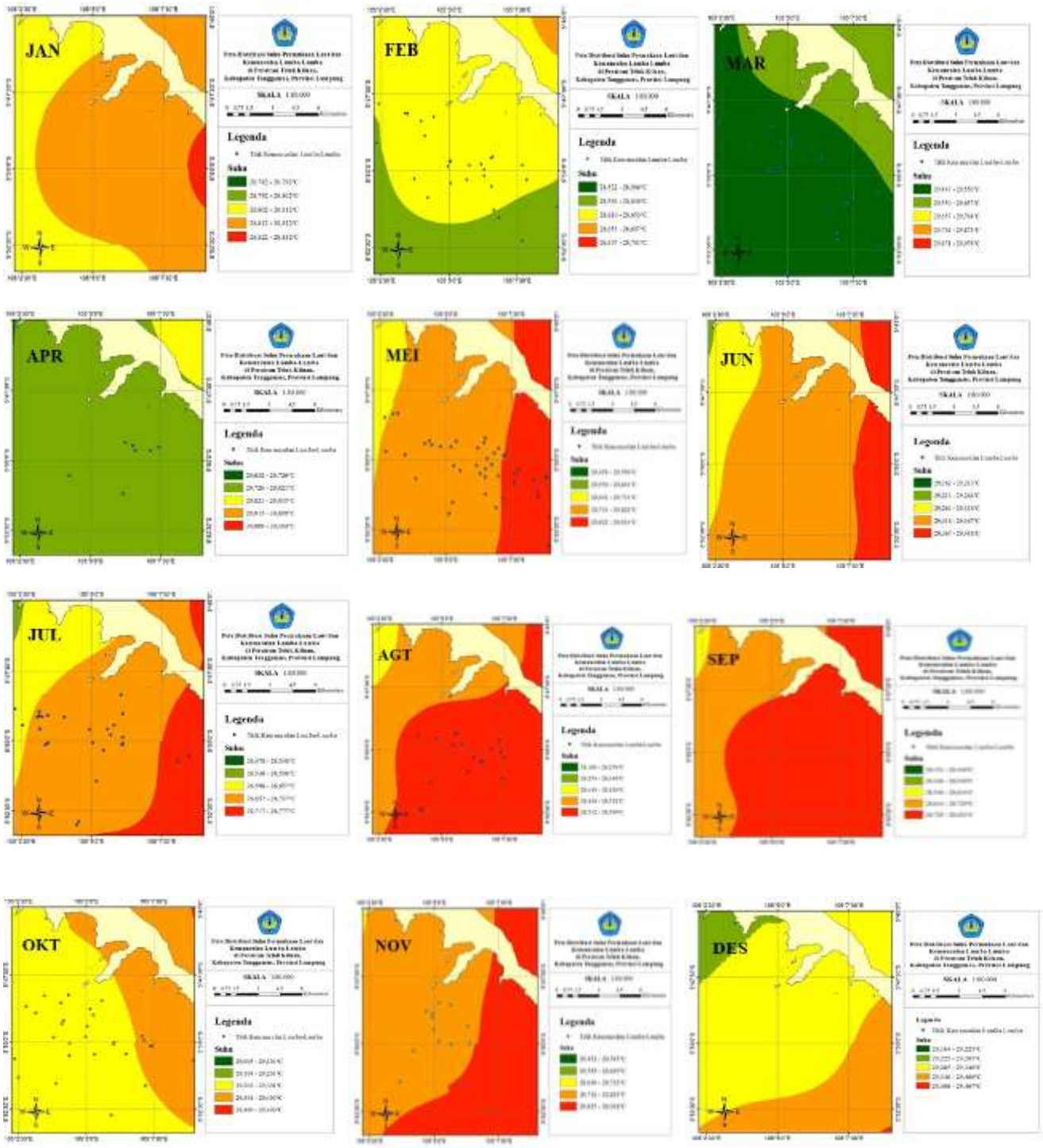


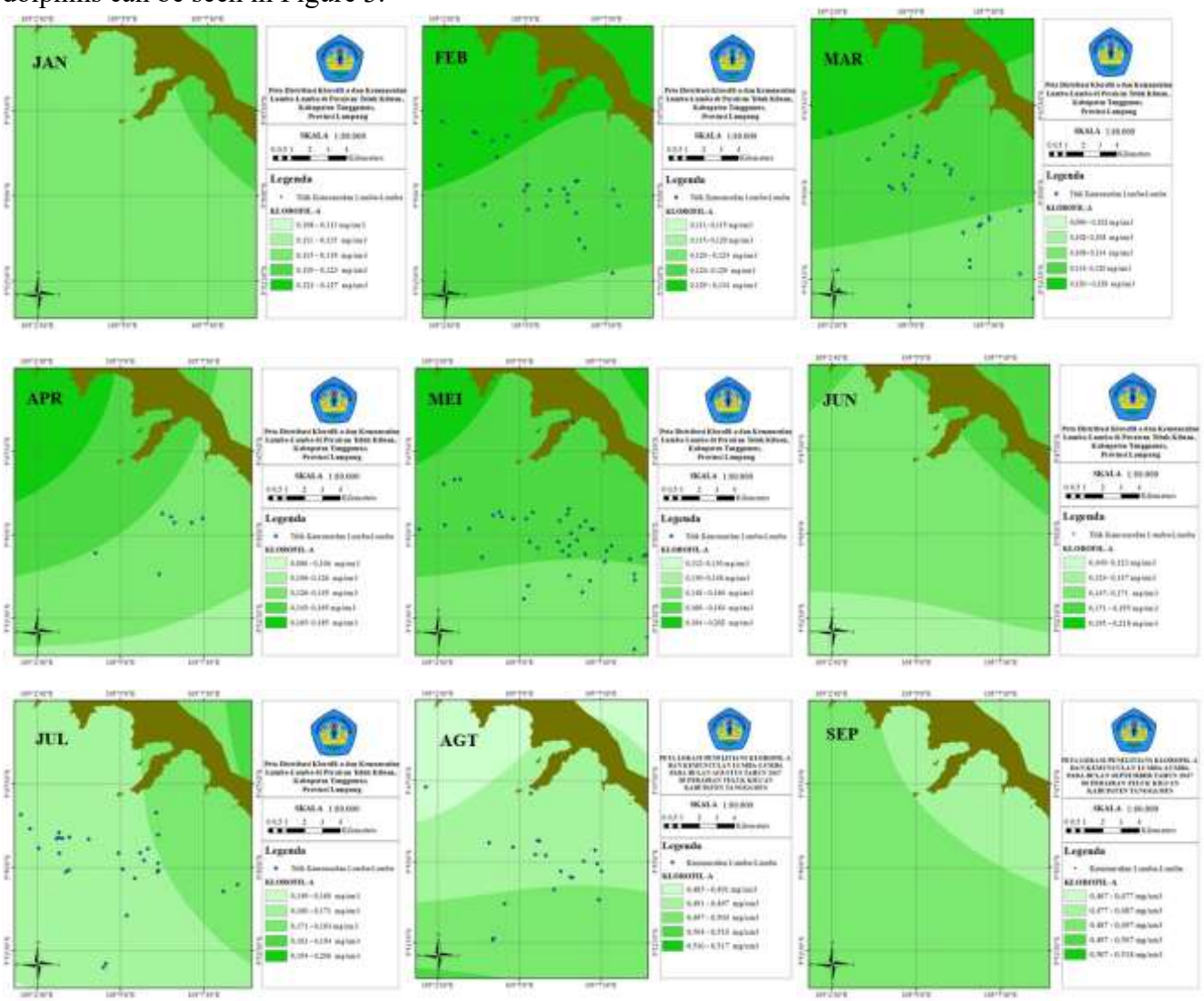
Figure 2. Distribution of Sea Surface Temperature with the Appearance of Dolphins

The sea surface temperature of Kiluan Bay waters ranges from 28.42-29.88°C. The water temperature of Kiluan Bay in the West Season ranges from 28.56-29.34°C, Transition Season I ranges from 29.44-29.88°C, East Season ranges from 28.42-29.36°C and Transition Season II ranges from 28.63-29.82°C. The highest water temperature in Transition Season I ranges from 29.44-29.88°C and the lowest in the West Season ranges from 28.56-29.34°C. The water temperature in the West Season ranges from 27-28°C, Transition Season I ranges from 28-31°C, East Season ranges from 29.5-30.5°C and Transition Season II ranges from 28.5-30.05°C (Khoirunnisa et al., 2017; Amri et al., 2014; Wirasatriya et al., 2018). The appearance of

dolphins in the West Season is around 31 times, Transition Season I is around 117 times, East Season is around 71 times and Transition Season II is around 64 times. The highest dolphin appearance is in Transition Season I around 117 times and the lowest is in the West Season around 31 times. The highest dolphin occurrence was in Transition Season I, 117 times at a temperature range of 29.44-29.88°C, while the lowest was in the West Season, 31 at a temperature range of 28.56-29.34°C. Sutton et al. (2019) said that the range of sea surface temperatures for cetaceans was found in the range of 25-33ºC in the East Nusa Tenggara National Park.

Distribution of Chlorophyll with the Occurrence of Dolphins

Chlorophyll is a pigment found in almost all types of phytoplankton. Chlorophyll is an indicator of the fertility of waters. The distribution of chlorophyll with the occurrence of dolphins can be seen in Figure 3.



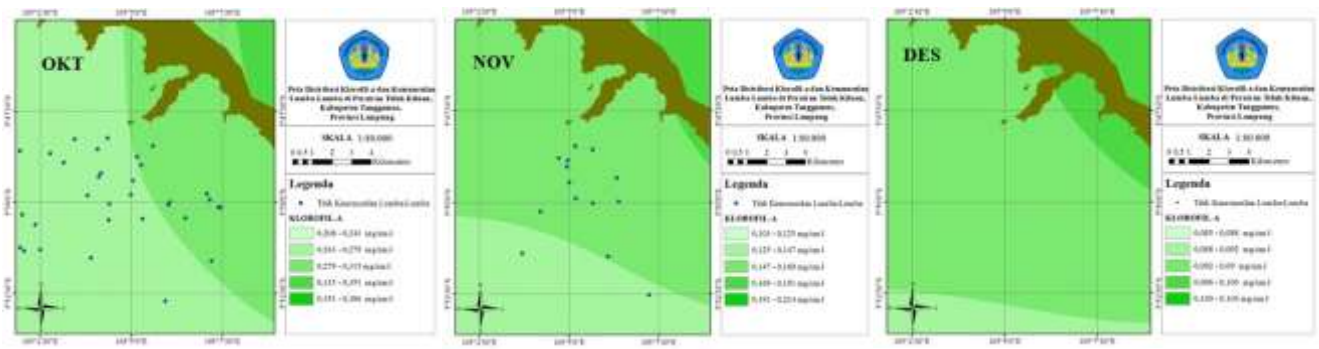


Figure 3. Distribution of Chlorophyll with the Occurrence of Dolphins

Chlorophyll concentration ranges from 0.096-0.497 mg/m³. Chlorophyll concentration of Kiluan Bay in West Season ranges from 0.096-0.134 mg/m³, Transition Season I ranges from 0.120-0.184 mg/m³, East Season ranges from 0.171-0.497 mg/m³ and Transition Season II ranges from 0.147-0.477 mg/m³. The highest chlorophyll concentration in East Season ranges from 0.171-0.497 mg/m³ while the lowest in West Season ranges from 0.096-0.134 mg/m³. Chlorophyll concentration in the West Season ranges from 0.1-1.0 mg/m³, Transition Season I ranges from 0.8-2.0 mg/m³, East Season ranges from 0.8-3.5 mg/m³ and Transition Season II ranges from 0.8-3.0 mg/m³ (Khoirunnisa et al., 2017; Amri et al., 2014; Wirasatriya et al., 2018). The highest dolphin occurrence was in Transition Season I as many as 117 times in the range of chlorophyll concentration of 0.120-0.184 mg/m³ while the lowest was in the West Season as many as 31 in the range of chlorophyll concentration of 0.096-0.134 mg/m³. The concentration of chlorophyll at the time of cetacean emergence in the Sawu Sea is around 0.06-0.87 mg/m^3 (Putra et al., 2016). Huo et al. (2020) stated that the optimal chlorophyll concentration is in the range of 0.02-0.7 mg/m^3 indicating fertile and nutrient-rich waters.

Relationship between Sea Surface Temperature and Chlorophyll with Dolphin Emergence

Temperature is an important factor in the life of marine organisms. In addition to temperature, the presence of biota in the sea is also influenced by other parameters such as chlorophyll. The range of sea surface temperature and chlorophyll with dolphin emergence can be seen in Table 1.

Table 1. Range of Sea Surface Temperature and Chlorophyll with Dolphin Emergence

No	Month	Number of Occurrences	Temperature (°C)	Chlorophyll (mg/m^3)
1	January	-	28.81-28.82	0.115-0.119
2	February	31	28.56-28.65	0.129-0.134
3	March	44	29.44-29.65	0.120-0.126
4	April	13	29.72-29.82	0.145-0.165
5	May	60	29.73-29.88	0.166-0.184
6	June	-	29.31-29.36	0.171-0.195
7	July	33	28.59-28.71	0.183-0.194
8	August	38	28.42-28.51	0.491-0.497
9	September	-	28.63-28.82	0.467-0.477
10	October	50	29.03-29.40	0.279-0.315
11	November	14	29.73-29.82	0.147-0.619
12	December	-	29.28-29.34	0.096-0.100

The highest dolphin occurrence in Transition Season I was around 117 times at a temperature range of 29.44-29.88°C with a chlorophyll concentration of 0.120-0.184 mg/m³ and the lowest in the West Season was around 31 times at a temperature range of 28.56-29.34°C with a chlorophyll concentration of 0.096-0.134 mg/m³. Maro et al. (2021) said that dolphins are often found at sea surface temperatures ranging from 26.4-30.5°C and chlorophyll concentrations ranging from 0.3-0.6 mg/m^3. Cetacean groups prefer areas of water mass mixing with high primary productivity and optimal sea surface temperatures (Sutton et al., 2019).

Identification of Types and Time of Appearance of Dolphins

The dolphins found in Kiluan Bay Waters are bottlenose dolphins (*Tursiops truncatus*). *T. trucantus* has a relatively upright body with a short snout with a high dorsal fin that ends slightly bent like a crescent moon and emerges from the middle of the back. The back is light gray to slightly black and sometimes spotted. There is a dark line from the eyes to the flippers. These dolphins are commonly found in the Indian Ocean (Morton et al., 2021). The results of the study showed that the intensity and number of appearances of dolphins in Kiluan Bay were highest in the morning at intervals compared to noon and evening. The visual behavior of dolphins includes traveling (swimming in groups), resting (swimming slowly), and foraging (looking for food).

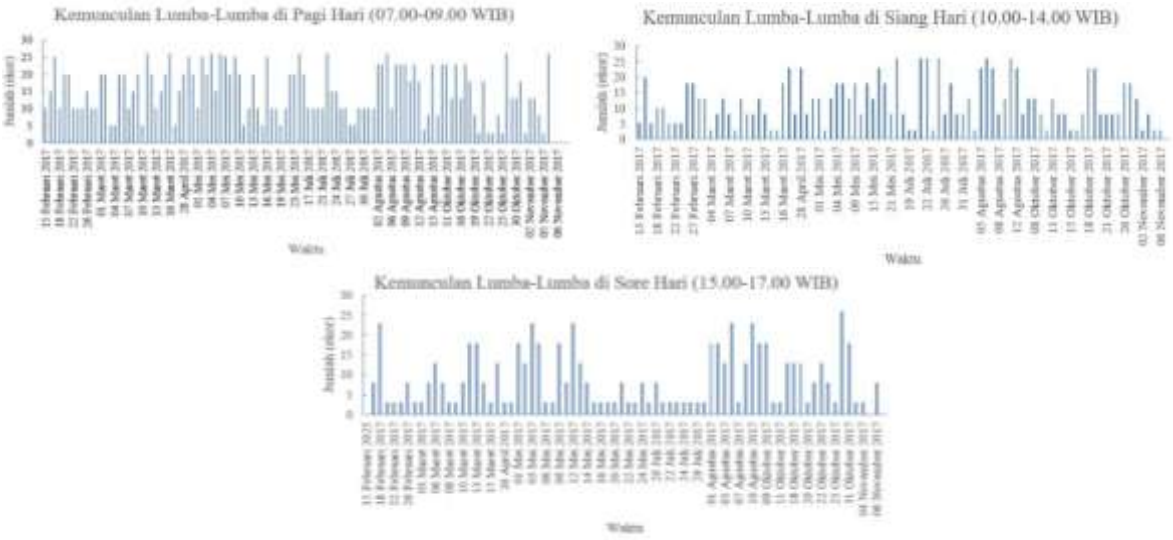


Figure 4. Time of Appearance of Dolphins in (a) Morning, (b) Afternoon and (c) Evening

DISCUSSION

The waters of Kiluan Bay are part of Semangka Bay which cannot be separated from the influence of water masses from the Indian Ocean and Java Sea through the Sunda Strait. Water masses in the Java Sea tend to be characterized by high temperatures while water masses from the Indian Ocean have lower temperatures. In the West Season the water temperature is very cold due to the push of water masses with cold temperatures from the Indian Ocean towards the Java Sea through the Sunda Strait. In addition, this is influenced by high rainfall. In Transition Season I, the transition from the West Season to the East Season is marked by the highest water temperature. This is because wind friction is not too great so that heating takes place very optimally. In the East Season the temperature is warm because the water mass from the Java Sea pushes into the Indian Ocean through the Sunda Strait. This indicates that there is a dominance of water masses from the Java Sea. In Transition Season II, the transition from the East Season to the West Season. The water temperature in Transition Season II is still quite high but lower than the East Season. This shows that there is still an indication of the dominance

of warm water masses originating from the Java Sea. Dolphins appear a lot in Transition Season I because in this season the sea surface temperature is high and is considered the optimal temperature for plankton breeding, increasing the density and biodiversity of plankton, and the ecological function as an attraction for migration to the area to find food and breed small fish, cephalopods, and ultimately cetaceans, as top predators in the food chain. Frantzis et al. (2011) added that groups of whales and dolphins migrate to waters rich in plankton and prey. The movement of currents from the Indian Ocean entering through the Sunda Strait meets the water mass from the Java Sea causing a process of mixing water masses and producing sea water masses rich in nutrients and primary productivity (Suton et al., 2019; Li & Yu, 2020). These supportive conditions attract a number of pelagic fish and other migratory species to search for food, thus encouraging migration patterns (Chung & Gong, 2019 & Lyu et al., 2016). Therefore, dolphins come to Kiluan Bay to search for food.

The chlorophyll concentration is very low due to the strong influence of the circulation of water masses from the Indian Ocean which is identical to cold temperatures and low chlorophyll. In Transition Season I, the chlorophyll concentration begins to increase higher than the West Season. This is related to the entry of water masses from the Java Sea which is the estuary of rivers in Java and Kalimantan. In the East Season, the chlorophyll concentration increases until it reaches its peak. In this season, there is a very strong influence from the flow of water masses from the Java Sea. This season can be said to be the optimal season for chlorophyll concentration. In addition, the high chlorophyll concentration in the East Season is also due to the influence of the upwelling phenomenon in South Java and also affects the surrounding waters. In Transition Season II, the chlorophyll concentration is still quite high but not higher than in the East Season. This shows that there is still a strong influence from the water mass from the Java Sea. High primary productivity in the sea will increase the biomass of small fish species and squid (cephalopods), considered as the main prey and ultimately attract marine mammal species such as whales and dolphins, which migrate to feed (Simond et al., 2019). Chlorophyll concentration describes the abundance of plankton in the waters which can be associated with plankton-eating fish found in these waters which are pelagic fish for dolphin food. In waters that have a high enough chlorophyll concentration, there is enough food for these fish. With the abundance of food for dolphins, dolphins will always come to the area to feed.

The occurrence of dolphins with sea surface temperature is more closely related to chlorophyll concentration. Dolphins prefer water masses with warm temperatures. This indicates that sea surface temperature has a greater effect on the occurrence of dolphins than chlorophyll because dolphins do not directly eat phytoplankton. Dolphins are one of the predators of small fish, crustaceans and squid. Therefore, there is a time lag between the time of increasing chlorophyll concentration and the increase in the number of dolphin occurrences. High chlorophyll concentrations are not always followed by an increase in dolphin occurrences, this is because there is a time lag where the increase in chlorophyll concentration does not directly affect the increase in the intensity of dolphin occurrences, but it takes some time so that chlorophyll as an indication of phytoplankton has been utilized by zooplankton as a food source, then zooplankton will be utilized by small fish as food for predatory organisms such as dolphins.

The number and intensity of dolphin occurrences in Kiluan Bay are greater in the morning compared to the afternoon and evening. It is suspected that dolphin activity is influenced by time. Time is related to the position of the sun's angle which is thought to affect the temperature of the sea surface. In addition to the position of the sun's angle, it is also influenced by the temperature of the sea surface. In the morning the sea surface temperature is relatively cooler and warmer, while during the day the sea surface temperature is higher and in the afternoon the waters still have a high temperature. The higher the position of the sun, the

greater the angle of incidence of light formed and will affect the sea surface temperature. Marine mammals relatively prefer relatively cool and warm surface temperatures for activities and avoid hot sea surface temperatures. The appearance of dolphins occurs most on Lovina Beach, Bali, stating that in the morning at 09.00-11.00 WITA (Purwahita, 2019). However, the results of the study differ from (Subhan et al., 2024) where dolphins in the Maurole waters, East Nusa Tenggara, occur more in the afternoon at 16.00 WITA. This is thought to be because marine mammals go to a place to rest after doing activities in the morning and afternoon. Cetaceans that appear on the surface of sea waters in the morning show migration behavior to search for food and reproduce (Diogou et al., 2019).

CONCLUSION

Sea surface temperature and chlorophyll concentration in Kiluan Bay vary throughout the year, influenced by differences in seasonal water mass circulation in Indonesian waters. The highest sea surface temperature in Kiluan Bay occurs in Transition Season I while the lowest occurs in the West Season. The highest chlorophyll concentration is in the East Season while the lowest is in the West Season. The emergence of dolphins is more strongly related to sea surface temperature than to chlorophyll concentration because there is a time lag where the increase in chlorophyll concentration values but requires some time for the predation process.

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