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Ectocarpus siliculosus (Dillwyn) Lyngbye (Phaeophyceae, Ectocarpales) in the waters of the southwestern coast of the Polish part of Baltic Sea

Abstract

This paper presents information on the occurrence of the taxon *Ectocarpus siliculosus* (Dillwyn) Lyngbye in the coastal waters of the Pomeranian Bay. The study was conducted on two sections of the coastal zone. Material was collected point-by-point at four sites in the coastal accumulation zone, collecting floating thalli brought by sea waves. Shoots of other plants washed ashore were also collected. No thalli of other brown or red algae were found in this zone, except for the abundant green algae of the genera *Ulva* sp. div. and *Cladophora* sp. div. growing on the stones. In the second section of the coastal zone, plant material was collected at reference sites located along a designated transect. Based on the collected samples, it was found that filamentous thalli of *Ectocarpus siliculosus*, despite favourable local conditions for their development and the presence of stable substrate structures, appear very rarely. Thalli brought by currents and waves from other parts of the sea were observed more frequently. In the collected samples, vegetative stages were observed more frequently than sporophyte thalli with developed sporangia.

Key words: brown algae, Baltic coastal zone, Western Pomerania.
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Introduction

Ectocarpus Lyngbye 1819 comprises sessile species found in the coastal zone of the sea. Filamentous thalluses grow on stones, shells, wooden spurs, and structural elements of port infrastructure. Species of the genus often occur epiphytically on other, primarily thallus-like algae, and less frequently on vascular marine plants.

The genus *Ectocarpus*, like other members of the order Ectocarpales, is characterised by an isomorphic alternation of generations. Morphologically identical sporophyte and

gametophyte generations occur cyclically. This particular feature prevents a correct species diagnosis in the absence of asexual reproductive organs.

Studies of *Ectocarpus* species in the Polish Baltic coastal zone

The first comprehensive study of the Baltic thalli flora was the work "*The Algenflora der gesamten Ostsee*" (Lakowitz 1907, 1929). More detailed data on the occurrence of thalli taxa of the *Ectocarpus* genus in the Polish Baltic coastal zone concern only certain regions covered by research conducted primarily by phycologists associated with research centres in Gdańsk. These are the results of research from the interwar period, primarily from the Gulf of Gdańsk, published by Bursa (1935, 1937). More recently, between 1971 and 1992, research on the biology and distribution of thalli algae was conducted by the team of Prof. Marcin Pliński (Pliński, Giebułtowska-Mindak 1976; Florczyk, 1992; Pliński et al., 1992), as well as by other authors (Kruk-Dowgiałło 1998; Kruk-Dowgiałło, Opioła 2001). Based on the conducted research and previously published data, one of the volumes in the series "*Flora of the Gulf of Gdańsk and adjacent waters (Southern Baltic)*" was created – the volume on the thallophytes "*Red Algae-Rhodophyta, Brown Algae-Phaeophyta*" (Pliński, Surosz, 2013).

In the central part of the coast, the Słupsk Bank is relatively well-researched floristically (Andrulewicz et al., 2004). A thorough study of the thalli flora of the Baltic Sea, along with basic ecological information, is also included in the monograph by Pankow (1971).

The aim of this study is to collect information on the occurrence and thalli morphology of the taxon *Ectocarpus siliculosus* (Dillwyn) Lyngbye in the coastal waters of the Pomeranian Bay. These studies were conducted in conjunction with an inventory of the seabed, its morphology, and its coverage by thalli algae formations and fauna.

Material and methods

The first series of research material collections took place during several field trips in 2007–2008. These included observations of the occurrence and distribution of *Ectocarpus siliculosus* (Dillwyn) Lyngbye and other thallose marine flora. The main studies were conducted using direct underwater monitoring during research project no. OR16-61535-OR1600015/07, which focused on identifying fish spawning conditions and spawning grounds in the coastal zone of the Pomeranian Bay from Międzyzdroje to Świętoujście (Fig. 1) (Gruszka et al., 2008).

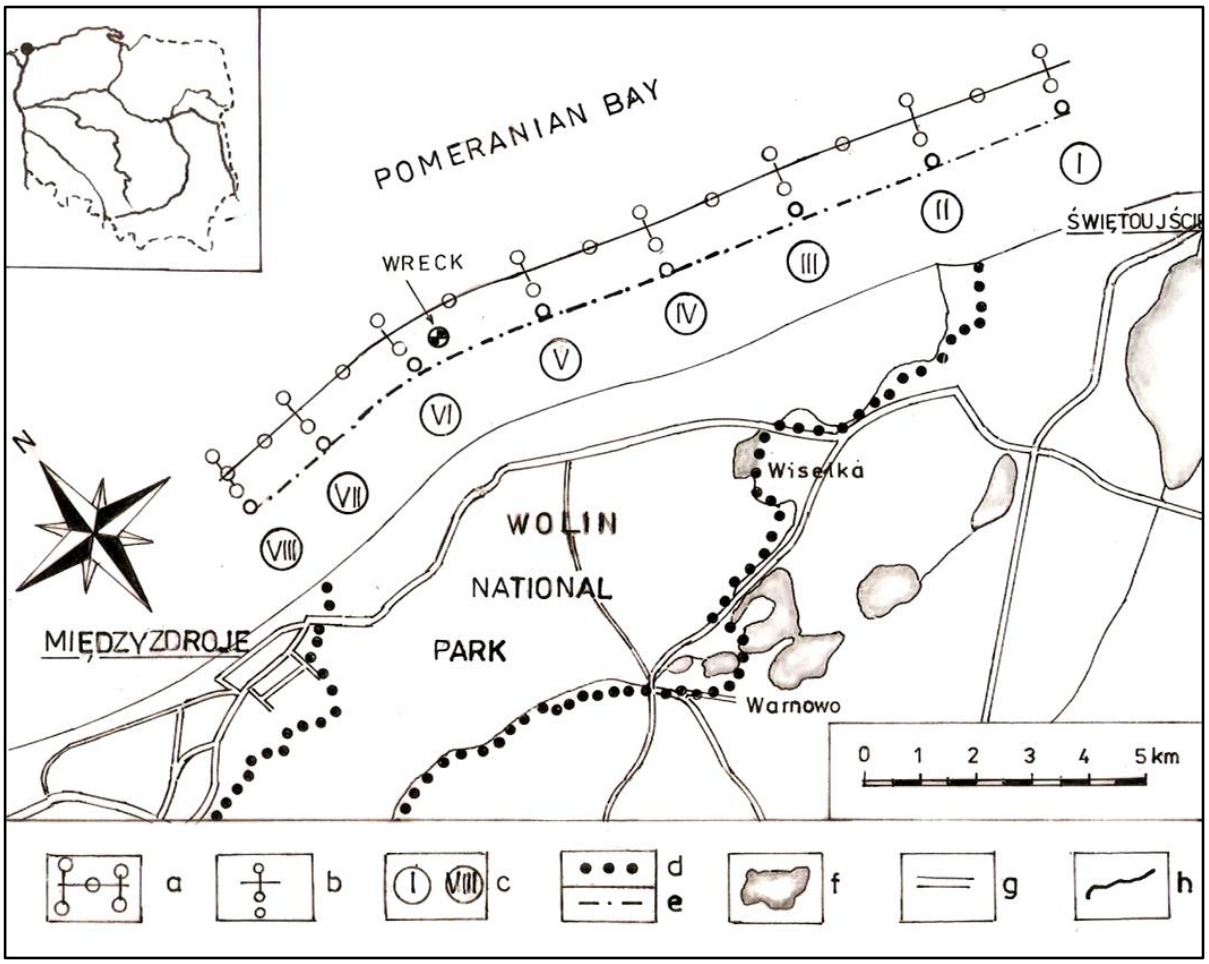

Fig. 1. A transect study of the phycoflora of thalli in the coastal zone of the Międzyzdroje-Świętoujście coast (based on the map published by Gruszka et al., 2008)

a – research transect; b – reference points of research profiles; c – research profile numbers; d – land borders of the Wolin National Park; e – border of the land zone; f – lakes; g – roads, streets; h – watercourses

These studies were conducted in a coastal water zone approximately 14.4 km long and 1 nautical mile wide (1,852 m). A transect was established within the zone, comprising eight research profiles spaced approximately 2 km apart along the shore. Three stations were designated on each profile within the coastal water zone, 0.5 and 1 nautical mile. An additional station was located 0.75 mile between each profile station. During the survey of the seabed by professional divers, video documentation was prepared, allowing for the assessment of its character and the presence of thalliform marine algae. Each research profile was analyzed at designated reference points from the shoreline. The designated reference stations covered a seabed area of approximately 25 m^2. Material was collected for microscopic analysis at sites where thalloid-forms of phycoflora were detected. A concrete

wreck of a sunken barge was also subjected to phycological analysis. However, no developing marine algal thalli were observed on its surface.

During second series of field research, between 2010 and 2015, plant material was also collected in the area of the construction of the external port infrastructure for the gas terminal in Świnoujście (Fig. 2). These were mainly thallus algae floating in the littoral surf zone.

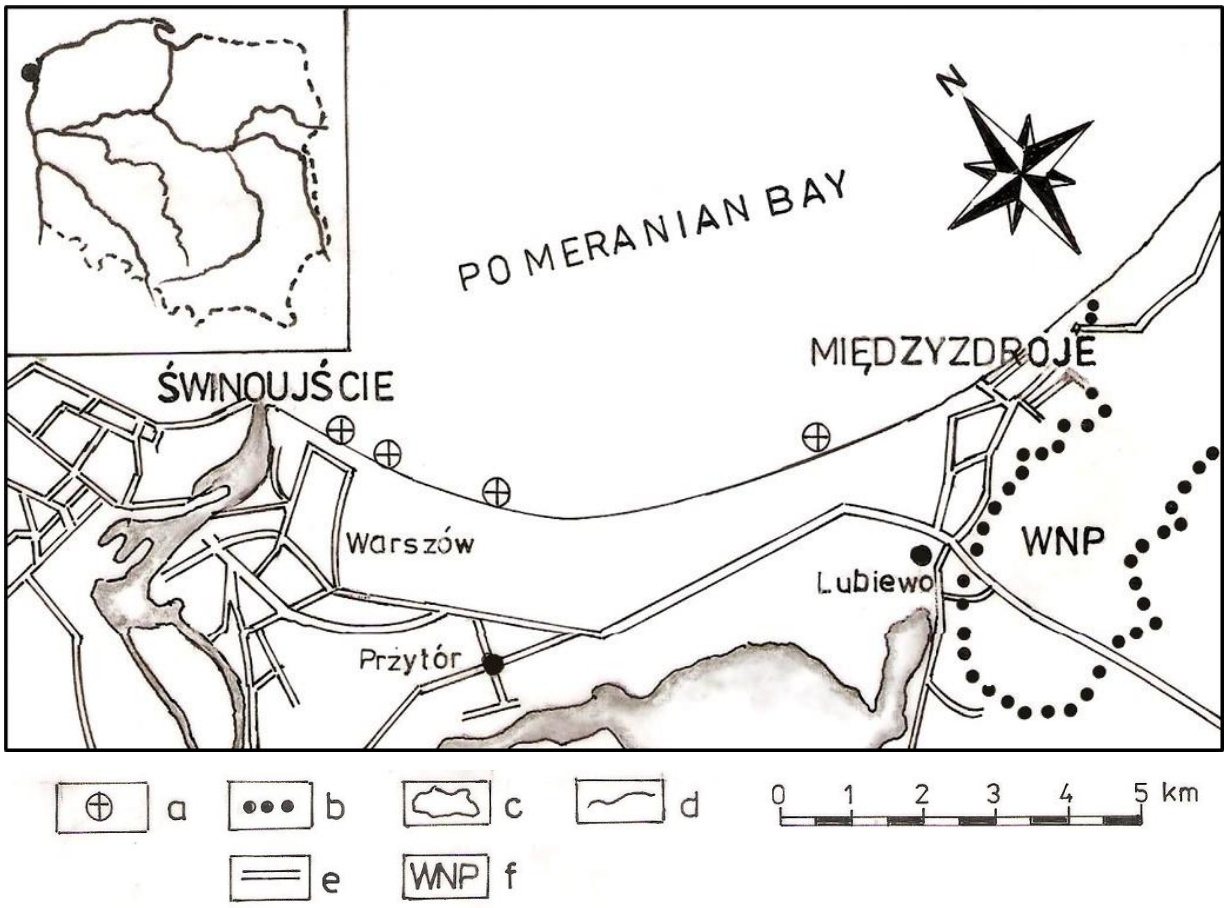

Fig. 2. Research and collection sites of phycoflora thalli in the Świnoujście-Międzyzdroje region
a – research sites; b – land borders of the Wolin National Park; c – lakes; d – watercourses; e – roads, streets; f – Wolin National Park (based on the map published by Gruszka et al., 2008)

Autumn and spring storm surges in the waters of the Pomeranian Bay very sporadically accumulated *Zostera marina* L. shoots, with filamentous *Ectocarpus siliculosus* thalli, in the coastal zone. In this sea zone, depending on the intensity of organic and mineral matter accumulation, a residual natural habitat of "kidzina" (annual vegetation of drift lines) formed on the seashore. From reference points on both the Świnoujście-Międzyzdroje and Międzyzdroje-Świętoujście coasts where *Ectocarpus* thalli were detected, material was

collected in containers for microscopic analysis. The collected research material was examined intravitally and then fixed with lactophenol (Starmach, 1963). Analysis of the collected research material was based on literature studies, including Gayral (1966), Pankow (1971), Starmach (1977), and Pliński, Surosz (2013). The species nomenclature was taken from the AlgaeBase – https://www.algaebase.org (Guiry, Guiry, 2025).

Results and comments

The bottom contours of the coastal zone waters determine the development and colonisation of thalliform formations

Analysis of the obtained observations allowed us to determine the accumulation of stable bottom structures, primarily boulders, stones, and other bottom structures that created favourable conditions for the occurrence of sessile thalli of representatives of the class Phaeophecaea. The collected and documented material and the nature of the seabed indicate that the studied coastal waters are not suitable for the settlement and development of thalliform algae. The seabed of the studied area is predominantly sandy or covered with organic sediment. Locally, significant accumulations of small mollusc shells, primarily *Mytilus trossulus* Gould, were noted, displaced by waves. In some sections, the seabed was covered with shell debris, also containing conchia of other mollusc species. This morphology and the lack of stable seabed elements do not support the development of thalliform algae. No thalliform algae were found on the surface of the post-war wreck located on the eastern side of reference point VI (Fig. 1).

A factor unfavourable to thalli development is the significant freshness of the water and its morphology. Hence, the absence of large thallus forms of Phaeophyceae is noticeable here. The presence of a few filamentous *Ectocarpus siliculosus* thalluses was detected only in profile IV (Fig. 1). These stages lacked sporangia. The extensive field of silt spoil from the dredging of the waterway contributed to the inhibition of thalli development. Sea currents and waves wash away mineral and organic compounds from the sediments, while fine silt particles covering the bottom negatively impact the development of thalliform plants.

Morphology of the thalli

The collected material revealed the presence of small, light brown thalli, formed as threads composed of a single row of cells. The thalli reached a height of approximately 10–15 cm. These were primarily vegetative stages. The threads branched irregularly laterally, sometimes

forked, and sparsely. The cells of the main axis of the thallus are rectangular in outline, rarely almost square, with slightly convex lateral walls and therefore slightly barrel-shaped, 15.3–40.0 µm long, 16.5–20.0 µm wide. The chromatophores are ribbon-like, more or less spirally twisted, loosely arranged within the cells. The apical portions of the thallus are unbranched, formed of strongly elongated cells, 60.0–74.1 µm long, 10.6–11.7 µm wide, their length exceeding their width by 6.2–6.9 times. Thallus with numerous multilocular sporangia (Fig. 3a, d; 4a, b – Appendix 1) and solitary unilocular sporangia (Fig. 3e – Appendix 1). Multilocular sporangia are numerous, distinctly fusiform, sometimes slightly constricted in the central part or just below it, borne on a short 1–3-celled pedicel or directly on the cells of the main axis of the thallus. The apical part of the sporangium is gently tapering and broadly rounded at the tip. Multilocular sporangia measure 62.6–84.6 µm in length, rarely exceeding 100 µm, but occasionally reaching 107.8–112.4 µm. Their width ranges from 16.2 to 24.3 (occasionally up to 26.6) µm. No hairs were observed on the sporangia collected during the thalli study. Unilocular sporangia, ovoid (Fig. 3e – Appendix 1), sessile, 60.2–64.9 µm long, 26.54–27.8 µm wide, are sparse on the thallus. The apical cells of the thallus are regularly rounded in their apical part (Fig. 4c, d – Appendix 1). The lateral branches and the apical parts of the main axes of the thallus have clearly defined groups of almost square intercalary growth cells.

The ecology of multi-chambered and single-chambered sporangia production

The lack of numerous thalli with asexual reproductive organs collected at different study dates prevented the determination of the most favourable time for sporangia formation. Therefore, it was impossible to determine the timing of their appearance throughout the year. Such information was presented for the waters of the Gulf of Gdańsk (Pliński, Giebułtowska 1976) and in a very detailed study by Florczyk (1992).

In the study area, sporangia were most abundant on thalli collected in July in the littoral zone east of Świnoujście. Multilocular sporangia clearly dominated the collected and analysed thalli. Their size and developmental advancement indicate that this was the period of their most abundant formation. Multilocular sporangia were by far the most common in the collected material. Single-locular sporangia appeared sporadically on the thalli.

Conclusions

Analysis of the potential colonisation of coastal waters by thalli of brown algae indicates that this section of the coastal marine zone, despite the accumulation of locally rocky structures covering the seabed, is not a habitat for sessile Phaeophyceae. The sporadic appearance of filamentous thalli of *Ectocarpus* and other representatives of typical marine flora is a consequence of sea currents brought from other parts of the sea, likely from the Słupsk Bank area. Monitoring studies conducted between 2009 and 2018 in the area of the gas terminal infrastructure confirmed the lack of thalli accumulation of this taxa.

Acknowledgements

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Conflict of interest

The author declare no conflict of interest related to this article.

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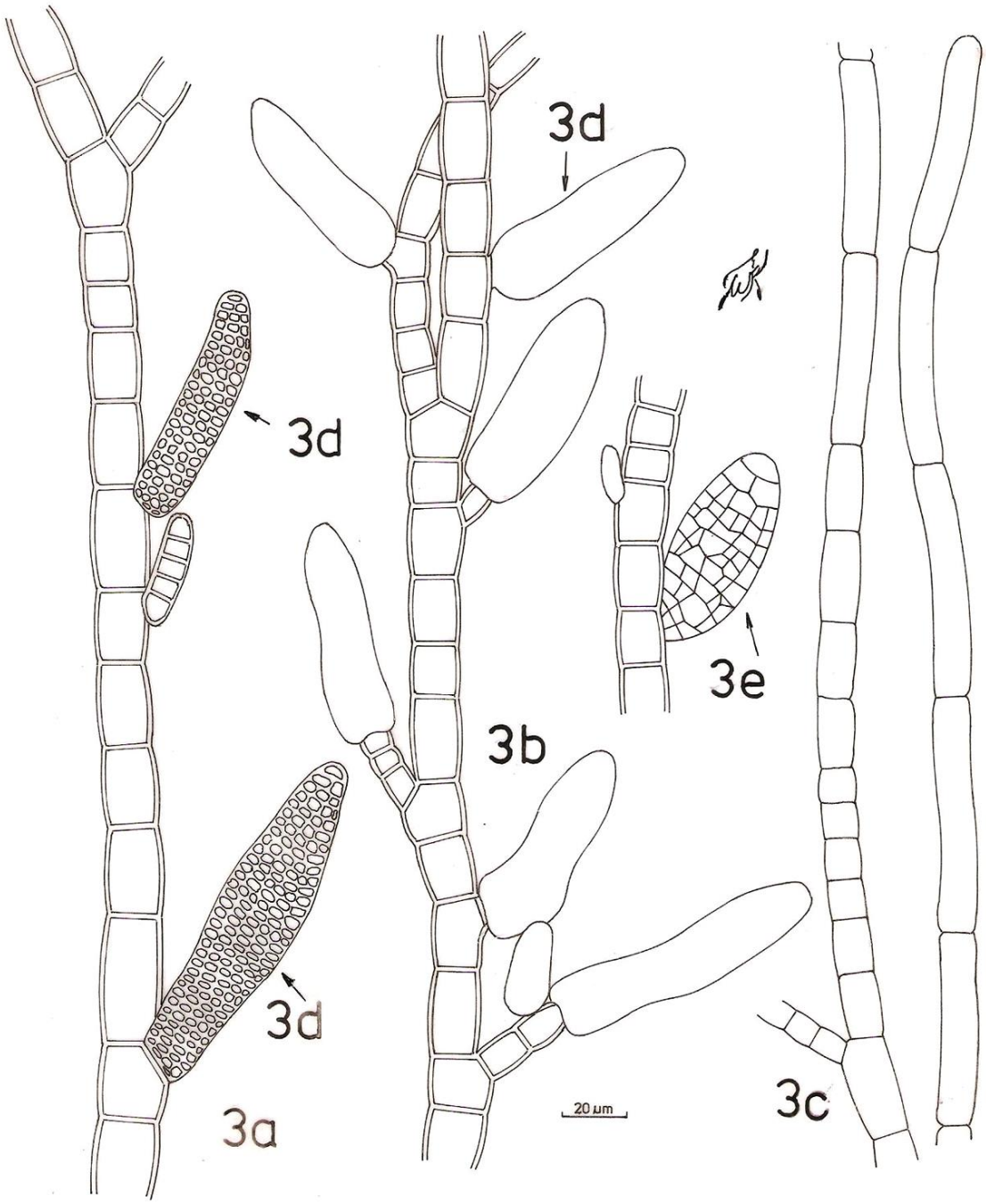

Fig. 3. Filamentous thallus of *Ectocarpus siliculosus* (Dillwyn) Lyngbye: 3a, 3b, 3c – successive sections of the lower part of the thallus; 3d – multi-chambered sporangia; 3e – single-chambered sporangia (Wojciech W.A. Kowalski)

Fig. 4. Branching and endings of the apical sections of the thallus of *Ectocarpus siliculosus* (Dillwyn) Lyngbye: 4a, 4b – upper parts of the thallus with forming multilocular sporangia; 4c, 4d – apical sections of the thallus (Wojciech W.A. Kowalski)

Ectocarpus siliculosus (Dillwyn) Lyngbye (Phaeophyceae, Ectocarpales) w wodach południowo-zachodniego wybrzeża polskiej części Bałtyku

Streszczenie

Niniejsza praca przedstawia informacje na temat występowania taksonu *Ectocarpus siliculosus* (Dillwyn) Lyngbye w wodach przybrzeżnych Zatoki Pomorskiej. Badania przeprowadzono na dwóch transektach strefy przybrzeżnej Zatoki Pomorskiej. Materiał zbierano punktowo w czterech miejscach w strefie akumulacji przybrzeżnej, między Świnoujściem a Międzyzdrojami, zbierając pływające plechy naniesione przez fale morskie. Zebrano również pędy innych roślin wyrzucone na brzeg. Badania przeprowadzono także z wykorzystaniem bezpośredniego monitoringu podwodnego w ramach projektu badawczego nr OR16-61535-OR1600015/07, prowadzonego w strefie przybrzeżnej Zatoki Pomorskiej, od Międzyzdrojów do Świętoujścia. W tej strefie nie stwierdzono jednak plech innych brunatnic ani krasnorostów, z wyjątkiem licznych zielenic z rodzajów *Ulva* sp. div. i *Cladophora* sp. div. rosnących na kamieniach. W drugim odcinku strefy przybrzeżnej materiał roślinny pobrano w punktach referencyjnych zlokalizowanych wzdłuż wyznaczonego transektu. Na podstawie pobranych próbek stwierdzono, że plechy nitkowate *E. siliculosus*, pomimo sprzyjających lokalnych warunków dla ich rozwoju i obecności stabilnych struktur podłoża, pojawiają się bardzo rzadko. Częściej obserwowano plechy przynoszone przez prądy i fale z innych części morza. W pobranych próbach częściej obserwowano stadia wegetatywne niż plechy sporofitów z rozwiniętymi zarodniami.

Słowa kluczowe: brunatnice, strefa przybrzeżna Bałtyku, Pomorze Zachodnie.

Information on the author

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The author is a specialist in the field of algology. His research interests concern both single species of algae and whole groups of marine and freshwater algae, with particular emphasis on rare and endangered taxa. A special taxonomic group of interest are the taxa associated with the ecosystems of peat bogs, as well as freshwater red algae. Now, he is a retired researcher at the Department of Botany and Nature Conservation, West Pomeranian University of Technology in Szczecin.