

# Distribution Nudibranch and Carnivorous Fish in The North Bali Sea

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## Abstract

The presence or absence of certain types of carnivorous coral fish in a coral reef ecosystem accurately indicates the health of a coral reef ecosystem and the organisms associated with it; one of them is the nudibranch. This research aims to determine whether the presence of carnivorous fish in coral reef ecosystems affects the quality of the nudibranch life cycle and the distribution size in terms of predation. Nine carnivorous fish species were found at the three research stations, the largest group being triggerfish and grouper found in Lovina Reef and Menjangan island. Observed from the size distribution of nudibranchs, the presence of nudibranchs in the three research locations shows sizes ranging from small to large, namely from the *Phyllidiidae* nudibranch group. The dead body of the nudibranch was found in Tulamben reef, but it could not be confirmed whether the nudibranch was preyed by carnivorous fish. Carnivorous fish are not predators and do not affect the life cycle of nudibranchs observed from the complete size distribution of nudibranchs from small to large. Nudibranch predators cannot digest nudibranch bodies because their bodies are venomous; they use them as self-defense against the predators. Nudibranchia are not always found when preyed on by fish.

**Keywords:** Nudibranch, Carnivorous fish, Predation, Coral reef, Bali

## INTRODUCTION

Coral reefs provide shelter and nursery for almost all coral reef organisms, making the basis of animal communities in coral reefs and ecosystems. The destruction of the coral community will directly affect the animals associated with it, for example, in the fish area (Municha *et al.*, 2017). Nudibranchs are mollusks of the subclass Opisthobranchs and are unique organisms to study among other invertebrates (Marchel *et al.*, 2021). Many nudibranchs of the suborder Doridinana, i.e., the family Phyllidiidae known as Phyllidia nudibranchs, have a global distribution, which is found in warm and tropical waters of the Indo-Pacific region (Gosliner *et al.*, 2018). One of the best, and sometimes even frustrating, aspects of nudibranchs is the unpredictable nature of their occurrence (abundance or scarcity) in one place (Gosliner *et al.*, 2018). One of the most surprising aspects of nudibranch biology is the scarcity of food by other marine animals. The effectiveness of the chemical defenses used by sea slugs is demonstrated by the fact that there aren't many of their known predators, or at the very least, there aren't many recordings of them being preyed upon (Kurnianda *et al.*, 2020). The most well-known sea slug predators are possibly other sea slugs (Anker *et al.*, 2020). In their study, Anker *et al.*, (2020) first recorded nudibranch preyed by the crab. To the best of our knowledge, carnivorous fish-eating sea slugs have not yet been observed in their natural habitat. However, a few types of crabs and hermit crabs have been employed in laboratory feeding trials to gauge the effectiveness of certain sea slug species' chemical defenses.

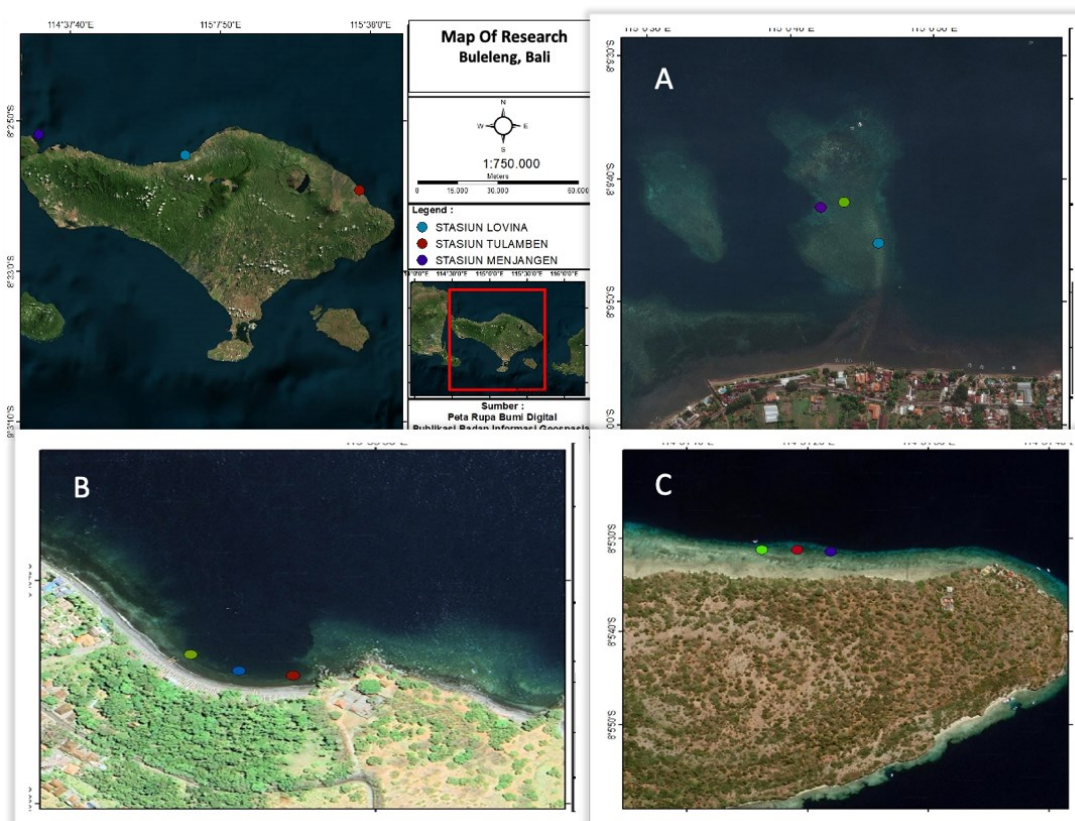
## MATERIALS AND METHODS

The survey was conducted in the North Bali Sea from April to May 2021, with three observation sites: Lovina Reef, Tulamben Reef, and Menjangan Island National Park. The locations of these stations are shown on the survey station map in Figure 1. Each site has three collection stations at a

depth of 5 meters. Lovina Reef at Station 1 (115°0'46.8"E 8°9'46.8"S), Station 2 (115°0'43.2"E 8°9'43.2"S), Station 3 (115°0'43.3 "E 8°9'42.2"S). Tulamben Reef, station 1 (115°35'49.2"E 8°16'44.4"S), station 2 (115°35'44.6"E 8°16'43.4"S), station 3 (115°35'45.6" E 8°16'44.4"S). Menjangan Island National Park, Station 1 (114°31'22.8"E 8°5'31.2"S), Station 2 (114°31'19.2"E 8°5'31.2"S), Station 3 (114°31' 15.6"E 8°5'31.2"S). The selection of the three sites represents a unique profile of the characteristics of coral reefs in the North Bali Sea.

Carnivorous fish data collection was carried out using the underwater visual census methods. The transect is 20 m long with a 1 m right and left border. Corallivorous and herbivorous fish were identified using a reef fish identification guide (Giyanto *et al.*, 2017). Observation of Nudibranch size was carried out using the survey method. The researcher dived and measured nudibranchs under the sea using a 30 cm ruler and photographed them at a depth of 5 meters. Nudibranch measurements were then grouped into three groups: large (> 4 cm), medium (1-4 cm) and small (<1 cm)

Data collection on coral reef fish uses an underwater quantification (UVC) system. Researchers set up a 50-meter-long transect in the laboratory. Data are taken in a transect with a width of 2.5 meters to the left and 2.5 meters to the right of the logger so that the visual field is as wide as the tail (cluster). Once at the point of observation, keep it for 5-10 minutes so that the water conditions return to normal and the coral fish that hide during the entry of the transect appear in their hiding place. Then, pictures and videos of the underwater fishes were taken and identified precisely using paper (Allen *et al.*, 2015). This study will analyse camera images using digital image analysis, including ImageJ from NIH software. This software can accurately identify the area of the image determined and selected



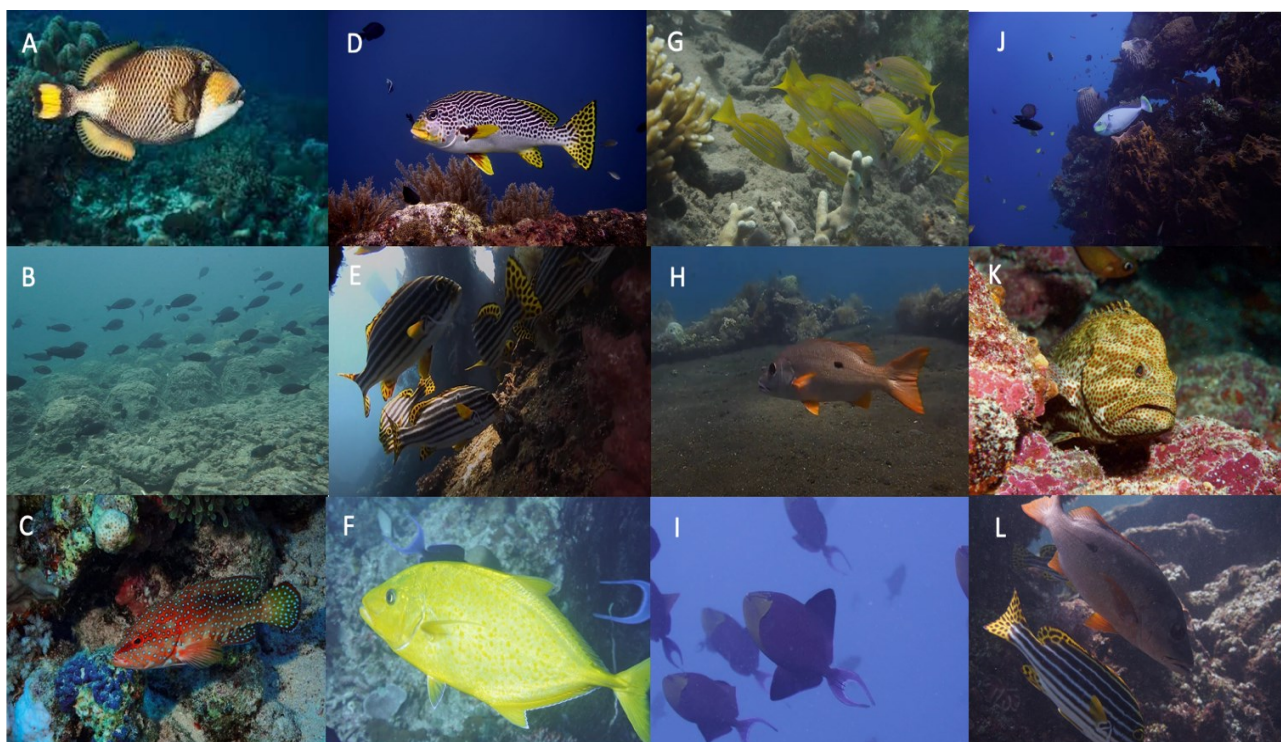
**Figure 1.** The map of the research study in the North Bali Sea, Lovina reef's (A), Tulamben reef's (B), Menjangan Island(C).

## RESULTS AND DISCUSSION

Several things, such as the physical condition or topography of the site, food availability, and fishing pressure, influence the abundance of carnivorous fish in an area (Cleary *et al.*, 2016). The most incredible abundance and richness of carnivorous fish species are on the Lovina coast, from the triggerfish species, followed by the Menjangan Island station and Tulamben beach. The existence of currents significantly affects the presence of carnivorous fish. Grimsditch (2014) stated that several sweetlips (Haemulidae) congregate in groups on rocky reefs during the day and feed on sandy bottoms at night. However, they are sometimes seen in smaller groups or as individuals (Rafly *et al.*, 2020). Many species are nocturnal. They are not aggressive towards other fish and are preyed upon by sea bass, snapper, sharks, and seabirds. They eat shrimp, other crustaceans, clams, and polychaete worms (Mudianta *et al.*, 2023). Smaller species also eat plankton, and larger species also eat echinoids.

In this study, the abundance of carnivorous fish was found in 9 species, namely Red snapper, Oriental sweetlips, Yellowmargin triggerfish, Clown triggerfish, Coral rock grouper, Titan triggerfish, Bluestrip snapper, Coral grouper, and Peacock grouper. The abundance of carnivorous fish is dominated by groupers and triggerfish (Figure. 2A,C,K). Triggerfish are found in large numbers on Lovina Reef, Grouper are found on Menjangan Island, and Sweetlips are more commonly found on Tulamben Reef (Figure.2D,E,L). The abundance of different fish at each station is thought to be caused by differences in the percentage of live coral cover which influences the survival of reef fish (Prasetia, 2015).

The existence of carnivorous reef fish also plays an essential role in the balance of the trophic levels of reef fish in an area (Riskiani *et al.*, 2019). Grouper fish (Serranidae) is a subfamily Epinephelinae of Serranidae, which consists of 15 genera and 159 species and is the second major group of coral predators after sharks. They stay near the seabed near cracks, stalking fish or



**Figure 2.** The underwater photos of fish in the North Bali Sea, Lovina reef(A,B,G), Menjangan island(A,C,F,I,K), Tulamben reef(D,E,H,J,L)

invertebrates and catching them with incredible speed (Evans *et al.*, 2014). Groupers are usually hermaphrodites, changing sex from female to several dominant males. Due to their body weight, territorial habits, and aggregation behavior, they are good feeders, although they sometimes carry grammystin poison (Grimsditch, 2014). The abundance of carnivorous fish will balance the abundance of herbivorous fish and directly affect the abundance and species richness of reef fish (Figure. 3). Kusuma *et al.* (2020), in their research on Enggano Island, stated that low coral cover causes a low abundance of fish. Coral reef fish are one of the fish that live permanently in coral reefs (Hoeksema, 2017). Damaged coral reefs will cause a decrease in the abundance of reef fish (Kusuma *et al.*, 2020). Nudibranchs are vulnerable to a large number of marine animals (Adiwijaya *et al.*, 2021). However, they have developed various unique and effective defense strategies that help them avoid as much predation as possible (Aguado *et al.*, 2007). Some have evolved to appear like their prey, sea sponges, and thus prevent the detection of predators through camouflage (Amelia *et al.*, 2022). In other species, they carry out the opposite adaptation; they have very bright colors and patterns, warning predators of their chemical defenses, such as fish, and thus giving the signal that they are not edible (Haber *et al.*, 2010).

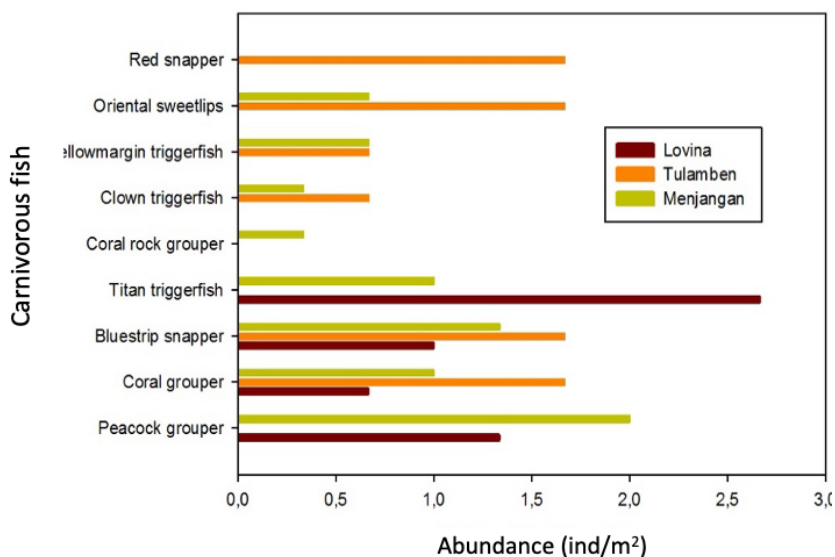


Figure 3. The graphic of fish abundance in the North Bali Sea

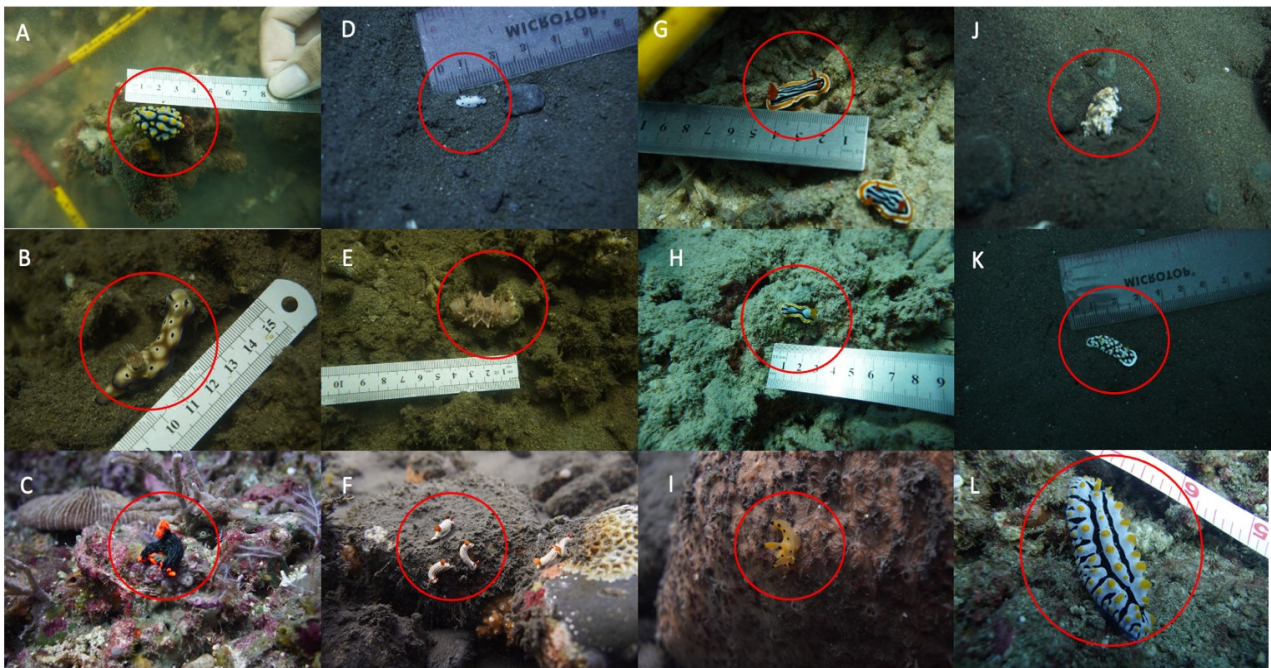
Table 1. The distribution size family of Nudibranch's

Family Nudibranch	Size Distribution (cm)
Phyllidae	0,81 -5,45
Chromodorididae	1,23-5,25
Discodorididae	3,14-5,8
Polyceridae	1-2,15
Facelinidae	0,2-08
Caliphyllidae	0,3-0,51
Goniodorididae	0,21-0,53
Dendronotidae	0,2-0,33
Trinchesidae	0,55-1,0
Tritoniidae	0,54-0,7
Aegiridae	3,7 - 5,19

The efficiency of the chemical defenses used by sea slugs is evidenced by the relatively few known predators or at least by the few recorded predations on them. More interestingly, some nudibranchs that feed on hydrozoids, like the family of animals related to jellyfish, can harbor hydrozoid stinging cells in their skin (Mehrotra *et al.*, 2019). The hydrozoids pass through the digestive system of the nudibranch without damaging it and are then concentrated in the body parts of the nudibranch, such as the cerata (Goodheart *et al.*, 2017). Any animal that tries to bite one of these nudibranchs will receive a painful sting and will likely not come near it again (Ompi *et al.*, 2019). The table above (Table 1) shows that 11 family nudibranchs found in northern Bali have various sizes ranging from small to large. The size range of nudibranchs varies at each station and for each species. Overall shell length ranges from 0.2 – 5.8 cm. The smallest size (0.2 cm) is from the Goniodorididae family, namely the *Trapania* species found at the Tulamben station, and the largest (5.80 mm) is from the Discodorididae family with the *Halgerda* Batangas species. Based on the length of the nudibranchs obtained, the nudibranchs are divided into three size classes, namely small (<1 cm), medium (1-4 cm) and large >4 cm). In general, the nudibranchs from the Phillydidae family on Lovina Beach were found to be mainly medium to large (Figure.4A,L), followed by the large Discodorididae family and the tiniest nudibranchs found only at Tulamben Station with <1cm in size(Figure. 4D).

Menjangan Island Station medium-sized nudibranch (Figure.4G). Each species has its own size distribution. Hence, it is difficult to distinguish whether the body size of a nudibranch indicates that the nudibranch is already in its adult phase or is still a juvenile. The information on the diversity of individual nudibranch sizes cannot be found, whether the small ones found on Tulamben Beach in this study may or may not be related to the reproductive period of these nudibranchs. This research was conducted in April and May, maybe not the reproductive period for particular species or the reproductive period. However, the larvae are still incubating in the mother's demibranch and have not yet been released into the water (Kaligis *et al.*, 2018).

Most of the nudibranchs found at the Lovina station and Menjangan Island were of medium size (1-4 cm), especially the nudibranch families Phyllididae, Chromodorididae and Discodorididae.



**Figure 4.** The photos of measuring Nudibranch under the water. Lovina reef(A,B,L),Tulamben reef(C,D,F,I ), Menjangan island(G,H,K), Dead body nudibranch in Tulamben reef(J).

It is estimated that nudibranchs in this size range are considered sexually mature (Chavanich *et al.*, 2013). To prove that the nudibranchs measuring 1-4 cm in this study are sexually mature, further It is estimated that nudibranchs in this size range are considered sexually mature (Chavanich *et al.*, 2013). To prove that the nudibranchs measuring 1-4 cm in this study are sexually mature, further research is needed by examining the gonads. To support conservation efforts, as an initial suggestion, nudibranchs measuring 1-4 cm should not be caught and extracted in the laboratory to search for new marine biological materials because, at this size, nudibranchs are thought to be sexually mature.

The correlation between carnivorous fish and the abundance of nudibranchs is that carnivorous fish is not too late influences the presence of nudibranchs on coral reefs at each research location. This current research found the dead body of the Nudibranch in Tulamben reef (**Figure.4J**) but can't confirm who attacked and tried to pray the nudibranch. Most sea slugs use large amounts of secondary metabolites, such as isocyanides, diterpenes, and sesquiterpenes, to enhance their unpleasant taste and avoid predation (Anker *et al.*, 2020).

They were observed and photographed the unusual parthenopid crab, *Lambrachaeus ramifer* Alcock, 1895 eating two species of aposematic colored sea slug, *Sagaminopteron nigropunctatum* Carlson & (Gastropteridae, Cephalaspidea) and *Mexichromis mariei* (Crosse) (Chromodorididae, Nudibranchia). This observation probably represents the first known case of in situ feeding of sea slugs by brachyuran crabs (Anker *et al.*, 2020). To state that carnivorous fish indicate nudibranch predators requires a series of very intensive studies. So far, Nudibranchia is not always found when preyed on by fish.

## CONCLUSION

The abundance of carnivorous fish was found in 9 species, namely Red snapper, Oriental sweetlips, Yellowmargin triggerfish, Clown triggerfish, Coral rock grouper, Titan triggerfish, Bluestrip snapper, Coral grouper, and Peacock grouper. That 11 family nudibranchs found in northern Bali have various sizes ranging from small to large. The size range of nudibranchs varies at each station and for each species. Overall shell length ranges from 0.2 – 5.8 cm. The smallest size (0.2 cm) is from the Goniodorididae family, namely the *Trapania* species found at the Tulamben station, and the largest (5.80 mm) is from the Discodorididae family with the *Halgerda Batangas* species.

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## REFERENCE

- Adiwijaya, C., Bengen, D.G., & Zamani, N.P. (2021). Coral reefs substrate composition influence on nudibranch diversity. *IOP Conference Series: Earth and Environmental Science*, 771(1), 012009. doi: 10.1088/1755-1315/771/1/012009
- Aguado, F., & Marin, A. (2007). Warning coloration associated with nematocyst-based defences in aeolidiidean nudibranchs. *Journal of Molluscan Studies*, 73(1), 23–28. doi: 10.1093/mollus/eyl026
- Allen, G.R., Steene, R.C., Humann, P. & Deloach, N. (2015). Reef fish identification : tropical Pacific (1st ed). New World Publication ; Odyssey Pub., Jacksonville, Fla., El Cajon, California.
- Amelia, J.M., Prasetya, I.N.D., & Setiabudi, G.I. (2022). Keanekaragaman dan Kelimpahan Nudibranch di Pantai Penimbangan Buleleng Bali. *Journal of Marine Research*, 11(3), 399–408. doi: 10.14710/jmr.v11i3.35005
- Anker, A., & Ivanov, Y. (2020). First record of the predation upon sea slugs (Cephalaspidea and Nudibranchia) by the peculiar elbow crab *Lambrachaeus ramifer* Alcock, 1895 (Decapoda: Parthenopidae). *Marine Biodiversity*, 50(2), 1-6. doi: 10.1007/s12526-020-01047-x
- Chavanich, S., Viyakarn, V., Sanpanich, K., & Harris, L.G. (2013). Diversity and occurrence of nudibranchs in Thailand. *Marine Biodiversity*, 43(1), 31–36. doi: 10.1007/s12526-012-0141-4

- Cleary, D.F.R., Polónia, A.R.M., Renema, W., Hoeksema, B.W., Rachello-Dolmen, P.G., Moolenbeek, R.G., Budiyanto, A., Yahmantoro, Tuti, Y., Giyanto, Draisma, S.G.A., Prud'homme van Reine, W. F., Hariyanto, R., Gittenberger, A., Rikoh, M.S., & de Voogd, N.J. (2016). Variation in the composition of corals, fishes, sponges, echinoderms, ascidians, molluscs, foraminifera and macroalgae across a pronounced in-to-offshore environmental gradient in the Jakarta Bay–Thousand Islands coral reef complex. *Marine Pollution Bulletin*, 110(2), 701–717. doi: 10.1016/j.marpolbul.2016.04.042
- Dodik Prasetya, I.N. (2015). Rekrutmen Karang Di Kawasan Wisata Lovina. *Jurnal Sains Dan Teknologi*, 1(2), 61-72 doi: 10.23887/jst-undiksha.v1i2.6037
- Evans, R.D., Wilson, S.K., Field, S.N., & Moore, J.A.Y. (2014). Importance of macroalgal fields as coral reef fish nursery habitat in north-west Australia. *Marine Biology*, 161(3), 599–607. doi: 10.1007/s00227-013-2362-x
- Grimsditch, G. (2014). A Study of Potential Coral Reef Bioindicators in the Mamanucas Region, Fiji, using Coral Cay Conservation Reef Check Data. University College London.
- Giyanto, Abrar, M., Hadi, T.A., Budiyanto, A., Hafizt, M., Salatalohy, A., & Iswari, M.Y. (2017). Status Terumbu Karang Indoneisa 2017 (Suharsono, Ed.). Pusat Penelitian Oseanografi - LIPI.
- Goodheart, J.A., & Bely, A.E. (2017). Sequestration of nematocysts by divergent cnidarian predators: mechanism, function, and evolution. *Invertebrate Biology*, 136(1), 75–91. doi: 10.1111/ivb.12154
- Gosliner, T., Valdes, A. & Behrens, D. (2018). *Nudibranch & Sea Slug Identification*. New World Publication, Jacksonville.
- Haber, M., Cerfeda, S., Carbone, M., Calado, G., Gaspar, H., Neves, R., Maharajan, V., Cimino, G., Gavagnin, M., Ghiselin, M. T., & Mollo, E. (2010). Coloration and Defense in the Nudibranch Gastropod *Hypselodoris fontandraui*. *The Biological Bulletin*, 218(2), 181–188. doi: 10.1086/BBLv218n2p181
- Hoeksema, B.W. (2017). The hidden biodiversity of tropical coral reefs. *Biodiversity*, 18(1), 8–12. doi: 10.1080/14888386.2017.1307787
- Kaligis, F., Eisenbarth, J.H., Schillo, D., Dialao, J., Schäberle, T.F., Böhringer, N., Bara, R., Reumschüssel, S., König, G.M., & Wägele, H. (2018). Second survey of heterobranch sea slugs (Mollusca, Gastropoda, Heterobranchia) from Bunaken National Park, North Sulawesi, Indonesia - how much do we know after 12 years? *Marine Biodiversity Records*, 11(1), 2-22. doi: 10.1186/s41200-018-0136-3
- Kurnianda, V., Winahyu, D. A., Firdaus, R., Wahyudi, E., & Musman, M. (2020). Biological and chemical diversity of the Indonesian marine nudibranchs based on MS/MS molecular networking approach. *Depik*, 9(1), 83–94. doi: 10.13170/depik.9.1.15126
- Kusuma, A., Renta, P., Purnama, D., Negara, B., Claudea, C., Budiharto, T., & Kholid, I. (2020). The Correlation Between Coral Cover and The Associated Reef Fishes Abundance in Enggano Island Bengkulu. *IOP Conference Series: Earth and Environmental Science*, 593(1), p.012034. doi: 10.1088/1755-1315/593/1/012034
- Marchel, M., Zahida, F., & Yuda, Ign. P. (2021). Keanekaragaman dan Kemelimpahan Nudibranchia di Perairan Tulamben, Bali. *Jurnal Moluska Indonesia*, 5(1), 34–41. doi: 10.54115/jmi.v5i1.6
- Mehrotra, R., Monchanin, C., Scott, C. M., Phongsuwan, N., Caballer Gutierrez, M., Chavanich, S., & Hoeksema, B. W. (2019). Selective consumption of sacoglossan sea slugs (Mollusca: Gastropoda) by scleractinian corals (Cnidaria: Anthozoa). *Plos One*, 14(4), e0215063. doi: 10.1371/journal.pone.0215063
- Mudianta, I. W., Artha, I.N.G.S., Muderawan, I.W., & Martiningsih, N.W. (2023). Chemical profile and antibacterial activity of essential oil from ironwood (*Eusideroxylon zwageri*) sawdust. *Cogent Food & Agriculture*, 9(1), p.2202033. doi: 10.1080/23311932.2023.2202033
- Muniaha, H., Nur, A.I., & Rahmadani, D. (2017). Studi kelimpahan ikan karang berdasarkan kondisi terumbu karang di Desa Tanjung Tiram Kabupaten Konawe Selatan. *Jurnal Manajemen Sumber Daya Perairan*, 2(1), 9-19
- Ompi, P.O., Boneka, F.B., Ompi, M., Rimper, J.S., Roeroe, K.A., & Kambey, A.D. (2019). Kelimpahan, Distribusi, Dan Keragamannudibranchia Di Nudifall Dan Nudiretreat Selat Lembeh, Sulawesi Utara. *Jurnal Pesisir Dan Laut Tropis*, 7(2), 113-120. doi: 10.35800/jplt.7.2.2019.24239

- Rafly, N.M., Gede Astawa Karang, I.W., & Widiastuti, W. (2020). Hubungan Rugositas Terumbu Karang terhadap Struktur Komunitas Ikan Corallivor dan Herbivor di Perairan Pemuteran, Bali. *Journal of Marine Research and Technology*, 3(1), 6-11. doi: 10.24843/jmrt.2020.v03.i01.p02
- Riskiani, I., Budimawan, B., & Bahar, A. (2019). The Analysis of Coral Reef Fishes Abundance Based on Coral Reef Condition in Marine Tourism Park of the Kapoposang Islands, South Sulawesi, Indonesia. *International Journal of Environment, Agriculture and Biotechnology*, 4(4), 1012–1017. doi: 10.22161/ijeab.4418