Analysis of specific shallow water current for endemic fish conservation at Natuna Islands, Indonesia

by Cek Turnitin

Submission date: 24-May-2023 11:36AM (UTC+0800)
Submission ID: 2100550206
File name: 2021.1908-1917.pdf (985.9K)
Word count: 5067
Character count: 26164

Analysis of specific shallow water current for endemic fish conservation at Natuna Islands, Indonesia

[1]Hariyadi, [2]Johannes Hutabarat, [2]Denny N. Sugianto, [2]Agus Hartoko, [2]Jahved F. Maro, [3]Erick Nugraha

[1] Faculty Fisheries and Marine Science, Marine Science Doctoral Programe, Diponegoro University, Semarang, Indonesia; [2] Faculty of Fisheries and Marine Science, Diponegoro University, Semarang, Indonesia; [3] Faculty of Fishing Technology, Jakarta Technical University of Fisheries, South Jakarta, Indonesia. Corresponding author: E. Nugraha, nugraha_eriq1@yahoo.co.id

Abstract. Natuna Sea has high biodiversity because of its location directly opposite the South China Sea and the high seas, so there are many endemic species in the waters. Currents greatly affect the distribution pattern of chlorophyll-a and sea surface temperature as important oceanographic variables for pelagic fish in Natuna Sea. The remote sensing technology approach is very important in mapping the current velocity distribution pattern in Natuna Sea with an analysis model using the MIKE 21 Current Model. The research was conducted in Natuna Sea in 2019 consisting of representing the eastern monsoon (May to October) and the West monsoon (November to April). Flow Model FM MIKE 21 Flow Model FM Hydrodynamic Module was used to simulate tidal and flow patterns. The current pattern in the east monsoon in May to October 2019 showed the dominant direction of arrival from the south to the north. Currents, average chlorophyll-a, and average sea surface temperature in the west monsoon in November to December 2019 in Natuna Waters using the MIKE 21 current distribution pattern model and Aqua Modis level 3 data found that the current distribution patterns in Natuna waters ranged from 0.1 to 0.5 m s^{-1}. The average chlorophyll-a in the west monsoon ranged from 0.1 to 0.7 mm m^{-3} and the average SST in the west monsoon ranged from 28.0 to 31.0°C. The results of the field survey conducted in Natuna waters found 2 endemic fish species (fish that exist only in one particular place, and not in others), namely Bombay duck fish (*Harpadon nehereus*) and Goatee croaker fish (*Dendrophysa russelii*).
Key Words: monsoons, sea surface temperature, chlorophyll-a, Bombay duck fish, goatee croacker fish.

Introduction. The characteristics of Natuna waters are influenced by seasons. According to Wyrtki (1961), Hartoko et al (2019), Nababan & Simamora (2012), and Deliama (2017), seasons in Indonesia are divided into northwest monsoons (west monsoons), southeast monsoons (east monsoons), and transitional monsoons or transitions between the two. At the time of transition, the wind direction is irregular, and it often rains suddenly. In coastal areas, the characteristics of the waters are also influenced by tides and input from the mainland. The waters of the southwest part of Natuna receive material input from rivers and anthropogenic activities. Several rivers flow into these waters, one of which is the Binjai River, the largest river in the region (Kusumaningtyas et al 2014; Nababan et al 2015). Natuna Sea borders with the South China Sea and countries in the ASEAN region; Vietnam, Cambodia, Singapore, Thailand, and Malaysia, so it is very strategic as one of the important international shipping lanes. The Natuna Sea is also a place for the mass exchange of water from the Indonesian Ocean to the South China Sea, which has a close interaction with the Monsoon that occurs in Indonesia, so it is necessary to know thoroughly about the characteristics of the water resources (Wyrtki 1961; Nababan & Simamora 2012).

Natuna Sea has high biodiversity because of its location directly opposite the South China Sea and the high seas, so there are many endemic species in the waters, including Bombay duck fish (*Harpadon nehereus*) and Goatee croaker fish (*Dendrophysa* *russelii*). With the existence of endemic species in Natuna Sea, it is necessary to conduct specific research in terms of oceanography, especially the surface current patterns, so that they can be the initial data in managing and conserving these species. Currents greatly affect the distribution pattern of chlorophyll-a and sea surface temperature as important oceanographic variables for pelagic fish in Natuna Sea.

The remote sensing technology approach is very important in mapping the current velocity distribution pattern in Natuna Sea with an analysis model using the MIKE 21 Current Model. Current data was carried out by modeling currents between bathymetry data and tidal data to obtain a model of marine distribution patterns in waters shallow, especially in Natuna Sea. This research represents an initial research in managing and conserving endemic species in Natuna Sea.

Material and Method

Description of the study site. The research was conducted in the Natuna Sea, Natuna in 2019 consisting of representing the eastern monsoon (May to October) and the West monsoon (November to April). The map of the research location can be seen in Figure 1.

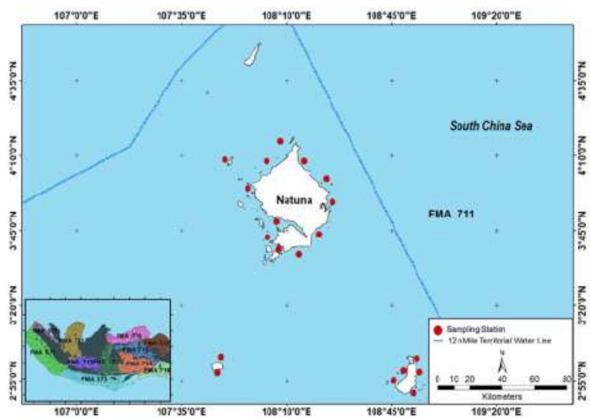

Figure 1. Station points of the field survey.

Data collection. This research was conducted using field observation methods to identify endemic species in the Natuna Sea, measuring field current patterns, and modeling current patterns and current velocity using Flow Model FM Mike 21. Satellite data processing was performed using Aqua Modis Level 3 with Chlorophyll-a data product, sea surface temperature (SST) and water depth using GEBCO (General Bathymetric Chart of the Oceans) data, then extracting data using the ArcGIS 10.8 application and then interpolating using the Kriging method referring to Maro et al (2021), Hartoko (2010), Hartoko et al (2016), Afifa et al (2020), Wirasatriya et al (2020), and Muskananfola et al (2021).

Data analysis. Flow Model FM MIKE 21 Flow Model FM Hydrodynamic Module was used to simulate tidal and flow patterns. This module was based on the numerical solution of the two-dimensional water equation. The builder equations in this hydrodynamics module consisted of continuity and momentum equations to simulate current patterns, including: The continuity equation for the two-dimensional flow average depth (average continuity equation), which can be written as (Garcia-Reyes et al 2015; Hartoko et al 2016):

$$\frac{\partial \zeta}{\partial t} + \frac{\partial p}{\partial x} + \frac{\partial q}{\partial y} = 0$$

Momentum equation for flow in the x-axis direction:

$$\frac{\partial p}{\partial t}+\frac{\partial}{\partial x}\left(\frac{p^2}{H}\right)+\frac{\partial}{\partial y}\left(\frac{pq}{H}\right)+gH\frac{\partial \zeta}{\partial x}+\frac{gp\sqrt{p^2+q^2}}{C^2H^2}-\frac{1}{\rho w}\left[\frac{\partial}{\partial x}(H\tau_{xx})+\frac{\partial}{\partial y}(H\tau_{xy})\right]-\Omega p-fVVx+\frac{h}{\rho w}\frac{\partial}{\partial x}(p_a)=0$$

Momentum equation for flow in the y-direction:

$$\frac{\partial q}{\partial t}+\frac{\partial}{\partial y}\left(\frac{q^2}{H}\right)+\frac{\partial}{\partial x}\left(\frac{pq}{H}\right)+gH\frac{\partial \zeta}{\partial y}+\frac{gq\sqrt{p^2+q^2}}{C^2H^2}-\frac{1}{\rho w}\left[\frac{\partial}{\partial y}(H\tau_{yy})+\frac{\partial}{\partial x}(H\tau_{xy})\right]-\Omega p-fVVy+\frac{h}{\rho w}\frac{\partial}{\partial y}(p_a)=0$$

Where:
x,y - coordinate space functions;
h - water depth;
ζ - sea level elevation;
p,q (x, y, f) - density level;
g - gravitational acceleration;
ρ - water density;
V_x, V_y, V_t - wind speed on the x and y axes;
τbx τby - base shear stress;
τ_{sx} τ_{sy} - surface shear stress;
τ_{xx}, τ_{xy}, τ_{yx}, τ_{yy} - turbulent shear stress;
ω - coriolis parameter;
ρw - seawater density;
fv - wind friction factor.

Results and Discussion

Distribution pattern of currents, chlorophyll-a and sea surface temperature in the east monsoon (May to October). The current pattern in the east monsoon in May to October 2019 showed the dominant direction of arrival from the south to the north. Based on the difference in color gradients, it can be seen that the velocity large currents occurred in some parts of the narrow waters flanked by two islands with a speed of 0.1 to 0.5 m s^{-1}. The map of the current distribution pattern can be seen in Figure 2.

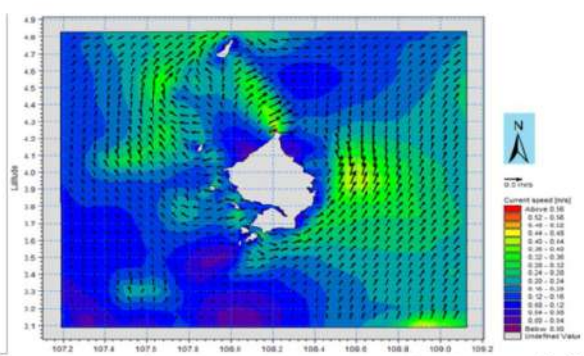

Figure 2. Distribution pattern of east monsoon currents in Natuna shallow coastal waters.

The water current in the shallow coastal waters of Natuna was the Ekman current. It has a regular current pattern. The main generator of currents in these waters was the east monsoon that moved from the waters of Java and Sumatra, where the movement of this current entered from the south of the Natuna Sea which moved into the north and northeast of the Natuna waters. This can be caused by the influence of the east monsoon wind that moved from the Indian Ocean waters to the Pacific Ocean waters. The surface current pattern in Natuna waters (Figure 2) showed a very different current direction in the east monsoon (May–October 2019). This current movement also had an impact on the distribution pattern of chlorophyll-a and sea surface temperature (SST) in the east monsoon in the coastal waters of Natuna, with the chlorophyll-a distribution ranging from 0.2 to 1.0 mm m^{-2} and the SST ranging from 28.0 to 30.0°C. The distribution of chlorophyll-a and east monsoon SST can be seen in Figure 3A and Figure 3B.

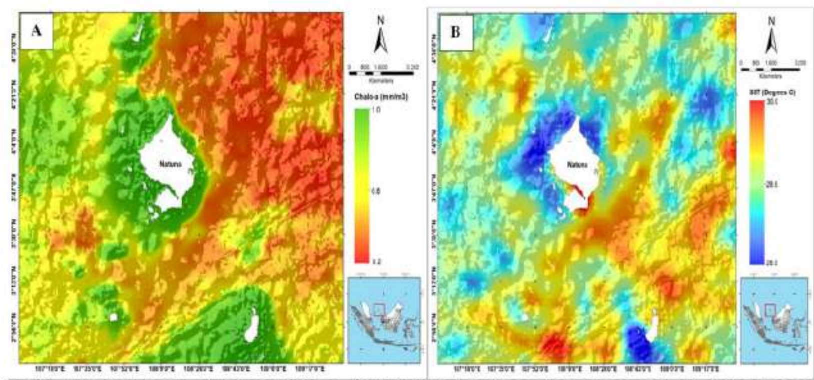

Figure 3. A: Average chlorophyll-a distribution of east monsoon; B. Average SST distribution of east monsoon.

According to the average distribution of chlorophyll-a and SST range in the east monsoon in Natuna waters, it can be elaborated that there was an increase in chlorophyll-a in each coastal area reached 8.0 to 1.0 mm m^{-3} with an average SST range of 28.0 to 30.0°C. In the SST range between 28.0 to 29.0°C in the coastal area of Natuna, there was an increase in chlorophyll-a reaching 0.8 to 1.0 mm m^{-3}. Comparing the increase in chlorophyll-a and SST to the current distribution pattern in the east monsoon (Figure 2) in Natuna waters, it can be shown that there was a confluence of currents in the coastal area which resulting in a water mass mixing that would increase nutrients and chlorophyll-a in the waters. This tendency would result in a decrease in sea surface temperature in Natuna waters.

Distribution pattern of currents, chlorophyll-a and sea surface temperature in the west monsoon (November-April). Research on the distribution pattern of currents, average chlorophyll-a, and average sea surface temperature in the west monsoon in November to December 2019 in Natuna Waters using the MIKE 21 current distribution pattern model and Aqua Modis level 3 data, found the current distribution patterns in Natuna waters ranged from 0.1 to 0.5 m s^{-1} in 2019. The current pattern distribution in the west monsoon can be seen in Figure 4.

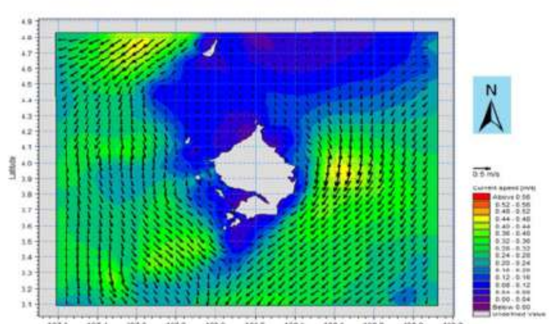

Figure 4. Current distribution patterns of west monsoon in Natuna Sea.

Based on Figure 4 regarding the current distribution pattern in the West monsoon of the Natuna Sea, the direction and pattern of inflow were from the South China Sea, the northern part of Natuna. It was when on the West monsoon when the west wind from the Pacific Ocean that entered Indonesian waters through the South China Sea was high enough that increasing current speed of up to 0.5 m s^{-1}, with a current color degradation pattern showing high clusters in the shallow waters of the Natuna Sea.

The average chlorophyll-a in the west monsoon ranged from 0.1 to 0.7 mm m^{-3} and the average SST in the west monsoon ranged from 28.0 to 31.0°C. The distribution pattern of the average chlorophyll-a and the average SST in western monsoon in Natuna waters can be seen in Figure 5A and Figure 5B.

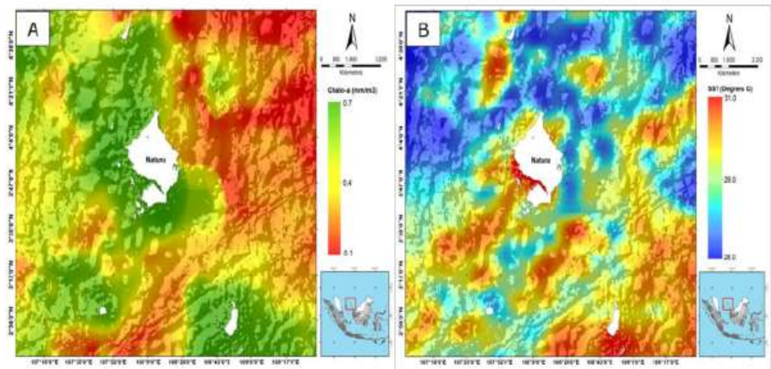

Figure 5. A. Average chlorophyll-a in the west monsoon; B. Average SST in the west monsoon in Natuna waters.

According to Figures 5A and 5B, it can be elaborated that there was an increase in chlorophyll-a reaching 0.7 mm m^{-3} in Natuna waters with an average SST range of 28.0 to 29.0°C. Comparing with the current distribution patterns in the west monsoon (Figure 4) in the Natuna waters, it can be explained that the main factor of the current direction pattern was the monsoon wind. In the west monsoon, the wind blew from the Pacific Ocean entering through the South China Sea into the Natuna waters with slower movement toward the coast due to the current collisions from the northern part and the north-western part of the Natuna Sea. This current collision resulted in an increase in chlorophyll-a and a decrease in SST in the shallow waters of the Natuna Sea.

Natuna waters depth. The water depth data analysis in the Natuna waters used GEBCO (General Bathymetric Chart of the Oceans) data. The data was cropped according to the research location, then was analyzed using 2D, and it was interpolated using a kriging distribution model. Results of the analysis found the depth of the natural waters ranging from 0 to 150 m. The results of the 2D model analysis can be seen in Figure 6.

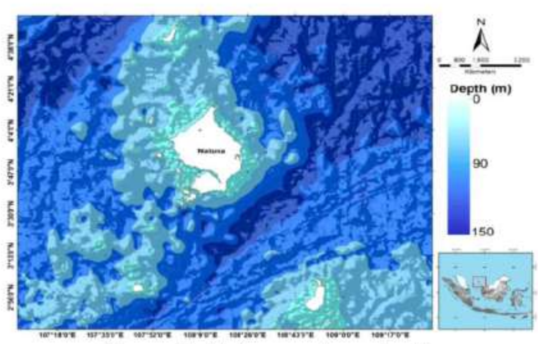

Figure 6. Natuna waters depth.

Based on the 2D model of the Natuna waters depth, it can be elaborated that in the northern part of Natuna towards the South China Sea, the depth range reached 150 m, while in the coastal part of Natuna, the depth ranged from 0 to 30 m.

Endemic species in Natuna waters. Results of the field survey (observations) conducted in Natuna waters and data collection of the species caught in the location through analysis of local market distribution found 2 endemic fish species (fish that exist only in one particular place, and not in others), namely *H. nehereus* and *D. russelii*. Images of each species can be seen in Figure 7A and Figure 7B.

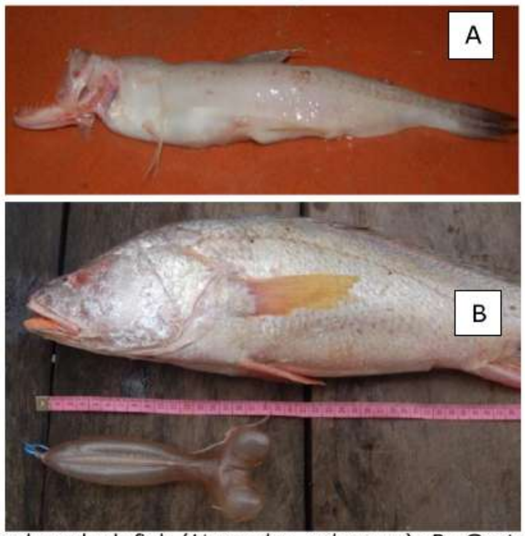

Figure 7. A: Bombay duck fish (*Harpadon nehereus*); B: Goatee croaker fish (*Dendrophysa russelii*).

Bombay duck fish (H. nehereus). Bombay duck fish has phylum: Chordata; class: Actinopterygii; order: Aulopiformes; family: Synodontidae; genus: Harpadon; species: *H. nehereus*; phylum: Chordata; class: Pisces; order: Myctophoide; family: Scopelidae; Genus: Harpodon; species: *H. neherous*. Lomek fish has a slightly flattened elongated body shape, the tip of the snout is short and rounded, and the tail fin has 3 parts: top, bottom, and middle as a continuation of the scale line. The teeth of the two jaws have various shapes; flat arch, large arch, and small arch. The body shape is bilaterally symmetrical, compressed, while the head shape is blunt (Siddique & Aktar 2011; Jin et al 2012; Bhattacharya et al 2016; Bo et al 2013; Salim et al 2020; Rupsankar 2010).

H. nehereus is a type of demersal fish, the preferred type of substrate is mud and fine sand, especially beaches close to river mouths (Kalhoroa et al 2020; Salim et al 2020; Bhattacharya et al 2016). The fish was located on the bottom of the waters with the speed of sea surface currents to breed in the range of 0.2 to 0.4 m s^{-1} with chlorophyll-a content ranging from 0.2 to 0.5 mm m^{-3} and an SST range ranging from 28 to 30°C in every appearance of *H. nehereus* at the bottom of the waters (Siddique & Aktar 2011; Bo et al 2013).

H. nehereus is a type of fish in Indonesian waters only found in the waters of Natuna and Bangka Belitung. This fish has important economic value in Natuna, Bangka Belitung, and several other coastal areas in Sumatra because it has important economic value. This fish needs to be protected and conserved in order to be sustainable.

Goatee croaker fish (D. russelii). Goatee croaker fish with classification phylum: Chordata; class: Actinopterygii; order: Perciformes; family: Sciaenidae; genus: Dendrophysa; species: *D. russelii* (Cuvier, 1829). This fish has a slightly flat elongated body (vertical), covered with scales to the head. The first and second dorsal fins are fused (Figure 7B). The back edge of the front gill cover is serrated. The special feature of the Gerot fish is a small mouth but covered by very thick lips (according to one of the local names of this fish). The pectoral fins are longer and tapered than the pelvic fins. The dorsal fin has 12 spines and 13 to 15 soft fin rays. Gerot fish has a silvery gray body-color, with 4-5 longitudinal dark gray stripes that are dashed and faint on the sides of the body. Three or four of these lines are above the lateral line of the body. On the dorsal fin, there are 2 to 3 bands of brown spots. This fish can reach a size of 80 cm, but generally between 40 to 50 cm (Annisa et al 2018; Suprapto 2017; Khairul et al 2018). This fish has an important economic value, especially in its swimming bubbles. The price of this fish is increasing highly because it has swimming bubbles which are very expensive and contains high collagen. This fish exists in sea waters close to rivers with a water temperature range of 28 to 30°C.

Discussion. The results of the study found an average range from 0.1 to 0.5 m s^{-1} for the current velocity in the east and west monsoons, in Natuna waters. In the east monsoon the current moved from the south to the north of Natuna (towards the South China Sea). According to Pamungkas (2018), Purba (2019), Maro et al (2021), Hartoko et al (2019), Wirasatriya et al (2020), and Muskananfola et al (2021), during the east monsoon, the wind moved from the continent of Asia to the continent of Australia, while in the west monsoon, the wind will move from the Australian continent to the Asian continent. The influence of the monsoon wind would also affect the Natuna Coastal waters, especially due to their location in between the Natuna Sea, Sumatra Sea and the Java Sea, which is the monsoon wind flow area (Setyawan & Pamungkas 2017). The research found that there was a collision of currents that had an impact on the distribution pattern of chlorophyll-a and sea surface temperature (SST) in the East monsoon in the coastal waters of Natuna. The results of the analysis of the average distribution of chlorophyll-a were in the range of 0.2 to 1.0 mm m^{-2} and the SST ranged from 28.0 to 30.0°C. Previous research found that if there is a collision between the sea surface currents in a body of water, the chlorophyll-a will increase and the SST will decrease (Muskananfola et al 2021; Pamungkas 2018; Maro et al 2021; Hartoko 2010; Sukresno et al 2015; Sukresno et al 2018; Lebrec et al 2019). This is common in the coastal areas, due to the presence of numerous small islands that are close to each other, thus blocking the movement of currents from deep waters to shallow waters. These waters tend to have a high level of fertility so that many organisms roam in these waters for shelter, foraging and spawning. Conversely, in the West monsoon (November to December), the movement pattern of the current is from the northern part of Natuna (the South China Sea) to the Natuna coastal waters. The results of the study found that the current movement was influenced by the west monsoon, which blew strongly from the Pacific Ocean towards the South China Sea, then towards the Natuna Coast, the Sumatra Sea and the Java Sea. According to Hartoko et al (2019), Maro et al (2021), Wirasatriya et al (2020), and Muskananfola et al (2021), the movement of incoming currents from the northern part of Indonesia was caused by the west monsoon wind blowing from the Pacific Ocean to the Indian Ocean, resulting in a significant increase in the current speed during that season.

During the West monsoon, an upwelling occurred in the Natuna coastal waters, resulting in a decrease of the SST and chlorophyll-a. Mixing the seawater masses (by upwelling) could decrease the SST and chlorophyll-a at sea level. Waters that have upwelling characteristics are fertile, in terms of nutrients and chlorophyll-a, which makes them attracting for many marine organisms in their migration for food and spawning (García-Reyes et al 2015; Chung & Gong 2019; Putra et al 2016; Wirasatriya et al 2020; Sukresno et al 2015; Putra & Mustika 2021).

The study found 2 types ofendemic fish, during the west and east monsoons, namely *H. nehereus* and *D. russelii*, which were found in the Natuna coastal waters, with a surface current velocity ranging from 0.1 to 0.5 m s^{-1}, a chlorophyll-a sea level ranging from 0.2 to 1.0 mm m^{-3}, an average SST ranging from 28 to 30°C, and an average water depth ranging from 0 to 150 m. According to Siddique & Aktar (2011), Jin et al (2012), Bhattacharya et al (2016), Annisa et al (2016), and Suprapto (2017), at the location of the appearance of *H. nehereus* and *D. russelii* in coastal waters, the average sea surface temperature ranged from 27 to 30°C, the sea surface currents ranged from 0.3 to 0.5 m s^{-1} and the average depth ranged from 0 to 20 m. A management of these endemic fish species has to be implemented in order to preserve their populations sustainability, considering their significant economic value, makink them more susceptible to be overexploited. Therefore, it is necessary to manage the species *H. nehereus* and *D. russelii* in Natuna waters in order to remain sustainable.

Conclusions. The research results of the oceanographic variables analysis, mainly the depth, SST, chlorophyll-a content and monsoonal current speed, will support the site selection and the attempt of endemic fish conservation, mainly in the shallow water of the coastal areas arround Natuna islands. The research occurred during the east season (May to October) and the west season (November to April) 2019. The SST ranged from 28.0 to 31.0°C, the current speed of west and east season ranged from 0.1 to 0.5 m s^{-1}, the chlorophyll-a content ranged from 0.2 to 1.0 mg m^{-3} and the depth ranged from 0 to 150 m. The two identified endemic fish are *H. nehereus* and *D. russelii*.

Acknowledgements. The authors would like to thank to the Dean Faculty of Fisheries and Marine Science, Diponegoro University, Semarang, Indonesia, for the research grant, But also to all other parties for their help during the field sampling and laboratory analysis.

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

References

Afifa F. H., Hartoko A., Purnomo P. W., 2020 Changes and vulnerability of coral reef ecosystem based on field and remote sensing data on Kemujan Island, Karimunjawa Islands, Indonesia. AACL Bioflux 13(2):1016-1026.

Annisa C. A., Rahardjo M. F., Zahid A., Simanjuntak C. P. H., Asriansyah A., Aditriawan R. M., 2018 [Diet and feeding habits of the Javelin Grunt, *Pomadasys kaakan* (Cuvier, 1830) in Pabean Bay, West Java]. Gadjah Mada University of Fisheries Journal 20(1):31-40. [In Indonesian].

Bhattacharya T., Ghorai T., Dora K. C., Sarkar S., Chowdhury S., 2016 Influence of chemical preservatives on the quality and shelf-life of dried Bombay duck (*Harpodon nehereus*). The Asian Journal of Animal Science 11(1):1-8.

Bo Z., Xu T., Wang R., Jin X., Sun Y., 2013 Complete mitochondrial genome of the bombay duck *Harpodon nehereus* (Aulopiformes, Synodontidae). Mitochondria DNA. The Journal of DNA Mapping, Sequencing, and Analysis 24(6):660-662.

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 30:575-587.

Deliama, 2017 [Estimation of sustainable potential and utilization level of sea anemone (*Sticodactyla gigantea*) in Makassar Strait Waters]. MSc thesis. Water Resources Management Study Program, Department of Fisheries, Faculty of Marine and Fishery Sciences, Hasanuddin University, Makassar, 27 p. [In Indonesian].

García-Reyes M., Sydeman W. J., Schoeman D. S., Rykaczewski R. R., Black B. A., Smit A. J., Bograd S. J., 2015 Under pressure: climate change, upwelling, and eastern boundary upwelling ecosystems. Frontiers in Marine Science 2:109.

Hartoko A., 2010 Spatial distribution of *Thunnus* sp., vertical and horizontal sub-surface multilayer temperature profiles of in-situ agro float data in Indian Ocean. Journal Of Coastal Development 14(1):61–74.

Hartoko A., Helmi M., Sukarno M., Hariyadi, 2016 Spatial tsunami wave modelling for the South Java Coastal Area, Indonesia. International Journal of GEOMATE 11(25):2455–2460.

Hartoko A., Febrianto A., Pamungkas A., Fachruddin I., Helmi M., Hariyadi, 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.
Jin T., Wu Y., Wang Q., 2012 Production and characteristics of protein hydrolysates from bombay duck (*Harpodon nehereus*). Journal of Food Processing and Preservation 36(1):30-37.
Kalhoroa M. T., Yongtong M., Kalhorob M. A., Shahc S. B. H., Memond A. M., Moshine M., Dahria M. A., 2020 Resource evaluation, stock, growth and mortality of the Bombay duck (*Harpodon nehereus* Hamilton, 1822) fishery in the coastal waters of Pakistan. Indian Journal of Geo Marine Sciences 49(7):1222-1228.
Khairul, Mawardi W., Riyanto M., 2018 [Use of blue light emitting diode (Led) lamps on floating chart catches in Aceh Jaya District]. Albacore Marine Fisheries Research Journal 1(2):235-243. [In Indonesian].
Kusumaningtyas M. A., Bramawanto R., Daulat A., Pranowo W. S., 2014 [The water quality of Natuna coastal water during transitional season]. DEPIK Journal of Science - Aquatic, Coastal and Fishery Sciences 3(1):10-20. [In Indonesian].
Lebrec M., Stefanski S., Gates R., Acar S., Golbuu Y., Claudel-Rusin A., Kurihara H., Rehdanz K., Paugam-Baudoin D., Tsunoda T., Swarzenski P. W., 2019 Ocean acidification impacts in select Pacific Basin coral reef ecosystems. Regional Studies in Marine Science 28:1-8.
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.
Muskananfola M. R., Jumsar, Wirasatriya A., 2021 Spatio-temporal distribution of chlorophyll-a concentration, sea surface temperature and wind speed using aqua-modis satellite imagery over the Savu Sea, Indonesia. Remote Sensing Applications: Society and Environment 22:1-9.
Nababan B., Hadianti S., Natih N. M. N., 2015 [Dynamic of sea level anomaly of indonesian waters]. Journal of Tropical Marine Science and Technology 7(1):259-272. [In Indonesian].
Nababan B., Simamora K., 2012 [Variability of chlorophyll-a concentration and sea surface temperature of Natuna Waters]. Journal of Tropical Marine Science and Technology 4(1):121-134. [In Indonesian].
Pamungkas A., 2018 [Characteristics of oceanographic parameters (tidals, currents, and waves) in the north and south waters of Bangka Island]. Marina Oceanography Bulletin 7(1):51-58. [In Indonesian].
Purba N. P., Pranowo W. S., Simanjuntak S. M., Faizal I., Jasmin H. H., Handyman D. I. W., Mulyani P. G., 2019 [Trajectory of microplastics at Savu Sea Marine National Park, East Nusa Tenggara]. DEPIK. Journal of Aquatic, Coastal and Fishery Sciences, 8(2):125-134. [In Indonesian].
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 47:1-19.
Putra M. I. H., Mustika P. L. K., 2021 Maximum entropy model: Estimating the relative suitability of cetacean habitat in the Northern Savu Sea, Indonesia. Marine Mammal Science 37(1):6–28.
Rupsankar C., 2010 Improvement of cooking quality and gel formation capacity of bombay duck (*Harpodon nehereus*) fish meat. Journal of Food Science and Technology 47(5):534–540.
Salim G., Handayani K. R., Anggoro S., Indarjo A., Syakti A. D., Ibrahim A. J., Ransangan J., Prakoso L. Y., 2020 Morphometric analysis of *Harpodon nehereus*, *Harpiosquilla raphidea*, and *Scylla serrata* in the coastal waters of Tarakan, North Kalimantan, Indonesia. Biodiversitas 21(10):4829-4838.
Setyawan W. B., Pamungkas A., 2017 [Comparison of oceanographic characteristics of the north and south coasts of Java Island: Tides, currents, and waves]. Proceedings

of the 2017 National Marine and Fisheries Seminar III. Trunojoyo University, Madura, pp. 191–202. [In Indonesian].
Siddique M. A. M., Aktar M., 2011 Changes of nutritional value of three marine dry fishes (*Johnius dussumieri*, *Harpodon nehereus* and *Lepturacanthus savala*) during Storage. Food and Nutrition Sciences 02(10):1082-1087.
Sukresno B., Hanintyo R., Kusuma D. W., Jatisworo D., Murdimanto A., 2018 Three-way error analysis of sea surface temperature (SST) between Himawari-8, Buoy, and Mur SST In Savu Sea. International Journal of Remote Sensing and Earth Sciences (IJReSES) 15(1):25-36.
Sukresno B., Hartoko A., Sulistyo B., Subiyanto, 2015 Empirical cumulative distribution function (ECDF) analysis of *Thunnus* sp. using ARGO float sub-surface multilayer temperature data in Indian Ocean South of Java. International Conference on Tropical and Coastal Region Eco-Development 2014 (ICTCRED 2014). Procedia Environmental Sciences 23:358–367.
Suprapto S., 2017 [Demersal fish biodiversity index in Arafura waters]. Indonesian Journal of Fisheries Research 14(3):321-335. [In Indonesian].
Wirasatriya A., Setiawan J. D., Sugianto D. N., Rosyadi I. A., Haryadi, Winarso G., Setiawan R. Y., Susanto R. D., 2020 Ekman dynamics variability along the southern coast of Java revealed by satellite data. International Journal of Remote Sensing 41(21):8475–8496.
Wyrtki K., 1961 Physical oceanography of the Southeast Asian waters. In: Scientific results of maritime investigations of the South China Sea and Gulf of Thailand 1959–1961. Naga Report 2. University of California/Scripps Institute of Oceanography, California, 195 p.

Received: 06 May 2021. Accepted: 30 June 2021. Published online: 12 July 2021.
Authors:
Hariyadi, Faculty of Fisheries and Marine Science, Marine Science Doctoral Programe, Diponegoro University, Prof. Sudarto Street, Semarang 50275, Central Java, Indonesia, e-mail: hargeoku@gmail.com
Johannes Hutabarat, Faculty of Fisheries and Marine Science, Diponegoro University, Prof. Sudarto Street, Semarang 50275, Central Java, Indonesia, e-mail: johannesfpik@gmail.com
Denny Nugroho Sugianto, Faculty of Fisheries and Marine Science, Diponegoro University, Prof. Sudarto Street, Semarang 50275, Central Java, Indonesia, e-mail: dennysugianto@yahoo.com
Agus Hartoko, Faculty of Fisheries and Marine Science, Diponegoro University, Prof. Sudarto Street, Semarang 50275, Central Java, Indonesia, e-mail: agushartoko.undip@gmail.com
Jahved Ferianto Maro, Faculty of Fisheries and Marine Science, Diponegoro University, Prof. Sudarto Street, Semarang 50275, Central Java, Indonesia, e-mail: yantogisuntrib@gmail.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

How to cite this article:
Hariyadi, Hutabarat J., Sugianto D. N., Hartoko A., Maro J. F., Nugraha E., 2021 Analysis of specific shallow water current for endemic fish conservation at Natuna Islands, Indonesia. AACL Bioflux 14(4):1908-1917.

Analysis of specific shallow water current for endemic fish conservation at Natuna Islands, Indonesia

ORIGINALITY REPORT

13%	10%	6%	3%
SIMILARITY INDEX	INTERNET SOURCES	PUBLICATIONS	STUDENT PAPERS

PRIMARY SOURCES

1	Submitted to Universitas Indonesia Student Paper	2%
2	etd.uwc.ac.za Internet Source	<1%
3	ddd.uab.cat Internet Source	<1%
4	Charissa M. Ferrera, Gil S. Jacinto, Chen-Tung Arthur Chen, Maria Lourdes San Diego-McGlone et al. "Carbonate parameters in high and low productivity areas of the Sulu Sea, Philippines", Marine Chemistry, 2017 Publication	<1%
5	jonuns.com Internet Source	<1%
6	training.theacademybydhi.com Internet Source	<1%
7	A'an Johan Wahyudi, Karlina Triana, Yukio Masumoto, Arief Rachman et al. "Carbon and nutrient enrichment potential of South Java	<1%

upwelling area as detected using hindcast biogeochemistry variables", Regional Studies in Marine Science, 2023
Publication

8	biostaging.pjsir.org Internet Source	<1 %
9	Submitted to Universitas Terbuka Student Paper	<1 %
10	Yoshiyuki Nozaki, Dia-Sotto Alibo, Hiroshi Amakawa, Toshitaka Gamo, Hiroshi Hasumoto. "Dissolved rare earth elements and hydrography in the Sulu Sea", Geochimica et Cosmochimica Acta, 1999 Publication	<1 %
11	researchers.mq.edu.au Internet Source	<1 %
12	www.freepatentsonline.com Internet Source	<1 %
13	www.cdc.gov Internet Source	<1 %
14	www.fishwallpapers.com Internet Source	<1 %
15	Tajima, Yoshimitsu, Yoshihiro Hamada, and Mohammad Asad Hussain. "Impact of Dynamic Morphology Change on Storm Surge	<1 %

Disaster Risks along the Meghna Estuary", Procedia Engineering, 2015.
Publication

16	Torcuato Pulido Mantas, Cecilia Varotti, Camilla Roveta, Marco Palma et al. "Mediterranean Sea shelters for the gold coral Savalia savaglia (Bertoloni, 1819): An assessment of potential distribution of a rare parasitic species", Marine Environmental Research, 2022 Publication	<1 %
17	info.sail.msk.ru Internet Source	<1 %
18	www.gbif.org Internet Source	<1 %
19	B Sukresno, A Murdimanto, R Hanintyo, D Jatisworo, D W Kusuma. "The use of CMEMS and Argo Float Data for Bigeye Tuna Fishing Ground Prediction", IOP Conference Series: Earth and Environmental Science, 2019 Publication	<1 %
20	Ritu Paliwal. "Applicability of MIKE 21 to assess temporal and spatial variation in water quality of an estuary under the impact of effluent from an industrial estate", Water Science & Technology, 2011 Publication	<1 %

21	Submitted to Universitas Jenderal Soedirman Student Paper	<1 %
22	ijstr.org Internet Source	<1 %
23	journal.ugm.ac.id Internet Source	<1 %
24	psasir.upm.edu.my Internet Source	<1 %
25	www.iasks.org Internet Source	<1 %
26	www.penerbit.utm.my Internet Source	<1 %
27	Achmad Fachruddin Syah, Emma Suri Yanti Siregar, Vincetius P Siregar, Syamsul B Agus. " Application of remotely sensed data and maximum entropy model in detecting potential fishing zones of Yellowfin tuna ( ) in the eastern Indian Ocean off Sumatera ", Journal of Physics: Conference Series, 2020 Publication	<1 %
28	M Saad, R M Milad, Y A A Faiz, N L Hikmah. "Fisheries community behaviour towards water quality of the Deket river, Lamongan district", IOP Conference Series: Earth and Environmental Science, 2021 Publication	<1 %

29 Mochamad Iqbal Herwata Putra, Putu Liza Kusuma Mustika. " Incorporating prey distribution into foraging habitat modelling for marine megafauna in the Solor waters of the Savu Sea, Indonesia ", Aquatic Conservation: Marine and Freshwater Ecosystems, 2020 — <1 %
Publication

---

30 Samiran Mandal, Nibedita Behera, Avijit Gangopadhyay, R. Dwi Susanto, Prem Chand Pandey. "Evidence of a chlorophyll “tongue” in the Malacca Strait from satellite observations", Journal of Marine Systems, 2021 — <1 %
Publication

---

31 journals.plos.org — <1 %
Internet Source

---

32 proceedings.unimal.ac.id — <1 %
Internet Source

---

33 repositorioinstitucional.uabc.mx — <1 %
Internet Source

---

34 www-odp.tamu.edu — <1 %
Internet Source

---

35 www.grafiati.com — <1 %
Internet Source

---

36 www.mpimet.mpg.de

Internet Source

<1%

---

37 A Sartimbul, H Nakata, E Rohadi, S H J Sari, M Najib, S Alisafira, S N Ikhsani, D Listiyaningsih. "Water temperature variation of Segara Anakan, Sempu Island, South Malang, Indonesia in relation to the climate variation", IOP Conference Series: Earth and Environmental Science, 2018

Publication

<1%

Exclude quotes	On	Exclude matches	Off
Exclude bibliography	On		