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Bottom macroalgae of the Admiralty Bay (King George Island, South Shetlands, Antarctica)

ABSTRACT: In the Admiralty Bay 36 taxa of macroalgae were found. Among them the most common were: green alga *Monostroma hariotti*, red algae — *Georgiella confluens*, *Iridaea cordata*, *Leptosarca simplex* and *Plocamium cartilagineum*, and brown algae — *Adenocystis utricularis*, *Ascoseira mirabilis*, *Desmarestia anceps*, *D. ligulata*, *D. menziesii* and *Himatothallus grandifolius*. The bottom surface covered with macroalgae (in the orthogonal projection on the water mirror) amounts to 36,9 km^2 i.e. 31% of the total surface of the bay. In the central part of the Admiralty Bay the macroalgae aggregations occupy 35% of the bottom surface and are most abundant in respect to the density, biomass, number of taxa (33) and diversity. There were distinguished 3 zones of vertical distribution of phytobenthos in the Admiralty Bay. I zone includes the macroalgae in epilittoral, littoral and sublittoral to the depth of 10 m. II and III zones are situated in sublittoral within the depths of 10—60 m and 60—90 m, respectively. Each zone is characterized by the occurrence of different aggregation of taxa. The bottom areas belong to I, II and III zone of macroalgae make 28%, 64% and 8% respectively in relation to the total surface of phytobenthos in the bay. Vertical range of the distinguished zones varies in different parts of the Bay in relation to the bottom character. Macroalgae occur down to the depth of 90—100 m. The composition of the macroalgae flora evidences for its transitory character between the benthic subantarctic flora and that of the areas adjacent to the Antarctic continent.

Key words: Antarctic, South Shetland Islands, benthos, macroalgae.

Introduction

Littoral and sublittoral zones of the Southern Ocean are characterized by the extremely abundant aggregations of thallophytic macroalgae, strongly contrasting with the absence of a diversified terrestrial flora in the Antarctic (Dell, 1972).

Ocean bottom flora in the area of the Antarctic Peninsula and the South

Shetlands (Figs. 1 and 2) was investigated by over a dozen of scientists. Delepine, Lamb and Zimmermann (1966) described the zones of algal occurrence in relation to the depth in the region of the Melchior Archipelago recording the highest density of algal aggregations in the depth of 42 m. Etcheverry (1968) has studied material of algae collected in the Paraiso Bay and in the region of the Arturo Prat Station (Greenwich Island). This author

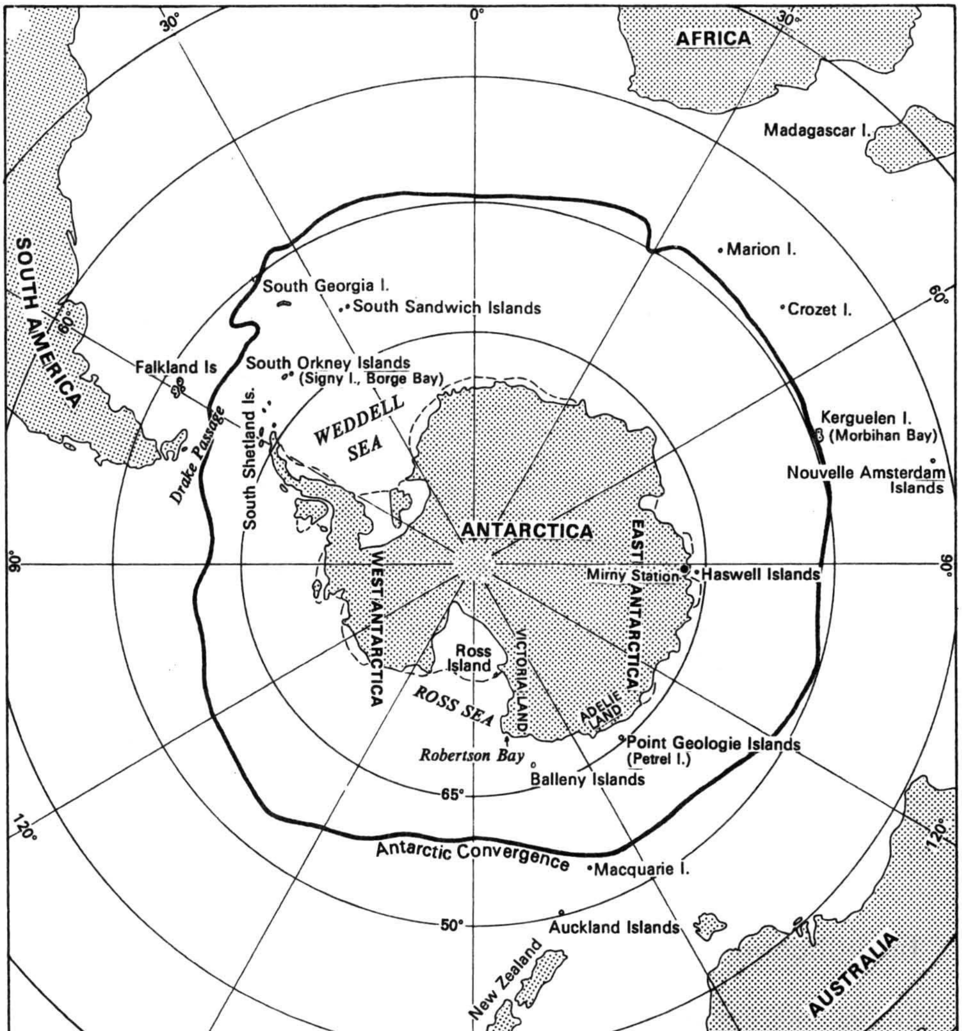

Fig. 1. Antarctic region.

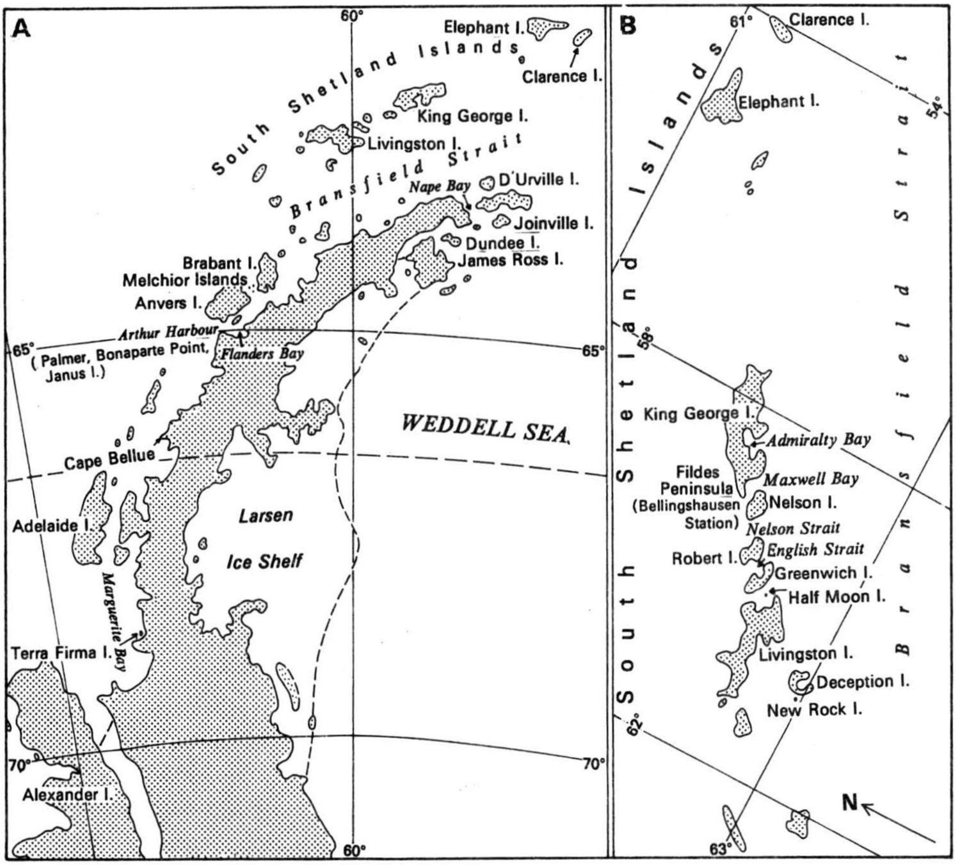

Fig. 2. West Antarctic region: A/ Antarctic Peninsula region: B/ South Shetland Islands.

observed that the phytobenthos of the littoral zone was weakly developed and was concentrated mainly in small tidal water bodies. The sublittoral was dominated by large Phaeophyta thalli of the genera *Desmarestia, Ascoseira, Cystosphaera, Phaeurus, Phyllogigas* and red algae of the genera *Plocamium, Myriogramme* and *Leptosomia.* Neushul (1965) has studied the phytobenthos along the Antarctic Peninsula and in the South Shetlands area (Half Moon Island) in the littoral and sublittoral, describing the species composition of algal aggregations and relating the regions of their occurrence to the depth. This author has concluded that the tidal zone (littoral) of the investigated areas was devoid of algae. Abundant algal aggregations occurred in greater depths, in the sublittoral, and were quantitatively dominated by Phaeophyta of the genera *Desmarestia* and *Phyllogigas.* Superficial underwater observations carried out along the King George Island revealed the occurrence of poor algal vegetation with the dominance of thalli of the genus *Desmarestia.* Similar investigations in the vicinity of King George Island (north-western coast of the Fildes Peninsula, Maxwell Bay, Nelson Strait) were carried out by Moe and Delaca (1976) and Delaca and Lipps (1976). As a result of these investigations a list of algal species and communities were determined. The Maxwell Bay, situated close to the Admiralty Bay (both in King George Island, South Shetlands) was an area of summer observations of bottom flora conducted by Petrov and Nikolaev (1982). These scientists distinguished four zones of thallophytic algae in the tidal zone and described also several species of Rhodophyta of the genera *Iridaea, Curdiea* and *Gigartina* of the lowest zone, whose upper limit becomes exposed during the lowest tide. These studies concerning the South Shetlands' algal flora enable to establish the list of bottom algae collected or observed in this region. Following species were recorded: Chrysophyta: *Antarctosaccion applanatum*; Chlorophyta: *Cladophora* sp., *Enteromorpha bulbosa, Monostroma hariotii, Urospora* sp., Phaeophyta: *Adenocystis utricularis, Ascoseira mirabilis, Cystosphaera jacquinotii, Desmarestia anceps, Desmarestia ligulata, Desmarestia menziesii, Desmarestia willii, Geminocarpus geminatus, Halopteris obovata, Lithoderma antarcticum, Myrionema* spp., *Phaeurus antarcticus, Phyllogigas grandifolius, Pylaiella littoralis*; Rhodophyta: *Antithamnion antarcticum, Ballia callitricha, Callophyllis* sp., *Curdiea racovitzae, Dasyptilon harveyi, Delesseria stephanocarpa, Delisea pulchra, Gigartina skottsbergii, Hildenbrandia lecannellieri, Iridaea obovata, Kallymenia antarctica, Leptosarca* sp., *Leptosomia* sp., *Litothamnium antarcticum, Microrhinus carnosus, Myriogramme manginii, Pantoneura plocamioides, Phycodrys austrogeorgica, Phyllophora* spp., *Picconiella plumosa, Plocamium coccineum, Plumariopsis eatoni, Porphyra endiviifolium, Rhodochorton* sp., *Sarcodia montagneana.*

Most of these algal species are typical not only of South Shetlands. Their occurrence was recorded both in the phytobenthos of subantarctic islands as well as around the Antarctic Continent. This confirms the transitional character of the phytobenthos of the South Shetland Islands which are a part of the Scotia Arc joining the subantarctic and Antarctic flora.

The detailed data concerning the macrophytobenthos of the Admiralty Bay are lacking. Nevertheless some preliminary results of Polish observations have been published (Zieliński 1981, Furmańczyk and Zieliński 1982). The number of macroalgae species was estimated then to be approximately 18, some of them were considered as dominant ones. These were: *Adenocystis utricularis, Himatothallus grandifolius, Desmarestia menziesii* and *Cystosphaera jacquinotii.* Moreover three zones of algal aggregations depending on depth were distinguished, and the lowest limit of the occurrence of algae was found to be about 90 m. A map of phytobenthos distribution in a part of the Admiralty Bay (from Point Thomas do Point Demay and in some other areas) was presented. Moreover the possibility of identification the places of occurrence of bottom macroalgae in the shallow waters through interpretation of the coloured air photos was confirmed.

Annex to the paper by K. Zieliński, Polish Polar Research

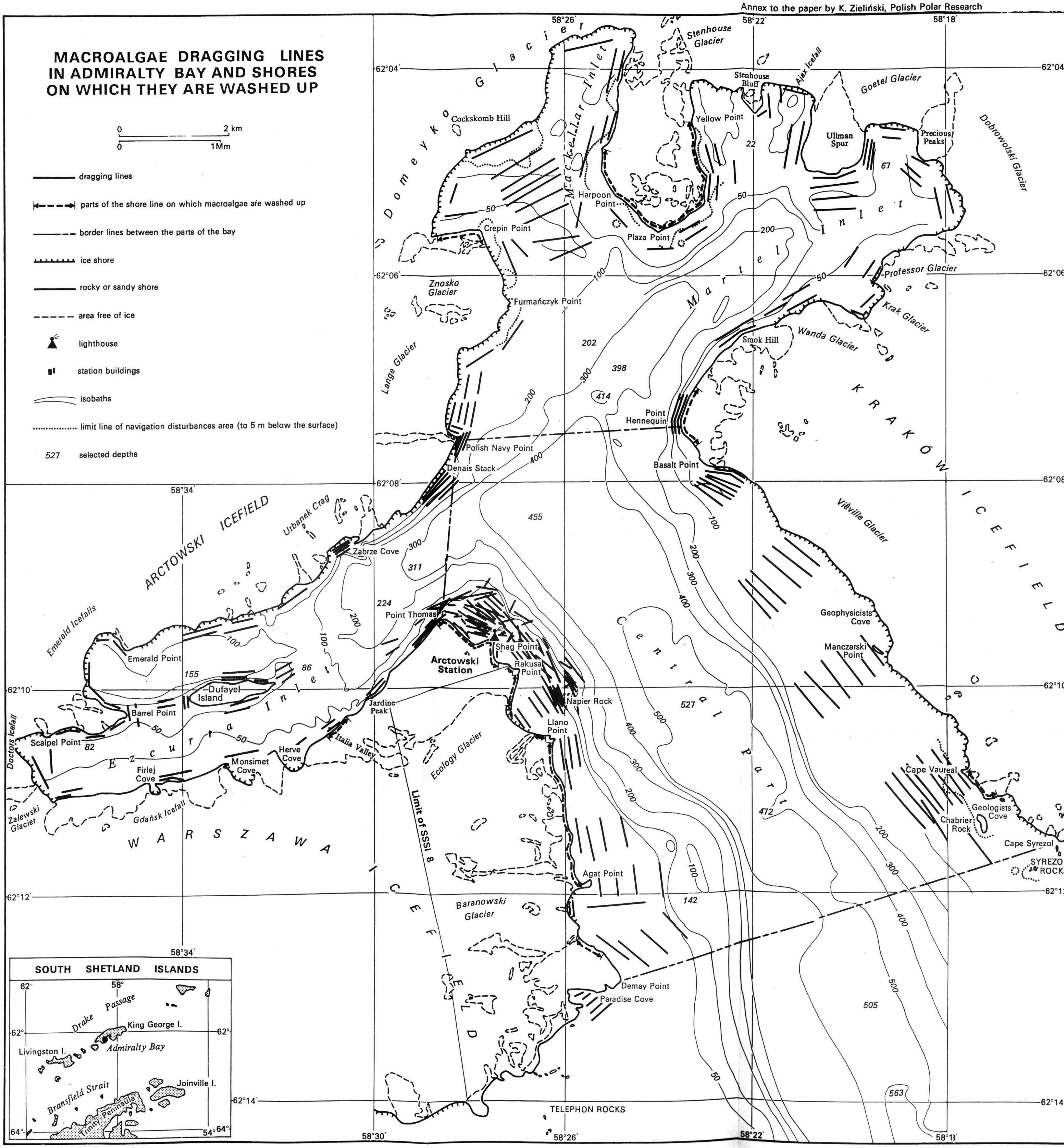

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Fig. 3. Macroalgae dragging lines in Admiralty Bay and shores on which they are washed up.

The aim of the present study was to determine the species composition of benthic macroalgae and their horizontal and vertical distribution within the whole area of the Admiralty Bay.

Investigated area and environmental conditions

The Admiralty Bay (Fig. 3) is the largest bay of the King George Island as well as in the whole South Shetlands Archipelago (Rakusa-Suszczewski 1980). The drainage area of the Admiralty Bay amounts to 242,46 km^2 which is covered in 91.3% with ice (Marsz and Rakusa-Suszczewski 1987). The surface of the Admiralty Bay itself amounts to 119,27 km^2, the average depth is 176,3 m and the volume of the bay is about 21 km^3 (Fedak and Marsz, unpubl. data). Admiralty Bay is a fiord with the branched system of bays. Southwards it opens widely to the Bransfield Strait; its limit is the line joining Demay Point and Syrezol Rock. There are three branches in the northern part of the Admiralty Bay: the Ezcurra Inlet to the south-west, the Mackellar and Martel Inlets to the north and north-east, respectively. The basin of the central part of the Bay in cross-section is U-shaped with the upper edges extending outwards and forming so called micro-shelf of dozens meters of depth (the proper shelf in West Antarctic region reaches 500 m of depth) (Rakusa-Suszczewski 1980, Zieliński 1981). The bottom of the central part of the bay is levelled and is lowering southwards attaining the maximal depth of 533 m. The basin of the Ezcurra Inlet is differentiated in respect to geomorphology and bathymetry (Marsz 1983). It is divided by a distinct underwater sill some 100—130 m high. To the east of this sill this basin is a typical irregular furrow valley of the depth from 150 to 270 m. To the west of the sill the mean depth range is from 50 to over 100 m. This rather steep sill causes distinct upwellings in this area.

The bottom of Mackellar and Martel Inlets is strongly affected by glacial erosion and their bathymetry is very diversified. In the central part of Mackellar Inlet the depth is small ranging from 2 to 40 m, and the bottom of the inlet is mainly rocky and stony. Only its northern and western bays have muddy bottom reaching from 60 to 80 m in depth. The Martel Inlet is deeper and its central part ranges from 70 to 270 m. Maximal depth to the north and north-east is about 50—60 m. The bottom of Martel Inlet is mostly muddy but stony and rocky parts of the bottom are spreading along the rocky coasts.

The shore line of the Admiralty Bay is about 84 km in length. Coasts formed by the fronts of immersed and supported glaciers are 39 km in length. Rocky cliff coasts are 26 km in length and sandy-gravel beaches are 19 km; these coasts extend mainly along the western coast of the Admiralty Bay from Point Thomas to Demay Point. According to Rakusa-Suszczewski (1980) during past 22 years the icy coast line retreated increasing the surface of the Admiralty Bay by about 1,8 km^2. The dynamics of changes of the glacier barriers has an effect on hydrological and atmospheric conditions in the coastal zone of the bay and thus on its flora and fauna both in marine and land environments. Most of the glacier barriers in the area of the Admiralty Bay are supported barriers. Despite of their height (more than 20 m) they do not form high icebergs but they produce mostly the ice-pack with small growlers which do not destroy bottom macroalgae that can be found before the fronts of glaciers. As a result of their action ice can grind the bottom algae only in shallow water from few to dozens meters and only just before the glacier barriers. Large icebergs coming from the Bransfield Strait into the Admiralty Bay are drifting in the central part of its basin and have no influence on macroalgae aggregations in the coastal zone. However the icebergs of average size and big growlers drifting along the western and eastern coast of the bay probably scrub the bottom at the depths of 20—40 m that is in the areas often richly overgrown with macroalgae. Thalli separated from the bottom were found close to the places of dislocation of icebergs just mentioned. These thalli were clearly mechanically affected by ice (craks, disruptions, crushes).

The hydrological and hydrochemical conditions in the Admiralty Bay are influenced by the exchange of waters with the Bransfield Strait, by the runs-off from land to the bay and by such characteristic for a fiord processes like: local water circulation, upwellings generated by winds and the great variability of conditions in the surface layer that is not found in the open ocean waters (Rakusa-Suszczewski 1980). The main cause of the water circulation in the Admiralty Bay and their exchange with the Bransfield Strait are irregular tides (Catewicz and Kowalik 1983). The irregularity and asymmetry of tides and a great inertia of water masses of the bay cause that the direction of current is not always concordant with the direction of tide; changes are irregular in intervals ranging from 5 up to 14 hours (Pruszak 1980). Waters from the Bransfield Strait flow into the Admiralty Bay close to the bottom towards the Ezcurra Inlet. Water outflow from the Admiralty Bay to the Bransfield Strait takes place mainly in the surface layer along the eastern coast of the bay. The current velocity in the central part of Bay varies from 30 cm s^{-1} close to the bottom to 50 cm s^{-1} at the depth of 50 m. In the Ezcurra Inlet these values range from 20 cm s^{-1} to 45 cm s^{-1}, respectively. The surface currents depend on the wind power and their velocity ranges from 20 to 30 cm s^{-1} near the shore and from 30 to 60 cm s^{-1} in the central part of the bay reaching the maximum of 100 cm s^{-1}. It was estimated that the water exchange in the Admiralty Bay within the upper 100 m layer lasts from 7 to 14 days (Pruszak 1980).

This comparatively quick water exchange in the bay along with local meteorological and hydrological conditions cause their strong mixing and the frequent lack of thermal stratification in summer. In 1978/79 the temperature of surface water ranged from 0.18°C to 2.81°C at the salinity varying between 16.40‰ and 34.16‰. In the deeper water variability of these parameters was much smaller and ranged in the layer close to the bottom at a depth of 480 m from −0.23 to 0.26°C and from 34.5‰ to 34.57‰, respectively (Szafrański and Lipski 1982). The melting of ice fragments from icebergs surrounding the Admiralty Bay may cause, particularly in the coastal zone, the changes in salinity and temperature (Rakusa-Suszczewski 1980). The water temperature ranged from about $-2°C$ to $2.5°C$ in the inshore zone in 1977 (Presler 1980). In sunny quiet days the water temperature in shallow water close to the coast can increase up to 5°C. The salinity increases gradually together with depth whereas the considerable decrease of the salinity can occur in the thin surface layer in the region of run-off of fresh waters from the land (Szafrański and Lipski 1982).

The total freezing up of the Admiralty Bay occurred irregularly in the last decade. The solid ice cover can persist for few months of Antarctic winter and its thickness can reach 0,5 m (Presler 1980).

Freshwater streams flowing into the Admiralty Bay are carrying considerable amounts of terrigenic material causing water turbidity which reduces the penetration of light. The general amount of inorganic suspension in waters of the bay changes in large range from 2.8 mg l^{-1} to 182.6 mg l^{-1}.

The average range of euphotic zone in the Ezcurra Inlet measured during Antarctic summer was 23 m and varied within the limits from 15 to 42 m in depth (Dera 1979, Olszewski 1983, Woźniak, Hapter and Maj 1983).

Waters of the Admiralty Bay are rich in oxygen. The oxygen content in the coastal surface waters was 9.4 ml 0_2 l^{-1}, and at the bottom at the entrance to the Bransfield Strait reached 5.4 ml 0_2 l^{-1}. The bottom waters in central basin contained 6 ml 0_2 l^{-1}, in the Ezcurra Inlet — 7 ml 0_2 l^{-1} (Samp 1980).

The amounts of nutrients in waters of the Admiralty Bay are similar to those of the open Antarctic waters (Samp 1980). In the coastal zone and in deeper layers phosphate concentration is higher in comparison to the surface layer reaching the maximum of 4.0 μ mol l^{-1}. The concentration of nitrates also increases together with depth reaching the maximum of 32.0 μ mol l^{-1}. The highest concentrations of nitrites, more then 0.4 μ mol l^{-1}, occur close to the run-off of nutrients from penguin rookery and in the west end of Ezcurra Inlet (Samp 1980). In the Ezcurra Inlet nutrients concentration is similar in the whole water column due to the strong mixing of water masses by wind and tides (Bojanowski 1983).

The quantity of organic carbon in the waters of Admiralty Bay varies between 1.62 mg l^{-1} and 3.22 mg l^{-1} for DOC and between 0.22 mg l^{-1} and 0.65 mg l^{-1} for POC. The maximum amount of DOC (more than 2.5 mg l^{-1}) and POC (more than 0.5 mg l^{-1}) was found in the range of depth from 25 m to 100 m and also in the coastal waters free from the ice cover during the Antarctic summer and fertilized by run-offs from the region of penguin rookeries. It was also found that the quantity of organic carbon changes within 24 hours cycle. The average quantity of DOC in the Admiralty Bay (about 2.26 mg l^{-1}) is lower from the average quantity of DOC in the waters of the Bransfield Strait (4.12 mg l^{-1}; Pęcherzewski 1980b). Dawson, Schramm and Bolter (1985) have found that the aggregations of bottom macroalgae change the quality and quantity of organic and inorganic matter in the waters of Admiralty Bay. These macroalgae are one of the sources of organic carbon in both forms (DOC and POC), and also of dissolved polysaccharides (DPCHO). The above data indicate that the Admiralty Bay is a typical shelf environment of West Antarctica with characteristic features for coastal zone of the whole South Shetlands Archipelago.

Material and methods

Investigations were carried out during two winterings at the Polish Antarctic „Arctowski" Station from December 1978 to December 1979 (III-rd Antarctic Expedition of Polish Academy of Sciences), from April 1982 to February 1983 (VI-th Antarctic Expedition of Polish Academy of Sciences) as well as during the BIOMASS III Expedition from November 1986 to January 1987.

The lack of solid ice cover in the Admiralty Bay in both winter seasons 1978/79 and 1982/83 made it possible to collect the samples of algae all over the year. The existence of aggregations of benthic macroalgae was recorded by dredging performed from a cutter. This cutter is 7 m in length, it is supplied with a diesel engine (Hatz) with a power of 24 MH as well as with a trawl winch.

The dredging was performed with use of the metallic rectangular dredges at the following size of mouth: a longer side 80—140 cm in length supplied with the steel teeth easing the scraping the thalli from the bottom; a shorter side 25—40 cm in length. Collecting sacks were made of nylon net (mesh size from 5 to 20 mm); the length of sacks ranged to 90 cm. Anchor dredges were also used that enabled the catching of the whole and large specimens of algae sometimes in great numbers even in one haul. The trawl winch had a steel line of the diameter of 3—4 mm and about 600 m in length so the catches were possible down to about 180 m in depth that allwed to determine the maximum depth of the occurrence of algae. In the shallow water zone from Point Thomas to Shag Point, before the front of Ecology Glacier and in the regions of Agat Point and Chabrier Rock algae were observed from boat with the use of sight-glass. Moreover, the direct observations amd collecting of algae were performed along the coast in the tidal zone. The algae were collected few times in littoral and sublittoral zone in the region of Shag Point with the help of two SCUBA divers.

The collected specimens of algae were preserved partly in 4% formaldehyde solution and the second part by slow drying in the temperature of 30° to 60°C. The wet material allowed to preserve the shape of thalli unchanged, whereas in dry specimens the colour was retained. Such material was used for determination.

The literature concerning the taxonomy of Antarctic benthic macroalgae is not rich and keys are mostly lacking, making the determination quite difficult. The author has used following papers during identification of the algae: Naylor (1955), Skottsberg and Neushul (1960), Neushul (1963), Arnaud and Delepine (1964), Papenfuss (1964), Moe and Silva (1977, 1981, 1983), Delepine and Asensi (1978), Moe and Henry (1982), Moe (1986). The difficulties in determination, mainly of red algae, were overcome due to the contact with Dr. R. L. Moe and Dr. P. C. Silva from the University of Berkeley (USA) as well as with Dr. Petrov of the Institute of Botany, Academy of Sciences of Soviet Union in Leningrad. The exchange of algal material enabled to verify the proper determinations. The only key for identification of the Antarctic bottom macroalgae appeared only recently (Delepine, Asensi and Etcheverry 1985), however it contains descriptions of only 24 taxa; this key allowed to confirm the author's previous determinations for one species of green alga, five species of brown algae and six species of red algae. All collected specimens of macroalgae in the Admiralty Bay were finally determined.

The picture of vertical distribution of macroalgae in the Admiralty Bay (Fig. 4) is based on the data coming from all samples of phytobenthos. Depth limits of the distinguished zones of macroalgae occurrence (10, 60 and 90 m) were evaluated on the basis of depth ranges of frequent occurrence of each taxon and mainly their occurrence in aggregations. The names of zones of vertical distribution of macroalgae presented in figure 4 are consistent with the nomenclature generally accepted and defined as follows: supralittoral — part of a coastline between the upper limit of occurrence of marine flora and the mean maximal tidal level (Feldmann 1951, Delepine and Hureau 1963, Delepine 1966, Delepine, Lamb and Zimmermann 1966), this zone is called epilittoral by Zaneveld (1968); littoral — a zone between the mean maximal and mean minimal of tidal level (tidal zone) (Feldmann 1951, Delepine and Hureau 1963, Delepine, Lamb and Zimmermann 1966, Zaneveld 1968), it is a mediolittoral according to Delepine (1966); infralittoral — a zone spreading below the average minimal of tidal level (Delepine and Hureau 1963, Delepine, Lamb and Zimmermann 1966); this is a sublittoral according to Zaneveld (1968). Feldmann (1951) distinguished upper infralittoral (from the average minimal tidal level down to the depth of 5—10 m) and lower infralittoral (below the depth of 5—10 m); Delepine (1966) on the other hand distinguished upper infralittoral, middle infralittoral and lower infralittoral (circalittoral), whereas Zaneveld (1968) distinguished upper sublittoral (infralittoral) (from the mean minimal tidal level down to the depth of 10 m) and the lower one (ranging from 10 to 37 m in depth) and elittoral (circalittoral) — spreading from 37 m in depth to the lower limit of occurrence of phytobenthos.

The regions of occurrence of bottom macroalgae were drawed on the map of Admiralty Bay. The outline of coastal line, the course of isobaths and the position of the majority of coastal points were marked according to the map of Admiralty Bay in the scale 1:25000 (Furmańczyk and Marsz 1980).

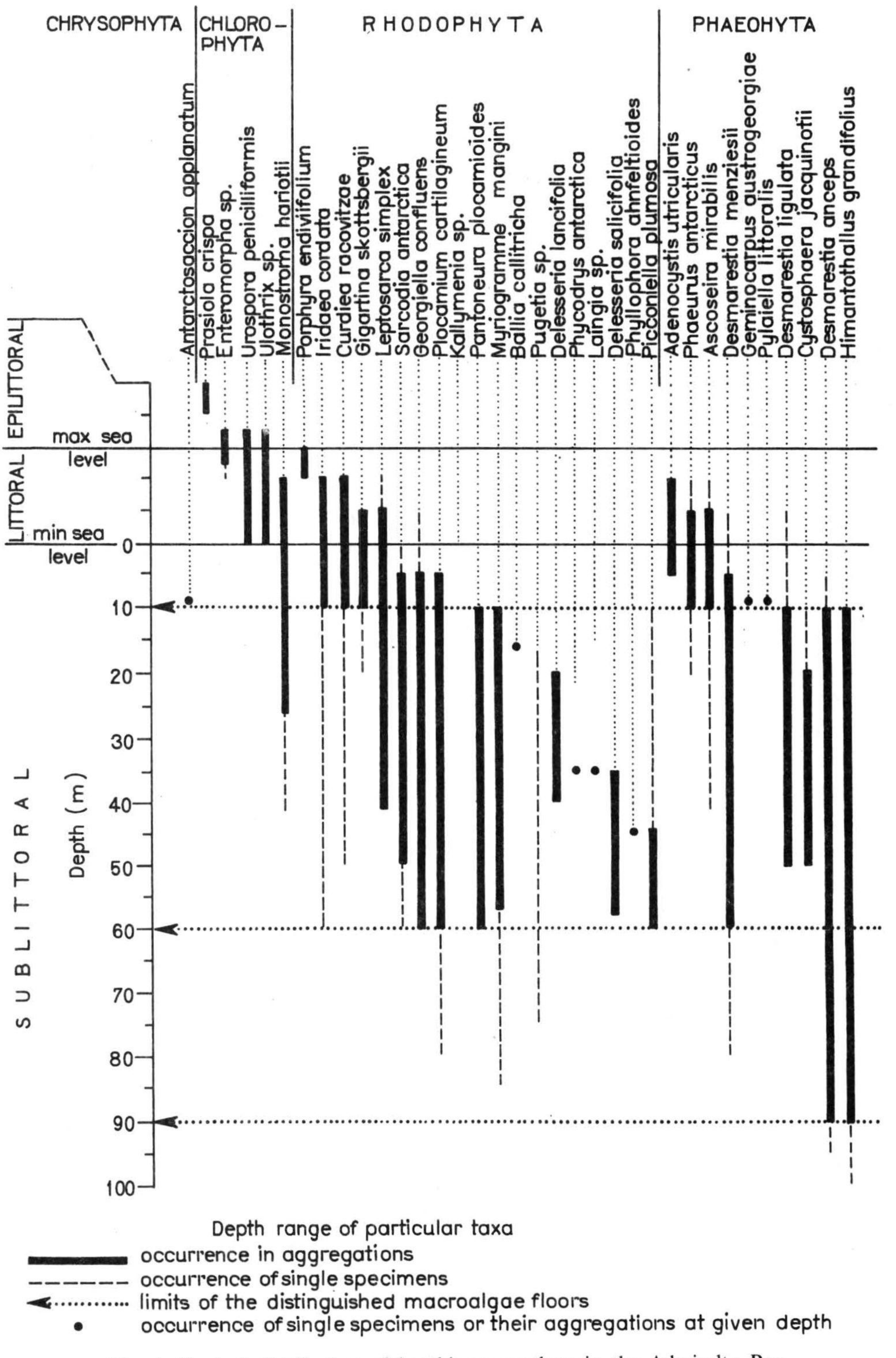

Fig. 4. Vertical distribution of benthic macroalgae in the Admiralty Bay.

Horizontal distribution of the aggregations of macrophytobenthos of the whole Admiralty Bay (Fig. 5) and the limits of ditinguished zones of macroalgae (Fig. 6) were determined on the basis of dredging transects, when the beginning and the end of each dredging were measured. These points were determined during the work on a cutter with the help of compass and measuring two horizontal angles in relation to the defined points on the coast of the bay. In total 278 dredgins were performed, during 60 cutter cruises. The bottom surface covered with macroalgae (Figs. 5 and 6) and the areas of the Admiralty Bay itself and of distinguished water subregions were measured by the graphic and planimetric method describing them in squ.km. The total length of the dredgins performed was 137 km.

Results

Flora composition and description of taxa

In the collected material the representatives of four classes were recorded, in all representing 36 taxa. 31 species were determined, two species of the genera *Ulothrix* and *Enteromorpha* remained indetermined, whereas three species of the genera *Kallymenia*, *Laingia* and *Pugetia* appeared to be the taxa not yet described; their descriptions are in preparation by Dr. R. Moe from the University of California, Berkeley, USA.

Below taxonomic position of all macroalgae found is presented:

Chrysophyta
Phaeothamniales
Phaeothamniaceae
Antarctosaccion applanatum (Gain) Delepine, Lamb et Zimmermann

Chlorophyta
Cladophorales
Cladophoraceae
Urospora penicilliformis (Roth) J. E. Areschoug
Schizogoniales
Prasiolaceae
Prasiola crispa (C. Agardh) Meneghini
Ulothrichales
Ulothrichaceae
Ulothrix sp.
Ulvales
Monostromaceae
Monostroma hariotii Gain

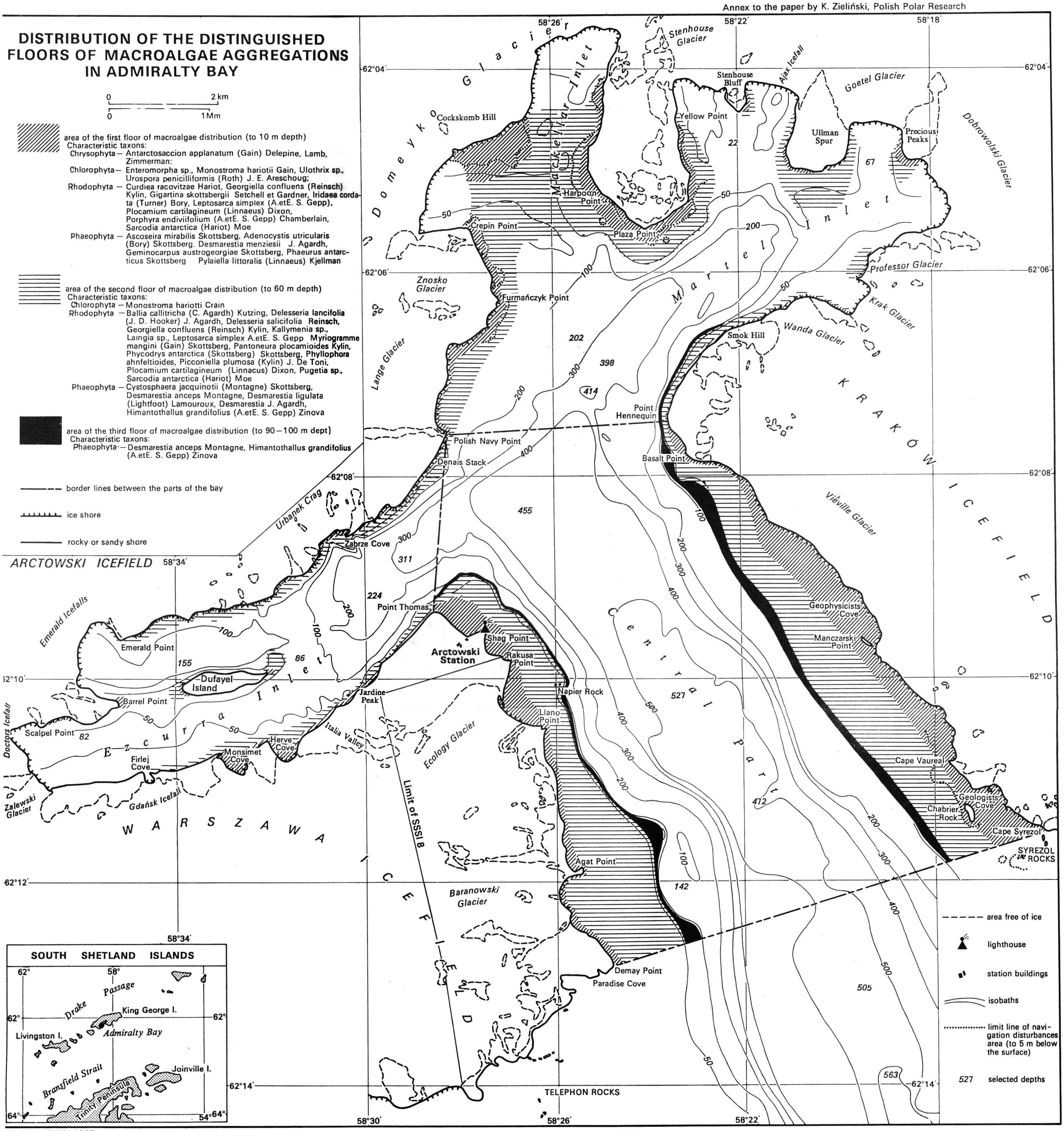

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Fig. 6. Distribution of the distinguished floors of macroalgae aggregations in Admiralty Bay.

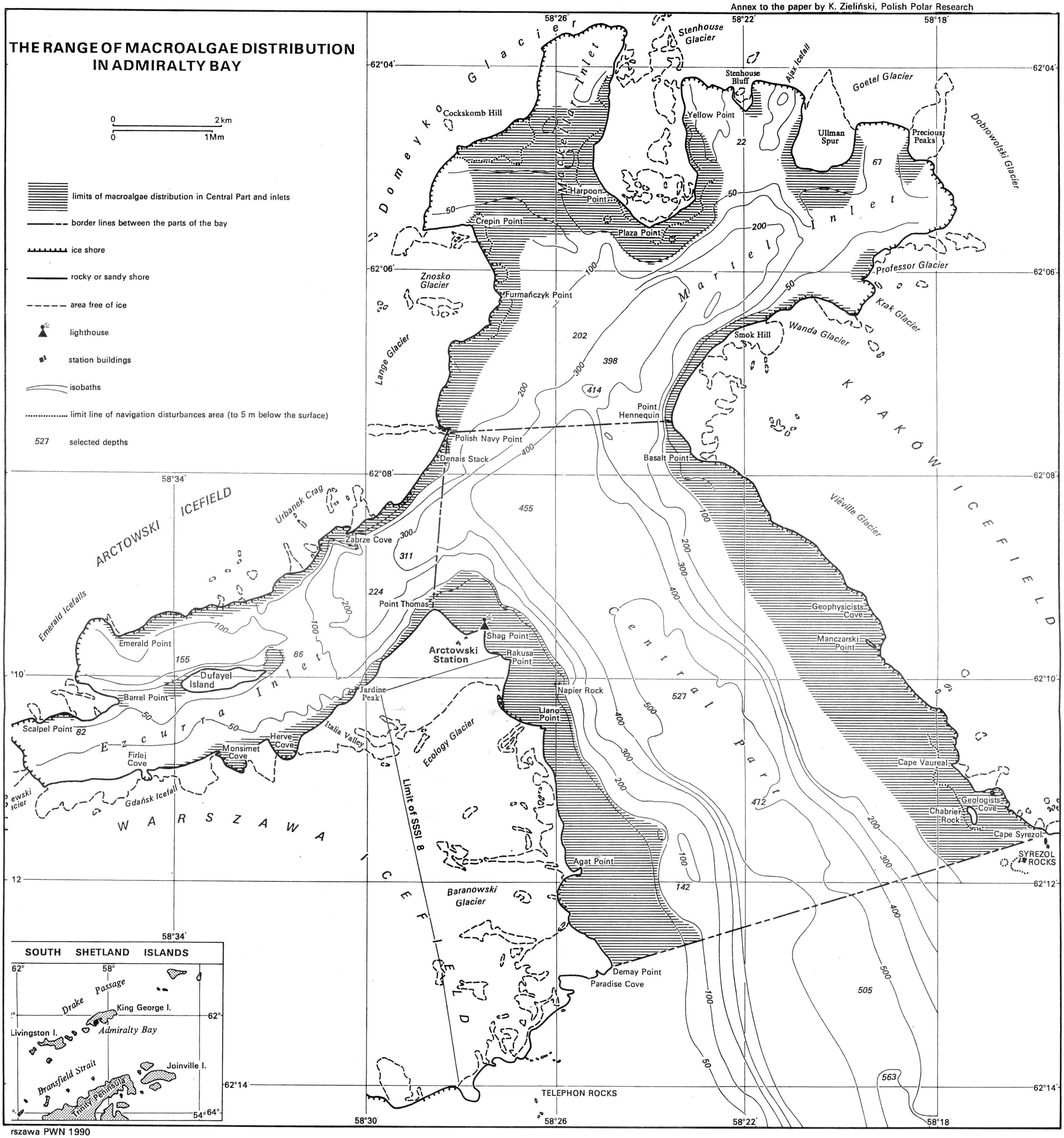

Fig. 5. The range of macroalgae distribution in Admiralty Bay.

Ulvaceae
Enteromorpha sp.

Phaeophyta

Ectocarpales
Ectocarpaceae
Geminocarpus austrogeorgiae Skottsberg
Pylaiella littoralis (Linnaeus) Kjellman
Desmarestiales
Desmarestiaceae
Himantothallus grandifolius (A. et E. S. Gepp) Zinova
Desmarestia anceps Montagne
Desmarestia ligulata (Lightfoot) Lamouroux
Desmarestia menziesii J. Agardh
Phaeurus antarcticus Skottsberg
Dictiosiphonales
Punctariaceae
Adenocystis utricularis (Bory) Skottsberg
Fucales
Ascoseiraceae
Ascoseira mirabilis Skottsberg
Fucaceae
Cystosphaera jacquinotii (Montagne) Skottsberg

Rhodophyta

Bangiales
Bangiaceae
Porphyra endiviifolium (A. et E. S. Gepp) Chamberlain
Ceramiales
Ceramiaceae
Ballia callitricha (C. Agardh) Kutzing
Georgiella confluens (Reinsch) Kylin
Delesseriaceae
Delesseria lancifolia (J. D. Hooker) J. Agardh
Delesseria salicifolia Reinsch
Myriogramme mangini (Gain) Skottsberg
Pantoneura plocamioides Kylin
Phycodrys antarctica (Skottsberg) Skottsberg
Rhodomelaceae
Picconiella plumosa (Kylin) J. De Toni
Gigartinales
Gigartinaceae
Iridaea cordata (Turner) Bory
Gigartina skottsbergii Setchell et Gardner

Gracilariaceae
Curdiea racovitzae Hariot
Phyllophoraceae
Phyllophora ahnfetioides Skottsberg
Plocamiaceae
Plocamium cartilagineum (Linnaeus) Dixon
Sarcodiaceae
Sarcodia antarctica (Hariot) Moe
Rhodymeniales
Rhodymeniaceae
Hymenocladiopsis crustigena Moe
Leptosarca simplex A. et E. S. Gepp
Antarctosaccion applanatum

Thin, lamellar thallus few milimetres in diameter. The occurrence of A. applanatum in the upper sublittoral (9 m) was recorded in the Mackellar Inlet.

Urospora penicilliformis and *Ulothrix* sp.

The filamentous straight and nonbranched thalli of the length from dozen milimetres to few centimetres. The threads of *Ulothrix* sp. thallus are much thiner and shorter than those of *Urospora penicilliformis.* Thalli densely overgrew smooth bottom surfaces in lower epilittoral and in littoral of the central part of the Bay.

Prasiola crispa

Thallus delicate, lamellar, irregularly corrugated, dozen milimetres in size. It occurs in aggregations overgrowing stony bottom in epilittoral and in the spray zone influenced by fecal material of animals. *P. crispa* is more common on land.

Monostroma hariotii

Delicate, tubular thallus ranging from few to dozen centimetres; very often overgrows the thalli of Desmarestia. It occurred in the tidal zone (littoral) and locally in sublittoral down to 26 m of depth. Quickly developping in summer after reaching few centimetres in length the thalli are torn. Common in the whole Admiralty Bay.

Enteromorpha sp.

Thalli in form of flattened strips, few centimetres in length, narrowing towards rhizoid. Aggregations of these thalli overgrew in summer the holes and crevices in surface layer of rocks of the upper littoral in central part of the Bay.

Geminocarpus austrogeorgiae; Pylaiella littoralis

Both species grow as epiphytes on *Desmarestia* thalli. Their thin thalli are filamentous with branches, reaching from few to dozen milimetres in length. Side branches of the filaments of *G. austrogeorgiae* are always paired. Their occurrence was recorded at 9 m of depth in the central part of the Bay and in the Mackellar Inlet.

Himatothallus grandifolius

Thallus in form of band-like, leather-type phylloid with corrugated edges; thalli are narrowing downwards forming short, flattened, most often helically twisted cauloid. Tips of phylloids undergo succesive erosion. *H. grandifolius* is attached to rocks and stones with a rhizoid formed of great number of inosculated appendages. Thalli can reach gigant size of the width of 1 m and total length in the range of 15—25 m. *H. grandifolius* formed rich aggregations in sublittoral in the depth from 10 to 90—100 m. Common in the whole Admiralty Bay.

Desmarestia anceps

Large thallus, composed of a pear-shaped, massive rhizoid passing into flattened cauloid with branches irregularly autgrowing on its both sides. Thalli reach few metres in length forming dense aggregations in sublittoral at the depth from 10 to 90—95 m. Common in the whole Admiralty Bay.

Desmarestia ligulata

Thallus is formed by flatwise irregularly branched lanceolate phylloids few milimetres in width, which grow out from a flattened, narrowing downwards cauloid. Several individuals share the rhizoid and constitute a cluster of thalli reaching few dozens centimetres in length. *D. ligulata* is an epiphyte of the red alga *Gigartina skottsbergii.* Most often it occurs in sublittoral at the depth of 10—50 m, rarely in lower littoral and in sublittoral at the depth less than 10 m. *D. ligulata* occurs in the whole Admiralty Bay, most often in the central part of the Bay and in the Martel Inlet.

Desmarestia menziesii

Thallus diversified in flattened cauloid with regularly outgrowing branches; cauloid grows out from the conical rhizoid. *D. menziesii* attains the length from few dozens centimetres to 2—3 m and occurs mainly in sublittoral at the depths from 5 m to 60 m, rarely in the tidal holes of littoral and in deeper sublittoral at 60—80 m. This species is common in the whole Admiralty Bay.

Phaeurus antarcticus

Thalli in the form of several branched hairy threads which grow out from the flat rhizoid common for few individuals. Thalli reach few dozens centimetres in length. This species overgrows crevices in the rocky bottom of lower littoral as well as in upper sublittoral down to the depth of 10 m. More rarely it can be found in mediolittoral and in sublittoral at the depth of 10—20 m. It occurs mainly in the central part of the Bay and rarely in the Martel Inlet.

Adenocystis utricularis

Obovate, rounded thallus in form of hollow sac few centimetres in length, tapering gradually in a cylindrical cauloid. Small rhizoid is usually common for several individuals. Clusters of thalli occur in aggregations in littoral and sublittoral down to the depth of 5 m, rarely deeper (even to 20 m). *A. utricularis* occurred often as epiphyte on the thalli of *Desmarestia*. *A. utricularis* occurs in the whole Admiralty Bay, mainly in its central part.

Ascoseira mirabilis

Palm-shaped thallus in form of lanceolate phylloids few centimetres in width growing out from dichotomously branched cauloid. It is fastened to the massive conical rhizoid. The thalli are few dozens centimetres in length; they occur most often in lower littoral and sublittoral down to the depth of 10 m, rarely in mediolittoral or in sublittoral at the depths ranging from 10 to 46 m. These thalli are found in the whole Admiralty Bay, but mainly in the central part of the Bay and in the Mackellar Inlet.

Cystosphaera jacquinotii

Thallus of diversified morphology, from round rhizoid devoid of appendages, through dichotomously branched cauloid with symmetrically outgrowing sickle-shaped phylloids. Characteristic stalked vesicles (pneumatocysts) are located in lower parts of thallus at the base of phylloids. The club-shaped also stalked reproduction organs occur in upper parts of thalli and are also situated at the phylloids bases. The thalli reach few metres of length and occur in the sublittoral in the depths of 20—50 m, rarely to 60 m. The aggregations of *C. jacquinotii* overgrow the bottom in the central part of the Bay only.

Porphyra endiviifolium

The lamellar thallus, irregularly shaped reaches few centimetres in length. The aggregations of thalli overgrew crevices of the rocky bottom of upper littoral in the central part of the Bay.

Ballia callitricha

Few centimetres in length, delicate, pinnately branched thallus with characteristic featherlike endings. This species was found in sublittoral as a epiphyte growing on the thallus of red alga, *Pugetia* sp. at the depth of 16 m in the Mackellar Inlet.

Georgiella confluens

Flat, branched, bushy thallus of the span of dozen centimetres. It occurs mainly in sublittoral in the depth from 5 m to 60 m, rarely in lower littoral and in upper sublittoral above the depth of 5 m. *G. confluens* most often was found in the central part of the Bay, rarely in the Mackellar and Ezcurra Inlets.

Delesseria lancifolia

Delicate, elongated leaflike thallus reaching few dozens centimetres in length and few centimetres in width with characteristic venation of cauloid. Phylloid tapers into the thin and short cauloid that ends in a flat, rounded rhizoid. *D. lancifolia* occurred in sublittoral between the depths of 20 m and 40 m in the central part of the Bay, in the Mackellar and Martel Inlets.

Delesseria salicifolia

Thallus diversified in a flat, narrow cauloid with the outgrowing leaflike phylloids few centimetres in length. *D. salicifolia* reaches few dozens centimetres in length and occurred in sublittoral in the depths from 35 to 58 m in the central part of the Bay and in the Mackellar Inlet.

Myriogramme mangini

Thallus in form of leaflike phylloids devoid of venation growing out irregularly from the thin cauloid; it attains few centimetres in span. *M. mangini* was found in sublittoral at the depths from 10 to 57 m, rarely deeper, at most to the depth of 85 m. It occurred mainly in the central part of the Bay, more rarely in the Martel Inlet.

Pantoneura plocamioides

Bushy, densely branched thallus attaining the span of dozen centimetres. It was found in the sublittoral at the depths from 10 m to 60 m in the central part of the Bay and in the Mackellar Inlet.

Phycodrys antarctica

Thalli few centimetres in length; their shape and venation are characteristic and make them very similar to the leaves of trees. They were found in sublittoral at the depth of 35 m in the Ezcurra Inlet.

Picconiella plumosa

Delicate, bushy thalli few centimetres in length. They can be found in sublittoral mainly at the depths from 45 to 60 m, rarely within the range from 10 to 45 m. *P. plumosa* occurred first of all in the Ezcurra Inlet, more rarely in the central part of the Bay.

Iridaea cordata

Lamellar thallus with irregular but usually of foliaceous shapes, attaining the length of dozen centimetres. It is fastened to the bottom by a round rhizoid shared by several individuals. The richest aggregations of these thalli occurred in the tidal zone (middle and lower littoral) as well as in sublittoral mainly down to the depth of 10 m. Single thalli were also found in sublittoral between 10 and 60 m. *I. cordata* occurred in the whole Admiralty Bay, most often in the central part of the Bay and in the Mackellar Inlet.

Gigartina skottsbergii

Lamellar, leatherlike, somewhat cartilaginous thalli of very variable shape attains the span of few dozens centimetres. *G. skottsbergii* is fastened to the rocks by a dozen of short rhizoids; most often it was found in the crevices of rocky bottom from the tidal zone (lower littoral) down to the depth of 10 m in upper sublittoral and rarely deeper, at 10—20 m. The occurrence of this species was recorded in the central part of the Bay.

Curdiea racovitzae

Leatherlike thallus of the variable shape outgrowing from a conical rhizoid common for several individuals. It reaches few dozens centimetres in diameter. *C. racovitzae* forms very rich aggregations from medio-littoral down to a depth of 10 m in sublittoral; in the depths from 10 to 50 m it was found rarely. Most often the thalli of this species occurred in the central part of the Bay, more rarely in the Mackellar Inlet.

Phyllophora ahnfeltioides

Few centimetres in length thallus of this species in form of dichotomously branched, flattened strips was found in sublittoral at a depth of 45 m in the central part of the Bay.

Plocamium cartilagineum

Bushy, branched thalli with a span of a dozen centimetres, often overgrowing the thalli of various algae as an epiphyte; it was found in sublittoral, most often in the depths from 5 to 60 m, rarely within the range of 60—80 m. *P. cartilagineum* occurred in the whole Admiralty Bay, mainly in the central part of the Bay and in the Mackellar Inlet.

Sarcodia antarctica

Thallus outgrowing from a single rhizoid forms several band-shaped branches, each with a characteristic fork-shaped ending. Thalli reach the length of few dozens centimetres occurring in the sublittoral mainly at the depths from 5 to 50 m, rarely in the depths 1—5 m or 50—60 m. They were found in the central part of the Bay.

Hymenocladiopsis crustigena

Tape-shaped thallus some 10—15 mm in width, with numerous irregularly outgrowing longitudinal branches of the length of few centimetres. This species occurs probably in lower sublittoral. The specimens found were broken fragments of thalli probably detached from the shallower region of the bay. They were taken from the industrial bottom trawl which was used for trawling at a depth below 200 m along the western shore of the central part of the Bay.

Leptosarca simplex

Thalli elongated, thin band-shaped and with corrugated edges, narrowing downwards and forming thin and short cauloids outgrowing from basal fragments of old thalli. The thalli of this species overgrow rocks, stones and thalli of other algae, reaching the length from few dozens centimetres to about 2—3 m. Their unusually rich aggregations developed at the beginning of Antarctic summer, mainly in lower littoral and in sublittoral down to the depth of 40 m. Rarely they were found in medio-littoral. *L simplex* is common in the whole Admiralty Bay; most rarely it was found in the Martel Inlet.

Kallymenia sp.

Lamellar thallus of irregular shape, reaching a span of few dozens centimetres. A fragment of thallus of this yet undescribed species was found in sublittoral at the depth of 10 m in the central part of the Bay.

Laingia sp.

Thallus composed of short cauloid passing into leaflike phylloid of the length of few centimetres. Few specimens of this hitherto undescribed species were found in sublittoral at the depth of 35 m in the central part of the Bay.

Pugetia sp.

Lamellar, leather-like thallus with fuzzy margins some dozen centimetres in span. Single specimens of this species to be described were found in sublittoral within the depth range of 16—75 m in the central part of the Bay and in the Mackellar Inlet.

Horizontal and vertical distribution of macroalgae

In the Admiralty Bay the bottom area overgrown by aggregations of algae occupies 36,9 km^2 in an orthogonal projection on water surface which is 31% of the whole surface of the Bay (119,8 km^2) (Fig. 5). Macroalgae of the central part of the Bay occupy 35% of its surface, in its eastern part including the Mackellar and Martel Inlets — 32%, and in the western part — the Ezcurra Inlet — 16%.

In the central part of the Admiralty Bay the micro-shelf spreading along its western and eastern coasts is overgrown by very rich aggregations of macroalgae. They occupy the bottom surface of 21,8 km^2 of the total surface of 63 km^2 of this part of the Bay. The bottom areas covered with macroalgae spread from the coast towards the middle of the bay to the distance of 500—550 m in the region of Shag Point, Llano Point and Basalt Point and to the distance of 1700—1800 m in the region of Cape Syrezol, Geophysicists Cove and Demay Point which is concordant with a course of isobaths of 90 to 100 m. The aggregations of algae in this part of the Bay are the richest in respect to density, biomass as well as to diversity of taxa. Just here 33 of 36 taxa recorded in the whole Bay were found.

In north-eastern part of the Admiralty Bay embracing the Mackellar and Martel Inlets of the surface of 37,1 km^2 macroalgae occupy 11,9 km^2. The largest areas of bottom overgrown by phytobenthos occur in Mackellar Inlet and spread from the front of Domeyko Glacier towards Hennequin Point to the distance of 2200 m occupying the whole width of the Inlet from the front of Znosko Glacier to Harpoon Point. The limit of algae occurrence runs at the depth of 55—60 m. The muddy parts of the bottom, free of algae occurred in western and northern parts of Mackellar Inlet along the fronts of glaciers. Between Furmańczyk Point and Polish Navy Point the border of the areas overgrown by algae lies within the distance of 350—700 m from the coast and at a depth of 50—70 m. In the Martel Inlet macroalgae overgrow the bottom in a form of the belt 100—250 m wide along the coast from Hennequin Point to Wanda Glacier. The depth of range limit varies here in relation to the character of the bottom from 20 to 90 m. Around the Keller Peninsula, from Plaza Point to Yellow Point the belt of macroalgae reaches locally a distance of 600 m from the coast attaining maximum depth of 500 m. Furthermore, algae occur in small areas around Ullman Spur, Precious Peak, before the front of Professor Glacier and on eastern side of Stenhouse Bluff entering far in the fiord to the maximum distance of 700 m, 450 m, 300 m and 250 m from the shore, respectively. The lower limits of bottom areas covered by algae are situated here within 16—30 m of depth. The remaining part of the bottom of Martel Inlet is covered with silt and devoid of algae. The aggregations of macroalgae occurring in Mackellar and Martel Inlets take second place in respect to the diversity of taxa of which 21 were found there altogether; with only 13 taxa in Martel Inlet alone. The density and biomass of the phytobenthos aggregations are here, without doubt lower, though in some places of Mackellar Inlet they are comparable to the density and biomass of phytobenthos in the central part of the Bay.

In the western part of the Admiralty Bay encompassing the Ezcurra Inlet with a surface of 19,7 km^2 the macroalgae occupy 3,2 km^2 of a bottom surface. The algae aggregations occur in a narrow belt reaching towards a centre of the Inlet the distance of 50—200 m and are distributed along the coast from Thomas Point to Firley Cove, from Emerald Point to Polish Navy Point and in the regions of Scalpel Point and Barrel Point. This distance increases to 200—500 m around western and eastern Dufayell Island points as well as in the region of Monsimet Cove and Herve Cove. The lower limit of the occurrence of macroalgae in the region of Scalpel Point, Barrel Point and along the coast from Emerald Point to Zabrze Cove lies in the range of 5—20 m, from Firley Point to Thomas Point it runs at the depth of 20—40 m, in the region of western and eastern Dufayell Island points it runs at the depth of 40—50 m and in front of Denais Stack it reaches the depth of 60 m. The remaining parts of the bottom of Ezcurra Inlet situated in the direct vicinity of the glaciers are muddy and devoid of algae. Phytobenthos of Ezcurra Inlet is the poorest in respect to density and biomass of macroalgae aggregations as well as to the diversity of taxa in comparison to the remaining parts of the Admiralty Bay. Only 12 taxa were found here.

The distribution of phytobenthos in the Admiralty Bay in relation to the depth (Fig. 4) indicates that the poorest zone is the epilittoral where only Prasiola crispa occurs; just above the border between epilittoral and littoral appear the algae: *Enteromorpha* sp., *Urospora penicilliformis*, *Ulothrix* sp. and *Porphyra endiviifolium* which also occur below, in the littoral. Apart from them in littoral occur the algae which also overgrow the bottom in sublittoral down to the depth of 10 m. These are the following species: *Monostroma hariotii, Iridaea cordata, Curdiea racovitzae, Gigartina skottsbergii, Leptosarca simplex, Adenocystis utricularis, Phaeurus antarcticus, Ascoseira mirabilis. Iridaea cordata, Curdiea racovitzae* and *Gigartina skottsbergii* occur sometimes below the depth of 10 m reaching the depths of 60, 50 and 20 m, respectively. The remaining algae, including *Monostroma hariotii* and *Leptosarca simplex* overgrow the bottom in sublittoral where also following algae occur: *Antarctosaccion applanatum, Sarcodia antarctica, Georgiella confluens, Plocamium cartilagineum, Kallymenia* sp., *Pantoneura plocamioides, Myriogramme mangini, Ballia callitricha, Pugetia* sp., *Delesseria lancifolia, Phycodrys antarctica, Laingia* sp., *Delesseria salicifolia, Phyllophora ahnfeltioides, Picconiella plumosa, Desmarestia menziesii, Geminocarpus austrogeorgiae, Pylaiella littoralis, Desmarestia ligulata, Cystosphaera jacquinotii, Desmarestia anceps* and *Himantothallus grandifolius.* The upper limit of the occurrence for the majority of algae mentioned above is the depth of 5—10 m, the lower one is 50—60 m. The thalli of *Desmarestia anceps* and *Himantothallus grandifolius* overgrow the bottom even to the depth of 90—100 m. *Plocamium cartilagineum* and *Desmarestia menziesii* were rarely found down to the depth of 80 m, whereas *Pugetia* sp. and *Myriogramme mangini* to the depths of 75 m and 85 m, respectively. *Picconiella plumosa* occurred mainly within the depth range 45—60 m and rarely in the depths 10—45 m. *Antarctosaccion applanatum* and *Kallymenia* sp. were recorded at the depth of 9 m. Thalli of *Desmarestia menziesii* and *Desmarestia ligulata* were rarely found in littoral. The limits of occurrence of algae *Delesseria lancifolia, Delesseria salicifolia* and Cystosphaera jacquinotii are ranged from 30—35 m to 40—58 m.

The observations of vertical distribution of macroalgae allowed to distinguish three zones of phytobenthos in the Admiralty Bay (Fig. 4). Lower limits of each zone seem to run approximatively at the depths of about 10 m, 60 m and 90 m, respectively. Each zone is characterized by the different groups of taxa:

I-st zone — encompasses the epilittoral, littoral and sublittoral down to the depth of 10 m. The set of taxa of this zone includes the representatives of four groups. Chrysophyta are represented by 1 taxon: *Antarctosaccion applanatum;* Chlorophyta — by 5 taxa: *Prasiola crispa, Enteromorpha* sp., *Urospora penicilliformis, Ulothrix* sp. and *Monostroma hariotii;* Rhodophyta — by 8 taxa: *Porphyra endiviifolium, Iridaea cordata, Curdiea racovitzae, Gigartina skottsbergii, Leptosarca simplex, Sarcodia antarctica, Georgiella confluens* and *Plocamium cartilagineum*; Phaeophyta — by 6 taxa: *Adenocystis utricularis, Phaeurus antarcticus, Ascoseira mirabilis, Desmarestia menziesii, Geminocarpus austrogeorgiae* and *Pylaiella littoralis.* In total, the set of macroalgae of the I-st zone is formed by 20 various species which are not uniformly distributed. The smallest number of algae occurs in the epilittoral and at its border with littoral. In the littoral and below in sublittoral down to the depth of 10 m the amount of algae increases. Although, the number of red algae species is two times higher than that of brown algae, the biomass of the representatives of both groups occurring in the first zone is similar. The share of green algae in the total biomass of macroalgae is very small, though locally, for example in central and lower littoral along the front of Ecology Glacier only dense aggregations of green algae *Urospora penicilliformis* and *Ulothrix* sp. occurred.

II-nd zone — is situated in sublittoral within the range of depths from 10 to 60 m. Chlorophyta are represented by one taxon: *Monostroma hariotii*; Rhodophyta — by 15 taxa: *Leptosarca simplex, Sarcodia antarctica, Georgiella confluens, Plocamium cartilagineum, Kallymenia* sp., *Pantoneura plocamioides, Myriogramme mangini, Ballia callitricha, Pugetia* sp., *Delesseria salicifolia, Phyllophora ahnfeltioides* and *Picconiella plumosa*; Phaeophyta — by 5 taxa: *Desmarestia menziesii, Desmarestia ligulata, Cystosphaera jacquinotii, Desmarestia anceps* and *Himantothallus grandifolius*. Several of these species such as: *Monostroma hariotii, Leptosarca simplex, Sarcodia antarctica, Georgiella confluens, Plocamium cartilagineum* and *Desmarestia menziesii* occur also in the I-st zone. The set of macroalgae of the II-nd zone is the richest consisting of 21 taxa. The number of red algae species is three times higher than that of brown algae but these latter decide on the biomass of macroalgae occurring in the II-nd zone of phytobenthos.

III-rd zone — begins approximately at the depth of 60 m and reaches down to the depth of about 90—100 m which is the lower limit of macroalgae occurrence in the Admiralty Bay. The set of species of the III-rd zone is formed mainly by two brown algae: *Desmarestia anceps* and *Himantothallus grandifolius* which dominate the biomass of phytobenthos in the zone discussed.

The range of occurrence of distinguished macroalgae zones differs in various parts of the Admiralty Bay (Fig. 6). The bottom region belonging to the I-st zone of phytobenthos covers the surface of 10,2 km^2, that of the II-nd zone — 23,7 km^2 and of the III-rd zone — 3,0 km^2 which makes respectively 28%, 64% and 8% of 36,9 km^2 of total bottom surface covered with algae in the whole Admiralty Bay region.

In the central part of the Bay all three zones of macroalgae do occur. The belt of phytobenthos of the I-st zone covers the surface of 6,1 km^2 which is 28% of 21,8 km^2 of a total bottom surface covered in this part of the Bay with algae. Maximal range of the I-st zone is 750 m from the coast. Areas of the II-nd and III-rd zones are 13,7 km^2 and 2,5 km^2 respectively, which makes 63% and 11% of the bottom covered with macroalgae in the part of the Bay discussed. II-nd zone reaches maximally a distance of 1700 m towards a center of bay, the III-rd zone — a distance of 1800 m. A wide micro-shelf and gentle slope of the bottom as well as its hard nature cause that the algal sets connected with each zone are most fully represented in the central part of the Bay.

In north-eastern part of bay encompassing Martel and Mackellar Inlets the I-st zone of macroalgae covers the surface of 3,2 km^2 that is 27% of 11,9 km^2 of total phytobenthos area in this part of the Bay. The belt of the I-st zone reaches maximally the distance of 700 m from the coast. The II-nd zone occupies the surface of 8,2 km^2 that is 69% of 11,9 km^2 of the total bottom area covered with algae of the discussed part of the Bay reaching maximally the distance of 2200 m from the coast. The largest regions of the bottom belonging to the I-st and II-nd zones of phytobenthos occur from Polish Navy Point to Furmańczyk Point and in Mackellar Inlet itself. Due to the rapid change of the bottom character — from rocky and stony to the silty and muddy, the Mackellar and Martel Inlets are devoid of the algae down from the depth of 50—60, i.e. from the lower limit of the II-nd zone of phytobenthos. Therefore the belt of the III-rd zone occurs only in the region from Hennequin Point to Smok Hill covering the surface of 0,5 km^2, i.e. 4% of 11,9 km^2 total phytobenthos surface in this part of the Bay. The belt of the III-rd zone reaches maximally the distance of 300 m from the coast only.

In the western part of the Bay encompassing the Ezcurra Inlet the I-st zone of macroalgae covers 0,9 km^2 of the bottom, i.e. 28% of the 3,2 km^2 of total bottom surface covered with algae in this part of the Bay. The width of the belt of the I-st zone is 300 m in the widest place. The belt of the II-nd zone occupies the surface of 1,8 km^2, i.e. 56% of the total phytobenthos surface of the bottom of this Inlet and reaches the maximal distance of 500 m from the coast. The lower limit of the occurrence of the II-nd zone of macroalgae runs in the Ezcurra Inlet at the depth of 20—60 m and therefore III-rd zone of phytobenthos does not occur here at all.

Discussion

The region of King George Island in the South Shetlands Archipelago in composition of its algal flora represents the geographical region called „Low Antarctic" (Heywood and Whitaker 1984) joining subantarctic zone with the region around the Antarctic continent — so called „High Antarctic". Number of taxa characteristic for subantarctic region is 81 (Heywood and Whitaker 1984), for „Low Antarctic" region varies between 40 and 61 (Moe and DeLaca 1976, Heywood and Whitaker 1984) and for „High Antarctic" region it is determined as 11—19 (Zaneveld 1968, Heywood and Whitaker 1984). Therefore 36 taxa found so far in the Admiralty Bay make rather high share of their total amount in this region. Among all recorded macroalgae in the Admiralty Bay the level of endemism is very high reaching 75%. The difference between particular classes are considerable. The endemism among brown algae is 90% and among red algae — 70%. The endemism among green algae is only 40%. The only representative of Chrysophyta is an endemic as well. As follows from data given by Heywood and Whitaker (1984), at similar latitudes in Antarctic, i.e. in „Low Antarctic" the general level of endemism of algae reaches 77% and for Chlorophyta, Phaeophyta and Rhodophyta amounts to 33,3%, 73,3% and 91,7%, respectively; so it is almost identical with the respective shares recorded for phytobenthos of the Admiralty Bay.

Thus the phytobenthos of the Admiralty Bay is of the transient character between the rich subantarctic bottom flora and the bottom flora of the areas close to the Antarctic continent (Delepine 1966).

Among macroalgae occurring in the Admiralty Bay the following species are most common: green algae — *Monostroma hariotii*; brown algae — *Adenocystis utricularis, Ascoseira mirabilis, Desmarestia anceps, Desmarestia ligulata, Desmarestia menziesii, Himantothallus grandifolius* and red algae — *Georgiella confluens, Iridaea cordata, Leptosarca simplex* and *Plocamium cartilagineum.* The species just mentioned occur in fact on the bottom of all parts of the Bay, which are covered with macroalgae aggregations. Thalli of remaining taxa occur only in particular regions. For example green algae — *Enteromorpha* sp., *Prasiola crispa, Ulothrix* sp., *Urospora penicilliformis*; brown alga — *Cystosphaera jacquinotii* and red algae — *Gigartina skottsbergii, Hymenocladiopsis crustigena, Kallymenia* sp., *Laingia* sp., *Phyllophora ahnfeltioides, Porphyra endiviifolium, Sarcodia antarctica* were found only in the central part of the Bay. The brown alga *Cystosphaera jacquinotii* forms dense aggregations which can be found only in the small area along western coast of the central part of the Bay from Rakusa Point to Napier Rock. The thalli of Chrysophyta *Antarctosaccion applanatum* and of red alga *Ballia callitricha* were found only in the Mackellar Inlet and the red alga *Phycodrys antarctica* — in the Ezcurra Inlet. The brown algae *Geminocarpus austrogeorgiae, Pylaiella littoralis* and red algae *Curdiea racovitzae, Delesseria salicifolia, Pantoneura plocamioides, Picconiella plumosa, Pugetia* sp. were found only in the central part of the Bay and in the Mackellar Inlet, red alga *Myriogramme mangini* and brown alga *Phaeurus antarcticus* in the central part of the Bay and in the Martel Inlet, while red alga *Delesseria lancifolia* in the central part of the Bay and in the Mackellar and Martel Inlets. Among algae occurring in the bottom of the central part of the Bay and of Mackellar and Martel Inlets most common were, along with those formerly mentioned, the following species: green algae — *Ulothrix* sp. and *Urospora penicilliformis*; brown alga *Phaeurus antarcticus* and red algae — *Curdiea racovitzae, Gigartina skottsbergii, Myriogramme mangini, Pantoneura plocamioides, Picconiella plumosa* and *Sarcodia antarctica.*

Investigations of Petrov and Nikolaev (1982) in the Maxwell Bay in the region of „Bellingshausen" Station (King George Island, South Shetlands) confirmed the high frequency of the occurrence of such species like *Monostroma hariotii, Ulothrix* sp., *Urospora penicilliformis, Adenocystis utricularis, Desmarestia menziesii, Iridaea cordata* and *Leptosarca simplex* in the region discussed. Neushul (1965) has found that brown algae of the genus *Desmarestia* belong to the prevailing forms of bottom flora in the region of King George Island and Livingston Island, Half Moon Island and Harmony Cove. The occurrence of following algae were also recorded there: *Monostroma hariotii, Adenocystis utricularis, Cystosphaera jacquinotii Iridaea cordata* and *Leptosarca simplex* (Neushul 1963). Collections and observations of phytobenthos carried out outside the Admiralty Bay (Zieliński 1981 and unpublished materials) beyond the Demay Point in the region of Paradise Cove and Telefon Rocks (Bransfield Strait), confirm the presence of the abundant macroalgae aggregations observed also by Neushul (1963, 1965) among which the following species prevailed: *Ascoseira mirabilis, Cystosphaera jacquinotii, Desmarestia anceps, Desmarestia ligulata, Desmarestia menziesii, Himantothallus grandifolius, Phaeurus antarcticus, Curdiea racovitzae, Georgiella confluens, Gigartina skottsbergii, Iridaea cordata* and *Plocamium cartilagineum.* These algae occurred also in the Admiralty Bay. In the list of Antarctic macroalgae of Papenfuss (1964) following taxa found in the South Shetlands area are mentioned: *Monostroma hariotii, Ulothrix* sp., *Urospora penicilliformis, Adenocystis utricularis, Ascoseira mirabilis, Cystosphaera jacquinotii, Desmarestia anceps, Desmarestia menziesii, Himantothallus grandifolius,* whereas in the list such taxa like *Enteromorpha* sp.,*Prasiola crispa, Desmarestia ligulata, Phaeurus antarcticus* and red algae are lacking. For the region of Antarctic Peninsula Papenfuss (1964) records the occurrence of almost all algae found in the Admiralty Bay. Most of brown algae occurring in the Admiralty Bay and green alga *Monostroma hariotii* are typical of the South Shetlands area (Delepine, Asensi and Etcheverry 1985), whereas in the region of Antarctic Peninsula, besides all algae formerly mentioned also following red algae occur: *Ballia callitricha, Leptosarca simplex, Plocamium cartilagineum, Porphyra endiviifolium.* Moe and DeLaca (1976) have found that the bottom flora of north-western coast of Fildes Peninsula and Maxwell Bay (King George Island, South Shetlands) is composed of green algae: *Enteromorpha* sp., *Monostroma hariotii,* brown algae: *Adennocystis utricularis, Desmarestia anceps, Desmarestia ligulata, Himantothallus grandifolius, Phaeurus antarcticus,* as well as red algae: *Curdiea racovitzae, Gigartina skottsbergii, Leptosarca simplex* and *Picconiella plumosa.* The occurrence of remaining taxa found also in the Admiralty Bay was recorded by Moe and DeLaca (1976) along the South Shetlands and the Antarctic Peninsula. DeLaca and Lipps (1976) observed the abundant macroalgae aggregations in the region of Anvers Island (Bonaparte Point and Janus Island, Antarctic Peninsula) with a distinct dominance of brown algae *Desmarestia menzesii* and *Himantothallus grandifolius.* Most of the algae found by these authors occurs also in the Admiralty Bay. Brown algae of the genus *Desmarestia* and *Himantothallus* grandifolius are dominant components of phytobenthos also in the South Orkneys area in the region of Borge Bay (Signy Island) (Richardson 1979). This author recorded also the occurrence of rich aggregations of brown alga *Ascoseira mirabilis* and red algae of genera *Iridaea, Gigartina* and

Myriogramme. In conclusion one can say that the composition of macroalgae of the Admiralty Bay is typical of the area spreading out from South Orkneys and South Shetlands up to Antarctic Peninsula that is of the southern part of the Scotia Arc which can be identified as the „Low Antarctic" area (Heywood and Whitaker 1984) or as the Polar Floristic Region according to Zinova (1958).

Some algal species occur in the Admiralty Bay as epiphytes overgrowing thalli of different species. Most often specimens of *Monostroma hariotii, Adenocystis utricularis, Phaeurus antarcticus* and *Leptosarca simplex* are found overgrowing the branched phylloids of *Desmarestia menziesii. Desmarestia ligulata* overgrows most often the thalli of red alga *Curdiea racovitzae*, while *Georgiella confluens* overgrows the rhizoids of algae *Desmarestia anceps* and *Himantothallus grandifolius*. Antarctosaccion applanatum occurred only on the thalli of *Plocamium cartilagineum* whereas *Ballia callitricha* on the thalli of *Pugetia* sp. Similar observations were done in the areas of South Shetlands, Antarctic Peninsula as well as in the vicinity of Antarctic continent. In the region of Half Moon Island (South Shetlands) and Hope Bay (Antarctic Peninsula) *Monostroma hariotii* and *Adenocystis utricularis* were the main epiphytes on the thalli of the genus *Desmarestia*. At the Petrel Island (Adelie Land) it was found that the cauloids and rhizoids of *Desmarestia* and *Himantothallus grandifolius* were overgrown by numerous red algae. Small red algae such as *Georgiella confluens, Myriogramme smithii* and *Plocamium coccineum* were also recorded as frequent epiphytes (Heywood and Whitaker 1984). The alga *Desmarestia ligulata* in the region of Palmer Station (Arthur Harbour, Anvers Island) are almost always overgrown by the thalli of *Curdiea racovitzae* and *Antarctosaccion applanatum* by thalli of *Plocamium cartilagineum* quite similarly as in the Admiralty Bay (R. Moe — personal communication).

The horizontal distribution of phytobenthos in the Antarctic Zone was presented so far in the form of simple schemes with spots marking the most frequent macroalgae species. Neushul (1968) has presented in this way the occurrence of 10 species of algae all over the area of the Southern Ocean. The scheme given by Delepine (1966) presented in form of concentric circles the zones of ranges of some selected macroalgae species in the whole Southern Ocean. The same author (Delepine 1976) on the basis of the aerial photo-interpretation and field investigations made out the more precise map of distribution of most abundant algae — *Macrocystis pyrifera* and *Durvillea antarctica* for the Morbihan Bay (Kerguelen Island, Subantarctic). He has estimated that the surface covered by these algae aggregations was 10—12 km^2 which makes 17% of the area of 60—70 km^2 of the whole Morbihan Bay. Richardson (1979) drew up the map of phytobenthos for the Borge Bay (Signy Island, South Orkneys) where brown algae *Desmarestia* spp., *Himantothallus grandifolius* and *Adenocystis utricularis* are mentioned, whereas the precise distribution of only two first species over the small area in the shallow zone (down to the depth 10—12 m) are presented.

Maps of horizontal distribution of bottom macroalgae aggregations in the Admiralty Bay (Figs. 5 and 6) are the first work of that type for the area of the Bay itself as well as for all South Shetlands. It was calculated that the areas of algal aggregations occupy up to 30% of the Admiralty Bay bottom surface; this estimation is two times larger than the result obtained in first attempt of charting the bottom of Admiralty Bay in 1979 (Zieliński 1981). That time unusually abundant aggregations of phytobenthos were recorded in the central part of Bay and along its western coast from Thomas Point to Demay Point; now the occurrence of macroalgae was also registered along the eastern coast of central part of the Bay, from Hennequin Point to Cape Vaureal, in Mackellar Inlet and in Martel Inlet. Furthermore, the bottom areas covered with macroalgae were identified in the Ezcurra Inlet. The occurrence of macroalgae aggregations was also confirmed by interpretation of the colour aerial photographs of the shallow water zone of Admiralty Bay (Furmańczyk and Zieliński 1982).

There are few data relating to the biomass of Antarctic phytobenthos. In the region of subantarctic Kerguelen Island (Morbihan Bay) Delepine (1976) has found that the wet weight of algae *Macrocystis pyrifera* and *Durvillea antarctica* varied between 3,4 kg m^{-2} and 22,5 kg m^{-2}. Heywood and Whitaker (1984) have calculated that in South Orkneys area (Signy Island) the aggregations of thalli of brown alga *Himantothallus grandifolius* in the places of their most dense occurrence reach maximally 3,7 kg m^{-2} of wet weight. White and Robins (1972) have found in the Borge Bay (Signy Island) that the average wet weight of phytobenthos was 1,37 kg m^{-2}, whereas Richardson (1979) noted that the average wet weight of macroalgae in the same region reached 0,98 kg m^{-2}. Petrov and Nikolaev (1982) measured the biomass of dominant species of algae in the littoral of Maxwell Bay (King George Island, South Shetlands) in the places of their most dense aggregations and found that the wet weight of thalli of *Adenocystis utricularis, Iridaea obovata, Curdiea racovitzae* and *Leptosarca simplex, Porphyra endiviifolium, Urospora penicilliformis* was 15,8 kg m^{-2}, 10 kg m^{-2}, 8 kg m^{-2}, 2,4 kg m^{-2} and 2,9 kg m^{-2}, respectively. Taking into account the above data and own observations one can approximately estimate the average biomass of macroalgae in the Admiralty Bay to be about 2 kg m^{-2} giving the total biomass of 73 800 tons in the area of 36,9 km^2 of the bottom covered by macroalgae. Thus the biomass of macroalgae concentrated in 1/3 of total bottom area of the Admiralty Bay is comparable with the biomass of bottom fauna estimated as some 66 700 tons of wet weight by Jażdżewski et al. (1986), but occurring in three times larger bottom area.

Summarizing, the bottom macroalgae despite covering of only 30% of bottom surface of the whole Bay, taking into account the high density of their aggregations and thus considerable biomass constitute the most important organic components of the total benthos of the Admiralty Bay.

The distribution of bottom macroalgae depends on many physical, chemical and biological factors (Feldman 1951, Trainor 1978). In subantarctic and Antarctic waters along with base edaphic factor the main role play dynamic factors: exposure to waves and currents as well as the presence of ice and its action (Dell 1972, Heywood and Whitaker 1984). DeLaca and Lipps (1976) when examining plant and animal communities in the Artur Harbour (Anvers Island, Palmer Archipelago) have found that maximal amounts of macroalgae occurred on the rocky bottom down to the depth of 43 m. Neushul (1965) observed in the region of Half Moon Island (South Shetlands) that the occurrence of macroalgae in littoral as well as their abundance in sublittoral are connected with the hard and mostly rocky bottom. Zaneveld (1968) stressed that one of the main factors limiting the presence of macroalgae on the bottom in the region of Victoria Land (Ross Sea) was a kind of the bottom, since algae fasten themselves mainly to stones and rocks and sometimes occur also on the bottom of gravel. Lee (1973) discussing the reasons of low diversity of phytobenthos in the Arctic Zone (northern coasts of Canada) which occurred only on small, isolated areas suggested that along with the unfavorable climate the decisive factor is the lack of hard bottom. Richardson (1979) when examining the relation of phytobenthos occurrence to the depth and type of the bottom in the Borge Bay (Signy Island, South Orkneys) observed that macroalgae occurred most abundantly on diversified rocky and stony bottom and the highest density of the thalli of *Himantothallus grandifolius* occurred on the bottom of stones and gravel. Quite similar situation was observed in the Admiralty Bay. Hard bottom occurs mainly in the central part of the Bay. In the western part (Ezcurra Inlet) and the north-eastern part (Mackellar Inlet and Martel Inlet) the bottom changes rather quickly together with the distance from the coast and the belt of rocky bottom is not wide; the bottom becomes soft, of silt and mud. The change of the bottom character limits the zones settled by algae; their lower limit reaches in the Mackellar Inlet only the depth of 55—60 m, in the Martel Inlet this limit changes from 20 to 90 m, reaching locally only the depth of 16 m. The similar situation was observed in the Ezcurra Inlet where the narrow belt of macroalgae reaches the depths from 5 to 50 m.

Moe and DeLaca (1976) observed that huge aggregations of algae, mainly Rhodophyta and brown alga of the genus *Desmarestia*, seem to be more dense and diversified in open areas exposed to waves and currents (Joubin Island, Anvers Island, Antarctic Peninsula; New Rock, in the vicinity of Deception Island, South Shetlands), in comparison to the protected bays and fjords (Flanders Bay, east of Adelaide Island, Antarctic Peninsula) where the aggregations of algae were poor and not diversified. In the Admiralty Bay the most abundant aggregations of phytobenthos occur in the open bottom areas along the western and eastern coasts of central part of the Bay thus confirming the observations mentioned above. At the same time one can suggest the favorable influence on macroalgae development of the inflow of water rich in nutrients running from the region of penguin rookeries and breeding grounds, and resting places of pinnipeds (Samp 1980, Myrcha, Pietr and Tatur 1985). The poverty of macroalgae in the Ezcurra and Martel Inlets confirms the observations of Moe and DeLaca (1976) on the importance of water movements; on the other hand one can explain this also by the previously discussed character of the bottom. It is also possible however that this poverty can be connected with the phenomenon observed by Gruzov (1978). This author has found the lack or the poverty of macroalgae in the region of Haswell Island (East Antarctic) in places where the ice sheet covered with snow strongly diminished the penetration of light during 9—10 months in a year. Zaneveld (1968) however has found that the abundant aggregations of macroalgae around Ross Island and along the Victoria Land (Ross Sea) occurred under the ice 2—6 m thick reaching far from the coast to the distance of 13—37 km and covered by snow 5 m thick. On the other hand Zaneveld (1966b) suggested earlier, that the benthic flora can overgrow the bottom under the shelf ice in the Ross Sea in the regions where ice is thin or with crevices enabling sufficient light penetration. The solid ice cover on the surface of the whole Admiralty Bay does not appear every year; the forming of the ice cover needs the favorable set of atmospheric and hydrological conditions (Presler 1980). However the major parts of Ezcurra, Mackellar and Martel Inlets, are covered by ice during every Antarctic winter and this ice persists locally until January. Along the remaining coasts of the Admiralty Bay even when the solid ice cover is lacking it occurs the coastal ice — snowy layer reaching locally a distance of few hundreds metres from the coast. This layer occurring over steep slopes of the bottom also limits the penetration of light, and for example along southern coasts of Ezcurra Inlet and around the Hennequin Point is able to reduce the algal growth. To recapitulate, in the Ezcurra, Mackellar and Martel Inlets macroalgae do not occur in the bottom areas before fronts of glaciers and in places where they contact with the coasts free of ice (Gdańsk Icefall, Zalewski Glacier, Doctors Icefall, Emerald Icefall, western and eastern parts of front of Domeyko Glacier, Stenhouse Glacier, Ajax Icefall, Goetel Glacier, Dobrowolski Glacier, Krak Glacier, Wanda Glacier). The processes of erosion and ablation take place here producing of huge amounts of mineral substances (Pęcherzewski 1980a) which run off to the Admiralty Bay in the form of fluvioglacial waters and form muddy sediments in sheltered parts of the area making impossible the fastening of algae to the bottom.

Ice is also an important factor limiting the occurrence of macroalgae in the Antarctic (Trainor 1978, Heywood and Whitaker 1984). Along with previously discussed importance of ice it influences mechanically the macroalgae aggregations overgrowing open bottom areas (Neushul 1965, Zaneveld 1966b, Etcheverry 1968, Gruzov 1978). Delepine, Lamb and Zimmermann (1966) observed in the region of Melchior Archipelago (Antarctic Peninsula) that the algae of epilittoral and littoral zone are much influenced by ice, where it covers rocks on the bottom for six months in a year partly or completely hampering the growth of thalli. The algae of littoral zone occurred only in the most sheltered places (Zinova 1958). Neushul (1965) observed in the region of Half Moon Island (South Shetlands) that the vast areas of tidal zone (littoral) were devoid of algae except of tidal pools and crevices in the bottom. The shallow water of the outer side of the island was covered with the crushed ice that was moved by waves and rubbed the bottom; its destructive influence was multiplied by the hummocking giving in effect the lack of algae in the region. In the Admiralty Bay along the coast from Thomas Point to Agat Rock only the belt of upper tidal zone some dozen meters in width was devoid of algae. In the region of Shag Point, Agat Rock and Chabrier Rock the coastal rocks form a very diversified bottom and so are an ideal shelter for the algae occurring there: *Adenocystis utricularis, Ascoseira mirabilis, Curdiea racovitzae, Desmarestia menziesii, Gigartina skottsbergii, Iridaea cordata, Phaeurus antarcticus.* They overgrow vertical rocky walls and occur also in the crevices which are out of reach of small ice fragments from the ice fields often recorded here. On the other hand the composed rock surfaces and bottom stones were completely devoid of algae. Ice can destroy algae in littoral as well as in many places remote from the coast (Moe and DeLaca 1976). These authors observed the traces of acting ice mostly above the depth of 5—10 m but in the region of Cape Bellue and Terra Firma Island (Antarctic Peninsula) even down to the depth of 25 m. The different situation was observed by these authors in the region of Greenwich Island (South Shetlands), in the English Strait and the Joubin Islands (the Antarctic Peninsula), where algae situated deeper in sublittoral were especially exposed to the trituration by icebergs. They have found also that algae occurring in the regions of permanent operation of ice are dwarfed and form smaller aggregations. Neushul (1965) observed in the region of Half Moon Island (South Shetlands) icebergs ploughing the bottom of sublittoral. Moreover he has stated that thalli were detached from the bottom by the anchor ice formed around the rocks. This phenomenon was also confirmed by Gruzov (1978). Especially exposed to the destroying action of icebergs in the sublittoral are the great thalli of *Desmarestia anceps, Desmarestia menziesii* and *Himantothallus grandifolius* which was observed along the South Shetlands and Antarctic Peninsula by DeLaca and Lipps (1976). In the Admiralty Bay the aggregations of big thalli of *Ascoseira mirabilis, Cystosphaera jacquinotii, Desmarestia anceps, Desmarestia menziesii* and *Himantothallus grandifolius* were detached of the bottom by big growlers and icebergs at the depths of 10—40 m. Icebergs rubbing the bottom were observed most often along western and eastern coasts of the central part of the Bay, so in the places of the highest density of macroalgae. Neushul (1965) and Moe and DeLaca

(1976) stated that the effect of ice on phytobenthos depends on the development of coastline, on the shape of the bottom as well as on the distance from productive glaciers. In the Admiralty Bay abundant and diversified aggregations of macroalgae occured in front of Ecology and Baranowski Glaciers, along the barrier of *Viéville* Glacier in the central part of the Bay as well as in front of the central part of Domeyko Glacier in the Mackellar Inlet. Only a direct vicinity of these glaciers some dozens metres wide is cleared from the algae. In the Admiralty Bay region there are no typical immersed glaciers. All barriers mentioned are the supported barriers of small activity, which do not form big icebergs that are normally formed by calving from the immersed glaciers, but only small pack ice and small icebergs some 15—20 m in height above the sea level (Fedak and Marsz, unpubl. data) which do not enter the shallow waters and which do not have the destructive effect on macroalgae of these regions. Ice cliffs of the Ezcurra, Mackellar and Martel Inlets are the barriers deeply supported and formed by the ice of icefalls (Marsz and Rakusa-Suszczewski 1987). They produce small icebergs (about 15 m in height) and growlers that have little influence on the poorer aggregations of macroalgae occurring here whereas, as a result of especially intensive ablation processes in this region, the sedimentation of silt on the bottom in the vicinity of ice barriers is very distinct. So, it is difficult to decide which of these factors just discussed decisively determine the phytobenthos aggregations and their range. It seems that each of the studied bottom areas of the Admiralty Bay has its own individual hydrological character.

The occurrence of particular species of macroalgae in the Antarctic is depth dependent and Dell (1972) described their vertical distribution. Delepine (1966) comparing the communities of macroalgae in the regions of Kerguelen, Crozet and Nouvelle Amsterdam Islands (the Subantarctic) and of Melchior Archipelago (Antarctic Peninsula) described several zones of phytobenthos. In the region of subantarctic islands the sublittoral was characterized by lack of algae; in the mediolittoral (the tidal zone) occurred *Porphyra* sp., *Ulothrix* sp., *Urospora* sp., *Iridaea* sp., *Adenocystis utricularis* and *Durvillea* sp.; their range determined the upper limit of infralittoral (Delepine and Grua 1964). In the infralittoral *Acrosiphonia* sp., *Desmarestia* spp., *Iridaea* sp., *Laminaria* spp., *Macrocystis* sp., *Ulva* sp. and red algae occured. In the region of Melchior Archipelago the zones distinguished were characterized by different composition of algae (Delepine 1966, Delepine, Lamb and Zimmermann 1966). In the supralittoral free of ice and snow during the Antarctic summer *Prasiola* sp. occurred. In the littoral phytobenthos was also of seasonal character due to the effect of destructive action of ice. In summer mainly green algae occurred here: *Monostroma hariotii, Ulothrix* sp., *Urospora* sp. as well as red algae: *Curdiea racovitzae, Iridaea obovata, Gigartina skottsbergii, Leptosarca simplex*; similar observations were reported by Zinova (1958). Delepine (1966) distinguished the upper, medium and lower infralittoral. The upper one ranging from minimal sea level to a depth of 10 m was characterized by the occurrence of such littoral algae as *Monostroma hariotii, Leptosarca simplex* and typical for the zone: *Ascoseira mirabilis* and *Phycodrys antarctica.* Here can be also found some algae from medium infralittoral which ranges from 10 to 30 m in depth. In medium infralittoral were present: *Kallymenia antarctica, Desmarestia anceps, Desmarestia menziesii, Gigartina* sp., *Myriogramme mangini* and first of all *Himantothallus grandifolius.* In lower infralittoral down from the depth of 30 m red algae occurred: *Phycodrys antarctica, Phyllophora antarctica* and *Picconiella plumosa* that was found also in the medium infralittoral. The similar zonation of phytobenthos along the Antarctic Peninsula was presented by DeLaca and Lipps (1976) who have distinguished 5 zones of the algal aggregations on the hard bottom. First two zones describe the mediolittoral with green algae, brown alga Adenocystis utricularis and red algae: *Curdiea racovitzae, Gigartina skottsbergii, Iridaea cordata.* Three remaining zones include the infralittoral with the characteristic aggregations of brown algae: *Desmarestia anceps, Desmarestia menziesii, Himantothallus grandifolius* and red algae: *Curdiea* sp., *Georgiella confluens, Myriogramme* spp., *Pantoneura plocamioides, Phycodrys antarctica, Picconiella plumosa, Plocamium cartilagineum, Sarcodia* sp. Along the zones just described in the tidal zone there were distinguished rock pools of supralittoral, littoral and infralittoral. They form the habitats similar to those of the infralittoral (inaccessible for ice) enabling the development of many thalli which are not quite characteristic for the tidal zone (mediolittoral); this phenomenon causes that the zonation of phytobenthos can be somewhat obscured (Delepine 1966, Delepine, Lamb and Zimmermann 1966). At the coasts of Antarctic continent (Point Geologie Archipelago, Adelie Coast) Delepine and Hureau (1963) distinguished also the zone of supralittoral with the green alga *Prasiola crispa,* zone of littoral (mediolittoral) with green alga *Ulothrix* sp. and a zone of infralittoral with the algae: *Monostroma hariotii, Desmarestia* spp. and *Himantothallus grandifolius.* The same zones, though differently named, were also described by Zaneveld (1966b, 1968) for the Ross Sea region. In the epilittoral, which was an equivalent of the supralittoral, occurred *Prasiola crispa* and *Ulothrix* sp. Littoral, corresponding here to mediolittoral, due to the rubbing action of ice, was devoid of algae. Sublittoral (an equivalent of infralittoral) included two zones, i.e. the upper one to the depth of 10 m and the lower zone situated in the range of depths 10—37 m. In the upper zone the phytobenthos was abundant even under the thick layer of ice. Here occur the algae *Monostroma hariotii* and *Iridaea cordata,* whereas in the lower one — *Desmarestia menziesii, Himantothallus grandifolius, Leptosarca simplex, Plocamium cartilagineum* and *Phycodrys antarctica.* Elittoral of Zaneveld was the lowest zone below the depth of 37 m which is the upper limit of occurrence of the red alga *Ballia callitricha.*

Each of three zones of phytobenthos distinguished in the Admiralty Bay is characterized by the specific group of taxa. The depth ranges of the occurrence of majority of algae of each of three groups allowed their separation by the borders which seem to run at the depths of about 10 and 60 m. Therefore, the first zone of phytobenthos in the Admiralty Bay includes epilittoral, littoral as well as the upper zone of sublittoral whereas the two remaining zones are situated in the lower part of sublittoral. The composition of macroalgae and their range within the first zone distinguished in the Admiralty Bay are similar to those from supralittoral, mediolittoral and upper infralittoral in the region of Antarctic Peninsula (Delepine 1966, Delepine, Lamb and Zimmermann 1966, DeLaca and Lipps 1966). However, in comparison to the Antarctic continent (Zaneveld 1968) in the Admiralty Bay the disturbing effect of ice in littoral is considerably smaller and so this zone is here richer in algae and almost identical with the littoral described in the adjacent Maxwell Bay (King George Island, South Shetlands) by Petrov and Nikolaev (1982). The possibility of existence of the border between first and second zone at a depth of about 10 m was suggested by the papers by Delepine (1966) and Zaneveld (1966a) as well as by the earlier preliminary description of vertical distribution of algae in the Admiralty Bay (Zieliński 1981). Moreover the upper limit of occurrence of the brown alga *Himantothallus grandifolius* runs in general, similarly as in the Admiralty Bay, at the depth of about 10 m which was also observed by Delepine, Lamb and Zimmermann (1966).

The second zone of phytobenthos in the Admiralty Bay, extremely rich in algae, also resembles the picture of central and lower infralittoral from the region of Melchior Island (Delepine 1966) or lower sublittoral and elittoral from the region of Ross Sea (Zaneveld 1966b, 1968). Down from the limiting depth of 60 m in the Admiralty Bay spreads the third zone with characteristic giant brown algae — *Desmarestia anceps* and *Himantothallus grandifolius*. This zone can be compared to the elittoral zone (ibid.) but the upper limit of elittoral ran not at a depth of 60 m but at a depth of 37 m. The macroalgae aggregations in the Antarctic become poorer below the depth of about 40 m in comparison to the depth range 10—40 m, though many species occur even below a depth of 100 m, for instance *Monostroma hariotii, Desmarestia menziesii, Himantothallus grandifolius, Ballia callitricha, Leptosarca simplex, Phycodrys antarctica, Plocamium cartilagineum* (Heywood and Whitaker 1984). The lowest third zone of phytobenthos in the Admiralty Bay does not occupy large bottom area but considering the large size of brown algae occurring here a considerable part of the biomass is concentrated in this zone. The limit of this zone runs at the depth of about 90—100 m and at the same time it is the lowest limit of occurrence of macroalgae in the Admiralty Bay which was also found earlier (Zieliński 1981).

Delepine, Lamb and Zimmermann (1966) found the following lower limits of the occurrence of some algae for *Desmarestia* spp. more than 30 netres, for *Ascoseira mirabilis* and *Leptosarca simplex* — about 9 metres, for *Curdiea* sp., *Gigartina* sp. and *Iridaea* sp. — about 17 metres. Delepine (1966) found that the lower limit of occurrence of algae *Durvillea antarctica* and *Macrocystis pyrifera* in the Morbihan Bay (Kerguelen Island, Subantarctic) runs along an isobath of 20 metres. DeLaca and Lipps (1976) observed the algae down to the depth of 43 m suggesting that lower limits of their occurrence depends on the bottom type, the influence of waves and the penetration of light. Zaneveld (1966a) pointed out that some species of algae in the Ross Sea can occur at considerable depths; for example: *Monostroma hariotii* — 350 m, *Ballia callitricha* and *Plocamium cartilagineum* — 311 m, *Iridaea cordata* — 183 m, *Leptosarca simplex* — 475 m, *Himantothallus grandifolius* — 320 m and that the absolute lower limit of occurrence of phytobenthos is probably even 668 m (Zaneveld 1968). In the Admiralty Bay the algae were collected at the depths below 90—100 m but usually they were the fragments of thalli detached from the bottom by ice at smaller depths and then transferred by icebergs or currents to the deeper parts of the Bay. Some reports on macroalgae occurrence at the depths below of 100 metres were probably caused by the error of depth measuring (Heywood and Whitaker 1984) or they were the result of transportation of algae detached from the bottom by icebergs and currents (Skottsberg and Neushul 1960, Neushul 1965). Zaneveld (1968) who studied the region of Ross Island and of Victoria Land (Ross Sea) was of the opinion that the transport by icebergs plays small role in the transport of algal material. The detailed study of algal material obtained by the commercial bottom trawl from the depths below 200 m in the central part of the Admiralty Bay showed that the total amount of thalli caught by the trawl was not large taking into account the time of trawling and the trawl width; moreover most of thalli were only the fragments of specimens or it was a whole thallus long ago detached from a rhizoid with broken cauloid surface, or with broken edges of phylloids; clear marks of decomposition of thalli were also recognized (Zieliński, unpubl. data).

Summarizing, the vertical distribution of macroalgae in the Admiralty Bay is similar to the vertical distribution of phytobenthos in the region of subantarctic islands, South Shetlands, Antarctic Peninsula as well as in the area around the Antarctic continent.

The distribution of macroalgae aggregations is rather patchy in each distinguished zone and so the distinction of larger number of zones seems to be not justified.

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Streszczenie

W wyniku dwuletnich badań w 1979 i 1982 r. oraz w czasie lata antarktycznego 1986/87 wykonano w sumie 278 dragowań makroglonów dennych o łącznej długości 137 km na obszarze całej Zatoki Admiralicji (119 km^2) (Rys. 3) do głębokości 180 m, stwierdzając występowanie 36 taksonów (w tym 31 gatunków i 5 rodzajów) z czego 1 takson z gromady złocienic, 5 taksonów z gromady zielenic, 10 z gromady brunatnic i 20 z gromady krasnorostów. Liczba znalezionych taksonów stanowi 60% ogólnej ich liczby stwierdzonej w rejonie Szetlandów Południowych i Półwyspu Antarktycznego. Taksony endemiczne stanowią 75% całkowitej ich liczby w Zatoce, osiągając w gromadzie brunatnic, krasnorostów i zielenic odpowiednio 90%, 70% i 40%. Wielkości te są niemal identyczne z odnotowanymi dla rejonu Południowych Szetlandów. Liczba taksonów makroglonów i ich skład w Zatoce Admiralicji, a także procent endemiczności pozwalają stwierdzić, że fitobentos Zatoki Admiralicji ma charakter przejściowy pomiędzy florą denną Subantarktyki i florą denną obszaru przylegającego do kontynentu Antarktydy.

Spośród stwierdzonych w Zatoce Admiralicji makroglonów najpospolitsze są następujące taksony: zielenice — *Monostroma hariotii*; krasnorosty — *Georgiella confluens, Iridaea cordata, Leptosarca simplex, Plocamium cartilagineum*; brunatnice — *Adenocystis utricularis, Ascoseira mirabilis, Desmarestia anceps, D. ligulata, D. menziesii* i *Himantothallus grandifolius*.

W Zatoce Admiralicji powierzchnia dna pokryta fitobentosem zajmuje w rzucie prostokątnym na płaszczyznę lustra wody 36,9 km^2, co stanowi 31% jej całkowitej powierzchni (Rys. 5). W centralnej części Zatoki skupiska makroglonów zajmują 35% powierzchni i są najbogatsze pod względem gęstości, biomasy, ilości i różnorodności taksonów. Znaleziono tu 33 taksony. We fiordach Mackellar i Martel skupiska makroglonów zajmują 32% powierzchni i znaleziono tu 21

taksonów. Skupiska makroglonów we fiordzie Ezcurra zajmują 16% powierzchni i są najuboższe pod względem gęstości, biomasy, różnorodności i ilości taksonów, których znaleziono tu tylko 12.

Obserwacje pionowego rozmieszczenia makroglonów w Zatoce Admiralicji pozwoliły wyróżnić trzy piętra fitobentosu, których granice przebiegają na głębokościach 10, 60 oraz 90—100 m. Pierwsze piętro fitobentosu obejmuje epilitoral, litoral i sublitoral do głębokości 10 m i skupia 20 taksonów (w tym 1 złocienica, 5 zielenic, 6 brunatnic i 8 krasnorostów), których ilość wzrasta wraz ze wzrostem głębokości. Pomimo przewagi ilości krasnorostów w stosunku do brunatnic, o biomasie fitobentosu pierwszego piętra decydują przedstawiciele zarówno krasnorostów, jak i brunatnic. Drugie piętro fitobentosu mieści się w sublitoralu, w zakresie głębokości 10—60 m. Ugrupowanie makroglonów tego piętra jest najbogatsze i obejmuje 21 taksonów (w tym 1 zielenicę, 5 brunatnic i 15 krasnorostów). Pomimo trzykrotnej przewagi liczby krasnorostów w stosunku do liczby brunatnic, o biomasie makroglonów tego piętra decydują brunatnice. Trzecie piętro fitobentosu rozciąga się od głębokości 60 m do głębokości 90—100 m, która jest dolną granicą występowania fitobentosu w Zatoce Admiralicji. Ugrupowanie makroglonów tworzą głównie gigantycznych rozmiarów brunatnice, które decydują o biomasie fitobentosu tego piętra.

Zasięg występowania wyróżnionych pięter fitobentosu w rzucie horyzontalnym zmienia się w różnych rejonach Zatoki Admiralicji (Rys. 6). Obszary dna należące do I, II i III piętra makroglonów stanowią odpowiednio 28%, 64% i 8% w stosunku do całkowitej powierzchni fitobentosu. W centralnej części Zatoki powierzchnie dna należące do I, II i III piętra makroglonów stanowią odpowiednio 28%, 63% i 11% powierzchni fitobentosu w tej części Zatoki. Skalisto-kamieniste podłoże stwarza dogodne warunki do przytwierdzania się plech, które występują tu do głębokości 90—100 m. We fiordach Mackellar i Martel powierzchnie dna należące do I i II piętra stanowią 27% i 69% powierzchni fitobentosu w tej części Zatoki. Ze względu na zmianę charakteru dna z twardego na ilasto-mulaste makroglony występują tu przeważnie do głębokości 50—60 m, a pas III piętra makroglonów stanowi tu zaledwie 4% powierzchni fitobentosu. We fiordzie Ezcurra I i II piętro stanowi 28% i 56% powierzchni fitobentosu w tej części Zatoki. Skupiska makroglonów są tu najuboższe,występują do głębokości 20—60 m, co związane jest z obecnością osadów mułu, uniemożliwiających przytwierdzanie się plech do podłoża. We fiordzie Ezcurra III piętro makroglonów w ogóle nie występuje. Względna obfitość taksonów w średnim i dolnym litoralu jest cechą charakterystyczną dla całej Zatoki, związaną z panującymi w tym obszarze warunkami lodowymi, których niszczące działanie jest ograniczone w wyniku regresu czół lodowców. Rozmieszczenie pionowe makroglonów w Zatoce Admiralicji jest podobne do innych rejonów Antarktyki.