ANALISIS BIOTA MAKROFOULING PADA BERBAGAI JENIS SUBSTRAT BUATAN (KAYU, BETON DAN FIBER) DI PERAIRAN SURAMADU

SKRIPSI

Diajukan guna memenuhi salah satu persyaratan untuk memperoleh gelar Sarjana Sains (S.Si) pada program studi ilmu kelautan

UIN SUNAN AMPEL
S U R A B A Y A

Disusun Oleh:

Elberta Elysia Fawnia Dewi

NIM: 09040422056

PROGRAM STUDI ILMU KELAUTAN

FAKULTAS SAINS DAN TEKNOLOGI

UNIVERSITAS ISLAM NEGERI SUNAN AMPEL

SURABAYA

2026

PERNYATAAN KEASLIAN

Saya yang bertanda tangan di bawah ini,

Nama : Elberta Elysia Fawnia Dewi

NIM : 09040422056

Program studi : Ilmu Kelautan

Angkatan : 2022

Menyatakan bahwa saya tidak melakukan plagiat dalam penelitian skripsi saya yang berjudul "ANALISIS BIOTA MAKROFOULING PADA BERBAGAI JENIS SUBSTRAT BUATAN (KAYU, BETON DAN FIBER) DI PERAIRAN SURAMADU". Apabila suatu saat nanti terbukti saya melakukan tindak plagiasi, maka saya bersedia menerima sanksi yang telah ditetapkan.

Demikian pernyataan ini saya buat dengan sebenar-benarnya.

Surabaya, 26 Mei 2026

Elberta Elysia Fawnia Dewi

NIM 09040422056

LEMBAR PERSETUJUAN PEMBIMBING

Skripsi oleh:

Nama : Elberta Elysia Fawnia Dewi

Nim : 09040422056

Judul : Analisis Biota Makrofouling pada Berbagai Jenis Substrat Buatan (Beton, Kayu dan Fiber) di Perairan Suramadu

Ini telah diperiksa dan disetujui untuk diujikan

Surabaya, 26 Mei 2026

Dosen Pembimbing 1	Dosen Pembimbing 2
Rizqi Abdi Perdanawati, M.T.	Wiga Alif Violando M.P., M.Sc.
NIP. 198809262014032002	NIP: 199203292019031012

LEMBAR PENGESAHAN TIM PENGUJI SKRIPSI

Skripsi Elberta Elysa Fawnia Dewi ini telah dipertahankan

didepan tim penguji skripsi

Surabaya, 08 Juni 2026

Mengesahkan,

Dosen Penguji 1

Mauludiyah., M.T
NIP.198211172025212008

Dosen Penguji 2

Khoirotul Ummah., M.Si
NIP.199105302019032019

Dosen Penguji 3

Rizqi Abdi Perdanawati., M.T
NIP. 198809262014032002

Dosen Penguji 4

Wiga Alif Violando M.P., M.Sc.
NIP: 199203292019031012

Mengetahui,
Dekan Fakultas Sains dan Teknologi
UIN Sunan Ampel Surabaya

A. Saepul Hamdani, M.Pd
NIP.196507312000031002

LEMBAR PERSETUJUAN PUBLIKASI

KEMENTERIAN AGAMA
UNIVERSITAS ISLAM NEGERI SUNAN AMPEL SURABAYA
PERPUSTAKAAN
Jl. Jend. A. Yani 117 Surabaya 60237 Telp. 031-8431972 Fax.031-8413300
E-Mail: perpus@uinsby.ac.id

LEMBAR PERNYATAAN PERSETUJUAN PUBLIKASI
KARYA ILMIAH UNTUK KEPENTINGAN AKADEMIS

Sebagai sivitas akademika UIN Sunan Ampel Surabaya, yang bertanda tangan di bawah ini, saya:

Nama : Elberta Elysia Fawnia Dewi
NIM : 09040422056
Fakultas/Jurusan : Ilmu Kelautan
E-mail address : elbertaelysia3@gmail.com

Demi pengembangan ilmu pengetahuan, menyetujui untuk memberikan kepada Perpustakaan UIN Sunan Ampel Surabaya, Hak Bebas Royalti Non-Eksklusif atas karya ilmiah :
☐ Skripsi ☐ Tesis ☐ Desertasi ☐ Lain-lain (.....)
yang berjudul :

ANALISIS BIOTA MAKROFOULING PADA BERBAGAI JENIS SUBSTRAT BUATAN (KAYU, BETON DAN FIBER) DI PERAIRAN SURAMADU

beserta perangkat yang diperlukan (bila ada). Dengan Hak Bebas Royalti Non-Ekslusif ini Perpustakaan UIN Sunan Ampel Surabaya berhak menyimpan, mengalih-media/format-kan, mengelolanya dalam bentuk pangkalan data (database), mendistribusikannya, dan menampilkan/mempublikasikannya di Internet atau media lain secara ***fulltext*** untuk kepentingan akademis tanpa perlu meminta ijin dari saya selama tetap mencantumkan nama saya sebagai penulis/pencipta dan atau penerbit yang bersangkutan.

Saya bersedia untuk menanggung secara pribadi, tanpa melibatkan pihak Perpustakaan UIN Sunan Ampel Surabaya, segala bentuk tuntutan hukum yang timbul atas pelanggaran Hak Cipta dalam karya ilmiah saya ini.

Demikian pernyataan ini yang saya buat dengan sebenarnya.

Surabaya, 19 Juni 2026

Penulis

( )
Elberta Elysia Fawnia Dewi

ABSTRAK

Biofouling merupakan proses penempelan organisme laut pada permukaan material yang terendam di perairan dan dipengaruhi oleh karakteristik substrat seperti tekstur permukaan, porositas, dan daya serap air. Penelitian ini bertujuan untuk menganalisis perbedaan komunitas makrofouling pada berbagai substrat buatan, tingkat resapan substrat, serta pengaruhnya terhadap penempelan makrofouling di Perairan Suramadu. Penelitian menggunakan metode purposive sampling dengan substrat beton, kayu, dan fiber yang dipasang pada zona pasang surut di tiang pancang ke-4 Suramadu. Parameter oseanografi yang diukur meliputi suhu, salinitas, pH, oksigen terlarut, nitrat, dan fosfat. Hasil penelitian menunjukkan bahwa keanekaragaman makrofouling pada seluruh substrat tergolong rendah dan didominasi oleh *Amphibalanus sp*. Pertumbuhan makrofouling tertinggi ditemukan pada substrat kayu dengan persentase tutupan 16,93%, kepadatan 8,03 ind/cm², dan peningkatan berat relatif 20%, sedangkan substrat fiber menunjukkan nilai terendah dengan persentase tutupan 8,14%, kepadatan 1,69 ind/cm². Substrat kayu juga memiliki daya serap air dan porositas terbuka tertinggi, masing-masing sebesar 21,59% dan 27,11%, sedangkan fiber terendah sebesar 2,36% dan 2,72%. Tingkat resapan substrat berpengaruh terhadap penempelan makrofouling. Substrat dengan daya serap air dan porositas lebih tinggi cenderung mendukung kolonisasi organisme. Penelitian ini memberikan informasi mengenai hubungan karakteristik fisik substrat dengan penempelan makrofouling yang dapat dimanfaatkan untuk memahami dinamika biofouling pada struktur terendam di lingkungan pesisir.

Kata Kunci : Makrofouling, Substrat Buatan, Zona Pasang Surut

UIN SUNAN AMPEL
S U R A B A Y A

http://digilib.uinsa.ac.id/ http://digilib.uinsa.ac.id/ http://digilib.uinsa.ac.id/

ABSTRACT

Biofouling is the process by which marine organisms attach to submerged surfaces and is influenced by substrate characteristics such as surface texture, porosity, and water absorption capacity. This study aimed to analyze differences in macrofouling communities among various artificial substrates, evaluate substrate absorption properties, and determine their influence on macrofouling attachment in the Suramadu Waters. A purposive sampling method was employed using concrete, wood, and fiberglass substrates installed in the intertidal zone at the fourth bridge pier of Suramadu. Oceanographic parameters measured included temperature, salinity, pH, dissolved oxygen (DO), nitrate, and phosphate. The results showed that macrofouling diversity was low across all substrates and was dominated by Amphibalanus sp. The highest macrofouling growth was observed on the wood substrate, with a coverage percentage of 16.93%, a density of 8.03 ind/cm², and a relative weight increase of 13.57%, whereas the fiberglass substrate exhibited the lowest values, with a coverage percentage of 8.14% and a density of 1.69 ind/cm². The wood substrate also showed the highest water absorption and open porosity values, reaching 21.59% and 27.11%, respectively, while the fiberglass substrate had the lowest values at 2.36% and 2.72%. Substrate absorption capacity significantly influenced macrofouling attachment, with substrates exhibiting higher water absorption and porosity tending to support greater organism colonization. This study provides information on the relationship between substrate physical characteristics and macrofouling attachment, contributing to a better understanding of biofouling dynamics on submerged structures in coastal environments.

Keywords : Macrofouling, Artificial Substrates, Intertidal Zone.

UIN SUNAN AMPEL
S U R A B A Y A

http://digilib.uinsa.ac.id/ http://digilib.uinsa.ac.id/ http://digilib.uinsa.ac.id/

DAFTAR ISI

UIN SUNAN AMPEL
S U R A B A Y A
http://digilib.uinsa.ac.id/ http://digilib.uinsa.ac.id/ http://digilib.uinsa.ac.id/

UIN SUNAN AMPEL
S U R A B A Y A

http://digilib.uinsa.ac.id/ http://digilib.uinsa.ac.id/ http://digilib.uinsa.ac.id/

UIN SUNAN AMPEL
S U R A B A Y A

http://digilib.uinsa.ac.id/ http://digilib.uinsa.ac.id/ http://digilib.uinsa.ac.id/

DAFTAR GAMBAR

UIN SUNAN AMPEL
S U R A B A Y A
http://digilib.uinsa.ac.id/ http://digilib.uinsa.ac.id/ http://digilib.uinsa.ac.id/

UIN SUNAN AMPEL
S U R A B A Y A

http://digilib.uinsa.ac.id/ http://digilib.uinsa.ac.id/ http://digilib.uinsa.ac.id/

DAFTAR TABEL

UIN SUNAN AMPEL
S U R A B A Y A

http://digilib.uinsa.ac.id/ http://digilib.uinsa.ac.id/ http://digilib.uinsa.ac.id/

DAFTAR PUSTAKA

Abdulrohiim, M. S., Widagdo, S., & Prasita, V. D. (2022). *Distribusi Salinitas dan Temperatur Permukaan Berdasarkan Angin dan Arus di Selat Madura*. *4*(1), 1–15.

Akbar Alif, M. R., & Nurgayah, W. (2023). Studi Kepadatan Biofouling Pada Dermaga Kayu dan Dermaga Beton di Teluk Kendari. *Sapa Laut*. https://doi.org/http://dx.doi.org/10.33772/jsl.v8i2.43188

Al, Kautsar, Rizqi Abdi perdanawati, N. (2020). Laju penempelan macrofouling pada tiang pancang jembatan Suramadu. *Jurnal Ilmu Kelautan Kepulauan*, *3*(2). https://doi.org/10.33387/jikk.v3i2.2587

Alm, M., Anna, R., Ulrika, A., Páll, L., Stefania, Ó., Björn, G., & Blomberg, A. (2021). Genomic Characterization of the Barnacle Balanus improvisus Reveals Extreme Nucleotide Diversity in Coding Regions. *Marine Biotechnology*, 402–416. https://doi.org/10.1007/s10126-021-10033-8

Ardiansah, N. J. D., Sakinah, W., Yasim, A., Arianto, P. Y., Sumarji, S., & Widityo, P. G. (2025). Analisis Penambahan Ekstrak Daun Belimbing Wuluh Pada Cat Minyak Terhadap Laju Pertumbuhan Biofouling. *Jurnal Manajemen Pesisir Dan Laut*, *3*(01), 49. https://doi.org/10.36841/mapel.v3i01.6401

Arianti, M. P., & Kabul Fadilah1. (2023). *Analisis Kualitas Air Laut Terhadap Aktivitas Kapal Di Pelabuhan Surabaya Berdasarkan Parameter Anti-fouling*. *4*(1), 86–90.

Badakumar, B. (2024). Mitigating Biofouling in Cooling Water System : Actibromide to Combat Perna viridis Infestation and environmental impact. *Research Square*, 2–42.

Barr, J. M., Munroe, D., Rose, J. M., Calvo, L., Cheng, K. M., Bayer, S., & Kreeger, D. (2024). Seasonal Feeding Behavior of Aquaculture Eastern Oysters (Crassostrea virginica) in the Mid - Atlantic. *Estuaries and Coasts*, *47*(3), 789–

UIN SUNAN AMPEL
S U R A B A Y A
http://digilib.uinsa.ac.id/ http://digilib.uinsa.ac.id/ http://digilib.uinsa.ac.id/

804. https://doi.org/10.1007/s12237-023-01293-9

Blomberg, A. (2019). *Osmoregulation in Barnacles : An Evolutionary Perspective of Potential Mechanisms and Future Research Directions*. *10*(August). https://doi.org/10.3389/fphys.2019.00877

Bonacina, L., Fasano, F., Mezzanotte, V., & Fornaroli, R. (2023). Effects of water temperature on freshwater macroinvertebrates: a systematic review. *Biological Reviews*, *98*(1), 191–221. https://doi.org/10.1111/brv.12903

Candri, D. A. (2022). Keanekaragaman Teritip pada Tiga Ekosistem (Hutan Mangrove, Padang Lamun dan Terumbu Karang) di Perairan Sekotong. *Samota Journal of Biological Sciences*, *1*(1), 27–38. https://doi.org/10.29303/sjbios.v1i1.1384

Carmona-Rodríguez, A., Antón, C., Climent, M. Á., Garcés, P., Montiel, V., & Ramos-Esplá, A. A. (2024). Sessile Biofouling on Electrolytic Carbonated Structures: Stages of Colonization and Succession. *Journal of Marine Science and Engineering*, *12*(3). https://doi.org/10.3390/jmse12030443

Charles, M., Faillettaz, R., Desroy, N., Fournier, J., & Costil, K. (2018). Distribution, associated species and extent of biofouling "reefs" formed by the alien species Ficopomatus enigmaticus (Annelida, Polychaeta) in marinas. *Estuarine, Coastal and Shelf Science*, *212*, 164–175. https://doi.org/10.1016/j.ecss.2018.07.007

Checa, A. G., González-segura, A., Rodríguez-navarro, A. B., & Lagos, N. A. (2020). *Microstructure and crystallography of the wall plates of the giant barnacle Austromegabalanus psittacus : a material organized by crystal growth*.

Chen, W., Wang, Y., Wang, M., Huang, Y., & Xu, Y. (2023). Effects of Different Fouling Organisms on Corrosion Behavior of Carbon Steel in Dalian Seawater. *Metals*, *13*(9). https://doi.org/10.3390/met13091503

Cima, F. (2023). Larval Settlement on Marine Surfaces: The Role of Physico-Chemical Interactions. *Journal of Marine Science and Engineering*, *11*(4).

UIN SUNAN AMPEL
S U R A B A Y A

http://digilib.uinsa.ac.id/ http://digilib.uinsa.ac.id/ http://digilib.uinsa.ac.id/

https://doi.org/10.3390/jmse11040859

Davidson, I., Cahill, P., Hinz, A., Kluza, D., Scianni, C., & Georgiades, E. (2021). A Review of Biofouling of Ships' Internal Seawater Systems. *Frontiers in Marine Science*, *8*. https://doi.org/10.3389/fmars.2021.761531

Dishon, G., Resetarits, H. M., Tsai, B., Black, K., Grossmann, J., & Smith, J. E. (2023). Image - based analysis and quantification of biofouling in cultures of the red alga Asparagopsis taxiformis. *Journal of Applied Phycology*, 209–218. https://doi.org/10.1007/s10811-022-02884-y

Djunaidi, Widagdo, A., Kelana, P. K., Pramesty, T. D., Arkham, M. N., Haris, R. B. K., Hutapea, R. Y., & Habib, M. E. (2024). Study of Sea Water Quality Based on Physical-Chemical Parameters in the. *Jurnal Segara*, *19*(1), 58–64.

Dwi, A. P., Fittroh, L. M., Indriyawati, N., Dewi, K., Aprilia, N. A., Adila, I., Ariyanti, A. P., Qolbi, D. L., Amanda, V. T., & Tauri, S. (2025). Growth Rate and Diversity of Biofouling in The Waters of Socah Village, Socah District, Bangkalan. *Juvenil*, *6*(1), 31–43.

Dynowski, P., & Zróbek, A. (2025). *A Review of Additive Manufacturing Techniques in Artificial Reef Construction : Materials , Processes , and Ecological Impact*.

Elysia, V. (2014). Peran Pembangunan Jembatan Suramadu Terhadap Percepatan Pembangunan Di Kabupaten Bangkalan. *Forum Ilmiah*, *11*, 1–13.

Farihah, R. A. (2019). *Sebaran horizontal konsentrasi nitrat dan nitrit pada kondisi pasang surut di Perairan Cilauteureun, Garut.*. *5*, 378–389.

Fitriyah, A. (2022). *Fitoplankton pada saat air pasang dan surut di Muara Ujung*. *15*(1), 1–2.

Fittroh, L. M., Indriyawati, N., Dewi, K., Ayu, N., Adila, I., Ariyanti, A. P., Qolbi, D. L., Amanda, V. T., Tauri, S., Timur, J., Socah, D., Socah, K., Jenis, K., & Air, P. K. (2025). *Laju pertumbuhan dan keanekaragaman biofouling di perairan.* *6*(1), 31–43.

UIN SUNAN AMPEL
S U R A B A Y A
http://digilib.uinsa.ac.id/ http://digilib.uinsa.ac.id/ http://digilib.uinsa.ac.id/

Fragassa, C., Mattiello, S., Fronduti, M., Gobbo, J. Del, Gagic, R., & Santulli, C. (2024). *Prevention of Biofouling Due to Water Absorption of Natural Fiber Composites in the Aquatic Environment : A Critical Review*.

Fredriksson, M., Rüggeberg, M., Nord, T., & Greeley, L. (2023). Water sorption in wood cell walls – data exploration of the influential physicochemical characteristics. *Cellulose*, 1857–1871. https://doi.org/10.1007/s10570-022-04973-0

Fu, D., Zhong, Y., Chen, F., Yu, G., & Zhang, X. (2020). Analysis of dissolved oxygen and nutrients in Zhanjiang Bay and the adjacent sea area in spring. *Sustainability (Switzerland)*, *12*(3). https://doi.org/10.3390/su12030889

Georgiades, E., Scianni, C., & Tamburri, M. N. (2023). *Bio fi lms associated with ship submerged surfaces : implications for ship biofouling management and the environment*. *June*, 1–6. https://doi.org/10.3389/fmars.2023.1197366

Ginter-kramarczyk, D., & Kruszelnicka, I. (2021). *Biofilm on the polymer composites - qualitative and quantitative microbiological analysis*. 641–649.

Gombak, J. (2021). *Mechanical properties, water absorption, and failure analyses of kenaf fiber reinforced epoxy matrix composites. 22*(2), 316–326.

Gould, W. J., & Cunningham, S. A. (2021). Global-scale patterns of observed sea surface salinity intensified since the 1870s. *Communications Earth and Environment*, *2*(1), 1–7. https://doi.org/10.1038/s43247-021-00161-3

Guo, Z., Wang, L., Cong, W., Jiang, Z., & Liang, Z. (2021). Comparative analysis of the ecological succession of microbial communities on two artificial reef materials. *Microorganisms*, *9*(1), 1–18. https://doi.org/10.3390/microorganisms9010120

Ha, Y., Park, B., Kim, Y., & Lee, K. (2021). *Experimental Investigation on Structural Responses of a Partially Submerged 2D Flat Plate with Hammering and Breaking Waves for Numerical Validation*.

Hamzah, F., & Trenggono, M. (2014). Oksigen Terlarut Di Selat Lombok. *Jurnal Kelautan Nasional*, *9*(1), 21. https://doi.org/10.15578/jkn.v9i1.6199

UIN SUNAN AMPEL
S U R A B A Y A
http://digilib.uinsa.ac.id/ http://digilib.uinsa.ac.id/ http://digilib.uinsa.ac.id/

Hayek, M., Salgues, M., Souche, J. C., Cunge, E., Giraudel, C., & Paireau, O. (2021). Influence of the intrinsic characteristics of cementitious materials on biofouling in the marine environment. *Sustainability (Switzerland)*, *13*(5), 1–24. https://doi.org/10.3390/su13052625

He, S., Xue, Q., Fu, Z., Bao, L., Li, K., Zhang, G., Zhang, H., & Qiu, T. (2025). Biofouling Community Dynamics on Nylon and Polyethylene Aquaculture Nets in the North Yellow Sea: Colonization Patterns and Mytilus edulis Mechanical Properties. *Water (Switzerland)*, *17*(9). https://doi.org/10.3390/w17091250

Hindenberg, L. M., & Büsse, S. (2022). *Functional morphology of cirri in the barnacle Amphibalanus improvisus (crustacea : Balanidae)*. *August*, 1–12. https://doi.org/10.1002/jmor.21517

Iglikowska, A., Ronowicz, M., & Kuklin, P. (2018). *Trace element accumulation in the shell of the Arctic cirriped Balanus balanus*. 43–56. https://doi.org/10.1007/s10750-018-3564-5

James, B. D., Kimmins, K. M., Nguyen, M. T., Lausch, A. J., & Sone, E. D. (2021). Attachment of zebra and quagga mussel adhesive plaques to diverse substrates. *Scientific Reports*, *11*(1), 1–10. https://doi.org/10.1038/s41598-021-03227-6

Kasmini, L., & Agung Setia. (2022). *DEPIK Biology and ecological functional of Genus Crassostrea (Bivalvia : Ostreidae): a review*. *11*(November 2021), 75–84. https://doi.org/10.13170/depik.11.1.23444

Khasanah, N., Anggoro, S., & Purnomo, P. W. (2023). Karakteristik Hasil Tangkapan dan Pola Osmoregulasi Larva Ikan Sidat (Anguilla sp.) di Perairan Muara dan Bendung Kebasen Sungai Serayu. *Management of Aquatic Resources Journal (MAQUARES)*, *10*(2), 63–71. https://doi.org/10.14710/marj.v10i2.28249

Kim, S. L., & Yu, O. H. (2024). Invasion and ecological impact of the biofouling tube worm Hydroides elegans (Polychaeta: Serpulidae) in Korean coastal waters. *Frontiers in Marine Science*, *11*. https://doi.org/10.3389/fmars.2024.1416546

UIN SUNAN AMPEL
S U R A B A Y A
http://digilib.uinsa.ac.id/ http://digilib.uinsa.ac.id/ http://digilib.uinsa.ac.id/

Kirkiz, I., & Cavas, L. (2023). *First Barnacle (Amphibalanus amphitrite) Adhesion Strength Data on the Self-Polishing Coatings Off the Aegean Sea*. https://doi.org/10.1021/acsomega.3c03948

Kvetkina, A., Kostina, E., Gladkikh, I., Chausova, V., Yurchenko, E., Bakunina, I., Pivkin, M., Anastyuk, S., Popov, R., Monastyrnaya, M., Kozlovskaya, E., Isaeva, M., Dmitrenok, P., & Leychenko, E. (2021). Deep-sea anemones are prospective source of new antimicrobial and cytotoxic compounds. *Marine Drugs*, *19*(12), 1–18. https://doi.org/10.3390/md19120654

Lam, K., & Morton, B. (2006). *Morphological andMitochondrial-DNA Analysis of the Indo-West Pacific Rock Oysters (Ostreidae: Saccostrea Species)*. *April*, 235–245. https://doi.org/10.1093/mollus/eyl002

Lenak, M. M., Roeroe, K., Paruntu, C., Mangindaan, R., Manembu, I., & Rimper, J. (2025). Study of Scleractinian Coral Recruitment in the Waters of Tanjung Pisok and Siladen Island, Bunaken National Park. *Jurnal Ilmiah Platax*, *13*(1), 58–65. https://doi.org/10.35800/jip.v13i1.58540

Lestari, H. A., Samawi, M. F., Faizal, A., Moore, A. M., & Jompa, J. (2021). Physical and Chemical Parameters of Estuarine Waters around South Sulawesi. *Indonesian Journal of Geography*, *53*(3), 373–387. https://doi.org/10.22146/IJG.67831

Li, J., Sun, W., Cao, Y., Wu, J., Duan, L., Zhang, M., Luo, X., Deng, Q., Peng, Z., Mou, X., Li, W., & Wang, P. (2025). Increased temperature enhances microbial-mediated lignin decomposition in river sediment. *Microbiome*, *13*(1). https://doi.org/10.1186/s40168-025-02076-z

Li, Y., & Cao, Y. (2019). The molecular mechanisms underlying mussel adhesion. *Nanoscale Advances*, *1*(11), 4246–4257. https://doi.org/10.1039/c9na00582j

Liang, C., Strickland, J., Ye, Z., Wu, W., Hu, B., & Rittschof, D. (2019). Biochemistry of Barnacle Adhesion: An Updated Review. *Frontiers in Marine Science*, *6*(September), 1–20. https://doi.org/10.3389/fmars.2019.00565

Liu, Q., Guo, Y., Yang, Y., Mao, J., Wang, X., & Liu, H. (2024). *Geometric*

UIN SUNAN AMPEL
S U R A B A Y A
http://digilib.uinsa.ac.id/ http://digilib.uinsa.ac.id/ http://digilib.uinsa.ac.id/

morphometric methods for identification of oyster species based on morphology. 1–16. https://doi.org/10.3897/BDJ.12.e115019

Lungari, F. F., Balansa, W., & Sambeka, Y. (2022). Uji Material Plywood Perahu Penangkap Tuna Tipe Pumpboat Di Sangihe Terhadap Serangan Biofoulling. *Jurnal Ilmiah Tindalung*, *8*(1), 1–6. https://doi.org/10.54484/jit.v8i1.513

Marochow, T., Jusufagic, L., Finlay, J. A., Allen, P., Clare, A. S., & Rosenhahn, A. (2026). *Materials Advances Reducing attachment of marine diatoms and bacteria by fine tuning the modulus of PDMS based coatings*. 366–376. https://doi.org/10.1039/d5ma01133g

Maslukah, L., & Indrayanti, E. (2014). *Proses Pasang Surut dalam Pola Fluktuasi Nutrien Fosfat di Muara Sungai Demaan , Jepara*. *3*(1), 10–12.

Matikinca, P., & Zondi, V. (2025a). *The implications of arti fi cial substrate material type for sessile fouling communities along the South African east coast*. *March*, 1–13. https://doi.org/10.3389/fmars.2025.1511921

Matikinca, P., & Zondi, V. (2025b). The implications of artificial substrate material type for sessile fouling communities along the South African east coast. *Frontiers in Marine Science*, *12*. https://doi.org/10.3389/fmars.2025.1511921

Mugge, R. L., & Moseley, R. D. (2023). *Substrate Specificity of Biofilms Proximate to Historic Shipwrecks*. 1–19.

Musdalipah. (2023). Eksplorasi Keanekaragaman Spons Asal WilayahPesisir Sulawesi Tenggara Sebagai Bahan Baku Obat. *Jurnal Warta Farmasi*, *11*(2), 1–18. https://doi.org/10.46356/wfarmasi.v8i1

Nurjumanis, A., Pranowo, W. S., Setiyadi, J., Sumardana, I. W. E., & Sunaryo, S. (2024). Distribusi Nitrat di Perairan Selat Sunda. *Jurnal Hidropilar*, *10*(1), 1–8. https://doi.org/10.37875/hidropilar.v10i1.286

Obayomi, K. S., Mustapha, L. S., Yahya, M. D., & Obayomi, O. V. (2025). Antimicrobial materials for water infrastructure: Mitigating biofouling and pathogen contamination. *Journal of Hazardous Materials Advances*, *20*. https://doi.org/10.1016/j.hazadv.2025.100896

UIN SUNAN AMPEL
S U R A B A Y A
http://digilib.uinsa.ac.id/ http://digilib.uinsa.ac.id/ http://digilib.uinsa.ac.id/

Oyster, P., Farming, L., Maxima, P., Lahan, D. I., Pt, B., Pearl, A., Jefri, E., & Yasir, I. (2019). *Budidaya PT . Autore Pearl Culture Lombok Biofouling Culture Lombok Biofouling Found on Pearl Oyster (Pinctada maxima) Land Farming of PT . Autore Pearl Culture , Lombok*. *March*. https://doi.org/10.20956/jiks.v3i2.3001

Perdanawati, R. A., Risdanareni, P., Setiamarga, D. H. E., & Jaya, J. (2025). *The Effect of Biofouling on Cement based Concrete Substrate : Insights from Microfouling and Macrofouling Growth*. *06001*.

Petersen, D. S., Gorb, S. N., & Heepe, L. (2020). *The Influence of Material and Roughness on the Settlement and the Adhesive Strength of the Barnacle Balanus Improvisus in the Baltic Sea*. *7*(August), 1–14. https://doi.org/10.3389/fmars.2020.00664

Putri, D. S., Jayanthi, O. W., Wicaksono, A., Kartika, A. G. D., Effendy, M., Hariyanti, A., & Rahmadani, P. A. (2021). Distribusi Nitrat di Perairan Padelegan sebagai Bahan Baku Garam yang Berkualitas. *Juvenil: Jurnal Ilmiah Kelautan Dan Perikanan*, *2*(4), 288–292. http://doi.org/10.21107/juvenil.v2i4.12822ABSTRAK

Putriningtias, A., Bahri, S., Faisal, T. M., & Harahap, A. (2021). Water Quality in Coastal Area of Ujung Perling Island, Langsa City, Aceh. *Habitus Aquatica: Journal of Aquatic Resources and Fisheries Management*, *2*(2), 95–99.

Putro, S. P., Dafiq, M., Haqi, A. L., Muhammad, F., Hariyati, R., & Helmi, M. (2024). *The influence of different substrate types on the diversity of macrofouling organisms at the submerged coastal ecosystem of Karimunjawa Islands , Indonesia*. *25*(8), 3394–3400. https://doi.org/10.13057/biodiv/d250810

Rahmadani, P. A., Wicaksono, A., Jayanthi, O. W., Effendy, M., Nuzula, N. I., Kartika, A. G. D., Syaifullah, M., Putri, D. S., & Hariyanti, A. (2021). Analisa Kadar Fosfat Sebagai Parameter Cemaran Bahan Baku. *Juvenil*, *2*(4), 318–323.

Raine, J. J., Aldred, N., & Clare, A. S. (2020). *Anatomy and Ultrastructure of the*

UIN SUNAN AMPEL
S U R A B A Y A
http://digilib.uinsa.ac.id/ http://digilib.uinsa.ac.id/ http://digilib.uinsa.ac.id/

Cyprid Temporary Adhesive System in Two Species of Acorn Barnacle.

Ranawudd, U. I., Apriansyah, A., & Safitri, I. (2025). Penentuan Indeks Kesehatan Laut Berdasarkan Parameter Oseanografi di Perairan Kabupaten Sambas. *Jurnal Ilmu Lingkungan*, *23*(2), 487–490. https://doi.org/10.14710/jil.23.2.487-490

Richard, K. N., Hunsucker, K. Z., Hunsucker, T., & Swain, G. (2024). The Benefits of Biofouling – Promoting the Growth of Benthic Organisms to Enhance Ecosystem Services. *Journal of Ecological Engineering*, *25*(9), 133–155. https://doi.org/10.12911/22998993/190642

Riisgård, H. U., & Larsen, P. S. (2026). *Ciliary Structures and Particle-Capture Mechanisms in Marine Filter-Feeding Bivalves*. 1–15.

Rizqina, C. (2017). *Hubungan antara kandungan nitrat dan fosfat dengan kelimpahan fitoplankton di Perairan Pulau Pari, Kepulauan Seribu.. 6*, 43–50.

Roberts, E. A., & Carrington, E. (2023). Energetic scope limits growth but not byssal thread production of two Mytilid mussels. *Journal of Experimental Marine Biology and Ecology*, *567*. https://doi.org/10.1016/j.jembe.2023.151927

Rombe, K. H., Rosalina, D., Jusliana, Surachmat, A., Arafat, Y., Hawati, Najih, M. R., Amiluddin, M., Rahman, A., & Hermawan, R. (2023). Kepadatan Dan Keanekaragaman Animal Fouling Pada Dermaga Beton Di Pulau Harapan, Balai Taman Nasional Kepulauan Seribu Density and Diversity of Animal Fouling At the Concrete Pier on Pulau Harapan, Seribu Island. *Jurnal Kelautan*, *16*(3), 243–250. http://doi.org/10.21107/jk.v16i3.21201ABSTRAK

Sa'adah, N. (2023). *Analisis Porositas dan Permeabilitas Batuan pada Daerah Rawan Longsor menggunakan Teknik Pengolahan Citra Digital (Studi Kasus Daerah Longsor Desa Prendengan Kecamatan Banjarmangu Kabupaten Banjarnegara)*. *21*(02), 12–19.

Sakinah, W., Kusnadi, R. F., Prasetiaji, D. B., Aji, P. P., Widityo, R. P. G., &

UIN SUNAN AMPEL
S U R A B A Y A
http://digilib.uinsa.ac.id/ http://digilib.uinsa.ac.id/ http://digilib.uinsa.ac.id/

Kristianta, F. X. (2023). The Effect of Shipbuilding Material Type on Biofouling Growth at Boom Marina, Banyuwangi, East Java, Indonesia. *Jurnal Kelautan: Indonesian Journal of Marine Science and Technology*, *16*(1), 44–51. https://doi.org/10.21107/jk.v16i1.17964

Sari, R. S., Wulandari, S. Y., Maslukah, L., Kunarso, K., & Wirasatriya, A. (2022). Konsentrasi Ion Fosfat di Perairan Wiso, Ujungbatu, Jepara. *Indonesian Journal of Oceanography*, *4*(1), 88–95. https://doi.org/10.14710/ijoce.v4i1.13233

Shaw, J., Kang, Y., Triano, C., Hoppe, C. J., Aldred, N., Metzler, R. A., & Dickinson, G. H. (2024). *Elemental Properties in Adult Acorn Barnacles*. 1–14.

Solin, D. P., Utomo, N., & Zainab, S. (2019). *Analisis Hubungan Antara Porositas Dengan Penyerapan Air*. *5*, 33–36.

Stanley, S. M. (2015). *Treatise Online (Functional Shell Morphology of Noncementing Bivalvia)*. *1*(71).

Tesler, A. B. (2025). *Anti - Biofouling Coatings Based on Ultra - Slippery Surfaces*. 1537–1542. https://doi.org/10.1002/cbin.70065

Thybring, E. E., Fredriksson, M., Zelinka, S. L., & Glass, S. V. (2022). *Water in Wood : A Review of Current Understanding and Knowledge Gaps*.

Uzun, D., Ozyurt, R., Demirel, Y. K., & Turan, O. (2020). Does the barnacle settlement pattern affect ship resistance and powering? *Applied Ocean Research*, *95*. https://doi.org/10.1016/j.apor.2019.102020

Vinagre, P. A., Simas, T., Cruz, E., Pinori, E., & Svenson, J. (2020). *Marine Biofouling : A European Database for the Marine Renewable Energy Sector*.

Vuong, P., McKinley, A., & Kaur, P. (2023a). Understanding biofouling and contaminant accretion on submerged marine structures. *Npj Materials Degradation*, *7*(1), 1–11. https://doi.org/10.1038/s41529-023-00370-5

Vuong, P., McKinley, A., & Kaur, P. (2023b). Understanding biofouling and

UIN SUNAN AMPEL
S U R A B A Y A
http://digilib.uinsa.ac.id/ http://digilib.uinsa.ac.id/ http://digilib.uinsa.ac.id/

contaminant accretion on submerged marine structures. *Npj Materials Degradation*, *7*(1), 1–11. https://doi.org/10.1038/s41529-023-00370-5

Wahyu, I. E. N., Prasita, V. D., & Pranowo, W. S. (2024). Karakter Oksigen (O_2) Terlarut di Perairan Selat Madura Tahun 2022. *Jurnal Hidropilar*, *10*(1), 9–16. https://doi.org/10.37875/hidropilar.v10i1.331

Wahyuni, E. A. (2017). *Karakteristik pH dan Pengaruhnya Terhadap Bakteri Coliform di Perairan Selat Madura Kabupaten Pamekasan*. *6*(3), 214–220. https://doi.org/10.13170/depik.6.3.5875

Wang, F., & Zhao, L. (2023). *Coordinated Trajectory Planning for Multiple Autonomous Underwater Vehicles : A Parallel Grey Wolf Optimizer*.

Wang, Y., Li, L., An, M., Sun, Y., Yu, Z., & Huang, H. (2022). *applied sciences Factors Influencing the Capillary Water Absorption Characteristics of Concrete and Their Relationship to Pore Structure*.

Weber, F., & Esmaeili, N. (2023). Marine biofouling and the role of biocidal coatings in balancing environmental impacts. *Biofouling*, *39*(6), 661–681. https://doi.org/10.1080/08927014.2023.2246906

Widyanto, S. W., Ma'muri, & Prasetiawan, N. R. (2019). Desain Prototipe Antifouling Pada Pengembangan Teknologi Pemantauan. *Artikel Pemakalah Paralel*, 407–416.

Wong, F., Myan, Y., Walker, J., & Paramor, O. (2013). *The interaction of marine fouling organisms with topography of varied scale and geometry : a review*. 1–13.

Xu, X., & Wang, Z. (2025). *Exogenous adenosine promotes barnacle (Amphibalanus amphitrite) cyprid settlement through molecular signaling and improved adhesive mechanics*. 1–11.

Yan, G., Sun, J., Wang, Z., Qian, P. Y., & He, L. (2020). Insights into the synthesis, secretion and curing of barnacle cyprid adhesive via transcriptomic and proteomic analyses of the cement gland. *Marine Drugs*, *18*(4). https://doi.org/10.3390/md18040186

UIN SUNAN AMPEL
S U R A B A Y A

http://digilib.uinsa.ac.id/ http://digilib.uinsa.ac.id/ http://digilib.uinsa.ac.id/

Yang, L., Gao, D., Zhang, Y., & Tang, J. (2019). *Relationship between sorptivity and capillary coefficient for water absorption of cement-based materials : theory analysis and experiment*.

Yanovski, R., Barak, H., Brickner, I., Kushmaro, A., & Abelson, A. (2024). The microbial community of coral reefs: biofilm composition on artificial substrates under different environmental conditions. *Marine Biology*, *171*(3). https://doi.org/10.1007/s00227-024-04400-x

Yılmazer, S. (2023). *Water absorption, thickness swelling and mechanical properties of cement bonded wood. 2023*(25), 1–10. https://doi.org/10.4067/s0718-221x2023000100434

Yulianda, F., & Atmadipura, A. S. (2020). *Pertumbuhan Tiram Crassostrea Sp . Yang Menempel Pada Pengumpul Kerang Dan Batu (Growth of Oyster Crassostrea Sp Settled on Shell and Stone Collectors)*. *4*(2), 56–59.

Yurchenko, O. V, Skiteva, O. I., Voronezhskaya, E. E., & Dyachuk, V. A. (2018). *Nervous system development in the Pacific oyster , Crassostrea gigas (Mollusca : Bivalvia)*. 1–21.

Yusal, M. S., & Hasyim, A. (2022). Kajian Kualitas Air Berdasarkan Keanekaragaman Meiofauna dan Parameter Fisika-Kimia di Pesisir Losari, Makassar. *Jurnal Ilmu Lingkungan*, *20*(1), 45–57. https://doi.org/10.14710/jil.20.1.45-57

UIN SUNAN AMPEL
S U R A B A Y A

http://digilib.uinsa.ac.id/ http://digilib.uinsa.ac.id/ http://digilib.uinsa.ac.id/