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AN UPDATE AND REVIEW OF THE SEAWEEDS FROM SUDAN

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Abstract

Sudan's coastline is located in the central part of the Red Sea on the western coast. It hosts some spots of biological interest like Sanganeb Atoll and Dongonab Bay. Nevertheless, there is paucity in the information concerning Sudan's seaweeds composition and distribution. The present paper is a trial to provide a comprehensive list of the taxa recorded from Sudan. This is achieved by reviewing the available literature, examining the collection of the preserved samples available at the Faculty of Marine Science and Fisheries, Red Sea University and field trip collection. Accordingly a total of 112 entities were recorded, 106 from the available literature and 6 new additions. Comprehensive phycological surveys are required to include all species present.

Introduction

Although the Red Sea has a less diverse species compared to other tropical marine environment (**Krupp, 1993**), it contains distinct biota with significant level of endemism. About 9% of its seaweed flora is endemic (**Walker, 1985**). Red Sea algal communities are influenced by some of its physical parameters. These may include surface water temperature and salinity that exhibit a marked gradient moving from north to the south (**UNEP, 1997**). Generally, while surface water temperature tends to increase from north to south, salinity decreases in same direction. The tidal pattern is characterized with a central node near Jeddah, tidal amplitude increases moving away from this point to the north or to the south. According to some of these parameters, the Red Sea is subdivided into three regions, the northern, the central, and the southern. Red Sea seaweeds are characterized with a clear seasonality (**Sheppard et al., 1992**) in accordance with changes in seasonal surface water temperature. Remaining of the thallus of some annual species could be seen during unfavorable season. For example remaining of *Turbinaria* sp. holdfasts are common on coral stones in summer. Sudan coast is located in the central part of the Red Sea on the western coast. It extends to 750 km with some hot spots of biological interest such as Sanganeb Atoll and Dongonab Bay.

Realizing the paucity of information on the marine flora of Sudan, the present paper is a trial to compile a preliminary list of the Sudanese seaweeds, and to identify the lack in information required to be filled by research.

Phycological studies along the Sudanese Red Sea:

The prominent reference to Sudanese seaweeds is the historic compilation of **Papenfuss** published in **1968**. A relatively recent review on phycological work done along the Sudanese Red Sea coast was provided by **Sheppard et al. (1992)**. **Elhag and Karim (1980)** investigated the association of macroalgae in small area in Suakin with reference to zonation and seasonality. He mentioned 14 entities from the area with complete taxonomic names that to date are used as a reference. In the eighties several studies were carried out on coral reef ecosystems of the Sudan. These studies included seaweeds as a one of the major reef components. **Vine and Vine (1980)** profiled and located the important members of sessile flora associated with Sudanese coral reef. **Elhag (1993)** provided a list of seaweeds from Sanganeb Atoll, with few entities identified to species level. On one hand his work to date is very significant as it added more species as new records in Sudanese Red Sea. On the other hand it also highlights the problem of the scarcity of phycologists in the country and unrevealed the volume of work required to provide the basic phycological knowledge about this resource.

Three approaches were implemented to obtain the required information on the Sudanese seaweeds. The aims of this paper were :

- Examination of the preserved seaweed samples at Faculty of Marine Science and Fisheries, Red Sea University, Portsudan, Sudan.
- Review of the available literature on Sudanese seaweeds on the Algae Base Website. References to information from this source are referred to as **Papenfuss (1968)**.
- Ground truthing to verify the existing knowledge and to recommend new additions.

Material and methods:

Sandy shores and reef backs in the vicinity of Port Sudan harbor (Figure 1) were surveyed during December 2009 and January 2010 to examine existing algal lawns and to record present plants. Transects perpendicular to shoreline were located and species encountered were listed. Samples were taken to the laboratory for further examination and treatment. Morphological measurements were done using a vernier caliber and a ruler following **Edding et al. (2006)**. Measured attributes include total thallus length, width and thickness. Each attribute was measured 3 times on the same specimen to the nearest millimeters. For the red algae samples cross sections were made with a razor and sections were stained with aniline blue before examined under the microscope.

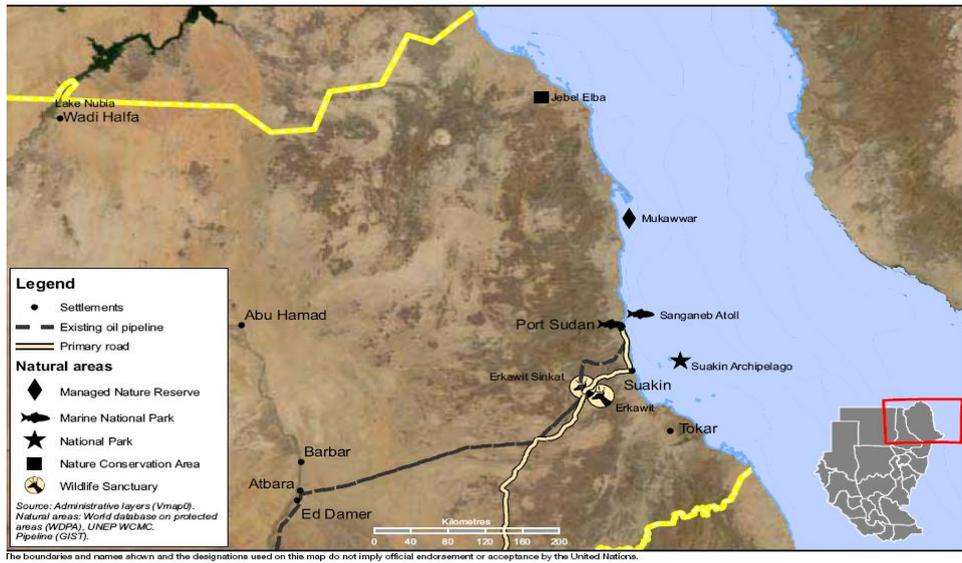


Figure (1): Location map of the study area with some aspect of conservation efforts in Sudan coastal zone.

Results

Table (1) represents the recorded taxa of Sudan’s marine macroalgae. The list includes 112 entities including 47 of red algae, 27of brown algae, and 38 of green algae.

Description of the new additions:

The present paper adds 6 entities to the Sudanese seaweed species list. These include 2 red seaweeds, and 4 green seaweeds. However, the authors believe that there exist many species to be added if comprehensive surveys and collections are made.

1. *Acetabularia* sp. 1: Thallus green, length of 11 cm, made up of a prostrated stalk giving rise to vertical branched stalks. Vertical stalk composed of periodically repeated whorls of flattened caps. Cap consists of fused segment. Cap diameter ranges from 3 to 5 mm.

Table 1: List of taxa of marine macroalgae recorded in Sudan.

Taxon	No of species *	Location	Reference
Rhodophyta			
<i>Liagora turneri</i> Zanardini			Papenfuss, 1968
<i>Galaxaura oblongata</i> (Ellis et Solander) Lamouroux			Papenfuss, 1968
<i>Gelidiella acerosa</i> (Forsskål) Feldmann et Hamel			Papenfuss, 1968
<i>Gelidium corneum</i> (Hudson) Lamouroux			Papenfuss, 1968

<i>Gelidium crinale</i> (Turner) Lamouroux			Papenfuss, 1968
<i>Dudresnaya verticillata</i> (Withering) LeJolis			Papenfuss, 1968
<i>Choreonema thuretii</i> (Bornet) Schmitz			Papenfuss, 1968
<i>Corallina tenella</i> (Kützting) Heydrich			Papenfuss, 1968
<i>Corallina</i> sp. Linnaeus	2	Sanganeb	Elhag, 1993
<i>Jania rubens</i> (Linnaeus) Lamouroux		Sanganeb	Papenfuss, 1968; Elhag, 1993
<i>Jania</i> sp. Lamouroux		Sanganeb	Elhag, 1993
<i>Lithophyllum affine</i> (Foslie) Foslie			Papenfuss, 1968
<i>Lithophyllum fasciculatum</i> (Lamarck) Foslie			Papenfuss, 1968
<i>Lithophyllum</i> sp. Philippi		Sanganeb	Elhag, 1993
<i>Lithothamnium crispatum</i> Hauck			Papenfuss, 1968
<i>Lithothamnium polymorphum</i> (Linnaeus) J. E. Areschoug			Papenfuss, 1968
<i>Neogonoiolithon myriocarpum</i> (Foslie) Setchell et Mason			Papenfuss, 1968
<i>Pseudolithophyllum expansum</i> (Philippi) Lemoine			Papenfuss, 1968
<i>Halymenia floresia</i> (Clemente) C. Agardh			Papenfuss, 1968
<i>Gracilaria</i> sp. Greville	2	Portsudan	Present paper
<i>Sarconema filiforme</i> Rayss			Papenfuss, 1968; Atewberhan and Van Reine, 2005.
<i>Sarconema furcellatum</i> Zanardini			Papenfuss, 1968
<i>Hypnea valentiae</i> (Turner) Montagne			Papenfuss, 1968
<i>Lomentaria squarrosa</i> (Kützting) LeJolis			Papenfuss, 1968
<i>Centroceras</i> sp. Kützting		Sanganeb	Elhag, 1993
<i>Ceramium</i> sp1. Roth	2	Sanganeb	Elhag, 1993
<i>Ceramium</i> sp2. Roth		Suakin	Elhag and Karim, 1980
<i>Spyridia filamentosa</i> (Wulfen) Harvey			Papenfuss, 1968
<i>Spyridia</i> sp. Harvey	2	Sanganeb	Elhag, 1993
<i>Martensia</i> sp. Hering		Sanganeb	Elhag, 1993
<i>Dasya</i> sp. C. Agardh		Sanganeb	Elhag, 1993
<i>Acanthophora</i> sp. Lamouroux		Sanganeb	Elhag, 1993
<i>Chondria</i> sp. C. Agardh		Sanganeb	Elhag, 1993
<i>Digenea simplex</i> (Wulfen) C. Agardh			Papenfuss, 1968
<i>Herposiphonia</i> sp.1 Nägeli	2	Sanganeb	Elhag, 1993
<i>Chondrophycus papillosus</i> (C. Agardh) Garbary et Harper			Papenfuss, 1968
<i>Laurencia obtuse</i> (Hudson) Lamouroux		Sanganeb	Papenfuss, 1968 and Elhag, 1993
<i>Laurencia papillosa</i> (C. Agardh) Greville		Suakin	Papenfuss, 1968; Elhag and Karim, 1980
<i>Laurencia</i> sp1. Lamouroux		Suakin	Elhag and Karim, 1980
<i>Laurencia</i> sp2. Lamouroux	3	Sanganeb	Elhag, 1993
<i>Leveillea jungermannoides</i> (Hering et Martens) Harvey			Papenfuss, 1968
<i>Leveillea</i> sp. Decaisne		Sanganeb	Elhag, 1993
<i>Lophocladia lallemandi</i> (Montagne) Schmitz			Papenfuss, 1968
<i>Lophocladia</i> sp. (J. Agardh) Schmitz		Sanganeb	Elhag, 1993
<i>Polysiphonia utricularis</i> (Lightfoot ex Dillwyn) Greville			Papenfuss, 1968
<i>Polysiphonia</i> sp1. Greville		Suakin	Elhag and Karim, 1980
<i>Polysiphonia</i> sp2. Greville	2	Sanganeb	Elhag, 1993
Total No.	47		
Phaeophyta			
<i>Ectocarpus</i> sp. Lyngbye		Sanganeb	Elhag, 1993
<i>Sphacelaria furcigera</i> Kützting			Papenfuss, 1968
<i>Sphacelaria</i> sp. Lyngbye		Sanganeb	Elhag, 1993

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<i>Zanardinia collaris</i> (C. Agardh) P.L. et H.M. Crouan			Papenfuss, 1968
<i>Dictyopteris</i> sp. Lamouroux		Sanganeb	Elhag, 1993
<i>Dictyota dichotoma</i> (Hudson) Lamouroux		Sanganeb	Papenfuss, 1968 and Elhag, 1993
<i>Dictyota dichotoma</i> var. <i>intricate</i> (C. Agardh) Greville			Papenfuss, 1968
<i>Dictyota</i> sp. Lamouroux	2	Sanganeb	Elhag, 1993
<i>Padina pavonica</i> (Linnaeus) Thivy		Suakin and Sanganeb	Papenfuss, 1968; Elhag and Karim, 1980; Elhag, 1993
<i>Pocockiella variegata</i> (Lamouroux) Papenfuss			Papenfuss, 1968.
<i>Pocockiella</i> sp. Papenfuss		Sanganeb	Elhag, 1993
<i>Lobophora variegata</i> (Lamouroux) Womersley ex Oliveira			Papenfuss, 1968
<i>Eudesme virescens</i> (Carmichael ex Berkeley) J. Agardh			Papenfuss, 1968.
<i>Colpomenia sinuosa</i> (Mertens ex Roth) Derbés et Solier			Papenfuss, 1968.
<i>Hydroclathrus clathratus</i> (C. Agardh) Howe			Papenfuss, 1968
<i>Chnoospora</i> sp. J. Agardh		Sanganeb	Elhag, 1993
<i>Cystoseira amentacea</i> (C. Agardh) Bory			Papenfuss, 1968
<i>Cystoseira myrica</i> (Gmelin) C. Agardh		Suakin	Papenfuss, 1968; Elhag and Karim, 1980
<i>Sargassum dentifolium</i> (Turner) C. Agardh			Papenfuss, 1968
<i>Sargassum linifolium</i> C. Agardh			Papenfuss, 1968
<i>Sargassum subrepandum</i> (Forsskål) C. Agardh			Papenfuss, 1968
<i>Sargassum subrepandum</i> var. <i>brevifolium</i> J. Agardh			Papenfuss, 1968
<i>Sargassum vaysierianum</i> Montagne			Papenfuss, 1968
<i>Sargassum</i> sp. C. Agardh	2	Sanganeb	Elhag, 1993
<i>Turbinaria triquetra</i> (J. Agardh) J. Agardh			Papenfuss, 1968
<i>Turbinaria decurrens</i> Bory de Saint-Vincent		Suakin and Sanganeb	Elhag and Karim, 1980; Elhag, 1993
<i>Turbinaria elatensis</i> Taylor		Sanganeb	Elhag 1993
Total No.	27		
Chlorophyta			
<i>Enteromorpha compressa</i> (Linnaeus) Nees			Papenfuss, 1968
<i>Ulva lactuca</i> Linnaeus			Papenfuss, 1968
<i>Fritschiella tuberosa</i> Iyengar			www.algaebase.org.
<i>Chaetomorpha linum</i> (Müller) Kützing			Papenfuss, 1968
<i>Chaetomorpha</i> sp. Kützing		Sanganeb	Elhag, 1993
<i>Cladophora albida</i> (Nees) Kützing			Papenfuss, 1968; Ateweberhan and Van Reine, 2005.
<i>Cladophora prolifera</i> (Roth) Kützing		Sanganeb	Elhag, 1993
<i>Cladophora</i> sp1. Kützing		Suakin	Elhag and Karim, 1980
<i>Cladophora</i> sp2. Kützing		Sanganeb	Elhag, 1993
<i>Microdictyon</i> sp. Decaisne		Sanganeb	Elhag, 1993
<i>Cladophoropsis</i> sp. Børgesen		Sanganeb	Elhag, 1993
<i>Boodlea</i> sp. Murray et De Toni	2	Sanganeb	Elhag, 1993
<i>Dictyosphaeria cavernosa</i> (Forsskål) Børgesen		Suakin and Sanganeb	Papenfuss, 1968; Elhag and Karim, 1980; Elhag 1993
<i>Valonia aegagropila</i> C. Agardh			Papenfuss, 1968
<i>Bryopsis implexa</i> De Notaris			Papenfuss, 1968
<i>Bryopsis plumosa</i> (Hudson) C. Agardh			Papenfuss, 1968
<i>Bryopsis</i> sp. Lamouroux	2	Sanganeb	Elhag, 1993
<i>Caulerpa cupressoides</i> (Vahl) C. Agardh		Suakin	Elhag and Karim, 1980

<i>Caulerpa cupressoides</i> var. <i>lycopodium</i> Weber-van Bosse			Papenfuss, 1968
<i>Caulerpa racemosa</i> var. <i>peltata</i> (Lamouroux) Eubank			Papenfuss, 1968
<i>Caulerpa racemosa</i> (Forsskål) J. Agardh		Suakin	Papenfuss, 1968; Elhag and Karim, 1980
<i>Caulerpa scalpelliformis</i> var. <i>denticulate</i> (Decaisne) Weber-van Bosse			Papenfuss, 1968
<i>Caulerpa selago</i> (Turner) C. Agardh			Ateweberhan and Van Reine, 2005
<i>Caulerpa serrulata</i> (Forsskål) J. Agardh		Suakin and Sanganeb	Papenfuss, 1968; Elhag and Karim, 1980; Elhag, 1993
<i>Codium tenue</i> Kützting			Papenfuss, 1968
<i>Codium tomentosum</i> Stackhouse			Papenfuss, 1968
<i>Codium</i> sp. Stackhouse	2	Sanganeb	Elhag, 1993
<i>Avrainvillea amadelpha</i> (Montagne) A. Gepp & E. Gepp			Papenfuss, 1968
<i>Avrainvilleae erecta</i> (Berkeley) A. et E.S. Gepp			Papenfuss, 1968
<i>Halimeda cylindracea</i> Decaisne		Portsudan	Present paper
<i>Halimeda discoidea</i> Decaisne			Papenfuss, 1968
<i>Halimeda macroloba</i> Decaisne		Portsudan	Present paper
<i>Halimeda opuntia</i> (Linnaeus) Lamouroux		Portsudan	Present paper
<i>Halimeda tuna</i> (Ellis et Solander) Lamouroux		Suakin and Sanganeb	Papenfuss, 1968; Elhag and Karim, 1980; Elhag 1993
<i>Udotea argentea</i> Zanardini			Papenfuss, 1968
<i>Udotea minima</i> Ernst			Papenfuss, 1968
<i>Udotea</i> sp. Lamouroux	2	Sanganeb	Elhag, 1993
<i>Acetabularia</i> sp. Lamouroux		Portsudan, Dongonab	Present paper
Total No.	38		

*Numbers refer to the number of plants reported from the locality by the author.

2. *Halimeda opuntia* (Linnaeus) Lamouroux: Thallus erect, whitish green, total length of about 7 to 11 cm, constructed of articulated sequence of flat calcified segments. Segment length ranges from 4 to 7 mm. segment width range from 6 mm to 1.5 cm.

3. *Halimeda cylindracea* Decaisne: Thallus erect to pendant, light green, palmate shape, total length up to 23 cm, constructed of articulated sequence of calcified cylindrical segments. Segment average width is 0.45 cm, average length 0.66 cm, average thickness 1.3 cm branching sympodial. Stipe short, flat, 1.33 cm in length, and arising from a bulbous holdfast 5.5 cm in length, with adhering sand particles.

4. *Halimeda macroloba* Decaisne: Thallus erect to pendant, whitish green, total length about 15 cm. Thallus constructed of articulated sequence of flat calcified segments. Segment width ranges from 1.33 cm to 2.50 cm, segment length ranges from 1.04 cm to 2.10 cm. Stipe average length 1.38 cm, arising from discoid holdfast.

5. *Gracilaria* sp. Terete species: Thallus terete, erect, or partially pendant, cartilaginous, solitary or caespitose, regularly dichotomous, 4 to 8 cm long, 3 to 4.5 mm in thickness, light red to dark purple in color, arising from a disc like

rhizoid of 1 cm in diameter (Figure 2). Thallus margins smooth frequently with branchlets, may form secondary rhizoids when come in contact with solid objects. Apex of branches is obtuse to spinose. Frond in transverse section consists of cortex 1 to 2 layers of small pigmented cells, and medulla of large roundish parenchyma cells in young thallus, hexagonal or pentagonal in mature ones transition of cells from medulla to cortex abrupt. Cystocarp protruding, spherical, scattered on both side of thallus.



Figure (2): showing the habit of the terete *Gracilaria* sp.

6. *Gracilatia* Flat Species: Thallus prostrate, flat, cartilaginous, strap shaped, ceaspitose, dichotomously branched, length up to 16 cm, width vary from base (3 to 9 mm) to apex (2 mm), reddish to dark brown in color. Thallus margins smooth rarely with tooth-like proliferations. Stipe cylindrical, 1 to 1.5 cm long, 3 to 5 mm in thickness, arising from a discoid rhizoid. Frond in transverse section consists of cortex of 1 layer of small pigmented cells and medulla of large elongated parenchyma cells (Figure 3). Transition of cells are from medulla to cortex abrupt. Cystocarp protruding, spherical, scattered on both side of thallus, without or with slight constriction at the base. Nutritive filaments are not seen.



Figure (3): The arrangement of cells in the thallus of the flat *Gracilaria* sp.

Discussion

After compiling the available scattered records on Sudanese marine macroalgae, the total number of the taxa is now 112 including 47 taxa of the red, 27 taxa of the brown and 38 taxa of the green. The present list adds 6 new taxa to that list.

It is obvious that the list is taxonomically incomplete and significant number of the taxa has just been identified to the genus level. Therefore, high possibility exists that a species may be listed more than one time affecting the total number of taxa. Despite this, the total number of Sudan's seaweed taxa fall far behind all the records from the neighbouring countries for example that of Eritrea is 286 taxa. Additionally, it is probable that the list may contain incorrect taxonomic names especially for the seaweeds taxa known for their morphological plasticity and difficulty in identification. It particularly, reflects the well known difficulties in identifying red seaweeds.

Many assumptions may explain the situation, some of these could be technical associated with the nature and practice of the discipline of phycology itself, and the other could be of socioeconomic and ecological nature. Technically, unfortunately voucher specimens of the old species collected are not available either because they had not been made or were deposited abroad making it difficult to trace back identifications. The absence of a herbarium is a major constrain in front of either revising or studying seaweeds in Sudan. Preserved samples are badly managed and consequently significant specimens were lost. Collections were made in different seasons, different habitats and by different individuals with varying level of expertise. The same situation has also been realized for the seaweeds of the Eritrean coast (**Ateweberhan and Van Reine, 2005**).

The biogeographic pattern of Red Sea benthic algae presented in **Sheppard *et al.* (1992)** indicates the presence of a latitudinal division across the central area around Jeddah to Suakin. Ecological hypotheses were postulated to explain the situation. Of these are the relatively narrow littoral zone in the northern and central Red Sea, the cooler surface water temperature moving to the north, and the narrow tidal amplitude that is known to influence algal distribution. In addition, the comparatively low number of species reported from the central Red Sea had lead to the hypothesis that this part could possibly been poorly or incompletely sampled. This could be attributed to the fact that most of the collections of Red Sea marine algae were carried out around Sinai in the north and Dahlak in the south (**Sheppard *et al.*, 1992**). Therefore, they included few records of marine algae from the central Red Sea (Saudi Arabia and Sudan coasts).

However, and in opinion, the major reason behind the scarcity of information on Sudan's seaweeds in particular and that of the Red Sea in general is of socioeconomic nature that leads to the underestimation of the resource.

Seaweeds in the central and southern parts of the Red Sea have no direct or indirect consumption. Unlike fisheries, the resource is not known to be utilized locally or even exported to other countries. In Sudan, although the sea cucumber resource is not utilized locally, it has gained a significant value only because of the increased demand from the Asian countries. It is known that the socioeconomic value of a resource could flourish research and investigation as the case with agarophytes and carrageenophytes.

It could be inferred from the records available that so far no comprehensive phycological studies have been done along the Sudanese coast. The little done is sporadic, taxonomically incomplete, incomprehensive and either unavailable or unpublished in the scientific literature. Therefore, it is very critical to undertake comprehensive taxonomic survey of the Sudanese marine algae first to incorporate the significant changes in this field and second to provide baseline data before implementation of the proposed coastal projects that may cause significant changes.

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Presently a PhD program on the taxonomy of the red algal family Gracilariaceae is conducted by the first author, part of the results presented here is taken from that program.

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مراجعة وتحديث لقائمة الطحالب البحرية في السودان

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يقع ساحل السودان في الجزء الأوسط من البحر الأحمر على الساحل الغربي وبها بعض المواقع ذات الأهمية البيولوجية مثل ارخبيل سنجانيب وخليج دنجوناب. ومع ذلك، فإن هناك ندرة في المعلومات المتعلقة بتركيب وتوزيع الطحالب البحرية السودانيه. وهذه البحث محاوله جادة لتقديم قائمة شاملة للأصناف المسجلة من السودان. ويتحقق هذا من خلال مراجعة الأبحاث المتوفرة و المنشورة، وأيضا دراسة مجموعة من العينات المحفوظة المتاحة في كلية علوم البحار والمصايد التابع لجامعة البحر الأحمر بالسودان، وكذلك القيام ببعض الرحلات للتجميع الحقلى. وفقا لذلك تم تسجيل 112 نوع منهم 106 من الأبحاث المنشورة و6 أنواع جديدة. ولحصر أشمل و أكبر تتطلب فرق استطلاعيه شاملة لى تشمل جميع الأنواع الحاليه.