



Baseline

Crinoids found as non-native rafters on beached fishing gear in the Netherlands (1936–1951) before the Plasticene

Bert W. Hoeksema^{a,b,*} , Piet A.J. Bakker^c ^a Marine Evolution and Ecology Group, Naturalis Biodiversity Center, P.O. Box 9517, 2300 RA, Leiden, the Netherlands^b Groningen Institute for Evolutionary Life Sciences, University of Groningen, P.O. Box 11103, 9700 CC, Groningen, the Netherlands^c Collections, Naturalis Biodiversity Center, P.O. Box 9517, 2300 RA, Leiden, the Netherlands

ARTICLE INFO

Keywords:

Antedon bifida
Long-distance dispersal
Marine litter
Museum collections
Plastic era
Rafting

ABSTRACT

Seven samples of juvenile *Antedon bifida* (Pennant, 1777) were collected at five localities along the North Sea beach of the Netherlands from January 1936 to December 1951. This crinoid echinoderm is not native to the Netherlands and naturally occurs on rocky substrates ranging from the Shetland Islands to the Canary Islands and the western Mediterranean. The samples were found on bunches of cork fishing floats that had washed ashore. The specimens were deposited in the echinoderm collections of two museum, where they were rediscovered recently. They represent the first records of rafting crinoids on marine anthropogenic litter and predate the Plasticene, which started in the 1950s when plastic started to replace many other materials. Museum collections may still contain undiscovered specimens of non-native species found before their first recorded introduction, potentially shifting baselines back in time.

There is a growing amount of literature on marine anthropogenic debris that may serve as substrate for various kinds of fouling invertebrates, ranging in depth from the sea floor (Ballesteros et al., 2018; Hoeksema and Hermanto, 2018; Mantelatto et al., 2020; Gönülal et al., 2024; Mehrotra et al., 2024; Payton et al., 2026; Pongsakun et al., 2026) to the ocean surface (Hoeksema et al., 2018; Faria and Kitahara, 2020; Rech et al., 2021, 2023; González-Ortegón et al., 2024). The latter category may act as a vector for long-distance dispersal by species that are able to survive for long periods of time, possibly reaching localities outside their native range (Rech et al., 2016, 2018a; García-Gómez et al., 2021).

A large component of marine litter consists of plastics, which started to become increasingly abundant since the mid-20th century, also considered the start of the Plasticene era because it stratigraphically marks the lower depositional record of a growing layer of plastic (Zalasiewicz et al., 2016; Haram et al., 2020). However, some authors prefer to include the first half of the 20th century in this era because the first plastic was invented in 1907 (Rangel-Buitrago et al., 2022; Ilchukwu et al., 2023).

Lost fishing gear is suspected to be the most dominant part of marine plastic pollution (Rech et al., 2018b; Richardson et al., 2019; Wright et al., 2021; Shankar et al., 2025). This concerns nets and ropes

consisting of filaments and fibres made of nylon, polyethylene or polypropylene (Nelms et al., 2021; Føre et al., 2023). Before the 1950s, nets and ropes were made of non-synthetic fibres, such as cotton, flax or hemp (Sahrhage and Lundbeck, 1992; Deroiné et al., 2019; Le Gué et al., 2025). Historically, fishing buoys were also made of organic materials, such as wood, bamboo, or bark (in particular cork), which have been used for thousands of years (Brabazon, 1848; Holdsworth, 1883; Stockwell, 1947; Yamaguchi, 1989a; Alfaro Giner, 2010).

Fishing buoys are also found as part of derelict fishing gear in the sea or on the shore (Stachowitsch, 2018; Haram et al., 2021). Glass fish net floats, invented in the 1840s, were first utilized in Europe and later in Japan (Yamaguchi, 1989b; Ebbesmeyer and Scigliano, 2009; Stachowitsch, 2018). Some of these glass balls have been found washed up on beaches with fouling organisms, such as corals (Jokiel, 1984; Adema, 1987). In the Plasticene, fishing floats were increasingly made of polystyrene, polyurethane and polyvinylchloride (PVC) (Pruter, 1987; Chaves and Silveira, 2016; Stachowitsch, 2018), which also turned up in studies on rafting invertebrates (Thiel and Gutow, 2005a; Astudillo et al., 2009; Goldstein et al., 2014; Kiessling et al., 2015; Rech et al., 2018a, 2025). Alternatively, metal fish buoys also came into use in the 1950s (Bates, 2025).

Little published information is available about washed-up fishing

* Corresponding author at: Groningen Institute for Evolutionary Life Sciences, University of Groningen, P.O. Box 11103, 9700 CC, Groningen, the Netherlands.
E-mail address: bert.hoeksema@naturalis.nl (B.W. Hoeksema).



Fig. 1. Storage jars containing juvenile *Antedon bifida* that was beached at the Netherlands. The specimens are stored in ethanol 70% with museum collection numbers: (a) ZMA.ECH.C.7112.01, (b) ZMA.ECH.C.7103, (c) ZMA.ECH.C.7113, (d) RMNH.ECH.3948 and RMNH.ECH.3949, (e) ZMA.ECH.C.7105, (f) RMNH.ECH.2211. Scale bars: 1 cm. Photo credits: P.A.J. Bakker.

gear that predates the Plasticene. At that time, not much attention was given to marine debris itself and more emphasis was given to rafting organisms found on it, in particular those that had drifted from far away. Such observations were often made by beachcombers with an interest in natural history (Moore, 2014). Moreover, floating debris in the pre-Plasticene would probably have degraded more easily than plastic litter, therefore being more short-lived and drifting over shorter

distances. In contrast, present-day plastic objects are well-known for being buoyant and durable, depending on their size (Fazey and Ryan, 2016; Kaandorp et al., 2023). Thus, published observations on degradable litter of the pre-Plasticene serving as substrate for rafting animals are uncommon. Classic examples are a wooden beam (Fielden, 1893), a floating log (Jones, 1907), and a coconut shell (Crossland, 1952), all reported to be occupied by corals.

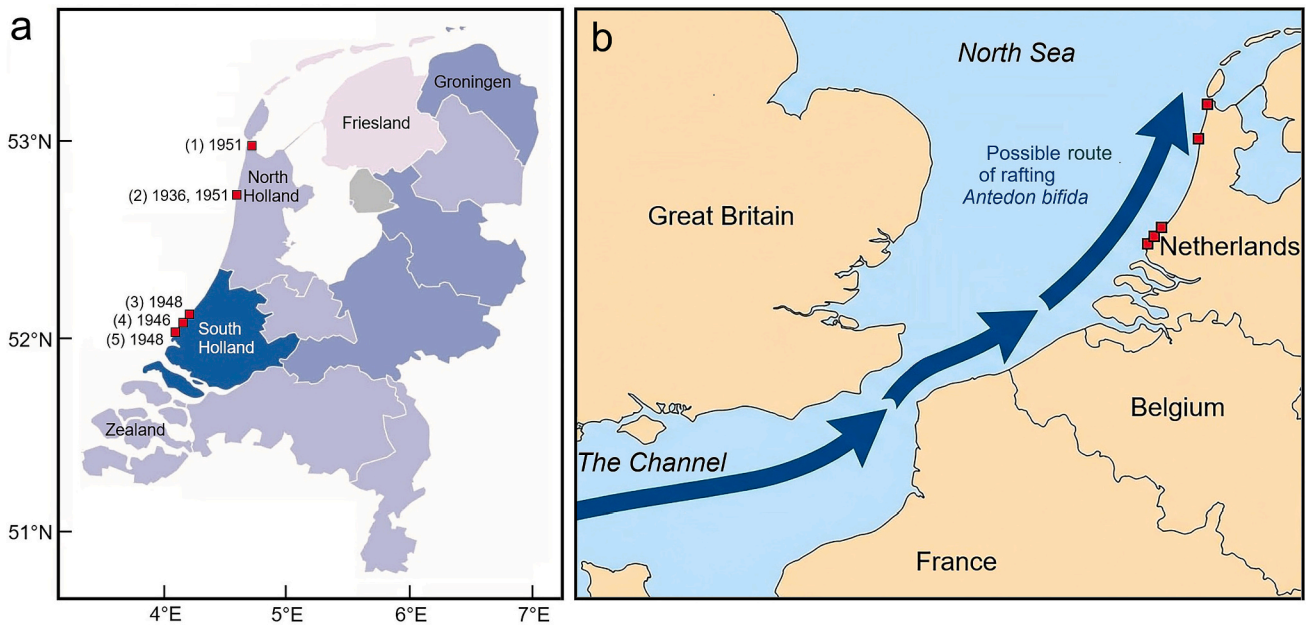


Fig. 2. Maps (1936–1951) of the Netherlands and the southern North Sea. **a** Dutch coastal provinces and the beach localities (1–5 in Table 1) where specimens of *Antedon bifida* were found on cork fishing floats (red squares). **b** The most probable trajectory of rafting *A. bifida* from the Channel to the Netherlands (after Wolff, 2005; Meyerjürgens et al., 2019). (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)



Fig. 3. Examples of cork floats. **(a, b)** Two original French cork floats that served as substrate for bryozoans (RMNH.BRY.2520) collected on 19 October 1947 at locality 4 (Fig. 2) by J. van der Meulen; scale bars: 2.5 cm. Photo credits: P.A.J. Bakker.

With the centuries-long use of cork fishing floats in the pre-Plasticene it is likely that they could have served as substrate for marine invertebrates after they got lost and started to drift with currents. Despite this, not many examples are known or they may have been forgotten. There are various little-mentioned historical records of bryozoans on cork floats along the Dutch coast (Lacourt, 1949) and a recent Irish record of some corals on a large piece of cork (Quigley et al., 2020). Also, many people (except for beachcombing naturalists) may not have paid much attention to biodegradable cork floats, whereas nowadays plastic floats are considered litter that is worthy of investigation. In retrospect,

traditional cork floats might also have been able to assist in long-distance transport of rafting animals and they could also have been relevant in the dispersal of non-native species, like present-day plastic materials (Thiel and Haye, 2006; Spencer et al., 2025). However, published evidence for this hypothesis appears to be lacking. Therefore we report here on non-native crinoids found on cork floats washed-up along the Dutch North Sea coastline before the Plasticene.

During a maintenance check of the Echinodermata collection at Naturalis Biodiversity Center in Leiden, six jars were found containing seven samples of juvenile rosy feather star, *Antedon bifida* (Pennant,

Table 1

Localities where beached cork floats with juvenile *Antedon bifida* specimens were collected along the Dutch North Sea coast from 1936 to 1951 (Fig. 2). Naturalis museum catalogue numbers: RMNH = Rijksmuseum van Natuurlijke Historie, Leiden; ZMA = Zoologisch Museum van Amsterdam.

Locality	Date	Collector	Museum catalogue nrs.
1. Den Helder, North Holland	19 January 1951	C. Swennen	ZMA.ECH. C.7112.01
2. Camperduin, North Holland	11 January 1936	C.O. van Regteren Altena	ZMA.ECH. C.7103, 7113
2. Camperduin, North Holland	9 December 1951	H. Leys	RMNH. ECH.3948
3. Between Scheveningen and Wassenaar, South Holland	21 September 1948	P. Leenhouts	ZMA.ECH. C.7105
4. Kijkduin, South Holland	19 October 1946	J. van der Meulen	RMNH. ECH.2211
5. s-Gravenzande, South Holland	9 September 1948	A. Bloklander	RMNH. ECH.3949

1777), stored in ethanol (70%). The specimens belonged to the collections of the previous Rijksmuseum van Natuurlijke Historie at Leiden (catalogue numbers starting with “RMNH.ECH”) and the former Zoologisch Museum van Amsterdam at Amsterdam (cat. Nrs. starting with “ZMA.ECH.C.”) (Fig. 1).

The specimens were collected on North Sea beaches along the coastline of the provinces of North Holland and South Holland in the period 1936–1951 (Fig. 2; Table 1). They were found attached to bundles of so-called French cork floats, similar to those with bryozoans (Lacourt, 1949; Fig. 3), which were probably held together by ropes and nets (Fig. S1). Bunches of cork were commonly used by French and British fishermen in the western part of the Channel to mark their lobster pots (Wolff, 2005). They may have become detached during storms after which they may have been transported by currents to the Dutch coastline, following a common trajectory of floating macroalgae and litter (Wolff, 2005; Meyerjürgens et al., 2019).

Antedon bifida is a comatulid crinoid of the phylum Echinodermata, which occurs in the NE Atlantic, ranging from the Shetland Islands to the Canary Islands and the western Mediterranean (Hill, 2008). It is most commonly recorded in the western Channel off western France (Brittany) and around the British Isles, apart from their southeastern part (Messing et al., 2026). One locality has been reported from offshore the Netherlands in the southern North Sea (Messing et al., 2026), which is based on a record by Massin and De Ridder (1989), who mention no specific locality besides “Pays Bas” (Netherlands) and do not cite a source. However, in their publication there is a reference on Dutch echinoderms (Wolff, 1968), which reports on juvenile *A. bifida* on floating objects washed ashore in the Netherlands, likely from the English Channel because of the accompanying seaweed flora. Wolff (1968) refers to unspecified museum specimens which are probably the same as those reported in the present study. The offshore locality mentioned by Messing et al. (2026) is therefore unjustified.

Antedon bifida naturally lives on rocky shore lines (Nichols, 1994; Readman and Hill, 2016), from the shallow sublittoral to depths of 450 m, but most commonly at 15–40 m (La Touche, 1978; Hill, 2008). Rocky

coastlines cannot be found in the Netherlands, except for dikes, such as those in the province of Zeeland, which is popular among SCUBA divers, but *A. bifida* has never been reported from there and neither from offshore wrecks, platforms, wind turbines, and other man-made benthic structures in the Dutch part of the North Sea (Wolff, 1968; Lengkeek et al., 2013; Schutter et al., 2019; Coolen et al., 2020; ter Hofstede et al., 2022; Mavraki et al., 2025; Stichting Anemoon, 2026). In free-living stage, the crinoid clings to rocky substrates by using its apical cirri (Lahaye and Jangoux, 1987). It is unclear whether the juvenile specimens on the cork floats were found dead or alive, but they were clearly detached from their original settlement stalk (Fig. 4). It is unclear whether they were collected while clinging to cork floats (e.g., Fig. 3) or entangled in nets or ropes attached to the buoys (Appendix A: Fig. S1).

Two aspects are remarkable in this story, one historical and the other biological. This case demonstrates that also before the Plasticene discarded fishing gear served as vector for the dispersal of marine invertebrates to destinations where they are not native. This implies that some invertebrate species rafting on lost fishing gear could have become introduced in non-native areas much earlier than the 1950s, after which research efforts became increasingly directed towards marine plastic pollution. Thus the baseline of discarded fishing gear as dispersal vector does not start with the Plasticene, but earlier, when fishing materials were less durable and may have become lost much more easily. Natural history collections may become important in finding early records of non-native invertebrates on man-made substrates, either dead or alive, and nearby or remote from their native range. This example shows the importance of natural history collections as a depository for zoological voucher specimens collected from beached litter or other artificial substrates, making them available for future studies (Hoeksema et al., 2012, 2025; Samimi-Namin et al., 2022).

It is peculiar that in the present case a non-native species was found on six occasions within a time span of only 16 years, from January 1936 to December 1951, by six different observers at five localities in only two provinces along the Dutch North Sea coastline (Table 1; Fig. 2). This raises the question why they were not recorded earlier, not in a larger area, and also not later, on plastic floats. Perhaps the first finding increased awareness among naturalist beachcombers to look out for French cork floats as substrates for fouling alien species (Fig. 3), encouraging a chase for new records and causing an observer-expectancy effect (see Hoeksema and Yonow, 2021). These two provinces were probably more densely populated by citizen scientists with easy access to the beach than the other Dutch coastal provinces. It is remarkable that these six observers took the effort to bring the specimens to natural history museums (also based in these two provinces), indicating that they recognized their scientific relevance. Perhaps afterwards, lost fishing gear made of more durable plastic did not wash up as frequently, or it did not catch new specimens in the native range, and interest in *A. bifida* may have become lost in the Netherlands.

This observation is of zoological relevance because echinoderms, and crinoids in particular, are not commonly reported in studies on rafting or beached litter (Thiel and Gutow, 2005b). Rafting of juvenile or adult crinoids on algae has been suggested as an possible explanation for the wide range of the comatulid *Aporometra wilsoni* (Bell, 1888) across southern Australia, but there are no published observations to support this theory (Helgen and Rouse, 2006). This is not an improbable



Fig. 4. Samples of juvenile *Antedon bifida* beached at the Netherlands while attached to clusters of cork fishing floats in the period 1936–1951. Museum collection numbers: (a, b) ZMA.ECH.C.7103, (c, d) ZMA.ECH.C.7105, (e, f) RMNH.ECH.2211. Scale bars. 0.25 cm. Photo credits: L. Meester.

hypothesis though, since rafting on seaweed has been reported for the crinoid *Comanthus* sp. in Japan (Hirosaki, 1964). Furthermore, there are several records of fossil stalked crinoids on driftwood (Hagdorn, 2016; Hunter et al., 2020).

Recent faunistic studies about rafting on derelict fishing gear and other litter, usually mention annelids, arthropods, bryozoans, cnidarians, and molluscs (Rech et al., 2018a, 2018b, 2018c, 2021; Haram et al., 2023; Kannan et al., 2023; Mghili et al., 2023), and occasionally ophiuroids (brittle stars) (Goldstein et al., 2014; Mghili et al., 2022;

Subías-Baratau et al., 2022), which have the ability to cling to solid substrates with the help of their spiny, flexible arms. Thus, there appear to be no other records of rafting crinoids on man-made substrates, besides those of 75–90 years ago in the present study. This study suggests that additional unique fouling or rafting specimens may still be hidden in historical museum collections, where also old historical records of non-native species can be found, shifting baselines backward in time (Miyazaki et al., 2015; Encarnação et al., 2022; Hoeksema et al., 2025).

CRedit authorship contribution statement

Bert W. Hoeksema: Writing – review & editing, Writing – original draft, Supervision, Investigation, Conceptualization. **Piet A.J. Bakker:** Writing – review & editing, Methodology, Data curation.

Funding

This study did not receive external funding.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Acknowledgements

We thank Lisl Meester for taking the photographs of the samples. We are grateful to the editor and two anonymous reviewers for their constructive comments on the manuscript.

Appendix A. Supplementary data

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.marpolbul.2026.119834>.

Data availability

All data is contained in the present article, including Electronic Supplementary Material

References

- Adema, J.P.H.M., 1987. Een glazen drijver van een visnet aangespoeld op het strand tussen Katwijk en Noordwijk. *Het Zeepaard* 47, 146–152.
- Alfaro Giner, C., 2010. Fishing nets in the ancient world: the historical and archaeological evidence. In: Bekker-Nielsen, T., Bernal Casasola, D. (Eds.), *ancient nets and fishing gear: proceedings of the international workshop on nets and fishing gear in classical antiquity: a first approach: Cádiz, November 15-17, 2007*, Universidad de Cádiz, Spain, and Aarhus University press, Denmark, pp. 55–81.
- Astudillo, J.C., Bravo, M., Dumont, C.P., Thiel, M., 2009. Detached aquaculture buoys in the SE Pacific: potential dispersal vehicles for associated organisms. *Aquat. Biol.* 5, 219–231. <https://doi.org/10.3354/ab>.
- Ballesteros, L.V., Matthews, J.L., Hoeksema, B.W., 2018. Pollution and coral damage caused by derelict fishing gear on coral reefs around Koh Tao, Gulf of Thailand. *Mar. Pollut. Bull.* 135, 1107–1116. <https://doi.org/10.1016/j.marpolbul.2018.08.033>.
- Bates, S.M., 2025. *Networks: The Technological Development and Economic Significance of the Pelagic Trawl*. PhD Thesis. University of Iceland, Reykjavik.
- Brabazon, W., 1848. *The Deep Sea and Coast Fisheries of Ireland with Suggestions for the Working of a Fishing Company*. James McGlashan, Dublin.
- Chaves, P.D.T., Silveira, B.E.D., 2016. Artisanal fishing net float loss and a proposal for a float design solution. *Braz. J. Oceanogr.* 64, 89–94. <https://doi.org/10.1590/S1679-87592016114306401>.
- Coolen, J.W., van der Weide, B., Cuperus, J., Blomberg, M., van Moorsel, G.W., Faasse, M.A., et al., 2020. Benthic biodiversity on old platforms, young wind farms, and rocky reefs. *ICES J. Mar. Sci.* 77, 1250–1265. <https://doi.org/10.1093/icesjms/isy092>.
- Crossland, C., 1952. *Madreporaria, Hydrocorallinae, Heliopora and Tubipora*. In: *Great Barrier Reef Expedition 1928–29, Scientific Reports*, 6. British Museum (Natural History), London, pp. 86–257.
- Deroiné, M., Pillin, I., Le Maguer, G., Chauvel, M., Grohens, Y., 2019. Development of new generation fishing gear: a resistant and biodegradable monofilament. *Polym. Test.* 74, 163–169. <https://doi.org/10.1016/j.polymertesting.2018.11.039>.
- Ebbesmeyer, C., Scigliano, E., 2009. *Flotsametrics and the Floating World*. Harper Collins, New York.
- Encarnação, J., Krug, L.A., Teodósio, M.A., Morais, P., 2022. Coastal counter currents increase propagule pressure of an aquatic invasive species to an area where previous introductions failed. *Estuar. Coasts* 45, 2504–2518. <https://doi.org/10.1007/s12237-022-01092-8>.
- Faria, L.C., Kitahara, M.V., 2020. Invasive corals hitchhiking in the southwestern Atlantic. *Ecology* 101, e03066. <https://doi.org/10.1002/ecy.3066>.
- Fazey, F.M., Ryan, P.G., 2016. Debris size and buoyancy influence the dispersal distance of stranded litter. *Mar. Pollut. Bull.* 110, 371–377. <https://doi.org/10.1016/j.marpolbul.2016.06.039>.
- Fielden, H.W., 1893. Transportation of coral by the Gulf Stream. *The Zoologist (Ser. 3)* 17, 352–353.
- Føre, H.M., Hattlebrekke, H.H., Grimaldo, E., 2023. Alternative rope materials in towed fishing gear to reduce plastic waste, a comparative study of mechanical properties and tolerance against wear and tear. In: *Proceedings of the ASME 2023 42nd International Conference on Ocean, Offshore and Arctic Engineering*. <https://doi.org/10.1115/OMAE2023-104444>. OMAE2023, June 11–16, 2023, Melbourne, Australia.
- García-Gómez, J.C., Garrigós, M., Garrigós, J., 2021. Plastic as a vector of dispersion for marine species with invasive potential. A review. *Front. Ecol. Evol.* 9, 629756. <https://doi.org/10.3389/fevo.2021.629756>.
- Goldstein, M.C., Carson, H.S., Eriksen, M., 2014. Relationship of diversity and habitat area in North Pacific plastic-associated rafting communities. *Mar. Biol.* 161, 1441–1453. <https://doi.org/10.1007/s00227-014-2432-8>.
- Gönülal, O., Dalyan, C., Kesici, N.B., Aytan, Ü., 2024. Distribution and composition of seafloor litter and associated macrofouling organisms in the northeastern Mediterranean Sea. *Mar. Pollut. Bull.* 202, 116328. <https://doi.org/10.1016/j.marpolbul.2024.116328>.
- González-Ortegón, E., Demmer, J., Robins, P., Jenkins, S., 2024. Floating plastics as a potential dispersal vector for rafting marine non-native species. *Mar. Pollut. Bull.* 207, 116919. <https://doi.org/10.1016/j.marpolbul.2024.116919>.
- Hagdorn, H., 2016. From benthic to pseudoplanktonic life: morphological remodeling of the Triassic crinoid *Traumatocrinus* and the Jurassic *Seiocrinus* during habitat change. *Pal. Zeitschr.* 90, 225–241. <https://doi.org/10.1007/s12542-016-0285-9>.
- Haram, L.E., Carlton, J.T., Centurioni, L., Choong, H., Cornwell, B., Crowley, M., et al., 2023. Extent and reproduction of coastal species on plastic debris in the North Pacific subtropical gyre. *Nat. Ecol. Evol.* 7, 687–697. <https://doi.org/10.1038/s41559-023-01997-y>.
- Haram, L.E., Carlton, J.T., Centurioni, L., Crowley, M., Hafner, J., Maximenko, N., et al., 2021. Emergence of a neopelagic community through the establishment of coastal species on the high seas. *Nat. Commun.* 12, 6885. <https://doi.org/10.1038/s41467-021-27188-6>.
- Haram, L.E., Carlton, J.T., Ruiz, G.M., Maximenko, N.A., 2020. A Plasticene lexicon. *Mar. Pollut. Bull.* 150, 110714. <https://doi.org/10.1016/j.marpolbul.2019.110714>.
- Helgen, L.E., Rouse, G.W., 2006. Species delimitation and distribution in *Aporometra* (Crinoidea: Echinodermata): endemic Australian featherstars. *Invertebr. Syst.* 20, 395–414. <https://doi.org/10.1071/is05050>.
- Hill, J.M., 2008. *Antedon bifida* - rosy feather star. In: Tyler-Walters, H. (ed.), *Marine Life Information Network: Biology and Sensitivity Key Information Resources*, Plymouth: Marine Biological Association of the United Kingdom. <https://www.marlin.ac.uk/species/detail/1521> (Accessed 27 February 2026).
- Hirosaki, Y., 1964. Ecological study on fishes with the drifting seaweeds. III. Accompanying animals excluding fishes. *Misc. Rep. Res. Inst. Nat. Resour. Tokyo* 62, 63–70.
- Hoeksema, B.W., Hermanto, B., 2018. Plastic nets as substrate for reef corals in Lembah Strait, Indonesia. *Coral Reefs* 37, 631. <https://doi.org/10.1007/s00338-294-018-1686-x>.
- Hoeksema, B.W., Padoja, K., Poprawski, Y., 2018. Long-distance transport of a West Atlantic stony coral on a plastic raft. *Ecology* 99, 2402–2404. <https://doi.org/10.1002/ecy.2405>.
- Hoeksema, B.W., Roos, P.J., Cadée, G.C., 2012. Trans-Atlantic rafting by the brooding reef coral *Favia fragum* on man-made flotsam. *Mar. Ecol. Prog. Ser.* 445, 209–218. <https://doi.org/10.3354/meps09460>.
- Hoeksema, B.W., Taekema, W., Samimi-Namin, K., 2025. Dead non-native corals (*Tubastraea coccinea*) and their associated fauna trawled from the North Sea provide evidence for long-distance transport by hull fouling. *Mar. Pollut. Bull.* 215, 117839. <https://doi.org/10.1016/j.marpolbul.2025.117839>.
- Hoeksema, B.W., Yonow, N., 2021. Rarity in the native range of the Lessepsian migrant *Plocamopherus ocellatus* (Nudibranchia): fact or artifact? *Ecology* 102, e03481. <https://doi.org/10.1002/ecy.3481>.
- Holdsworth, E.W., 1883. *The Sea Fisheries of Great Britain and Ireland*. Edward Stanford, London.
- Hunter, A.W., Casenove, D., Mayers, C., Mitchell, E.G., 2020. Reconstructing the ecology of a Jurassic pseudoplanktonic raft colony. *R. Soc. Open Sci.* 7, 200142. <https://doi.org/10.1098/rsos.200142>.
- Ilechukwu, I., Das, R.R., Reimer, J.D., 2023. Review of microplastics in museum specimens: an under-utilized tool to better understand the Plasticene. *Mar. Pollut. Bull.* 191, 114922. <https://doi.org/10.1016/j.marpolbul.2023.114922>.
- Jokiel, P.L., 1984. Long distance dispersal of reef corals by rafting. *Coral Reefs* 3, 113–116. <https://doi.org/10.1007/BF00263761>.
- Jones, F.W., 1907. On the growth-forms and supposed species in corals. *Proc. Zool. Soc. London* 77, 518–556. <https://doi.org/10.1111/j.1469-7998.1907.tb06945.x>.
- Kaandorp, M.L.A., Lobelle, D., Kehl, C., Dijkstra, H.A., van Sebille, E., 2023. Global mass of buoyant marine plastics dominated by large long-lived debris. *Nat. Geosci.* 16, 689–694. <https://doi.org/10.1038/s41561-023-01216-0>.
- Kannan, G., Mghili, B., Di Martino, E., Sanchez-Vidal, A., Figuerola, B., 2023. Increasing risk of invasions by organisms on marine debris in the southeast coast of India. *Mar. Pollut. Bull.* 195, 115469. <https://doi.org/10.1016/j.marpolbul.2023.115469>.
- Kiessling, T., Gutow, L., Thiel, M., 2015. Marine litter as habitat and dispersal vector. In: Bergmann, M., Gutow, L., Klages, M. (Eds.), *Marine Anthropogenic Litter*. Springer, Cham, pp. 141–181. https://doi.org/10.1007/978-3-319-16510-3_6.
- La Touche, R.W., 1978. The feeding behaviour of the featherstar *Antedon bifida* (Echinodermata: Crinoidea). *J. Mar. Biol. Assoc. UK* 58, 877–890. <https://doi.org/10.1017/S0025315400056836>.
- Lacourt, A.W., 1949. Bryozoa of the Netherlands. *Arch. Néerl. Zool.* 8, 289–322.

- Lahaye, M.C., Jangoux, M., 1987. The skeleton of the stalked stages of the comatulid crinoid *Antedon bifida* (Echinodermata). *Zoomorphology* 107, 58–65. <https://doi.org/10.1007/BF00312130>.
- Le Gué, L., Arhant, M., Davies, P., Vincent, B., Tanguy, E., 2025. Biodegradable twine for trawl fishing: seawater ageing and net modelling. *Mar. Pollut. Bull.* 211, 117433. <https://doi.org/10.1016/j.marpolbul.2024.117433>.
- Lengkeek, W., Coolen, J.W.P., Gittenberger, A., Schrieken, N., 2013. Ecological relevance of shipwrecks in the North Sea. *Nederl. Faun. Med.* 41, 49–57.
- Mantelatto, M.C., Póvoa, A.A., Skinner, L.F., Araujo, F.V., Creed, J.C., 2020. Marine litter and wood debris as habitat and vector for the range expansion of invasive corals (*Tubastraea* spp.). *Mar. Pollut. Bull.* 160, 111659. <https://doi.org/10.1016/j.marpolbul.2020.111659>.
- Massin, C., De Ridder, C., 1989. Les échinodermes de Belgique. In: Wouters, K., Baert, L. (Eds.), *Invertébrés de Belgique*. l'Institut Royal des Sciences Naturelles de Belgique, Brussels, Belgium, pp. 395–402.
- Mavraki, N., Bos, O.G., van der Weide, B., Bittner, O., Vlaswinkel, B.M., Nalmpanti, M., Coolen, J.W., 2025. Inventory of the biofouling community on the first offshore solar energy farm in the North Sea. *J. Sea Res.* 208, 102627. <https://doi.org/10.1016/j.seares.2025.102627>.
- Mehrotra, R., Monchanin, C., Desmolles, M., Traipitsiriwat, S., Chakrabongse, D., Patel, A., et al., 2024. Assessing the scale and ecological impact of derelict and discarded fishing gear across Thailand via the MARsCI citizen science protocol. *Mar. Pollut. Bull.* 205, 116577. <https://doi.org/10.1016/j.marpolbul.2024.116577>.
- Messing, C., Gondim, A.I., Markello, K., Poatskievick Pierezan, B., Taylor, K., Eléaume, M., 2026. World list of Crinoidea. *Antedon bifida* (pennant, 1777). <http://www.marinespecies.org/aphia.php?p=taxdetails&id=124201> (Accessed 27 February 2026).
- Meyerjürgens, J., Badewien, T.H., Garaba, S.P., Wolff, J.O., Zielinski, O., 2019. A state-of-the-art compact surface drifter reveals pathways of floating marine litter in the German Bight. *Front. Mar. Sci.* 6, 58. <https://doi.org/10.3389/fmars.2019.00058>.
- Mghili, B., De-la-Torre, G., Analla, M., Aksissou, M., 2022. Marine macroinvertebrates fouled in marine anthropogenic litter in the Moroccan Mediterranean. *Mar. Pollut. Bull.* 185, 114266. <https://doi.org/10.1016/j.marpolbul.2022.114266>.
- Mghili, B., De-la-Torre, G.E., Aksissou, M., 2023. Assessing the potential for the introduction and spread of alien species with marine litter. *Mar. Pollut. Bull.* 191, 114913. <https://doi.org/10.1016/j.marpolbul.2023.114913>.
- Miyazaki, Y., Murase, A., Senou, H., 2015. A natural history museum as a platform for accumulating verifiable information on non-native fishes: a Japanese example. *Manag. Biol. Invasions* 6, 105–110. <https://doi.org/10.3391/mbi.2015.6.1.08>.
- Moore, P.G., 2014. Popularizing marine natural history in eighteenth- and nineteenth-century Britain. *Arch. Nat. Hist.* 41, 45–62. <https://doi.org/10.3366/anh.2014.0209>.
- Nelms, S.E., Duncan, E.M., Patel, S., Badola, R., Bhola, S., Chakma, S., et al., 2021. Riverine plastic pollution from fisheries: insights from the Ganges River system. *Sci. Total Environ.* 756, 143305. <https://doi.org/10.1016/j.scitotenv.2020.143305>.
- Nichols, D., 1994. Reproductive seasonality in the comatulid crinoid *Antedon bifida* (Pennant) from the English Channel. *Philos. Trans. R. Soc. Lond. Ser. B Biol. Sci.* 343, 113–134. <https://doi.org/10.1098/rstb.1994.0015>.
- Payton, T.G., Sims, R.J., Bulik, L.T., Childress, M.J., 2026. Marine clean-up dives remove more than just marine litter. *Mar. Pollut. Bull.* 226, 119382. <https://doi.org/10.1016/j.marpolbul.2026.119382>.
- Pengsakun, S., Yeemin, T., Sutthacheep, M., Junrak, L., Klinthong, W., Aunkhongthong, W., et al., 2026. Environmental effects of plastic pollution from lost, discarded, and abandoned fishing gear (ALDFG) on underwater pinnacles in the Gulf of Thailand. *Front. Mar. Sci.* 12, 1670284. <https://doi.org/10.3389/fmars.2025.1670284>.
- Pruter, A.T., 1987. Sources, quantities and distribution of persistent plastics in the marine environment. *Mar. Pollut. Bull.* 18, 305–310. [https://doi.org/10.1016/S0025-326X\(87\)80016-4](https://doi.org/10.1016/S0025-326X(87)80016-4).
- Quigley, D.T.G., McNamara, L., Hill, R., 2020. Further records of rafting northern star corals (*Astrangia poculata* (Ellis and Solander)) (Cnidaria: Anthozoa: Rhizangiidae) from Irish waters. *Ir. Nat. J.* 37, 52–54.
- Rangel-Buitrago, N., Neal, W., Williams, A., 2022. The Plasticene: time and rocks. *Mar. Pollut. Bull.* 185, 114358. <https://doi.org/10.1016/j.marpolbul.2022.114358>.
- Readman, J., Hill, J.M., 2016. *Antedon* spp., solitary ascidians and fine hydroids on sheltered circalittoral rock. In Tyler-Walters, H., Hiscock K. (eds.) *Marine Life Information Network: Biology and Sensitivity Key Information Reviews*, Plymouth: Marine Biological Association of the United Kingdom (Accessed 18 March 2026). doi:10.17031/marlinhab.313.1.
- Rech, S., Arias, R.M., Vadell, S., Gordon, D., Thiel, M., 2023. Daily accumulation rates of floating debris and attached biota on continental and oceanic island shores in the SE Pacific: testing predictions based on global models. *PeerJ* 11, e15550. <https://doi.org/10.7717/peerj.15550>.
- Rech, S., Borrell, Y., García-Vázquez, E., 2018a. Anthropogenic marine litter composition in coastal areas may be a predictor of potentially invasive rafting fauna. *PLoS One* 13, e0191859. <https://doi.org/10.1371/journal.pone.0191859>.
- Rech, S., Borrell, Y., García-Vázquez, E., 2016. Marine litter as a vector for non-native species: what we need to know. *Mar. Pollut. Bull.* 113, 40–43. <https://doi.org/10.1016/j.marpolbul.2016.08.032>.
- Rech, S., Gusmao, J.B., Kiessling, T., Hidalgo-Ruz, V., Meerhoff, E., Gatta-Rosemary, M., et al., 2021. A desert in the ocean – depauperate fouling communities on marine litter in the hyper-oligotrophic South Pacific subtropical gyre. *Sci. Total Environ.* 759, 143545. <https://doi.org/10.1016/j.scitotenv.2020.143545>.
- Rech, S., Salmina, S., Pichs, Y.J.B., García-Vázquez, E., 2018b. Dispersal of alien invasive species on anthropogenic litter from European mariculture areas. *Mar. Pollut. Bull.* 131, 10–16. <https://doi.org/10.1016/j.marpolbul.2018.03.038>.
- Rech, S., Thiel, M., Pichs, Y.J.B., García-Vázquez, E., 2018c. Travelling light: fouling biota on macroplastics arriving on beaches of remote Rapa Nui (Easter Island) in the South Pacific subtropical gyre. *Mar. Pollut. Bull.* 137, 119–128. <https://doi.org/10.1016/j.marpolbul.2018.10.015>.
- Rech, S., Thiel, M., Ruiz, G.M., Haram, L.E., Carlton, J.T., 2025. Ocean rafting: marine litter and benthic stopovers amplify species dispersal opportunities. *Glob. Ecol. Biogeogr.* 34, e70031. <https://doi.org/10.1111/geb.70031>.
- Richardson, K., Hardesty, B.D., Wilcox, C., 2019. Estimates of fishing gear loss rates at a global scale: a literature review and meta-analysis. *Fish. Fish.* 20, 1218–1231. <https://doi.org/10.1111/faf.12407>.
- Sahrhage, D., Lundbeck, J., 1992. *Development of Modern Fisheries. A History of Fishing*. Springer, Berlin, pp. 167–280. https://doi.org/10.1007/978-3-642-77411-9_6.
- Samimi-Namin, K., van Ofwegen, L.P., Hoeksema, B.W., Woodall, L.C., Meijer zu Schlochtern, M., McFadden, C.S., 2022. New records of the cryptogenic soft coral genus *Stragulum* (Tubiporidae) from the eastern Caribbean and the Persian Gulf. *Diversity* 14, 909. <https://doi.org/10.3390/d14110909>.
- Schutter, M., Dorenbosch, M., Driessen, F.M., Lengkeek, W., Bos, O.G., Coolen, J.W., 2019. Oil and gas platforms as artificial substrates for epibenthic North Sea fauna: effects of location and depth. *J. Sea Res.* 153, 101782. <https://doi.org/10.1016/j.seares.2019.101782>.
- Shankar, V.S., De, K., Jacob, S., Satyakeerthy, T.R., 2025. Unveiling the risk of marine litter and derelict fishing gear in remote coral reefs of the Andaman and Nicobar Islands, North Indian Ocean. *Mar. Pollut. Bull.* 212, 117591. <https://doi.org/10.1016/j.marpolbul.2025.117591>.
- Spencer, H.G., Fraser, C.I., Poulin, E., González-Wever, C.A., 2025. Towards a more nuanced understanding of long-distance rafting: case studies from the Southern Ocean. *Glob. Ecol. Biogeogr.* 34, e70007. <https://doi.org/10.1111/geb.70007>.
- Stachowitsch, M., 2018. *The Beachcomber's Guide to Marine Debris*. Springer, Cham, Switzerland. https://doi.org/10.1007/978-3-319-90728-4_11.
- Stichting Anemoon, 2026. Soorteninformatie. Available online: <https://www.anemoon.org/soorteninformatie/categoryid/2> (accessed 2 March 2026).
- Stockwell, P., 1947. The culture of cork oak in Spain. *Econ. Bot.* 1, 381–388. <https://doi.org/10.1007/BF02858898>.
- Subías-Barata, A., Sanchez-Vidal, A., Di Martino, E., Figuerola, B., 2022. Marine biofouling organisms on beached, buoyant and benthic plastic debris in the Catalan Sea. *Mar. Pollut. Bull.* 175, 113405. <https://doi.org/10.1016/j.marpolbul.2022.113405>.
- ter Hofstede, R., Driessen, F.M.F., Elzinga, P.J., van Koningsveld, M., Schutter, M., 2022. Offshore wind farms contribute to epibenthic biodiversity in the North Sea. *J. Sea Res.* 185, 102229. <https://doi.org/10.1016/j.seares.2022.102229>.
- Thiel, M., Gutow, L., 2005a. The ecology of rafting in the marine environment. I. The floating substrata. *Oceanogr. Mar. Biol. Annu. Rev.* 42, 181–264.
- Thiel, M., Gutow, L., 2005b. The ecology of rafting in the marine environment. II. The rafting organisms and community. *Oceanogr. Mar. Biol. Annu. Rev.* 43, 289–428.
- Thiel, M., Haye, P.A., 2006. The ecology of rafting in the marine environment. III. Biogeographical and evolutionary consequences. *Oceanogr. Mar. Biol. Annu. Rev.* 44, 323–429.
- Wolff, W.J., 1968. The Echinodermata of the estuarine region of the rivers Rhine, Meuse, and Scheldt, with a list of species occurring in the coastal waters of the Netherlands. *Neth. J. Sea Res.* 4, 59–85. [https://doi.org/10.1016/0077-7579\(68\)90007-0](https://doi.org/10.1016/0077-7579(68)90007-0).
- Wolff, W.J., 2005. Non-indigenous marine and estuarine species in the Netherlands. *Zool. Med. Leiden* 79, 1–116.
- Wright, L.S., Napper, I.E., Thompson, R.C., 2021. Potential microplastic release from beached fishing gear in Great Britain's region of highest fishing litter density. *Mar. Pollut. Bull.* 173, 113115. <https://doi.org/10.1016/j.marpolbul.2021.113115>.
- Yamaguchi, Y., 1989a. Tuna long-line fishing I: historical aspects. *Mar. Behav. Physiol.* 15, 1–11. <https://doi.org/10.1080/10236248909378714>.
- Yamaguchi, Y., 1989b. Tuna long-line fishing V: conclusion. *Mar. Behav. Physiol.* 15, 75–81. <https://doi.org/10.1080/10236248909378718>.
- Zalasiewicz, J., Waters, C.N., Ivar do Sul, J.A., Corcoran, P.L., Barnosky, A.D., Cearreta, A., et al., 2016. The geological cycle of plastics and their use as a stratigraphic indicator of the Anthropocene. *Anthropocene* 13, 4–17. doi:<https://doi.org/10.1016/j.ancene.2016.01.002>.