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Status of the macroalgae and seagrass vegetation after the 1991 Gulf War oil spill

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A b s t r a c t: The intertidal zone of the Saudi Arabian Gulf coast is almost devoid of macroalgae or seagrasses, even in non-polluted sites. Because of the extreme climatic conditions these plants are restricted to subtidal habitats which have not been affected by the oil spill. Their diversity in the Dawhat ad-Dafi and Dawhat al-Musallamiya area is at least as high as in other similar regions of the Gulf. Their biomass can locally be very high, at least during part of the year. A species list of the Chlorophyta, Phaeophyta and Rhodophyta from the region is included.

حالة الطحالب الكبيرة والحشائش البحرية عقب حدوث بقعة الزيت عام ١٩٩١م

أولفر دوكليرك وأريك كوبيجانز

خلاصة: تخلو منطقة مابين المد والجزر على الساحل السعودي للخليج العربي تقريباً من الطحالب الكبيرة والحشائش البحرية حتى في المواقع التي لم تتلوث. وبسبب الظروف المناخية المتطرفة فإن وجود هذة النباتات يقتصر على بيئات ما تحت المد والجزر التي لم تتأثر ببقعة الزيت وكان تنوعها في منطقتي دوحة الدفي ودوحة المسلمية لايقل عنه في المناطق المماثلة الأخرى من الخليج وقد تكون كتلتها الحية على النطاق المحلي عالية على الأقل خلال فترة معينة من العام. ويتضمن البحث قائمة بأنواع كل الطحالب الخضر Chlorophyta والطحالب البنية Phaeophyta الموجودة في المنطقة.

INTRODUCTION

The seagrasses and macroalgae of Saudi Arabia north of the Jubail area had never been studied from a biological point of view before the 1991 oil spill. The only recent data with which we can compare our results are those of BASSON (1979a, b) on the seaweeds of the Arabian Gulf Coast of Saudi Arabia and those of AL HASAN & JONES (1989) on the marine algal flora and seagrasses of the coast of Kuwait.

MATERIALS AND METHODS

The well pronounced seasons result in a wide range of water temperatures and salinities. The fieldwork was therefore planned for different seasons: 13 - 28 May 1992 (E. Coppejans), 17 July - 20 August 1992 (E. Coppejans & O. De Clerck), 30 October - 14 November 1992 (O. De Clerck) and 19 February - 5 March 1993 (O. De Clerck). Observations and collections were made only in the area of the Jubail Marine Wildlife Sanctuary (between Ras az-Zaur and the north-eastern point of Abu Ali) and were mainly carried out along the continental shore (including Dawhat ad-Dafi and Dawhat al-Musallamiya). The Island of Karan was visited once (August 1992).

These activities were carried out by wading in the intertidal zone at low tide, by snorkelling and by SCUBA diving in the subtidal zone. In this way the following habitats were studied: mangrove stands, salt-marshes, "bare" intertidal sand and mudflats,

including tidal channels and shallow sand pools with stone and shell fragments, rocky shores, also including intertidal pools. In the subtidal area the fringing reefs as well as the patch reefs, seagrass meadows and bare sandy areas were also visited. The collected material was either prepared as herbarium specimens or preserved in 4 % formalin with sea water. The preserved samples were used for the anatomical analysis whereas the dried specimens are more useful for the study of the morphological variability of the species (due to ecological factors and to seasonal development). Both approaches are necessary for accurate identifications which were carried out in Gent.

The dried specimens result in a "complete" reference collection which is deposited in the herbarium of the Universiteit Gent (GENT), and a collection containing at least a specimen of every species deposited in the King Fahd University in Riyadh.

RESULTS

The supralittoral and intertidal zones: The intertidal zone (and even the supralittoral fringe) of tropical coasts is generally richly covered by a large number of seaweeds and seagrasses which form distinct zones. The Gulf shoreline of Saudi Arabia is, on the contrary, almost devoid of algae and seagrasses. This is due to the extreme annual fluctuations in temperature and salinity (JOHN et al. 1990, BASSON et al. 1977).

Salt-marshes: Large areas of this vegetation have been heavily polluted by the oil spill, but even the non-polluted sites are devoid of any algal growth (except for the extended, thick mats of Cyanophyta). This is confirmed by BASSON et al. (1977). In other tropical regions, algae such as *Vaucheria*, *Enteromorpha* and *Ulva* develop in this biotope. *Ulva* occurs in areas with a higher nutrient level like Tarut Bay but has not been found in the study area.

Mangroves: Vast surfaces of this shrubby vegetation have also been severely damaged by the oil spill. However, once again the absence of the Bostrychietum, an algal association which is very characteristic on the pneumatophores of mangroves in most tropical areas (COPPEJANS & GALLIN 1989), is not due to the pollution: *Bostrychia* and the associated species of this algal community have never been recorded in the Gulf area. Even the control sites of Tarut Bay, which were not polluted by the 1991 oil spill contain no Bostrychietum. Here the *Avicennia* pneumatophores are generally covered by a layer of blue-green algae, and some of these aerial roots growing in the tidal channels are covered by epiphytic *Chondria dasyphylla, Polysiphonia kampsaxii* and *Cladophora nitellopsis* during the cold season.

Sandy and muddy coasts: This is the zone where, in other regions of the Indian Ocean, a well-marked zonation occurs for different seagrasses, mixed with some algae (COPPEJANS et al. 1992). On the coastline north of Jubail even the non-polluted areas seem to be completely devoid of any macroscopic vegetation. This is the result of the "scoring" effect of the sun during summer and of the cold temperatures in winter. In the cold season, however, small stones or shell fragments may be covered by *Cladophora*, especially in the shallow tidal pools or tidal channels. Here, even some seagrass (*Halodule*) growth may occur, especially towards low water mark. Shell fragments which were recently washed ashore and stick in the oiled surfaces may also show some *Cladophora* growth in winter.

Rocky substrate: The upper and middle parts of the intertidal rocks were also almost completely devoid of macroscopic vegetation. In parts of the Indian Ocean this zone is covered by a relatively dense cover of various macroalgae. Here again the extreme climatic conditions prohibit the development of this vegetation in the Gulf region. Deeper rock pools locally have some algal growth: *Cystoseira myrica*, *C. trinodis* and *Hormophysa cuneiformis* are the most characteristic species. Old specimens of these are frequently covered by several epiphytes: *Hincksia mitchelliae*, *Sphacelaria rigidula*, *Jania rubens* and *Fosliella farinosa*. The lower part of the intertidal zone (in fact the infralittoral fringe, between mean and spring low water mark) along sheltered coasts is generally characterised by a dense vegetation of *Digenea simplex*. In shallow pools close to the extreme low water line a relatively rich algal flora was developed, especially in spring, with *Dictyosphaeria cavernosa*, *Cladophora nitellopsis*, *Chondria dasyphylla*, *Laurencia obtusa*, *L. papillosa*, *Polysiphonia opaca, Ceramium strictum* and *Hypnea cornuta.* Along exposed coasts (such as Abu Ali) *Cladophoropsis sundanensis* forms cushion-like coverings in the infralittoral fringe.

The subtidal zone: This habitat has not been affected by the oil spill (except for a few restricted areas) and therefore shows the typical vegetation types.

Soft substrate: Sand and muddy sand substrates are by far dominant in the subtidal zone. They are either bare or covered by seagrasses; *Halodule uninervis* is the dominant species, forming extensive meadows from low water mark down to -3 m. Locally it can be replaced by *Halophila stipulacea* and also by some *Halophila ovalis*. Both of these mainly develop close to low water mark and mainly as colonising species (e.g. shifting sand banks). In a few areas the green alga *Avrainvillea amadelpha* is mixed with *Halodule*. Below -3 m the seagrass cover declines rapidly and another Chlorophyte, *Caulerpa sertularioides*, locally colonises the available space in patches down to -6 m.

Hard substrate: Fringing coral reefs are fairly well developed along the north-west coast of Abu Ali Island as well as along the east coast of Ras az-Zaur Bay. Shallow patch reefs are distributed over the central area of Dawhat ad-Dafi. They all have a similar and diversified algal flora: their upper surface, close to the water surface, is frequently covered by *Sporolithon molle*. In winter they are largely covered by the cerebriform *Colpomenia sinuosa* and the filamentous *Hincksia mitchelliae*. These species die off in spring; large quantities of loose-lying, decaying specimens of *Colpomenia* are then found in the lagoon of Abu Ali as well as in sheltered subtidal bays around the patch reefs. At the same time the perennial bases of *Sargassum* start forming new annual branches which quite quickly grow into dense bushy vegetations, reaching 1 m in height and locally completely covering the reef. In the summer the annual branches of *Sargassum* are shed and large masses of them are found drifting in patches until they are washed ashore. Together with *Halodule* leaves, drift-wood and other organic material they form a specific biotope at spring high water level with a typical associated fauna. Around Karan this dense vegetation has not been observed, but the stolonoidal stage of *Turbinaria ornata* covers vast areas of the reefs. Along the continental coast vertical and overhanging walls generally have a very colourful and rich flora (especially in spring with huge specimens of *Asparagopsis taxiformis*); at Karan they show large populations of *Lobophora variegata*. *Avrainvillea amadelpha* frequently develops in the coral crevices close to the water surface, mainly at the seaward side of the reefs.

On partly sand-covered, hard substrates between coral heads an algal vegetation develops which is generally dominated by *Hormophysa cuneiformis*, *Cystoseira trinodis* and *Sargassum decurrens*, locally mixed with *Padina gymnospora* and *Dictyota indica*.

Extensive *Sargassum* beds are also present on hard substrates between -4 and -6 m north of Abu Ali. *Dictyopteris membranacea* (a new record for the Gulf) grows extensively on the vertical walls.

Different *Sargassum* species as well as *Cystoseira trinodis* die off towards the summer, leaving the hard substrate rather bare. Hence observations over the different seasons are absolutely essential to understand the annual fluctuations in the biomass of the submerged vegetation.

CONCLUSIONS AND DISCUSSION

The climatic conditions of the supralittoral and intertidal zones are so extreme (especially in summer) that they inhibit macroalgal and seagrass development along the Gulf coast of Saudi Arabia. The oil spill almost exclusively covered these areas and therefore did not influence the algal development. Moreover, some tar-covered rocks of the infralittoral fringe ("Abu Ali slipway") have become completely colonised by *Padina minor*, *Dictyota indica*, *Colpomenia sinuosa*, *Hincksia mitchelliae* and *Spacelaria tribuloides*.

As seaweeds do not have true roots but root-like or discoidal holdfasts by which they can attach themselves to any hard substrate (rock, coral, shells, plants, buoys, ropes, boats and also hardened oil) if the quantity of toxic components is not too high. Moreover their respiration and nutrient uptake takes place over the whole thallus surface and therefore they are partly independent of the substrate quality. Finally as most seaweeds are annual, recolonisation takes place very quickly by spores coming from non-polluted areas.

The preparation of an inventory for the area studied is not yet complete (e.g. most of the smaller epiphytes have still been omitted from the analysis) and identifications are still proceeding, but from the available data it already appears that the seaweed and seagrass vegetation of the area between Ras az-Zaur and Abu Ali is very rich (compared to other regions in the Gulf). Finally the absence of representatives of the genus *Ulva* on the one hand and the very restricted amounts of *Enteromorpha* on the other hand indicate low levels of eutrophication as compared to Kuwait and Tarut Bay where the growth of these species is luxuriant.

SPECIES LIST:

Chlorophyta: (20 taxa = 19 species + 1 ecad)
Entocladia viridis Reinke
Phaeophila dendroides (Crouan frat.) Batters
Enteromorpha clathrata (Roth) Greville
Enteromorpha flexuosa (Wulfen ex Roth) J. Agardh
Chaetomorpha aerea (Dillwyn) Kützing
Chaetomorpha gracilis (Kützing) Kützing
Chaetomorpha linum (Müller) Kützing f. *brachyarthra* Kützing
Chaetomorpha mediterranea (Kützing) Kützing
Cladophora cf. *'coelothrix'*
Cladophora koeiei Børgesen
Cladophora nitellopsis Børgesen
Rhizoclonium tortuosum (Dillwyn) Kützing
Cladophoropsis sundanensis Reinbold
Dictyosphaeria cavernosa (Forsskål) Børgesen
Bryopsis hypnoides Lamouroux
Trichosolen sp.
Caulerpa sertularioides (Gmelin) Howe ecad *sertularioides*
Caulerpa sertularioides (Gmelin) Howe ecad *farlowii*
Avrainvillea amadelpha (Montagne) Gepp & Gepp
Acetabularia calyculus Quoy & Gaimard

Phaeophyta: (25 taxa = 24 species + 1 variety)
Feldmannia indica (Sonder) Womersley & Bailey
Feldmannia irregularis (Kützing) Hamel
Hincksia mitchelliae (Harvey) Silva
Sphacelaria rigidula Kützing
Sphacelaria tribuloides Meneghini
Dictyota sp. 1
Dictyota sp. 2
Dictyota indica Sonder
Dictyopteris membranacea (Stackhouse) Batters
Lobophora variegata (Lamouroux) Womersley
Padina gymnospora (Kützing) Vickers
Padina minor Yamada
Nemacystus decipiens (Suringar) Kuckuck
Colpomenia sinuosa (mertens ex Roth) Derbès & Solier
Hydroclathrus clathratus (C. Agardh) Howe
Cystoseira myrica (Gmelin) J. Agardh
Cystoseira trinodis (Forsskål) C. Agardh
Hormophysa cuneiformis (Gmelin) P.C. Silva
Sargassum angustifolium (Turner) J. Agardh
Sargassum binderi Sonder
Sargassum boveanum J. Agardh
Sargassum boveanum J. Agardh var. *aterrimum* Grunow
Sargassum decurrens (Turner) C. Agardh
Sargassum latifolium (Turner) C. Agardh
Turbinaria ornata (Turner) J. Agardh var. *ornata* f. *evesiculosa* (Barton) Taylor

Xanthophyta: (1 species)
Vaucheria piloboloides Thuret

Rhodophyta: (42 species)
Chroodactylon ornatum (C. Agardh) Basson
Erythrotrichia carnea (Dillwyn) J. Agardh
Acrochaetium savianum (Meneghini) Nägeli
Liagora distenta (Mertens) J. Agardh
Asparagopsis taxiformis (Delile) Trevisan
Gelidiella myriocladia (Børgesen) Feldmann & Hamel
Gelidium pusillum (Stackhouse) Le Jolis
Wurdemannia miniata (Sprengel) Feldmann & Hamel
Dudresnaya sp.
Peyssonnelia simulans Weber-van Bosse
Jania rubens (Linnaeus) Lamouroux
Fosliella farinosa (Lamouroux) Howe
Hypnea cervicornis J. Agardh
Hypnea cornuta (Kützing) J. Agardh
Champia parvula (C. Agardh) Harvey
Callithamniae sp.
Anotrichium tenue (C. Agardh) Nägeli
Antithamnion cruciatum (C. Agardh) Nägeli
Centroceras clavulatum (C. Agardh) Montagne
Ceramium codii (Richards) Feldmann-Mazoyer
Ceramium fastigiatum (Wulfen ex Roth) Harvey f. *flaccidum* Petersen
Ceramium strictum (Kützing) Harvey
Crouania attenuata (C. Agardh) J. Agardh
Spyridia filamentosa (Wulfen) Harvey
Hypoglossum sp.
Dasya baillouviana (Gmelin) Montagne
Dasya cf. *corymbifera* J. Agardh
Heterosiphonia crispella (C. Agardh) Wynne
Acanthophora spicifera (Vahl) Børgesen
Chondria collinsiana Howe
Chondria dasyphylla (Woodward) C. Agardh
Digenea simplex (Wulfen) C. Agardh
Herposiphonia secunda (C. Agardh) Ambronn f. *tenella* (C. Agardh) Wynne
Laurencia obtusa (Hudson) Lamouroux
Laurencia papillosa (C. Agardh) Greville
Laurencia patentiramea (Montagne) Kützing
Leveillea jungermannioides (Hering & Martens) Harvey
Polysiphonia crassicollis Børgesen
Polysiphonia kampsaxii Børgesen
Polysiphonia opaca (C. Agardh) Zanardini
Polysiphonia cf. *scopulorum* Harvey var. *villum* (J. Agardh) Hollenberg
Polysiphonia sp.

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