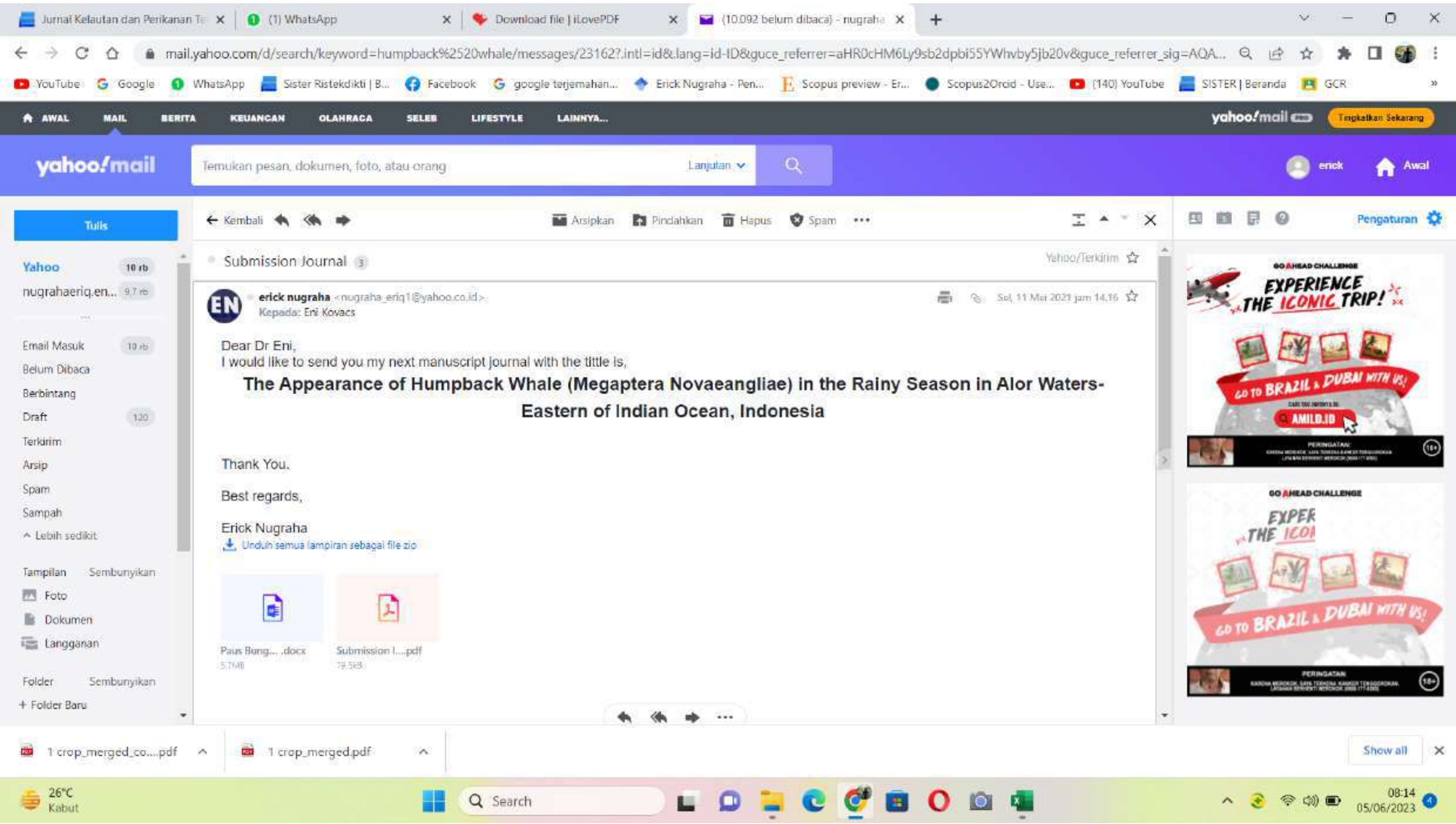

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# The Appearance of Humpback Whale (*Megaptera Novaeangliae*) in the Rainy Season in Alor Waters-Eastern of Indian Ocean, Indonesia

[1]Jahved Ferianto Maro, [2]Agus Hartoko, [2]Sutrisno Anggoro, [2]Max Rudolf Muskananfola, [3]Lumban Nauli Lumban Toruan, [3]Micael Dakahamapu, [4]Erick Nugraha.

[1]Faculty Fisheries and Marine Science, Coastal Resources Management Doctoral Programe, Diponegoro University, Semarang, Indonesia; [2]Faculty Fisheries and Marine Science, Coastal Resources Management, Diponegoro University, Semarang, Indonesia; [3]Faculty of Fisheries and Marine Science, Nusa Cendana University, Kupang, Indonesia; [3]Environmental Practitioners. Indonesia; [4]Faculty of Fishing Technology, Jakarta Technical University of Fisheries, South Jakarta, Indonesia; Corresponding author: E. Nugraha, nugraha_eriq1@yahoo.co.id

**Abstract.** The appearance of Humpback Whale (*Megaptera Novaeangliae*) in Alor Waters-Indonesia the Eastern of Indian Ocean is the one of new findings in the marine protected area of Pantar strait and its surrounding sea of Alor regency. Since 2015, the waters of Alor regency have been designated as a marine protected area, *Megaptera Novaeangliae* have never been found in this waters. This research aims to see the trajectory using biooseanography predictions of *Megaptera Novaeangliae* in the marine protected area of Pantar strait and its surrounding sea. The data used in this research are field data survey, Copernicu Marine Service Data, Argo Float and Ocean Color.gsfc.nasa.gov. The field survey was conducted on march to december 2020. The results of the research showed that it was around 15 *Megaptera Novaeangliae* crossed Alor waters in the afternoon from 05.00 to 05.45 pm on Desember 1st, 2020 by jumping on the surface of waters for about 3 seconds and drowning itself into the water then reappears to the surface of water for about 5 minutes and jumping again for about 5 seconds. The coordinates of the appearance Lattitude: -8.123086 Longitude: 124.063298. The range of the average physical factors of the waters includes the range of mean of sea surface temperature that ranging from 25.0$^0$C to 31.0$^0$C, chlorophyll content ranges between 0.2 mm/m$^3$ to 0.8 mm/m3, waters depth > 50 m, range of the average surface currents of waters 0.2 m/s to 0.6 m/s with the type of zooplankton found is the crustacean class Arthropoda phylum with 1957 Individu/l. This findings will be used as recommendation of *Megaptera Novaeangliae* species protection in Alor waters-Indonesia the Eastern of Indian Ocean.
**Keywords**: Oceanographic Variables, Remote Sensing, Pantar Strait, Mammals.

**Introduction.** Indonesian waters are inhabited by 31 species of *Cetacean* (whale, porpoise, dolphin); twelve of which are whales, while the rest are dolphins and dugongs (*Dugong dugong*) (Rosas & Uhart 2012). Both are resident and migrant, these fishes are distributed throughout the coastal waters to the deep sea zone (Salim 2011). Several species of cetaceans that are true migratory use Eastern Indonesian waters as a migration route between the Indian to Pacific Oceans and vice-versa through 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 world's attention is mostly focused on the protection of marine mammals and tend to see their migratory patterns and distribution, especially cetaceans (Dréo et al 2019). This was due to the decreasing population of cetaceans as the result of the influence of human activities; such as illegal logging, pollution and environmental destruction, thus causing the existence of cetaceans has to be protected (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 et al 1992; Dawbin 1959; Secchi et al 2011). According to (IWC 1998; Chittleborough 1965; Findlay et al 2011; Secchi et al 2011) the *Megaptera novaeangliae* is one of the species that is immensely hunted to be killed and consumed, causing a significant decrease of the species in the southern hemisphere, including the South Atlantic and South America.

The waters of the Alor Strait and its surroundings are located in the Province of East Nusa Tenggara, which is one of the areas located in the Indonesian Exclusive Economic Zone (ZEEI) next to the west coast. Timor Leste and Australia are also the areas of the trajectory of 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 the dynamic oceanographic variables. Such as a significant changes in sea surface and vertical temperature variability and salinity during the southeast monsoon season. The dynamic of the waters occur in the surface layer which influenced by monsoon wind patterns. This condition results in upwelling in the Savu Sea waters. The process of stirred up water mass (upwelling) in the waters affects the living conditions of phytoplankton, hydrology, and the nutrient enrichment in the waters (Sediadi 2004; Packard et al 2015). One of the significant impacts of upwelling is the increasing fertility (abundance of plankton as natural food) and the increasing sea water temperature (warm), thus providing comfort for a group of cetaceans, including the *Megaptera novaeangliae* and the Bottle-nose Dolphin *(Tursiops truncatus)* which are migrating in the waters of the Alor Strait (Mujiyanto et al 2017).

The Alor Strait is part of the Pantar Strait Conservation Area Nature Preserve 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 *Megaptera 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 based on the background of the problem, the monitoring research on the *Megaptera novaeangliae* in the Alor Strait waters using field observation and observed the bio-oceanography of the *Megaptera novaeangliae* method is inevitable.

## Materials and Method

The research was conducted in the Pantar Strait, Alor, East Nusa Tenggara from March to December 2020. Field survey method was modified from (Dharmadi et al 2017; Mujiyanto et al 2017) which is the zig-zag track method using a boat 10 GT with two observation decks that was done by two different groups of on-deck observers. Water samples were taken in every appearance of cetaceans to identify the plankton. Field photography documentation of cetaceans appearance wa also done for further identification. Field photographs were taken using Canon camera and drone. The ship was traveling at a speed of 7 to 8 knots on each survey trajectory. Map of the research area can be seen in Figure 1.

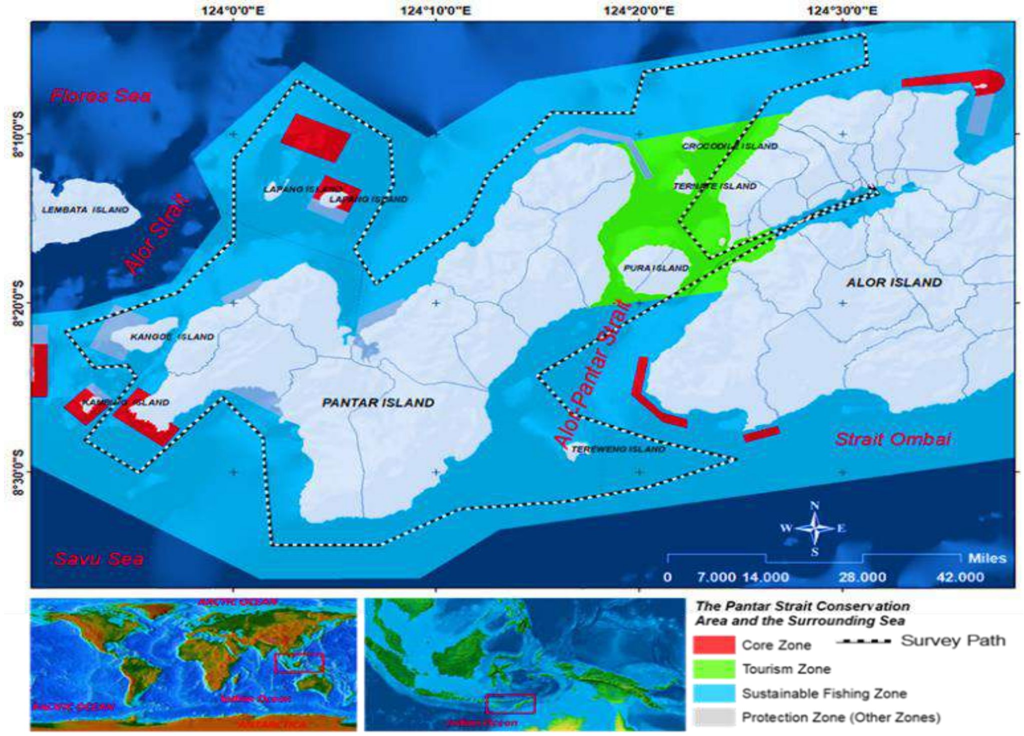


Figure 1. Map of research locations for *Megaptera novaeangliae* in the Alor Strait (MMAF Decree 2015)

Regarding the processing of oceanographic data, the writers used 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) in the Alor Strait waters. 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 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.

## Result and Discussion

### Appearance and Distribution of the *Megaptera novaeangliae* in the Alor Strait

The study had discovered three points of the *Megaptera novaeangliae* appearance in the Alor Strait, with the number of each point can be seen in the graph as in Figure 2.

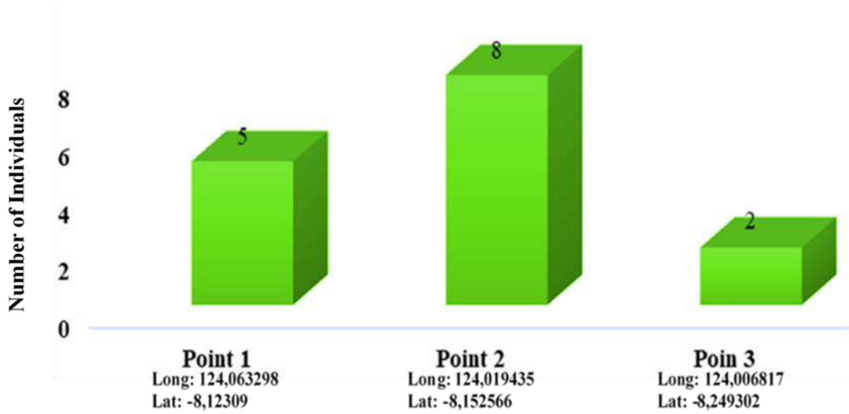


Figure 2. Appearance of *Megaptera novaeangliae* at Alor strait

Figure 2 shows the of appearance of *Megaptera novaeangliae* at each observation point. There were five of the *Megaptera novaeangliae* appeared in the first point at coordinate (Long: 124.063298; Lat: -8.123086); eight were seen in the second point at coordinate (Long: 124.019435; Lat: -8.152566) and two were seen in the third point at coordinate (Long: 124.006817; Lat: -8.249302). The appearance of the *Megaptera novaeangliae* in Alor waters was found in the afternoon from 05.00 to 05.45 pm on December 1st 2020, which was precisely during the rainy season in Indonesia. The photograph appearance of the *Megaptera novaeangliae* at each point as presented in Figure 3, 4 and 5.

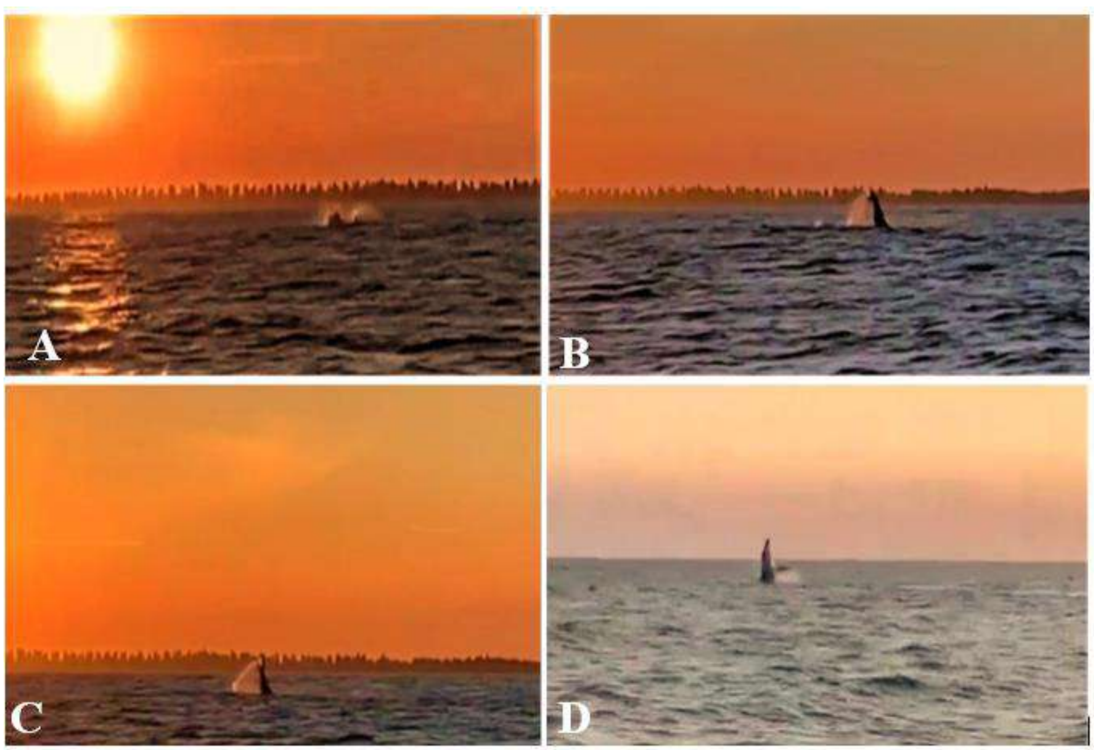


Figure 3. (A,B,C & D) The appearance of a *Megaptera novaeangliae* with jumping behavior Point-1 with coordinate *Long*: 124.063298; *Lat* : -8.123086


Figure 4. (A, B, C & D) The appearance of a *Megaptera novaeangliae* with jumping behavior at Point 2 with coordinate *Long*: 124.019435; *Lat*: -8.152566.


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 Point 2 with coordinates: *Long*: 124.019435; *Lat*: -8.152566.

The appearance of the *Megaptera novaeangliae* at three points in the Alor Strait waters had the same behavior; it jumping over the sea surface, slamming its tail into the water, flipping, and hitting its body in the waterbody which can be seen in Figures 4, 5, and 6. The *Megaptera novaeangliae* jump 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 and jumped back for about five seconds and sang (made a sound at the sea level). The map of the *Megaptera novaeangliae* appearance as in Figure 6.

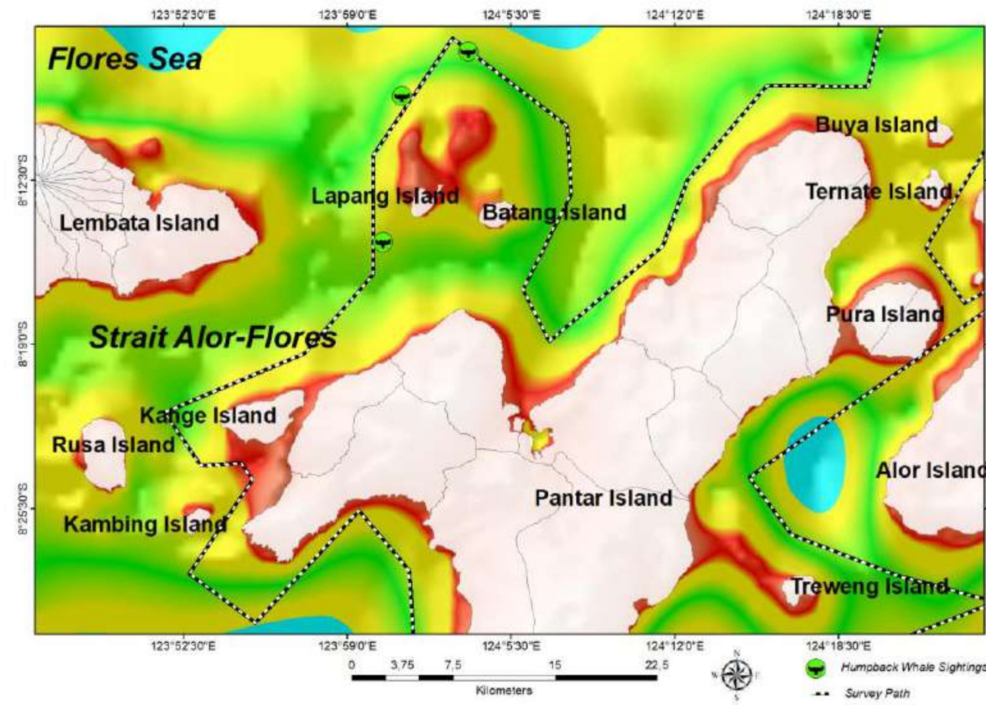


Figure 6. Map of the Appearance of the *Megaptera novaeangliae* in the Alor Strait

According to (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) the *Megaptera 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 itself into the air at an angle (slope of 0 to 70 degrees) over the sea surface. Then, it rotates on its long axis, landing on its back with its belly rising up then singing. Singing is an important point of the *Megaptera novaeangliae* social behavior with the idea that the sound of its singing has a component of intrasexual selection and / or intersexual selection.

The tubercles of the *Megaptera 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 *Megaptera novaeangliae's* fin exhibits high maneuverability related to its unique feeding behavior, whereas its eyeballs are similar to other cetaceans and show adaptation to diving and migration, contributing to the perception of differences in temperature, pressure and lighting (Woodward et al 2006; Hampe et al 2015); Rodrigues et al 2014).

The group of the *Megaptera novaeangliae* that was 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 *Megaptera novaeangliae* in the Alor Strait waters with a distance of ± 700 km from Australian waters, migrating for food and mating. According to (Palsboll et al 1979; IWC 1998) the *Megaptera novaeangliae* could migrate to find food and mate with a distance of 8,000 km to the breeding grounds in the tropics in the last months of the year which is July to October in the southern hemisphere and December to March in the northern hemisphere.

In order to gain enough strength and body mass for giving birth and breastfeeding their babies intensively for several months, the pregnant female *Megaptera novaeangliae* could swim thousands kilometers to the nutrient-rich arctic or mid-temperature waters where they could find their food. Usually, the female pregnant *Megaptera novaeangliae* arrives earlier than other whales which are not pregnant or in adolescence (IWC.int/humpback-whale, (2021).

According to Craig et al (2014) the female pregnant *Megaptera novaeangliae* 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 quite protected and close to coastal areas, the writers assumed that one of the reasons of the *Megaptera novaeangliae* appearance in the Alor Strait waters in rainy season of December 2020, was because of migrating for reproduction or giving birth. Furthermore, seeing its group behavior and the attraction of throwing its body, then opening its mouth to the surface of the water, then releasing large bubbles in the waters and drowning itself by poking its tail in the water, it can be assumed that the *Megaptera novaeangliae* migrated to find food and mate in the Alor Strait waters. Results of this research found three classes of zooplankton from different phyla at three points of the sighting location of the *Megaptera novaeangliae*, along with the identification of zooplankton in the Alor Strait. The highest density of zooplankton in individuals per-liter was found from the class of *Crustacea* of the phylum *Arthropod*, with a total of 1,957 individuals per-liter found at three points, which can be seen in Table 1 and Figure 7.

Table 1

Density of zooplankton at point-3 on the appearance of
*Megaptera novaeangliae* at Alor strait

| ***Zooplankton*** | ***CLASS*** | **ST 1** (Ind/l) | **ST2** (Ind/l) | **ST3** (Ind/l) | **Total** (Ind/l) |
|---|---|---|---|---|---|
| *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 |

Source: Research Results, 2020

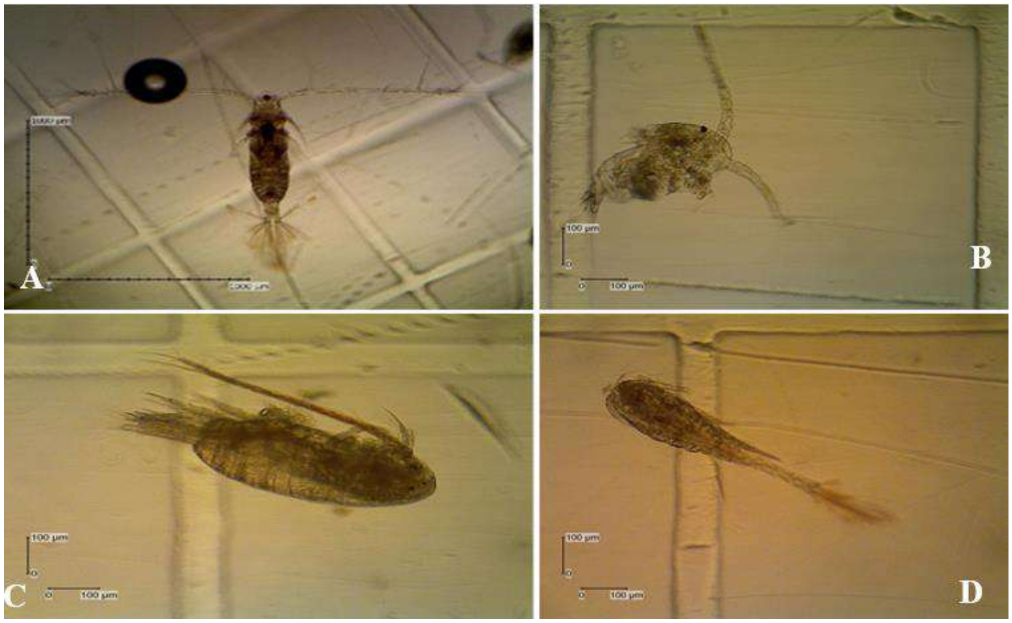


Figure 7. (A, B, C & D) Diversity of Crustacea dominant
at point-3 of the *Megaptera novaeangliae* appearance

According to Nybakken (1992) most of the zooplankton is class *crustacean* belongs to the *arthropod* phylum, only *crustaceans* that live as plankton. They are the most important zooplankton for fish in freshwater and sea water. *Crustaceans* mean 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; Chen 2012) the *Megaptera novaeangliae* has a cranial elevation, which means the excretion of filtered water. Cranial elevation of *Megaptera novaeangliae* begins with a small splash in the mouth anterior, followed by a continuous outflow in the middle or posterior area of the mouth, then releasing the turbulence-free droplet inside the mouth during swallowing. The submersion of the *Megaptera 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. The abundance of *zooplankton* of class *Crustacea* at the three points of the *Megaptera novaeangliae* appearance, it can be assumed that one of the reasons of its appearance in Alor waters is to migrate for food. This is because the type of plankton from the *crustacean* class is part of the cetacean diet, including the *Megaptera novaeangliae*

**Oceanographic Variables Supporting the Appearance of the *Megaptera 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, which is still influenced by the water mass of the Indian Ocean and the Pacific Ocean, makes Alor waters quite sensitive to changes in sea water temperature, especially at the point where the *Megaptera novaeangliae* appears in Alor Waters. Research results through ARGO (*Array for Real-Time Geostrophic Oceanography*) data analysis showed that the monthly average of sea water temperature from 2006 to 2020 at a depth of 0 to 200 meters ranged from 18.0 to 28.0°C which can be seen in Figure 8. Meanwhile, the monthly average of 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.

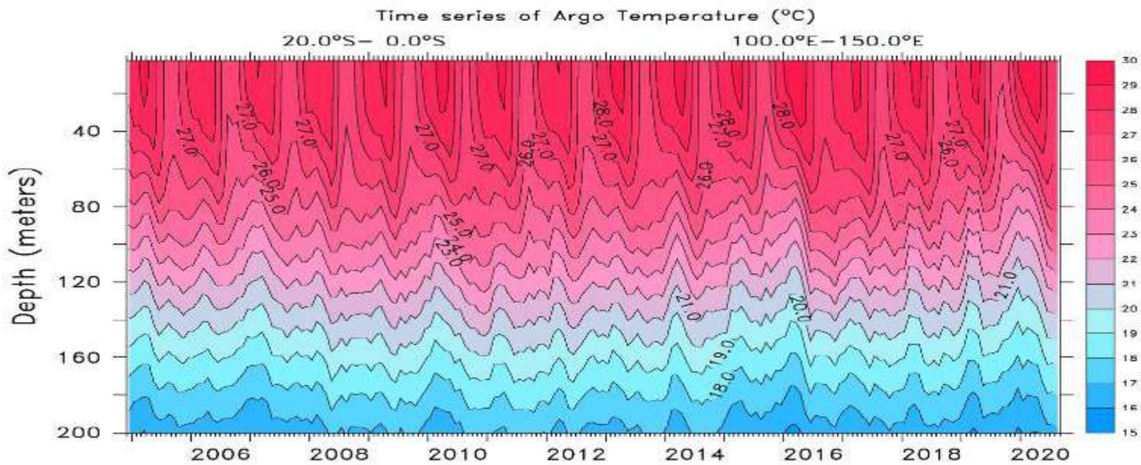


Figure 8. Yearly average of seawater temperature at depth of 0 to 200 m on Point-3 of the *Megaptera novaeangliae* sighting in Alor strait.

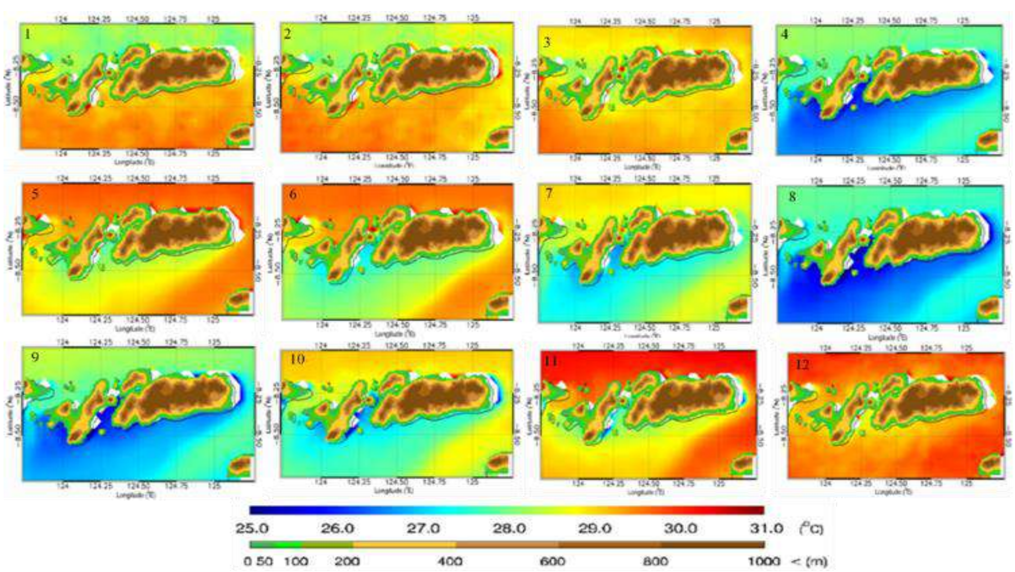


Figure 9. Monthly (1-12) average of sea surface temperature 2020

Using ARGO and Aqua MODIS data, the research found that the average depth and sea surface temperature in the Alor Strait waters including its surrounding seas in the tropics are still in the normal category for the emergence of cetaceans, especially the *Megaptera novaeangliae*. This is supported by the research of Houser et al (2004) which explains that the average temperature range in the tropics for the appearance of cetaceans is between 20 to 31°C. Forcada et al (1996) documented the preferred temperature for cetaceans to be between 22.3 to 26.3°C (average 24.2°C). The same case was conveyed by (Laran & Gannier, 2008; Gregr & Trites 2001; Hamazaki 2002; Doniol-Valcroze et al 2007) that consistently, sea surface temperature and depth for the presence of cetaceans in water bodies ranges from 22.4 to 26.7°C (average 23.08°C). This is also supported by Putra et al (2016) found the appearance of cetaceans in the Savu sea waters in the range of 30 to 31°C sea urface temperature. The average distribution of chlorophyll-a and the average monthly sea surface flow velocity based on the results during 2020 based on Aqua MODIS data analysis in the Alor Strait seawater ranged from 0.2 to 0.8 mm/m$^3$ with current velocities ranging from 0.2 to 0.6 m/s which as in Figure 10 and 11.

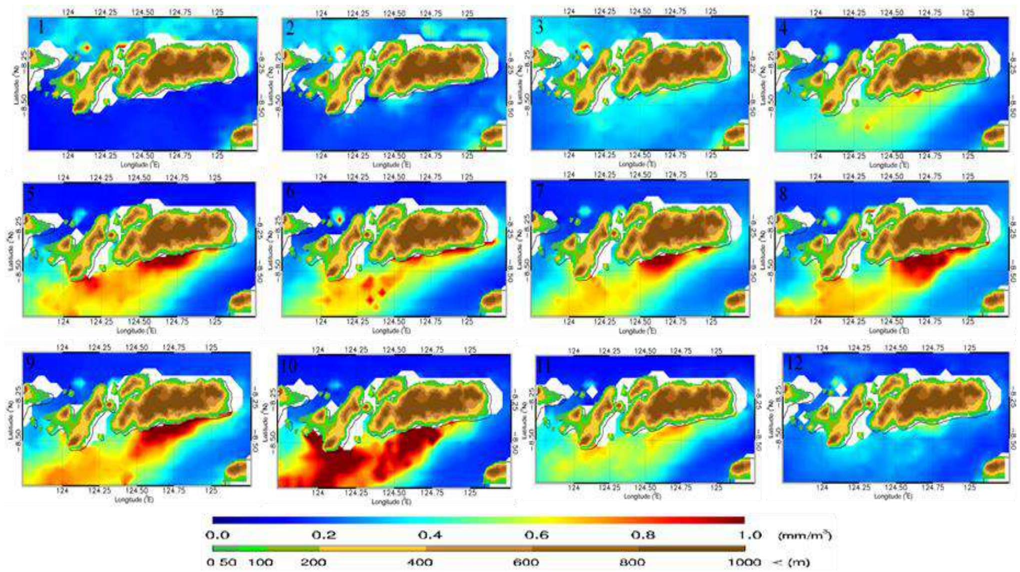


Figure 10. Monthly average of seawater chlorophyll-a 2020 at Alor strait

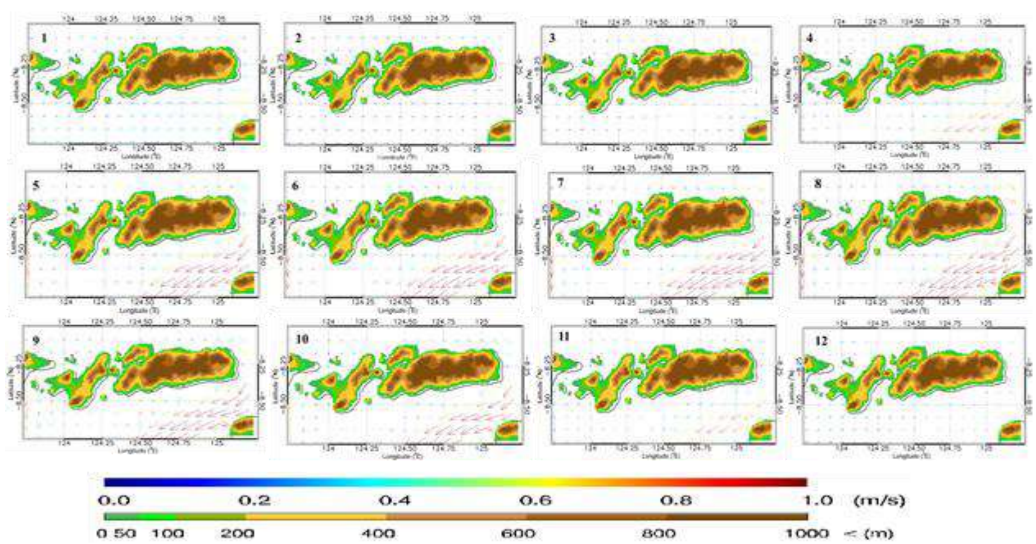


Figure 11. Monthly (1 to 12) of Alor strait current speed average in 2020

The research of found that the average range of chlorophyll-a and current velocities for the emergence of cetaceans in Alor waters ranging from 0.1 to 0.6 mm/m$^3$ for chlorophyll-a, with mean sea surface flow velocities ranging from 0.2 to 0.6 m/s. 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 *Megaptera novaeangliae* in the Alor Strait had an appearance point not far from the coast, which was approximately 7 to 12 km from the coast, with the depth more than 50 m. According to (Putra et al 2016; Salim 2011), cetaceans, especially whales, were found in the Savu Sea waters at a depth less than 100 m. The water depth model where the *Megaptera novaeangliae* was found in the Alor Strait used GEBCO data as in Figure 12.

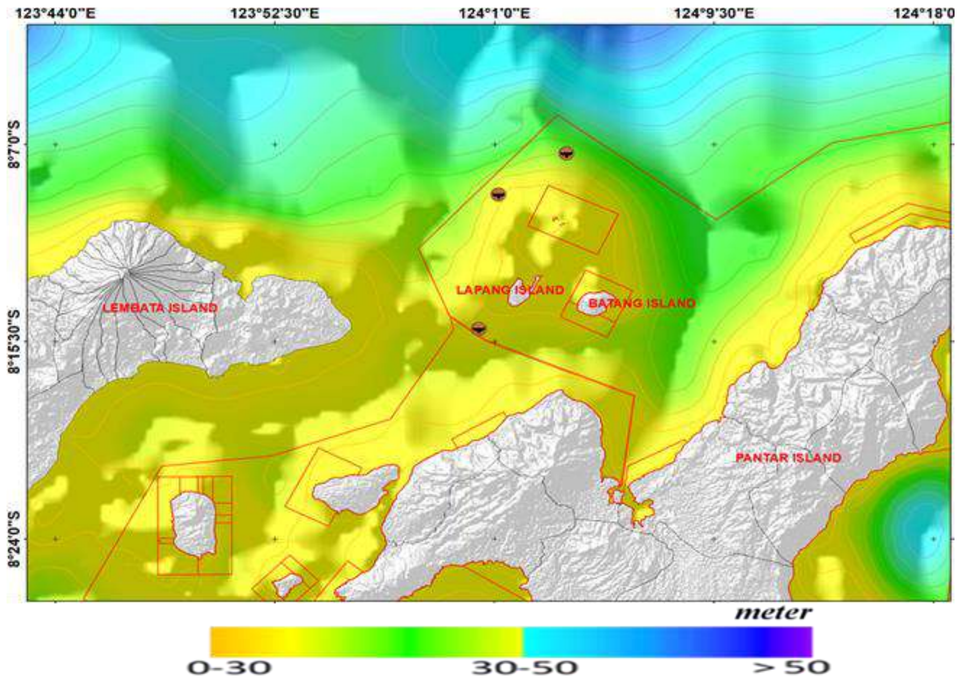


Figure 12. Depth at three observation points at Alor strait.

**Conclusions.** The results of the research showed that it was around 15 *Megaptera novaeangliae* crossed Alor waters in the afternoon from 05.00 to 05.45 pm on Desember 1st, 2020 by jumping on the surface of waters for about 3 seconds and drowning itself into the water then reappears to the surface of water for about 5 minutes and jumping again for about 5 seconds. The coordinates of the appearance in Lattitude: -8.123086 and Longitude: 124.063298. The range of the average physical factors of the waters includes the range of mean of sea surface temperature that ranging from 25.0 to 31.0$^0$C, chlorophyll content ranges between 0.2 to 0.8 mm/m$^3$, waters depth > 50 m, range of the average surface currents of waters 0.2 to 0.6 m/s with the type of zooplankton found is the crustacean class Arthropoda phylum with 1,957 Individu/l. This findings will be used as recommendation of *Megaptera novaeangliae* species protection in Alor waters- the Eastern of Indian Ocean, Indonesia.

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Authors:
Jahved Ferianto Maro. Faculty of Fisheries and Marine Science, Coastal Resources Management Doctoral Programe, Diponegoro University, Prof. Sudarto Street, Semarang 50275, Central Java, Indonesia. e-mail: yantogisuntrib@gmail.com
Agus Hartoko. Faculty of Fisheries and Marine Science, Coastal Resources Management, Diponegoro University, Prof. Sudarto Street, Semarang 50275, Central Java, Indonesia. e-mail: agushartoko.undip@gmail.com

Sutrisno Anggoro. Faculty of Fisheries and Marine Science, Coastal Resources Management, Diponegoro University, Prof. Sudarto Street, Semarang 50275, Central Java, Indonesia. e-mail: sutrisno.anggoro@yahoo.co.id
Max Rudolf. Muskananfola. Faculty of Fisheries and Marine Science, Coastal Resources Management,Diponegoro University, Prof. Sudarto Street, Semarang 50275, Central Java, Indonesia. e-mail: maxmuskananfola@yahoo.com
Lumban Nauli Lumban Toruan. Faculty of Fisheries and Marine Science, Coastal Resources Management, Nusa Cendana University, Jl. Adi Sucipto, Penfui, Kelapa Lima, Kupang City 85001, East Nusa Tenggara, Indonesia. e-mail: naulitoruan@gmail.com
Micael Dakahamapu. Environmental Practitioners*.* Kalabahi City street, Air Kenari Kalabahi, District Alor 85819. East Nusa Tenggara, Indonesia. e-mail : mikeinspire@yahoo.com
Erick Nugraha, Faculty of Fishing Technology, Jakarta Technical University of Fisheries, Jakarta, Indonesia, AUP Street, Pasarminggu 12520, South Jakarta, Indonesia. e-mail: nugraha_eriq1@yahoo.co.id

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Submission letter

Article title:

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Name of the authors:

Jahved Ferianto Maro, Agus Hartoko, Sutrisno Anggoro, Max Rudolf Muskananfola, Lumban Nauli Lumban Toruan, Micael Dakahamapu,
Erick Nugraha.

Hereby I would like to submit the manuscript entitled "**article title**" to Aquaculture, Aquarium, Conservation & Legislation - International Journal of the Bioflux Society.

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Corresponding author

Erick Nugraha
May 11, 2021

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**Eni Kovacs** Please see below the e-mail from the 24th of May. ---------- Forwarded message --------- From: Eni Kovacs <ek.bioflux@gmail.com> D — Min, 30 Mei 2021 jam 15.45

## Revision

**Eni Kovacs** <ek.bioflux@gmail.com>
Kepada: erick nugraha
Rab, 9 Jun 2021 jam 01.31

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Regarding your manuscript submitted to AACL Bioflux, the editorial team has some requests prior to acceptance (please see the attachment).

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Thank you for understanding!

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# The appearance of the humpback whale (*Megaptera novaeangliae*) ~~in~~ during the rainy season, in the Alor Waters~~- Eastern of Indian Ocean~~, Indonesia

[1]Jahved F. Maro, [2]Agus Hartoko, [2]Sutrisno Anggoro, [2]Max R. Muskananfola, [3]Lumban N. L. Toruan, [3]Micael Dakahamapu, [4]Erick Nugraha

[1] Faculty Fisheries and Marine Science, Coastal Resources Management Doctoral Programe, Diponegoro University, Semarang, Indonesia; [2] Faculty Fisheries and Marine Science, Coastal Resources Management, Diponegoro University, Semarang, Indonesia; [3] Faculty of Fisheries and Marine Science, Nusa Cendana University, Kupang, Indonesia; [3] Environmental Practitioners. Indonesia; [4] Faculty of Fishing Technology, Jakarta Technical University of Fisheries, South Jakarta, Indonesia. Corresponding author: E. Nugraha, nugraha_eriq1@yahoo.co.id

**Abstract**. The appearance of the humpback whale (*Megaptera novaeangliae*) in the Alor Waters~~-~~, Indonesia, located in the Eastern ~~of~~ Indian Ocean, is the one of new findings in the marine protected area of Pantar strait and its 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 ~~this~~ these waters. The research aims to ~~see~~ track their trajectory, ~~using~~ based on ~~biooseanography~~ bio-oceanography predictions, ~~of *M. novaeangliae*~~ in the marine protected area of Pantar strait and its surrounding sea. T~~he data used in t~~his research ~~are~~ uses a field data survey, and database sources like the Copernicus Marine Service Data, Argo Floats and ~~O~~oceanc~~-C~~olor.gsfc.nasa.gov. The field survey was conducted on ~~march~~ March to ~~december~~ December 2020. The results of the research showed that ~~it was~~ around 15 *M. novaeangliae* specimens crossed the Alor waters on December 1st 2020, in the afternoon, from 05.00 to 05.45 pm ~~on December 1st~~, ~~2020 by~~ . They were jumping ~~on~~ above the water surface ~~of waters~~ for about 3 seconds and ~~drowning itself~~diving into the water, then ~~reappears~~ they were reappearing ~~to~~ at the water surface ~~of water~~ for about 5 minutes and jumping again for about 5 seconds. The coordinates of the appearance were: ~~Lattitude:~~ -8.123086° of lattitude and ~~Longitude:~~ 124.063298° of longitude. The ~~range of the~~ average physical factors of the waters ~~includes~~ were: ~~the~~ a ~~range of mean of~~ sea surface temperature ~~that~~ ranging from 25 to 31°C, a chlorophyll content ~~ranges~~ ranging between 0.2 to 0.8 mm ~~/~~m$^{-3}$, a water~~s~~ depth >50 m~~,~~ and a ~~range of the average~~ speed of the water surface currents of ~~- waters~~ 0.2 to 0.6 m s$^{-1}$ ~~with the~~. The type of dominant zooplankton found is the crustacean ~~class~~ from the phylum *Arthropoda* ~~*phylum*~~, with a density of 1,957 individuals L$^{-1}$. ~~This~~ These findings will ~~be used~~inform ~~as recommendation of~~the policies concerning the *Megaptera Novaeangliae* sp. ~~species~~ protection in the Alor waters ~~Indonesia the Eastern of Indian Ocean~~.

**Key Words**: oceanographic variables, remote sensing, Pantar strait, mammals.

**Introduction**. Indonesian waters are inhabited by 31 species of ~~Cetacean~~ cetaceans (whale, porpoise, dolphin~~);~~ ), twelve of which ~~are~~ being whales~~, while~~ and the ~~rest are~~othrs being dolphins and dugongs (*Dugong dugong*) (Rosas & Uhart 2012). Both ~~are~~ resident and migrant, these ~~fishes~~ species are distributed throughout the coastal waters, towards the deep sea zone (Salim 2011). Several species of cetaceans ~~that~~ are true migratory, ~~use~~ using the Eastern Indonesian waters as a migration route ~~between~~ from the Indian Ocean to the Pacific Ocean~~s~~ and vice-versa, ~~through~~ 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

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as the entry point for the migration routes of marine mammals (cetaceans) such as whales and dolphins.

Nowadays, ~~the world's attention is mostly focused on~~ the protection of marine mammals is a priority for the marine biology research, ~~and tend to see~~being based on the ~~their~~ study of migratory ~~patterns~~ and distribution patterns, especially in the cetaceans' case (Dréo et al 2019). ~~This was due to the decreasing~~ The decrease of the population of cetaceans is~~as~~ due to the ~~result of the~~ influence of human activities~~;~~ , resulting ~~such as illegal logging,~~in pollution and environmental destruction~~, thus causing the existence of cetaceans has to be protected~~ (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 ~~et al~~ 1992; Dawbin 1959; Secchi et al 2011). According to several studies (IWC 1998; Chittleborough 1965; Findlay et al 2011; Secchi et al 2011), ~~the~~ *M. novaeangliae* is one of the over-hunted species, ~~that is immensely hunted to be killed and consumed~~, which ~~causing~~ causes a significant decrease of its ~~the species~~populations in the southern hemisphere, including the South Atlantic and South America.

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The waters of the Alor Strait and its surroundings are located in the Province of East Nusa Tenggara, which is one of the areas ~~located in~~of the Indonesian Exclusive Economic Zone (ZEEI), next to the west coast. Timor Leste and Australia are ~~also the areas of~~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 ~~the~~ dynamic oceanographic variables. S~~uch as a s~~ignificant changes occur in the sea surface, due to the~~and~~ vertical temperature variability and salinity during the southeast monsoon season. The dynamics of the waters ~~occur~~ in the surface layer ~~which~~ is influenced by the monsoon wind patterns~~.~~ , determining ~~This condition results in~~ the upwelling in the Savu Sea waters. The process of ~~stirred~~ stirring up the water masses (upwelling) ~~in the waters~~ affects the living conditions of the phytoplankton, the hydrology~~,~~ and the nutrient enrichment in the waters (Sediadi 2004; Packard et al 2015). ~~One of~~Among the most significant impacts of the upwelling ~~is~~ are ~~the~~ an ~~increasing~~ increased fertility (abundance of plankton as natural food) and ~~the~~ an ~~increasing~~ increased sea water temperature (warm),~~ thus~~ providing comfort ~~for~~ to a group of cetacean species, including the *M. novaeangliae* and the Bottle-nose Dolphin (*Tursiops truncatus*), which are migrating ~~in~~ to the waters of the Alor Strait (Mujiyanto et al 2017).

The Alor Strait is part of the Pantar Strait Conservation Area~~ Nature Preserve~~ 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 ~~based on the background of the problem, the~~ a monitoring research experiment on the *M. novaeangliae* in the Alor Strait waters, using the field observation ~~and observed~~of the bio-oceanography~~ of the Megaptera novaeangliae method is inevitable~~.

## 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. ~~Field~~ The field survey method, ~~was~~ modified from (Dharmadi et al 2017; Mujiyanto et al 2017), was ~~which is~~ the zig-zag track method using a boat of 10 GT with two observation decks, involving ~~that was done by~~ two different groups of on-deck observers. Water samples were taken ~~in~~ at every cetaceans appearance event, in order ~~of cetaceans~~ to determine~~identify~~ the plankton distribution. Field photography documentation of cetaceans appearance was also ~~done~~ performed for further identification. ~~Field photographs~~Pictures were taken using Canon camera and drone. The ship was traveling at a speed of 7 to 8 knots on each survey trajectory. Map of the research area can be seen in Figure 1.

Regarding the processing of Alor Strait oceanographic data, the ~~writers used~~ 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~~in the Alor Strait waters~~. 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.

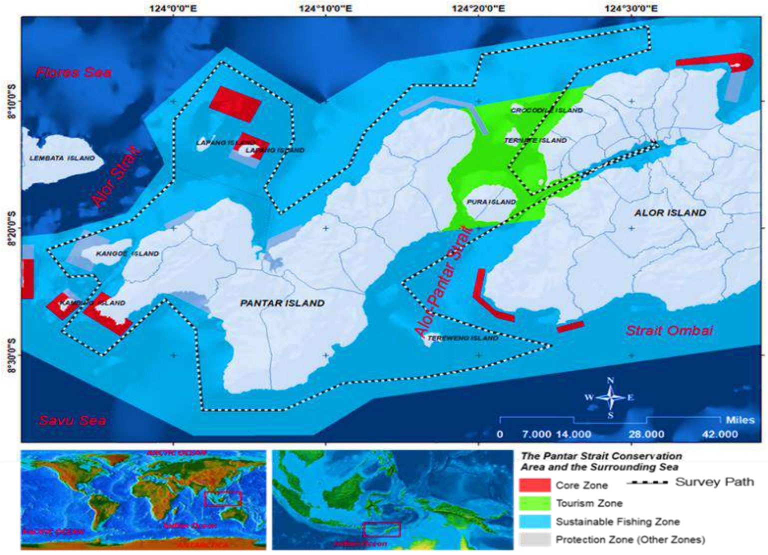


Figure 1. Map of research locations for *Megaptera novaeangliae* in the Alor Strait (MMAF Decree 2015).

## Results and Discussion

***Appearance and distribution of the M. novaeangliae in the Alor Strait***. The study had discovered three points of the Megaptera novaeangliae appearance in the Alor Strait, ~~with the number of each point can~~as it can be seen ~~in the graph as~~ in Figure 2.

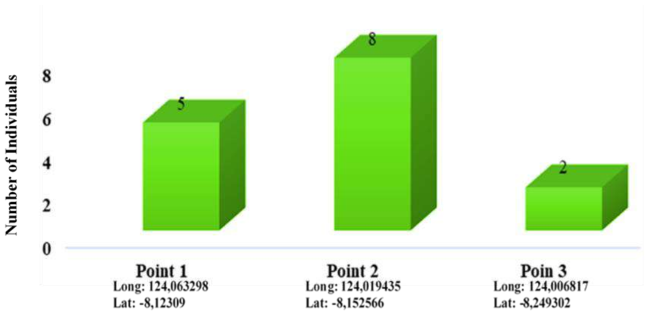


Figure 2. Appearance of *Megaptera novaeangliae* at Alor strait.

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Figure 2 shows the of appearance of *M.novaeangliae* at each observation point. There were five of the *M. novaeangliae* appeared in the first point at coordinate (Long: 124.063298; Lat: -8.123086); eight were seen in the second point at coordinate (Long: 124.019435; Lat: -8.152566) and two were seen in the third point at coordinate (Long: 124.006817; Lat: -8.249302). The appearance of the *M. novaeangliae* in Alor waters was found occured in the afternoon from 05.00 to 05.45 pm on December 1st 2020, which was precisely during the rainy season in Indonesia. The photograph *M. novaeangliae* appearance event of the *M. novaeangliae* at each point was recorded in the picturesas presented in Figures 3, 4 and 5.

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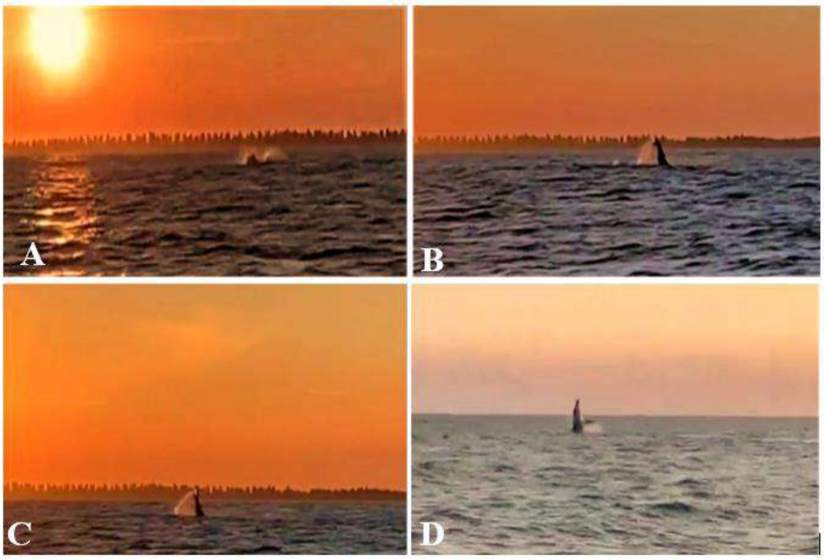


Figure 3. (A,B,C & D) The appearance of a *Megaptera novaeangliae* with jumping behavior at the Point -1 with (of coordinates *Long:* 124.063298°; longitude and *Lat* : -8.123086° latitude)

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Figure 4. (A, B, C & D) The appearance of a *Megaptera novaeangliae* with jumping behavior at Point 2 with coordinate *Long*: 124.019435; *Lat*: -8.152566.

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Original photos?


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 Point 2 with coordinates: *Long*: 124.019435; *Lat*: -8.152566.

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Original photos?

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~~body,~~, 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~~,~~, ~~and~~ 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 ~~as~~ is shown in Figure 6.

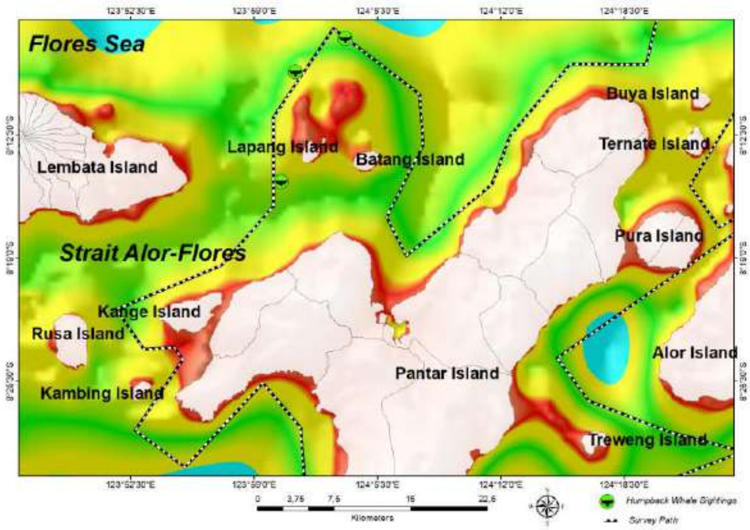


Figure 6. Map of the appearance of the *Megaptera novaeangliae* in the Alor Strait.

According to several studies (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) the *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 ~~itself~~ into the air at ~~an~~ a variable angle (of slope ~~of 0~~up to 70 degrees), over the sea surface. Then, it rotates on its long axis, landing on its back with its belly rising up and ~~then~~ eventually singing. Singing is an important point of the *M. novaeangliae* social behavior, ~~with the idea~~considering that the sound ~~of its singing has a component~~can be related to the~~of~~ intrasexual competition~~selection~~ 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~~,~~. I~~i~~ts eyeballs are similar to other cetaceans and show adaptation to diving and migration, contributing to the perception of ~~differences in~~ temperature, pressure and light~~ing~~ differences (Woodward et al 2006; Hampe et al 2015; Rodrigues et al 2014).

The group of the *M. novaeangliae* ~~that was~~ 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 (Palsbø~~o~~ll et al 1979; IWC 1998) the *M. novaeangliae* could ~~migrate to find food and mate with~~cover a distance of 8,000 km ~~to~~ from the breeding grounds, in the ~~tropics~~ tropical zones, ~~in~~ from ~~the last months of the year which is~~ 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 ~~intensively~~ for several months, the pregnant *M. novaeangliae* female ~~*M. novaeangliae*~~ could swim thousands kilometers to the nutrient-rich arctic or mid-temperature waters, where they could find their food. Usually, the

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~~female~~ 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 ~~female~~ 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 ~~because of~~the ~~migrating~~ migration for reproduction or giving birth. Furthermore, ~~seeing~~ considering its group behavior ~~and the attraction of~~( ~~-~~throwing its body in the air~~,~~ ~~then~~ and diving by poking its tail in the water opening its mouth ~~to~~ at the water surface ~~of the water,~~ and releasing large bubbles in the waters ~~and drowning itself by poking its tail in the water,~~ ) it can be assumed that the *M. novaeangliae* migrated ~~to find food~~for foraging and ~~mate~~ mating in the Alor Strait waters. ~~Results of the~~This research found and identified zooplankton from three classes of ~~zooplankton from~~ of different phyla, at three points ~~of~~ where *M. novaeangliae* ~~sighting~~ specimens were observed~~location, along with the identification of zooplankton in the Alor Strait~~. The ~~highest density of zooplankton was found from the~~ class of *Crustacea* of the phylum *Arthropod*~~,~~ was represented with the highest density of zooplankton. A ~~with a~~ total of 1,957 individuals $L^{-1}$ were found at the three points, ~~which~~ as it can be seen in Table 1 and Figure 7.

Table 1

Density of zooplankton at the P~~p~~oint ~~-~~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 |

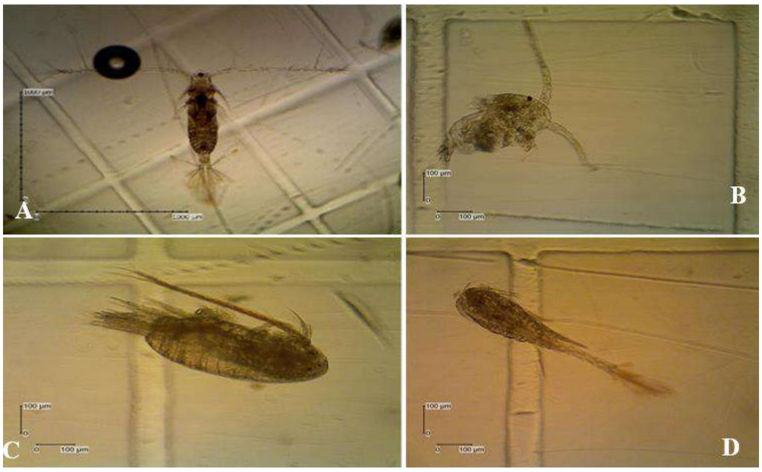


Figure 7. (A, B, C & D) Diversity of crustacea dominant at the P~~p~~oint ~~-~~3 of the *Megaptera novaeangliae* appearance.

According to Nybakken (1992), ~~most of~~ the zooplankton species which are the most important as fish food are~~is~~ ~~from the~~ class of the crustaceans, ~~belongs~~ belonging to the

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arthropod phylum~~, only crustaceans that live as plankton. They are the most important zooplankton for fish in freshwater and sea water. ~~. Crustaceans ~~mean~~ 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; Chen 2012) the *M. novaeangliae* has a cranial elevation~~, which means~~ serving to the excretion of filtered water. Cranial elevation of *M. novaeangliae* begins with a small splash in the anterior mouth~~ anterior~~, followed by a continuous outflow in the middle or posterior area of the mouth, then releasing the turbulence-free droplet inside the mouth 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. ~~The~~ 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 ~~its~~ their appearance in the Alor waters is ~~to migrate~~ migrating for food. This is because the type of plankton from the crustacean class is part of the cetacean diet, including the *M. novaeangliae*.

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***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).

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Alor Strait~~, which~~ is still influenced by the water mass of the Indian Ocean and the Pacific Ocean, which makes ~~Alor~~ its waters quite sensitive to temperature changes~~ in sea water temperature~~, 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 meters, ranged from 18.0 to 28.0°C, which can be seen in Figure 8. ~~Meanwhile, the~~ 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.

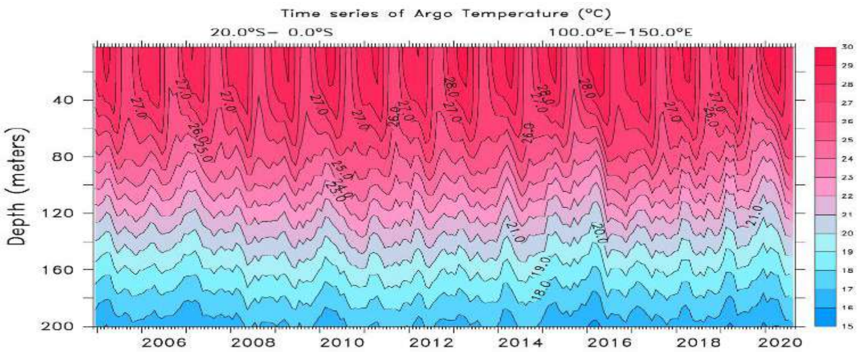


Figure 8. Yearly average of seawater temperature at a depth of 0 to 200 m, at the~~on~~ Point~~-~~ 3 of the *Megaptera novaeangliae* sighting in Alor strait.

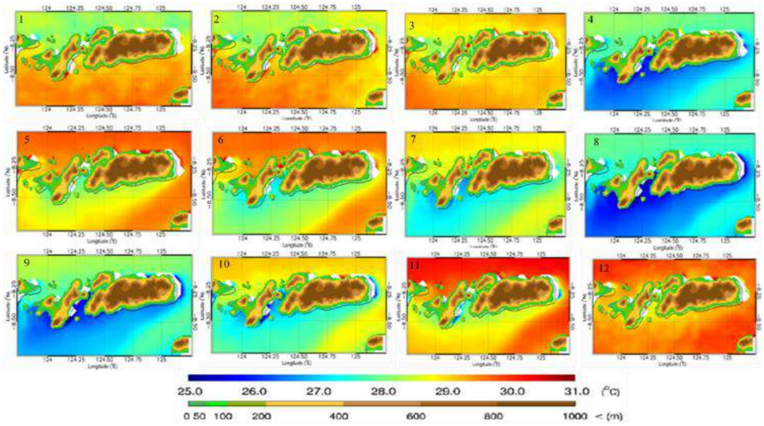


Figure 9. Monthly (1-12) average of sea surface temperature 2020.

~~Using~~ From the ARGO and Aqua MODIS data, the research ~~found~~ determined that the average depth and sea surface temperature in the Alor Strait waters, including its surrounding seas ~~in~~ 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 ~~in the tropics for~~ 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 ~~to be~~ between 22.3 ~~to~~ and 26.3°C (average 24.2°C). Consistently, ~~The~~ the same sea surface and depth temperature ~~case was conveyed~~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 2007), as ~~that consistently~~, ~~sea surface temperature and depth for the presence of cetaceans in water bodies ranges~~ ranging from 22.4 to 26.7°C (average 23.08°C). ~~This is also supported by~~ 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 ~~sea urface temperature~~. The average distribution of chlorophyll-a and the average monthly sea surface flow velocity, based on the results obtained during 2020 ~~based on~~from the Aqua MODIS data analysis in the Alor Strait seawater, ranged from 0.2 to 0.8 mm/m$^3$ ~~with current velocities ranging~~and from 0.2 to 0.6 m s$^{-1}$, respectively, ~~which~~ as in Figure 10 and Figure 11.

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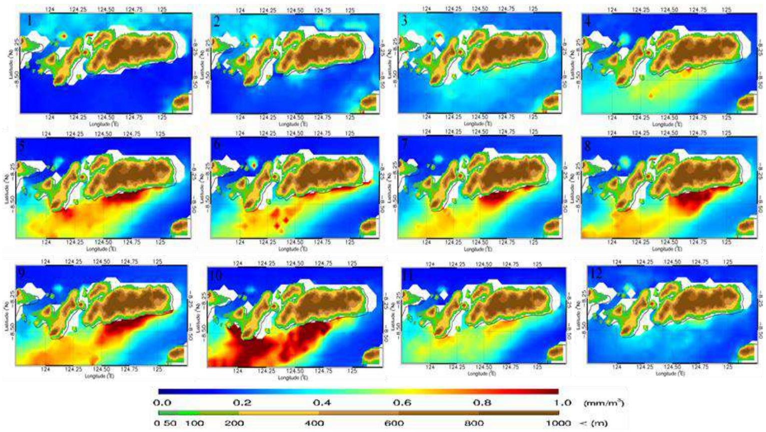


Figure 10. Monthly average of seawater chlorophyll-a 2020 at Alor strait.

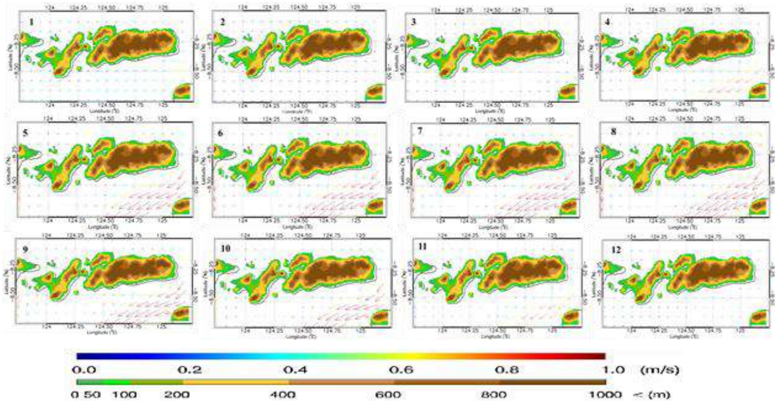

Figure 11. Monthly (1 to 12) ~~of~~ Alor strait's current speed average in 2020.

The research ~~of~~ found that the average ~~range of~~ chlorophyll-a and the mean sea surface flow velocities ~~current velocities~~ for the emergence of cetaceans in Alor waters were ranging from 0.1 to 0.6 mm/m$^3$ ~~for chlorophyll-a, with mean sea surface flow velocities ranging~~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.

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The appearance of the *M. novaeangliae* in the Alor Strait ~~had an appearance~~was located ~~point not far from the coast, which was~~at approximately 7 to 12 km from the coast, with ~~the~~ 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 ~~water~~ depth modeling of the waters where the *M. novaeangliae* was found in the Alor Strait used the GEBCO data, as in Figure 12.

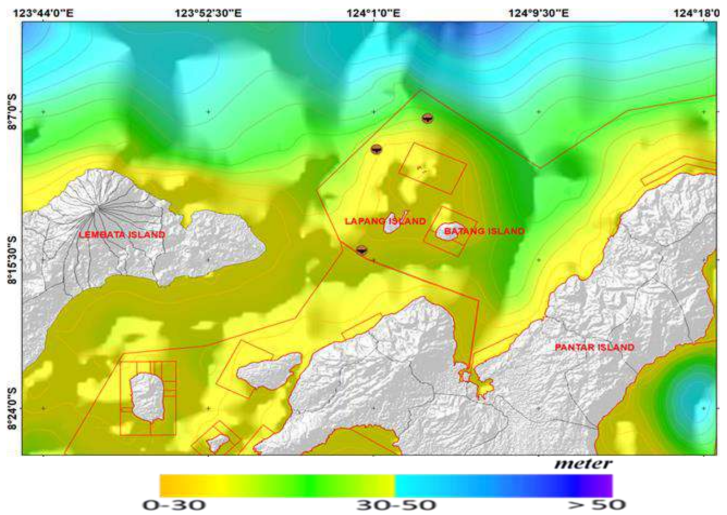

Figure 12. Depth at three observation points at Alor strait.

**Conclusions**. The results of the research showed that ~~it was~~ around 15 *M. novaeangliae* crossed the Alor waters in the afternoon of December 1st 2020, from 05.00 to 05.45 pm ~~on December 1st, 2020~~, ~~by jumping on the surface of waters for about 3 seconds and~~

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~~drowning itself into the water then reappears to the surface of water for about 5 minutes and jumping again for about 5 seconds~~with a mating behavior. The coordinates of the appearance were in Latitude: -8.123086 and Longitude: 124.063298. The ~~range of the~~ average physical factors of the waters ~~includes~~ included: the ~~range of mean of~~ sea surface temperature ~~that~~ ranging from 25.0 to 31.0$^0$C, the chlorophyll content ~~ranges~~ ranging ~~between~~ from 0.2 to 0.8 mm/m$^3$, the waters depth >50 m, the ~~range of the average~~ surface water currents ~~of waters~~ 0.2 to 0.6 m s$^{-1}$. T~~with t~~he dominant type of zooplankton found ~~is the~~consisted of crustaceans from the ~~class~~ Arthropoda phylum, with a density of 1,957 individuals L$^{-1}$. This findings will ~~be used as recommendation~~support ~~of~~ 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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Authors:
Jahved Ferianto Maro, Faculty of Fisheries and Marine Science, Coastal Resources Management Doctoral Programe, Diponegoro University, Prof. Sudarto Street, Semarang 50275, Central Java, Indonesia. e-mail: yantogisuntrib@gmail.com
Agus Hartoko, Faculty of Fisheries and Marine Science, Coastal Resources Management, Diponegoro University, Prof. Sudarto Street, Semarang 50275, Central Java, Indonesia. e-mail: agushartoko.undip@gmail.com
Sutrisno Anggoro, Faculty of Fisheries and Marine Science, Coastal Resources Management, Diponegoro University, Prof. Sudarto Street, Semarang 50275, Central Java, Indonesia. e-mail: sutrisno.anggoro@yahoo.co.id
Max Rudolf Muskananfola, Faculty of Fisheries and Marine Science, Coastal Resources Management,Diponegoro University, Prof. Sudarto Street, Semarang 50275, Central Java, Indonesia. e-mail: maxmuskananfola@yahoo.com
Lumban Nauli Lumban Toruan, Faculty of Fisheries and Marine Science, Coastal Resources Management, Nusa Cendana University, Jl. Adi Sucipto, Penfui, Kelapa Lima, Kupang City 85001, East Nusa Tenggara, Indonesia. e-mail: naulitoruan@gmail.com
Micael Dakahamapu, Environmental Practitioners. Kalabahi City street, Air Kenari Kalabahi, District Alor 85819. East Nusa Tenggara, Indonesia. e-mail : mikeinspire@yahoo.com
Erick Nugraha, Faculty of Fishing Technology, Jakarta Technical University of Fisheries, Jakarta, Indonesia, AUP Street, Pasarminggu 12520, South Jakarta, Indonesia. e-mail: nugraha_eriq1@yahoo.co.id

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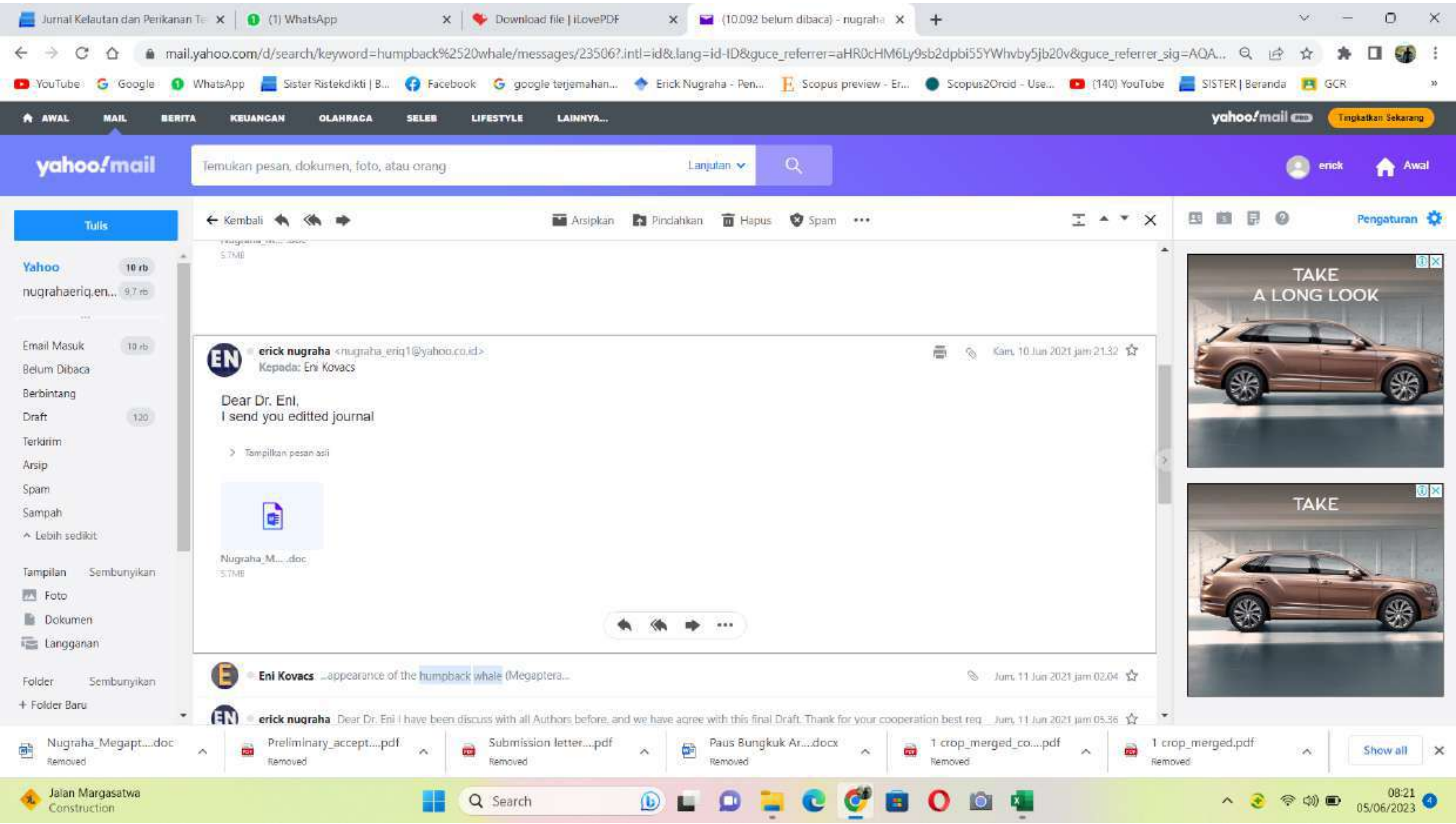
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# The appearance of the humpback whale (*Megaptera novaeangliae*) during the rainy season, in the Alor Waters, Indonesia

[1]Jahved F. Maro, [2]Agus Hartoko, [2]Sutrisno Anggoro, [2]Max R. Muskananfola, [3]Lumban N. L. Toruan, [4]Micael Dakahamapu, [5]Erick Nugraha

[1] Faculty Fisheries and Marine Science, Coastal Resources Management Doctoral Program, Diponegoro University, Semarang, Indonesia; [2] Faculty Fisheries and Marine Science, Coastal Resources Management, Diponegoro University, Semarang, Indonesia; [3] Faculty of Fisheries and Marine Science, Nusa Cendana University, East Nusa Tenggara, Indonesia; [4] Environmental Practitioners, East Nusa Tenggara, Indonesia; [5] Faculty of Fishing Technology, Jakarta Technical University of Fisheries, South Jakarta, Indonesia. Corresponding author: E. Nugraha, nugraha_eriq1@yahoo.co.id

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**Abstract**. The appearance of humpback whale (*Megaptera novaeangliae*) in Alor Waters-Indonesia, located in the Eastern Indian Ocean, is the one of new findings in the marine protected area of Pantar strait and its 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 aims to track their trajectory, base on bio-oceanography predictions, in the marine protected area of Pantar strait and its surrounding sea. This research uses a field data survey, and database sources like the Copernicus Marine Service Data, Argo Floats and oceancolor.gsfc.nasa.gov. The field survey was conducted on March to December 2020. The results of the research showed that around 15 *M. novaeangliae* specimens crossed the Alor waters on December $1^{st}$ 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° of latitude and 124.063298° of 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 to 0.8 $mm\ m^{-3}$, a waters depth >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 *Megaptera Novaeangliae* sp. protection in the Alor waters.

**Key Words**: oceanographic variables, remote sensing, Pantar strait, mammals.

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**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.

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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

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**Commented [A8R7]:** corrected, thank you 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 (IWC 1998; Chittleborough 1965; Findlay et al 2011; Secchi et al 2011), *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.

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 the *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; 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. 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.

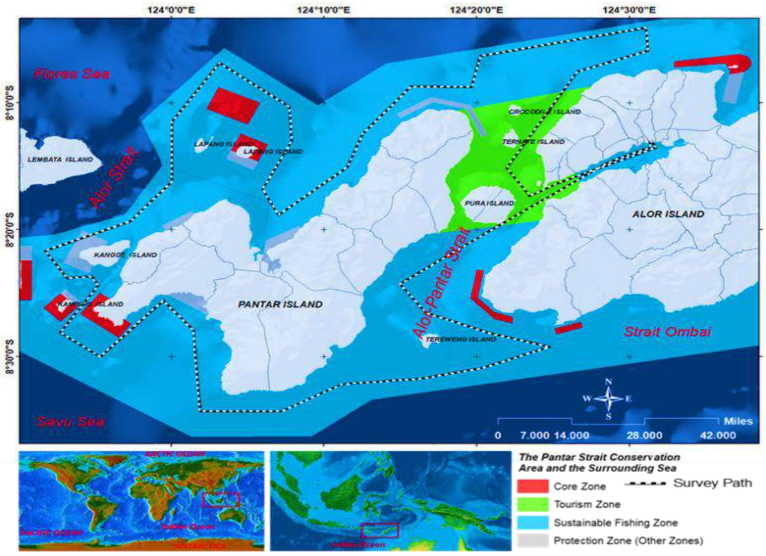


Figure 1. Map of research locations for *M. novaeangliae* in the Alor Strait (MMAF Decree 2015).

## Results and Discussion

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

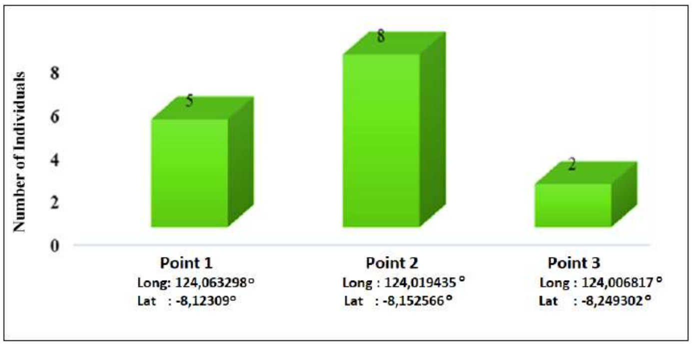


Figure 2. Appearance of *M. novaeangliae* at Alor strait.

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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.

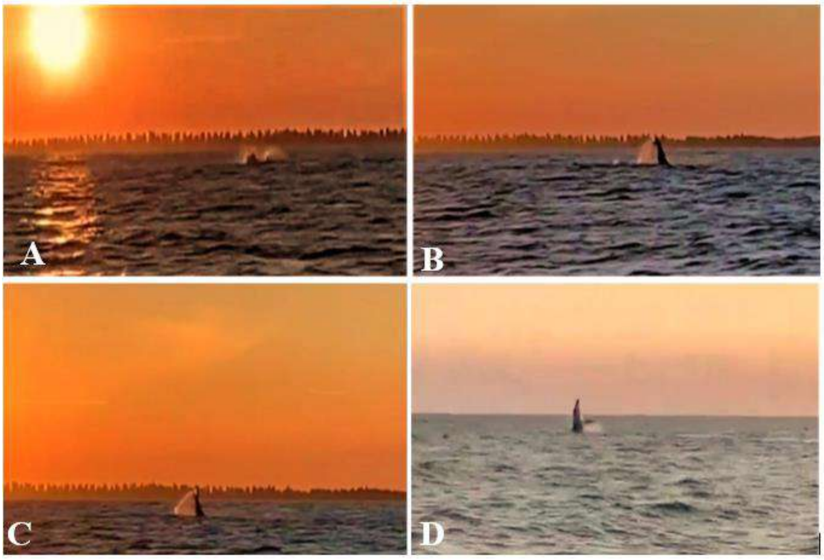


Figure 3. (A,B,C & D) The appearance of a *M. novaeangliae* with jumping behavior at the Point 1 (of coordinates 124.063298º longitude and 8.123086º latitude).


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

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

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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.

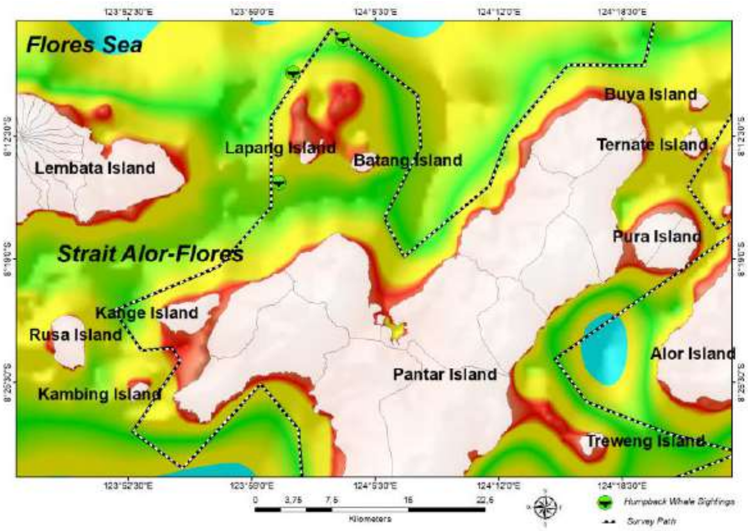


Figure 6. Map of the appearance of the *M. novaeangliae* in the Alor Strait.

According to several studies (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) the *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 up to 70 degrees), over the sea surface. 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; IWC 1998) the *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).

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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 the migration 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 *M. 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 |

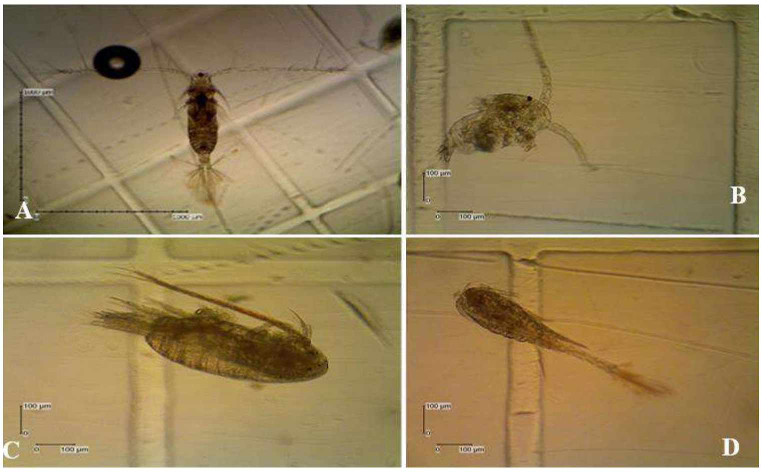

Figure 7. (A, B, C & D) Diversity of crustacea dominant at the Point 3 of the *M. novaeangliae* appearance.

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; Chen 2012) ~~the *M. novaeangliae* has a cranial elevation serving to the excretion of filtered water. Cranial elevation of *M. novaeangliae* begins with a small splash in the anterior mouth, followed by a continuous outflow in the middle or posterior area of the mouth, then releasing the turbulence-free droplet inside the mouth during swallowing.~~ The *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 meters, 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

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(Moderate Resolution Imaging Spectroradiometer*)* data ranged from 25.0 to 31.0°C, as in Figure 9.

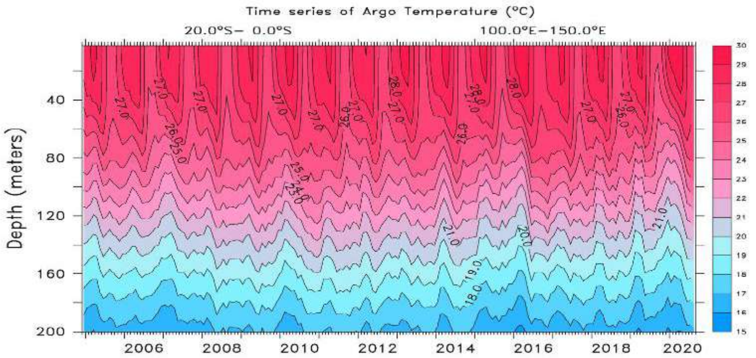


Figure 8. Yearly average of seawater temperature at a depth of 0 to 200 m, at the Point 3 of the *M. novaeangliae* sighting in Alor strait.

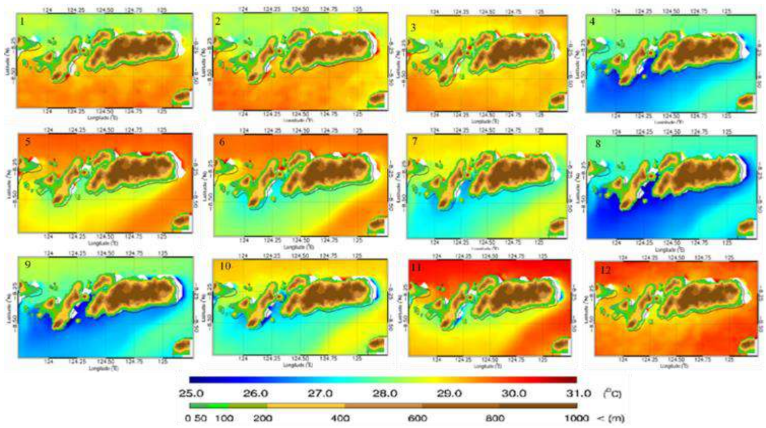


Figure 9. Monthly (1-12) average of sea surface temperature 2020.

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.

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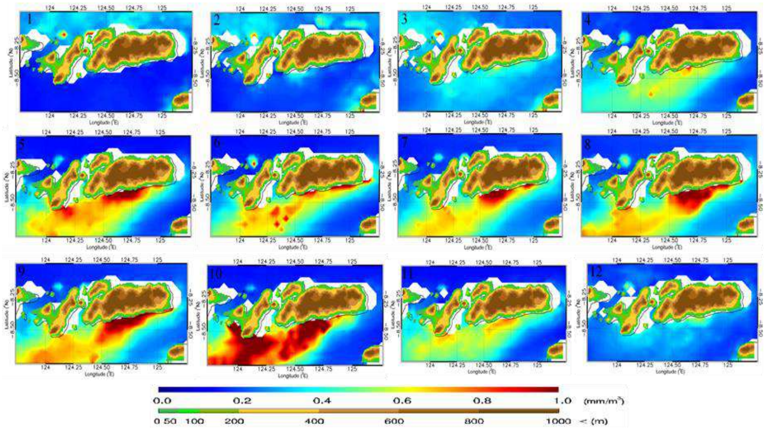


Figure 10. Monthly average of seawater chlorophyll-a 2020 at Alor strait.

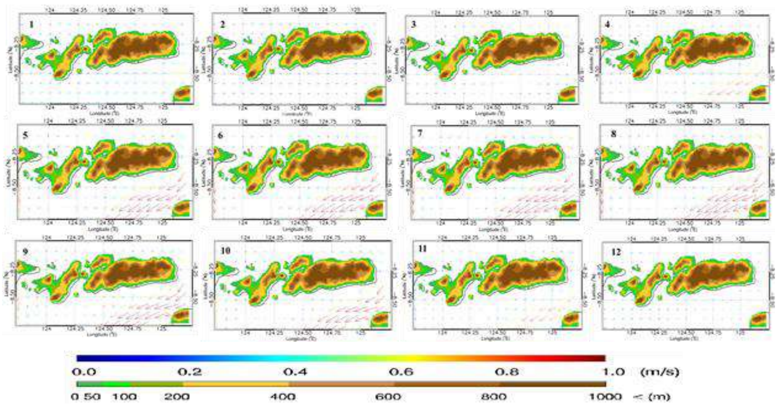


Figure 11. Monthly (1 to 12) Alor strait's current speed average in 2020.

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.

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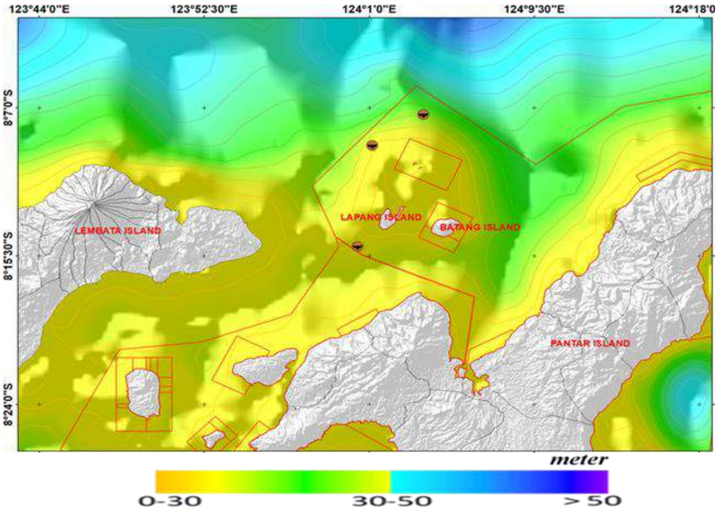


Figure 12. Depth at three observation points at Alor strait.

**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.

**Acknowledgments**. The authors would like to thank the Local Government of East Nusa Tenggara Province and the Office of World Wildlife Fund for Nature (WWF) at Solor-Alor. Sincere thanks to the LPDP Indonesian Government for the scholarship attributed to Jahved Ferianto Maro, in the framework of the Doctoral Program of Coastal Management, Faculty of Fisheries and Marine Sciences and the Institute of Research and Community Services, and also to the Diponegoro University, Semarang, Indonesia for the funding support through the contract no. 233-39/UN7.6.1/PP/2020. Special thanks to the National Aeronautics and Space Administration (NASA) for making available the MODIS AquaTerra satellite data, https://argo.ucsd.edu/, Copernicus Marine Service, the SeaDas software application and MIKE 21, to the ESRI for the permit to use the ArcGis 10.8 software for processing the satellite data and to all other parties for their help and contributions.

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

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Authors:
Jahved Ferianto Maro, Faculty of Fisheries and Marine Science, Coastal Resources Management Doctoral Programe, Diponegoro University, Prof. Sudarto Street, Semarang 50275, Central Java, Indonesia. e-mail: yantogisuntrib@gmail.com
Agus Hartoko, Faculty of Fisheries and Marine Science, Coastal Resources Management, Diponegoro University, Prof. Sudarto Street, Semarang 50275, Central Java, Indonesia. e-mail: agushartoko.undip@gmail.com
Sutrisno Anggoro, Faculty of Fisheries and Marine Science, Coastal Resources Management, Diponegoro University, Prof. Sudarto Street, Semarang 50275, Central Java, Indonesia. e-mail: sutrisno.anggoro@yahoo.co.id
Max Rudolf Muskananfola, Faculty of Fisheries and Marine Science, Coastal Resources Management,Diponegoro University, Prof. Sudarto Street, Semarang 50275, Central Java, Indonesia. e-mail: maxmuskananfola@yahoo.com
Lumban Nauli Lumban Toruan, Faculty of Fisheries and Marine Science, Coastal Resources Management, Nusa Cendana University, Jl. Adi Sucipto, Penfui, Kelapa Lima, Kupang City 85001, East Nusa Tenggara, Indonesia. e-mail: naulitoruan@gmail.com
Micael Dakahamapu, Environmental Practitioners. Kalabahi City street, Air Kenari Kalabahi, District Alor 85819. East Nusa Tenggara, Indonesia. e-mail : mikeinspire@yahoo.com
Erick Nugraha, Faculty of Fishing Technology, Jakarta Technical University of Fisheries, Jakarta, Indonesia, AUP Street, Pasarminggu 12520, South Jakarta, Indonesia. e-mail: nugraha_eriq1@yahoo.co.id


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**Eni Kovacs** <ek.bioflux@gmail.com>
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# The appearance of the humpback whale (*Megaptera novaeangliae*) during the rainy season in the Alor Waters, Indonesia

[1]Jahved F. Maro, [2]Agus Hartoko, [2]Sutrisno Anggoro, [2]Max R. Muskananfola, [3]Lumban N. L. Toruan, [4]Micael Dakahamapu, [5]Erick Nugraha

[1] Faculty Fisheries and Marine Science, Coastal Resources Management Doctoral Program, Diponegoro University, Semarang, Indonesia; [2] Faculty Fisheries and Marine Science, Coastal Resources Management, Diponegoro University, Semarang, Indonesia; [3] Faculty of Fisheries and Marine Science, Nusa Cendana University, East Nusa Tenggara, Indonesia; [4] Environmental Practitioners, East Nusa Tenggara, Indonesia; [5] Faculty of Fishing Technology, Jakarta Technical University of Fisheries, South Jakarta, Indonesia. Corresponding author: E. Nugraha, nugraha_eriq1@yahoo.co.id

**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 oceancolor.gsfc.nasa.gov. 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; 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. 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.

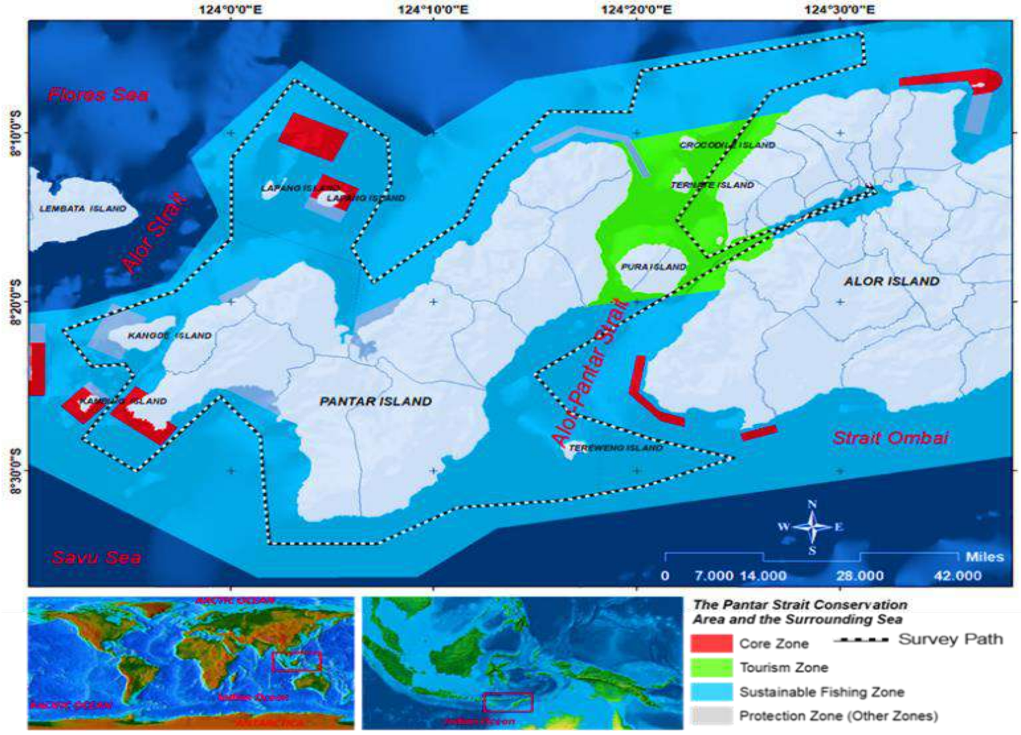


Figure 1. Map of research locations for *Megaptera novaeangliae* in the Alor Strait (MMAF Decree 2015).

## 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.

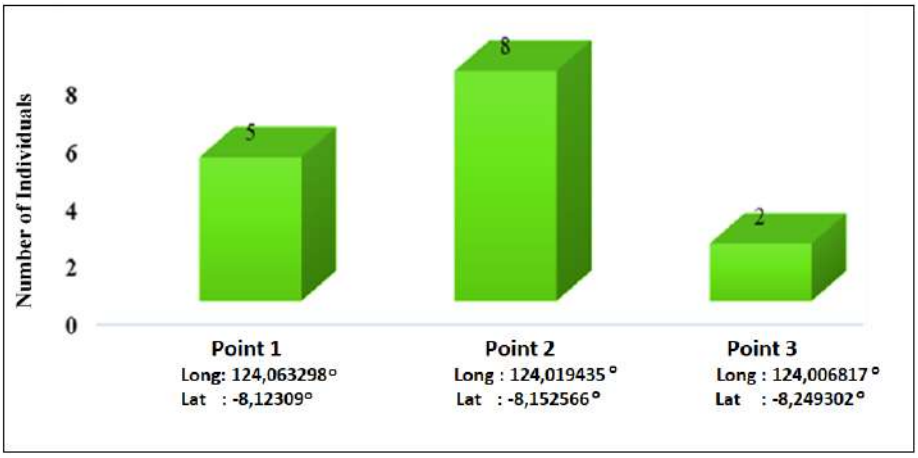


Figure 2. Appearance of *Megaptera novaeangliae* at Alor Strait.

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 1$^{st}$ 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.

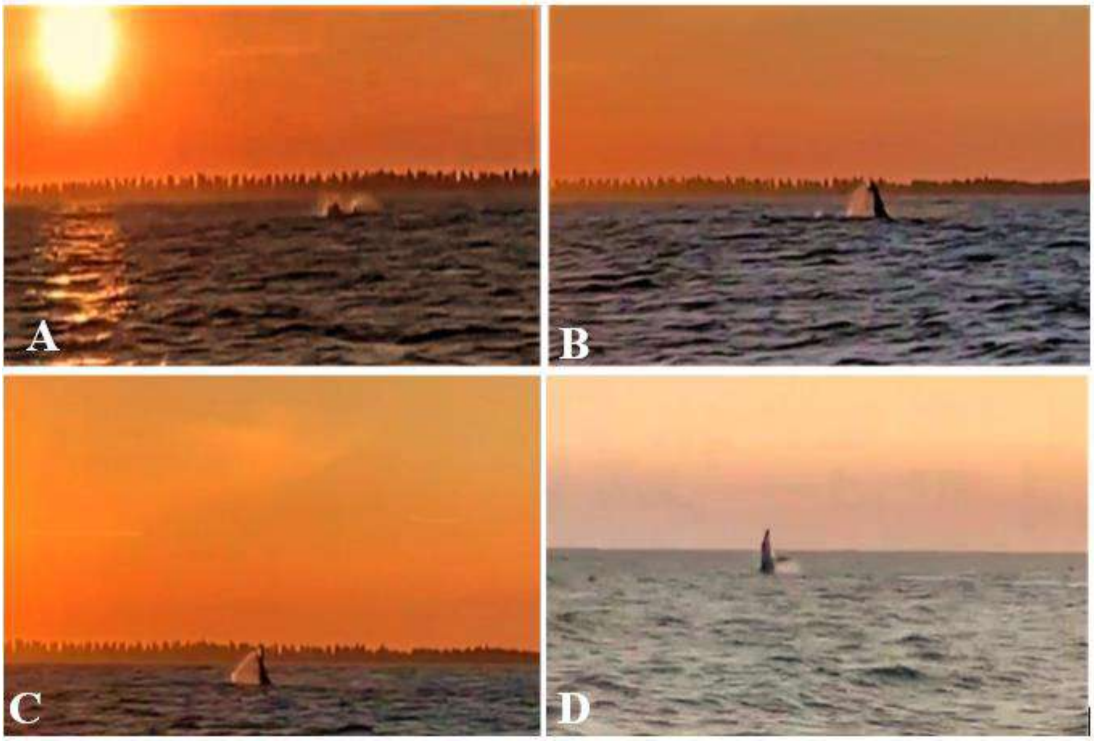

Figure 3. (A, B, C & D) The appearance of a *Megaptera novaeangliae* with jumping behavior at the Point 1 (coordinates 124.063298° longitude and 8.123086° latitude) (original).

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° longitude and 8.152566 152566° 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.

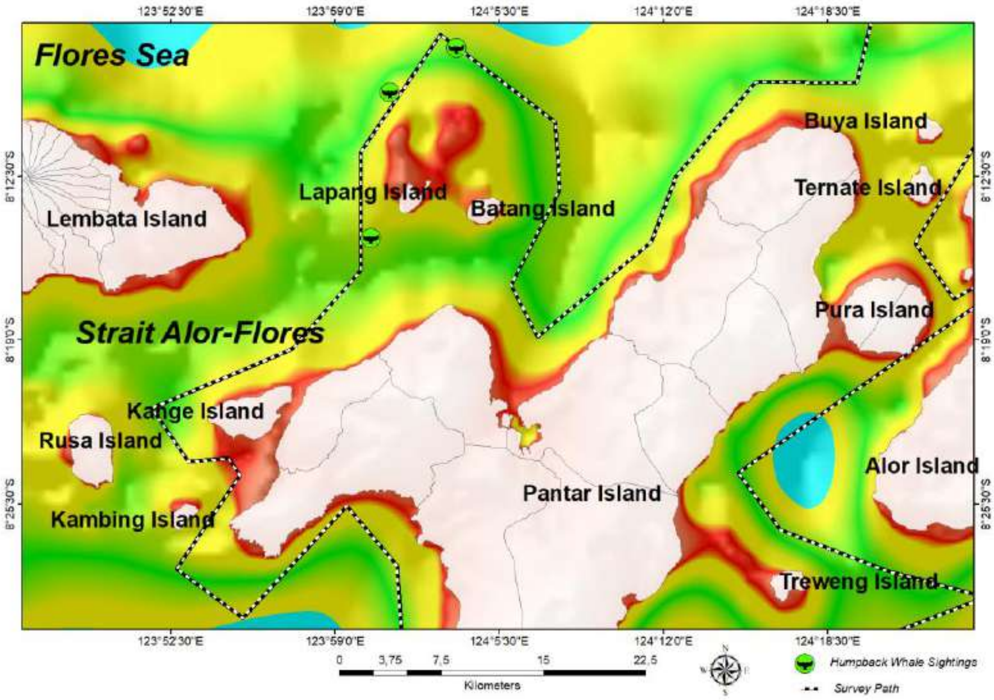


Figure 6. Map of the appearance of the *Megaptera novaeangliae* in the Alor Strait.

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 |

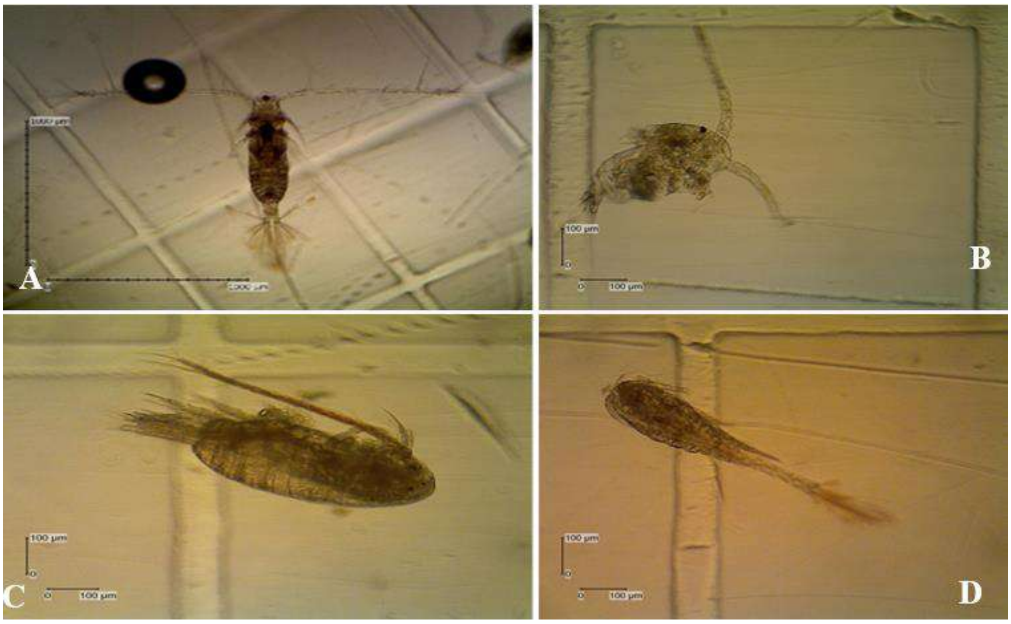


Figure 7. (A, B, C & D) Diversity of crustacea dominant at the Point 3 of the *Megaptera novaeangliae* appearance.

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 meters, 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.

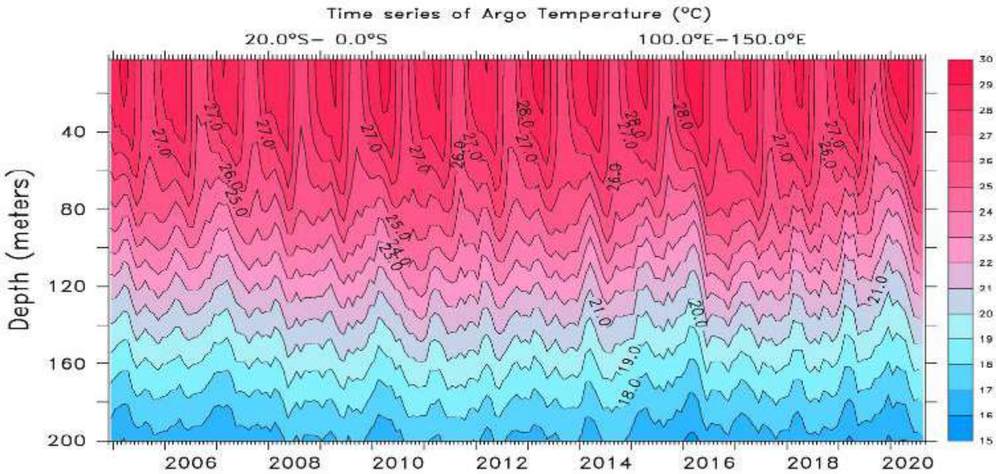


Figure 8. Yearly average of seawater temperature at a depth of 0 to 200 m, at Point 3 of the *Megaptera novaeangliae* sighting in Alor Strait.

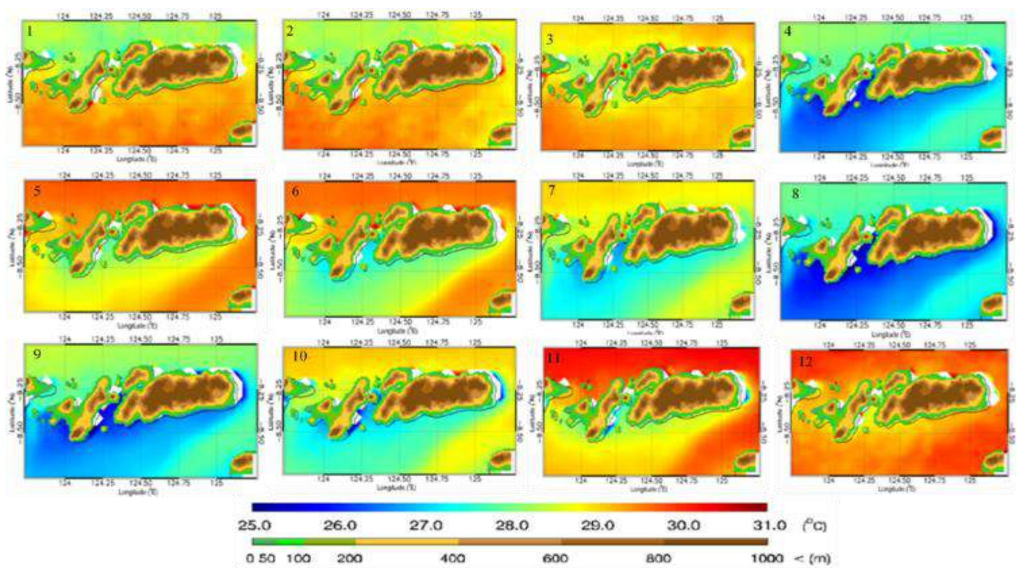


Figure 9. Monthly (1-12) average of sea surface temperature 2020.

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.

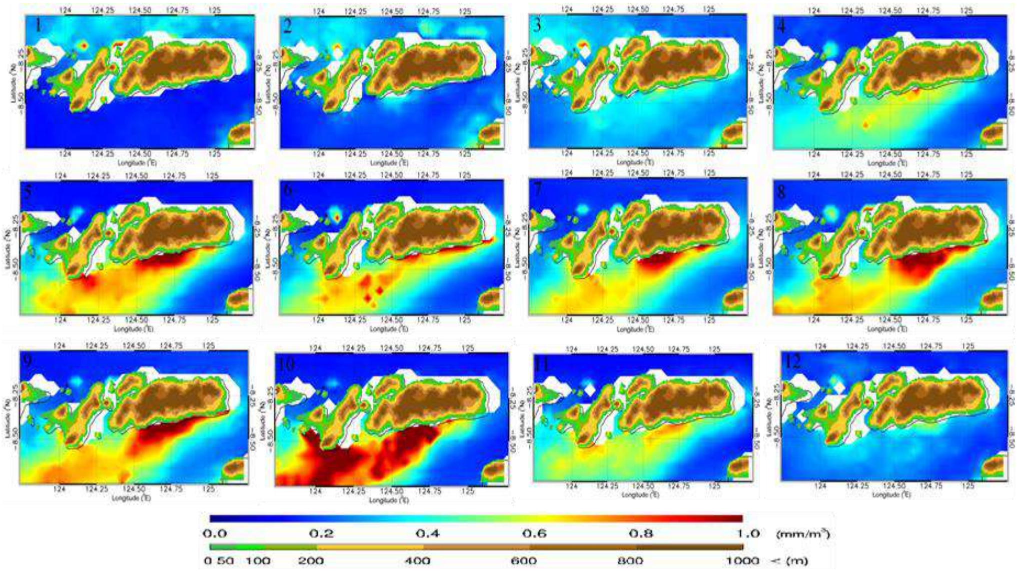

Figure 10. Monthly average of seawater chlorophyll-a 2020 at Alor strait.

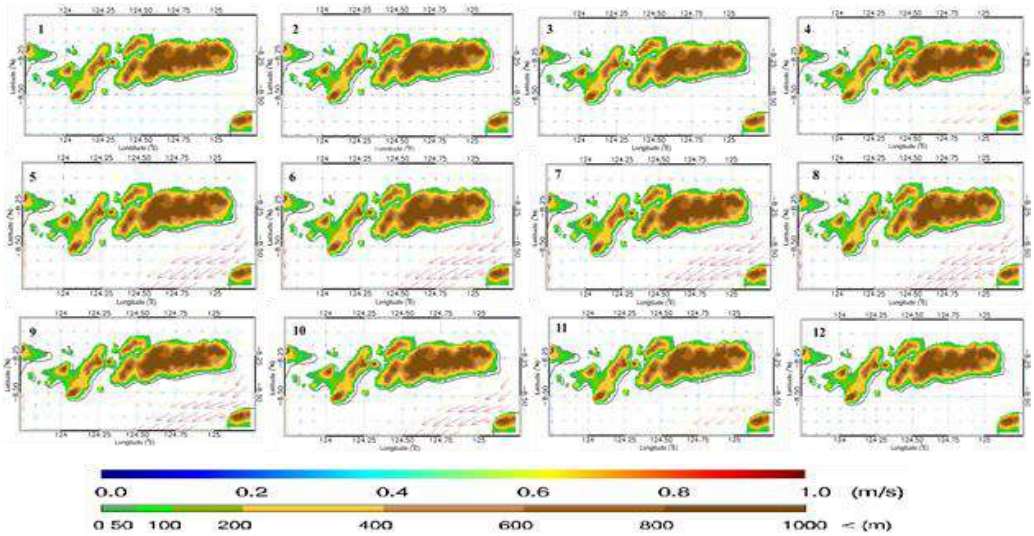

Figure 11. Monthly (1 to 12) Alor strait's current speed average in 2020.

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.

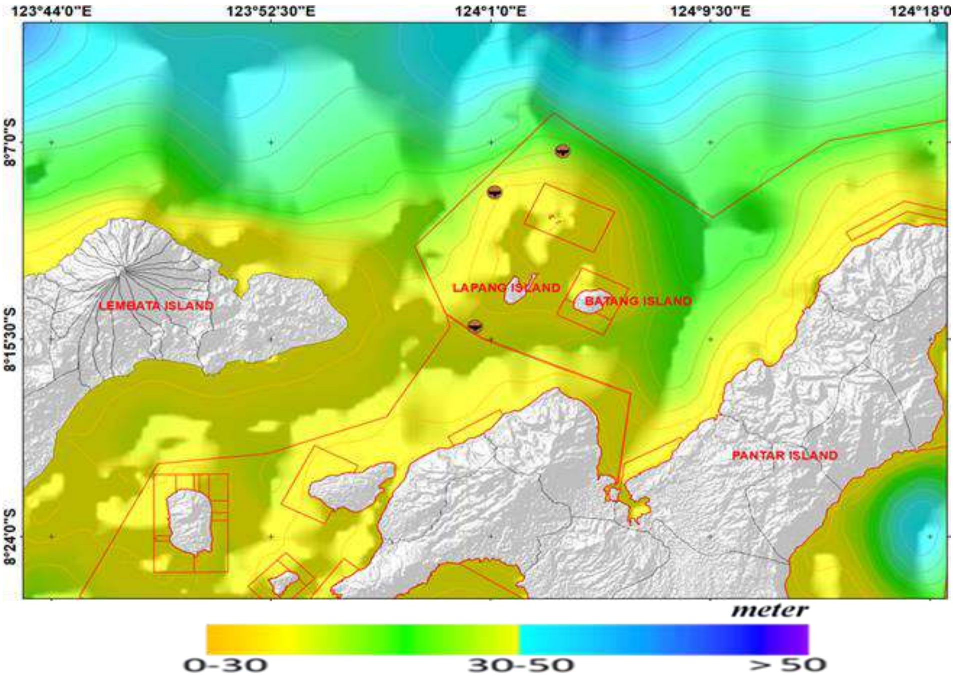

Figure 12. Depth at three observation points at Alor Strait.

**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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Authors:
Jahved Ferianto Maro, Faculty of Fisheries and Marine Science, Coastal Resources Management Doctoral Programe, Diponegoro University, Prof. Sudarto Street, Semarang 50275, Central Java, Indonesia. e-mail: yantogisuntrib@gmail.com
Agus Hartoko, Faculty of Fisheries and Marine Science, Coastal Resources Management, Diponegoro University, Prof. Sudarto Street, Semarang 50275, Central Java, Indonesia. e-mail: agushartoko.undip@gmail.com
Sutrisno Anggoro, Faculty of Fisheries and Marine Science, Coastal Resources Management, Diponegoro University, Prof. Sudarto Street, Semarang 50275, Central Java, Indonesia. e-mail: sutrisno.anggoro@yahoo.co.id
Max Rudolf Muskananfola, Faculty of Fisheries and Marine Science, Coastal Resources Management,Diponegoro University, Prof. Sudarto Street, Semarang 50275, Central Java, Indonesia. e-mail: maxmuskananfola@yahoo.com
Lumban Nauli Lumban Toruan, Faculty of Fisheries and Marine Science, Coastal Resources Management, Nusa Cendana University, Jl. Adi Sucipto, Penfui, Kelapa Lima, Kupang City 85001, East Nusa Tenggara, Indonesia. e-mail: naulitoruan@gmail.com
Micael Dakahamapu, Environmental Practitioners. Kalabahi City street, Air Kenari Kalabahi, District Alor 85819. East Nusa Tenggara, Indonesia. e-mail : mikeinspire@yahoo.com
Erick Nugraha, Faculty of Fishing Technology, Jakarta Technical University of Fisheries, Jakarta, Indonesia, AUP Street, Pasarminggu 12520, South Jakarta, Indonesia. e-mail: nugraha_eriq1@yahoo.co.id

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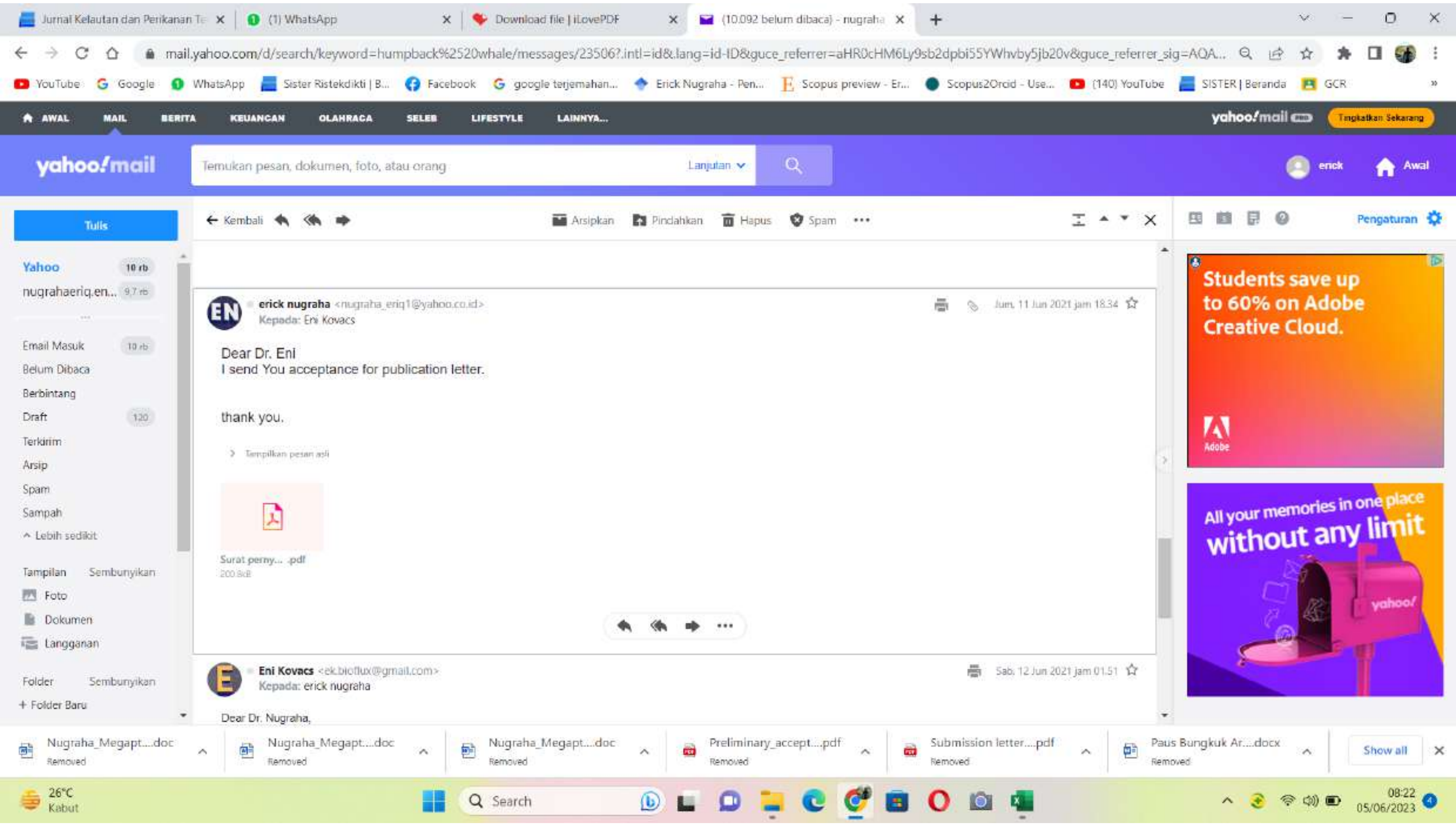

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Name of the authors:


Jahved Ferianto Maro, Agus Hartoko, Sutrisno Anggoro,

Max R. Muskananfola, L. N. L. Toruan, Micael Dakahamapu,

Corresponding author,

Erick Nugraha


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