

# 15IJEAB-107201912-Mahfud.pdf

*by*

---

FILE	15IJEAB-107201912-MAHFUD.PDF (518.02K)	WORD COUNT	2742
TIME SUBMITTED	12-AUG-2019 10:11PM (UTC+0700)	CHARACTER COUNT	14991
SUBMISSION ID	1159611033		

# Hotspots of Bony Flying fish (*H. Oxycephalus*) Distribution Constrained by Physical Oceanographic Condition in the central of Makassar Strait during Boreal Winter

Mahfud Palo<sup>1</sup>, Najamuddin<sup>1</sup>, Mukti Zainuddin<sup>1</sup>, St Aisjah Farhum<sup>1</sup>

<sup>1</sup>Faculty of Marine Science and Fisheries, Hasanuddin University, Makassar, Indonesia  
Email: mahfud\_palo@yahoo.com

**Abstract**— This study performed descriptive and qualitative approach to identify favourable Bony Flyingfish (*H. Oxycephalus*) distribution using primary data from gillnet flyingsih catches and multisensors satellite oceanography of sea surface temperature (SST) and chlorophyll-a (Chl-a) during boreal winter of 2016 (September 2016 – February 2017) in the central of Makassar strait. Emperical Cumulative Distribution Function (ECDF) has been used to analyze the suitability of physical oceanographic parameters with Bony Flyingfish catch. The results show that during boreal winter transition (September to October 2016) hotspot of Bony flyingfish distributed in the coastal water off of Pinrang region and then moved to the north at the frontal water between coastal and off Majene region during the rest of boreal winter (November 2016 – February 2017) with corresponding SST and Chl-a of 29.5 – 31.0C and 0.1 – 0.9 mg/m<sup>3</sup>, respectively. ECDF analysis indicated that SST has stronger association than Chl-a contributed on the increase of Bony flyingsih catch in the hotspots areas. The movement of hotspot from off water of Pinrang in September at the south of central Makassar to the north in the off water of Majene during the peak of boreal winter was analysed due to the Indonesian throughflow generated eddy which is still stronger during transition boreal winter and became favourable condition for the hotspot of flyingfish in the Pinrang water.

**Keywords**— physical oceanographic parameters, Bony flyingfish (*H. Oxycephalus*), Indonesian throughflow generated eddy.

## I. INTRODUCTION

Flyingfish catches in Majene water in the central of Makassar strait generally use Gillnet as fishing gear. This technique is considered having high selectibility to ensure sustainable flyingfish catches ([1],[2]).

Based on several studies of catches of flyingfished types in the Indonesian waters, [3] found that Makassar strait and Flores sea have 11 types and then central Maluku (Ambon and surrounding waters) 8 types.

Flyingfish (*H. oxycephalus*) is most dominant catch using gillnet in the Majene water, central of Makassar strait [2]. *H. oxycephalus* species are most dominant caught in Naku water, south of Ambon island [4], in the Seram water [5], and also in the south china sea water associated with Kuroshio current [6].

Satellite oceanography is a remote sensing technology that is now efficiently exploiting ocean and fisheries aspects in term of natural resources management. This technology could monitor all physical aspects in the sea regionally and synoptically, so that useful for any benefit

to look for favourable conditions of fishing catches and many purposes such as biological hotspots [7] a potential area favourable for fishing catches associated with certain conducive oceanographic conditions (upwelling, front and eddy).

In physical perspective, the Makassar strait is the main pathways on the Indo-Pacific feature what so called the Indonesian throughflow (ITF) [8]. This strait is known with very dinamic water affected by water masses and current exchanges between Pacific and Indian Ocean, the ITF, and monsoonal current) [9]. Interctions between two different monsoon (wet and dry) and the ITF will influence current circulation and variability of SST and Chl-a in the Makassar strait [10], besides the regional climate change could affect the structure and transformation of physical and chemical properties in this region [11].

Dynamics of physical oceanographic processes will impact on pelagic fish distribution in some certain waters and will find favourable contion for spawning, migration

and protection [12]. [13] showed that flyingfish is associated with favourable SST, so that accurate prediction of high potential catch of flyingfish (*H. oxycephalus*) could be implemented using other oceanographic parameters, such as Chlorophyll-a, current, and salinity. Meanwhile traditional fishermen still do fishing with intuitive feeling without any support of this technology using satellite remote sensing.

Flyingfish data from Majene local government fisheries department (Dinas during last decade showed catch decreasing trend. One factor is our less knowledge on the hotspot distribution of flyingfish changing by season and regional climate variations. In the Makassar strait. This study is intending to use descriptive and qualitative method applying multisensor satellite remote sensing of SST and Chl-a together with flyingfish (*H. oxycephalus*) catch to see the hotspot areas during the boreal winter in the central of Makassar Strait.

## II. DATA AND METHODS

Descriptive and qualitative method will be applied to use multisensor satellite oceanography that can derive sea surface temperature and chlorophyll-a, and will be related to flyingfish catches using empirical cumulative distribution function analysis. All the data are set from September 2016 until February 2017 to accommodate boreal winter.

### 2.1 Research Area

In order to get flyingfish catch data, we determine Somba in Sendana, one of the coastal sub-districts in Majene Regency, West Sulawesi Province, as the fishing base. The research area is located at coordinates 03° 22' 51.8" S and 118° 50' 47.8" E. The fishing area of drifting gillnets for the capture of *H. oxycephalus* is in the central of Makassar Strait, in area with coordinates of 2° 57' 50.40" - 3° 53' 45.60" S; 118° 7' 4.8" - 118° 46' 19.20" E and 3° 53' 28.68" - 4° 16' 48.24" S; 119° 6' 43.08" - 119° 20' 48.43" E as shown in Figure 1.

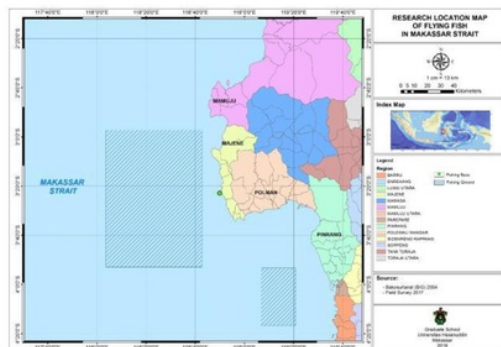


Fig.1: Fishing area of drifting gillnet in the central of Makassar Strait

### 2.2 DATA

This study utilizes primary data of gillnet flyingfish catch (*H. oxycephalus*) per trip (Catch Per Unit Effort/CPUE) and secondary data of monthly sea surface temperature (SST) and monthly chlorophyll-a (Chl-a) from Aqua/MODIS satellite images. All the image data are free cloud coverage and had been atmospheric and geometrically corrected. The SST and Chl-a data are taken from the MODIS web ([www.oceancolor.gsfc.nasa.gov](http://www.oceancolor.gsfc.nasa.gov)). Catch data are analysed by counting weight per hauling that can represent catch fluctuation spatially and temporally before further analysis to see the relation with SST and Chl-a. In order to increase the quality of flyingfish catch data, interview had been applied to the fishermen.

### 2.3 Empirical Cumulative Distribution Function (ECDF)

The study applies empirical cumulative distribution function (ECDF) method to see the relationship between oceanographic parameters (SST and Chl-a) and highest flyingfish catch (CPUE) using 3 functions [14,15] as follow:

$$f(x) = \frac{1}{n} \sum_{i=1}^n I(x_i) \quad \dots \dots \dots (1)$$

With indicator function

$$I(x_i) = \begin{cases} 1, & \text{if } (x_i \leq t) \\ 0, & \text{otherwise} \end{cases}$$

$$g(t) = \frac{1}{n} \sum_{i=1}^n \frac{y_i}{y} I(x_i) \quad \dots \dots \dots (2)$$

$$D(t) = \max |f(t) - g(t)| \quad \dots \dots \dots (3)$$

where:

- $f(t)$  : Empirical cumulative frequency distribution function
- $g(t)$  : Catch-weighted cumulative distribution function
- $I(x_i)$  : Indicator function
- $D(t)$  : Absolute value of the difference between two curves  $f(t)$  and  $g(t)$  at any point  $t$  and assessed by standard Kolmogorov-Smirnov test
- $n$  : The number of fishing trips
- $x_i$  : The measurement for satellite-derived oceanographic variables in a fishing trip.
- $i$  : An index ranging the ordered observation

- from lowest and highest value of oceanographic variables.
- yi : The CPUE in a fishing trip i and averaged estimate of all CPUE fishing trips.
- max : Certain number of 13 variable where difference between 2 curves  $|g(t)-f(t)|$  is maximum.

### III. RESULTS AND DISCUSSIONS

#### 3.1 RESULTS

Flyingfish CPUE in the research area during boreal winter (September 2016 – February 2017) indicated abundant hotspot around off of Pinrang water in September 2016 and spread to the north around Majene water in October 2016 with catches in the ranges of 65 kg and 107.89 kg, respectively (Fig. 2a and 2b). During November 2016 – February 2017, the flyingfish CPUE reduced significantly and located in the off water of Majene with catch around 86 kg. In general, flyingfish CPUE has the highest catch during transition period of boreal winter in September and October compared to the rest of boreal winter during November 2016 – February 2017.

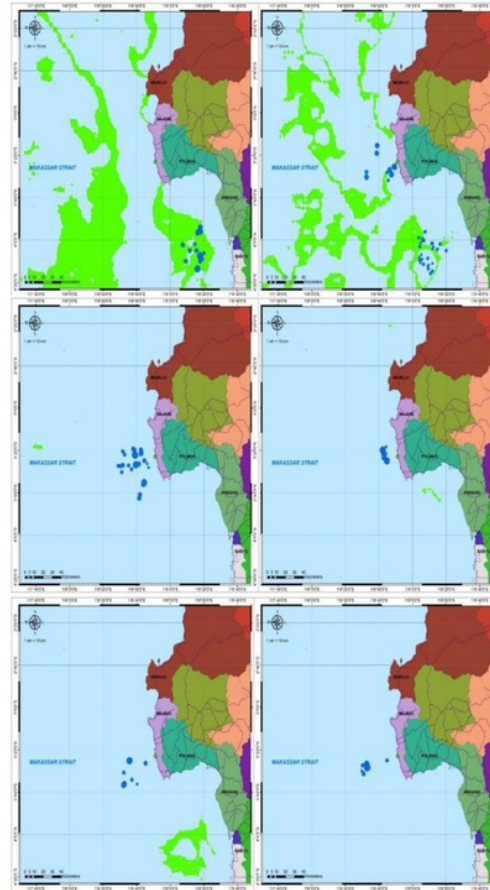


Fig.2: Distribution of optimum area (green zone) and catch of flyingfish (*H. oxycephalus*) (kg) in September 2016 - February 2017

Sea surface temperature (SST) distribution during boreal winter (September 2016 – February 2017) was dominated by high SST feature stronger in September and October 2016 in the range of 30.5 – 31°C and decreased significantly around the main pathway of the Indonesian throughflow (ITF) from November 2016 until February 2017, in the range of 29.0 – 29.30 °C. Figure 3 shows the SST distribution superimpose with the flyingfish catch during boreal winter in the central of Makassar strait

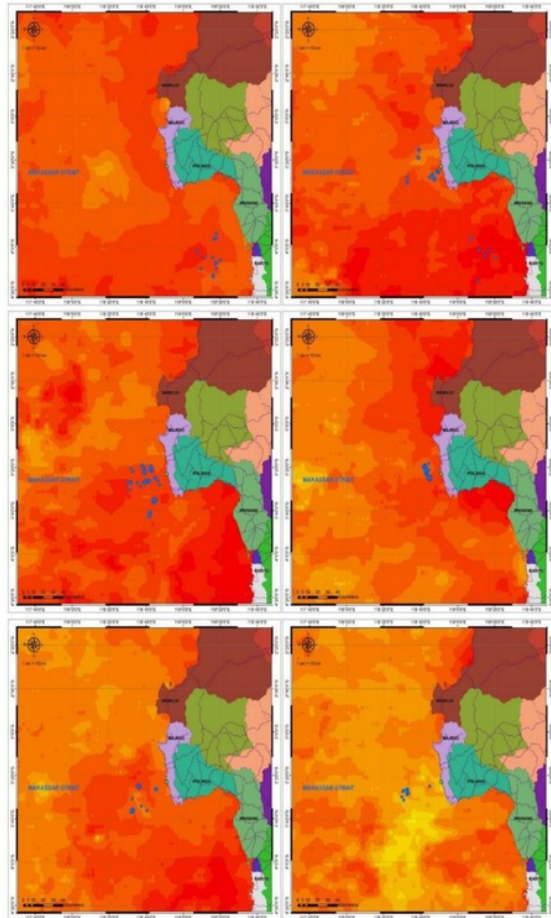


Fig.3: Distribution of SST ( $^{\circ}\text{C}$ ) and catch of flying fish (*H. oxycephalus*) (kg) in September 2016-February 2017

Chlorophyll-a (Chl-a) concentration during boreal winter (September 2016 – February 2017) revealed less productivity in most central of Makassar strait, except in the coastal region around Majene bay during September – October 2016 in the range of  $0.1 - 0.9 \text{ mg.m}^{-3}$ . Chl-a expanded broadly along the main pathway of ITF and coastal areas in the west Sulawesi province with Chl-a concentration increase in the range of  $0.1 - 1.3 \text{ mg.m}^{-3}$ . Figure 4 introduces the Chl-a concentration superimpose with the flyingfish catch during boreal winter in the central of Makassar strait.

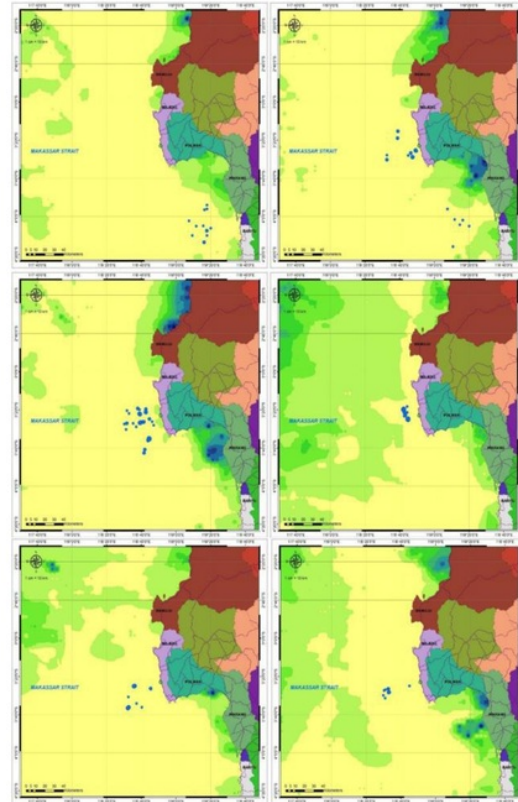


Fig.4: Distribution of CHL-a ( $\text{mg.m}^{-3}$ ) and catch of flying fish (*H. oxycephalus*) (kg) in September 2016-February 2017

### 3.2 DISCUSSIONS

High flyingfish CPUE occurred in September and October 2016 located off Pinrang water surrounding with relatively homogeneous high temperature distribution in that region. In the following month at the rest of boreal winter during November 2016 – February 2017, the flyingfish CPUE moved to the north in the central of Makassar strait around off Majene water where the hotspots associated with frontal areas. The high flyingfish catch is likely favorable on higher temperature in the range of  $30.5 - 31^{\circ}\text{C}$  during September – October 2016 in the off Pinrang water and reduces to less temperature in the range of  $29.5 - 30^{\circ}\text{C}$  in the rest of boreal winter during November 2016 – February 2017 constrained by frontal areas around the hotspots in the Majene water.

Less Chl-a concentration during September – October 2016 infers that high flyingfish CPUE during that transition period to boreal winter does not favorable to high flyingfish catch off the Pinrang water. Frontal region

revealed by SST distribution around hotspots consistent also seen on the Chl-a distribution during the rest of boreal winter from November 2016 until February 2017 around Majene water.

Figure 5 shows ECDF analysis to identify oceanographic variable of SST favorable to potential high flyingfish catch in the central Makassar strait. The cumulative distribution curved difference between two functions has confident level of 95%. The result supported the qualitative analysis on the stronger association of high flyingfish CPUE with the SST in the range 29.5 – 31.0 °C as shown on Fig. 5 for September 2016 ECDF analysis.

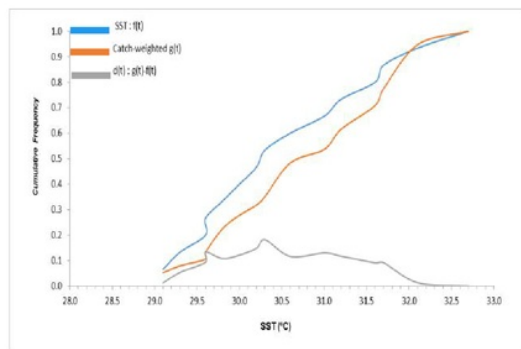


Fig.5: Empirical Cumulative Distribution Function for the SST as weighted by flyingfish catch and also absolute difference of the two curved functions in September 2016.

High flyingfish CPUE in September and October 2016 was associated with high temperature and had stronger favourable condition with SST compare to Chl-a (ECDF analysis figure is not shown). What cause this strong relationship occurred around off Pinrang water compare to the less flyingfish CPUE around Majene water during the rest boreal winter from November 2016 until February 2017. Figure 6 is taken from Metzger et. al., 2010 performing mean current system during 2004-2005 simulated by HYCOM in the Makassar strait. There is eddy around hotspot in the off Pinrang water. It is analysed that the high flyingfish catch during September was due to eddy in that associated region.

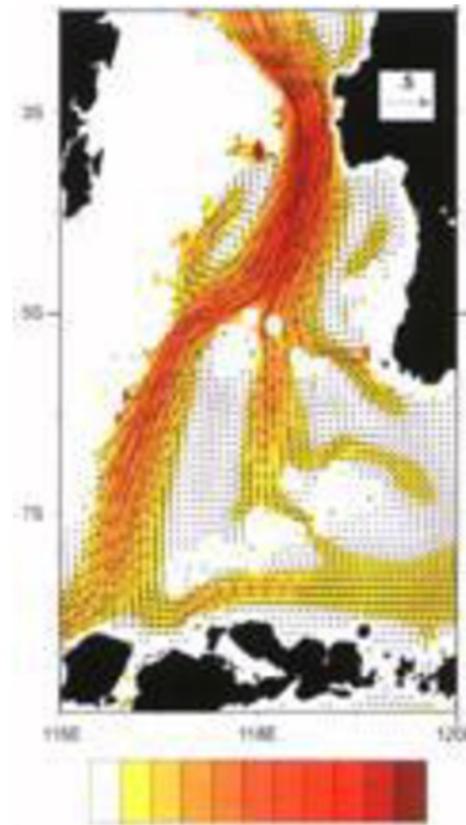


Fig.6: HYCOM mean simulated circulation in the Makassar strait during 2004-2005 (Fig. Taken from [16]).

#### IV. CONCLUSION

There are two prominent hotspots for the potential flyingfish catches in the central of Makassar strait: firstly in the coastal water off Pinrang region during boreal winter transition (September to October 2016) and secondly in the Majene water during the rest of boreal winter from November 2016 until February 2017. High potential flyingfish catch in the coastal water off Pinrang region was analysed due to eddy in that region, meanwhile around Majene water caused by frontogenesis as shown by SST and Chl-a in the ranges of 29.5 – 31.0°C and 0.1 – 0.9 mg.m<sup>-3</sup>. ECDF analysis indicated that SST has stronger association compare to Chl-a on the increase of flyingfish catch.

#### ACKNOWLEDGEMENTS

Thanks to the fishermen of the drifting gillnet in the Somba of Majene Regency, Southern of Makassar Strait

for their willingness to give a ride to researchers following the capture of flying fish. Thanks also to brothers Achmad Fatanah, Supardi, Fitriadi and Muh. Sadly for assistance and cooperation during the research.

#### REFERENCES

- [1] Hutubessy B.G., A.Syahailatua and J.W.Mosse, 2005. Gillnet Selectivity in Catching of Flying Fish in Naku Waters, Ambon Island. Torani, Vol 15 (6): 356-370.
- [2] Palo, M., 2009. Flying Fish (Exocoetidae) Drift Gill Net Selectivity in the Majene Waters Makassar Strait. Torani Vol. 19 (3): 137– 142.
- [3] Syahailaut, A., 2006. Flying Fish Fisheries in Indonesia: Research towards Management. Oseana, PPO LIPI. Vol. XXXI (3): 21-31.
- [4] Hutubessy, B. G. and A. Syahailatua, 2010. Performace of Gillnet-Mesh Size Selectivity for Three Flyingfish Species in Ambon Waters, Moluccas Province. Marine Research in Indonesia, Vol 35 No. 2: 39-46
- [5] Tuapetel F., N. Nessa, S. A. Ali, and Sudirman. 2015. Distribution, Species Composition and Size of Flying Fish (Exocoetidae) in the Seram Sea. International Journal of Scientific & Technology Research, vol. 4, issue 03, 2015: 75-76.
- [6] Chang S.K., C.Wei Chang and E. Ame, 2012. Species Composition and Distribution of the Dominant Flying Fishes (Exocoetidae) Associated with the Kuroshio Current, South China Sea. The Raffles Bulletin of Zoology, National University of Singapore 2012 60(2): 539–550.
- [7] Block, B.A., S.L.H. Teo, A. Walli, A. Boustany, M.J.W. Stokesbury, C.J. Farwell, K.C. Weng, H. Dewar and T.D. Williams, 2005. Electronic tagging and population structure of Atlantic bluefin tuna. Nature 434, 1121–1127.
- [8] Wajsowicz, R.C., A.L. Gordon, A. Ffield and R.D. Susanto, 2003. Estimating transport in makassar strait. Deep-Sea Res. 50, 2163–2181.
- [9] Ilahude, A.G. and A. Nontji. 1999. Indonesian Oceanography and Global Climate Change (El Nino and La Nina). AIP Workshop, Research and Development Center for Oceanology-LIPI, Jakarta.
- [10] Gordon, A.L., 2005. Oceanography of the Indonesian Seas and Their Throughflow. Oceanography Vol. 18, No. 4.
- [11] Dueri, S., L. Bopp and O. Maury, 2014. Projecting the impacts of climate change on skipjack tuna abundance and spatial distribution. Glob. Change Biol. 1–12.
- [12] Palacios, D.M., S.J. Bograd, D.G. Foley and F.B. Schwing. 2006. Oceanographic Characteristics of Biological Hot Spots in the North Pacific: A Remote Sensing Perspective. Deep-Sea Research II. 53:250-269.
- [13] Ali, S.A., M.N. Nessa, I. Djawad and S.A. Omar. 2005. Relationship between gonad maturity of flying fish with several environmental parameters in the Flores Sea, South Sulawesi. Torani. No. 6 (special edition):403-410.
- [14] Andrade, H.A. and A.E. Garcia .1999. Skipjack tuna in relation to sea surface temperature off the southern Brazilian coast. Fisheries Oceanography. 8: 245-254.
- [15] Zainuddin, M., K. Saitoh and S. Saitoh. 2008. Albacore tuna fishing ground in relation to oceanographic conditions of northwestern North Pacific using remotely sensed satellite data. Fisheries Oceanography. 17(2): 61-73.
- [16] Metzger, E.J., H.E. Hurlburt, X., Xu, Jay F. Shiver, A.L. Gordon, J. Sprintall, R.D. Susanto. and H.M Van Aken. 2010. Simulated and observed circulation in the Indonesian Seas: 1/12 global HYCOM and the INSTANT observations. Dyn, Atm. Oce. 50. 275-300.

ORIGINALITY REPORT

% **13**  
SIMILARITY INDEX

% **9**  
INTERNET SOURCES

% **11**  
PUBLICATIONS

% **4**  
STUDENT PAPERS

PRIMARY SOURCES

**1** MUKTI ZAINUDDIN. "Albacore (Thunnus alalunga) fishing ground in relation to oceanographic conditions in the western North Pacific Ocean using remotely sensed satellite data", Fisheries Oceanography, 3/2008  
Publication % **3**

**2** [www.neliti.com](http://www.neliti.com)  
Internet Source % **3**

**3** Marcelo do Nascimento Araujo, Marisol Ferraz, Fabiana Karla Araújo Américo, Fabrício Francisco Santos Silva et al. "Seed quality of *Amburana cearensis* (Allemão) A.C. Sm. (Fabaceae) is influenced by storage condition", Journal of Seed Science, 2017  
Publication % **2**

**4** [media.neliti.com](http://media.neliti.com)  
Internet Source % **1**

**5** [repository.unhas.ac.id](http://repository.unhas.ac.id)  
Internet Source % **1**

Wei Yu, Xinjun Chen, Qian Yi, Yong Chen.

6

"Spatio-temporal distributions and habitat hotspots of the winter–spring cohort of neon flying squid *Ommastrephes bartramii* in relation to oceanographic conditions in the Northwest Pacific Ocean", Fisheries Research, 2016

Publication

% 1

7

Sukresno, Bambang, Agus Hartoko, Budi Sulistyono, and Subiyanto. "Empirical Cumulative Distribution Function (ECDF) Analysis of *Thunnus*.sp Using ARGO Float Sub-surface Multilayer Temperature Data in Indian Ocean South of Java", Procedia Environmental Sciences, 2015.

Publication

% 1

8

[es.scribd.com](http://es.scribd.com)

Internet Source

<% 1

9

[id.scribd.com](http://id.scribd.com)

Internet Source

<% 1

10

Vincent S. Saba. "Challenges of modeling depth-integrated marine primary productivity over multiple decades: A case study at BATS and HOT", Global Biogeochemical Cycles, 09/15/2010

Publication

<% 1

11

[www.dcf-germany.de](http://www.dcf-germany.de)

Internet Source

<% 1

12

Peng Zhang, Jian Xu, Jan F. Schröder, Ann Holbourn, Wolfgang Kuhnt, Karlos G.D. Kochhann, Fei Ke, Zhen Wang, Hanning Wu. "Variability of the Indonesian Throughflow thermal profile over the last 25-kyr: A perspective from the southern Makassar Strait", *Global and Planetary Change*, 2018

Publication

&lt;% 1

13

Shenglong Yang, Junjie Ma, Yumei Wu, Xiumei Fan, Shaofei Jin, Xuezhong Chen. "Relationship between temporal–spatial distribution of fishing grounds of bigeye tuna (*Thunnus obesus*) and thermocline characteristics in the Atlantic Ocean", *Acta Ecologica Sinica*, 2015

Publication

&lt;% 1

14

ARS Putri, M Zainuddin. "Application of remotely sensed satellite data to identify Skipjack Tuna distributions and abundance in the coastal waters of Bone Gulf", *IOP Conference Series: Earth and Environmental Science*, 2019

Publication

&lt;% 1

EXCLUDE QUOTES ON

EXCLUDE BIBLIOGRAPHY ON

EXCLUDE MATCHES

&lt; 5 WORDS