The appearance of the humpback whale (*Megaptera novaeangliae*) during the rainy season in the Alor Waters, Indonesia

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Abstract. The appearance of humpback whale (*Megaptera novaeangliae*) in Alor Waters, Indonesia, located in the Eastern Indian Ocean, is one of the new findings in the marine protected area of Pantar Strait and the surrounding sea of Alor regency. Since 2015, when the waters of Alor regency have been designated as a marine protected area, *M. novaeangliae* specimens have never been found in these waters. The research aimed to track their trajectory, based on bio-oceanography predictions, in the marine protected area of Pantar Strait and its surrounding sea. This research used a field data survey, and database sources like the Copernicus Marine Service Data, Argo Floats and GEBCO data. The field survey was conducted from March to December 2020. The results of the research showed that around 15 *M. novaeangliae* specimens crossed the Alor waters on December 1st 2020 in the afternoon, from 05.00 to 05.45 pm. They were jumping above the water surface for about 3 seconds and diving into the water, then they were reappearing at the water surface for about 5 minutes and jumping again for about 5 seconds. The coordinates of the appearance were -8.123086° latitude and 124.063298° longitude. The average physical factors of the waters were: a sea surface temperature ranging from 25 to 31°C, a chlorophyll content ranging between 0.2 and 0.8 mm m^{-3}, a waters depth of >50 m, and a speed of the water surface currents of 0.2 to 0.6 m s^{-1}. The type of dominant zooplankton found is the crustacean from the phylum Arthropoda, with a density of 1,957 individuals L^{-1}. These findings will inform the policies concerning the *M. novaeangliae* protection in the Alor waters.

Key Words: oceanographic variables, remote sensing, Pantar Strait, mammals.

Introduction. Indonesian waters are inhabited by 31 species of cetaceans (whale, porpoise, dolphin), twelve of which being whales and the others being dolphins and dugongs (*Dugong dugong*) (Rosas et al 2012). Both resident and migrant, these species are distributed throughout the coastal waters, towards the deep sea zone (Salim 2011). Several species of cetaceans are true migratory, using the Eastern Indonesian waters as a migration route from the Indian Ocean to the Pacific Ocean and vice-versa, crossing the waters of the Komodo Islands, Solor-Lembata (East Nusa Tenggara), Banda Sea (Moluccas), Southeast Sulawesi, North Sulawesi and Papua (Sorong and Fakfak) (Salim 2011). The waters of Eastern Indonesia, particularly in several inter-island deep canals, are assumed to serve as the entry point for the migration routes of marine mammals (cetaceans), such as whales and dolphins.

Nowadays, the protection of marine mammals is a priority for the marine biology research, being based on the study of migratory and distribution patterns, especially in the cetacean's case (Dréo et al 2019). The decrease of the population of cetaceans is due to the influence of human activities, resulting in pollution and environmental destruction

(Bejder et al 2019). The humpback whale (*Megaptera novaeangliae*) is a cosmopolitan species that exists in all major ocean basins, from tropical to arctic waters (Clapham 1992; Dawbin 1959; Secchi et al 2011). According to several studies, *M. novaeangliae* is one of the over-hunted species, which causes a significant decrease of its populations in the southern hemisphere, including the South Atlantic and South America (IWC 1998; Chittleborough 1965; Findlay et al 2011; Secchi et al 2011).

The waters of the Alor Strait and its surroundings are located in the Province of East Nusa Tenggara, which is one of the areas of the Indonesian Exclusive Economic Zone (ZEEI), next to the west coast. Timor Leste and Australia are on the trajectory of the Indonesian Throughflow, considered as the confluence of two current masses from the Pacific Ocean and Indian Ocean (Putra et al 2016).

The waters of the Alor Strait are unique, with dynamic oceanographic variables. Significant changes occur in the sea surface, due to the vertical temperature variability and salinity during the southeast monsoon season. The dynamics of the waters in the surface layer is influenced by the monsoon wind patterns, determining the upwelling in the Savu Sea waters. The process of stirring up the water masses (upwelling) affects the living conditions of the phytoplankton, the hydrology and the nutrient enrichment in the waters (Sediadi 2004; Packard et al 2015). Among the most significant impacts of the upwelling are an increased fertility (abundance of plankton as natural food) and an increased sea water temperature (warm), providing comfort to a group of cetacean species, including the *M. novaeangliae* and the bottle-nose dolphin (*Tursiops truncatus*), which are migrating to the waters of the Alor Strait (Mujiyanto et al 2017).

The Alor Strait is part of the Pantar Strait Conservation Area and its surrounding sea which has been arranged in the Ministerial Regulation No. 5/KEPMEN-KP/2015, by the Ministry of Marine Affairs and Fisheries Republic of Indonesia. The appearance of the *M. novaeangliae* in the Alor Strait waters was initially informed by some fishermen in the location. The fishermen reported the information to the researchers, so further monitoring and research on this species could be conducted. Therefore, the objective of this study was to design and implement a monitoring research experiment on *M. novaeangliae* in the Alor Strait waters, using the field observation of the bio-oceanography.

Material and Method

Description of the study site. The research was conducted in the Pantar Strait, Alor, East Nusa Tenggara from March to December 2020. The field survey method, modified from Dharmadi et al (2017) and Mujiyanto et al (2017), was the zig-zag track method using a boat of 10 GT with two observation decks, involving two different groups of on-deck observers. Water samples were taken at every cetaceans appearance event, in order to determine the plankton distribution. Field photography documentation of cetaceans appearance was also performed for further identification. Pictures were taken using Canon camera and drone. The ship was traveling at a speed of 7 to 8 knots on each survey trajectory. The map of the research area can be seen in Figure 1.

Regarding the processing of Alor Strait oceanographic data, the Aqua MODIS (Moderate Resolution Imaging Spectroradiometer) satellite image data, Copernicus Marine Service Data, ARGO (Array for Real-Time Geostrophic Oceanography) Float and GEBCO data (General Bathymetric Chart of the Oceans) were used. The data were processed using the ArcGIS 10.8, applying the kriging interpolation method (Wirasatriya et al 2020; Hartoko 2010; Hartoko et al 2019). Data processed in the study are the sea surface temperature, chlorophyll-a, current speed, wind speed and depth. Data processing was carried out at the Marine Geomatics Research Laboratory, Diponegoro University, Semarang.

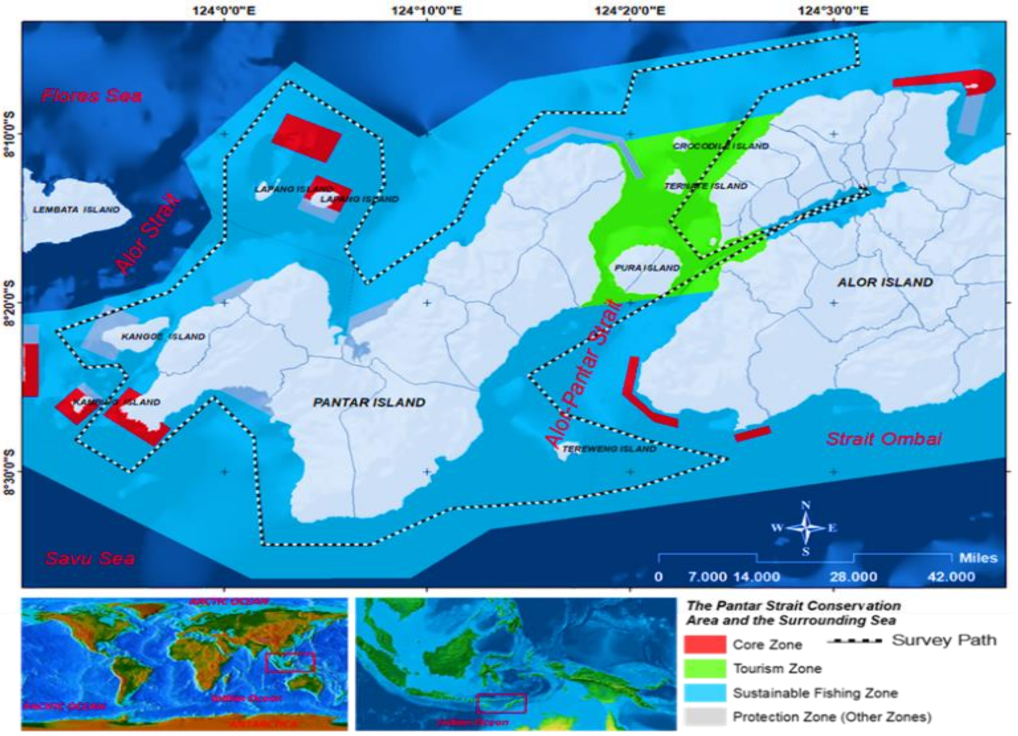

Figure 1. Map of research locations for *Megaptera novaeangliae* in the Alor Strait (MMAF Decree 2015).

Results and Discussion

Appearance and distribution of the M. novaeangliae in the Alor Strait. The study discovered three points of the *M. novaeangliae* appearance in the Alor Strait, they can be seen in Figure 2.

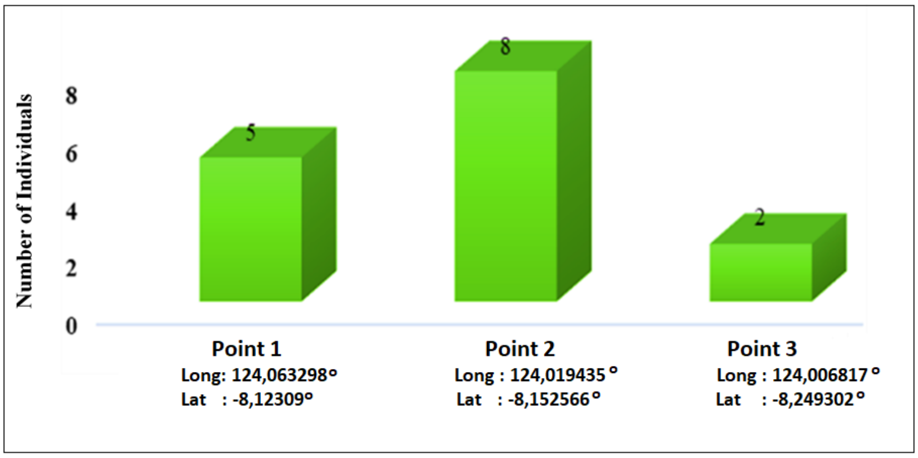

Figure 2. Appearance of *Megaptera novaeangliae* at Alor Strait.

Figure 2 shows the of appearance of *M. novaeangliae* at each observation point. The appearance of the *M. novaeangliae* in Alor waters occurred in the afternoon from 05.00 to 05.45 pm on December 1st 2020, which was precisely during the rainy season in Indonesia. *M. novaeangliae* appearance event at each point was recorded in the pictures presented in Figures 3, 4 and 5.

Figure 3. (A, B, C & D) The appearance of a *Megaptera novaeangliae* with jumping behavior at the Point 1 (coordinates 124.063298° longitude and 8.123086° latitude) (original).

Figure 4. (A, B, C & D) The appearance of a *Megaptera novaeangliae* with jumping behavior at the Point 2 (coordinates: 124.019435° longitude and 8.152566° latitude) (original).

Figure 5. (A, B, C & D) Appearance of the *Megaptera novaeangliae* with Salto's demeanor and threw his body into the body of water at the Point 2 (coordinates: 124.019435^o longitude and 8.152566 152566^o latitude) (original).

The appearance of the *M. novaeangliae* at three points in the Alor Strait waters had the same behavior: it was jumping over the sea surface, slamming its tail into the water, flipping and hitting its body in the water, which can be seen in Figures 4, 5, and 6. The *M. novaeangliae* was jumping over the sea surface using its elongated pectoral fins during maneuver and swam back into the water, then came back to the water surface for about five minutes, jumped back for about five seconds and sang (made a sound at the sea level). The map of the zone of the *M. novaeangliae* appearance is shown in Figure 6.

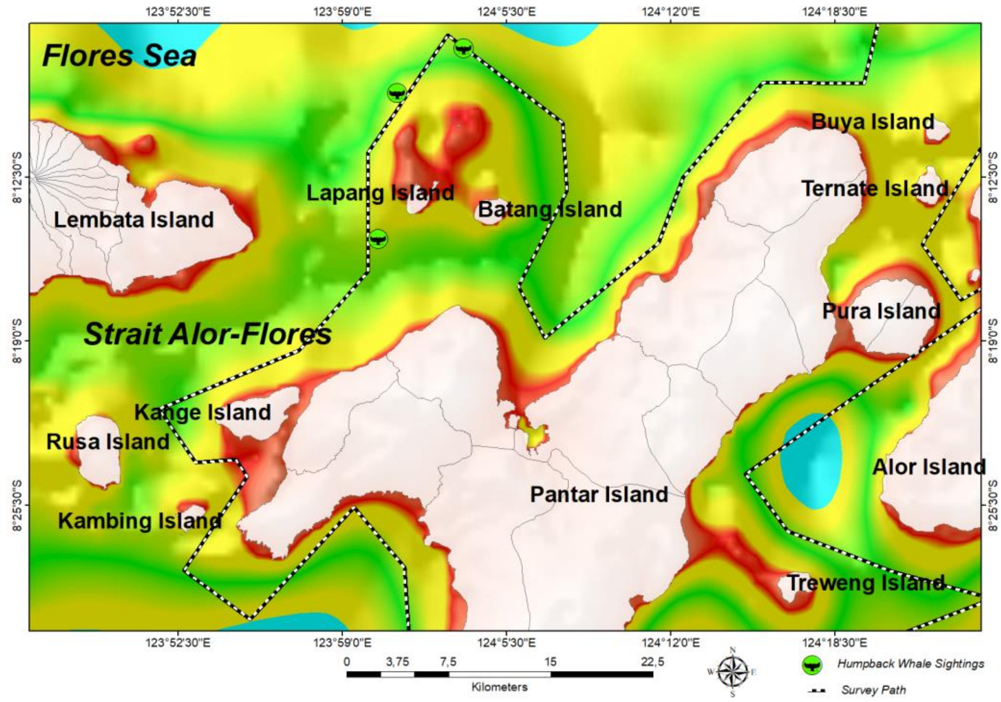

Figure 6. Map of the appearance of the *Megaptera novaeangliae* in the Alor Strait.

According to several studies, *M. novaeangliae* leaps out of the water (jumping through the seawater), hits the surface of the water with its long fins, then hits the water surface with its tail (lobtail) and freezes in a vertical position with its head above the water (spyhop); it breaks through by swimming from the depth to the surface of the water at an oblique angle, then jumps into the air at a variable angle (of slope upto 70 degrees), over the sea surface(Clapham 2009; Galvin 2006; Fish & Battle 1995; Parsons et al 2008; McSweeney et al 1989; Zerbini et al 2004; Calambokidis & Barlow 2004; Kügler et al 2020; Mohebbi-Kalkhoran et al 2019). Then, it rotates on its long axis, landing on its back with its belly rising up and eventually singing. Singing is an important point of the *M. novaeangliae* social behavior, considering that the sound can be related to the intrasexual competition and/or intersexual selection.

The tubercles of *M. novaeangliae* in front of its body are used as an enhanced lifting device to control the water flow over its fins and maintain the lift at high angles of attack. The morphology of the fin exhibits high maneuverability related to its unique feeding behavior. Its eyeballs are similar to other cetaceans and show adaptation to diving and migration, contributing to the perception of temperature, pressure and light differences (Woodward et al 2006; Hampe et al 2015; Rodrigues et al 2014).

The group of the *M. novaeangliae* found in the Alor Strait during the rainy season in December 2020 was assumed to have migrated from the Atlantic Ocean and Australian seawaters. This was due to the appearance of the *M. novaeangliae* in the Alor Strait waters with a distance of ±700 km from Australian waters, migrating for food and mating. According to Palsbøll et al (1997) and to the IWC (1998), *M. novaeangliae* could cover a distance of 8,000 km from the breeding grounds, in the tropical zones, from July to October in the southern hemisphere and from December to March in the northern hemisphere. In order to gain enough strength and body mass for giving birth and intensively breastfeeding their babies for several months, the pregnant M. novaeangliae female could swim thousands kilometers to the nutrient-rich arctic or mid-temperature waters, where they could find their food. Usually, the pregnant *M. novaeangliae* female arrives earlier than other whales which are not pregnant or in their adolescence period (IWC.int/humpback-whale 2021).

According to Craig et al (2014), the pregnant *M. novaeangliae* female seeks for recessed waters (bays) to give birth so that its newborn can be protected. Based on this research, considering the condition of the Alor Strait waters which are protected and close to coastal areas, it is assumed that one of the reasons of the *M. novaeangliae* appearance in the Alor Strait waters in the rainy season of December 2020, was themigration for reproduction or giving birth. Furthermore, considering its group behavior (throwing its body in the air and diving by poking its tail in the water opening its mouth at the water surface and releasing large bubbles in the waters) it can be assumed that the *M. novaeangliae* migrated for foraging and mating in the Alor Strait waters. This research found and identified zooplankton from three classes of of different phyla, at three points where *M. novaeangliae* specimens were observed. The class of Crustacea of the phylum Arthropod was represented with the highest density of zooplankton. A total of 1,957 individuals L^{-1} were found at the three points, as it can be seen in Table 1 and Figure 7.

Table 1

Density of zooplankton at the Point 3 on the appearance of *Megaptera novaeangliae* at Alor Strait

Zooplankton	*Class*	*ST1*	*ST2*	*ST3*	*Total*
		Ind L^{-1}			
Protozoa	Sarcodina	130	127	145	402
Annelida (=annulata)	Polychaeta	95	30	72	197
Arthropoda	Crustacea	677	647	633	1957
Mollusca	Gastropoda	112	145	105	362
Echinodermata	Ophiuroidea	6	10	23	39

Figure 7. (A, B, C & D) Diversity of crustacea dominant at the Point 3 of the *Megaptera novaeangliae* appearance (original).

According to Nybakken (1992), the zooplankton species which are the most important as fish food are from the class of the crustaceans, belonging to the arthropod phylum. Crustaceans are animals that have cells consisting of chitin or calcium, which are difficult to digest. Crustaceans can be divided into 2 groups: Entomostraca or low-level crustaceans and Malacostracea or high-level crustaceans.

According to Werth et al (2019), Burkard et al (2015) and Chen (2012), *M. novaeangliae* has cranial elevation, i.e. the expulsion of filtered water begins with a small splash in the anterior of the mouth, followed by a continuous outflow in the middle or posterior area of the mouth apart from the splash in the mouth which is free of turbulence during swallowing.

The submersion of the *M. novaeangliae* head creates a vortex in the undersea and water surface, large enough for the purpose of gathering prey, such as groups of small shrimp and small fish to eat. Due to the abundance of zooplankton of the class Crustacea at the three points of the *M. novaeangliae* specimens appearance, it can be assumed that one of the reasons of their appearance in the Alor waters is migrating for food. This is because the type of plankton from the crustacean class is part of the cetacean diet, including the *M. novaeangliae*.

Oceanographic variables supporting the appearance of the M. novaeangliae in the Alor Strait. Oceanographic variables such as sea depth temperature, chlorophyll-a, current velocity and the waters depth are important indicators in supporting the presence of cetaceans in a waterbody (Ballance et al 2006; Tynan et al 2005; Cañadas et al 2002; Hamazaki 2002; Praca et al 2009).

Alor Strait is still influenced by the water mass of the Indian Ocean and the Pacific Ocean, which makes its waters quite sensitive to temperature changes, especially at the points where the *M. novaeangliae* appears in Alor Waters. Research results obtained through ARGO (Array for Real-Time Geostrophic Oceanography) data analysis showed that the monthly average of the sea water temperature from 2006 to 2020, at a depth of 0 to 200 m, ranged from 18.0 to 28.0°C, which can be seen in Figure 8. The monthly average of the sea surface temperature data processed through Aqua MODIS (Moderate Resolution Imaging Spectroradiometer) data ranged from 25.0 to 31.0°C, as in Figure 9.

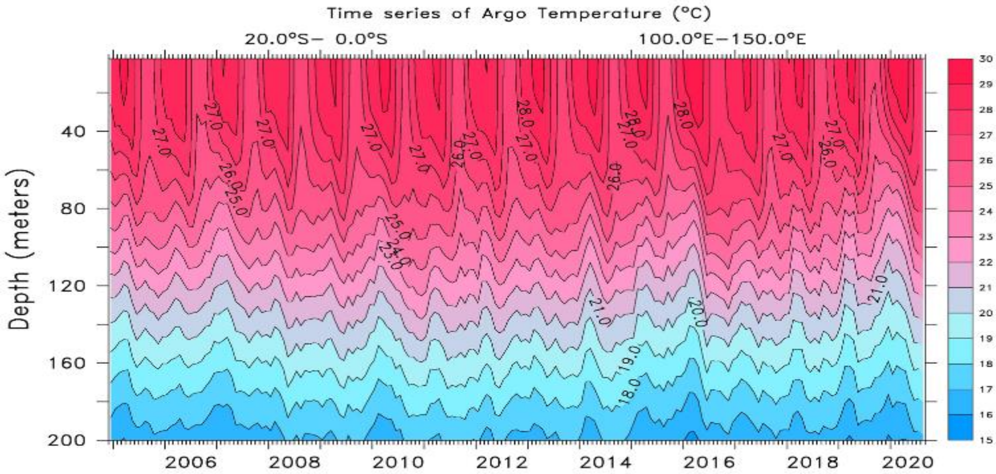

Figure 8. Yearly average of seawater temperature at a depth of 0 to 200 m, at Point 3 of the *Megaptera novaeangliae* sighting in Alor Strait.

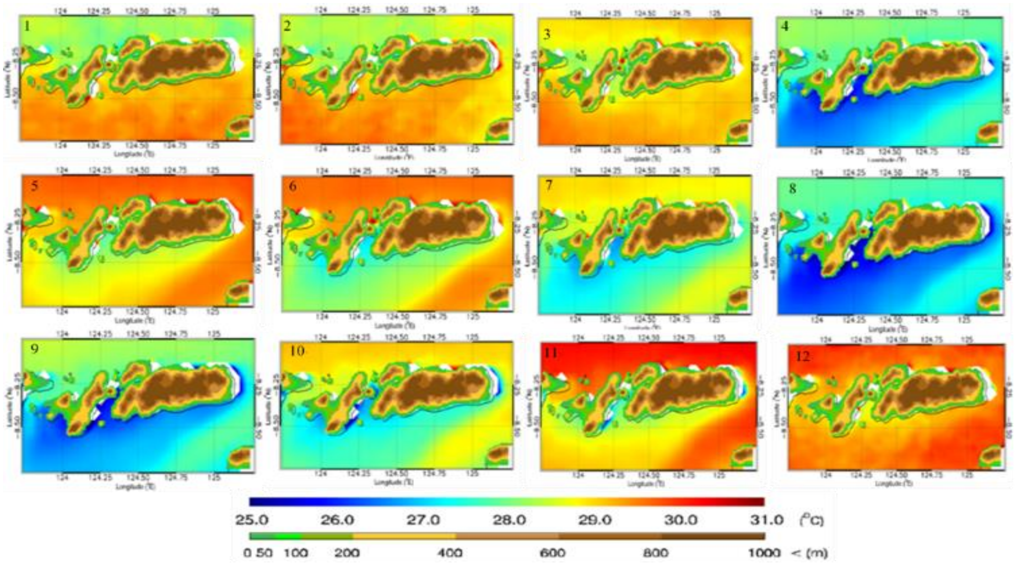

Figure 9. Monthly (1-12) average of sea surface temperature 2020.

From the ARGO and Aqua MODIS data, the research determined that the average depth and sea surface temperature in the Alor Strait waters, including its surrounding seas at the tropics, are still in the normal category for the emergence of cetaceans, especially the *M. novaeangliae*. This is supported by the research of Houser et al (2004), which explains that at the tropics the average temperature range at the time of the appearance of cetaceans is between 20 to 31°C. Forcada et al (1996) documented the preferred temperature for cetaceans as ranging between 22.3 and 26.3°C (average 24.2°C). Consistently, the same sea surface and depth temperature values for the presence of cetaceans in water bodies were determined by other studies (Laran & Gannier 2008; Gregr & Trites 2001; Hamazaki 2002; Doniol-Valcroze et al 2011), as ranging from 22.4 to 26.7°C (average 23.08°C). Putra et al (2016) found the sea surface temeperature of the appearance of cetaceans in the Savu sea waters in the range of 30 to 31°C. The average distribution of chlorophyll-a and the average monthly sea surface flow velocity, based on the results obtained during 2020 from the Aqua MODIS data analysis in the Alor Strait seawater, ranged from 0.2 to 0.8 mm m^{-3} and from 0.2 to 0.6 m s^{-1}, respectively, as in Figure 10 and Figure 11.

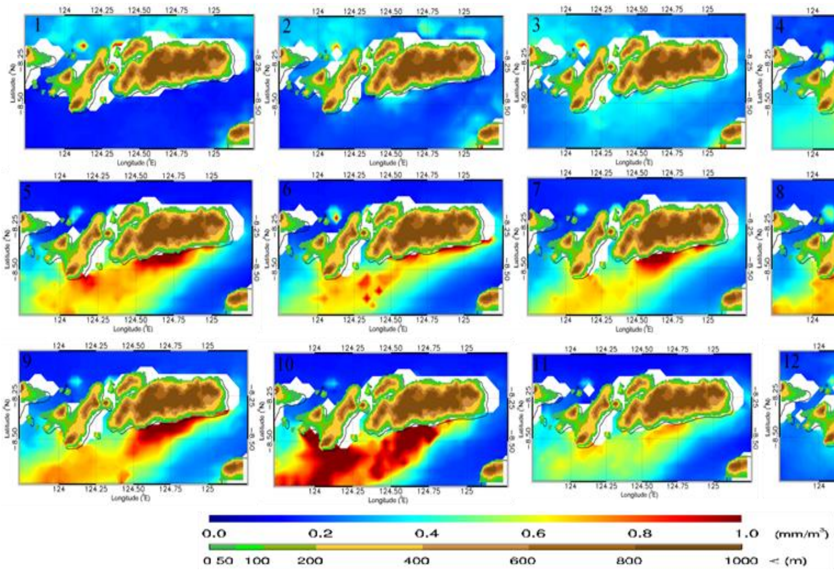

Figure 10. Monthly average of seawater chlorophyll-a 2020 at Alor Strait.

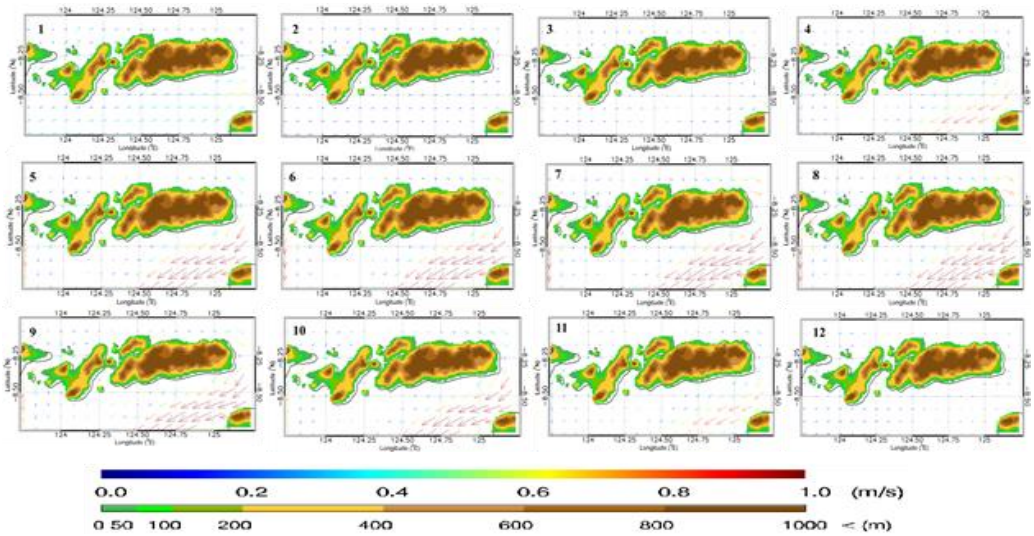

Figure 11. Monthly (1 to 12) Alor strait's current speed average in 2020.

The research found that the average chlorophyll-a and the mean sea surface flow velocities for the emergence of cetaceans in Alor waters were ranging from 0.1 to 0.6 mm m^{-3} and from 0.2 to 0.6 m s^{-1}, respectively. To this extent, it can be concluded that the average range of chlorophyll-a and the average flow velocity in the Alor Strait are still categorized as normal for the emergence of cetaceans in the Alor Strait.

The appearance of the *M. novaeangliae* in the Alor Strait was located at approximately 7 to 12 km from the coast, with a depth of more than 50 m. According to certain studies (Putra et al 2016; Salim 2011), cetaceans, especially whales, were found in the Savu Sea waters at a depth of less than 100 m. The depth modeling of the waters where the *M. novaeangliae* was found in the Alor Strait used the GEBCO data, as in Figure 12.

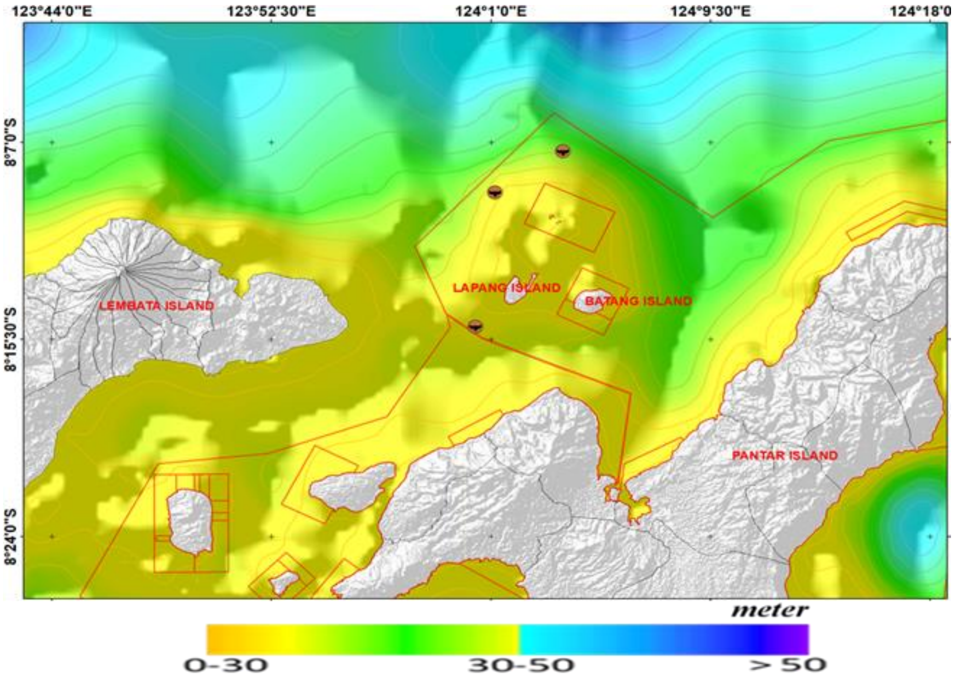

Figure 12. Depth at three observation points at Alor Strait.

Conclusions. The results of the research showed that around 15 *M. novaeangliae* crossed the Alor waters in the afternoon of December 1st 2020, from 05.00 to 05.45 pm with a mating behavior. The coordinates of the appearance were in: 8.123086° latitude and 124.063298° longitude. The average physical factors of the waters included: the sea surface temperature ranging from 25.0 to 31.0^{0}C, the chlorophyll content ranging from 0.2 to 0.8 mm m^{-3}, the waters depth >50 m, the surface water currents 0.2 to 0.6 m s^{-1}. The dominant type of zooplankton found consisted of crustaceans from the Arthropoda phylum, with a density of 1,957 individuals L^{-1}. This findings will support the *M. novaeangliae* species protection in Alor waters- the Eastern of Indian Ocean, Indonesia.

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

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