Population, habitat, and distribution of sea horses in Morotai waters, North Maluku Province

Nurafni, Kismanto Koroy, Djainudin Alwi

Department of Marine Science, Faculty of Fisheries and Marine Science, Morotai Pacific University, Morotai Island, North Maluku Province, Indonesia. Corresponding author: K. Koroy, kismantokoroy@gmail.com

Abstract. The sea horse is a source of multiple benefits, as souvenirs, traditional medicine, and ornamental fish. The increasing need for seahorses has resulted in massive exploitation, causing habitat degradation and even causing the extinction of several seahorse species. This study aimed to analyze the population and distribution mapping of seahorses found in the waters of Morotai Island. The research was carried out in the waters of Morotai Island and it was conducted from June 2022 to July 2023 in 6 (six) districts, namely; South Morotai, South West Morotai, Rao Island, East Morotai, North Morotai, and Morotai Jaya. Data in this study was related to the populations analysis and to their distribution mapping at the study site. Based on the research results, the distribution of seahorses was determined at the 6 (six) research locations, showing a spread across South Morotai waters.
Key Words: density, abundance, mapping, seahorses.

Introduction. The sea horse has multiple benefits, as souvenirs, traditional medicine, and ornamental fish. The increasing need for seahorses has resulted in massive exploitation, causing habitat degradation and even causing the extinction of several seahorse species. In America and Europe, seahorses are used as aquarium ornamental fish, while in China, they are used as traditional medicine (Putri et al 2019). The consumption of seahorses in the Asian region reaches 45 tons year^{-1}, with the largest consuming countries being China (20 tons year^{-1}), Taiwan (11.2 tons year^{-1}), Hong Kong (10 tons year^{-1}) and other Asian countries (3.8 tons year^{-1}) (Mulalinda 2017).

The high market demand causes seahorse catches to continue to increase. This greatly affects the abundance of populations in nature. According to Syafiuddin et al (2018), the increasing need for seahorses has resulted in massive exploitation, causing habitat degradation and even causing the extinction of some species. Martin-smith & Vincent (2005) reported that seahorses are included in the category of Appendix II from the Convention on International Trade in Endangered Species (CITES), so that fishing and trading are limited according to quotas. According to the Ministry of Trade (2013), in Indonesia provisions for the export of seahorses are stipulated in the Regulation no. 50 of 2013 concerning the Export of Natural Plants and Wild Animals which are not protected by law and are included in the CITES list. Five types of seahorses are included in the list of export regulations of the Ministry of Commerce: *Hippocampus comes*, *Hippocampus histrix*, *Hippocampus kuda*, *Hippocampus spinosissimus*, and *Hippocampus kellogi*.

In addition to direct utilization the decline in seahorse populations can result from environmental changes destroying seahorse habitats in mangroves, sea grasses, algae, and coral reefs. Information regarding seahorses is still limited; there are 35 species of seahorses in the world, while in Indonesia, there are 12 species of seahorses found, namely: *Hippocampus barbouri*, *H. comes*, *H. histrix*, *H. kellogi*, *H. kuda*, *Hippocampus bargibanti*, *Hippocampus trimaculatus*, *H. spinosissimus*, *Hippocampus denise*, *Hippocampus pontohi*, *Hippocampus satomiae*, *Hippocampus severnsi* (Sadili et al 2015). According to data from the International Union for Conservation of Nature and Natural Resources, as many as 20 species are registered as data-deficient, illustrating a need for more information regarding seahorses. Rare animal species or small densities with limited

distribution patterns are more affected by human activities and cause a higher risk of extinction, so global distribution data is very important in identifying the distribution of seahorses (Zhang & Vincent 2018). Data on the distribution of seahorses in North Maluku waters is minimal, especially in the Morotai Island district.

Morotai Island is one of the districts in North Maluku province, which has an abundant biodiversity. In addition to biodiversity, Morotai has a historical value. Apart from being a water conservation area, Morotai Island is also designated by the national policy as a Special Economic Zone (KEK), a National Tourism Strategy Area (KSPN), and an Integrated Marine Fisheries Center (SKPT) (Koroy et al 2023). Until now, there is still a minimal research data informing the policies on marine resources (especially seahorses) on the distribution of species, habitats, and conditions of seahorse populations, concerning North Maluku and specifically in the waters of Morotai Island. A research on the habitat characteristics and density of the *H. kuda* was conducted in 2021, but only in the waters of Ternate, North Maluku (Dody et al 2021). On the other hand, the government has established a marine conservation area for Morotai Island, which requires data regarding the distribution, habitat, and population.

This study aimed to analyze the population and distribution mapping of seahorses found in the waters of Morotai Island, and it was conducted from June 2022 to July 2023 in 6 districts, namely: South Morotai, South West Morotai, Rao Island, East Morotai, North Morotai, and Morotai Jaya. The study focused on the population analysis and mapping of the distribution of seahorses found at the study site.

Material and Method

Description of the study sites. The research was carried out in the waters of Morotai Island, from June 2022 to July 2023 (Figure 1).

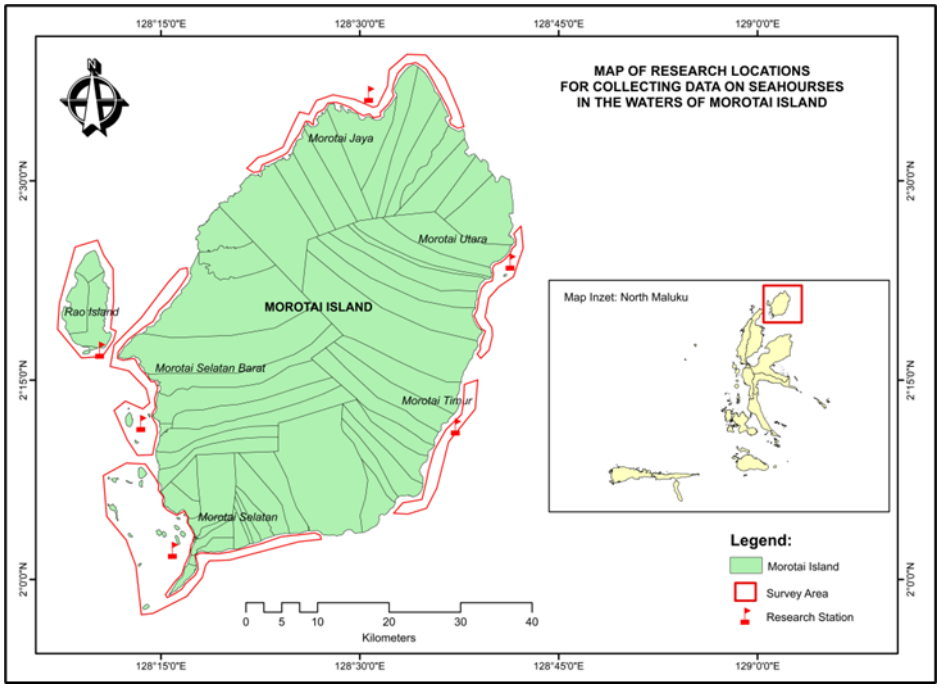

Figure 1. Map of research locations in six districts.

Administratively, the conservation area is located in Morotai Island regency, from Rao Island to Tanjung Dehegila waters, including 3 sub-districts, namely: South Morotai sub-district (Army Dock Waters, Kokoya Island, Mitita Island), Morotai South West sub-district (Cucumare Waters, Wayabula Ngele-Ngele Kecil), and Pulau Rao District (Samiyamau, Posi-Posi Rao 1, and Posi-Posi Rao 2). The designation as conservation area of the zone extending from Rao Island Waters to Tanjung Dehegila and its surroundings is based on the Decree of the Ministry of Maritime Affairs and Fisheries of the Republic of Indonesia

number 67/KEPMEN-KP/2020 (Ministry of Fisheries and Maritime Affair 2020). Regarding the development of water conservation areas for protecting, preserving, and utilizing the fishery potential of aquatic habitats and biota. Apart from being regulated by the marine protected areas (KKP) policy, the development of the zone from Rao Island to Tanjung Dehegila will be managed through the regulations concerning the Aquatic Tourism Parks. The physical environment of the Rao Island–Tanjung Dehegila Waters conservation area and its surroundings has climatic conditions influenced by tropical seas, consisting of three seasons, namely the rainy season (November-February), the dry season (April-October), and the transition season (March-October).

Tools and materials. The tools and materials used in this study were: seser fishing gear, roller meter, raffia rope, measuring tape/calipers, buckets, recording devices, GPS, hand refractometer, Secchi disk, current meter, pH meter, thermometer, camera, underwater flashlight, camera, magnifying glass, scuba gear, and boat. The studies of Lourie et al (2004) and Sadili et al (2015) were used as guidelines for the seahorse species identification.

Data retrieval. Data collection on seahorses used a purposive sampling method carried out in the seahorse fishing area, based on information from the local community. Data were collected at 18 points throughout 6 districts: South Morotai, South West Morotai, Rao Island, East Morotai, North Morotai, and Morotai Jaya. Seahorses were caught using the seser and snorkeling equipment, by swimming, using a GPS to estimate the sampling area. In addition, measurements of environmental parameters such as water pH, salinity, current speed, temperature, brightness and observations of seahorse habitat were performed. The mapping of potential seahorse species in the waters of Morotai Island used the *ArcGIS* application by making distribution maps based on coordinate data taken using GPS.Research Flowchart. Research implementation begun with field observations/surveys to formulate problems and limit research variables. Data collection consisted of primary and secondary data about seahorses, regarding the population, habitat, and distribution throughout the 6 districts in Morotai waters. The stages of the research implementation process are as shown in Figure 2:

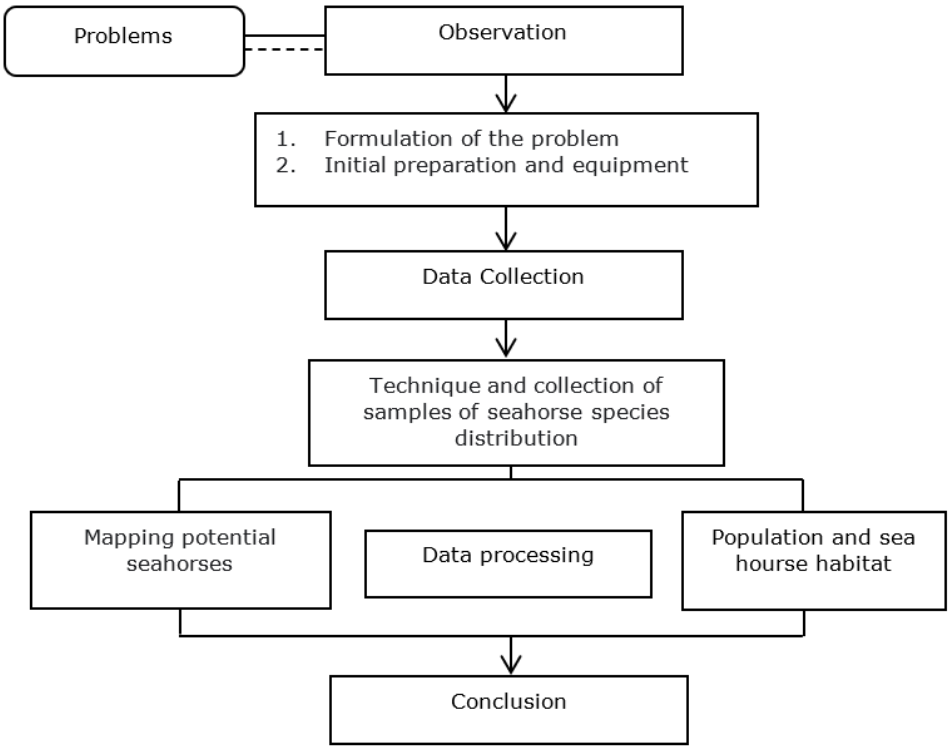

Figure 2. Research flowchart.

Data analysis. Data analysis in this study consisted of population analysis and distribution mapping of the seahorses found at the study site. Based on the following formulae for population density (Sadili et al 2015).

$$K = \frac{X}{A}$$

Where:
K - density (tails m^{-2});
X - number of individuals caught (tail);
A - combed area (m^2).

Population size is based on the formula (Sadili et al 2015):

$$P = Kx\ TA$$

Where:
P - population (tail);
K - density (tails m^{-2});
TA - total area (m^2).

Mapping the distribution of sea horse species in the waters of Morotai Island used the ArcGIS application by making a distribution map for each sub-district, based on coordinate data taken using GPS.

Results. The local (study site) seahorse distributions are illustrated in Figure 3.

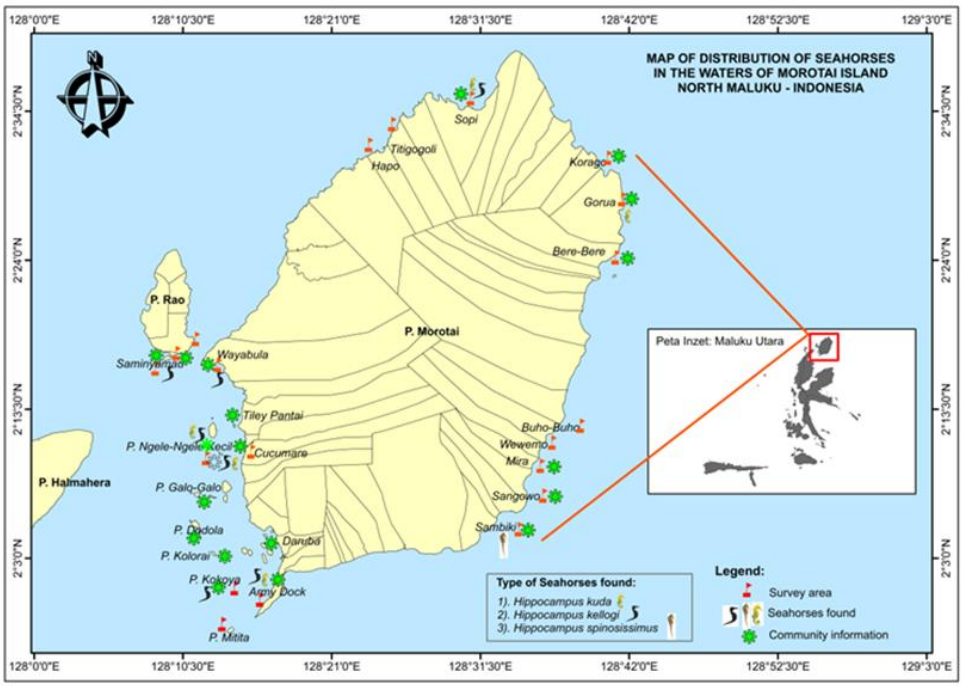

Figure 3. Distribution of seahorses found in Morotai waters.

Seahorses were found in the waters of the Morotai Island, in the South Morotai sub-district (Armydcok and Kokoya Island), but they were not found at 1 sampling point in the South Morotai sub-district (Mitita Island). In the South-West Morotai sub-district, they were found in the waters of Wayabula, Cucumare and in the waters of the Ngele-Ngele Island. In the Rao Island waters there were detected only in the Samiyamau waters, and at two other sampling points they were not found (Figure 4). In the East Morotai waters, they were found at 1 sampling point, namely the Sambiki Village, while at two other sampling points they were not found (although, according to the information received, the community often found seahorses there). In the North Morotai District, they were found only at 1 sampling point, in the waters of the Gorua Village, while at two other points, they were not found.

In the Morotai Jaya waters, they were found only at one sampling point, in the waters of the Sopi Village, and at 2 other sampling points they were not detected.

The density breakdown by species of seahorses found at the study sites is as follows: in the South Morotai, *H. kuda* (0.006 tails m^{-2}), *H. kellogi* (0.02 tails m^{-2}); in the waters of Morotai South West, *H. kuda* (0.006 tails m^{-2}) and *H. kellogi* (0.02 tails m^{-2}); in the waters of Rao Island, *H. kellogi* (0.003 tails m^{-2}); in the East Morotai waters, *H. spinosissimus* (0.003 tails m^{-2}); in the North Morotai, *H. equine* (0.007 tails m^{-2}); in Morotai Jaya waters, *H. kellogi* (0.013 tails m^{-2}) and *H. kuda* (0.003 tails m^{-2}). The total populations of seahorses found at the 6 research locations were of 8 individuals in South Morotai waters, 8 in South West Morotai, 1 in Rao Island, 1 in East Morotai, 2 in North Morotai, and 5 in Morotai Jaya.

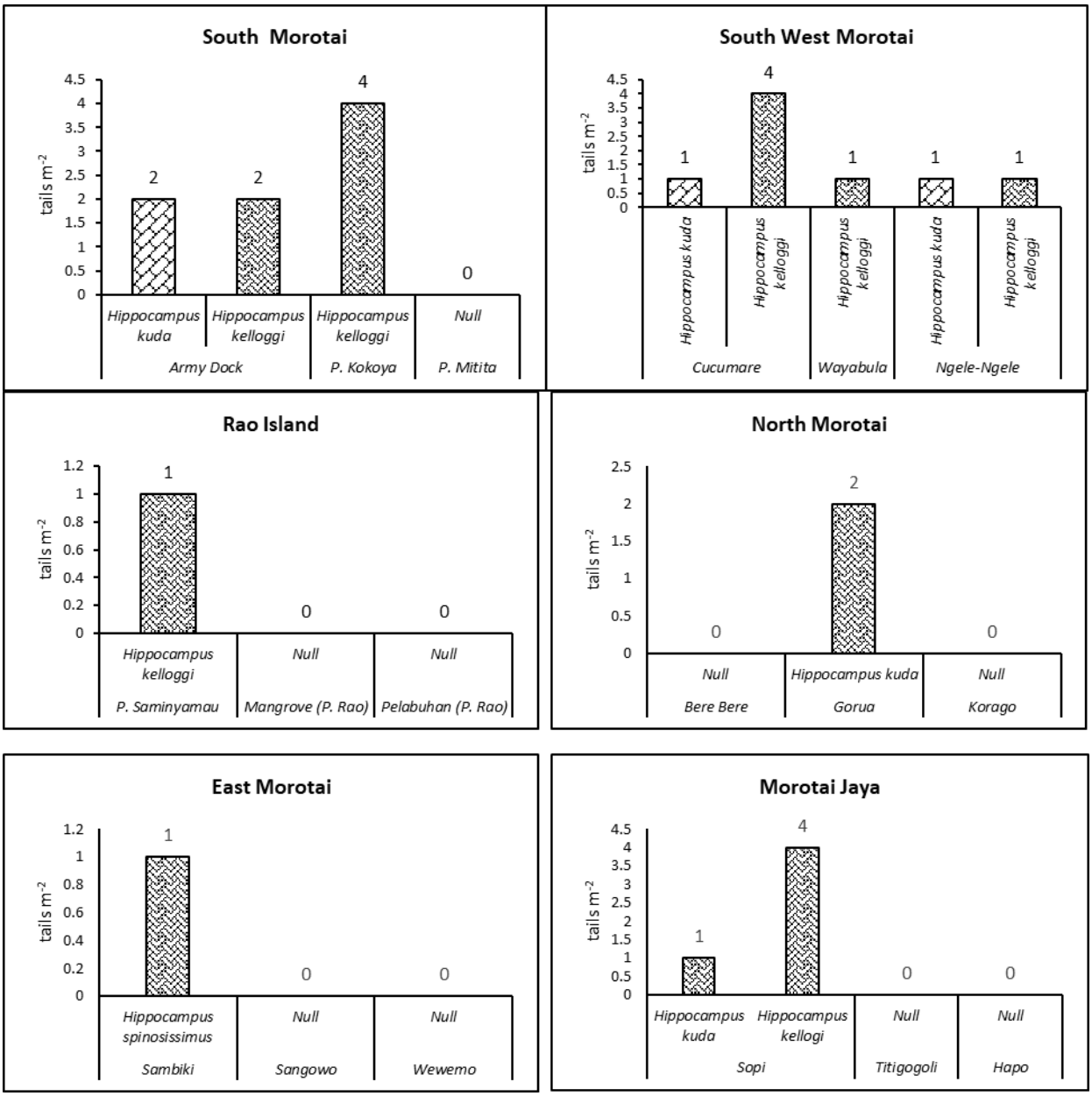

Figure 4. Seahorse population in the six studied districts.

Water parameters. Water parameters are important factors in supporting marine biota's life, including sea horses. The observed parameters were: pH, temperature, salinity, current speed, and brightness (Table 1).

The temperature measurements in the waters of South Morotai (Army Dock, Kokoya Island, and Mitita Island) ranged from 32-32.5ºC. The waters of the South West Morotai District (Cucumare, Wayabula and Ngele-ngele islands) and the waters of Rao Island

District (Samiyamau island, at the sampling points 1 and 2) had the same temperature range of 31-32ºC. The temperature in the East Morotai waters (Sambiki, Sangowo, and Wewemo) was of 30.5-30.7ºC, while in the North Morotai (Bere Bere, Gorua, and Korago) it ranged from 31-31.5ºC, while in Morotai Jaya waters the temperature it was between 28.9 and 31.4ºC. The direct measurements of the degree of acidity (pH) in the 6 (six) sub-districts of the study locations ranged from 5.7 to 7.19 (Table 1), indicating that the pH in the waters of Morotai Island, which was the study location, was classified as low to normal.

The salinity values at the study sites varied as follows: in the waters of Mitita Island, Armydock, and Kokoya Island, it ranged from 33 to 35‰ (South Morotai); in the Cucumare, Wayabula, and in Ngele-ngele waters it ranged from 29 to 34‰ (Morotai South West); in the Samiyamau waters, at the sampling points 1 and 2 (Rao Island) the salinity value was of 33‰. In the East Morotai waters (Sambiki, Sangowo, Wewemo), the salinity ranged 33-35.8‰, in the North Morotai (Bere Bere, Gorua, and Korago), the salinity ranged 29.5-34.7‰ and in Morotai Jaya waters (Sopi, Hapo and Titigogoli) the salinity ranged 23-33.6‰. The current velocity measurements at the research sites in the waters of South Morotai (Mitita Island, Army Dock, and Kokoya Island) ranged from 0.03 to 0.06 m s^{-2}; in Morotai South West (Cucumare, Wayabula and Ngele-Ngele) waters it ranged 0.05-0.10 m s^{-2}, in Rao Island (waters of Samiyamau Island, Posi-Posi Rao 1 and Posi-Posi Rao 2) it ranged 0.04-0.28 m s^{-2}. In the East Morotai waters (Sambiki, Sangowo, and Wewemo) it ranged 0.02-0.08 m s^{-2}, in North Morotai (Bere Bere, Gorua and Korago) it ranged 0.01-0.02 m s^{-2}, while in Morotai Jaya (Sopi, Hapo and Titigogoli) it ranged 0.02-0.07 m s^{-2}. Measurement of the brightness of the waters at the research location averaged between 1 and 2 m.

Table 1

Environmental parameters

Site	*Water parameters*				
	Average				
	pH	*Salinity (‰)*	*Temperature (ºC)*	*Current speed (m s^{-2})*	*Brightness (m)*
South Morotai	5.7-6	33-35	32-32.5	0.03-0.06	1.8-2
West South Morotai	6	29-34	31-32	0.05-0.10	1-2
Rao Island	6	33	31-32	0.04-0.28	1-1.25
East Morotai	6.46-7.19	33-35.8	30.5-30.7	0.02-0.08	1-2
North Morotai	6.24-6.74	29.5-34.7	31-31.5	0.01-0.02	1-2
Morotai Jaya	6.47-6.52	23-33.6	28.9-31.4	0.02-0.07	1-2

The parameter measurement locations at three data collection points for each sub-district were: South Morotai (Armydock waters, Mitita Island, Kokoya Island), West South Morotai (Cucumare waters, Wayabula and Ngele-Ngele Island), Rao Island (Saminyamau and Posi-Posi Rao), East Morotai (Sambiki, Sangowo, and Wewemo waters), North Morotai (Bere-Bere, Korago, and Gorua waters) and Morotai Jaya (Sopi, Hapo, and Titilogi waters).

Discussion. Based on the observations in the field, 3 types of seahorses were found: the *H. kuda*, *H. kellogi*, and *H. spinosissimus*. In the waters of South Morotai, South West Morotai, Rao Island, East Morotai, North Morotai, and Morotai Jaya, seahorses were found in only found at several sampling points. In the waters of Rao Island, only one species was found. In the waters of South Morotai and South West Morotai, 2 species were found, at East Morotai 1 species, at North Morotai 1 species, and in Morotai Jaya 2 species, spread over three points in each sub-district. Meanwhile, based on the information from the Rao Island, East Morotai, and North Morotai communities, seahorses are often found during the season, by fishermen orswimmers. This is in line with the results of the research conducted by Fianda et al (2015), stating that the season can affect the abundance of seahorses and the distribution peaks occur from February to May.

According to Sadili et al (2015), the sea horse species *H. kuda* has a fairly large distribution compared to *H. kellogi*. The distribution of seahorses *H. kuda* in Indonesia is found in the waters of Riau, Padang, Belitung, Bandar Lampung, Pangandaran, Tanjung Redep, Sulawesi, West Bali, Komodo Island, Flores, Ambon, and Manokwari. The map data for the distribution of seahorse species (Figure 5) shows that the species *H. kuda* was found in Army Dock waters, Cucumare waters, and Ngele-Ngele Kecil waters. The he species *H. kellogi* was found in Army Dock waters, Kokoya islands, Cucumare, Ngele-Ngele Kecil, Wayabula, and Samiyamau waters. In addition to the field observation, information on the seahorse species distribution at the research location was collected from the public.

The number of seahorses is currently small, and the fishing locations for seahorses are far from the coastline; the waters are clear, and there is no disturbance from community activities. Seahorses' distribution depends on the ecosystem's condition (seagrass, mangroves, and coral reefs). Most of the seahorses are found in habitats near seagrasses, mangroves, seaweed, and artificial habitats. According to Lazic et al (2018), the distribution of seahorses can be found in artificial habitats, macroalgae, and substrate textures. According to Lourie et al (2004), *H. kellogi* was detected in European countries, China, Japan, Micronesia, Malaysia, Philippines, Pakistan, Vietnam, Thailand, and the United Republic of Tanzania. *H. kellogi* is also found in several countries such as Bahrain, Bangladesh, Australia, Brunei Darussalam, China (Hong Kong SAR and Province of Taiwan), Cambodia, Djibouti, Egypt, Eritrea, Iraq, Islamic Republic of Iran, Israel, Kenya, Kuwait, Myanmar, Oman, Qatar, Saudi Arabia, Seychelles, Singapore, Somalia, Sri Lanka, Sudan, United Arab Emirates, Yemen. Furthermore, the species *H. kuda*, has been also detected in several countries such as Australia, Cambodia, China (Hong Kong SAR and Province of Taiwan), Fiji, France (New Caledonia and Tahiti), Ecoria, Indonesia, Japan, Malaysia, Pakistan, Papua New Guinea, Philippines, Federated States of Micronesia and Singapore. Locally, *H. kellogi* and *H. kuda* are found in the waters of Banyuwangi, Nusa Tenggara Timur (NTT), and Cilacap.

According to Musick et al (2000), the existence of seahorses depends on the condition of their habitat, namely coral reefs and seagrasses. According to Kuang & Chark (2004), *H. kuda* like habitats associated with seaweed and sea grass. A poor distribution can affect the survival of seahorses in nature. According to Martínez et al (2023), the distribution of *H. kellogi* is found at depths of 1 to 30 m in subtidal waters. In addition, water quality factors and physical disturbances can influence the decline in seahorse populations (Martin-smith & Vincent 2005). Zhang & Vincent (2018) reported that it is very important to link distribution variables and habitat in order to be able to determine the distribution of seahorses. Harasti et al (2022) stated that population decline could occur due to the destruction of the habitat of seahorses. Geographical habitat conditions can affect the distribution of seahorses (Martínez et al 2023).

Habitats for seahorses are often found along the coast, seashores, and shallow seas, inhabiting places abundant in coral reefs, mangroves, seagrass beds, seaweed, and artificial habitats. Habitat characteristics at the study site indicate that most of the locations are in the intertidal zone or areas that are still affected by tides, and there are seagrass ecosystems, coral reefs, mangroves, seaweed with sandy substrate types, coral rubble, and muddy sand. Borges et al (2022) reported seahorses occupying mangrove habitats. According to the Convention on International Trade in Endangered Species (2020), seahorses can live in natural and artificial habitats. However, several species of seahorses can change habitats along with their growth form. Lazic et al (2022) stated that artificial substrates are seahorses' most commonly found habitat. Dody et al (2021) stated that seahorses usually live near plants such as mangroves and seagrasses in shallow waters. Saher et al (2021) stated that seahorses can live in coral reefs and seagrass habitats.

The number of seahorse populations found in the 6 sub-districts and 18 sampling points of the study was reduced, namely 1 to 8 individuals. This shows that the population of seahorses is very small due to the influence of natural factors, namely the weather and accidental capture by fishing nets. Borges et al (2022) stated that human pressure, expansion of tourism activities, and increased sea transportation could threaten seahorse populations. Some of the factors causing population decline is pollution, overfishing and climate change. The increase in seahorse populations depends on habitat conditions such

as seagrass beds (Curtis & Vincent 2005). Habitat conditions greatly determine the number of seahorse populations, as reported by Tamara et al (2023).

The density of seahorses in Morotai waters ranges from 0.003-0.013 tails m^{-2}. Kurniawan (2016) found a density of seahorses of 0.001-0.002 tails m^{-2}. In the Philippines, the density of seahorses is 0.02 tails m^{-2} (Foster & Apale 2016). The detected value of seahorse density is similar to Lourie et al (2016) and Foster & Vincent (2004). Low seahorse densities are caused by excessive exploitation activities and by human activities that affect the seahorse habitat. Putri et al (2019) stated that the waste disposal affected the habitat, which caused a decrease in the population and density of seahorses. Lourie et al (1999) reported that seahorses that have lost their partners do not reproduce until they find their partners again. However, seahorses usually take a long time to find their partners again. This affects the presence of seahorses in nature.

Water parameters are the supporting factors for the life of seahorses, including salinity, temperature, pH, brightness, and current speed. The results of salinity measurements at the study sites varied. In the waters of Mitita Island, Armydock, and Kokoya Island, it ranged 33-35‰; in Cucumare, Wayabula, and Ngele-ngele waters, it ranged 29-34‰, while in Samiyamau waters, Posi Posi Rao 1 and Posi Posi Rao 2 had the same salinity value of 33‰. In East Morotai, North Morotai, and Morotai Jaya waters, the salinity was 23-35.8‰. At Morotai Jaya, where the rivers flow into the sea, the salinity was 23‰.Seahorses have euryhaline properties so that they can survive up to a salinity of 38 (Asri et al 2019). The temperature at the study sites ranged from 28.5-32.5ºC spread across 6 study locations. Based on the concerning seawater quality standards for marine biota, the salinity values at the study sites are still within the normal range for seahorse growth (Ministry of Environment Decree 2004).

Putri et al (2019) reported that water temperature measurements of 27.4-33.5ºC are appropriate for seahorse growth. Sea water temperature physiologically affects the behavior of seahorses. Lourie & Randall (2003) show that the water temperature ranges 20-30ºC, while during the spawning process, the water temperature is 24-28ºC. *H. kuda* can tolerate temperature changes. The degree of acidity (pH) at the study site ranged from 5.7 to 7.19. The low pH value is thought to be due to household waste disposal and domestic water discharge. Saraswati & Pebriani (2016) stated that photosynthetic activity and household waste can affect the pH value. Munandar et al (2020) reported measured pH values of 7.20-7.90. Brightness is a condition of good water quality for biota life. The measured values at the research location averaged 1-2 m, which is acceptable at the observation sites, located in seagrass ecosystems, coral reefs, artificial substrates, and mangroves with mainly shallow waters. However, Morotai Jaya had 2 cloudy water zones because the substrate at the location was mixed with mud, but the brightness value at the location was still normal for the marine biota. According to the Ministry of Environment Decree (2004), the quality standard for water brightness for marine life is >3 m. Sun et al (2020) stated that brightness is a factor that supports the seahorse fecundity process. The results of the current speed measurement at the research location were 0.03-0.28 m s^{-2}. Differences in the topography of the bottom of the waters at each study location cause current velocities that vary quite largely.

Conclusions. Based on this research, the population distribution of seahorse species was determined at 6 locations spread across South Morotai waters (8 *H. kuda* and *H. kellogi* individuals), Morotai South West (8 *H. kuda* and *Hippocampus Kellogi* individuals), Rao Island waters (1 *H. kellogi* individual), East Morotai waters (1 *H. spinosissimus* individual), North Morotai waters (2 *H. kuda* individuals) and Morotai Jaya waters (6 *H. kuda* and *H. kellogi* individuals).

Acknowledgements. The authors would like to tahnk to the Directorate of Research, Technology and Community Services (DRTPM) of the Ministry of Education, Culture, Research, and Technology for funding this research through the 2022-2023 PDKN Grant and to all parties who helped and were involved during data collection in the field.

Conflict of interest. The authors declare no conflict of interest.

References

Asri M., Syarifudin, Niartiningsih A., 2019 [Survival and growth of juvenile sea horse *(Hippocampus barbouri*) in flowing water systems with different volume changes of water]. Journal of Marine Science 5(1):44–50. [In Indonesian].

Borges A. K. M., Alves R. R., Oliveira T., 2022 A collaborative approach to determine priority actions for seahorse conservation in a brazilian estuary. Conferencia Brasileira de Projetos de Conservacao da Biodiversidade 2:25–26.

Curtis J. M. R., Vincent A. C. J., 2005 Distribution of sympatric seahorse species along a gradient of habitat complexity in a seagrass- dominated community. Marine Ecology Progress Series 291:81–91.

Dody S., Manuputty G., Limmon G., 2021 [Habitat characteristcs and density of spotted seahorse *Hippocampus kuda* at waters of Ternate Island and surroundings, Maluku Utara, Indonesia]. IOP Conference Series: Earth and Environmental Science 805:1–10. [In Indonesian].

Fianda C., Pratomo A., Idris F., 2015 [Identification and inventory of sea horse species (*Hipocampus* sp.) that live in the waters of Bintan Island, Riau Archipelago Province]. Maritime Raja Ali Haji Maritime, 10 p. [In Indonesian].

Foster S., Apale C. M. A., 2016 Exploitation, trade, conservation and management of seahorses in the Philippines. Project Seahorses and ZSL-Philippines, 40 p.

Foster S. J., Vincent C. J., 2004 Life history and ecology of seahorses : implications for conservation and management. Jurnal of Fish Biology 65:1–61.

Harasti D., Brennan M., Booth D. J., 2022 Assessing the effectiveness of conservation stocking for the endangered white's seahorse *Hippocampus whitei*. Frontiers in Marine Science 9:1–11.

Koroy K., Nurafni, Alwi D., 2023 [Types of sea horses (*Hippocampus* sp.) in the Marine Protected Area (KKP) of Morotai Island]. Deepublish. Yogyakarta, 83 p. [In Indonesian].

Kuang C. C., Chark L. H., 2004 A record of seahorse species (Family Syngnathidae) in East Malaysia, with notes on their conservation. Malayan Nature Journal 56(4):409–420.

Lazic T., Nota A., Amoruso V., Tiralongo F., Pierri C., Gristina M., 2022 Assessing seahorses distribution along the Italian coasts through citizen science and social media platforms. IEEE International Workshop on Metrology for the Sea; Learning to Measure Sea Health Parameters (Metro Sea) 28:554–558.

Lazic T., Pierri C., Gristina M., Carlucci R., Cardone F., Colangelo P., Desiderato A., Mercurio M., Bertrandino M. S., Longo C., Carbonara P., Corriero G., 2018 Distribution and habitat preferences of *Hippocampus* species along the Apulian coast. Wiley Diversity and Distributions 28:1–12.

Lourie S. A., Foster S. J., Cooper E. W. T., Vincent A. C. J., 2004 A guide to the identification of seahorses. University of British Columbia and World Wildlife Fund, 120 p.

Lourie S. A., Pollom R. A., Foster S. J., 2016 A global revision of the seahorses *Hippocampus rafinesque* 1810 (Actinopterygii: Syngnathiformes): taxonomy and biogeography with recommendations for further research. Zootaxa 4146(1):001-066.

Lourie S. A., Pritchard J. C., Casey S. P., Truong S. I. K. Y., Hall H. J., Vincent A. C. J., 1999 The taxonomy of Vietnam's exploited seahorses (family Syngnathidae). Biological Journal Ofthe Linnean Society 66:231–256.

Lourie S. A., Randall, J. E., 2003 A new pygmy seahorse, *Hippocampus denise* (Teleostei: Syngnathidae), from the Indo-Pacific. Zoologi Studies 42(2):284–291.

Martin S. K. M., Vincent A. C. J., 2005 Seahorse declines in the Derwent estuary, Tasmania in the absence of fishing pressure. Biological Conservation 123:533–545.

Martin S. K. M., Vincent A. C. J., 2005 Proposals for amendment of Appendices I and II Results. CITES Secretariat, Geneva. http://cites.org/sites/default/files/eng/news/world/cop12_prop_results.pdf.

Martínez E. C., Stanton L. M., Correia M. J., Vincent A. C. J., 2023 Comprehensive review of advances in life history of 35 seahorse species, drawn from community. Fisheries Centre Research Report 31(1):1-108

Mulalinda P., 2017 [Morphology and efficacious nutritional content of sea horses]. Scientific

Corner 14(2):23–28. [In Indonesian].
Munandar R. K., Sulistiono, Setyobudiandi I., 2020 [Seagrass ecosystem management for the sustainability of seahorse populations in Sebong Pereh Village, Bintan Regency]. Journal of Indonesian Agricultural Sciences (JIPI) 25(3):405–411. [In Indonesian].
Musick B. J. A., Harbin M. M., Berkeley S. A., Burgess G. H., Eklund A. M., Findley L., Gilmore R. G., Golden J. T., Ha D. S., Huntsman G. R., McGovern J. C., Parker S. J., Poss S. G., Sala E., Schmidt T. W., Sedberry G. R., Weeks H., Wright S. G., 2000 Marine, estuarine, and diadromous fish stocks at risk of extinction in North America (Exclusive of Pacific Salmonids). Endangered Species 25(11):6–30.
Putri M. R. A., Suryandari A., Haryadi J., 2019 [Resources of sea horses (*Hippocampus* spp.) in the waters of Bintan Island, Lampung Bay and Tanakeke Island]. Oceanology and Limnology in Indonesia 4(1):27–40. [In Indonesian].
Sadili D., Sarmintohadi, Ramli I., 2015 [Guidelines for identification and monitoring of seahorse populations]. Directorate of Conservation and Marine Biodiversity, Jakarta, 92 p. [In Indonesian].
Saher N. U., Kamal M., Rodini M., Naz F., Narejo A. H., 2021 First record and morphological identification of the seahorse *Hippocampus kellogi* great seahorse Jordan and Snyder (1902) in coastal waters of Pakistan. Oceanography and Fisheries 13(2):1–7.
Saraswati S. A., Pebriani D. A. A., 2016 [Monitoring seahorse populations in the coastal waters of Padang Bai Karangasem, Bali]. Journal of Fisheries Science 7(2):100–105. [In Indonesian].
Setyono D. E. D., 2020 [Biological characteristics of seahorses (*Hippocampus* spp.) As the basic knowledge of its cultivation]. Oseana 45(1):70–81. [In Indonesian].
Sun J., Xie S., Shao P., Xia S., Yang Y., Cui P., Chen S., 2020 Broodstock cultivation of the yellow seahorse *Hippocampus kuda* Bleeker in the aquarium culture system. IOP Conference Series: Earth and Environmental Science 585:1–6.
Syafiuddin, Niartiningsih A., Nesa M. N., 2018 [Growth and survival of sea horses (*Hippocampus barbouri*) in growth floating net cages]. Proceedings of the Hasanuddin University Maritime and Fishery National Symposium, Makassar 5:283–288. [In Indonesian].
Tamara L., Fosso B., Bachir B., Giuseppe C., Michele G., Marinella M., Graziano P., Monica S., Pierri C., 2023 *Hippocampus guttulatus* diet based on DNA metabarcoding. Frontiers in Marine Science 10:1–10.
Zhang X., Vincent A. C. J., 2018 Predicting distributions, habitat preferences and associated conservation implications for a genus of rare fishes, seahorses (*Hippocampus* spp). Wiley Diversity and Distributions 24:1005–1017.
*** CITES, 2020 Species of Wild Fauna and Flora: Appendices I, II and III. Available at: https://cites.org/sites/default /files/eng/app/2020/E-Appendices-2020-08-28.pdf
*** Ministry of Fisheries and Maritime Affair, 2020 [Decree of the Minister of Marine Affairs and Fisheries of the Republic of Indonesia Number 67/Kepmen-KP/2020 concerning the Marine Protected Area of Rao-Tanjung Dehegila Island and its surrounding waters in North Maluku Province]. Jakarta, Indonesia. [In Indonesian].
*** Ministry of Environment Decree, 2004 [Decree of the Minister of Environment Number 51 of 2004 concerning Sea Water Quality Standards]. Available at: https://ppkl.menlhk.go.id/website/filebox/824/191009100640Keputusan%20MENLH%20Nomor%2051%20tahun%202004%20%20tentang%20Baku%20Mutu%20Air%20Laut.pdf. [InIndonesian]
*** Ministry of Trade No 50 of 2013 [Provisions on The export of natural plants and wildlife not protected by law and included in the Cites List]. https:// peraturan.bpk.go.id/Details/129299/Permendag No. 50/M-DAG/PER/9/2013 Tahun 2013 (bpk.go.id). [In Indonesian].

Received: 31 July 2023. Accepted: 03 October 2023. Published online: 21 October 2023.
Authors:
Nurafni, Pasifik Morotai University, Faculty of Fisheries and Marine Science , Jl. Siswa Darame, 97771, Morotai, Indonesia, e-mail: nurafni1710@gmail.com
Kismanto Koroy, Pasifik Morotai University, Faculty of Fisheries and Marine Science , Jl. Siswa Darame, 97771, Morotai, Indonesia, e-mail: kismantokoroy@gmail.com
Djainudin Alwi, Pasifik Morotai University, Faculty of Fisheries and Marine Science , Jl. Siswa Darame, 97771, Morotai, Indonesia, e-mail: djainudinalwi@gmail.com

How to cite this article:
Nurafni, Koroy K., Alwi D., 2023 Population, habitat, and distribution of sea horses in Morotai waters, North Maluku Province. AACL Bioflux 16(5):2678-2688.