Sea surface temperature and chlorophyll-a concentrations from MODIS satellite data and presence of cetaceans in Savu, Indonesia

by Cek Turnitin

Sea surface temperature and chlorophyll-a concentrations from MODIS satellite data and presence of cetaceans in Savu, Indonesia

[1]Jahved F. Maro, [1]Agus Hartoko, [1]Sutrisno Anggoro, [1]Max R. Muskananfola, [2]Erick Nugraha

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

Abstract. This study demonstrated that the presence of cetacean in the Savu seas was in accordance with the patterns of sea surface temperature (SST) and chlorophyll-a concentrations, as indicators of a favourable seawater temperature and of the presence of its natural diet. The aim of this study was to analize the monthly average sea surface temperature (SST) and chlorophyll-a from January to December 2018, based on the MODIS Aqua satellite data and on the field validation for May 2018, and on the cetacean sighting surveys in Savu seawater. Results of field SST data measurementranged from 26.4 to 30.5°C. The SST satellite data ranged from 26.7 to 31.4°C and chlorophyll-a concentration ranged from 0.5-0.83 mg m^{-3}. Field cetacean observations had identified four dolphins and two whales species, namely the bottlenose dolphin (*Tursiops truncatus*), Fraser's dolphin (*Lagenodelphis hosei*), pantropical spinner dolphin (*Stenella longirostris*) and pantropical spotted dolphin (*Stenella attenuata*). The two species of whales found were the pygmy feresa whale (*Feresa attenuata*) and pygmy sperm whale (*Kogia breviceps*) from 12 field survey points.

Key Words: oceanographic variables, cetaceans, remote sensing.

Introduction. Indonesian seawaters are inhabited by 31 species of cetaceans and the dugong (Rosas et al 2012). These marine mammals are spread from the coast to the deep sea of Indonesia, showing both resident and migratory behavior (Salim 2011). Several species of cetaceans with migratory behavior occupy the eastern part of Indonesia seawaters and their migratory pathways extend from the Indian to Pacific Ocean through the straits of Komodo Island, Solor, Lembata, Alor, Wetar, Banda Sea, southeast Sulawesi, east Sulawesi and Sorong (Papua Island), at the north (Salim 2011). The eastern part of Indonesia seawaters, especially in some inter islands, have functioned as the entry point strait for cetaceans as well as for some species of sea turtles. At present, most of the world's attention is given to the issue of protection, presence observation, migratory and distribution patterns of marine mammals, especially for cetaceans (Dréo et al 2019). The issues mainly in regard the declining population of cetaceans caused by human activities, such as illegal fishing, pollution, and environmental degradation (González et al 2019; Sutton et al 2019). In-depth and holistic research on cetacean ecology and migratory pathways in Indonesia is very limited, although they constitute the basis for their conservation.

Savu Sea belongs to the province of East Nusa Tenggara (ENT), with extension areas up to Indonesia's Exclusive Economic Zone (EEZ), next to the west coast borders of Timor Leste National Marine Park of East Nusa Tenggara (Putra et al 2016). Savu Sea has unique seawater conditions with a significant increase in the sea surface temperature (SST) during the southeast monsoon and low SST during the east monsoon. The dynamics of seawater mass displacement occur in the surface layer due to a vertical dynamic pattern of seawater temperature l resulting in an upwelling process, as well as in a horizontal mixing process due to the monsoonal wind pattern in Savu Sea. The impact of the vertical seawater upwelling process triggers the seawater nutrient enrichment and phytoplankton biomass at the upper layer on shallow straits and along the coastal area (Sediadi 2004; Packard et al 2015).

The SST has a significant impact on the upwelling and on the natural abundance of plankton biomass, copepods and small crustaceans (Mujiyanto et al 2017), attracting groups of cetaceans which migrate into the Savu Sea through the Lembata, Alor and Wetar straits (Hartoko 2013). The study of Priyadarshana et al (2016) using MODIS Aqua satellite imagery and field surveys in the Gulf of Sri Lanka had found that the cetacean distribution and migratory pattern was explained mainly by the foraging habits. In the Indian Ocean studies have reported the presence of sperm whales in depths up to 20 m swimming toward the beach for feeding (Reisinger et al 2015; Citta et al 2018; Stepanuk et al 2018).

Holistic investigations on cetaceans were necessary to the marine authorities of East Nusa Tenggara Province for a sustainable management based on evidence data of oceanographic variables, such as: sea surface temperature, current pattern, upwelling, plankton abundance and data related to the cetaceans in the Savu Sea, resulting in an accurate, comprehensive and integrated scientific research report. Documented observations of cetacean behavior have reported blowing, logging, fluking, flipper-slapping, slap, spy-hopping, breaching and feeding (Kahn 2016).

Remote sensing technology is one method which has potential to be effective in conducting surveys over large areas and in narrow straits (Hartoko et al 2019). The satellite data used in this study was MODIS AquaTerra, for SST and chlorophyll-a in the Savu seawater. The aim of the study was to conduct spatial analysis and determine monthly ranges of SST and chlorophyll-a and their relationship to the presence of cetaceans in Savu seawater within East Nusa Tenggara Province, producing possible recommendations for a sustainable management by the local government.

Material and Method. Field cetacean boat track-line surveys were conducted over 10 days in November 2018 with 12 survey points along the Savu sea, East Nusa Tenggara Province, Indonesia as presented in Figure 1.

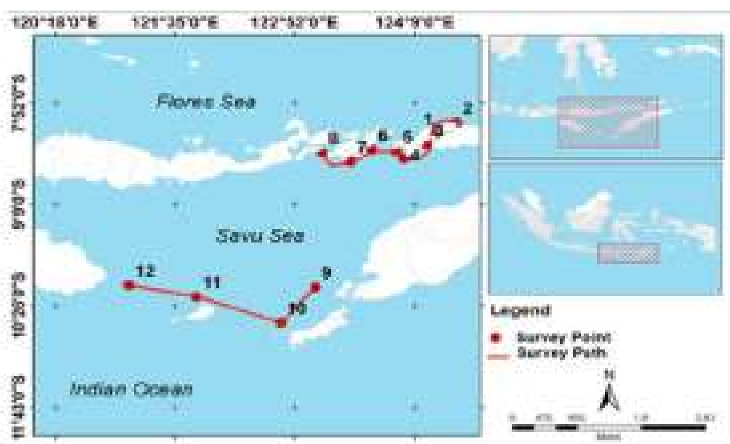

Figure 1. Station points of the field survey.

In the present study we used several survey tools, including the Marine Conservation Agency survey boat for surveyor sightings, Global Positioning System (GPS) to mark survey points coordinates, Nikon D5500 Camera for cetacean sighting documentations, Drone for aerial survey boat and cetacean sighting documentations, Water Quality Checker to measure in-situ sea water temperature, Binoculars for cetacean sighting identification, Hydrophone, Cetacean Identification Book for cetacean species identification, ArcMap 10.3, SeaDas 7.3, and Er-Mapper software for satellite data processing. The MODIS AquaTerra level-3 of ASCII data file was downloaded from NASA link https://oceancolor.gfsc.nasa.gov (2019) for sea surface temperatures and chlorophyll-a data analysis.

Field survey method. Field observations were based on a methodology used also by Guinet et al 2009, Kahn 2016, Forney & Barlow 1998, Diogou et al 2019, Perrin et al 2018. The use of the zigzag method aims to obtain an estimate of cetacean density and avoid glare from the sun. The method of field observation, the observer group consisted of 4 observers who were placed on the front deck, on the left, center and right side of the boat. The design of the observation experiment can be seen in Figure 2. The required field data is recorded and recorded in the logbook and returned to the original track. Field data and information recorded are date and time of appearance of cetaceans, GPS position, angle of cetacean position to boat, relative distance of cetaceans from boats, cetacean swimming direction, species, number, sea surface temperature, chlorophyll-a and cetacean behavior.

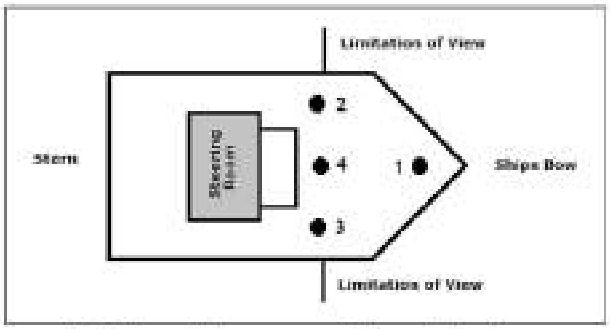

Figure 2. On board observer positions during the survey.

Acquisition of satellite data. Acquisition of MODIS Aqua Terra satellite level 3 data used in the study were downloaded from National Aeronautics and Space Administration (NASA 2019) for the sea surface temperature (SST) and chlorophyll-a data. The study used original spectral of ASCI format level 3 data which was then processed using SeaDas 7.3 software and followed by a cropping at the level of the focused research area of Savu Sea.

Satellite data processing method and analysis. The first step of satellite raw data processing was involving data transform from the original satellite raw data in a numeric ASCI format consisting of coordinates and SST or chlorophyll-a data, then transformed into a spatial layer using an interpolation process based on a geo-statistic gridding method using ErMapper and ArcGis 10.3 software (Hartoko & Helmi 2004; Hartoko et al 2019; Dréo et al 2019).

Results

Distribution of sea surface temperature. Sea surface temperature was measured by using a water quality checker at 12 stations, in the range of 26.4–30.5°C (Figure 3A). Sea surface temperature based on MODIS AquaTerra satellite data was in the range of 26.7–31.4°C (Figure 3B), while analysis of MODIS AquaTerra satellite in November 2018 resulted in a SST range of 26.7–31.4°C. The position choice of stations 1 to 8 was intended to represent the Alor strait, stations 7 and 8 the Lembata–Lamalera strait and stations 9–12 the Sawu strait and Rote Islands, as the entrance gate of the Indian Ocean into the Savu Sea.

The east monsoon of November 2018 is regarded as the peak of the cetacean presence, in comparison with a lower MODIS satellite SST observed during the west monsoon of January 2018. More precisely, the recorded SST in the Savu Sea during the cetacean presence event in November 2018 was 26.7–28.6°C, exhibiting a cooled-pool seawater mass, compared to the SST range of 28.6–31.4°C outside of the Savu Sea (Figure 3B).

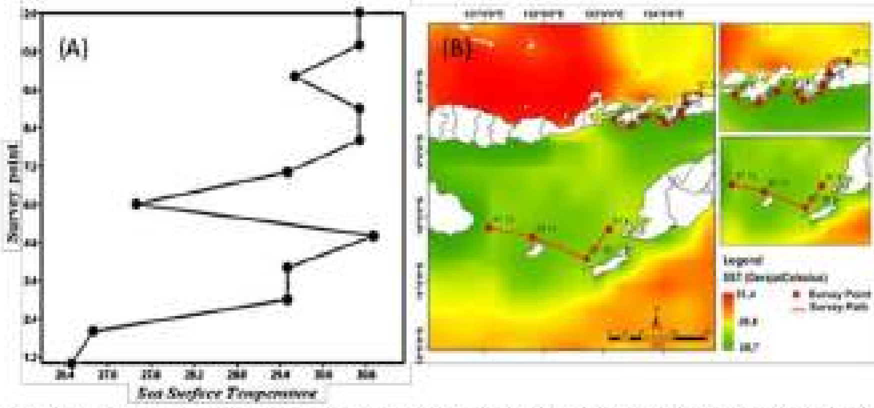

Figure 3. Distribution of SST from November 2018 field measurement (Figure 3A) and monthly distribution of SST data from the MODIS AquaTerra satellite (3B).

The results of the monthly SST analysis for 1 year using MODIS AquaTerra data found that the lowest SST detected was recorded in July, with a temperature range of 26-27°C (Figure 4).

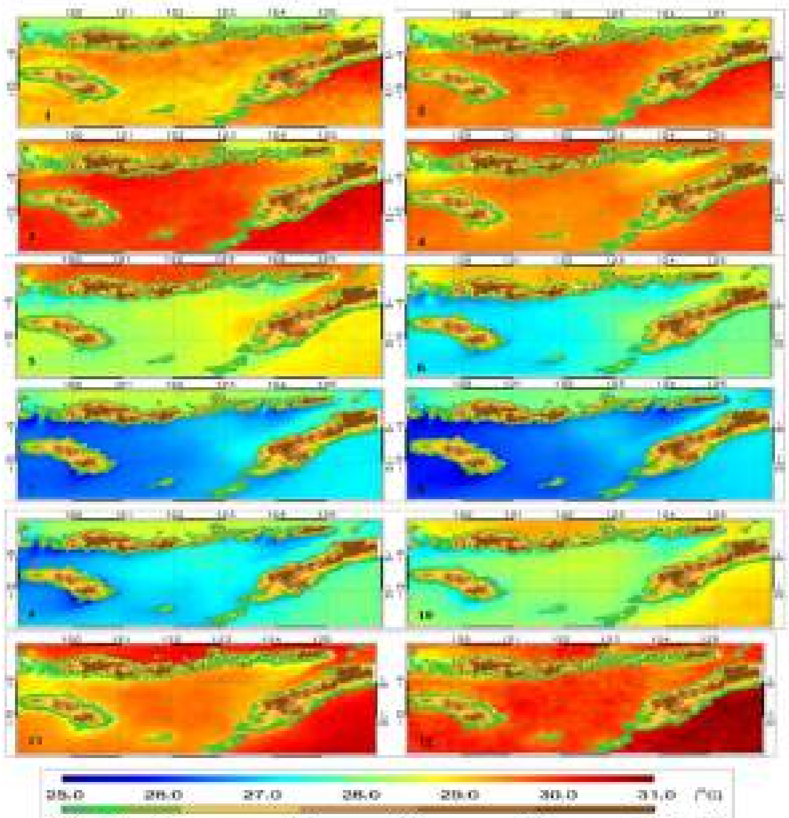

Figure 4. Monthly average of SST data from the MODIS satellite, in January–December 2018 in the Savu Sea.

The range of SST recorded before the cetacean presence event in January 2018 was in the range of 27-32.5°C. The average SST range was higher in December and January 2018. Cetacean sightings in November 2018 were assessed due to the increasing number of seawater mixing processes in the Savu Sea due to the west monsoon winds. The impact is upwelling so that the Savu Sea has a warm and nutrient-rich SPL. Therefore, cetaceans come to the Savu Sea to find food.

Spatial distribution of chlorophyll-a. Monthly spatial analysis of colorophyll-a concentrations using the Aqua Terra MODIS level 3 satellite data downloaded from the official NASA link https://oceancolor.gsfc.nasa.gov. Then the chlorophyll-a data were analyzed by the IDL application using the kriging analysis method, so it was found that the chlorophyll-a concentration in the Savu Sea was in the range of 0.5-0.83 mg m^{-3} when cetaceans appeared in November 2018 in the Savu Sea (Figure 5).

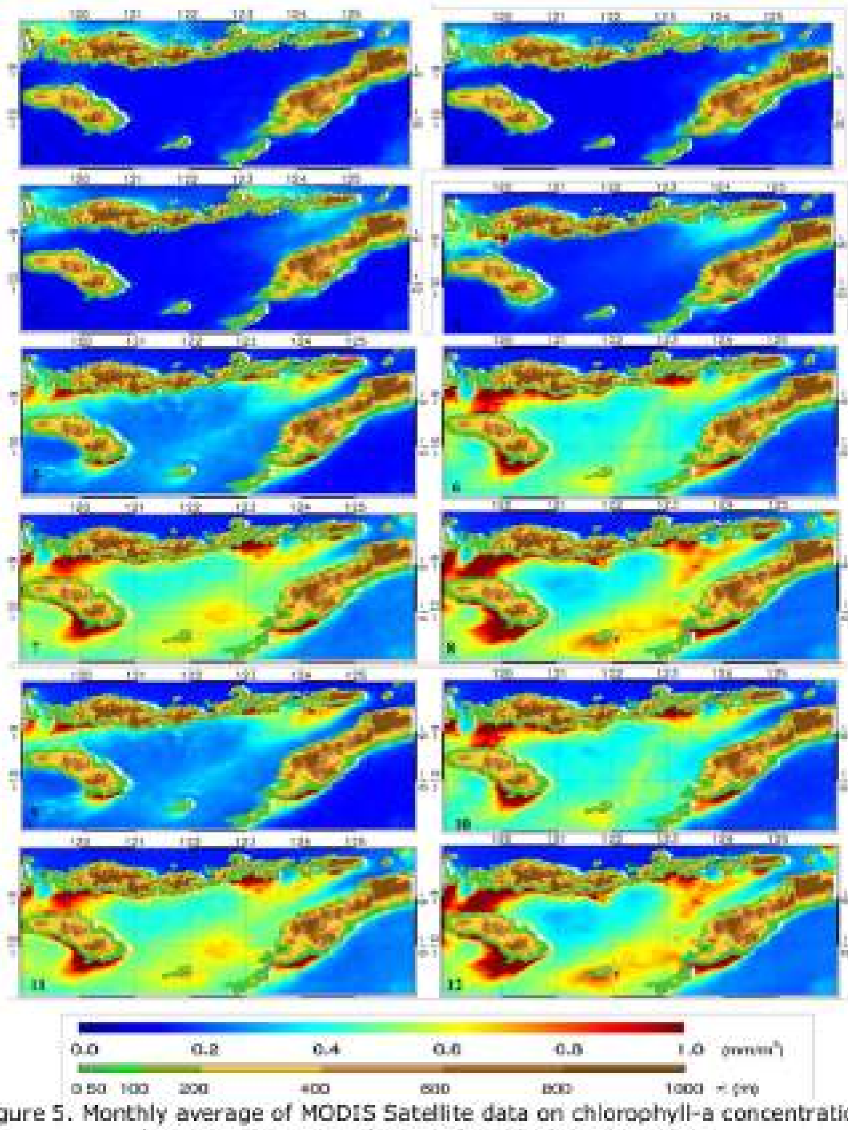

Figure 5. Monthly average of MODIS Satellite data on chlorophyll-a concentration, between January and December 2018, at Savu Sea.

In comparison, the chlorophyll-a concentration during the event was higher than during the west-monsoon in January 2018 (before the cetacean presence in November 2018), which was found to be in the range of 0.34–0.65 mg m^{-3}, as well as during the west monsoon of January 2019, after the peak season, which was in the range of 0.05-1.24 mg m^{-3}, as it can be seen in Figure 6A and Figure 6B.

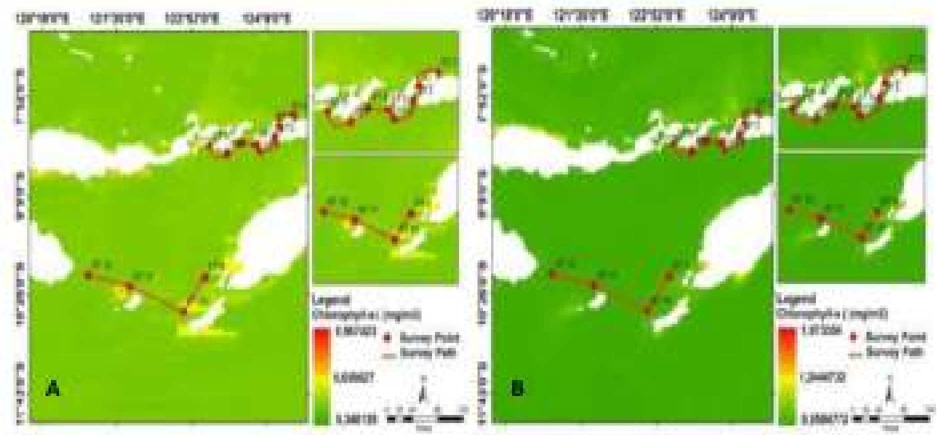

Figure 6. Spatial distribution of chlorophyll-a concentration in January 2018 (A) and January 2019 (B) in the Savu Sea.

Both before and after the peak of the cetacean period, the seawater chlorophyll-a was spread evenly inside and outside of the Savu Sea. The results of SST and chlorophyll-a data extraction from the Aqua MODIS satellite in the waters of the Savu Sea in 2018, in order to compare the SST and chlorophyll-a distribution data for the emergence of cetaceans, can be seen in Figure 7A and Figure 7B.

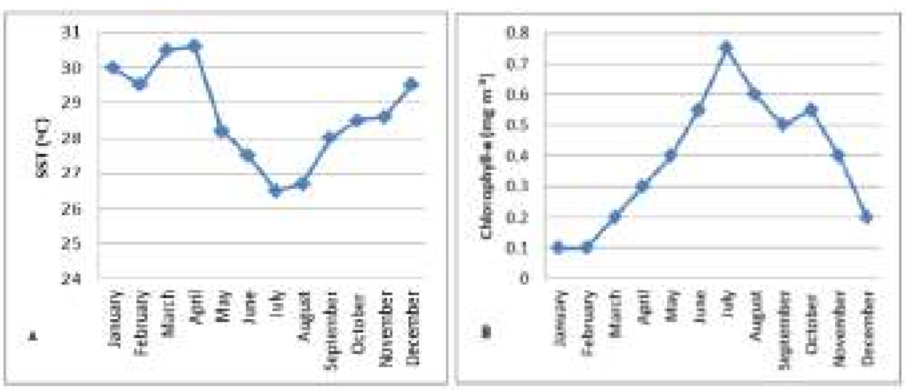

Figure 7. Variation in average SST (A); Variation in average chlorophyll-a (B) January-December 2018 of MODIS satellite data.

Judging from Figures 7A and 7B it can be said that the decrease in SST in April-July is in the range of 28-26°C with the chlorophyll-a range increasing from February to July in the range of 0.1-0.8 mg m^{-3}. The presence of cetaceans in Savu waters in November 2018 is in accordance with monthly SST and chlorophyll-a variations (in data from the MODIS satellite), showing an average SST of 28.5°C and an average chlorophyll-a of 0.4 mg m^{-3}.

Field cetacean sightings in the Savu seawater. Field observations in the Savu Sea during November 2018 reported six species of cetaceans, four species of dolphins and two species of whales. Cetacean species and their percentage of appearance time in water bodies of each species are presented in Figure 8.

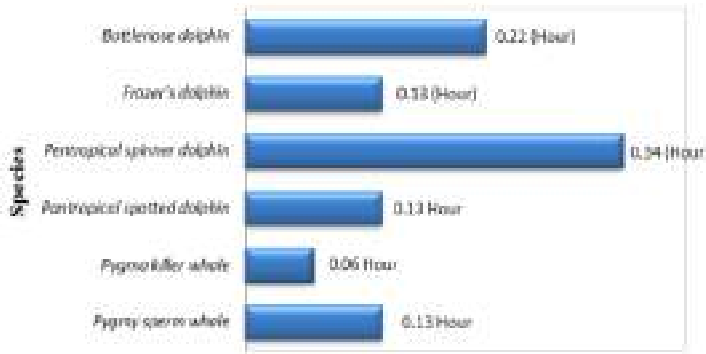

Figure 8. Types of cetaceans and time of appearance of cetaceans in the Savu Sea.

Looking at the graph in Figure 8, it can be seen that 4 species of cetaceans were found: the Pantropical spinning dolphin (*Stenella longirostris*) was recorded at the survey points (ST) 1, 2, 3, 4, 6, 10 and 11, showing arcs, the bow and the antenna goes around behaviors. Pantropical dolphins (*Stenella attenuata*) were recorded at the survey points (ST) 1, 2, and 5 showing air avoidance and aerial behaviors. The whales recorded were dwarf killer whales (*Feresa attenuate*) and dwarf sperm whales (*Kogia breviceps*) at the survey points (ST) 1, 2, 3, and 4 which exhibited avoidance and logging behavior, with an average appearance time in water bodies ranging from 0.6 to 0.34 hours. The emergence of cetaceans in the Savu Sea waters can be seen in Figure 9.

Figure 10. Dolphin (A and B) and whale (C and D) in the Savu sea during field observations (original).

Discussion. The current study revealed that the cetacean sightings were in accordance with the field SST spatial distribution data in the range of 26.5-30.5°C during November 2018. This study assumes the cold pond SST pattern recorded during November 2018 (Figures 3A, 3B) will be much different from the SST pattern in December 2018 (Figure 4), with a higher SST pattern in the Savu Sea and the surrounding seawaters. Research by Sutton et al (2019), National Marine Park East Nusa Tenggara (2018) and Kahn (2017) reported that the range of in-situ SST for cetaceans was between 25–33°C. This SST range was regarded also as the optimum temperature for plankton breeding, increasing the plankton density and biodiversity and ecological functions as migratory attractor to the area for feeding and reproduction of small fishes, cephalopods and ultimately for cetaceans, as the top predator in the food chain. Similar research by Frantzis et al (2011) showed that whales and dolphins were migrating towards plankton and prey rich seawater.

The high level of primary productivity in Savu Sea has caused unique oceanographical phenomena based on the combination of the SST (Figure 3A, 3B, 4 and 7A) and chlorophyll-a in the seawater mass (Figure 5, 6A, 6B and 7B). It is assumed that the vertical current movement from the south Indian Ocean entered through the strait between Sawu and the Rote Islands and resulted in an upwelling through the main Lamalera, Alor and Wetar straits. Further northward seawater mass from Indian Ocean caused a horizontal mixing process with the Pacific Ocean water mass at Banda Sea and resulted in a nutrient rich seawater mass. The high nutrients and primary productivity in the Savu Sea by means of phytoplankton biomass was also confirmed by the MODIS satellite chlorophyll-a data as in Figure 5. Previous research indicates that the Savu Sea has a high level of primary productivity as a result of the vertical mixing of cool Indian Ocean waters under currents that move upward into the Savu Sea, bringing high quantities of nutrients from the deeper water column.

The mixing of the cold Indian Ocean with the warm Pacific Ocean water increases the nutrient concentration and primary production in the Savu Sea (Suton et al 2019; Li & Yu 2020). These favorable ecological conditions have attracted some pelagic fish and other migratory species for feeding, inducing their migratory pattern (Hartoko & Helmi 2004; Chung & Gong 2019; Lyu et al 2016). Chlorophyll-a concentration data from the MODIS satellite indicated values in the range of 0.06-0.87 mg m^{-3}, during the cetacean sightings in Savu Sea, in November 2018, which was also confirmed by the research of Putra et al (2016). Huo et al (2020) stated that the optimal chlorophyll-a concentrations are in the range of 0.02-0.7 mg m^{-3}, indicating a fertile or rich of nutrient seawater.

The high primary productivity in seawater will increase the biomass of small fish species and squid (cephalopods), regarded as the main prey and ultimately attracts species of marine mammals such as whales and dolphins, which migrate for feeding (Simond et al 2019). The current study revealed that the range of chlorophyll-a concentration inside the Savu Sea 0.6-0.8 mgm^{-3} was found to be tenfold higher than in the surrounding areas, in the Indian Ocean, with only 0.06 mg m^{-3}. The two species of whales and four species of dolphins observed in the current study were assumed to be suitable with this favorable current mixing areas (FCMA) in the Savu Sea, with a high primary productivity and an optimum sea surface temperatures (Hartoko 2009; Hartoko 2010; Sutton et al 2019). The presence of cetaceans with behavior of bow riding traveling, bow riding, feeding riding and aerials in the FCMA in the Savu Sea was related to the migratory behavior and instinct for feeding (Diogou et al 2019; Rudolph et al 1997; Kahn 2017).

The two whale species and four dolphin species observed in this study correspond to a favorable current mixing area with high primary productivity and optimal sea surface temperature (Sutton et al 2019). Sightings of the bottlenose dolphin (*Tursiops truncatus*) were found at stations 2, 4 and 7, with bow-riding behavior. Fraser's dolphin (*Lagenodelphis hosei*) was found at stations 1, 2, 4, 5, 12, with the bow and aerial behavior. The pantropical spinning dolphin (*Stenella longirostris*) was found at stations 1, 2, 3, 4, 6, 10, 11, with bow, traveling, bow riding and aerial behavior. The pantropical leopard dolphin (*Stenella attenuata*) was found at stations 1, 2, 3, 5 with aerial and air avoidance behavior. Based on field observation data, dolphins were found in the sea surface temperature range of 26.4-30.5°C and chlorophyll-a ranged from 0.3 to 0.6 mg m^{-3}. The dwarf killer whale (*Feresa attenuate*) and the dwarf sperm whale (*Kogia breviceps*) were found at stations 1, 2, 3, 4, with avoidance and logging behavior, corresponding to a sea surface temperature range between 26.4-28.7°C and chlorophyll 0.2–0.8 mg m^{-3}. The average appearance of cetaceans in the Savu Sea waters ranges from 0.6 to 0.34

hours. Cetacean observed behavior was of types: traveling by bow, bow, eating, and space. Cetaceans appearing at the marine waters' surface with an average time span of 0.5-0.55 hours show migratory feeding and reproducing behavior (Rudolph et al 1997; Diogou et al 2019).

Conclusions. The cool seawater phenomena in November 2018 in the Savu Sea, corresponding to field SST spatial distribution ranging from 26.4 to 30.5°C, was regarded as the oceanographic variable the most influencing on the presence, sightings and migrating paths of the cetacean at the Savu Sea. The satellite chlorophyll-a concentration in the Savu Sea, in November 2018, ranged from 0.06 to 0.87 mg m^{-3}. Four species of dolphins were observed: the bottlenose dolphins (*T. truncatus*), the Fraser's dolphins (*L. hosei*), the pygmy spinning dolphins (*S. longirostris*) and the pantropical spotted dolphins (*S. attenuata*), and two species of whales: the pygmy killer whales (*F. attenuate*) and the pygmy sperm whale (*K. breviceps*).

Acknowledgements. 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 concerning the Doctoral Program of Coastal Management, at the Faculty of Fisheries and Marine Sciences and to the Institute of Research and Community Services, and the Diponegoro University, Semarang, Indonesia, for their funding support under the contract no. 233-39/UN7.6.1/PP/2020. Special thanks to the National Aeronautics and Space Administration (NASA) for the use of MODIS AquaTerra satellite data and the SeaDas software application, and to ESRI for the use of ArcGis 10.3 software to process the satellite data and to all other parties for their help and contributions.

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

References

Citta J. J., Okkonen S. R, Quakenbush L. T., Maslowski W., Osinski R., George J. C., Small R. J., Brower H., Heide M. P., Harwood L. A., 2018 Oceanographic characteristics associated with autumn movements of bowhead whales in the Chukchi Sea. Deep-Sea Research Part II (152):121-131.

Chung C. C., Gong G. C., 2019 Attribution of the growth of a distinct population of *Synechococcus* to the coverage of lateral water on an upwelling. Terrestrial, Atmospheric and Oceanic Sciences 30(4):575-587.

Diogou N., Palacios D. M., Nieukirk S. L., Nystuen J. A., Papathanassiou E., Katsanevakis S., Klinck H., 2019 Sperm whale (*Physeter macrocephalus*) acoustic ecology at ocean station PAPA in the Gulf of Alaska – Part 1: Detectability and Seasonality. Deep-Sea Research Part I (150):103-147.

Dréo, Richard, Bouffaut L., Leroy E., Barruol G., Samaran F., 2019 Baleen whale distribution and seasonal occurrence revealed by an ocean bottom seismometer network in the Western Indian Ocean. Deep-Sea Research Part II: Topical Studies in Oceanography 16:132-144.

Frantzis A., Airoldi S., Notarbartolo-di-sciara G., Johnson C., Mazzariol S., 2011 Inter-basin movements of mediterranean sperm whales provide insight into their population structure and conservation. Deep-Sea Research Part I 58(4):454-459.

Forney K. A., Barlow J., 1998 Seasonal patterns in the abundance and distribution of California cetaceans, 1991-1992. Marine Mammal Science 14(3):460-489.

González C., Victoria, Piola A., O'Brien T. D., Tormosov D. D., Acha E. M., 2019 Circumpolar frontal systems as potential feeding grounds of southern right whales. Progress in Oceanography 176:102-123.

Guinet C., Taupier-Letage I., Mate B., Petiau E., 2009 Scale-dependent habitat use by a large free-ranging predator, the Mediterranean fin whale. Deep-Sea Research I 56:801-811.

Hartoko A., 2013 Oceanographic characters and plankton resources of Indonesia. Graha Ilmu, Jogjakarta, Indonesia, 166 p.
Hartoko A., Helmi M., 2004 Development of digital multilayer ecological model for Padang coastal water West Sumatra. Journal of Coastal Management 7(3):129-136.
Hartoko A., 2009 Ocean observation on SST variability and sub-surface sea water temperature off the North Papua the fate of El Nino 1997 & 2007 and La Nina 2002: Field measurement and TRITON Buoy data. Journal of Coastal Development 13(1):1-10.
Hartoko A., 2010 Spatial distribution of *Thunnus* sp., vertical and horizontal sub-surface multilayer temperature profiles of in-situ ARGO float data in Indian Ocean. Journal of Coastal Development 14(1):1-14.
Hartoko A., Febrianto A., Pamungkas A., Fachruddin I., Helmi M., Hariadi, 2019 The myth and legend of Sadai and Gaspar Strait Bangka Belitung (Banca-Billiton) and oceanographic conditions. International Journal of GEOMATE 17(62):212-218.
Huo Y., Liu Q., Zhang F., Li C., Tao Z., Bi H., Fan C., Zhang J., Sun S., 2020 Biomass and estimated production, and feeding pressure on zooplankton of chaetognaths in the Yellow Sea, China. Terrestrial, Atmospheric and Oceanic Sciences, pp. 61-75.
Kahn B., 2017 Blue whales of the Savu Sea, Indonesia. 17th Biannual Marine Mammal Conference - Blue Whale Workshop, Cape Town, South Africa, pp. 1-3.
Kahn B., 2016 Oceanic cetaceans & associated habitats Solomon Islands Marine Assessment. The Nature Conservancy, Indo-Pacific Resource Centre, pp. 5-15.
Li Y. X., Yu J. Y., 2020 Why rare tropical cyclone formation after maturity of super El Niño events in the western North Pacific? Terrestrial, Atmospheric and Oceanic Sciences 31(1):21-32.
Lyu C. G., Tian J., Yang W. B., Tian Q. J., Lin Y. H., Liu Z. M., Zhang H. M., 2016 Diurnal variation of solar-blind ultraviolet upwelling radiance led by observation geometry factors on geostationary attitude sensor limb viewing. Terrestrial, Atmospheric and Oceanic Sciences, pp. 943-953.
Mujiyanto, Riswanto, Nastiti A. S., 2017 Effectiveness of sub zone cetacean protection in marine protected areas Savu. National, Sea, Marine Park, East Nusa Tenggara, Areas Savu, S.E.A. National, Marine Park, and East Nusa Tenggara. Journal of Coastal and Ocean 1(2):1-12.
Packard T., Osma N., Fernández-Urruzola I., Codispoti L. A., Christensen J. P., Gómez M. 2015 Peruvian upwelling plankton respiration: calculations of carbon flux, nutrient retention efficiency, and heterotrophic energy production. Biogeosciences (12):2641-2654.
Perrin W. F., Mallette S. D., Brownell R. L., 2018 Minke whales. *Balaenoptera acutorostrata* and *B. bonaerensis*. Encyclopedia of Marine Mammals, pp. 608-613.
Priyadarshana T., Randage S. M., Alling A., Calderan S., Gordon J., Leaper R., Porter L., 2016 Distribution patterns of blue whale (*Balaenoptera musculus*) and shipping off southern Sri Lanka. Regional Studies in Marine Science 3:181-188.
Putra M. I. H., Lewis S. A., Kurniasih E. M., Prabuning D., Faiqoh E., 2016 Plankton biomass models based on GIS and Remote sensing technique for predicting marine megafauna hotspots in the Solor Waters. IOP Conference Series Earth and Environmental Science 47(1):12-15.
Reisinger R. R., Keith M., Andrews R. D., de Bruyn P. J. N., 2015 Movement and diving of killer whales (*Orcinus orca*) at a Southern Ocean Archipelago. Journal of Experimental Marine Biology and Ecology 473:190-120.
Rosas C. L., Gil M. N., Uhart M. M., 2012 Trace metal concentrations in southern right whale *(Eubalaena australis)* at Peninsula Valdés, Argentina. Marine Pollution Bulletin 64(6):1255-1260.
Rudolph P., Smeenk C., Leatherwood S., 1997 Preliminary checklist of cetacea in the Indonesian archipelago and adjacent waters. Jurnal of Zoologische Verhandelingen Leiden 312:1-48.
Salim D., 2011 Conservation of marine mammals (*Cetacea*) at Savu Sea. East Nusa Tenggara. Marine Journal 4(1):24-41.

Sediadi A., 2004 Effect of upwelling to the abundance and phytoplankton distribution at Banda Sea. Makara Sains 8(2):43-51.

Simond A. E., Houde M., Lesage V., Michaud R., Zbinden D., Verreault J., 2019 Associations between organohalogen exposure and thyroid- and steroid-related gene responses in St. Lawrence Estuary belugas and minke whales. Marine Pollution Bulletin 145:174-184.

Stepanuk J. E. F., Read A. J., Baird R. W., Webster D. L., Thorne L. H., 2018 Spatiotemporal patterns of overlap between short-finned pilot whales and the U.S. pelagic longline fishery in the Mid-Atlantic Bight: An assessment to inform the management of fisheries bycatch. Fisheries Research 208:309-320.

Sutton A. L., Curt K. S., Jenner K. C. S., Jenner M. M., 2019 Deep-sea research part II habitat associations of cetaceans and seabirds in the tropical eastern Indian Ocean. Deep-Sea Research Part II 166:171-186.

*** NASA, 2019 https://oceancolor.gsfc.nasa.gov.

*** National Marine Park East Nusa Tenggara, Areas Savu Sea, 2018 Effectiveness of sub zone cetacean protection in marine protected areas of Savu Sea. Research report.

Received: 03 March 2021. Accepted: 24 April 2021. Published online: 07 May 2021.

Authors:
Jahved Ferianto Maro, Diponegoro University, Fisheries and Marine Science Faculty, Coastal Resources Management Doctoral Program, Prof. Sudarto Street, Semarang, 50275 Central Java, Indonesia, e-mail: yantogiuntrib@gmail.com
Agus Hartoko, Diponegoro University, Fisheries and Marine Science Faculty, Coastal Resources Management Doctoral Program, Prof. Sudarto Street, Semarang, 50275 Central Java, Indonesia, e-mail: agushartoko.undip@gmail.com
Sutrisno Anggoro, Diponegoro University, Fisheries and Marine Science Faculty, Coastal Resources Management Doctoral Program, Prof. Sudarto Street, Semarang, 50275 Central Java, Indonesia, e-mail: sutrisnoanggoro52@gmail.com
Max Rudolf Muskananfola, Diponegoro University, Fisheries and Marine Science Faculty, Coastal Resources Management Doctoral Program, Prof. Sudarto Street, Semarang, 50275 Central Java, Indonesia, e-mail: maxmuskananfola@yahoo.com
Erick Nugraha, Jakarta Technical University of Fisheries, Faculty of FishingTechnology, 12520 South Jakarta, Indonesia, e-mail: nugraha_eriq1@yahoo.co.id

How to cite this article:
Maro J. F., Hartoko A., Anggoro S., Muskananfola M. R., Nugraha E., 2021 Sea surface temperature and chlorophyll-a concentrations from MODIS satellite data and presence of cetaceans in Savu, Indonesia. AACL Bioflux 14(3):1190-1200.

Sea surface temperature and chlorophyll-a concentrations from MODIS satellite data and presence of cetaceans in Savu, Indonesia

ORIGINALITY REPORT

8%	6%	5%	3%
SIMILARITY INDEX	INTERNET SOURCES	PUBLICATIONS	STUDENT PAPERS

PRIMARY SOURCES

1	Submitted to iGroup Student Paper	2%
2	digital.library.adelaide.edu.au Internet Source	<1%
3	www.technicalgeography.org Internet Source	<1%
4	medica-musc.researchcommons.org Internet Source	<1%
5	Sepri, A Hartoko, WS Suradi, A Ghofar. "Impact of climate variability on skipjack tuna (Katsuwonus pelamis) catches in the Indonesian Fisheries Management Area (FMA) 715", IOP Conference Series: Earth and Environmental Science, 2021 Publication	<1%
6	Daniel M. Alongi. "Tropical Marine Ecology", Wiley, 2021 Publication	<1%

7	academic.oup.com Internet Source	<1 %
8	Matthew L. Druckenmiller, John J. Citta, Megan C. Ferguson, Janet T. Clarke, John Craighead George, Lori Quakenbush. "Trends in sea-ice cover within bowhead whale habitats in the Pacific Arctic", Deep Sea Research Part II: Topical Studies in Oceanography, 2017 Publication	<1 %
9	MS Soldevilla, SM Wiggins, JA Hildebrand, EM Oleson, MC Ferguson. "Risso's and Pacific white-sided dolphin habitat modeling from passive acoustic monitoring", Marine Ecology Progress Series, 2011 Publication	<1 %
10	journals.plos.org Internet Source	<1 %
11	www.govsupport.us Internet Source	<1 %
12	Ally Rice, Ana Širović, Jennifer S. Trickey, Amanda J. Debich et al. "Cetacean occurrence in the Gulf of Alaska from long-term passive acoustic monitoring", Marine Biology, 2021 Publication	<1 %
13	Bénédicte Madon, Damien Le Guyader, Jean-Luc Jung, Benjamin De Montgolfier et al.	<1 %

"Pairing AIS data and underwater topography to assess maritime traffic pressures on cetaceans: Case study in the Guadeloupean waters of the Agoa sanctuary", Marine Policy, 2022
Publication

14	argo.ucsd.edu Internet Source	<1%
15	digital.library.txstate.edu Internet Source	<1%
16	etheses.dur.ac.uk Internet Source	<1%
17	geomatejournal.com Internet Source	<1%
18	www.coursehero.com Internet Source	<1%
19	www.hstteis.com Internet Source	<1%
20	www.vliz.be Internet Source	<1%
21	C. Lambert, S. Laran, L. David, G. Dorémus, E. Pettex, O. Van Canneyt, V. Ridoux. "How does ocean seasonality drive habitat preferences of highly mobile top predators? Part I: The north-western Mediterranean Sea", Deep Sea	<1%

Research Part II: Topical Studies in Oceanography, 2017
Publication

Exclude quotes	On	Exclude matches	Off
Exclude bibliography	On		