



# AACL Bioflux

**Country** [Romania](#) - [SJR Ranking of Romania](#)

**Subject Area and Category** [Agricultural and Biological Sciences](#)  
[Aquatic Science](#)  
[Ecology, Evolution, Behavior and Systematics](#)  
[Environmental Science](#)  
[Management, Monitoring, Policy and Law](#)  
[Water Science and Technology](#)

# 14

H Index

**Publisher** [Bioflux Publishing House](#)

**Publication type** Journals

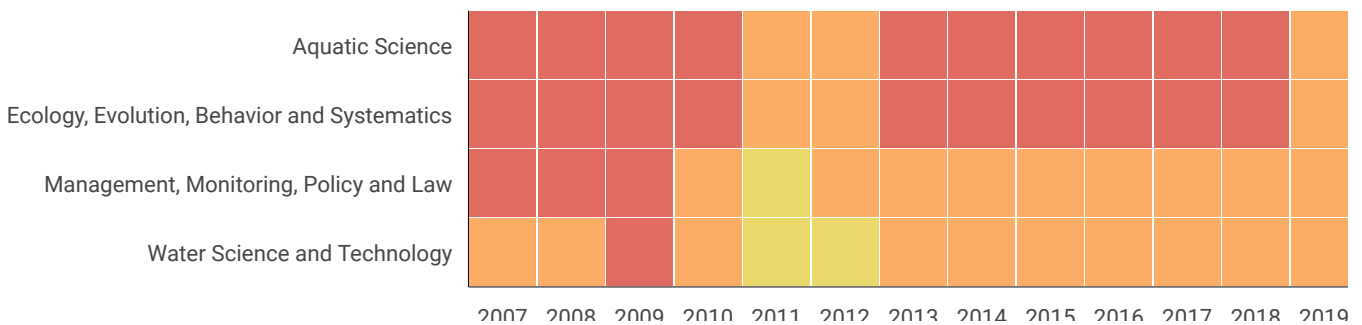
**ISSN** 18449166, 18448143

**Coverage** 2006, 2009-2020

**Scope** Information not localized

 [Join the conversation about this journal](#)

## Quartiles

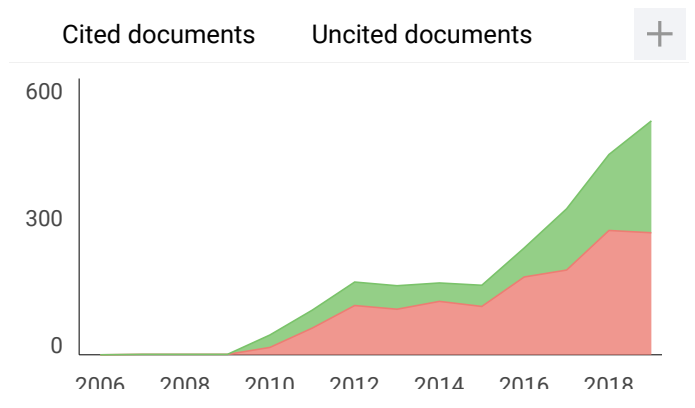
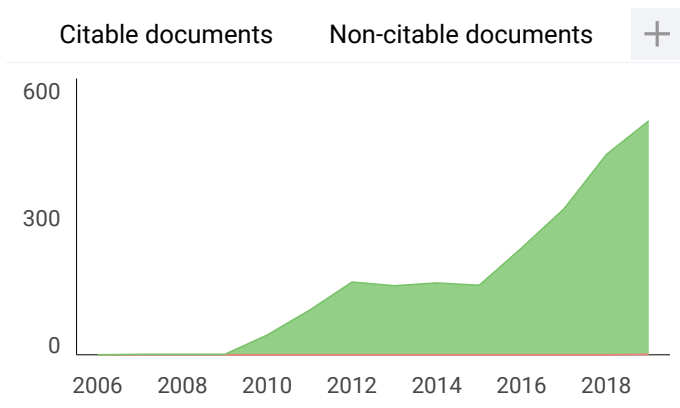
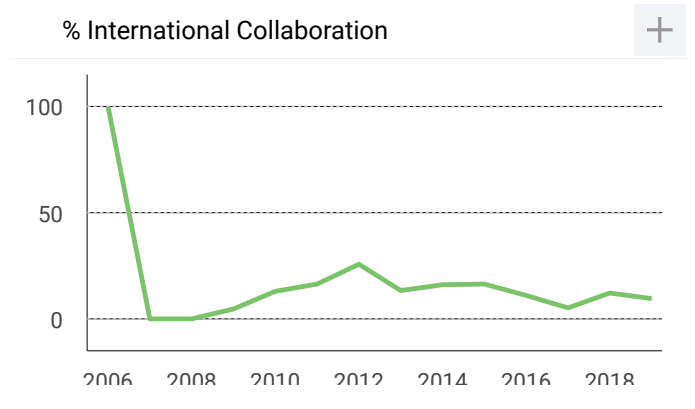
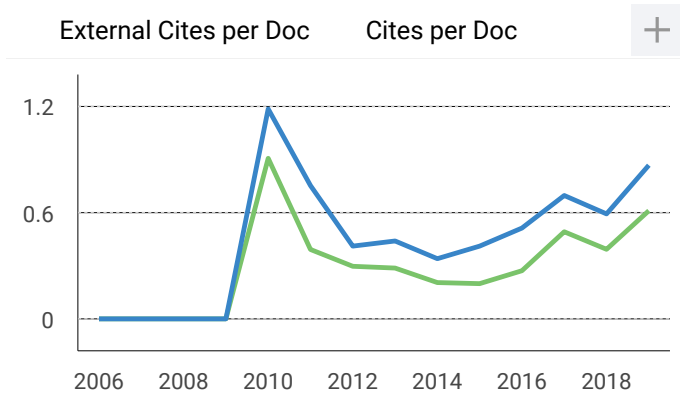
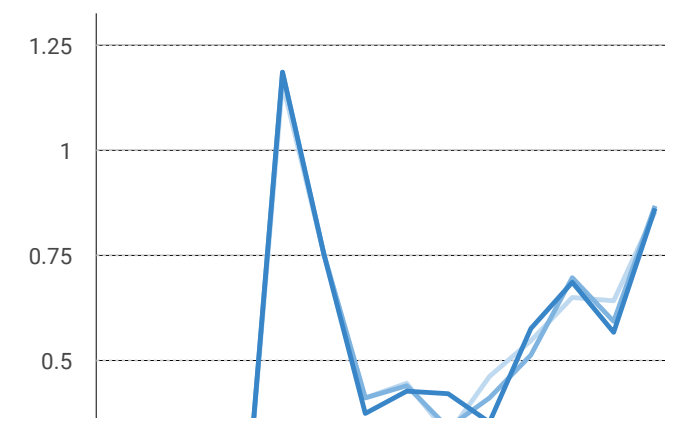
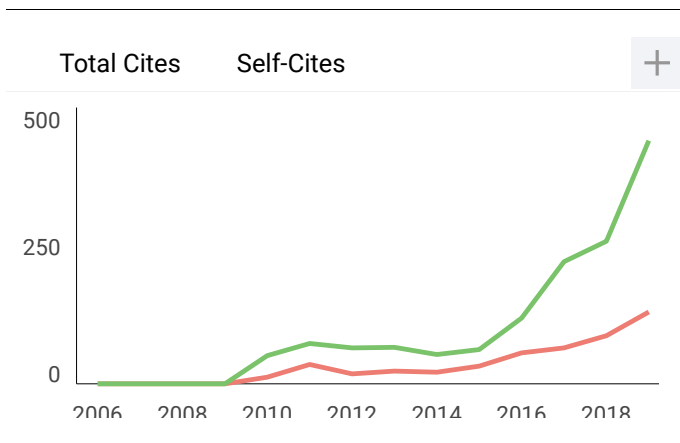


SJR



Citations per document





**AACL Bioflux**

**Q3**    Aquatic Science  
best quartile

**SJR 2019**  
0.28

powered by scimagojr.com

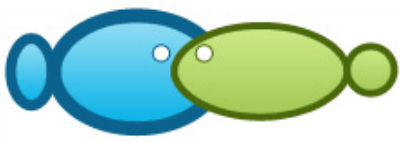
← Show this widget in your own website

Just copy the code below and paste within your html code:

```
<a href="https://www.scima
```



Loading comments...



**AACL Bioflux**

[Instructions to authors](#)

[Submission letter](#)

[Model of paper](#)

[Reviewer information pack](#)

[Editorial Board Expanded](#)

[Coverage / databases](#)

[Volume 13\(6\)/2020](#)

[Volume 13\(5\)/2020](#)

[Volume 13\(4\)/2020](#)

[Volume 13\(3\)/2020 \(June, 30\)](#)

[Volume 13\(2\)/2020 \(April, 30\)](#)

[Volume 13\(1\)/2020 \(February, 28\)](#)

[Volume 12\(6\)/2019 \(December, 30\)](#)

[Volume 12\(5\)/2019 \(October, 30\)](#)

[Volume 12\(4\)/2019 \(August, 30\)](#)

[Volume 12\(3\)/2019 \(June, 30\)](#)

[Volume 12\(2\)/2019 \(April, 30\)](#)

[Volume 12\(1\)/2019 \(February, 28\)](#)

[Volume 11\(6\)/2018 \(December, 30\)](#)

[Volume 11\(5\)/2018 \(October, 30\)](#)

[Volume 11\(4\)/2018 \(August, 30\)](#)

[Volume 11\(3\)/2018 \(June, 30\)](#)

[Volume 11\(2\)/2018 \(April, 30\)](#)

[Volume 11\(1\)/2018 \(February, 28\)](#)

[Volume 10\(6\)/2017 \(December, 30\)](#)

[Volume 10\(5\)/2017 \(October, 30\)](#)

[Volume 10\(4\)/2017 \(August, 30\)](#)

[Volume 10\(3\)/2017 \(June, 30\)](#)

# Aquaculture, Aquarium, Conservation & Legislation - International Journal of the Bioflux Society

ISSN 1844-9166 (online)

ISSN 1844-8143 (print)

Published by Bioflux - bimonthly -

in cooperation with The Natural Sciences Museum Complex (Constanta, Romania)

Peer-reviewed (each article was independently evaluated before publication by two specialists)

The journal includes original papers, short communications, and reviews on Aquaculture (Biology, Technology, Economics, Marketing), Fish Genetics and Improvement, Aquarium Sciences, Fisheries, Ichthyology, Aquatic Ecology, Conservation of Aquatic Resources and Legislation (in connection with aquatic issues) from wide world.

The manuscripts should be submitted to [zoobiomag2004@yahoo.com](mailto:zoobiomag2004@yahoo.com)

## Editor-in-Chief:

Petrescu-Mag I. Valentin: USAMV Cluj, Cluj-Napoca, University of Oradea (Romania)

Gavriloaie Ionel-Claudiu (reserve): SC Bioflux SRL, Cluj-Napoca (Romania).

## Editors:

Abdel-Rahim Mohamed M.: National Institute of Oceanography and Fisheries, Alexandria (Egypt)

Adascalitei Oana: Maritime University of Constanta, Constanta (Romania)

Amira Aicha Beya: Badji Mokhtar Annaba University, Annaba (Algeria)

Arockiaraj A. Jesu: SRM University, Chennai (India)

Appelbaum Samuel: Ben-Gurion University of the Negev (Israel)

Baharuddin Nursalwa: Universiti Malaysia Terengganu, Terengganu (Malaysia)

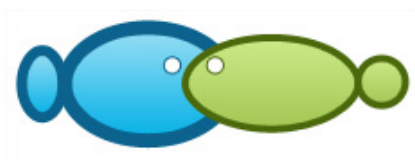
Boaru Anca: USAMV Cluj, Cluj-Napoca (Romania)

Volume 10(2)/2017 (April, 30)	Botha Miklos: Bioflux SRL, Cluj-Napoca (Romania)
Volume 10(1)/2017 (February, 28)	Breden Felix: Simon Fraser University (Canada)
Volume 9(6)/2016 (December, 30)	Burny Philippe: Universite de Liege, Gembloux (Belgium)
Volume 9(5)/2016 (October, 30)	Caipang Cristopher M.A.: Temasek Polytechnic (Singapore)
Volume 9(4)/2016 (August, 30)	Chapman Frank: University of Florida, Gainesville (USA)
Volume 9(3)/2016 (June, 30)	Coroian Cristian: USAMV Cluj, Cluj-Napoca (Romania)
Volume 9(2)/2016 (April, 30)	Creanga Steofil: USAMV Iasi, Iasi (Romania)
Volume 9(1)/2016 (February, 28)	Cristea Victor: Dunarea de Jos University of Galati, Galati (Romania)
Volume 8(6)/2015 (December, 30)	Das Simon Kumar: Universiti Kebangsaan Malaysia, Bangi, Selangor (Malaysia)
Volume 8(5)/2015 (October, 30)	Dimaggio Matthew A.: University of Florida (USA)
Volume 8(4)/2015 (August, 30)	Dimaggio Matthew A.: University of Florida (USA)
Volume 8(3)/2015 (June, 30)	Firica Cristian Manuel: Spiru Haret University Bucharest, Craiova (Romania)
Volume 8(2)/2015 (April, 30)	Georgescu Bogdan: USAMV Cluj, Cluj-Napoca (Romania)
Volume 8(1)/2015 (February, 28)	Karayucel Ismihan: University of Sinop, Sinop (Turkey)
Volume 7(6)/2014 (December, 30)	Khamesipour Faham: Shiraz University, Shiraz (Iran)
Volume 7(5)/2014 (October, 30)	Khamesipour Faham: Shiraz University, Shiraz (Iran)
Volume 7(4)/2014 (August, 30)	Kosco Jan: Presov University, Presov (Slovakia)
Volume 7(3)/2014 (June, 30)	Kovacs Eniko: USAMV Cluj, Cluj-Napoca (Romania)
Volume 7(2)/2014 (April, 15)	Mehrad Bahar: Gorgan University of Agricultural Sciences and Nat. Res. (Iran)
Volume 7(1)/2014 (February, 15)	Miclaus Viorel: USAMV Cluj, Cluj-Napoca (Romania)
Volume 6(6)/2013 (November, 15)	Mihociu Tamara: R&D National Institute for Food Bioresources (Romania)
Volume 6(5)/2013 (September, 15)	Molnar Kalman: Hungarian Academy of Sciences, Budapest (Hungary)
Volume 6(4)/2013 (July, 25)	Muchlisin Zainal Abidin: Universiti Sains (Malaysia), Syiah Kuala University (Indonesia)
Volume 6(3)/2013 (May, 15)	Muntean George Catalin: USAMV Cluj, Cluj-Napoca (Romania)
Volume 6(2)/2013 (March, 15)	Muntean George Catalin: USAMV Cluj, Cluj-Napoca (Romania)
Volume 6(1)/2013 (January, 15)	Nowak Michal: University of Agriculture in Krakow (Poland)
Volume 5(5)/2012 (December, 30)	Nyanti Lee: Universiti Malaysia Sarawak, Sarawak (Malaysia)
Volume 5(4)/2012 (September, 30)	Olivotto Ike: Universita Politecnica delle Marche, Ancona (Italy)
Volume 5(3)/2012 (July, 30)	Oroian Firuta Camelia: USAMV Cluj, Cluj-Napoca (Romania)
Volume 5(2)/2012 (June, 30)	Papuc Tudor: USAMV Cluj, Cluj-Napoca (Romania)
Volume 5(1)/2012 (March, 15)	Parvulescu Lucian: West University of Timisoara (Romania)
Volume 4(5)/2011 (December, 30)	Pasarin Benone: USAMV Iasi, Iasi (Romania)
Volume 4(4)/2011 (October, 30)	Pattikawa Jesaja Ajub: Pattimura University, Ambon (Indonesia)
Volume 4(3)/2011 (July, 30)	Petrescu Dacinia Crina: Babes-Bolyai University, Cluj-Napoca (Romania)

<b>Volume 4(2)/2011 (April, 30)</b>	Petrescu-Mag Ruxandra Malina: Babes-Bolyai University, Cluj-Napoca (Romania)
<b>Volume 4(1)/2011 (January, 30)</b>	Petrovici Milca: West University of Timisoara (Romania)
<b>Volume 3(5)/2010 (December, 5)</b>	Pratasik Silvester Benny: Sam Ratulangi University, Manado (Indonesia)
<b>Volume 3(4)/2010 (December, 1)</b>	Proorocu Marian: USAMV Cluj, Cluj-Napoca (Romania)
<b>Volume 3(3)/2010 (November, 15)</b>	Ray Sunuram: Khulna University (Bangladesh)
<b>Volume 3(2)/2010 (July, 30)</b>	Rhyne Andrew: Roger Williams University; New England Aquarium, Boston (USA)
<b>Volume 3(1)/2010 (February, 28)</b>	Ruchin Alexander B.: Joint Directorate of the Mordovia State Nature Reserve and National Park «Smolny», Saransk (Russia)
<b>Volume 2(4)/2009 (October, 30)</b>	Safirescu Calin: USAMV Cluj, Cluj-Napoca (Romania)
<b>Volume 2(3)/2009 (July, 30)</b>	Serrano Jr. Augusto E.: University of the Philippines Visayas (Philippines)
<b>Volume 2(2)/2009 (April, 30)</b>	Sima Nicusor Flaviu: USAMV Cluj, Cluj-Napoca (Romania)
<b>Volume 2(1)/2009 (January, 30)</b>	Tlusty Michael F.: New England Aquarium, Boston (USA)
<b>Volume 1(2)/2008 (December, 30)</b>	Vesa Stefan Cristian: Iuliu Hatieganu UMF, Cluj-Napoca (Romania)
<b>Volume 1(1)/2008 (September, 30)</b>	Vintila Iuliana: Dunarea de Jos University of Galati, Galati (Romania)
<b>Volume Pilot/2007 (December, 30) - available printed only</b>	Wariaghli Fatima: University Mohammed V in Rabat, Rabat (Morocco)
<b>Pontus Euxinus, Volume 1 (1980) - Parent Journal</b>	Yusli Wardiatno: Bogor Agricultural University, Bogor (Indonesia).



design: [www.simple-webdesign.com](http://www.simple-webdesign.com)



**AACL Bioflux**

**Volume 10(2)/2017**

Instructions to authors

**First pages, 2017 AACL Bioflux 10(2):i-viii.**

Submission letter

**Supriyono E., Prihardianto R. W., Nirmala K., 2017 The stress and growth responses of spiny lobster *Panulirus homarus* reared in recirculation system equipped by PVC shelter. AACL Bioflux 10(2):147-155.**

Model of paper

**Abinawanto A., Pratiwi I. A., Lestari R., 2017 Sperm motility of giant gourami (*Osphronemus goramy*, Lacepede, 1801) at several concentrations of honey combined with DMSO after short-time storage. AACL Bioflux 10(2):156-163.**

Reviewer information pack

**Najamuddin, Baso A., Musbir, Akmaluddin, Nelwan A., Sudirman, Hajar I., Palo M., Zainuddin M., 2017 Performance of fishing gear on skipjack tuna *Katsuwonus pelamis* in south Sulawesi, Indonesia. AACL Bioflux 10(2):164-171.**

Editorial Board Expanded

Coverage / databases

Volume 13(6)/2020

Volume 13(5)/2020

Volume 13(4)/2020

**Baruddin N. A., Shazili N. A. M., Pradit S., 2017 Sequential extraction analysis of heavy metals in relation to bioaccumulation in mangrove, *Rhizophora mucronata* from Kelantan Delta, Malaysia. AACL Bioflux 10(2):172-181.**

Volume 13(3)/2020 (June, 30)

Volume 13(2)/2020 (April, 30)

Volume 13(1)/2020 (February, 28)

**Hardi E. H., Saptiani G., Kusuma I. W., Suwinarti W., Nugroho R. A., 2017 Immunomodulatory and antibacterial effects of *Boesenbergia pandurata*, *Solanum ferox*, and *Zingiber zerumbet* on tilapia, *Oreochromis niloticus*. AACL Bioflux 10(2):182-190.**

Volume 12(6)/2019 (December, 30)

Volume 12(5)/2019 (October, 30)

Volume 12(4)/2019 (August, 30)

Volume 12(3)/2019 (June, 30)

**Fitri A. D. P., Boesono H., Sabdono A., Supadminingsih F. N., Adlina N., 2017 The mud crab (*Scylla serrata*) behavior in different inclination angles of funnel and escape vent for trap net. AACL Bioflux 10(2):191-199.**

Volume 12(2)/2019 (April, 30)

Volume 12(1)/2019 (February, 28)

**Chantarasiri A., Boontanom P., Nuiplot N., 2017 Isolation and characterization of *Lysinibacillus sphaericus* BR2308 from coastal wetland in Thailand for the biodegradation of lignin. AACL Bioflux 10(2):200-209.**

Volume 11(6)/2018 (December, 30)

Volume 11(5)/2018 (October, 30)

Volume 11(4)/2018 (August, 30)

**Arisman N., Istiqomah N., Oka H., Yoshimatsu T., 2017 Temporal change of salinity stress in Manila clam *Ruditapes philippinarum*: implication for biodefense mechanism in response to climate change. AACL Bioflux 10(2):210-216.**

Volume 11(3)/2018 (June, 30)

Volume 11(2)/2018 (April, 30)

**Efrizal E., 2017 Effects of stocking density on survival rate and larval development of blue swimming crab, *Portunus pelagicus* (Linnaeus, 1758) under laboratory conditions. AACL Bioflux 10(2):217-226.**

Volume 11(1)/2018 (February, 28)

Volume 10(6)/2017 (December, 30)

Volume 10(5)/2017 (October, 30)

**Tadjuddah M., Anadi L., Mustafa A., Arami H., Abdullah, Kamri S., Wianti N. I., 2017 Growth pattern and size structure of skipjack tuna caught in Banda Sea, Indonesia. AACL Bioflux 10(2):227-233.**

Volume 10(4)/2017 (August, 30)

Volume 10(3)/2017 (June, 30)

- Volume 10(2)/2017 (April, 30) Limmon G. V., Rijoly F., Ongkers O. T. S., Loupatty S. R., Pattikawa J. A., 2017 Reef fish in the southern coastal waters of Ambon Island, Maluku Province, Indonesia. *AACL Bioflux* 10(2):234-240.
- Volume 10(1)/2017 (February, 28)
- Volume 9(6)/2016 (December, 30) Junianto, Zahidah, Apriliani I. M., 2017 Evaluation of heavy metal contamination in various fish meat from Cirata Dam, West Jawa, Indonesia. *AACL Bioflux* 10(2):241-246.
- Volume 9(5)/2016 (October, 30)
- Volume 9(4)/2016 (August, 30)
- Volume 9(3)/2016 (June, 30) Nasmia, Natsir S., Rosyida E., Rusaini, Yala Z. R., 2017 Toxicity of liquid extract of seaweed *Sargassum* sp. on the growth of microalgae *Skeletonema costatum*. *AACL Bioflux* 10(2):247-253.
- Volume 9(2)/2016 (April, 30)
- Volume 9(1)/2016 (February, 28)
- Volume 8(6)/2015 (December, 30) Hasim, KoniyoY., Kasim F., 2017 Suitable location map of floating net cage for environmentally friendly fish farming development with Geographic Information System applications in Lake Limboto, Gorontalo, Indonesia. *AACL Bioflux* 10(2):254-264.
- Volume 8(5)/2015 (October, 30)
- Volume 8(4)/2015 (August, 30)
- Volume 8(3)/2015 (June, 30) Purnamawati, Djokosetiyanto D., Nirmala K., Harris E., Affandi R., 2017 Survival and growth of striped snakehead fish (*Channa striata* Bloch.) juvenile reared in acid sulfate water and rainwater medium. *AACL Bioflux* 10(2):265-273.
- Volume 8(2)/2015 (April, 30)
- Volume 8(1)/2015 (February, 28)
- Volume 7(6)/2014 (December, 30) Dangeubun J. L., Metungun J., 2017 Hematology of *Vibrio alginolyticus*-infected humpback grouper, *Cromileptes altivelis*, under treatment of *Alstonia acuminata* shoot extract. *AACL Bioflux* 10(2):274-284.
- Volume 7(5)/2014 (October, 30)
- Volume 7(4)/2014 (August, 30) Rumahlatu D., Leiwakabessy F., 2017 Biodiversity of gastropoda in the coastal waters of Ambon Island, Indonesia. *AACL Bioflux* 10(2):285-296.
- Volume 7(3)/2014 (June, 30)
- Volume 7(2)/2014 (April, 15) Hashim M., Abidin D. A. Z., Das S. K., Mazlan A. G., 2017 Length-weight relationship, condition factor and TROPH of *Scatophagus argus* in Malaysian coastal waters. *AACL Bioflux* 10(2):297-307.
- Volume 7(1)/2014 (February, 15)
- Volume 6(6)/2013 (November, 15) Wahyudin R. A., Hakim A. A., Qonita Y., Boer M., Farajallah A., Mashar A., Wardiatno Y., 2017 Lobster diversity of Palabuhanratu Bay, South Java, Indonesia with new distribution record of *Panulirus ornatus*, *P. polyphagus* and *Parribacus antarcticus*. *AACL Bioflux* 10(2):308-327.
- Volume 6(5)/2013 (September, 15)
- Volume 6(4)/2013 (July, 25)
- Volume 6(3)/2013 (May, 15)
- Volume 6(2)/2013 (March, 15) Mahardika K., Mastuti I., Zafran Z., 2017 Histopathological study on nephropathy caused by oral administration with melamine and cyanuric acid in humpback grouper (*Cromileptes altivelis*). *AACL Bioflux* 10(2):328-334.
- Volume 6(1)/2013 (January, 15)
- Volume 5(5)/2012 (December, 30) Pronina G. I., 2017 Physiological and immunological features of males and females of the immunologically resistant carp breed (*Cyprinus carpio* L.). *AACL Bioflux* 10(2):335-340.
- Volume 5(4)/2012 (September, 30)
- Volume 5(3)/2012 (July, 30)
- Volume 5(2)/2012 (June, 30)
- Volume 5(1)/2012 (March, 15) Shafie M. S. I., Wong A. B. H., Harun S., Fikri A. H., 2017 Land use influence on the aquatic insect communities on tropical forest streams of Liwagu River, Sabah, Malaysia. *AACL Bioflux* 10(2):341-352.
- Volume 4(5)/2011 (December, 30)
- Volume 4(4)/2011 (October, 30)
- Volume 4(3)/2011 (July, 30) Kabir M., Shahbazi A., Kouhanestani Z. M., Shahraki F. R., 2017 Spatial-temporal variability in water quality in Ghareh-chai River, Golestan Province, Iran. *AACL Bioflux* 10(2):353-364.

Volume 4(2)/2011 (April, 30)  
Volume 4(1)/2011 (January, 30)  
Volume 3(5)/2010 (December, 5)  
Volume 3(4)/2010 (December, 1)  
Volume 3(3)/2010 (November, 15)  
  
Volume 3(2)/2010 (July, 30)  
Volume 3(1)/2010 (February, 28)  
Volume 2(4)/2009 (October, 30)  
  
Volume 2(3)/2009 (July, 30)  
Volume 2(2)/2009 (April, 30)  
  
Volume 2(1)/2009 (January, 30)  
Volume 1(2)/2008 (December, 30)  
Volume 1(1)/2008 (September, 30)  
Volume Pilot/2007 (December, 30) -  
available printed only  
Pontus Euxinus, Volume 1 (1980) -  
Parent Journal



**Virgula J. C., Cruz-Lacierda E. R., Estante E. G., Corre Jr. V. L., 2017 Copper sulfate as treatment for the ectoparasite *Amyloodinium ocellatum* (Dinoflagellida) on milkfish (*Chanos chanos*) fry. AACL Bioflux 10(2):365-371.**

**Ulmursida A., Ambariyanto A., Trianto A., 2017 Antibacterial activity of mangrove *Avicennia marina* leaves extract against *Virgibacillus marismortui* and *Micrococcus luteus* bacteria. AACL Bioflux 10(2):372-380.**

**Saha D., Pal S., Rahaman S. H., Nandy G., Chakraborty A., Aditya G., 2017 Exploitation pattern of small indigenous fish species: observations from fish markets of rural West Bengal, India. AACL Bioflux 10(2):381-390.**

**Seah Y. G., Ariffin A. F., Mat Jaafar T. N. A., 2017 Levels of COI divergence in Family Leiognathidae using sequences available in GenBank and BOLD Systems: A review on the accuracy of public databases. AACL Bioflux 10(2):391-401.**

**Febri S. P., Wiyono E. S., Wisudo S. H., Haluan J., Iskandar B. H., 2017 The role of women in small-scale fisheries of Langsa City, Aceh, Indonesia. AACL Bioflux 10(2):402-409.**

**Canini N. D., Metillo E. B., 2017 Temporal changes in the community structure of phytoplankton in Panguil Bay, Philippine mangrove estuary. AACL Bioflux 10(2):410-420.**

**Sirisinthuwanich K., Sangpradub N., Hanjavanit C., 2017 Impact of anthropogenic disturbance on benthic macroinvertebrate assemblages in the Phong River, Northeastern Thailand. AACL Bioflux 10(2):421-434.**

**Soukotta I. V. T., Bambang A. N., Sya'rani L., Saputra S. W., 2017 Estimation of MSY and MEY of skipjack tuna (*Katsuwonus pelamis*) fisheries of Banda Sea, Moluccas. AACL Bioflux 10(2):435-444.**

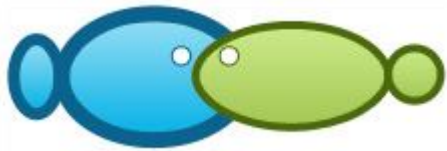
**Hong T. K., Bobby G., Addis S. N. K., Musa N., Wahid M. E. A., Zainathan S. C., 2017 Histopathology conditions of cultured oyster, *Crassostrea iredalei* from southern and east Malaysia. AACL Bioflux 10(2):445-454.**

**Meidong R., Doolgindachbaporn S., Sakai K., Tongpim S., 2017 Isolation and selection of lactic acid bacteria from Thai indigenous fermented foods for use as probiotics in tilapia fish *Oreochromis niloticus*. AACL Biolux 10(2):455-463.**

02.03.2017. 18:32

design: [www.simple-webdesign.com](http://www.simple-webdesign.com)





# Suitable location map of floating net cage for environmentally friendly fish farming development with Geographic Information Systems applications in Lake Limboto, Gorontalo, Indonesia

<sup>1</sup>Hasim, <sup>2</sup>Yuniarti Koniyo, <sup>3</sup>Faizal Kasim

<sup>1</sup> Magister program of Marine Sciences and Fisheries, Gorontalo State University, Indonesia; <sup>2</sup> Aquaculture Program, Gorontalo State University, Indonesia; <sup>3</sup> Aquatic Resources Management, Gorontalo State University, Indonesia. Corresponding author: Hasim, hasim@ung.ac.id

**Abstract.** The study aimed to: (1) analyze the degree of floating net cage system suitability for fish farming in Lake Limboto waters; (2) analyze the extent and distribution of suitable area of Lake Limboto waters for fish farming by floating net cage (KJA) system. The method of study was the integration of survey and laboratory. The analysis was the integration between multi-criteria analyses and Geographic Information Systems (GIS). Based on the analysis result, it showed that among eight physical-chemical parameters there were two of them categorized as suitable, while the others were not feasible. Among 16 observation stations, 11 stations were categorized as unsuitable, while the remains were classified as marginally suitable. The total area of lake waters suitable for KJA systems was 8.03 ha (0.36%), while 2195.57 (99.64%) was unsuitable.

**Key Words:** Suitability of KJA system, site evaluation, cage culture, GIS, multi-criteria analysis (MCA).

**Introduction.** Lake Limboto (Indonesia) is located in the lowlands of Gorontalo Province. It has 23 rivers and creeks as the inlet, and only one outlet. According to Hasim (2012), with the management of status quo as now, Lake Limboto will be lost in 2025. Besides, the quality of Lake Limboto waters decrease as the impact of various economic activities in the region.

Floating net cages (hereafter referred to as cage culture) are dominant aquaculture fish farming systems found in Lake Limboto beside capture fishery systems. The cage culture system had been introduced first since 1988 as trials for fish farming system in Limboto Lake. In 1993 the cages has 500 units and developed into 1,962 units in 2007. Until in 2009, the number of cages in Lake Limboto was reported to be more than 2,000 units (Marine and Fisheries Research Agency 2007).

On the other hand, Mc Donad et al (1996), Pulatso (2003) and Janssen (2001) stated that intensive fish in the lake has an impact on nutrient enrichment and reduces the potential water quality of fish farming, as well as provides the multiplication of phosphorus content. Further, it is stated that these activities have an effect on the carrying capacity of the lake.

Site suitability evaluation is an initial stage to determine the suitability of location for cage culture fish farming. Selecting a precise and good location is one of the critical success factors in cage culture system. The choice of location should consider environmental factors and water quality since the location feasibility is in accord with the survival requirements and the growth of farming commodity toward the aquatic environment.

The development of cage culture system units in Lake Limboto has not yet integrated with the consideration of its environmental carrying capacity. Facts show that

the location placement of the cage system does not consider the environmental conditions of the lake. The rapid development rate of cage unit number and the ignorance of environmental aspects will increase the ecological burden on Lake Limboto. The implication is that the lake water quality will decline. Further, a disease attack against the farmed fish will be high and cause economic losses.

Geographic information system (GIS) is one of the options in determining the ideal location to develop fish farming. It can integrate multiple data and information about fish farming in the form of layer which can later be overlaid with other data in order to produce a new output in the form of thematic maps with adequate high levels of efficiency and accuracy. Its utilization can assist or facilitate the data analysis and can help in determining the most appropriate location for fish farming.

Performing the management of Lake Limboto to achieve sustainability should be started from the economic activity which already exists in the lake, such as cage system fisheries. Therefore, planning and developing the farming fisheries of cage system in the lake must be based on scientific data. Studies evaluating the degree of suitability for fish farming of cage culture system using GIS technology ease the way to obtain the accurate information, because the GIS approach provides information based on spatial dimensions in order to obtain the exact extent and distribution of suitable area of fish fishing of cage system in Lake Limboto.

This study aimed to analyze the quality of water through some physical and chemical parameters and analyze the land suitability for cage culture fish farming system by GIS technology. The results of this study are expected to provide the scientific information on the status of fish farming for cage culture system and the information availability in the form of suitability map for cage culture fish farming system locations in Lake Limboto water.

**Material and Method.** This study was conducted in June-December 2015 and located in Lake Limboto which included several districts in the regency and municipality of Gorontalo, Gorontalo Province (Figure 1). The observation stations consist of 16 stations determined randomly (purposive random sampling) so that their spread represents Limboto Lake region. Each station is deployed in areas with and without floating net activities.

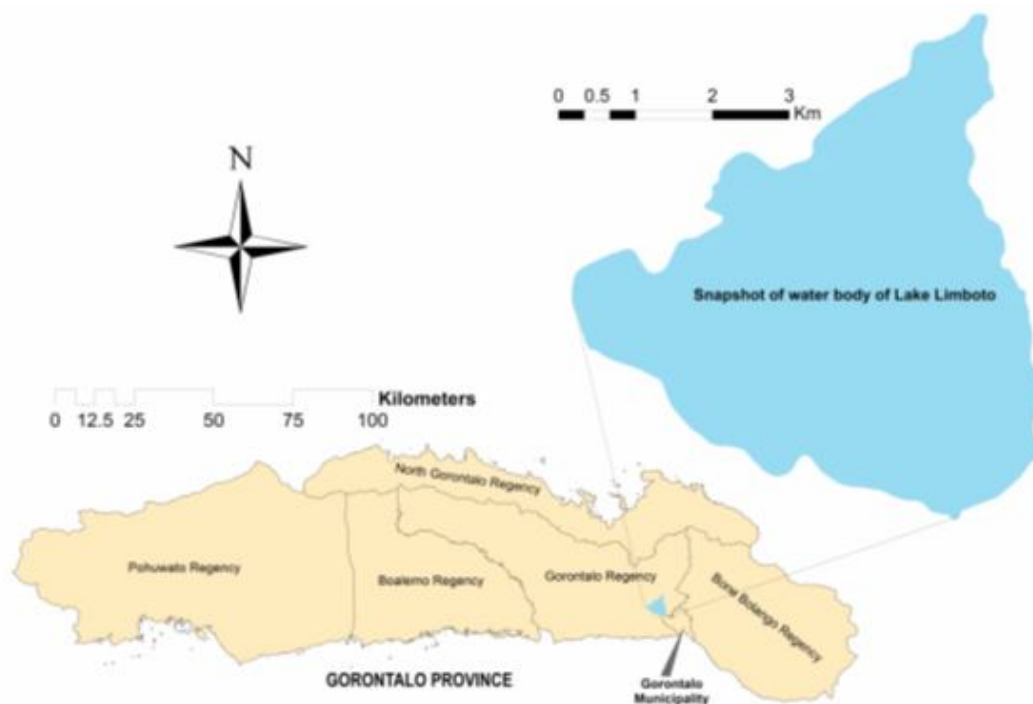


Figure 1. Site of research location and administration boundaries of Gorontalo Province.

Primary and secondary data were used in the study. Primary data was data from measurement results of chemical-physical parameter of the water, including measurements of temperature, current, DO, ammonia, depth, brightness, pH and BOD5 both performed in situ or ex situ whose outcomes were processed in the laboratory. While the secondary data was data related to the location map.

The suitability determination analysis was conducted by weighting or scoring methods through the area suitability matrix. In the weighting method, each parameter is calculated by different weighting and using the chemical physics parameters of the water as a reference. The determination of weighting and scoring was done to score the criteria supporting the farming activities. Weighting in the matrix can be seen in Table 1.

Table 1  
Suitability matrix for cage culture area (modified from Nurfiarini 2003; Khairunnisa et al 2014)

No	Parameter	Weight	S1 (very suitable)	Score	S2 (suitable)	Score	N (unsuitable)	Score
1	Temperature (°C)	3	28-32	3	26 - < 28	2	<26 and >32	1
2	TSS (mg/L)	1	25	3	26-80	2	>80	1
3	DO (mg/L)	3	>6	3	3-6	2	<3	1
4	Nitrate (mg/L)	1	>3.5	3	1.6-3.5	2	>1.5	1
5	Depth (m)	2	10-25	3	4 - <10	2	<4 - >25	1
6	Brightness (m)	1	>5	3	3-5	2	<3	1
7	pH	2	7.5-8.0	3	7.0-<7.5 or >8.0-8.5	2	<7.0 or >8.5	1
8	BOD5 (mg/L)	1	<3	3	3-5	2	>5	1

Based on the categories in suitability matrix table, score 3 is 'very suitable', score 2 is 'suitable', and score 1 is 'unsuitable'. Each parameter had different contribution toward the suitability level of KJA land. Therefore, the determination of weight and scores for each parameter was coincided with the effect of these parameters on the suitability value. The suitability score in every location was calculated by the following formula (Jumadi 2011):

$$N_{ij} = B_{ij} \times S_{ij}$$

$N_{ij}$  = total score in location,  $B_{ij}$  = weight in parameter- $i$  class  $j$ , and  $S_{ij}$  = score in parameter- $i$  class  $j$

Based on applied the formula above to matrix value on Table 1, then it were obtained the total maximum values ( $N_{ij}max$ ) and total minimum values ( $N_{ij}min$ ) are 42 and 14, respectively. These values obtained by calculated each weight of parameters with S1-score classes for  $N_{ij}max$  and N-scores classes for  $N_{ij}min$ . From both values, Suitability category of lake area was calculated in MS Excel environmental based on suitability class on Table 1 using the equation:

$$Class\ interval = \frac{N_{ij}max - N_{ij}min}{3}$$

MS Excel was used to operate the formulas above. Result from this step is discrete value of interval of suitability categories class which are consisted three categories, including: S1 - very suitable, at interval value of  $\geq 31 - 42$ , S2 - suitable, with interval 16-30, and N - unsuitable, range  $0 - \leq 16$ . Further analysis using GIS technique for MCA rule applied to all thematic map resulted from previous step using the range value suitability above to result final of distribution map of cage culture suitability area in Lake Limboto.

## Results and Discussion

**Temperature.** Temperature is a parameter which must be considered in the process of fish farming. The optimum water temperature for farming fisheries, according to Aisha and Subekhi (2012), ranged between 27-32°C. From the results of temperature measurements carried out in the waters of Lake Limboto, they showed that the water temperature in almost the entire station were feasible for activities of fish farming (Figure 2).

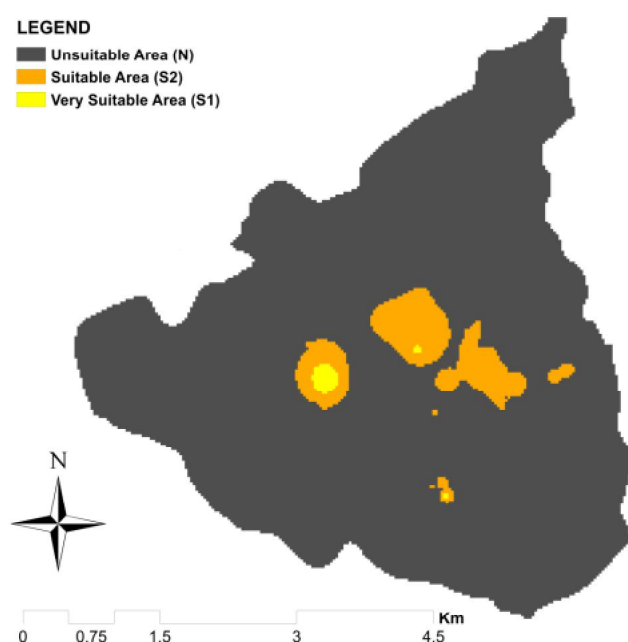


Figure 2. Suitability map of water temperature for cage culture system in Lake Limboto.

According to Supratno (2006), generally the growth rate of fish will increase in line with the rise of temperature to a certain extent. If the temperature rise exceeds the limit, it will cause the metabolic activity of aquatic organisms/animal increase. It will lead to reduction of dissolved gases in water which are essential to the life of fish or other aquatic animals. Although fish can adjust to the temperature rise, the temperature rise which exceeds the extreme tolerance limit (35°C) for a long time will cause the stress or death of fish.

**Bathymetry.** Bathymetry is a physical parameter indicating the size of water level from the bottom of a basin. It greatly affects activities of fish farming, especially of those using floating net cages. The minimum depth for farming activities with floating net cages is 2 m from the bottom. Based on the conducted measurements, the depth of Lake Limboto waters in overall stations was less than 2 m (Figure 3).

The biggest measurement result on the depth of water in Lake Limboto was found at station 14 (1.8 m) and the shallowest one was at station 4 (0.78 m). This situation showed that the depth parameters of Lake Limboto waters were classified in the category of 'unsuitable' for cage culture activities.

Based on field studies, there were two factors causing the depth of Lake Limboto become very shallow: (1) the ongoing drought in a long period and it was not expected to rain for five months. It was indicated by the drying of rivers to the estuary of Lake Limboto. Meanwhile, the other side of lake water evaporation was high due to the high intensity of sun; (2) there had been a cumulative sediment deposition in a long period as a result of sedimentation of particles carried by river water entering the body of lake. Shallowness of lake waters affected the reduction in column space of water, so that it became the limiting factor of fish survival.

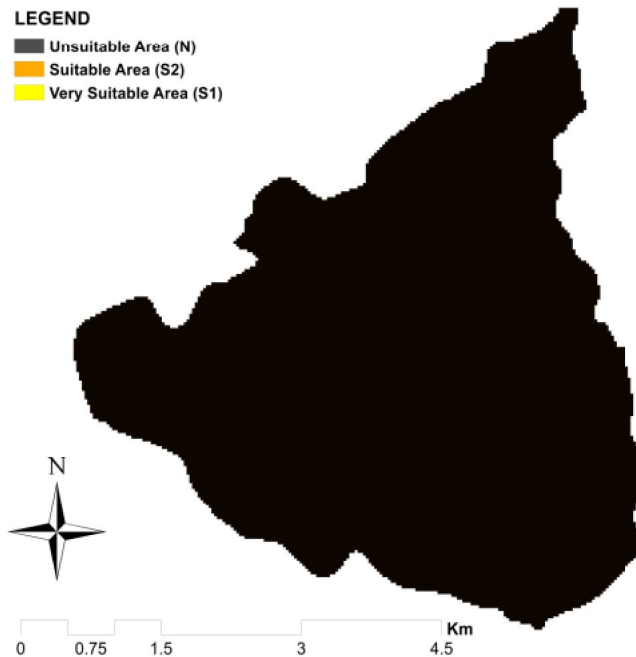


Figure 3. Suitability map of depth for cage culture system in Lake Limboto.

**Transparency.** Transparency is the light penetration in waters. Light penetration into water is greatly influenced by the light intensity, the angle of light, the condition of the water surface and the soluble or suspended particles (Boyd 1982). The surface layer of water receiving sunlight is called euphotic layer. In this layer, sunlight transforming into energy is important in the process of photosynthesis by phytoplankton as the primary producers of waters.

The Figure 4 shows that the transparency parameters of Lake Limboto waters are no longer suitable for activities of fish farming. It is because the parameter measurement result of brightness value throughout the station is less than 20 cm.

Meanwhile, the research conducted in 2006 revealed that the transparency of Lake Limboto waters ranged from 40 to 46 cm. Then in 2012 its transparency was 48-68.5 cm (Aisha & Subekhi 2012). The data directed that the transparency of Lake Limboto experienced fluctuation. Besides, the decrease of transparency values in 2012-2015 was very significant.

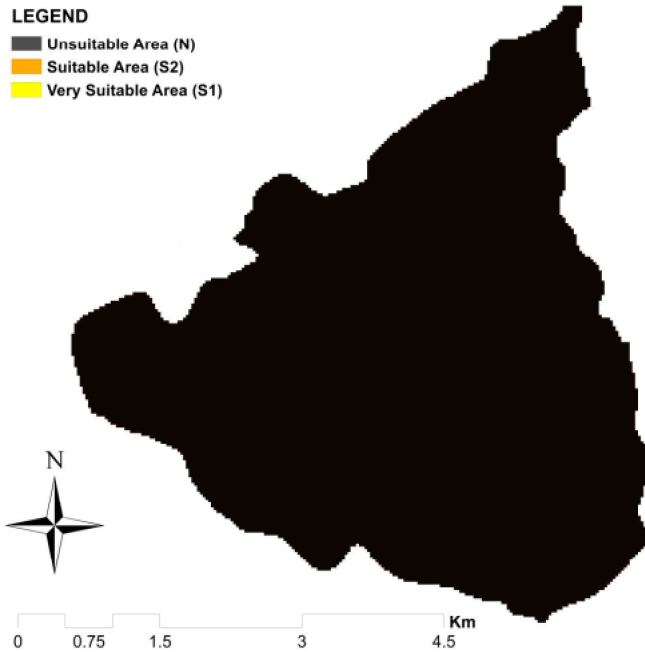


Figure 4. Suitability map of transparency for cage culture system in Lake Limboto.

**Acidity (pH).** pH is a measure of the hydrogen ion concentration of an aquatic medium. Mediums with a high concentration of hydrogen ions have a low pH and mediums with low concentrations of H<sup>+</sup> ions have a high pH. pH value <4 and >11 cause the death of fish. According to Boyd (1982), an ideal pH for fish is 6.5-9.0. While Alabaster & Lloyd (1982) stated that the ideal pH is 6.7 to 8.6. Next, the low pH can cause an increase of toxicity in waters and in turn will cause a decrease in fish appetite (Alabaster & Lloyd 1982).

The results of pH value measurement in Lake Limboto waters showed a uniform value of 6 (Figure 5).

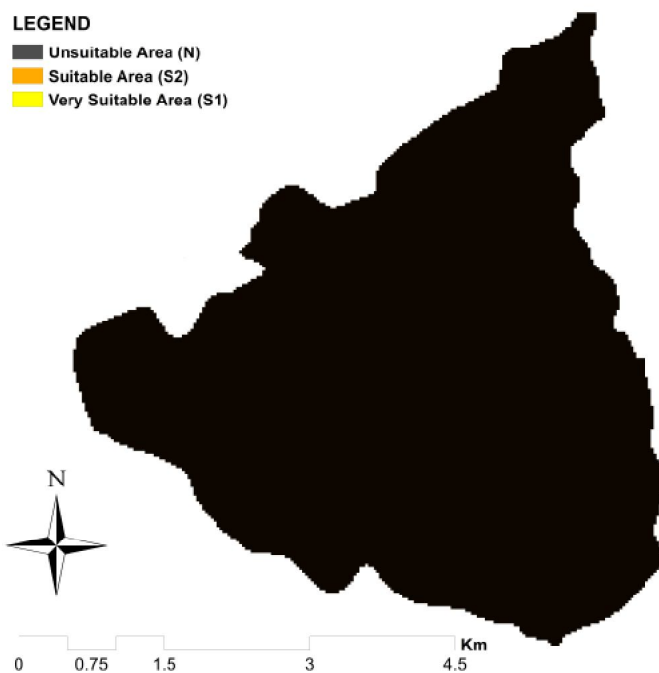


Figure 5. Suitability map of acidity for cage culture system in Lake Limboto.

According to the knowledge base which is arranged to determine the suitability category, Lake Limboto waters is classified as unsuitable for cage culture. As stated by Alabaster & Lloyd (1982), pH ranging of 5-6 may be lethal for fish.

**Dissolved oxygen (DO).** DO of waters is a water quality parameter which is the most critical in fish farming, since it could affect the survival of the farmed fish. According to Alabaster & Lloyd (1982) every species of fish has different sensitivity to the dissolved oxygen content. DO in waters is required for the respiration process, either of aquatic plants, fish, and other organisms living in water (Supratno 2006).

The optimum DO of waters for fish farming activities ranges between 5-9 mg/L (Alabaster & Lloyd 1982). Whole DO measurement result conducted in Lake Limboto waters was within the range of 7 mg/L and above (Figure 6). This showed that DO of Lake Limboto waters was very suitable for fish farming activities.

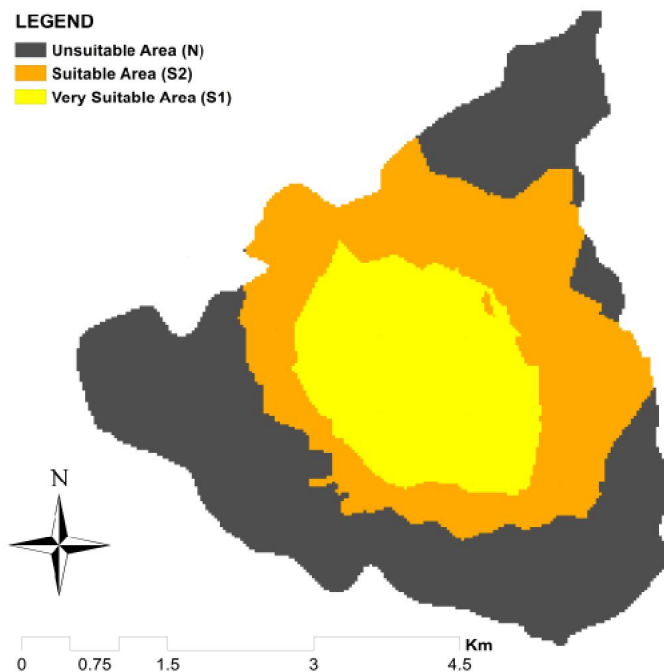


Figure 6. Suitability map of DO for cage culture system in Lake Limboto.

**Nitrate ( $NO_3$ ).** Nitrate is a fertility parameter in waters. It affects nutrients which play a role in the biomass formation of aquatic organisms. Indrayani et al (2015) stated that good nitrate levels for water are 2-5 mg/L. Our field measurement to nitrate content resulted in overall stations in Lake Limboto waters has value <1 mg/L. Based on matrix of parameter suitability (Table 1), eligibility requirements of cage culture fish farming system for nitrate parameter are between 1.6-3.5 mg/L. The result indicated that overall station was 'unsuitable' since the results were below the suitable range of nitrate (Figure 7).

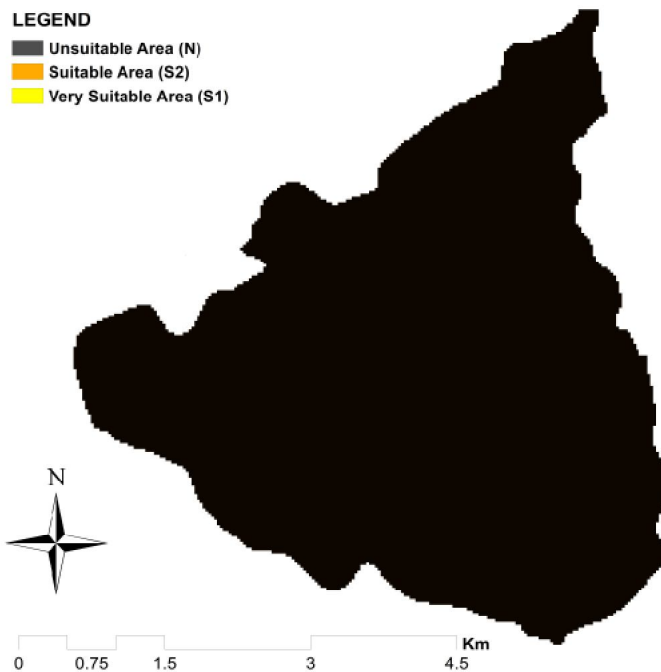


Figure 7. Suitability map of nitrate for cage culture system in Lake Limboto.

**Total suspended solids (TSS).** TSS is the concentration of suspended solids contained in waters. Alabaster & Lloyd (1982) stated that the increase in dissolved solids can directly kill fish, increase the disease and lower the growth rate, change the fish behavior and decline the fish reproduction.

The optimal water content of total suspended solids for fish farming activities are approximately <25 mg/L. The measurements result of TSS performed in Lake Limboto waters showed a value of >25 mg/L (Figure 8).

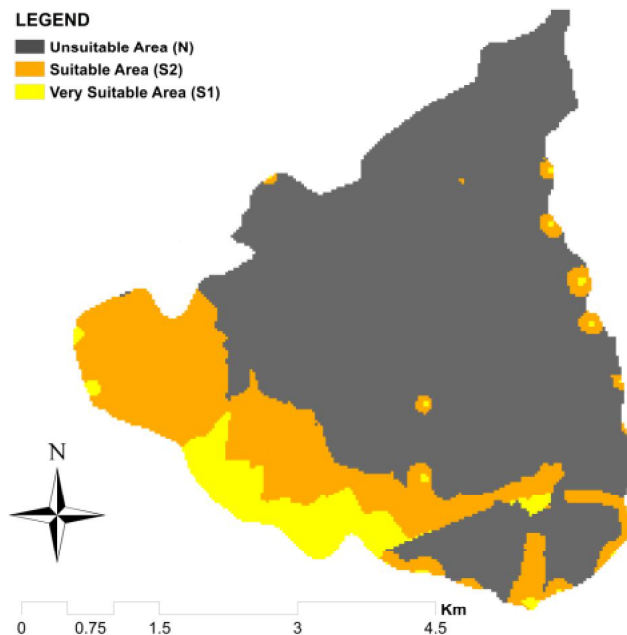


Figure 8. Map of TSS suitability for cage culture system in Lake Limboto.

**Biological oxygen demand (BOD).** Biological process in waters is a parameter indicating the amount of oxygen consumption in waters. According to Supratno (2006),



high content of BOD is caused by high levels of water contamination due to accumulation of the residual unconsumed feed. High BOD indicates the amount of oxygen used by microorganisms, mainly bacteria to break down organic material in the water. Thus, BOD is the relative measure of organic matter amount in water so that it closely associates with the fertility of the water.

BOD range of 2 to 4 mg L<sup>-1</sup> does not show pollution while levels beyond 5 mg L<sup>-1</sup> are indicative of serious pollution (Bhatnagar & Devi 2013). The measurement results of BOD content in Lake Limboto waters showed that Lake Limboto waters was not suitable for activities of cage culture, due to the very high BOD content available in Lake Limboto waters (Figure 9).

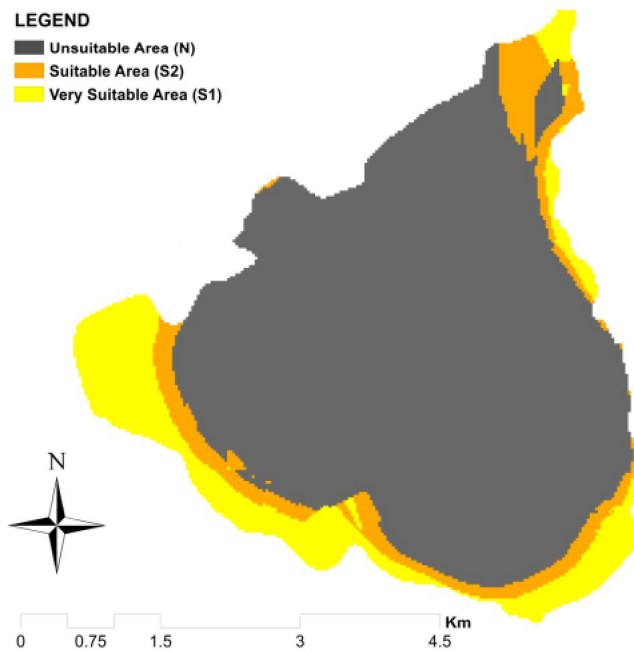


Figure 9. Map of BOD suitability for cage culture system in Lake Limboto.

**Suitability map of Lake Limboto waters for cage culture.** Based on the scoring and weighting results of the physico-chemical quality of the water, data and intersect results with the depth of waters, it formed the map of suitability level for cage culture of fish farming system in Lake Limboto (Figure 10).

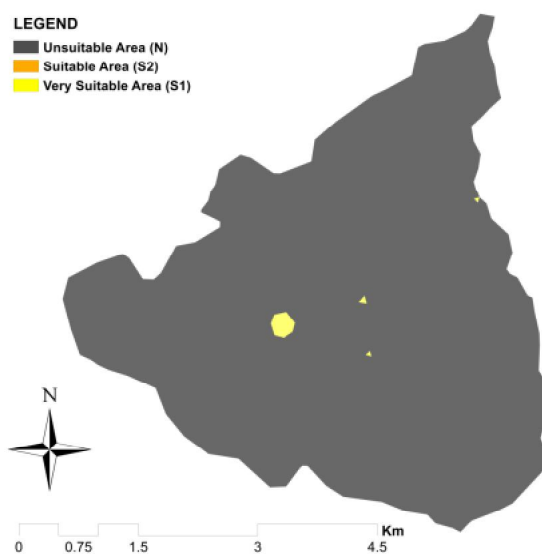


Figure 10. Suitability map of distributions area for cage culture in Lake Limboto waters.

Then, results from SIG tool known that assessment area of the feasibility level of cage culture for fish farming system in Lake Limboto were consisted of 2,195.57 ha (99.64%) was not suitable, while 8.03 ha (0.36%) was suitable or marginally appropriate. However, the area which was classified as suitable/marginally appropriate is not recommended to develop cage culture system due to the relatively shallow waters.

**Conclusions.** Some points which can be concluded from the discussion are:

1. There are eight physical and chemical parameters measured at 16 stations which demonstrate various values. In general, there are only two parameters satisfy the category of 'very suitable' namely temperature and DO;
2. Based on GIS analysis, the suitable waters for cage culture system based on appropriate marginal are 8.03 ha (0.36%), while the unsuitable area is about 2,195.57 ha (99.64%);
3. Overall, the depth of Lake Limboto waters is less than 2 meters, so it is not feasible for the development of cage culture system fish farming.

## References

- Aisha S., Subekhi K., 2012 Pengukuran dan Evaluasi Kualitas Air dalam Rangka Mendukung Pengelolaan Perikanan Di Danau Limboto. Gorontalo: Pusat Penelitian Limnologi- LIPI.
- Bhatnagar A., Devi P., 2013 Water quality guidelines for the management of pond fish culture. International Journal of Environmental Sciences 3(6):1980–2009.
- Boyd C. E., 1982 Water quality management in fish pond culture. Research and Development. Auburn University, Alabama USA, 359 pp.
- Hasim, 2012 Desain Kebijakan Pengelolaan Terpadu dan Berkelanjutan Pada Danau Limboto Provinsi Gorontalo. Disertasi IPB, Bogor.
- Indriyani E., Nitimulyo K. H., Hadisusanto S., Rustadi, 2015 Analisis Kandungan Nitrogen, Fosfor dan Karbon Organik Di Danau Sentani-Papua. Yogyakarta: Program Doktorat Fakultas Biologi Universitas Gadjah Mada. Jurnal Manusia dan Lingkungan 22(2):217-225.
- Janssen M. A., 2001 An exploratory integrated model to assess management of lake eutrophication. Ecological Modelling 140(1-2):111–124.
- Jumadi W., 2011 Penentuan Kesesuaian lahan Keramba Jaring Apung Kerapu Macan (*Ephinephelus fuscoguttatus*) Menggunakan Sistem Informasi Geografis di Pulau Panggang Kepulauan Seribu. Thesis, Institut Pertanian Bogor. Bogor, Indonesia.
- Khairunnisa, Barus T. A., Harahap Z. A., 2014 Analisis Kesesuaian Wilayah Untuk Budidaya Ikan Keramba Jaring Apung di Perairan Girsang Sipangan Bolon Danau Toba. Jurnal Aquacoastmarine 6(1), 11 pp.
- McDonald M. E., Tikkanen C. A., Axler R. P., Larsen C. P., Host G. S., 1996 Fish simulation culture model: a bioenergetic based model for aquaculture waste load application. Aquaculture Engineering 15:243-259.
- Nurfiarini A., 2003 A study on coastal fishery culture development and its influence on social economic condition of coastal residents of saleh gulf, Dompu Regency. Thesis, Bogor Agricultural University, Bogor, Indonesia.
- Pulatso S., 2003 The application of a phosphorus budget model estimating the carrying capacity of Kesikkopru Dam Lake. Turkish Journal of Veterinary and Animal Sciences 27:1127-1130.
- Supratno K. P. T., 2006 Evaluasi Lahan Tambak Wilayah Pesisir Jepara untuk Pemanfaatan Budidaya Ikan Kerapu. Tesis. Semarang: Program Studi Megister Manajemen Sumberdaya Pantai Program Pasca Sarjana Universitas Diponegoro.
- \*\*\* Marine and Fisheries Research Agency, 2007 Monograph of fisheries resources of Limboto Lake, Gorontalo. Department of Marine and Fisheries of Republic of Indonesia.

Received: 08 December 2016. Accepted: 14 March 2017. Published online: 23 March 2017.

Authors:

Hasim, Gorontalo State University, Magister program of Marine Sciences and Fisheries, Indonesia, Gorontalo, Jl. Jenderal Sudirman No. 6, e-mail: hasim@ung.ac.id

Yuniarti Koniyo, Gorontalo State University, Aquaculture Program, Indonesia, Gorontalo, Jl. Jenderal Sudirman No. 6, e-mail: lindakoniyo@yahoo.co.id

Faizal Kasim, Gorontalo State University, Aquatic Resources Management, Indonesia, Gorontalo, Jl. Jenderal Sudirman No. 6, e-mail: faizakasim@ung.ac.com

This is an open-access article distributed under the terms of the Creative Commons Attribution License, which permits unrestricted use, distribution and reproduction in any medium, provided the original author and source are credited.

How to cite this article:

Hasim, Koniyo Y., Kasim F., 2017 Suitable location map of floating net cage for environmentally friendly fish farming development with Geographic Information Systems applications in Lake Limboto, Gorontalo, Indonesia. AACL Bioflux 10(2): 254-264.