IUCN red listing of marine macroalgal species: a South African Case Study

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Abstract:

The IUCN Red List of Threatened Species is considered an important tool for conservation. However most evaluations have been restricted to terrestrial species and marine species are underrepresented. In contrast to terrestrial environments, the marine environment differs in dispersal restrictions and the difficulty of sampling. This has made it hard to gain sufficient knowledge and therefore literature on the majority of species and makes it difficult to assess the effects of disturbance on species and environments. Marine species are thought to be greatly affected by over-exploitation and by-catch. However a large proportion of the oceans diversity is situated on the coastal region, particularly as benthic organisms. These environments are considered to be a high risk of disturbance and habitat alteration due to human activities and therefore indicate that habitat loss could result in many species disappearing. The seaweed taxa have only had a total of 75 species listed. Besides being a taxonomically difficult group, there is also very little relevant literature available for effective IUCN evaluations. This study looks at assessing i. the effectiveness, to date, of identifying seaweed species at risk of extinction, including any fallbacks or complications that seaweed species may face during an IUCN evaluation, ii. what procedures need to be followed during the process of the evaluation, especially when limited data is available and iii. what species characteristics could be used to identify candidates for such an assessment. This was done using two methods, firstly by reviewing what seaweed species have been currently listed and the secondly through the form of a case study using three South African endemic species with restricted distribution. IUCN threat criteria fulfilled by species and the threat categories that they achieved were related to knowledge of species distribution for seaweed species. There was an increased degree of certainty when more literature or knowledge was available and when targeted surveys for individual species were undergone. Comprehensive studies on species population dynamics and natural population fluxes were also useful. Seaweed species with restricted dispersal are most likely to make it onto the IUCN list. There is a need for seaweed scientists to come up with a solution to tackle this lack of information. Overall the IUCN evaluation process should not need to adapt for seaweed species and that evaluations have the potential to be used as indicators of ecosystem change for a region..

Keywords: IUCN Red List, Marine Species, benthic organisms, habitat alteration, Seaweed, literature, case study, restricted distribution, indicators of change

Introduction:

The IUCN Red List of Threatened Species has become an important tool in the conservation effort for global biodiversity. The Red List is a relatively comprehensive global database of over forty thousand species from many different taxa. The conservation status for each species has been evaluated and assigned a category in relation to its risk of extinction. The assessment is based on a comparison on what is known of each species' distribution, population size, including trends over time, using a standardized quantitative set of criteria for each category (IUCN, 2008). Species under any major, foreseeable or potential threat are often chosen to be evaluated. Eight separate status categories are used to determine a species level of threat (Appendix 1). The Data Deficient (DD) category is assigned to organisms where insufficient information has been collected on the species' population size and abundance to assign any possible risk and is not considered a threat status, but promotes further research into the species. There are five threat categories; Least Concern (LC), Near Threatened (NT), Vulnerable (VU), Endangered (EN) and Critically Endangered (CE), with the latter three categories of significant concern. The final two categories are Extinct in the Wild (EW) and Extinct (EX). The IUCN Red List evaluation is a useful indicator for measuring the magnitude of change in local populations and ecosystems over time, signifying structural and habitat alterations and community composition alterations.

These evaluations have been biased to terrestrial species for several reasons. Unlike in terrestrial environments, which have been studied in much greater and wider detail, marine environments are harder to sample and harder to access, as a result there tends to be a limited amount of information that has been collected for literature for particularly of for many taxon (Gray 1997; Kappel 2005; Dulvy unpubl.). Threats such as habitat alteration and degradation have also been harder to detect in the marine environment (Gray 1997; Millar 2002). Differing spatial characteristics, including obvious physical boundaries, such as mountains, which isolate species within a certain area, restrict dispersal in terrestrial organisms. This difference in physical boundary variability, such as an ocean current system which can be responsible for long range distribution of marine species (Phillips 2001) often makes it difficult to assess marine population changes in size and distribution. It is also difficult to state with a high level of certainty when the last animal of a species has truly died, as there is often little information and literature available and it is hard to determine population size or distribution and even species individuality with little work on the species taxonomy (Dulvy unpubl.). Another reason has been the misconception that marine species are less vulnerable to extinction threats (Dulvy et al. 2003). Biologically, marine species are known to have attributes including high fecundity or the ability to disperse at a large scale, yet exploited species are often listed on the IUCN database. Economically it is thought that exploited species would become commercially extinct before being driven to extinction, which overlooks by catch species and species that are highly valued commercially (Dulvy et al. 2003). The sea still largely remains a mystery and this makes it difficult to focus conservation efforts with any major certainty. In the case of marine macroalgae, otherwise commonly known as seaweeds, a negative public perception and interest has been associated with the group (beside the connotations of the name seaweed and being thought of as non-aesthetic) which unjustifiably reduces its marketing value in the conservation eye and this must change(Millar 2002). Seaweeds play a very important role within the shallow coastal environment where they are the major primary producers, forming the base of marine aquatic food webs while also providing habitat and contributing to a significant proportion of global carbon fixation to name a few of their major ecosystem functions (Littler and Arnold 1982; Duarte and Cebrian 1996; Kinney and Roman 1998; Hurd 2000; Saunders 2008). Their combined ecosystem service is therefore considerable and the value of species used as a commercial resource in food and industry is well into the billions of dollars, most significantly in Asia. This group is therefore of great biological and economical importance yet they occur in the regions of the marine environment which are the most vulnerable to threats from human activity (Gray 1997; Millar 2002).

Most threats that oceanic species face are considered to be slightly different in both rank and reason to terrestrial species. In the marine world, exploitation and resultant by catch in fisheries operations have been considered the largest threats for resulting in extinction and ecosystem destruction, followed by habitat loss and alteration. while several significantly smaller risks involve invasive species, climate change, pollution and disease, compared to habitat loss being the most severe in the terrestrial environment (Dulvy et al. 2003; Kappel 2005; Halpern et al. 2008). This however is the result of most of the focus species having some form of commercial or aesthetic value and include a large proportion of pelagic organisms and fisheries, both legal and illegal, and are normally species with available quantitative data to help with the IUCN evaluations. There are other groups of marine organisms that have received little IUCN attention, this includes most benthic marine groups, which make up a significant portion of coastal biodiversity, with only corals having any significant representation (Gray 1997; Millar 2002; IUCN 2008). Benthic and pelagic organisms could be seen to have differing local and regional threats, and as benthic organisms have been shown to have higher diversity compared to pelagic organisms (Gray 1997), there could be a shift seen in the proportion of major threats facing marine organisms. There is increasing awareness and realisation that global coastlines are considered to be the most at threat for losing marine habitat and species (Gray 1997; Millar 2002). Suitable habitat loss and habitat alteration has already been stated as a major factor in the loss of seaweed species, such as the deposition of fine sediment on the Sydney Harbour sea floor, which was thought to be one of the leading factors in the extinction of *Vanvoorstia bennettiana* (Millar 2002)IUCN ref). Other threats that are noted to impact seaweed species negatively include global warming, which was considered as a major indirect factor in the 2007 IUCN assessment of seventy-four Galápagos seaweed species (IUCN 2008), environmental stress from fisheries and aquaculture, overharvesting and invasive species.

Of the forty thousand assessed Red List species, only three thousand marine species are included in the database (ICUN website ref) and although this number has doubled since the last IUCN Red List was released in 2007 , the number of species thought to be at risk of extinction or that are known to be extinct already is thought be largely underestimated (Dulvy et al. 2003; Dulvy unpubl.). Even though recent efforts have increased in the evaluation of marine organisms overall there is still considered to be a need for more data and focus on more marine groups of organisms (Dulvy et al. 2003; Kappel 2005; IUCN 2008). On a global scale very few marine species, compared to terrestrial species, have been identified for extinction. Of the three thousand assessed species only twenty-two percent have been given any threatened status despite increasing evidence that large numbers of populations and entire species are at risk (Dulvy et al. 2003; Kappel 2005; Dulvy unpubl.).

Marine plant groups have remained almost completely under-represented on the IUCN red data list of which sea grasses have received the most attention. Despite a few authors having noted the fact that several seaweed species may require IUCN recognition and that there are many more that are still to be looked at (Millar 2002; Dulvy et al. 2003) and there is the problem that there is little literature relevant to IUCN evaluations(Saunders 2008). Seaweed species only make up a total of seventy five species which have been successfully evaluated (IUCN, 2008). Seventy four of these species occur within the Galápagos Islands and where evaluated in a large scale IUCN assessment of the region (IUCN, 2008). The seventy fifth species is the extinct *Vanvoorstia bennettiana* (Bennett's seaweed) from Sydney Harbour region discussed earlier (Millar 2002). This is an example of a seaweed species, once commonly collected in the mid to late nineteen hundreds, which had been recently and extensively but unsuccessfully searched for. The several other species mentioned by both Millar (2002) and Dulvy (2003) have only been recognised in local policy (Millar 2002), and /or for local extinction (Dulvy et al. 2003). Overall, seaweed extinction risk assessments have included few species and have only been in very few isolated localities around the world.

The IUCN Red List evaluation has been successfully utilized for over ten thousand land plant species and has the potential to do the same for sea plants. One main difference separating land flora from marine is dispersal opportunities and boundaries. Dispersal in seaweed species can be restricted from their biological limitations and ocean current direction (Phillips 2001). The sea is an open environment and seaweed species have more opportunities on reaching suitable habitat and have to face fewer physical barriers and as a result can occur over extended distribution ranges (Wefer et al. 2003). This characteristic of the marine environment can lead to difficulties in determining species distribution through missing knowledge of populations in poorly studies regions, or could lead to erroneous range approximations when wash up is collected or observed far from known species locality. Taxonomically and morphologically seaweed species can be difficult to correctly identify as many species have either unresolved taxonomic problems or are inconspicuous due to differences in reproductive and vegetative forms and at different life history stages. This level of phenotypic plasticity makes it difficult to identify species at risk even for the experienced phycologist (Saunders 2008).

This project is divided into two parts: The first involves a review of how the current process of red listing of seaweed species is achieved, and the second involves a case study which evaluates South African seaweed species using IUCN red list criteria and guidelines to determine their level of threat. The aim of the first part is to determine i. how IUCN evaluations have been applied to seaweed species to date, ii. which criteria are commonly used, iii. why they are used and iv. what procedures are used to certify any category of threat or risk of extinction. The aim of the second part is to i. identify characteristics for seaweed species that may put them at risk of extinction and therefore allow further identification of other species that may be in the same situation, ii. practically assess the feasibility and potential for South African seaweed species to be placed on the IUCN database and iii. what procedures are still necessary to certify the results for such evaluations.

In combination of the above this project is aimed at assessing i. the effectiveness, to date, of identifying seaweed species at risk of extinction, including any fallbacks or complications that seaweed species may face during an IUCN evaluation, ii. what procedures need to be followed during the process of the evaluation, especially when limited data is available and iii. what species characteristics could be used to identify candidates for such an assessment.

From this one two questions will be addressed: 1. Does the different environmental conditions in the marine environment, compared to the terrestrial environment, lead to an underestimation, firstly, of the number of seaweed species at risk of extinction and secondly, the status threatened species achieve? 2. Should one attempt to refine or adapt the current IUCN criteria to take into account any characteristics of seaweed species or other marine benthic organisms?

Methods:

REVIEW OF THE CURRENT IUCN RED LISTED SEAWEED DATASET:

The IUCN (2008) red list website was sourced for all relevant information concerning the seaweed currently on the red data list. Documents concerning the IUCN Red List criteria and guidelines were then downloaded for reference purposes. The four seaweed classes were listed on appendix 2, which is a summary list of all red listed plant classes found on the website, helped to locate all seventy-five seaweed species in the database through the websites search function and each species threat category was recorded. Twenty species were noted with threat statuses other than DD, these and ten DD species randomly selected from the fifty-five in total made up the thirty IUCN listed species reviewed in this paper. All information including global location, distribution and localities, population trends, species characteristics, justification for their threatened status, whether or not they had been actively surveyed, year of last recorded collection or observation of the species, threat which they face and the habitat in which they occur was collected for each (Taylor 1945; Dawson 1963; Abbott 1967; Hedgpeth 1969; Mead et al. 1972; Acleto 1973; Cinelli and Colantoni 1974; Wellington 1975; Graham et al. 2007; IUCN 2008; Howe 1914; Wynne 1985). Lastly the criteria used to justify the category given to each species were noted. There are five criteria (A-E, See Appendix 3 and the review of current IUCN seaweeds for a better explanation of each criterion) used to evaluate species for a category of threat. Each criterion consists of different sub-criteria for which different species may fall in and not all sub-criteria have to be filled to qualify a species for the criterion unless otherwise stated.

Criterion A requires both historic and up to date information concerning the species to show changes in population size and distribution over three generations.

Criterion B ~~was~~ can often be associated with A as it also relies on geographic distribution data, however to use B the data needs to be more quantifiable and the current population trend needs to be known.

Criterion C requires a greater understanding and far more information on the individual species population, presently and over the last three generations, or ten years.

D has two sub-criteria based on calculations of actual population sizes or distributions for small and restricted populations.

Criterion E assess the risk of extension based on a quantitative analysis.

Pie charts were used to help visualise the proportions of each seaweed group, red, brown and green algae listed on the IUCN website and to visualise the proportion of species in each category. To review how the evaluation had been applied to seaweed species the following was done. Similarities of species in general and species within each category were identified to determine characteristics that were useful in the IUCN evaluations. An attempt was made to try link common features of species to criteria that justified their achieved categories and why some species were able to obtain a threatened status, while others were placed in the DD category.

A CASE STUDY OF SOUTH AFRICAN SEAWEED SPECIES:

To evaluate species for the IUCN red data list three documents must be obtained from the IUCN website. These are the Red List Assessment Datasheet, the IUCN – 2001 Categories & Criteria (Version 3.1) and the Guidelines for Using the IUCN Red List Categories and Criteria (v7.0) are essential for successfully understanding and completing the whole evaluation process.

Three species were selected to be evaluated. All had various degrees of restricted distribution, which is rare for most seaweed species, and were endemic to South Africa's marine flora. *Cystophora fibrosa** Simons, *Letterstedtia insignis* Areschoug (*Ulva insignis*) and *Mazzaella convoluta* (Areschoug ex J. Agardh) Hommersan one from each group, a brown fucoid (Phaeophyceae), a green (Chlorophyta) and a red (Rhodophyta). All three of these species have characteristics that justify their selection for this evaluation. Besides their distribution, each species also faces a number of threats that could be directly or indirectly caused by human activities that could affect habitat suitability. However there are also threats that may be considered highly improbable, which may place species with restricted distributions at risk. Oil spills could be one such example, however, on a coast line, such as South Africa's that has high ship activity these risks can be considered to be higher.

Information concerning population size and distribution of these species vary in resolution, but the extent of occurrence for each species can be estimated. These species occur across different stretches of the South African coastline with only a few known sites where they have been observed and/or sampled.

C. fibrosa was first recorded in the waters around the Cape Agulhas(Simons 1970), and then subsequently recorded at Dehoop Nature Reserve (Bolton and Stegenga 1990) and then observed within false bay at Platboom on the Cape Penisula(Stegenga et al. 1997). Populations have been recently observed over the last 10 years at the two recorded sites, Dehoop Nature Reserve (J. J. Bolton Pers. comm., this paper) and at the De Walle, Cape Agulhas (Damien Laird 2001, Pers. observation). Efforts to find it at the Platboom site in recent years have failed (Anderson & Bolton pers. comms.). Recently a sample was collected a new locality within the range of the species distribution on a UCT Phycology Honours field trip to Arniston (J. J. Bolton, Pers. comm.).

L. insignis and *M. convoluta* both have smaller distributions than *C. fibrosa*. *L. insignis* has only two recorded localities along the coast between East London and Port Elizabeth (Pocock 1959) and *M. convoluta* has only been found along the west coast of the Cape Peninsula from Table Bay to the Cape of Good Hope (Stegenga et al. 1997). *L. insignis*, once common along the coast between Port Elizabeth and East London (Pocock 1959), has not been recorded in over forty years after numerous recent targeted survey efforts within one of its known historic localities and no collections have been recorded along its whole historic extent of distribution.

One population for *C. fibrosa* was sampled for habitat information at one of its known localities, Koppie Alleen, Dehoop Nature Reserve, Western Cape, South Africa. The rocky shores of the area consist of flat intertidal platforms made up of aeolianite rock (Bolton and Stegenga 1990) and was sampled over a distance greater than five hundred meters for the presence or absence of the species. This habitat has many rocky pools and rock crevices, and this is where a restricted locality of *C. fibrosa* was found during a study by Bolton and Stegenga (1990). Rock pools found to be present with *C. fibrosa* where sampled during the morning low spring tide from the 18th till the 20th of August 2008. Three separate patches of *C. fibrosa* were found along the coast line in sites of neighbouring rock pools all over a hundred meters from each other. At each of these sites the width and length of each rock pool was measured and then the total area within which all the neighbouring rock pools at each site. A half meter squared quadrat was randomly thrown into each rock pool to measure population density and height of the tallest individual. The average depth of the quadrat and the deepest individual within the pool were also recorded. When significantly tall individuals where found outside the quadrant their height was measured. The presence of epiphytes and new growth was noted and whether or not juveniles were present within the pool. Deepest recorded plant individuals within the pool were used as a surrogate for pool depth and compared to density within the pool. Rock pool area was then also used to compare to plant density. This was to give an idea of the preferred species habitat of the species. The aim of this species survey was to assess the health of the population and to gain habitat and characteristic information on the species.

The IUCN red list assessment:

These three species were all evaluated using the guidelines and the criteria of the ICUN Red List assessment and given an IUCN threat status justified by what relevant information was available on each of the species (Appendix 4, 5 and 6). The ranking of each species was then compared to the reviewed species from the IUCN red list database.

While performing the Red List Assessment all difficulties and problems facing both these species and macroalgal species in general where noted for discussion.

* Note: *C. fibrosa* is actually a member of the genus *Cystoseira* based on recent chemical and molecular evidence and is pending a name change (both genus and species). The name *Cystoseria fibrosa* has been used previously for a different species, and is currently a synonym for Cystoseira baccata (S.G. Gmelin) P.C. Silva(Guiry 1996).

REVIEW OF THE CURRENT IUCN RED LISTED SEAWEED DATASET:

There are 75 seaweed species listed on the IUCN Red List of Threatened Species to date, comprising 58 red algae, 15 brown and 2 green algae (Figure 1). Seaweed species have only been on the Red List database since 2003 when the first recorded extinct seaweed was published (Millar 2002). Since then 74 more species have been added to the database, all of which were assessed in 2007 and make up a portion of threatened flora in the Galápagos Islands (IUCN 2008).

Over seventy percent of the species listed have not being given any definitive status and are currently listed as DD (Figure 2). Fifteen species have been listed with a threatened status, which include ten CE species (Figure 2). VU is listed four times and EN is only listed once. Only one species has been recorded as extinct and four species have a status of LC.

Although only fifteen species have been listed with threatened ranks, Red List criteria were used thirty-three times, and often more than one criterion was used for a species (Table 1). Table 1 illustrates the number of times a criterion was used to list each threat status (See Appendix 3 and immediately below for further explanations). Criteria within A2 and B were used almost entirely to list CR species. Criterion B by itself was used to list the only EN species. VU species were listed once by the criterion A2c and three times by criterion D2.

Criterion A requires both historic and up to date information concerning the species population size and distribution to determine any threats, even if they are not understood. As little is known about the threat the Galápagos species face and whether the reductions in population distribution have ceased only A2 is relevant. Species listed with the A2 criterion had a little more historic information concerning the species distribution and also targeted surveys any population trends for species where the focus is on the loss of populations and total distribution.

Seaweeds listed with criterion B were often associated with A2. For these species quantifiable geographic distribution data was available. The criterion also requires a species to fulfil a number of sub-criteria in combination with the criterion to be used to list the species. So an understanding of the nature of population trends is required. This however can pose problems for species which fit some of the sub-criteria, but not enough is known to fill the entire set of sub-criteria.

Criterion C was not used at all as it requires a greater understanding of a species situation particularly in population size, presently and over the last three generations, or ten years. No seaweed species had this level of data available. Unless a species is extensively studied and monitored this probably will never apply to seaweeds until the literature is available.

D has works with restricted species or small populations. It is therefore highly likely that any restricted species will fall within this criterion. Two sub-criteria are available and unless there is extensive work on the individual seaweed species, D1 will never be relevant to seaweed species assessments as it is based on population sizes. D2 relies on just having to know or estimate the number of localities and/or the total area of occurrence (AOO) for a species.

Criterion E will never be relevant for a seaweed species unless a quantitative analysis is actually performed.

The most common characteristic for most of the listed seaweeds, especially those listed other than DD and LC was their restricted distribution, with seaweed species often occurring in no more than three to five historic locations.

Each threat category had common characteristics and justifications listed for each of their species. Four CR species had been once conspicuous within their known localities as they are large species. This included *Dictyota galapagensis* once very common has shown a possible hundred percent decrease. Two were difficult to identify and five were considered rare, with one only being recorded once ever. Three species had had wider distributions while the rest had been only recorded in three or less historic locations. Seven species are not found in any of their known sites currently even after extensive targeted surveying. Overall six have been considered possibly extinct, *Phycodrina elegans, Schizymenia ecuadoreana and Spatoglossum schmittii*, being three examples. It has been sixty years since these six species were last recorded, while three others had been recorded in the last five years.

Little was known of the single EN species, *Sargassum setifolium*, but there was an observed decline in population distribution and size. There has been one recorded sample of the species within the last ten years. Targeted surveys have failed in attempts to collect more samples.

Two VU species were historically conspicuous within their known localities, while the other two were small and difficult to identify. One species, *Acrosorium papenfussii*, has not been seen in the last fifty years, while two other have recent recorded samples. Species listed as LC were all widespread (such as the most widespread *Ochtodes croker*), commonly occurring species that are easily identifiable and conspicuous, all of which have been recently sampled frequently and have no known threat.

DD species often had little or no survey work performed on them to confirm any recent records or observations on the species. Little was known of their population size or distribution and they were often regarded as inconspicuous species, difficult to identify and known from few locations. Five of the ten species had not been recorded for over fifty years, while three had had recent samples collected.

Most species in the Galápagos marine flora listed had loss of suitable habitat listed as the most possible result of population decline or loss and this related listed threats of Climate Change, El Nino and habitat alteration caused by an invasive native sea urchins. CR species and the EN species both had recorded significant losses in population distributions. VU species mostly had only one known site of occurrence and therefore a restricted distribution.

V. bennettiana, the only extinct seaweed, had a different set of potential threats listed in its Red List assessment. Development, area usage, pollution, waste water, sewage, oil spills, soil erosion and sedimentation were included as factors that could of all lead to the demise of *V. bennettiana*, but there is no direct evidence for which was the leading factor (Millar 2002).

The literature available for use in the Galápagos seaweed assessment consisted of only thirteen papers being used. The papers were restricted to the nineteen species not listed as DD. However the one extinct Australian species had eight cited references including Millar (2002).

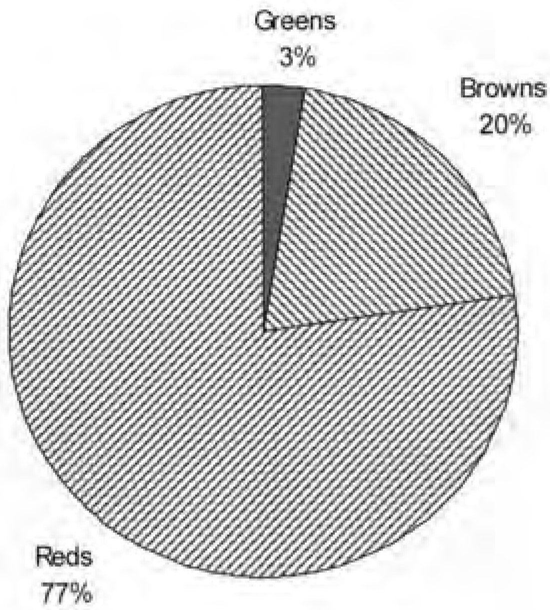

Figure 1: Proportion of species per macroalgal group listed on the IUCN Red Data list

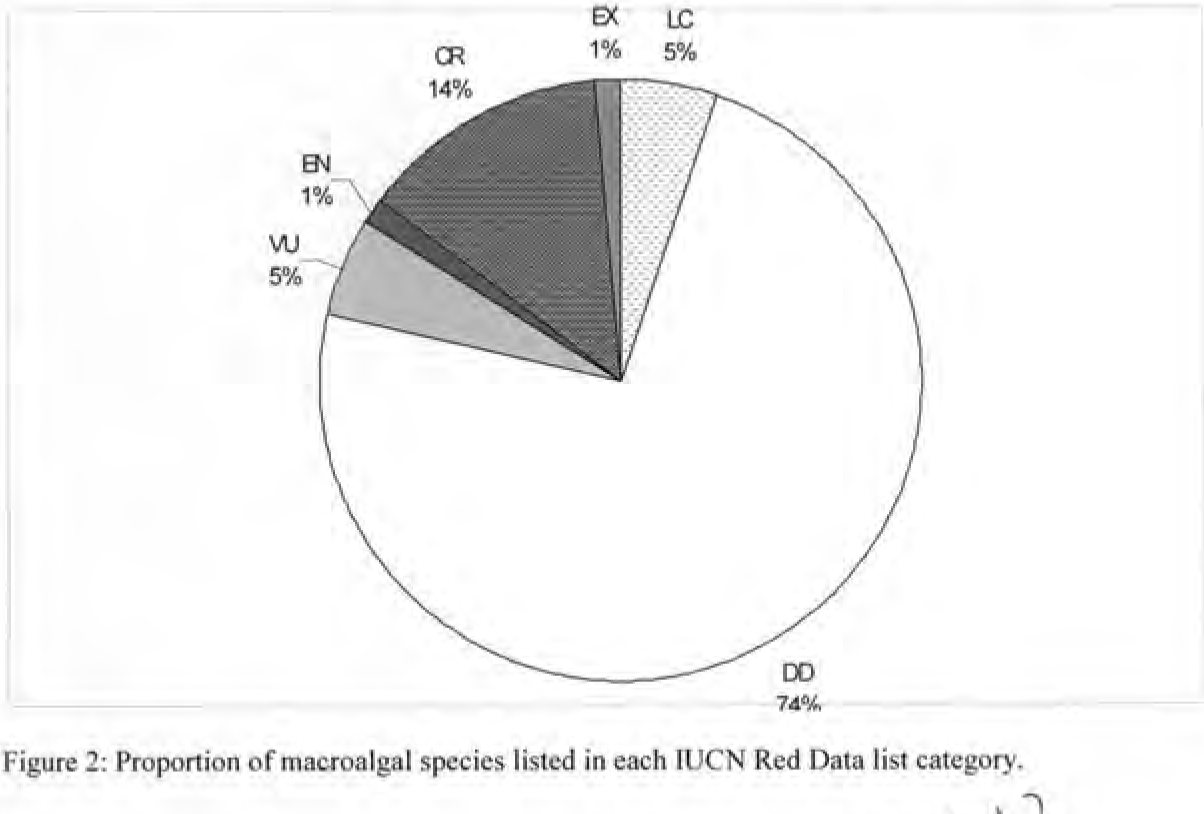

Figure 2: Proportion of macroalgal species listed in each IUCN Red Data list category.

dated?

Table 1: Red list criteria used to rank each threatened species of seaweed (Refer to Appendix 3 for criteria conditions).

Criteria		**CR**	**EN**	**VU**	**Total uses**
A2:	a	9	0	0	9
	c	5	0	1	6
B1:		2	1	0	3
B2:		2	1	0	3
a		2	1	0	3
bi		2	1	0	3
bii		0	1	0	1
biii		0	1	0	1
D2:		0	0	3	3
Species		10	1	4	15
Overall Use					33

SOUTH AFRICAN CASE STUDY SPECIES:

The three species selected for the IUCN assessment were considered separately below:
The following abbreviations were used in this analysis: Refer both to Appendix 1, 3 and to the section above for the meaning of the different criteria.

C. fibrosa:

Sampling and literature: *C. fibrosa* was measured for population distribution and habitat. It was found to only occur in neighbouring rocky pools in three restricted sites along the coastline. Over five hundred adult individuals where accounted for within the quadrats samples of the twenty-eight pools that the species recorded in during the investigation. This recorded value was only an estimated quarter of the entire population that was observed. Many of the adults had only old growth bases and holdfasts with only a small amount of recent spring growth were predominantly observed with a high epiphyte load. This occurred in shallow rock pools mainly at two of the three sites. There is no mention in either Simons (1970) or Stegenga *et al.* (1997) whether this species is perennial, however there was observations of spring growth patterns. The large site situated west of the Koppie Alleen cave showed healthy and bushy adults, all with significant holdfasts. The degree of shelter and/or the depth of the pool may have had an effect on the size of the individual or on whether it can keep its fronds. Larger individuals were found in deeper/sheltered pools with increased old growth fronds, so environmental stress may be the driver to the seasonal loss of fronds for only some individuals, while sheltered individuals are able to keep their fronds for multiple years of perennial growth. Pool depth, used as a measure of shelter, did have a significant positive relationship with density (Figure 3, $r^2 = 0.33$, $P < 0.002$), the same was found for average rock pool depth and the height of the tallest individual and deepest recorded individual and tallest individual ($r^2 = 0.20$, $P < 0.02$, $r^2 = 0.30$, $P < 0.006$). Volume and area of rock pools both had no effect on the presence of high densities of individuals.

Three relevant references along with the personal communications of John Bolton were used for this species in identifying the sample localities and the distribution (Simons 1970; Bolton and Stegenga 1990; Stegenga et al. 1997). No information regarding population size and little information regarding its life history habits was available.

IUCN assessment outcome (Appendix 3 and 4): *C. fibrosa* fulfilled the VU criteria for both A2ac and D2 and therefore was given the status of VU overall, according to the IUCN listing. It also had sufficient information available to fill some conditions for criterion B, but did not overall conditions for it to be relevant to the threatened status according to the Red List Guidelines. B2 was fulfilled for CR conditions and Ba. was fulfilled for EN conditions. Both achieved criteria were attained by estimating distribution from records and observations; however natural population trends are currently unknown which prevented *C. fibrosa* from obtaining the higher threat category CR status.

Justification for criteria and potential threats: According to observations this species is no longer found at Platboom one of its four known localities, which decreases the original population size and AOO of the species giving it criterion A2ac (J.J. Bolton and R.J. Anderson pers. comm.). It is also a naturally restricted species and so can apply to criteria D2. Three main threats are considered to be relevant to the species. Severe weather conditions, which include the alteration of suitable habitat. The potential of oil spills along the coast, which could result in the loss of entire populations due to the restricted distribution of populations.

L. insignis:

Literature: Only one relevant but extensive historic reference was available for use in the IUCN red list evaluation (Pocock 1959). However personal communication from two phycologists, John Bolton and Rob Anderson, both having often surveyed known locations for the species, were useful for a current assessment of the species.

IUCN assessment outcome (Appendix 3 and 5): *L. insignis* fulfilled the EN criteria for A2ac and B1b(i,ii,iii,iv,v)c(ii,iii,v)+2b(i,ii,iii,iv,v)c(ii,iii,v). Suggesting that the speciesDue to the comprehensiveness of the Pocock (1959) report, a well recorded and observed historic distribution was noted, which is not presently observed today despite extensive searching around Port Alfred (Salt Vlei Bay) and as no samples have been collected from sampling along the coast. This allowed the presumption that at a significant percentage of the population has been lost since the 1959, with no recording in the last ten years. it was noted to occur in fragmented populations, on the species as well as the knowledge that the species has declines in distribution since Pocock's report in 1959 completely fulfilled all the sub-criteria needed to use criterion B. As this species was numerous before the 1960's, if increased extensive surveys of its total distribution fail to collect any specimens over the next ten years then this species should be considered for extinction.

Justification for criteria and species threats: Plants were large and conspicuous, observed in large populations before 1959 and species was often collected in drift within its distribution range. Recent surveys have failed to collect any specimens (fulfilling criterion A2ac and B1 and B2 because geographical range has been lost). Populations are also known to fluctuate due to natural process and sand movement and there it fulfils criterion Bb.. Two main threats are considered for this species: sand movement after severe weather was noted by Pocock (1959) to greatly thin population density or remove them completely. Sand movement, both naturally and through human activities may result in unsuitable habitat for the species. There is also the potential for oil spills and other pollution to affect any restricted populations.

M. convoluta:

Literature: Besides personal communication from John Bolton and Rob Anderson and the species description in Stegenga et al.(1997) there was almost no relevant information.

IUCN assessment outcome (Appendix 3 and 6): *M. convoluta* did not achieve any threatened status category and was set as DD. VU criteria A2c, A4ac and D2 could have been filled. However there is a lack of information for the species population trends and the level of threats on the species. With further consideration VU could be used as the relevant listing for D2, but recent observation knowledge on the species is needed for anything higher.

Justification for criteria and species threats: Small distribution range restricted to one known location could of given it VU status using criterion D2. The major threat that this species faces is that of the harbour and urban development along its distribution (A4ac). However pollution and oil spills could also pose as potential threats, especially near an international harbour.

DISCUSSION:

IUCN LISTED SEAWEEDS:

Historic and present day species distribution and localities play an important role in successfully identifying seaweed species for threat categories on the IUCN Red List. This was provided by literature within the area of distribution from previous surveys and reports and all current work in the area of distribution. If this data was insufficient either historically or at present there would be no way of comparing the distributions to determine notable changes and these species were generally assigned Data Deficient (DD) categories. The fulfilment of criteria A2, B and D2 by the fifteen threatened seaweeds to achieve their assigned threatened category all related to the available distribution data. Species listed with the A2 criteria had often a little more historic information concerning the species and often recorded or observed losses in populations and loss of total distribution which was then measured. Criterion B was mostly associated with A2 as it also relies on estimated distribution figures for, although the data should be a little more quantifiable as it works with calculated species distribution. Criterion D2 is associated with restricted species, where little other information is available to justify other criteria.

If species were actively sought for in surveys within their historic localities, then they could still be placed in threatened categories, as this procedure increased the certainty that populations have been lost. Also, seaweeds in regions of high human population and extensively surveyed regions will also be more likely to achieve with high certainty any level of threat or to be confirmed extinct in IUCN evaluations, such as in the case of *V. bennettiana*.

Different levels of certainty do occur in the listed threatened Galápagos species, especially in the CR category. Some species that have been recorded recently have proof for their continued survival, while the others that have not been seen in the last decade could have disappeared completely. In this case targeted surveys for species should be conducted to monitor the historic distribution.

All 75 seaweed species (including the Australian species) had distributions totally or partly in locations that had undergone observed extensive habitat alteration and thus were considered at some level of threat. The idea of identifying potential threats to a regional coastline could be used to justify the evaluation of seaweed flora in a local area. Indirect effects from climate change and more direct effects from human activities tend to be the main threats that seaweeds face, which drive habitat loss and alteration which supports evidence in Millar (2002) and Dulvy et al. (2003). These evaluations have yet to include over-exploitation and by-catch, mentioned before as the major factors contributing to the loss of marine species (Dulvy et al. 2003; Kappel 2005; Halpern et al. 2008; Dulvy unpubl.).

CASE STUDY:

The three South African species selected for this case study had varying past and present information relevant to the assessment. Data sources containing distribution range, known localities and specific features or traits of the species, such as, whether it was common or conspicuous or a fluctuating or seasonal species, and any mention of threats were useful in the IUCN assessment. Pocock (1959) was by far the best source available, though it was only applicable to *L. insignis*.

Observations and targeted surveys by phycologists where also useful in retrieving any current distribution knowledge or sightings of species along the coast. The sampled population of *C. fibrosa* within this paper also helped further understand the specific intertidal range of the species and its various habitats compared to rock pool depth and exposure. It gave a good idea of the population status in the area and should be useful for any future assessment for the species. In the case of *M. convoluta* little is known of the species and no specific surveys have been carried out to sample the species, so without any real certainty of what is going on with this species, despite the high potential level of threats that it faces, no criteria could be filled without a high level of uncertainty.

As with the seaweed species already listed for the IUCN, similar criteria could be fulfilled by the South African species relating to the species distribution. Although *C. fibrosa* VU category is certain, as it will likely to alway be able to fulfil criteria D2 becuase of its distribution, *L. insignis* has the potential, pending a further more vigorous survey effort, not only to make the CR category, but perhaps even to be named as the first South African extinct seaweed.

Criterion B proofed elusive for *C. fibrosa* as not enough information concerning its current population trend status was available, and the same was true for *M. convoluta.*

IUCN SEAWEED ASSESSMENTS:

It is obvious that seaweeds, along with most benthic marine organisms, are under-represented on the IUCN Red List of Threatened species, with only two separate and recent assessments to date. There is evidence of seaweeds elsewhere facing threats resulting in habitat loss and alterations (Millar 2002; Dulvy et al. 2003) but these affected species have yet to be included in the IUCN Red List database. There is still a need to focus in other regions to get a better idea of how these organisms are faring with regard to threats on a global scale. Seaweeds with restricted range are the easiest targeted for IUCN evaluations. One must be careful though, as it may be easy for such species to fulfil the criterion D2 without any serious posing threats to the species, possibly overestimating the level of threat to the taxon.

USEFUL IN THE CONSIDERATION FOR IUCN RED LIST ASSESSMENTS:

It can be difficult to determine which species may be at risk (Dulvy et al. 2003), particularly if there is little relevant information concerning the species. The assessment of the Galápagos seaweed flora led to a considerable number of species being listed as threatened (15, 10 as CR). These species faced threats related to climate change, which amongst other major habitat suitability threats for seaweeds, including alien invasives and human related habitat alteration, would be common threats globally (Williams and Smith 2007; Saunders 2008) and therefore could suggest that most restricted range seaweed species around the world could be considered at some risk of extinction. This could support Dulvy et al. (2003) who suggested that further investigation could correlate geographic range and endemism with extinction threat in marine taxa. This may, however, only be restricted to benthic and possibly coastally restricted pelagic species, not including widespread oceanic species like sea turtles (Seminoff and Shanker 2008).

Although detailed recording of seaweed species populations and distributions are probably the best historic references, any historic distribution source for any species is useful. Herbarium specimens should be useful in any IUCN Red List assessment, however one much be cautious as many seaweeds are difficult to identify or our taxonomically problematic (Willis et al. 2003; Saunders 2008; Seminoff and Shanker 2008). This type of source data is useful for assessing species against the sub-criteria of criteria A and B. However to fully assess a species, some information about the present day distribution is required to compare. The best way to assess a species is to collect knowledge and data and information on any specimens, surveys and observations and particularly to assess the species' known localities, especially if it is thought to have disappeared from these sites (Yan Xie 2007). Otherwise it cannot be given any status with a high degree of certainty other than DD.

THE EFFECTIVENESS OF THE IUCN FOR SEAWEEDS AND AS A CONSERVATION TOOL:

One reason why seaweed species may have been neglected so far on the IUCN Red List is due to the limited knowledge and literature relevant to the IUCN criteria and categories, and the threats that seaweeds may face. This is considered to be a major obstacle in the red listing process (Seminoff and Shanker 2008). The deficiency of reliable data on the subject led to the large proportion of the IUCN listed seaweed species being DD. Seminoff and Shanker (2008) argue that the use of grey literature and personal communication is insufficient for good assessment of species. This therefore causes problems for many of the listed species as well as the three in this paper, as personal communication and observations were often used. One could argue that observations and personal communications, particularly from experts in a particular taxon, which have gained enormous knowledge in the field, are invaluable to such evaluations, especially when there is little literature to go by and can help in gaining further knowledge on the accessed species.

Although DD is meant to encourage further investigation into the species threatened status this would not always happen and in the case where species have not been recorded for over fifty years, or where threats are known but nothing is known about the species, species may fall short of much needed attention when only declared DD, as it is not even a category of threat(IUCN 2008).

Any other problems in listing seaweeds would only be related to the lack of relevant data, as seen in both *C. fibrosa* and *M. convoluta* above where not all sub-criteria for high levels of threat in criterion B could be filled.

Species with restricted populations, even when no known threat is obvious can still be considered at risk of extinction. Oil spills and severe weather patterns could alter habitats so they are not suitable for the species, completely eliminating restricted populations. This therefore lowers the concern of over-estimating the threatened status of taxa through the use of criteria D2 for small ranges and populations.

A regional assessment (such as along the South African Coastline) of endemic species, should include both common and rare as well as widespread species could be used as good tools for conservation for indicating changes. Also if a regional assessment of species is considered it is worth evaluating the state of the regions' flora by using a number of species. Although endemics and restricted species would be more susceptible to threats to extinction, populations of widespread non-endemics should also be considered. Widespread species could be threatened locally or even become nuisance weedy species that take over under disturbances conditions. Not only would this then update the status of the regional flora and help identify other species that may be at risk but also indicate any severe and/or negative habitat changes in the ecosystem that may have not been obvious before the survey, while also determining and further understanding the effects of threats such as climate change and human related activities, both which may have resulted in habitat alterations and a change in community composition (Yan Xie 2007; IUCN 2008).

CONCLUSION:

This project being a review of most of the current literature concerning seaweed species and IUCN assessment hopes to open up future opportunities to tackle IUCN Red List evaluations for floras in both South Africa and potentially other coastlines. The marine environment makes it difficult to access and assess seaweed species as well as to effectively determine population sizes, which is shown in the lack of literature. This therefore poses as a problem when considering species for extinction risks and effectively evaluating them. It would therefore not be logical to attempt to adapt the IUCN Red List criteria and assessment method for seaweed species, because of this insufficient available relevant data concerning the taxa. One thing missing is a consensus by phycologists on how one could tackle the serious problems relating to data deficiency. Initiatives such as the International Barcode of Life, are ways of improving knowledge of seaweed species, for not only species distribution, but also for accurate identification of species with problematic taxonomies(Saunders 2008).

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Appendix 1: IUCN Red List of Threatened Species Threat Categories taken from 2001 Categories & Criteria (version 3.1)

EXTINCT (EX)

A taxon is Extinct when there is no reasonable doubt that the last individual has died. A taxon is presumed Extinct when exhaustive surveys in known and/or expected habitat, at appropriate times (diurnal, seasonal, annual), throughout its historic range have failed to record an individual. Surveys should be over a time frame appropriate to the taxon's life cycle and life form.

EXTINCT IN THE WILD (EW)

A taxon is Extinct in the Wild when it is known only to survive in cultivation, in captivity or as a naturalized population (or populations) well outside the past range. A taxon is presumed Extinct in the Wild when exhaustive surveys in known and/or expected habitat, at appropriate times (diurnal, seasonal, annual), throughout its historic range have failed to record an individual. Surveys should be over a time frame appropriate to the taxon's life cycle and life form.

CRITICALLY ENDANGERED (CR)

A taxon is Critically Endangered when the best available evidence indicates that it meets any of the criteria A to E for Critically Endangered (see Section V), and it is therefore considered to be facing an extremely high risk of extinction in the wild.

ENDANGERED (EN)

A taxon is Endangered when the best available evidence indicates that it meets any of the criteria A to E for Endangered (see Section V), and it is therefore considered to be facing a very high risk of extinction in the wild.

VULNERABLE (VU)

A taxon is Vulnerable when the best available evidence indicates that it meets any of the criteria A to E for Vulnerable (see Section V), and it is therefore considered to be facing a high risk of extinction in the wild.

NEAR THREATENED (NT)

A taxon is Near Threatened when it has been evaluated against the criteria but does not qualify for Critically Endangered, Endangered or Vulnerable now, but is close to qualifying for or is likely to qualify for a threatened category in the near future.

LEAST CONCERN (LC)

A taxon is Least Concern when it has been evaluated against the criteria and does not qualify for Critically Endangered, Endangered, Vulnerable or Near Threatened. Widespread and abundant taxa are included in this category.

DATA DEFICIENT (DD)

A taxon is Data Deficient when there is inadequate information to make a direct, or indirect, assessment of its risk of extinction based on its distribution and/or population status. A taxon in this category may be well studied, and its biology well known, but appropriate data on abundance and/or distribution are lacking. Data Deficient is therefore not a category of threat. Listing of taxa in this category indicates that more information is required and acknowledges the possibility that future research will show that threatened classification is appropriate. It is important to make positive use of whatever data are available. In many cases great care should be exercised in choosing between DD and a threatened status. If the range of a taxon is suspected to be relatively circumscribed, and a considerable period of time has elapsed since the last record of the taxon, threatened status may well be justified.

NOT EVALUATED (NE)

A taxon is Not Evaluated when it is has not yet been evaluated against the criteria.

Appendix 2: Summary of threatened species per plant group (Data taken from Summary Statistics, Table 3b of the IUCN Red List Website, http://www.iucnredlist.org/static/stats).

Table 3b: Status category summary by major taxonomic group (plants)

Class*	EX	EW	Subtotal	CR	EN	VU	Subtotal	LR/cd	NT	DD	LC	Total
BRYOPSIDA	2	0	2	11	15	11	37	0	0	0	1	40
ANTHOCEROTOPSIDA	0	0	0	0	1	1	2	0	0	0	0	2
MARCHANTIOPSIDA	1	0	1	12	16	15	43	0	0	0	9	53
LYCOPODIOPSIDA	0	0	0	1	2	8	11	0	1	0	1	13
SELLAGINELLOPSIDA	0	0	0	0	0	1	1	0	1	0	0	2
ISOETOPSIDA	0	0	0	2	0	1	3	0	0	0	0	3
POLYPODIOPSIDA	3	0	3	29	37	58	124	0	14	45	7	193
CONIFEROPSIDA	0	0	0	21	54	97	172	25	63	26	334	620
CYCADOPSIDA	0	4	4	45	40	65	150	0	67	18	50	289
GINKGOOPSIDA	0	0	0	0	1	0	1	0	0	0	0	1
MAGNOLIOPSIDA	78	22	100	1299	1847	3976	7122	196	810	458	938	9624
LILIOPSIDA	2	2	4	149	267	366	782	17	109	138	105	1155
CHLOROPHYCEAE	0	0	0	0	0	0	0	0	0	1	0	1
ULVOPHYCEAE	0	0	0	0	0	0	0	0	0	1	0	1
FLORIDEOPHYCEAE	1	0	1	6	0	3	9	0	0	44	4	58
Total	87	28	115	1575	2280	4602	8457	238	1065	731	1449	12055

Status category summary by major taxonomic group (other groups)

Class*	EX	EW	Subtotal	CR	EN	VU	Subtotal	LR/cd	NT	DD	LC	Total
BASIDIOMYCETES	0	0	0	1	0	0	1	0	0	0	0	1
LECANOROMYCETES	0	0	0	1	1	0	2	0	0	0	0	2
PHAEOPHYCEAE	0	0	0	4	1	1	6	0	0	9	0	15
Total	0	0	0	6	2	1	9	0	0	9	0	18

Appendix 3: 2001 Red List Criteria. Summary of the five criteria (A-E) used to evaluate if species belongs in a category of threat (Critically Endangered, Endangered or Vulnerable). Taken from Guidelines for Using the IUCN Red List Categories and Criteria Version 7.0 (2008)

Use any of the criteria A-E	**Critically Endangered**	**Endangered**	**Vulnerable**
A. Population reduction	Declines measured over the longer of 10 years or 3 generations		
A1	≥ 90%	≥ 70%	≥ 50%
A2, A3 & A4	≥ 80%	≥ 50%	≥ 30%
A1. Population reduction observed, estimated, inferred, or suspected in the past where the causes of the reduction are clearly reversible AND understood AND ceased based on and specifying any of the following:			
	(a) direct observation		
	(b) an index of abundance appropriate to the taxon		
	(c) a decline in area of occupancy (AOO), extent of occurrence (EOO) and/or habitat quality		
	(d) actual or potential levels of exploitation		
	(e) effects of introduced taxa, hybridisation, pathogens, pollutants, competitors or parasites.		
A2. Population reduction observed, estimated, inferred, or suspected in the past where the causes of reduction may not have ceased OR may not be understood OR may not be reversible, based on any of (a) to (e) under A1.			
A3. Population reduction projected or suspected to be met in the future (up to a maximum of 100 years) based on any of (b) to (e) under A1.			
A4. An observed, estimated, inferred, projected or suspected population reduction (up to a maximum of 100 years) where the time period must include both the past and the future, and where the causes of reduction may not have ceased OR may not be understood OR may not be reversible, based on any of (a) to (e) under A1.			
B. Geographic range in the form of either B1 (extent of occurrence) OR B2 (area of occupancy)			
B1. Extent of occurrence	< 100 km^2	< 5,000 km^2	< 20,000 km^2
B2. or area of occupancy	< 10 km^2	< 500 km^2	< 2,000 km^2
and 2 of the following 3:			
(a) severely fragmented or # locations	= 1	≤ 5	≤ 10
(b) continuing decline in (i) extent of occurrence (ii) area of occupancy, (iii) area, extent and/or quality of habitat, (iv) number of locations or subpopulations and (v) number of mature individuals.			
(c) extreme fluctuations in any of (i) extent of occurrence, (ii) area of occupancy, (iii) number of locations or subpopulations and (iv) number of mature individuals.			
C. Small population size and decline			
Number of mature individuals	< 250	< 2,500	< 10,000
and either **C1** or **C2:**			
C1. An estimated continuing decline of at least:	25% in 3 years or 1 generation	20% in 5 years or 2 generations	10% in 10 years or 3 generations
up to a maximum of 100 years			
C2. A continuing decline and (a) and/or (b):			
(a i) # mature individuals in largest subpopulation:	< 50	< 250	< 1,000
(a ii) or % mature individuals in one subpopulation = :	90%	95%	100%
(b) extreme fluctuations in the number of mature individuals			
D. Very small or restricted population			
Either:			
(1) number of mature individuals	< 50	< 250	< 1,000
or			
(2) restricted area of occupancy:	na	na	AOO < 20km2 or # locations ≤5
E. Quantitative Analysis			
Indicating the probability of extinction in the wild to be at least:	50% in 10 years or 3 generations (100 years max)	20% in 20 years or 5 generations (100 years max)	10% in 100 years

Appendix 4: RED LIST ASSESSMENT for *Cystophora fibrosa*

Questionnaire

(please complete one questionnaire per taxon, extra sheets may be used)

1a. Scientific name (including authority details):

Cystophora fibrosa Simons (Pending move to Cystoseira, with new species name)

2a. Order	**2b. Family**
Fucales	Sargassaceae

3. Distribution

Describe the range in terms of countries of occurrence, subcountry units (e.g., states, provinces, etc.). For an inland water taxon, record the name/s of lakes, river systems, etc. in which it occurs. For a marine taxon, record names of estuaries, territorial waters, FAO fisheries areas:

Three known localities: Cape Point, Cape Agulhas, Koppie Alleen (Dehoop Nature Reserve) The extreme ends of the Western Overlap South Africa FAO: Atlantic, South East **Note:** A distribution map showing the extent of occurrence **MUST** be attached.

NOT HERE!

3a. Red List Assessment (Red List assessment using IUCN Red List Categories and Criteria: version 3.1. (IUCN 2001)). Cross (**X**) one of the following categories:

3b. Red List Criteria (For threatened taxa (i.e., those assessed as CR, EN or VU) record which criteria are met (e.g., A2c+3c; B1ab(iii); D) alongside the appropriate Category. For NT taxa, record criteria nearly met):

☐ Extinct (EX)

[ ] Extinct in the Wild (EW)	
[ ] Critically Endangered (CR)	
[ ] Endangered (EN)	
[X] Vulnerable (VU)	A2ac; D2
[ ] Near Threatened (NT)	

Note: If one of the threatened categories is selected (i.e. CR, EN or VU) then **ALL** the criteria, subcriteria and sub-subcriteria met for that category, must be listed in the box provided.

4. Rationale for the Red List Assessment (record the reasons why the taxon is assessed as above, including any population or range information used, inferences, assumptions, etc. For NT specify what criteria were nearly met and for DD specify what little information is known. Use additional sheets if necessary):

Three localities, one having no observed individuals over the last 10 years suggesting a possible loss of > 30% population and/or distribution. The other two have locally common populations within a highly restricted area and habitat, only $552m^2$ at Koppie Alleen.

Only occupying small sections of the intertidal zone in fragmented neighboring rocky pools. Inferred maximum available habitat over three hundred kilometers of coastlines at about thirty meters average intertidal width; AOO = $9km^2$.

6. Current Population Trend (cross (**X**) one of the following):

☐ Increasing ☐ Decreasing ☐ Stable ☒ Unknown

7. Date of Assessment (day/month/year):	**13 10 2008**

8a. Name/s of the Assessor/s

Nicholas P. Zaloumis and John J. Bolton

8b. Names of the Evaluators - *to be filled in By Red List Authority ONLY*

(<u>at least TWO</u> evaluators, and the name of the Red List Authority)

9. Text documentation

Brief notes (i.e., a short narrative, on the topics below to complement the information entered above or on the Authority Files in Annex 1 (use additional sheets if required).

9a. Taxonomy (any taxonomic notes of relevance - optional): Name change pending, chemical and molecular evidence that this species is in fact in the *Cystosei*ra genus. As the name *Cystosteira fibrosa* exists as a synonym of another taxon, a new species name is required.
9b. Geographic Range (including mention of important sites, and if known specify the extent of occurrence and area of occupancy): 3 Known localities The Cape Agulhas (Simons 1970), Koppie Alleen in the Dehoop nature Reserve (Bolton and Stegenga 1990). The last was an observed population at Platboom on the west coast of the Cape Penisula (Stegenga et al. 1997) Inferred AOO = 9km
9c. Population (for example, population size, abundance (rare, scarce, common, etc.), number and size of subpopulations if known, number of locations and degree of fragmentation):

Common at localities, known at Koppie Alleen to average at around 60 individuals per meter squared. An estimate of over 1000 individuals occurred throughout the area.
9d. Habitat and Ecology (including particulars about breeding ecology if relevant): Occurs in sheltered rock pools, with generally higher densities found in rock pools with a depth greater than 0.4m meters. Little or no co-occurrence with the local sea urchin (*Parechinus angulosus*) Very few juveniles observed in July, (only in a small percentage of observed pools), most small individuals are senescent adults with old hardened growth and new light brown new growth. Can grow up to half a meter and longer (Stegenga et al. 1997 ***??? Or pers. obs???.
9e. Threats (the main threats to the species, and if known, the severity and extent): Habitat alteration through natural processes and severe weather causing the movement of sand along coast covering suitable habitat. Pollution and the potential of an oil spill destroying all individuals in restricted range in known locations of which there are less than 5. Observes reduction of AOO and EOO with the potential loss of the Cape Peninsula population, reducing population size by just over 30%.
9f. Conservation Actions (including presence in protected areas and national/international legislation): One population in Dehoop Nature Reserve Marine Protected Area. Previous Platboom population was in marine reserve section of Table Mountain National Park.

10. Literature References (cited in full) used for the assessment and documentation:

Simons, R. H. 1970. Marine algae from southern Africa. 1. Six new species form the inter- and infra-tidal zones. *Division of Sea Fisheries Investigational Report* 88:1-13

Bolton, J.J. & Stegenga, H. 1990. The seaweeds of De Hoop Nature Reserve and their phytogeographical significance. *South African Journal of Botany* 56:233-8.

Annex 1. Authority Files For Habitats, Threats and Conservation Actions and Utilization

Habitats Authority File (Version 2.1)

Habitat Type	Score
10. Coastline	
10.1. Rocky Shores [includes rocky offshore islands and sea cliffs]	**X**
10.2. Sand, Shingle or Pebble Shores [includes sand bars, spits, sandy islets, dune systems]	
10.3. Estuarine Waters	
10.4. Intertidal Mud, Sand or Salt Flats	
10.5. Intertidal Marshes [includes salt marshes]	
10.6. Coastal Brackish/Saline Lagoons	
10.7. Coastal Freshwater Lagoons	
10.8. Karst and Other Subterranean Hydrological Systems [marine/coastal]	

Threat	Past	Present	Future
6. Pollution (affecting habitat and/or species)			
6.1. Atmospheric pollution			
6.1.1. Global warming/oceanic warming		?	X
6.1.2. Acid precipitation			
6.1.3. Ozone hole effects			
6.1.4. Smog			
6.1.5. Other			
6.1.6. Unknown			
6.3. Water pollution			
6.3.1. Agricultural			
6.3.2. Domestic			
6.3.3. Commercial/Industrial			
6.3.4. Other non-agricultural			
6.3.5. Thermal pollution			
6.3.6. Oil slicks			**X**
6.3.7. Sediment			
6.3.8. Sewage			

6.3.9. Solid waste			
6.3.10. Noise pollution			
6.3.11. Other			
6.3.12. Unknown			
6.4. Other			
6.5. Unknown			
7. Natural disasters			
7.1. Drought			
7.2. Storms/flooding			X
7.3. Temperature extremes			
7.4. Wildfire			
7.5. Volcanoes			
7.6. Avalanches/landslides			
7.7. Other			
7.8. Unknown			
9. Intrinsic Factors			
9.1. Limited dispersal			
9.2. Poor recruitment/reproduction/regeneration			X
9.3. High juvenile mortality			
9.4. Inbreeding			
9.5. Low densities			
9.6. Skewed sex ratios			
9.7. Slow growth rates			
9.8. Population fluctuations			
9.9. Restricted range			X
9.10. Other			
9.11. Unknown			

If you have selected "Other" for any of the threats options, please note details here:

Bolton, J. J. & Stegenga, H. 1990. The seaweeds of De Hoop Nature Reserve and their phytogeographical significance. South African Journal of Botany 56:233-8.

Simons, R. H. 1970. Marine algae from southern Africa. 1. Six new species from the inter- and infra-tidal zones. Division of Sea Fisheries Investigational Report 88:1-13.

Conservation Actions Authority File (Version 1.0)

In using this hierarchical classification of conservation actions, assessors are asked to indicate the conservation actions or measures that are in place and/or that are needed for each taxon. In suggesting what actions are needed, **assessors are asked to be realistic and not simply select everything. The selection should be for those actions which are most needed and which could realistically be achieved in approximately the next five years.** Selection of a higher level action e.g., 1.2. Legislation, does not mean that all the actions below this e.g., 1.2.1 Development and 1.2.2. Implementation, are indicated. It simply indicates that legislation is either in place or is needed as part of a policy-based action for the taxon concerned. Selection of any action lower down the hierarchy automatically implies that the higher levels are indicated, i.e. it is not necessary to indicate all the levels, just the lowest. For example, selecting action 4.4.2. Establishment, indicates that establishment of a protected area (action 4.4) is one of the habitat and site based actions (action 4.) required for the taxon concerned. Multiple conservation actions can be selected as required. If 'Other' is selected, the conservation action or measure must be specified. Multiple additions under 'Other' are allowed, although extensive use of this is not encouraged. If no conservation actions or measures are in place, this should be recorded, against conservation action 0. Similarly, if no conservation actions are needed, then it is also important to record this against conservation action 0 (both 'In Place' and the 'Needed' columns could be ticked). To indicate the actions use: **Yes** or **Y** or **X**.

Conservation Action	In Place	Needed
0. No conservation actions		
1. Policy-based actions		
1.1. Management plans		
1.1.1. Development		
1.1.2. Implementation		
1.2. Legislation		
1.2.1. Development		
1.2.1.1. International level	X	
1.2.1.2. National level	X	
1.2.1.3. Sub-national level		
1.2.2. Implementation		
1.2.2.1. International level		
1.2.2.2. National level		
1.2.2.3. Sub-national level		
1.3. Community management		
1.3.1. Governance		
1.3.2. Resource stewardship		
1.3.3. Livelihood alternatives		
1.4. Other		
2. Communication and Education		
2.1. Formal education		
2.2. Awareness		
2.3. Capacity-building/Training		
2.4. Other		
3. Research actions		
3.1. Taxonomy		
3.2. Population numbers and range		X
3.3. Biology and Ecology		X
3.4. Habitat status		X
3.5. Threats		X

3.6. Uses and harvest levels		
3.7. Cultural relevance		
3.8. Conservation measures		
3.9. Trends/Monitoring		X
3.10. Other		
4. Habitat and site-based actions		
4.1. Maintenance/Conservation		
4.2. Restoration		
4.3. Corridors		
4.4. Protected areas	X	
4.4.1. Identification of new protected areas		
4.4.2. Establishment		
4.4.3. Management		
4.4.4. Expansion		
4.5. Community-based initiatives		
4.6. Other		

If you have ticked "Other" for any of the conservation actions options, please note details here:

Appendix 5: RED LIST ASSESSMENT for *Letterstedtia insignis*

Questionnaire

(please complete one questionnaire per taxon, extra sheets may be used)

1a. Scientific name (including authority details):

Letterstedtia insignis Areschoug

1b. Synonym/s (if there has been a taxonomic change in the last 5 years or if widely used):

Ulva insignis Authority (look on algaebase.org)

2a. Order	**2b. Family**
Ulvales	Ulvaceae

3. Distribution

Describe the range in terms of countries of occurrence, subcountry units (e.g., states, provinces, etc.). For an inland water taxon, record the name/s of lakes, river systems, etc. in which it occurs. For a marine taxon, record names of estuaries, territorial waters, FAO fisheries areas:

Growing samples collected from two original known localities, Waterloo Bay, Just east of the mouth of the great Fish River and Salt Vlei Bay, four or five miles west of the Kowie River mouth (1942). It was then found attached at Kwaai Hoek near Richmond (1944), at Kleinemonde (1943 and 1947), at Kenton-on-Sea (1959) and several other places as far east as the mouth of the Keiskamma River. Considered to be growing in many places that have not been recorded yet as it was often collected as drift on the coast of the Eastern Cape Province between Port Elizabeth (the most western collection point) and East London suggesting that it was commonly growing in nearby waters along the coast (Pocock 1959).

South Africa

FAO: Atlantic, South East

Note: A distribution map showing the extent of occurrence **MUST** be attached.

3a. Red List Assessment (Red List assessment using IUCN Red List Categories and Criteria: version 3.1. (IUCN 2001)). Cross (**X**) one of the following categories:

3b. Red List Criteria (For threatened taxa (i.e., those assessed as CR, EN or VU) record which criteria are met (e.g., A2c+3c; B1ab(iii); D) alongside the appropriate Category. For NT taxa, record criteria nearly met):

[ ]	Extinct (EX)	
[ ]	Extinct in the Wild (EW)	
[ ]	Critically Endangered (CR)	
X	Endangered (EN)	A2ac; B1b(i,ii,iii,iv,v)c(ii,iii,v)+2(i,ii,iii,iv,v)c(ii,iii,v)
[ ]	Vulnerable (VU)	
[ ]	Near Threatened (NT)	

Note: If one of the threatened categories is selected (i.e. CR, EN or VU) then **ALL** the criteria, subcriteria and sub-subcriteria met for that category, must be listed in the box provided.

4. Rationale for the Red List Assessment (record the reasons why the taxon is assessed as above, including any population or range information used, inferences, assumptions, etc. For NT specify what criteria were nearly met and for DD specify what little information is known. Use additional sheets if necessary):

This species has a large and conspicuous adult form which was collected frequently in the drift and attached numerous times between 1942 and 1959 and was considered to be a common part of the Eastern Cape Coastal Flora between Port Elizabeth and East London. Recent floral surveys, both targeted in a known historic locality (Salt Vlei Bay) and general surveys along the coast have failed to result in any confirmed records of the species over the last 10 years. Pocock (1959) noted that there appeared to be the signs of habitat alterations due to ??? weather disturbance. Numerous and healthy first in 1942, the next visit, after heavy rains, saw no evidence of the presence of the macroalgae. However it was reported to have become abundant by 1958, but not at the same levels as in 1942. Other populations were recorded to have annual fluctuating numbers of adults. Since 1959, no confirmed sample has been collected and extensive surveys of most of the coast over the last ten years have failed to produce any records of the species. If more extensive surveys of all the known historic growths were to be performed this species could be placed in the CR threat status and if no individuals are found in ten years this species could be considered as extinct.

6. Current Population Trend (cross (**X**) one of the following):

	Increasing		Decreasing		Stable	**X**	Unknown

7. Date of Assessment (day/month/year): **13/10/2008**

8a. Name/s of the Assessor/s

Nicholas P. Zaloumis and John J. Bolton

8b. Names of the Evaluators - *to be filled in By Red List Authority ONLY*

(<u>at least TWO</u> evaluators, and the name of the Red List Authority)

9. Text documentation

Brief notes (i.e., a short narrative, on the topics below to complement the information entered above or on the Authority Files in Annex 1 (use additional sheets if required).

9a. Taxonomy (any taxonomic notes of relevance - optional):

Considered a unique species and has some uncertainty with which family it falls in. With no recent collections it is not possible to perform molecular work.

9b. Geographic Range (including mention of important sites, and if known specify the extent of occurrence and area of occupancy):

Growing samples collected from two original known localities, Waterloo Bay, Just east of the mouth of the great Fish River and Salt Vlei Bay, four or five miles west of the Kowie River mouth (1942). It was then found attached at Kwaai Hoek near Richmond (1944), at Kleinemonde (1943 and 1947), at Kenton-on-Sea (1959) and several other places as far east as the mouth of the Keiskamma River. Considered to be growing in many places that had not been recorded by 1959 as it was often collected as drift on the coast of the Eastern Cape Province between Port Elizabeth (the most western collection point) and East London suggesting that it was commonly growing in nearby waters along the coast (Pocock 1959).

9c. Population (for example, population size, abundance (rare, scarce, common, etc.), number and size of subpopulations if known, number of locations and degree of fragmentation):

Abundant populations recorded at most known localities. Considered common and in high density stands in both Waterloo and Salt Vlei Bay. No knowledge of population size and besides several known localities where it was sampled, it was also thought to occur at many more sites along the coast.

9d. Habitat and Ecology (including particulars about breeding ecology if relevant):

Has a few different external morphological habits recorded (Pocock 1959). Can grow up to over 1.2 meters in the subtidal zone and can be a smaller bushy plant in shallower water that is partially exposed at low tide and a stunted lettuce-like plant found on the intertidal zone. Careful study by Pocock (1959) produced a good understanding of the different morphs, but molecular evidence is absent to confirm that these are all the same species. Found growing in sandy gullies between parallel lines of small reefs running at right angles to the shore. Tallest morphs fully submerged at low tides.
9e. Threats (the main threats to the species, and if known, the severity and extent): At both Waterloo and Salt Vlei Bay, sand movement after severe weather and storms was recorded to completely bury populations of plants. Changes in sand movement via artificial structures, such as the creation of a marina at Salt Vlei bay, may change the dynamic of the area creating unsuitable habitat for the plant. There is the potential threat of oil spills and other pollutants along the coast. Other threats may be present but are not understood, as it is unknown why the algal species, once common along the coast, has not been recorded over the last 20 years..
9f. Conservation Actions (including presence in protected areas and national/international legislation): ?? is there any MPA's in the area Ask Rob for a list. There are quite a few small ones, but the ones we have surveyed, we haven't found it!

10. Literature References (cited in full) used for the assessment and documentation:

Pocock, M.A. (1959). *Letterstedtia insignis* Areschoug. *Hydrobiologia* 14:(1) 1-71

Annex 1. Authority Files For Habitats, Threats and Conservation Actions and Utilization

A. Habitats Authority File (Version 2.1)

Score: **1** = primary habitat type; **2** = secondary habitat type; **9** = possibly suitable habitat

Habitat Type	Score

9. Sea	
9.1. Open	
9.2. Shallow [usually less than 6 m deep at low tide; includes sea bays and straits]	X
9.3. Subtidal Aquatic Beds [kelp beds, sea- grass beds and tropical marine meadows]	X
9.4. Coral Reefs	
10. Coastline	
10.1. Rocky Shores [includes rocky offshore islands and sea cliffs]	X
10.2. Sand, Shingle or Pebble Shores [includes sand bars, spits, sandy islets, dune systems]	
10.3. Estuarine Waters	
10.4. Intertidal Mud, Sand or Salt Flats	
10.5. Intertidal Marshes [includes salt marshes]	
10.6. Coastal Brackish/Saline Lagoons	
10.7. Coastal Freshwater Lagoons	
10.8. Karst and Other Subterranean Hydrological Systems [marine/coastal]	

B. **Major Threats (Version 2.1)**

Threat	Past	Present	Future
0. No threats			
1. Habitat loss/degradation (human induced)			
1.1. Agriculture			
1.2. Land management of non-agricultural areas			
1.2.1. Abandonment			
1.2.2. Change of management regime			
1.2.3. Other			
1.2.4. Unknown	X	X	X

1.4. Infrastructure development			
1.4.1. Industry			
1.4.2. Human settlement	X	X	X
1.4.3. Tourism/recreation			
1.4.4. Transport - land/air			
1.4.5. Transport – water			
1.4.6. Dams			
1.4.7. Telecommunications			
1.4.8. Power lines			
1.4.9. Other			
1.4.10. Unknown			
6. Pollution (affecting habitat and/or species)			
6.3. Water pollution			
6.3.1. Agricultural			
6.3.2. Domestic			
6.3.3. Commercial/Industrial			
6.3.4. Other non-agricultural			
6.3.5. Thermal pollution			
6.3.6. Oil slicks			X
6.3.7. Sediment	X	X	
6.3.8. Sewage			
6.3.9. Solid waste			
6.3.10. Noise pollution			
6.3.11. Other			
6.3.12. Unknown			
6.4. Other			
6.5. Unknown			
7. Natural disasters			

7.1. Drought			
7.2. Storms/flooding	X		
7.3. Temperature extremes			
7.4. Wildfire			
7.5. Volcanoes			
7.6. Avalanches/landslides			
7.7. Other			
7.8. Unknown			
9. Intrinsic Factors			
9.1. Limited dispersal			
9.2. Poor recruitment/reproduction/regeneration			
9.3. High juvenile mortality			
9.4. Inbreeding			
9.5. Low densities			
9.6. Skewed sex ratios			
9.7. Slow growth rates			
9.8. Population fluctuations	X		
9.9. Restricted range			
9.10. Other			
9.11. Unknown			
10. Human disturbance			
10.1. Recreation/tourism	X	X	
10.2. Research			
10.3. War/civil unrest			
10.4. Transport			
10.5. Fire			
10.6. Other			
10.7. Unknown			

Appendix 6: RED LIST ASSESSMENT for ~~*Letterstedtia insignis*~~ Mazzaella convoluta

Questionnaire

(please complete one questionnaire per taxon, extra sheets may be used)

1a. Scientific name (including authority details):

Mazzaella convoluta (Areschoug ex J. Agardh) Hommersand

1b. Synonym/s (if there has been a taxonomic change in the last 5 years or if widely used):

Gigartina convoluta Areschoug ex J. Agardh

2a. Order	**2b. Family**
Gigartinales	Gigartinaceae

3. Distribution

Describe the range in terms of countries of occurrence, subcountry units (e.g., states, provinces, etc.). For an inland water taxon, record the name/s of lakes, river systems, etc. in which it occurs. For a marine taxon, record names of estuaries, territorial waters, FAO fisheries areas:

Known to be found along a 50km stretch of coastline between Table Bay and the Cape of Good Hope, confined to the west coast of the Cape Peninsula. Recorded within student samples occasionally (Bolton, J. J. Pers. Comm.). Misidentified samples have been found in one location in Namibia, but it is likely that these where in fact juvenile *Gigartina stiriata*. Overall there are 5 known localities.

South Africa

FAO: Atlantic, South East

Note: A distribution map showing the extent of occurrence **MUST** be attached.

3a. Red List Assessment (Red List assessment using IUCN Red List Categories and Criteria: version 3.1. (IUCN 2001)). Cross (**X**) one of the following categories:

☐ Extinct (EX)

☐ Extinct in the Wild (EW)

☐ Least Concern (LC)

☒ Data Deficient (DD)

☐ Not Evaluated (NE)

3b. Red List Criteria (For threatened taxa (i.e., those assessed as CR, EN or VU) record which criteria are met (e.g., A2c+3c; B1ab(iii); D) alongside the appropriate Category. For NT taxa, record criteria nearly met):

Note: If one of the threatened categories is selected (i.e. CR, EN or VU) then **ALL** the criteria, subcriteria and sub-subcriteria met for that category, must be listed in the box provided.

4. Rationale for the Red List Assessment (record the reasons why the taxon is assessed as above, including any population or range information used, inferences, assumptions, etc. For NT specify what criteria were nearly met and for DD specify what little information is known. Use additional sheets if necessary):

It is a small inconspicuous species with a small distribution range. Not enough information is known for the species to give any certain indication of its threatened status and more targeted surveys are needed. It is likely that it could be defined as vulnerable through criteria D2 by its area of occurrence; however nothing is known of its population trends in both size and distribution. Although JJ Bolton has observed very little of the species in recent years there is no evidence for current loss of species numbers or distribution.

Table Bay and the Cape Peninsula are sites for increased coastal development and Table Bay in particular has and is currently under commercial, urban and harbor development and has undergone severe coastal alteration in the past.

Being the site of one of South Africa's major harbors, it is also possible that disturbance, pollution and habitat alterations have encouraged and unsuitable habitat for the species to grow in.

So there are a list of potential threats that face this species making it necessary to keep an eye on the species. As habitat loss may infer evidence of population decline this species could also be considered as VU (A2c+4ac;D2), however further surveys and increased understanding of the species is needed

6. Current Population Trend (cross (**X**) one of the following):

[ ] Increasing [ ] Decreasing [ ] Stable [**X**] Unknown

7. Date of Assessment (day/month/year): **13 10 2008**

8a. Name/s of the Assessor/s

Nicholas P. Zaloumis and John J. Bolton

8b. Names of the Evaluators - *to be filled in By Red List Authority ONLY*

(at least TWO evaluators, and the name of the Red List Authority)

9. Text documentation

Brief notes (i.e., a short narrative, on the topics below to complement the information entered above or on the Authority Files in Annex 1 (use additional sheets if required).

9a. Taxonomy (any taxonomic notes of relevance - optional):

Easily confused with *Gigartina stiriata* Juveniles and was incorrectly thought to be *Gigartina convuluta* as a result. I don't think it is easily confused, except when it is pressed. The convolute thallus, when fresh, is very distinctive (G stiriata is flat!) However recent molecular evidence has ~~known~~ Shown that it is indeed separate and should be referred to as *Mazzaella convoluta*

9b. Geographic Range (including mention of important sites, and if known specify the extent of occurrence and area of occupancy):

There are 5 known sample localities and is known to be found along a 50km stretch of coastline between Table Bay and the Cape of Good Hope, confined to the west of the Cape Peninsula. Why not list the 5 localities??

Misidentified samples have been found in one location in Namibia, but it is likely that these where in fact juvenile *Gigartina stiriata* (Bolton, J.J pers. comm.).

9c. Population (for example, population size, abundance (rare, scarce, common, etc.), number and size of subpopulations if known, number of locations and degree of fragmentation):

Little is known of any population characteristics

9d. Habitat and Ecology (including particulars about breeding ecology if relevant):

Found on Rocky shores

9e. Threats (the main threats to the species, and if known, the severity and extent):

Habitat alteration along the coast could lead to a decrease in species. Harbor and development activities could also have and further decrease the species population.

9f. Conservation Actions (including presence in protected areas and national/international legislation):

Cape Point MPA This is part of Table Mountain National Park??? Get the proper name and coastal development legislation

10. Literature References (cited in full) used for the assessment and documentation:

Hommersand, M.H., Fredericq, S. & Freshwater, D.W. (1994). Phylogenetic systematics and biogeography of the Gigartinaceae (Gigartinales, Rhodophyta) based on sequence analysis of *rbc*L. *Botanica Marina* 37: 193-203

Annex 1. Authority Files For Habitats, Threats and Conservation Actions and Utilization

C. Habitats Authority File (Version 2.1)

10. Coastline	
10.1. Rocky Shores [includes rocky offshore islands and sea cliffs]	X
10.2. Sand, Shingle or Pebble Shores [includes sand bars, spits, sandy islets, dune systems]	
10.3. Estuarine Waters	
10.4. Intertidal Mud, Sand or Salt Flats	
10.5. Intertidal Marshes [includes salt marshes]	
10.6. Coastal Brackish/Saline Lagoons	
10.7. Coastal Freshwater Lagoons	
10.8. Karst and Other Subterranean Hydrological Systems [marine/coastal]	

D. Major Threats (Version 2.1)

Threat	Past	Present	Future
. No threats			
. Habitat loss/degradation (human induced)			
1.4. Infrastructure development			
1.4.1. Industry	X	X	X
1.4.2. Human settlement	X	X	X
6.3.1. Agricultural			
6.3.2. Domestic			
6.3.3. Commercial/Industrial	X	X	

6.3.4. Other non-agricultural			
6.3.5. Thermal pollution	X	X	
1.5. Invasive alien species (directly impacting habitat)	6.3.6. Oil slicks		
1.6. Change in native species dynamics (directly impacting habitat)	6.3.7. Sediment		
1.7. Fires 6.3.8. Sewage	X	X	
1.8. Other causes	6.3.9. Solid waste		
1.9. Unknown causes	6.3.10. Noise pollution		
. Pollution (affecting habitat and/or species)		6.3.11. Other	
6.3. Water pollution	6.3.12. Unknown		
			X
			X
			X
			X

X	X	X	
6.4. Other			
6.5. Unknown			

E. **Conservation Actions Authority File (Version 1.0)**

Conservation Action	**In Place**	**Needed**
0. No conservation actions		
1. Policy-based actions		
1.2. Legislation		
1.2.1. Development		
1.2.1.1. International level		
1.2.1.2. National level	X	
1.2.1.3. Sub-national level		

4. Habitat and site-based actions		
4.1. Maintenance/Conservation	X	
4.2. Restoration		
4.3. Corridors		
4.4. Protected areas		
4.4.1. Identification of new protected areas		
4.4.2. Establishment		
4.4.3. Management		
4.4.4. Expansion		X
4.5. Community-based initiatives		
4.6. Other		