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Geographical Analysis of the Relationship between Sampling Locations and Biological Variables of *Octopus cyanea* in Indonesian Waters

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ABSTRACT

This study aimed to analyze the relationship between sampling locations and biological variables of *Octopus cyanea* in Indonesian waters. Understanding the distribution and biological characteristics of this species is crucial for conservation and resource management. Sampling was conducted in the Alas Strait from July 2023 to June 2024, covering six stations with different environmental variations. Data collected included body size (length and weight) and geographic coordinates. Data analysis used descriptive statistics, Pearson correlation, and regression to explore the relationship between location and biological variables. Principal Component Analysis (PCA) results showed significant morphometric variation among individuals. Regression analysis showed a strong relationship between octopus length and weight at all stations, following an allometric growth model. Variations in sea depth and currents also contributed to differences in growth patterns. This study emphasizes the importance of environmental factors in influencing the growth and size of *O. cyanea*, with implications for sustainable fisheries management strategies.

INTRODUCTION

Indonesian waters are among the areas with the highest marine biodiversity in the world, providing a variety of resources that are both ecologically and economically important **(FAO, 2018; Kusuma *et al*., 2019)**. Among this wealth, the existence of invertebrate species such as *Octopus cyanea* is crucial to study, particularly regarding their sustainability in their natural habitats and their potential benefits **(Avila-Poveda, 2009)**. This species is widespread throughout Indonesia and plays an ecological role as a predator in coastal zones and the seabed **(Putra & Sari, 2020)**.

Understanding the distribution patterns and biological characteristics of *Octopus cyanea* relies heavily on sampling at various geographic locations **(Helfman, 2008)**. Sampling locations not only influence population representation but also influence observed biological variables, such as body size, weight, and age **(Harahap *et al*., 2021)**. Therefore, systematic geographic surveys are crucial so that the data obtained reflect actual conditions and can be used to support conservation and sustainable resource management.

The use of spatial analysis technology, such as Geographic Information Systems (GIS), allows researchers to accurately map the distribution of sampling locations and identify environmental factors that influence the biological variability of these species **(Fadli *et al*., 2018)**. This approach can help uncover patterns of relationships that might be hidden from conventional statistical data alone, thereby improving decision-making in marine resource management.

Furthermore, in the context of ecosystem-based natural resource management, it is crucial to deeply understand the relationship between sampling locations and observed biological variables **(Alejo-Plata & Gómez-Márquez, 2011)**. This spatial data can reveal biological differences between populations at various geographic points and the environmental factors that influence them. With this knowledge, more specific and effective conservation strategies can be designed to maintain the sustainability of *Octopus cyanea* populations in coastal areas of Indonesia **(Diana & Rahman, 2022)**.

Finally, this study of the geographic relationship between sampling locations and biological variables is expected to make a significant contribution to the development of a comprehensive ecological database in Indonesia, as well as supporting efforts to manage marine resources more wisely and responsibly **(Mulyani *et al.*, 2023, 2024)**. Thus, it is important for researchers to apply a multidisciplinary approach in understanding the population dynamics and geographical distribution of these invertebrate species.

MATERIALS AND METHODS

Research approach and design

This research adopted a quantitative approach with a correlational study design. The primary focus of the study was to analyze the relationship between sampling locations and biological variables of *Octopus cyanea* geographically and statistically. This approach enabled researchers to obtain objective numerical data that could be statistically analyzed to determine meaningful relationships.

Research location and time

Data collection was conducted in the Alas Strait, Indonesian waters, selected based on the potential presence of *Octopus cyanea* and its environmental diversity. Sampling was conducted over a full year, from July 2023 to June 2024, to capture seasonal and geographic variations that may influence biological variables. The research location map can be seen in Fig. (1). Where the location of the research station is as follows: Station 1 Pringgabaya, Station 2 Labuhan haji, Station 3 Tanjung Luar, Station 4 Poto Tano, Station 5 Taliwang, Station 6 Jereweh.

Sampling and biological variables

Octopus samples were collected using common fishing methods, such as bottom traps and nets. Each sample was recorded based on the geographic coordinates of the collection location using a GPS device. GPS (Global Positioning System) is a satellite navigation system that allows users to accurately determine their geographic position worldwide. The system uses a network of satellites that transmit signals to a GPS device, which then calculates its position based on the time it takes for the signal to reach the receiver. Parameters measured included body size (total length) and weight. Measurements were conducted directly in the field using standard measuring instruments and following established procedures to ensure data consistency.

Data analysis

Biological data were processed using descriptive statistics to display the data series and their distribution across various locations. Furthermore, correlation and significance analysis of the data, using the Pearson correlation test, and regression analysis were used to examine the relationship between location variables and biological variables such as size and weight.

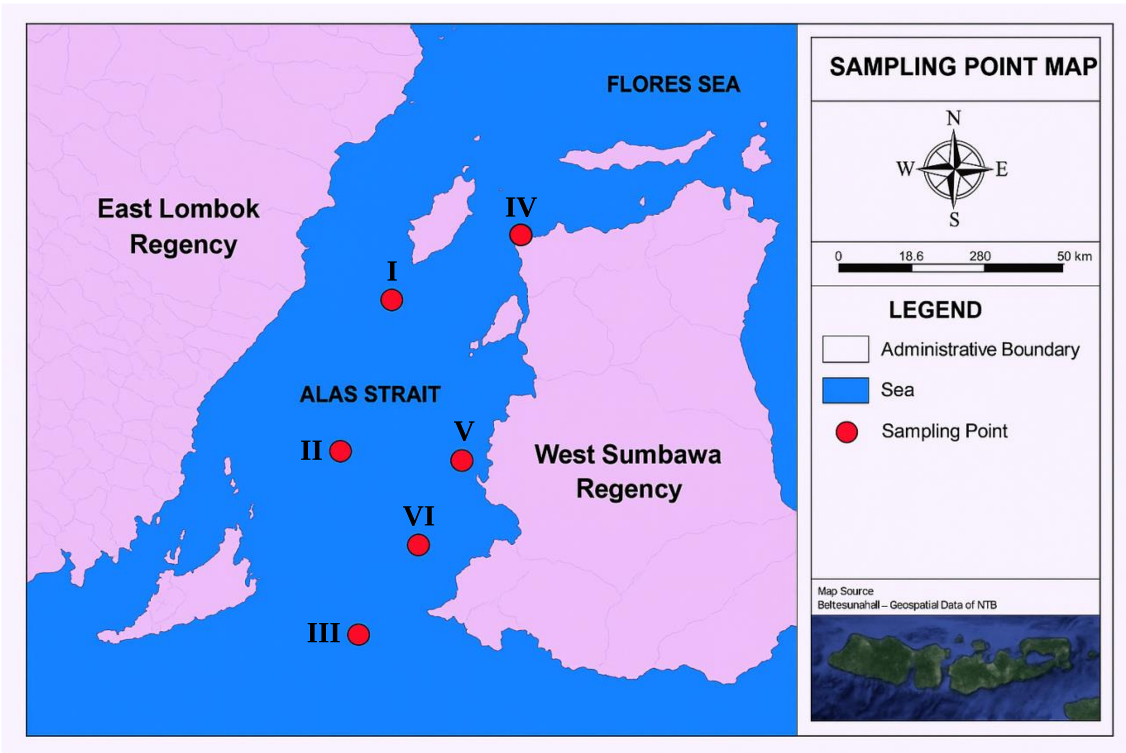

Fig. 1. Research location map

RESULTS

The results of Principal Component Analysis (PCA) on the correlation matrix of morphometric character data from captured octopus specimens and eighteen characters produced variance in the main components of Fig. (2). The first Principal Component F1 was found to be 80.75% and the second principal component F2 was obtained at 5.26%. The first and second characteristic roots were able to explain 86% of the data diversity and were sufficient to explain all the data because it was >70%.

Each species will have a different absolute size from one another. Differences in octopus size are caused by age, sex, environment, and environmental factors such as food, temperature, pH, and salinity. Morphological parameters in octopuses play an important role in determining whether there are differences between the same species from various geographic regions **(Norman, 2000; King, 2007)**. Morphological studies are a fundamental tool for understanding organism development, growth, systematics, variation, and the structure of a population's characteristics **(Hanlon & Messenger, 2018)**.

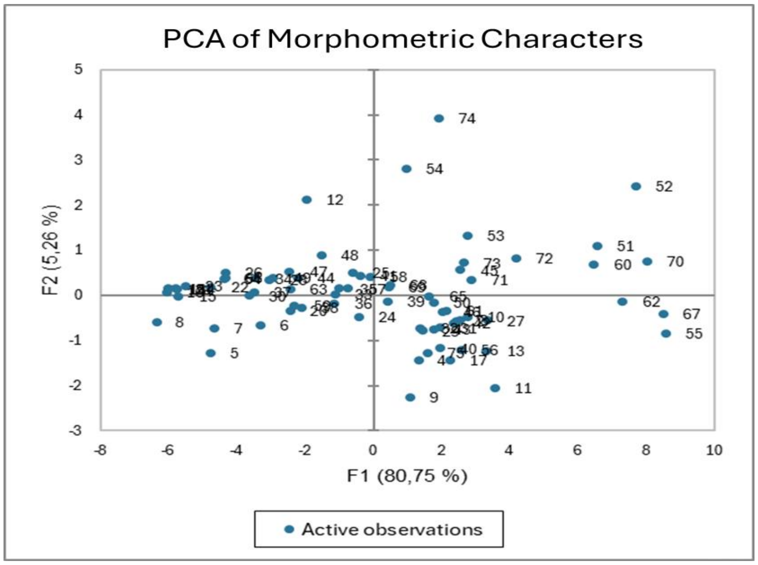

Fig. 2. Principal component analysis of morphometric characters

Dinh *et al*. (2022) stated that the relationship between length and weight plays a crucial role in evaluating the growth and biomass of a population and in assessing fisheries management. Furthermore, growth patterns and weight also play a crucial role in understanding the ecological adaptation of populations. **Al-Otaibi *et al*. (2022)** also stated that measuring the relationship between total length and total weight of a population can provide crucial information useful in formulating fisheries management strategies for wise exploitation.

Estimating growth rate, combined with age at gonadal maturity and lifespan, is a crucial element in understanding the population dynamics of organisms **(Jackson, 1989)**. Growth can simply be defined as an increase in length or weight over a period of time **(Mangold, 1987)**. Growth can also be determined through the length-weight relationship, in which weight is considered a function of length. Furthermore, growth can be measured using length data (the length of a specific, fixed body part) **(Omar, 2002)**. If b = 3 then the growth shows an isometric growth pattern, meaning the growth of body length (total or mantle) and body weight is balanced. If the value of b < 3 indicates a hypoalometric growth pattern (negative allometric or minor allometric), that is, the growth of body length (total or mantle) is faster than the increase in body weight. Conversely, if b > 3 indicates a hyperalometric growth pattern (positive allometric or major allometric), that is, the increase in body weight is faster than the increase in body length (total or mantle) **(Mamangkey *et al.*, 2019)**.

Relationship between length and weight

Male *O. cyanea* (n = 69) have a dorsal mantle length (PMd) range of 44 -162 mm with an average of 99 ± 32.1 mm and a weight range of 270 – 2146 g with an average of 958.4 ± 418.5 g. While female *O. cyanea* octopuses (n = 75) have a dorsal mantle length range of 44 - 166 mm with an average of 100.2 ± 29.2 cm and a weight range of 270 - 2282 g with an average of 938.9 ± 428.1 g. Regression analysis of the relationship between octopus length and weight showed the following results:

- Station 1: y = 1.3046x, R^2 = 0.751
- Station 2: y =1.396x, R^2 = 0.8547
- Station 3: y =1.7381x, R^2 = 0.8386
- Station 4: y =1.0998x, R^2 = 0.8826
- Station 5: y = 1.1845x, R^2 = 0.6624
- Station 6: y= 1.35x, R^2 = 0.6903

These results indicated that b<3 suggest a hypoalometric growth pattern (negative allometric or minor allometric), namely the growth of body length (total or mantle) is faster than the increase in body weight **(Morrison *et al.*, 2016; Omar, 2020)**. The graph of the relationship between the length and weight of the *O. cyanea* in the Alas Strait waters can be seen in Fig. (3).

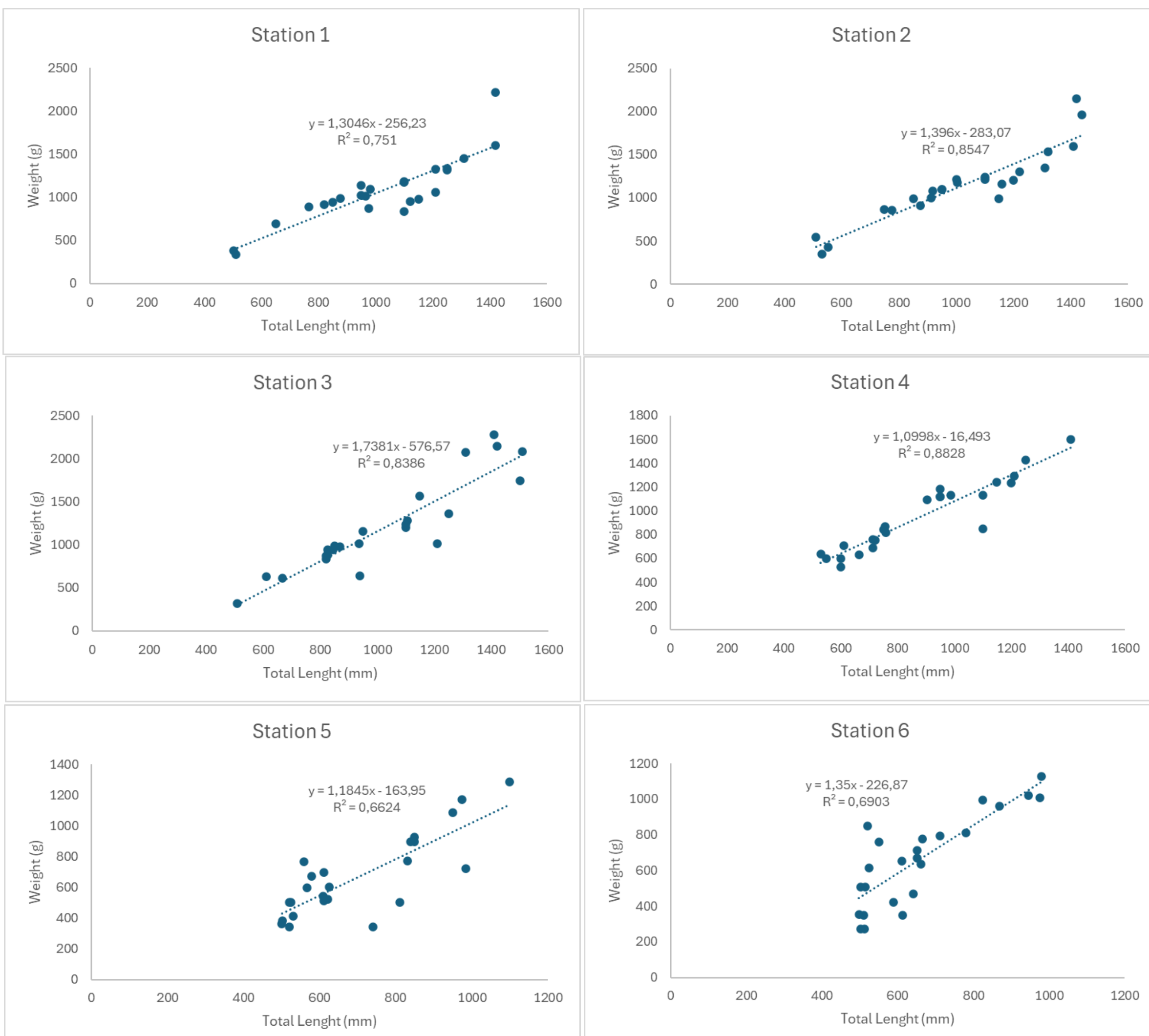

Fig. 3. Relationship between Length and Weight of *O. cyanea* in Alas Strait Waters

Water characteristics

Based on the depth map (Fig. 4) of Selat Alas, there is a significant variation in depth, ranging from around 30 meters to more than 550 meters. Areas near the coastline and small islands show relatively shallow depths, ranging from 30 to 150 meters. Meanwhile, the central and northwestern parts of the strait show greater depths, exceeding 390 meters and even more than 550 meters at certain points.

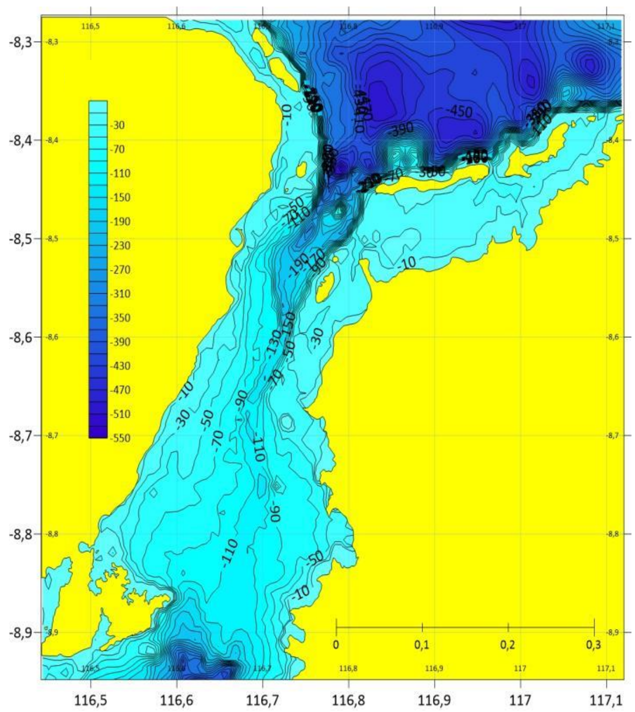

Fig. 4. Water depth data during research in the Alas Strait, Indonesian Waters

Fig. (5) shows a map of current speed and direction in the Alas Strait waters, showing significant variations in the strength and movement patterns of ocean currents. Current speeds range from low (<0.1 m/s) to high (>0.5 m/s), indicated by a color change from gentle to lighter depending on the speed category.In the northern and southern parts of the Alas Strait, there are areas with relatively higher current speeds (>0.5 m/s), indicated in red. These high current speeds are caused by the narrowing of the water flow as it passes through the strait, as well as interactions with varying underwater topography.

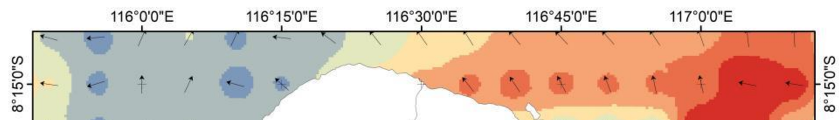

Fig. 5. Current strength and direction data for water currents during research in the Alas Strait, Indonesian waters

The direction of the current is indicated by arrows, indicating that the current moves in line with the geographic configuration of the Alas Strait. In some areas, the current appears to move northeast and southeast, following the general pattern of water movement in Indonesian waters, which is influenced by seasonal winds and equatorial currents. Conversely, areas with lower current speeds (0.1-0.3 m/s), indicated by gentler colors, tend to be found near the coast, where the water flow tends to be calmer. These conditions can create different environments for marine ecosystems, affecting the distribution of marine organisms such as fish larvae and plankton.

DISCUSSION

The graph of the relationship between length and weight of *Octopus cyanea* from six sample locations in the Alas Strait shows a strong correlation between these two variables. In general, the relationship between length and weight in marine animals follows an allometric growth model, where weight increases faster than length as individuals develop **(Dan-kishiya, 2013)**. The correlation between length and weight at each station showed a high coefficient of determination (R^2), indicating a strong relationship between total length and weight. At Station 1, this relationship was particularly strong ($R^2 = 0.915$), indicating that the variability in weight can be largely explained by length **(Smith *et al*., 2005)**. Similar results were observed at other stations, with consistently high R^2 values, indicating similar growth patterns across locations **(Rodríguez-Rúa *et al.*, 2005)**

Although all stations showed the same relationship, there was some variation in growth rates. Stations with higher R^2 generally indicate environments that support optimal growth, such as more abundant food availability or more stable environmental conditions **(Amodio *et al*., 2021)**. Different locations can have varying substrates, population densities, and predation pressure, all of which can affect individual growth. This strong relationship between length and weight also indicates that environmental conditions in the Alas Strait support optimal growth of *Octopus cyanea*. Previous research has suggested that environments with minimal temperature fluctuations and physical disturbances provide ideal conditions for the development of marine life **(Jennings & Kaiser, 1998; Türkmen *et al.*, 2002)**.

The uniformity of growth patterns across sample locations indicates that local environmental factors significantly impact octopus morphological development, consistent with the specific habitat theory, which states that species distribution is a function of adaptation to local biotic and abiotic environments **(López-Uriarte & Ríos-Jara, 2009)**. Furthermore, other factors, such as water characteristics, also influence octopus development.

One water characteristic is ocean depth, which is a key factor determining the habitat and distribution patterns of marine organisms, including cephalopods like *Octopus cyanea*. Areas with depths greater than 300 meters tend to have more stable temperatures, sufficient oxygen content, and diverse food sources, which support optimal octopus growth and reproduction **(Boyle & Rodhouse, 2005)**. In contrast, shallower, near-shore areas (depths of 30 to 70 meters) typically have more variable temperatures. Based on depth maps in the Alas Strait, which show depth variations ranging from approximately -30 to -510 meters, the effect of depth on captured *Octopus cyanea* can be comprehensively described as follows:

At the research site in the Alas Strait, the distribution of *Octopus cyanea* is significantly influenced by depth. Data indicate that octopuses tend to be found at depths of approximately 30 to 150 meters, where environmental conditions are relatively stable and temperatures support their activity **(Norman, 1993)**. At shallower depths, such as less than 30 meters, octopus presence tends to be more limited, likely influenced by factors such as predation from natural predators and higher levels of pollution. Conversely, at depths greater than 150 meters, octopus presence declines, likely due to lower temperatures and limited prey availability **(Boal *et al.*, 2010)**.

This depth variation influences aspects of octopus ecology, including their diet, growth rate, and reproduction. Depth captures indicate that octopuses are more active and abundant at intermediate depths, which corresponds to their optimal habitat. Therefore, depth plays a significant role in determining the distribution and abundance of Octopus cyanea in the Alas Strait.and fluctuating oxygen levels, which can limit growth and lead to smaller octopuses.

Food availability and distribution for *Octopus cyanea* are influenced by depth, as the transport and accumulation of plankton and other small organisms differ at different depths. At deeper depths, nutrient distribution is typically more even and constant, facilitating the animal's growth to larger sizes **(Lankow, 2022)**. Conversely, at shallower depths, nutrient supply can be more limited and more influenced by seasonal factors. The graph shows that locations with deeper depths (the western and northern parts of the map) exhibit a positive relationship between the length and weight of *O. cyanea*. This is consistent with the theory that depth provides environmental conditions more conducive to optimal growth **(Marzuki *et al.*, 2023)**. Therefore, these depth data are crucial for understanding the distribution and growth patterns of this species in the Alas Strait region.

Data on ocean current speed and direction in this region indicate that stronger currents and their travel patterns influence organism distribution. Areas with strong currents

typically have greater depths and allow for abundant nutrient distribution, thus supporting the growth of octopus size and shape **(Ghofar, 2005)**. Areas with relatively weak currents and shallow depths often have limited food supplies and a more restrictive environment, which impacts the growth of both small and large organisms. Ocean currents are a significant environmental factor influencing the distribution of marine organisms, including *O. cyanea (***Guard & Mgaya, 2002)**. Data on current speed and direction in this region indicate that areas with strong currents typically have a significant influence on the distribution patterns of both small and large organisms **(Widodo, 2006)**. In the context of octopus growth and size, ocean currents influence nutrient supply, plankton distribution, and other prey organisms that are the primary food source for *O. cyanea*.
Strong currents in the northern and northeastern parts of the Alas Strait (with current speeds >0.5 m/s) can accelerate the distribution of plankton and small organisms that serve as octopus food **(Denny & Gaylord, 2002)**. Consequently, in areas with stronger currents, octopus populations potentially have better access to food sources, supporting greater growth and heavier yields. Data on northwest- and northeast-trending currents suggest that these currents may facilitate the transport of food to specific areas (**López-Uriarte, 2006; Welsh, 2015)**.

The varying water depths and current patterns in the Alas Strait appear to play a significant role in influencing the growth and distribution of *Octopus cyanea*. Locations with deeper depths and strong currents tend to support higher nutrient availability, which in turn facilitates the growth of larger individuals. Conversely, areas with shallower depths and weaker currents may experience nutrient limitations, which can limit growth. This is in line with previous studies that emphasize the importance of marine environmental conditions in influencing cephalopod biological parameters.

CONCLUSION

The conclusion of this study shows that there is a strong and significant relationship between the length and weight of *Octopus cyanea* across all sampling sites in the Alas Strait. The relationship graph shows that at all stations, an increase in body length is consistently accompanied by an increase in body weight, as indicated by a high R^2 value. This confirms that key growth factors such as food and other environmental factors allow octopuses to reach sizes that conform to a common growth pattern. Thus, these length-weight relationship data reinforce the idea that environmental factors and current dynamics play a major role in determining the biological size of *O. cyanea*. This consistent relationship across sites indicates that despite varying environmental conditions, octopus growth patterns still follow general biological rules, with environmental factors being the primary factor influencing variation.

REFERENCES

Alejo-Plata, M.C. and Gómez-Márquez, J.L. (2015). Reproductive biology of *Octopus hubbsorum* (Cephalopoda: Octopodidae) from the coast of Oaxaca, Mexico. *American Malacological Bulletin*, 33(1): 1-12.

Amodio, P.; Josef, N.; Shasar, N. and Fiorito, G. (2021). Bipedal locomotion in *Octopus vulgaris*: A complementary observation and some preliminary considerations. *Ecology and Evolution*, 11(9): 3679–3684. doi: 10.1002/ece3.7328.

Avila-Poveda, O.H.; Colin-Flores, R.F. and Rosas, C. (2009). Gonad development during the early life of *Octopus maya* (Mollusca: Cephalopoda). *Biological Bulletin*, 216: 94–102.

Boal, J.G.; Prosser, K.N.; Holm, J.B.; Simmons, T.L.; Haas, R.E. and Nagle, G.T. (2010). Sexually Mature Cuttlefish are Attracted to the Eggs of Conspecifics. *Journal of Chemical Ecology*, 36: 834–836.

Boyle, P.R. and Rodhouse, P.G. (2005). *Cephalopods: Ecology and Fisheries*. Blackwell Science Ltd.

Dan-kishiya. (2013). Length-Weight Relationship And Condition Factor Of Five Fish Species From A Tropical Water Supply Reservoir In Abuja, Nigeria. *American Journal of Research Communication*, 1(19): 175–187.

Defeo, O. and Castilla, J.C. (2005). More than one bag for the world fishery crisis and keys for co-management successes in selected artisanal Latin American shellfisheries. *Reviews in Fish Biology and Fisheries*, 15(3): 265–283.

Denny, M. and Gaylord, B. (2002). The mechanics of wave-swept algae. *Journal of Experimental Biology*, 205(10).

Diana, R. and Rahman, A. (2022). Pendekatan spasial dalam konservasi spesies laut di Indonesia [Spatial approach in marine species conservation in Indonesia]. *Jurnal Ekologi dan Konservasi*, 15(2): 134-145.

Fadli, M.; Hidayat, R. and Putra, D. (2018). Pemanfaatan Sistem Informasi Geografis dalam studi distribusi spesies laut [Utilization of Geographic Information Systems in the study of marine species distribution]. *International Journal of Marine Science*, 9(3): 45-54.

FAO. (2018). *The State of World Fisheries and Aquaculture 2018: Meeting the Sustainable Development Goals*. Food and Agriculture Organization of the United Nations.

Ghofar, A. (2005). ENSO Effects on The Alas Strait Squid Resource and Fishery. *ILMU KELAUTAN: Indonesian Journal of Marine Sciences*, 10(2): 106–114. https://doi.org/10.14710/ik.ijms.10.2.106-114.

Guard, M. and Mgaya, Y.D. (2002). The artisanal fishery for *Octopus cyanea* Gray in Tanzania. *Ambio*, 31(7–8): 528–536.

Harahap, D.; Lubis, A. and Sulaiman, Z. (2021). Variasi biometrik populasi Octopus di perairan Indonesia [Biometric variation of Octopus populations in Indonesian waters]. *Jurnal Biologi Laut*, 16(1): 23-34.

Helfman, G.S. (2008). *Fish Conservation: A Guide to Understanding and Restoring Global Aquatic Biodiversity and Fishery Resources*. Journal of the North American Benthological Society, 27(3).

Jackson, G.D. (1989). The use of statolith microstructures to analyze life-history events in the small tropical cephalopod *Idiosepius pygmaeus*. *Fishery Bulletin of the National Oceanic and Atmospheric Administration*, 87: 265–272.

Jennings, S. and Kaiser, M.J. (1998). The Effects of Fishing on Marine Ecosystems. *Advances in Marine Biology*, 34: 201-212, 212e, 213-

352. https://doi.org/10.1016/S0065-2881(08)60212-6.

King, M. (2007). *Fisheries Biology, Assessment and Management* (2nd ed.). Wiley-Blackwell.

Kusuma, A.; Wulandari, P. and Sari, D. (2019). Keanekaragaman hayati dan keberlanjutan sumber daya laut Indonesia [Biodiversity and sustainability of Indonesian marine resources]. *Marine Biodiversity Journal*, 22(4): 789-805.

Lankow, A.J. (2022). *Examining the Effects of Prey Type and Water Temperature on the Feeding Behavior of a Benthic Generalist Mesopredator, the California Two-Spot Octopus (Octopus bimaculoides)*. University of California, Santa Cruz.

López-Uriarte, E. and Ríos-Jara, E. (2009). Reproductive biology of *Octopus hubbsorum* (Mollusca: Cephalopoda) along the central Mexican Pacific coast. *Bulletin of Marine Science*, 84: 109–121.

López-Uriarte, E. (2006). *Ciclo Vital y Pesca del Pulpo Octopus hubbsorum Berry 1953 (Cephalopoda: Octopodidae) en la Costa de Jalisco, México* [Life Cycle and Fishery of the Octopus *Octopus hubbsorum* Berry 1953 (Cephalopoda: Octopodidae) on the Coast of Jalisco, Mexico]. Ph.D. Dissertation, Universidad de Guadalajara, México.

Mangold, K. (1987). Reproduction. In P.R. Boyle (ed.), *Cephalopod life cycles, vol 2* (pp. 157–200). Academic Press.

Mamangkey, J.J.; Rogahang, F.H.N. and Adil, E. (2019). Analisis struktur populasi dan tingkat kemantangan gonad ikan payangka (*Ophieleotris aporos*) di Danau Tondano Sulawesi Utara [Analysis of population structure and gonadal maturity level of payangka fish (*Ophieleotris aporos*) in Lake Tondano, North Sulawesi]. *Frontiers, Jurnal Sains Dan Teknologi*, 2(3): 211–219.

Marzuki, M.; Diniariwisan, D. and Lestariningsih, W.A. (2023). Biological Identification of Octopuses and Index Values for Fisheries Management in the Alas Strait Area, West Nusa Tenggara. *Jurnal Penelitian Pendidikan IPA*, 9(12): 12149–12154. https://doi.org/10.29303/jppipa.v9i12.5956.

Morrison, C.A.; Robinson, R.A.; Clark, J.A. and Gill, J.A. (2016). Causes and consequences of spatial variation in sex ratios in a declining bird species. *Journal of Animal Ecology*, 85(5): 1298–1306. https://doi.org/10.1111/1365-2656.12556.

Mulyani, L.F.; Arfiati, D.; Ekawati, A.W. and Widodo, M.S. (2023). Identification of land suitability as the basis for cultivation of *Octopus cyanea* in Lombok waters. *BIO Web of Conferences*, 74: 04009. https://doi.org/10.1051/bioconf/20237404009.

Mulyani, L.F.; Cokrowati, N.; Asri, Y. and Sumsanto, M. (2024). Identifikasi Morfologi dan Morfometrik Pada *Octopus cyanea* Yang Ditangkap Di Perairan Lombok Timur [Morphological and Morphometric Identification of *Octopus cyanea* Caught in East Lombok Waters]. *Jurnal Airaha*, 13(01): 070-077.

Mulyani, L.F.; Arfiati, D.; Widodo, M.S. and Yamindago, A. (2024). Molecular Identification of Octopus (*Octopus cyanea*, Gray 1849) using Mt-DNA COI from Alas Strait Waters, Indonesia. *Egyptian Journal of Aquatic Biology & Fisheries*.

Norman, M.D. (1993). *Octopus ornatus* gould, 1852 (Cephalopoda: Octopodidae) in Australian waters: Morphology, distribution, and life history. *Proceedings of The*

Biological Society of Washington, 106(4): 645-660.

Otero, J.; Gonźalez, A.F.; Pilar-Sieiro, M. and Guerra, A. (2007). Reproductive cycle and energy allocation of *Octopus vulgaris* in Galician waters, NE Atlantic. *Fisheries Research*, 85: 122–129.

Omar, S.B.A. (2002). *Biologi Reproduksi Cumi-cumi (Sepioteuthis lessoniana* Lesson, 1830) [Reproductive Biology of Squid (*Sepioteuthis lessoniana* Lesson, 1830)]. Dissertation. Institut Pertanian Bogor.

Omar, S.B.A. (2020). Biologi Reproduksi Gurita, *Octopus cyanea* Gray, 1948 di Perairan Selat Makassar dan Teluk Bone [Reproductive Biology of Octopus, *Octopus cyanea* Gray, 1948 in the Makassar Strait and Bone Gulf Waters]. *Prosiding Simposium Nasional VII Kelautan dan Perikanan*, pp. 131–144.

Putra, R. and Sari, D. (2020). Peran ekologis *Octopus cyanea* di ekosistem pesisir [Ecological role of *Octopus cyanea* in coastal ecosystems]. *Jurnal Ekosistem Laut*, 10(2): 105-112.

Rodríguez-Rúa, A.; Pozuelo, I.; Prado, M.; Gómez, M.J. and Bruzón, M.A. (2005). The gametogenic cycle of *Octopus vulgaris* (Mollusca: Cephalopoda) as observe on the Atlantic coast of Andalusia (South of Spain). *Marine Biology*, 147: 927-33.

Smith, J.M.; Pierce, G.J.; Zuur, A.F. and Boyle, P.R. (2005). Seasonal patterns of investment in reproductive and somatic tissues in the squid *Loligo forbesi*. *Aquatic Living Resources*, 18: 341–351.

Türkmen, M.; Erdoğan, O.; Yildirim, A. and Akyurt, I. (2002). Reproduction tactics, age and growth of *Capoeta capoeta umbla* Heckel 1843 from the Aşkale Region of the Karasu River, Turkey. *Fisheries Research*, 54(3): 317–328. https://doi.org/10.1016/S0165-7836(01)00266-1.

Welsh, D.P. and Fuller, R.C. (2015). Influence of sex and habitat on the size and shape of anal and dorsal fins of the blackstripe topminnow *Fundulus notatus*. *Journal of Fish Biology*, 86(1): 217–227. https://doi.org/10.1111/jfb.12564.

Widodo, J. and Suadi. (2006). *Pengelolaan Sumberdaya Perikanan Laut* [Management of Marine Fishery Resources]. Gadjah Mada University Press.