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The intertidal algal flora of Isipingo Beach, Natal, South Africa, and its phycogeographical affinities

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ABSTRACT: The intertidal seaweed flora of Isipingo Beach, Natal, is described. Isipingo Beach lies on the sub-tropical east coast of southern Africa and is the only east coast locality studied in detail by pioneering biogeographers. A total of 172 species (37 chlorophytes, 26 phaeophytes and 109 rhodophytes) are recorded. A phycogeographical analysis of 124 species with sufficiently documented distributions, shows that 69 % are warm water species also known from the tropical coasts of Mozambique, Tanzania and Kenya. The phycogeographical affinity of the Isipingo flora is certainly with sub-tropical and tropical floras.

INTRODUCTION

The study of marine organisms along the coast of southern Africa was pioneered by Stephenson (1939, 1944, 1948). Stephenson and co-workers, in their quest to identify a zonation scheme relevant to southern African shores, studied the distribution of marine organisms at eight different localities (Stephenson et al., 1937; Bright, 1938a, 1938b; Eyre & Stephenson, 1938; Eyre et al., 1938; Stephenson et al., 1938; Eyre, 1939; Stephenson et al., 1940). Observations made during these investigations were combined to produce a zonation scheme applicable to the entire southern African shore and to identify three biogeographical provinces (Stephenson, 1939, 1944, 1948).

Stephenson (1948) identified cold temperate, warm temperate and sub-tropical provinces associated with the west, south and east coasts of the subcontinent (Fig. 1). The location of these provinces has long been associated with the ocean current pattern along the southern African shore (Isaac, 1937; Stephenson, 1948). The east coast is influenced by the warm Agulhas Current which has its origins in the South Equatorial Current of the Indian Ocean. The Agulhas Current, while cooling down as it moves south along the coast retains a core temperature of 25 °C which facilitates the spread of tropical marine organisms far to the south (Brown & Jarman, 1978). The west coast is influenced by the cold, north flowing Benguela Current which originates at the sub-tropical convergence, from Atlantic Central water. The Benguela Current is reinforced by the Antarctic West Wind drift making it considerably colder than the currents of the east and south coasts (Brown & Jarman, 1978). The mean annual sea temperature at Durban on the east coast is 21.7 °C, which is well above the annual temperature of 12.4 °C at Port Nolloth, situated at

the same latitude on the west coast (Fig. 1; temperature data for 1973–1983 supplied by the South African Maritime Office).

The three provinces described by Stephenson (1948) have generally been accepted (e.g. Brown & Jarman, 1978), but the west coast flora was considered by Bolton (1986) to be better described as warm temperate, though still distinct from the warm temperate south coast flora. A transitional change of species from cold water through warm temperate to warm water was observed to occur along the southern African coastline from west to east (Stephenson, 1944, 1948). Such a transition has been confirmed more recently with the identification of two transition regions: warm temperate west coast flora to warm temperate south coast flora (western overlap) in the region of Cape Agulhas (Bolton, 1986), and warm temperate south coast flora to sub-tropical east coast flora

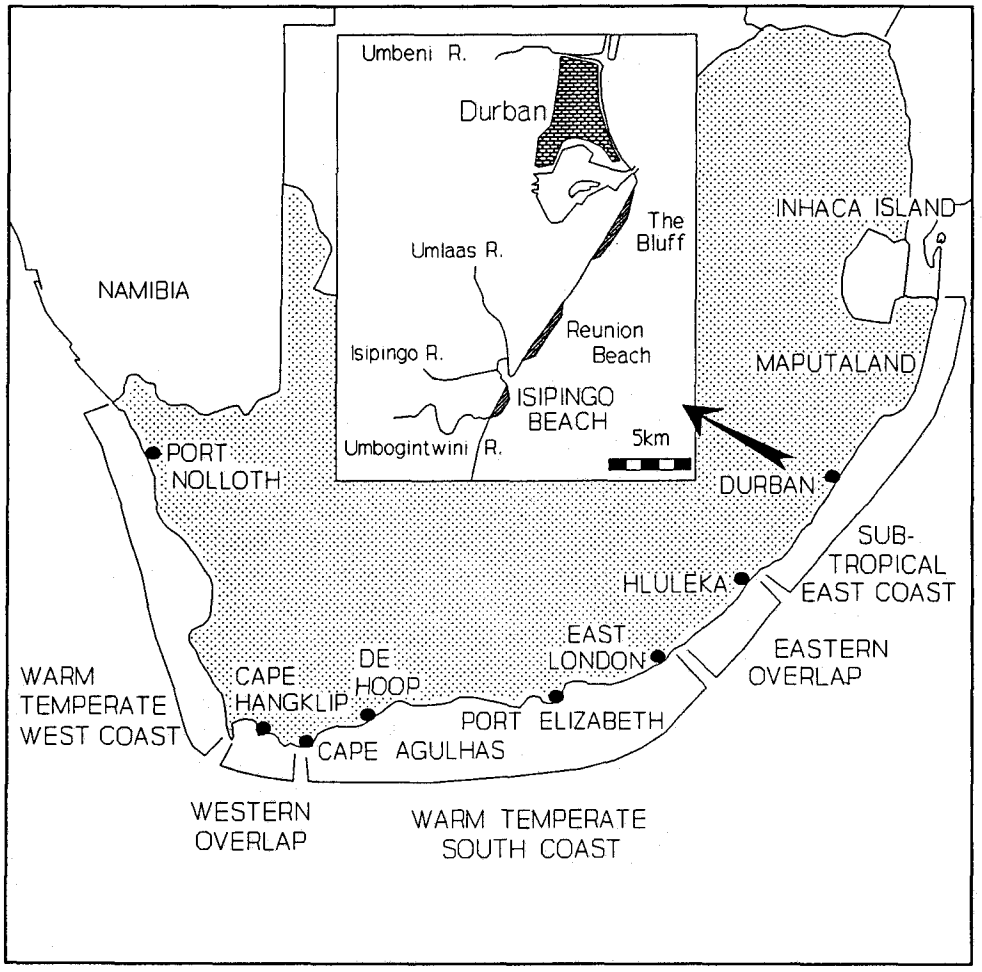

Fig. 1. Southern Africa and the localities mentioned in the text. Also shown are the phytogeographical provinces recognized by South African phytogeographers. The inset shows the location of Isipingo Beach, south west of Durban

(eastern overlap) in the region of Hluleka, Transkei (Bolton & Stegenga, 1987). Recently the central point of the western overlap was identified to occur at Cape Hangklip (Jackelman et al., 1991), an area slightly west of Cape Agulhas.

Most biogeographical work has been carried out in the two temperate provinces (e.g. Isaac, 1937; Stephenson et al., 1937; Bright, 1938a, 1938b; Eyre et al., 1938; Stephenson et al., 1938; Eyre, 1939; Stephenson et al., 1940; Isaac, 1949; Bolton, 1986; Bolton & Stegenga, 1987; Lawson et al., 1990; Jackelman et al., 1991). Ecological work in these provinces has also provided fairly comprehensive species lists (e.g. Klenk, 1985; Munnik, 1987; Anderson & Stegenga, 1989). Only one (Eyre & Stephenson, 1938) of the eight early studies by Stephenson and co-workers, was conducted on the east coast. Little has been done since, except for the largely ecological work of Thomson (1954), Guy & Jarman (1969), Sinton (1970), Jackson (1976) and Lambert (1976). The species lists included in these publications have been restricted to "ecologically important" species. The only extensive species list published for the east coast of southern Africa is a check list for Maputaland on the northern Natal coast listing 220 species (Seagrief, 1980). Recent work suggests that there are more than 400 seaweed species to be found on the coast of Natal (Norris & Aken, unpubl. data). Earlier, less extensive lists including Natal seaweeds are those by Barton (1893, 1896) listing 89 species, Delf & Michel (1921) listing 72 species, Stephenson (1948) listing 107 species and Simons (1976) listing 101 species.

This paper provides a list and biogeographical analysis of macroalgal species collected at Isipingo Beach on the Natal coast. Isipingo Beach was the only east coast locality studied in detail by Stephenson (Eyre & Stephenson, 1938) and it is from this historical locality that species considered characteristic of the sub-tropical east coast were first collected and identified.

COLLECTION SITE AND METHODS

Isipingo (29°60'S, 31°02'E; 18 km south of Durban; Fig. 1) is almost centrally situated on the east coast of South Africa. The rocky intertidal zonation pattern at Isipingo was described by Eyre & Stephenson (1938) and is typical of the east coast zonation pattern (Stephenson, 1944). The supralittoral fringe is dominated by the mollusc *Littorina* spp. and a few algal species such as *Bostrychia* spp. and *Rhizoclonium ambiguum*. The midlittoral zone is delimited by the rock oyster *Saccostrea cucullata* (Born.) Dollfuss & Doutzenberg above, and by the zoanthid *Palythoa nelliae* Pax. below. Intertidal algae of the midlittoral zone are mostly turf forming species such as *Caulacanthus ustulatus* and *Gelidium reptans*, except where rock pools support numerous larger species such as *Sargassum heterophyllum*, *Codium* spp. and *Galaxaura* spp. The sublittoral fringe is dominated by wave-resistant algae such as *Hypnea spicifera*, *Gelidium abbottorium* and *Plocamium corallorhiza* (Eyre & Stephenson, 1938; Thomson, 1954).

Samples were collected at monthly intervals from March, 1990–June, 1991. Seaweeds were preserved in 4 % formaldehyde in seawater. Fixed specimens were mounted on herbarium sheets or (in the case of smaller species) preserved in the form of permanent microscope slides (mounted in glycerine jelly stained with gentian violet; O'Brian & McCully, 1981). Each species was given a catalogue number. The liquid-preserved material, herbarium sheets and slides are housed in the Botany Department of the University of the Witwatersrand. Large, common, algae could usually be identified

using Simons (1976); some species, however, required the use of other taxonomic publications. Kylin (1938), Levring (1938), Papenfuss (1947), Silva (1959), Simons (1966), Jaasund (1976), Lawson & John (1982), Norris & Aken (1985), Wynne (1985), Norris (1986), Lambert et al. (1987), Norris (1987a, 1987b, 1987c), Norris et al. (1987), Norris & Molloy (1988), and King & Puttock (1989) were consulted when Simons (1976) proved unsatisfactory.

The phytogeographic affinity of the seaweed flora of Isipingo was assessed by means of a floristic ratio calculated using Cheney's (1977) formula:

$$\frac{R+C}{P}$$

Where C = no. of chlorophyte species
P = no. of phaeophyte species
R = no. of rhodophyte species.

In addition to this pseudo-quantitative indicator of "biogeographical nature" the distribution patterns of species with well documented distribution records were plotted according to their distribution around nine southern African sites. This served as an additional gauge of the affinity of the Isipingo region with neighbouring warm temperate and tropical regions.

RESULTS

A total of 172 algae were identified. This total was made up of 37 species of Chlorophyta (17 genera), 26 species of Phaeophyta (16 genera) and 109 species of Rhodophyta (67 genera). The Caulerpales, Dictyotales, Ceramiales, Corallinales and Gigartinales, orders rich in pantropical genera and species (Lüning, 1990) each contributed ten percent or more of the total species number. The floristic ratio of Cheney (1977; $R+C/_P$) gave a value of 5.6.

In the list below, nomenclature follows Seagrief (1984), except for recent changes in Silva et al. (1987), Norris (1987b, 1987c), Norris et al. (1987), King & Puttock (1989) and Norris (1990). The classification scheme of the Chlorophyta and Phaeophyta follows Silva et al. (1987), Lee (1989) and Lüning (1990) for the delimitation of orders and families. The delimitation of rhodophytan orders follows Garbary & Gabrielson (1990), family delimitation follows Silva et al. (1987) and Lüning (1990).

Division: Chlorophyta

Class: Ulvophyceae

Order: Caulerpales

Family: Caulerpaceae

Caulerpa filiformis (Suhr) Hering
Caulerpa racemosa (Forssk.) J.Ag. var. *laetevirens* (Mont.) Weber-van Bosse
Caulerpa racemosa (Forssk.) J.Ag. var. *peltata* (Lamour.) Eubank
Caulerpa racemosa (Forssk.) J.Ag. var. *racemosa* Papenf. et Egerod
Caulerpa racemosa (Forssk.) J.Ag. var. *turbinata* (J.Ag.) Eubank
Caulerpa racemosa (Forssk.) J.Ag. var. *zeyheri* (Sonder ex Kütz.) Weber-van Bosse

Family: Codiaceae

Codium capitatum Silva
Codium duthieae Silva
Codium extricatum Silva
Codium prostratum Levr.
Codium spongiosum Harv.

Family: Derbesiaceae

Bryopsis caespitosa Suhr ex Kütz.
Bryopsis flanaganii Barton
Bryopsis setacea Hering
Derbesia hollenbergii Taylor

Family: Udoteaceae

Halimeda cuneata Hering in Krauss
Pseudocodium devriesii Weber-van Bosse
Udotea orientalis A. et E. S. Gepp

Order: Cladophorales

Family: Anadyomenaceae

Microdictyon kraussii Gray

Family: Cladophoraceae

Chaetomorpha antennina (Bory) Kütz.
Chaetomorpha crassa (C. Ag.) Kütz.
Chaetomorpha linum (O. F. Müll.) Kütz.
Cladophora contexta Levr.
Cladophora radiosa (Suhr) Kütz.
Cladophora rugulosa Martens
Cladophora virgata (C. Ag.) Kütz.
Rhizoclonium ambiguum (Hook. f. et Harv.) Kütz.

Order: Dasycladales

Family: Dasycladaceae

Acetabularia calyculus Lamour.

Order: Siphonocladales

Family: Siphonocladaceae

Chamaedoris delphinii (Hariot) Feldmann et Boerg.
Cladophoropsis herpestica (Mont.) Howe

Family: Valoniaceae

Valonia aegagropila C. Ag.
Valonia macrophysa Kütz.

Order: Ulvales

Family: Ulvaceae

Enteromorpha compressa (L.) Grev.
Enteromorpha lingulata J. Ag.

Enteromorpha prolifera (O. F. Müll.) J. Ag.
Ulva fasciata Delile
Ulva rigida C. Ag.

Division: Phaeophyta

Class: Phaeophyceae

Order: Dictyosiphonales

Family: Chnoosporaceae

Chnoospora minima (Hering) Papenf.

Order: Dictyotales

Family: Dictyotaceae

Dictyopteris delicatula Lamour.
Dictyopteris longifolia Papenf. (in ed.)
Dictyopteris serrata (Aresch.) Hoyt.
Dictyota adnata Zan. sensu Jaasund
Dictyota cf. *ceylanica* Kütz.
Dictyota dichotoma (Hudson) Lamour. var. *intricata* (J. Ag.) Grev.
Dictyota divaricata Lamour.
Dictyota liturata J. Ag.
Dictyota naevosa (Suhr) J. Ag.
Dilophus suhrii (Kütz.) Papenf.
Lobophora variegata (Lamour.) Wom.
Padina boryana Thivy
Stoecheospermum marginatum (J. Ag.) Kütz.
Zonaria harveyana (Pappe ex Kütz.) Aresch.
Zonaria subarticulata (Lamour.) Papenf.
Zonaria tournefortii (Lamour.) Mont.

Order: Ectocarpales

Family: Ectocarpaceae

Ectocarpus rhodochortonoides Boerg.
Giffordia conifera (Boerg.) Taylor

Family: Ralfsiaceae

Ralfsia expansa (J. Ag.) J. Ag.

Order: Fucales

Family: Sargassaceae

Sargassum elegans Suhr
Sargassum heterophyllum (Turn.) C. Ag.
Turbinaria ornata (Turn.) J. Ag.

Order: Scytosiphonales

Family: Scytosiphonaceae

Colpomenia sinuosa (Roth) Derbes et Solier
Endarachne binghamiae J. Ag.

Order: Sphacelariales

Family: Sphacelariaceae

Sphacelaria novae-hollandiae Sonder

Division: Rhodophyta

Class: Rhodophyceae

Subclass: Florideophycidae

Order: Ceramiales

Family: Ceramiaceae

Antithamnion eliseae R. E. Norris
Ballia beckeri Schmitz ex Mazza
Callithamnion stuposum Suhr
Centroceras clavulatum (C. Ag.) Mont.
Ceramium centroceratiforme Simons
Ceramium glanduliferum Kylin
Ceramium obsoletum C. Ag.
Ceramium poeppigianum Grunow
Crouania franciscii Cormaci, Furnari et Scammacca
Griffithsia confervoides Suhr
Griffithsia schousboei Mont.
Griffithsia secunda Harv. ex J. Ag.
Gymnothamnion elegans (Schousboe ex C. Ag.) J. Ag.
Microcladia exserta Wynne
Pleonosporium filicinum (Harv. ex J. Ag.) De Toni
Spyridia cupressina (Harv.) Kütz.
Spyridia hypnoides (Bory) Papenf.

Family: Dasyaceae

Dasya scoparia Harv. ex J. Ag.
Heterosiphonia cf. *arenaria* Kylin

Family: Delesseriaceae

Acrosorium acrospermum (J. Ag.) Kylin
Acrosorium maculatum (Kütz.) Papenf.
Acrosorium uncinatum (Turner) Harv.
Apoglossum spathulatum (Sond.) Wom. et Shepl.
Caloglossa leprieurii (Mont.) J. Ag.
Platysiphonia miniata (C. Ag.) Boerg.
Pollexfenia minuta (Kylin) Papenf.

Family: Rhodomelaceae

Bostrychia tenella (Lamour.) J. Ag. ssp. *tenella*
Bostrychia tenella (Lamour.) J. Ag. ssp. *flagellifera* (Post) King et Puttock
Chondria dasyphylla (Woodw.) C. Ag.
Digenea subarticulata Simons
Falkenbergiella capensis Kylin

Herposiphonia heringii (Harv.) Falkenb.
Herposiphonia secunda (C. Ag.) Ambronn f. *tenella* (C. Ag.) Wynne
Kuetzingia natalensis J. Ag.
Laurencia flexuosa Kütz.
Laurencia natalensis Kylin
Laurencia pumila (Grunow) Papenf.
Lophosiphonia reptabunda (Suhr) Kylin
Murrayella periclados (C. Ag.) Schmitz
Ophidocladus simpliciusculus (Crouan) Falkenb.
Pachychaeta cryptoclada Falkenb.
Placophora binderi (J. Ag.) J. Ag.
Polysiphonia incompta Harv.
Polysiphonia cf. *scopularum* Harv.
Polyzonia elegans Suhr
Pterosiphonia cloiophylla (C. Ag.) Falkenb.
Pterosiphonia spinifera (Kütz.) Norris et Aken
Pterosiphonia stangeri (J. Ag.) Falkenb.
Rhodomelopsis africana Pocock
Stictosiphonia hookeri (Harv.) Hook. et Harv.
Symphyocladia marchantioides (Harv.) Falkenb.

Order: Corallinales

Family: Corallinaceae

Amphiroa anceps (Lamarck) Decaisne
Amphiroa bowerbankii Harv.
Amphiroa ephedraea (Lamarck) Decaisne
Amphiroa rigida Lamour.
Arthrocardia carinata (Kütz.) Johansen
Arthrocardia duthiae Johansen
Cheilosporum cultratum (Harv.) Aresch.
Cheilosporum proliferum (Lamour.) De Toni
Cheilosporum sagittatum (Lamour.) Aresch.
Corallina officinalis L.
Haliptilon subulatum (Ellis et Solander) Johansen
Jania adhaerens Lamour.
Jania crassa Lamour.
Jania verrucosa Lamour.
Lithophyllum spp.
Lithothamnion spp.
Melobesia membranacea (Esper) Lamour.
Metamastophora flabellata (Sonder) Setchell
Pneophyllum sp.
Polyporolithon patena (Hook. f. et Harv.) Mason
Titanoderma pustulatum (Lamour.) Naegeli

Order: Gelidiales

Family: Gelidiaceae

Gelidium abbottiorum R. E. Norris
Gelidium arenarium Kylin
Gelidium micropterum Kütz
Gelidium pteridifolium Norris, Hommersand et Fredericq
Gelidium reptans (Suhr) Kylin
Pterocladia caespitosum (Kylin) R. E. Norris
Pterocladia caloglossoides (Howe) Dawson

Order: Gigartinales

Family: Caulacanthaceae

Caulacanthus ustulatus (Turner) Kütz.

Family: Cryptonemiaceae

Polyopes constrictus (Turner) J. Ag.
Prionitis nodifera (Hering) Barton

Family: Gigartinaceae

Gigartina minima Kylin

Family: Gracilariaceae

Ceratodictyon variabile (Grev. ex J. Ag.) R. E. Norris
Gracilaria aculeata (Hering) Papenf.
Gracilaria millardetii (Mont.) J. Ag.
Gracilaria protea J. Ag.
Gracilaria salicornia (C. Ag.) Dawson
Gracilaria vieillardii Silva

Family: Hypneaceae

Hypnea intricata Kylin
Hypnea pannosa J. Ag.
Hypnea rosea Papenf.
Hypnea spicifera (Suhr) Harv. in J. Ag.
Hypnea tenuis Kylin
Hypnea viridis Papenf.

Family: Peyssonneliaceae

Peyssonnelia capensis Mont.

Family: Plocamiaceae

Plocamium beckeri Simons
Plocamium corallorhiza (Turner) Harv.
Plocamium suhrii Kütz.

Family: Rhizophyllidaceae

Portieria hornemannii (Lyngb.) Silva
Portieria tripinnatus (Hering) Silva

Order: Hildenbrandiales

Family: Hildenbrandiaceae

Hildenbrandia rosea Kütz.

Order: Nemaliales

Family: Helminthocladiaceae

Liagora ceranoides Lamour.

Family: Galaxauraceae

Galaxaura diesingiana Zan.
Galaxaura marginata (Ellis et Solander) Lamour.
Galaxaura obtusata (Ellis et Solander) Lamour.

Order: Rhodymeniales

Family: Champiaceae

Champia compressa Harv.

Family: Rhodymeniaceae

Botryocladia madagascariensis Feldmann
Rhodymenia natalensis Kylin

Phytogeographical affinities of the Isipingo flora

Distribution records for 124 of the 172 species occurring at Isipingo Beach are documented sufficiently for biogeographical analysis (i.e. were reported from particular localities on the South African Coast in at least two publications; references used included Barton, 1983, 1986; Delf & Michell, 1921; Stephenson et al., 1937; Bright, 1938a, 1938b; Eyre & Stephenson, 1938; Eyre et al., 1938; Stephenson et al., 1938; Eyre, 1939; Stephenson et al., 1940; Stephenson, 1948; Isaac, 1949; Simons, 1966; Klenk, 1985; Munnik, 1987; Seagrief, 1980, 1988; Norris & Aken, 1985; Bolton, 1986; Norris, 1986, 1987a, 1987b, 1987c; Bolton & Stegenga, 1987; Norris & Molloy, 1988; Anderson & Stegenga, 1989; Bolton & Stegenga, 1990; Jackelman et al., 1991). Figure 2 illustrates the distribution of the species around sites described by several authors (e.g. Stephenson, 1939, 1944, 1948; Brown & Jarman, 1978; Bolton, 1986; and Bolton & Stegenga, 1987) as significant in biogeographical studies along the South African coast. The seaweeds of Isipingo could be separated into four biogeographical classes based on their distributions: a cold water group containing 4 species, a ubiquitous group containing 9 species, a south coast group containing 26 species and a warm water group containing 85 species. Cold water species occur on both the west and south coasts, but do not extend east of Durban. This group included *Bryopsis setacea* and *Pterosiphonia cloiophylla*. The ubiquitous species occur along almost the entire coast of South Africa and may also extend further north; it includes *Enteromorpha compressa, Ralfsia expansa, Caulacanthus ustulatus, Centroceras clavulatum* and *Hypnea spicifera*. South coast species have their centres of distribution west of the Eastern Overlap and do not extend much east of Durban or west of the Western Overlap. This group includes species such as *Bryopsis flanaganii, Dictyota liturata, Dictyota naevosa, Endarachne binghamiae, Amphiroa bowerbankii, Callithamnion stuposum, Ceramium glanduliferum, Gigartina minima* and

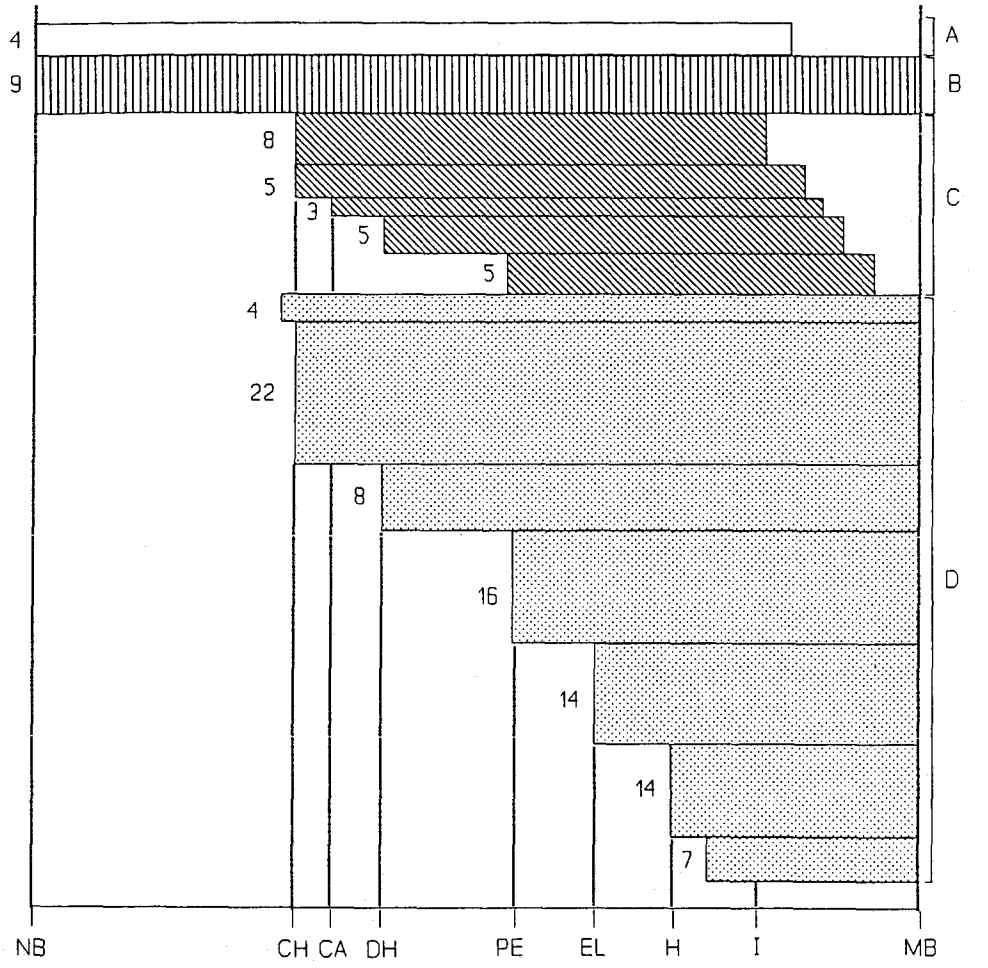

Fig. 2. Distribution of 124 of the seaweed species reported from Isipingo Beach along the South African coast. Four distribution groups are distinguished: cold water species (Group A), ubiquitous species (Group B), south coast species (Group C) and warm water species (Group D). The localities used are as follows: Namibian Border (NB), Cape Hangklip (CH), Cape Agulhas (CA), De Hoop (DH), Port Elizabeth (PE), East London (EL), Hluleka (H), Isipingo Beach (I) and Mozambique Border (MB)

Portieria tripinnatus. The bulk of the species (69 % of the total analysed) are warm water species, which, while extending along the south coast over varying distances, all extend into sub-tropical and tropical waters to the east of Durban. Most of the warm water species are known to occur on Inhaca Island, Mozambique (84 %; Critchley et al., in press) and several have been reported as far north as Tanzania (48 %; Jaasund, 1976), Kenya (40 %; Lawson, 1980) and Somalia (8 %; Lawson, 1980). This warm water group includes species such as *Acetabularia calyculus, Caulerpa racemosa* var. *peltata, Caulerpa racemosa* var. *turbinata, Chamaedoris delphinii, Codium spongiosum, Udotea*

orientalis, Valonia macrophysa, Dictyopteris delicatula, Padina boryana, Turbinaria ornata, Apoglossum spathulatum, Bostrychia tenella ssp. *tenella, Galaxaura marginata, Hypnea tenuis, Laurencia flexuosa, Murrayella periclados* and *Spyridia cupressina.*

DISCUSSION

Recently described were the seaweed floras of Cape Hangklip (Jackelman et al., 1992), De Hoop (Bolton & Stegenga, 1990), Port Elizabeth (Munnik, 1987), East London (Klenk, 1985) and Hluleka (Bolton & Stegenga, 1987). Isipingo has, respectively, 133 and 121 species in common with Hluleka and East London (eastern and western limits of Eastern Overlap; Bolton & Stegenga, 1987), most of which (60–70 %) are warm water species. Isipingo shares 108 species with Port Elizabeth and 83 species with De Hoop, of which 45–55 % are warm water species. Cape Hangklip and Isipingo have 71 species in common, of which only 40 % are warm water species. There is a marked decrease in the number of warm water species along the south coast (Fig. 2); 40 % of the warm water species found at Isipingo do not extend west of Hluleka and East London and an additional 20 % do not extend west of Port Elizabeth. Only 30 % of the warm water species found at Isipingo Beach reach Cape Hangklip at the Western Overlap.

While a number of warm water species do not extend beyond the Eastern Overlap (Hluleka and East London; Fig. 2) many appear to reach their distribution limits at Port Elizabeth, perhaps suggesting that the Eastern Overlap region should be extended further west on the South African south coast. The distribution data presented here is far from complete, but it would appear that the Eastern Overlap transition region, at least for south coast species, may extend as far north as the Isipingo/Durban region. Possibly the concept of clearly demarcated transition regions on the southern African coast needs to be re-evaluated.

Isipingo Beach shares between 80 and 60 % of its algal species with colder areas to the west, but most of these (about 60 %) are warm water species reaching the limits of their distributions along the south coast. The high floristic ratio (5.6) and the species distribution (Fig. 2) certainly supports the conclusion that its algal flora can be considered subtropical (Eyre & Stephenson, 1938). It may be more accurate to describe the flora as tropical since most of the warm water species are known to extend beyond the South African east coast into the coastal waters of Mozambique (Critchley et al., in press) and several have been recorded in the tropical floras of Tanzania (Jaasund, 1976), Kenya (Lawson, 1980) and even Somalia (Lawson, 1980).

Cheney (1977) introduced the (R + C)/P ratio to compare the biogeographical affinities of seaweed floras. He observed that, in general, there was an increase in the ratio of Chlorophyta and Rhodophyta species relative to Phaeophyta species towards the tropics. Ratios of less than three indicated temperate or cold water flora, while ratios of six or greater indicated a tropical flora, and intermediate values suggested a mixed flora. The (R + C)/P ratio obtained for the Isipingo flora (5.6) was near six and may be taken to suggest a tropical affinity. However, the applicability of the (R + C)/P ratio to southern African shores has been questioned (cf. Bolton, 1986).

Table 1 compares the (R + C)/P ratios obtained in several recent studies conducted along the South African shore. The majority of studies conducted along southern African shores have provided (R + C)/P ratios above or just below six. At most localities the

Table 1. Species numbers and floristic ratios obtained in twelve recent studies conducted along the southern African coast

Biogeographical region	No. of species (% of flora) Chlorophyta	Phaeophyta	Rhodophyta	Total	$\frac{(R + C)}{P}$
West Coast					
Namibia Coast[1]	34 (26)	22 (16)	80 (58)	136	5.2
Cape coast[2]	37 (13)	39 (15)	192 (72)	268	5.9
Western Overlap					
Cape Hangklip[3]	27 (14)	25 (12)	147 (74)	199	7.0
South Coast					
Eastern Cape[4]	44 (16)	35 (13)	188 (70)	267	6.6
De Hoop[5]	12 (10)	23 (18)	91 (72)	126	4.9
Port Elizabeth[6]	19 (18)	15 (14)	74 (68)	108	6.2
East London[7]	29 (19)	17 (12)	103 (69)	149	7.7
Eastern Overlap					
Hluleka[8]	33 (18)	25 (14)	120 (67)	178	6.1
East Coast					
Maputaland[9]	67 (30)	37 (17)	116 (53)	220	4.9
Natal coast[10]	78 (19)	61 (15)	271 (66)	410	5.7
Isipingo Beach[11]	37 (22)	26 (15)	109 (63)	172	5.6
Inhaca Island[12]	79 (35)	24 (11)	121 (54)	224	8.0

[1] Lawson et al. (1990), [2] Bolton (1986), [3] Jackelman et al. (1991), [4] Seagrief (1985), [5] Bolton & Stegenga (1990), [6] Munnik (1987), [7] Klenk (1987), [8] Bolton & Stegenga (1987), [9] Seagrief (1980), [10] Norris & Aken, unpublished data, [11] this study, [12] Critchley et al. (in press)

Phaeophyta species collected have represented only between 13 and 15% of the total flora. This percentage results in a floristic ratio of between 5.6 and 6.6 (indicating a tropical affinity). It has been suggested that the proliferation of brown algal species in colder areas, which has occurred in the northern hemisphere, has not occurred in southern Africa (Bolton, 1986). This could explain the predominantly high floristic ratios obtained for the southern African shore regardless of biogeographical affinities.

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