JNCC Report 748

Technical assistance programme for effective coastal-marine management in the Turks and Caicos Islands (DPLUS119)

WP2: Status assessments for marine/coastal habitats within TCI territorial waters – Sensitivity assessments

Appendix 5: Sensitivity Assessment for the Turks and Caicos Islands sand habitats

November 2023

ISSN 0963 8091

JNCC Report 748: Technical assistance programme for effective coastal-marine management in the Turks and Caicos Islands (DPLUS119). WP2: Status assessments for marine/coastal habitats within TCI territorial waters – Sensitivity assessments

Appendix 5. Sensitivity Assessment for Turks and Caicos Islands sand habitats

Supplementary Material to the report 'Status assessments for marine/coastal habitats within Turks and Caicos Islands territorial waters' (Savage *et al.* 2023). This report was prepared as part of the Darwin Plus 119 project 'Technical assistance programme for effective coastal-marine management in Turks and Caicos Islands'.

Habitat

Sand

Description (taken from The Nature Conservancy benthic class description)

Characterized by a low relief, sand substrate with a bare to sparse living community cover (greater than 10%). Typically covered by a layer of cyanobacteria and commonly includes green algae genera: Halimeda and Caulerpa. The dominant community group in this habitat class is almost evenly split by cyanobacteria and macroalgae. The community group of secondary dominance is relatively evenly split by sponges and macroalgae. This habitat has a median depth of 15 m but can be found anywhere in the visible areas of the satellite imagery (0–30 m in depth).

Sensitivity characteristics/ features

The sand habitat contains very little living cover. The species which inhabit this environment are primarily the green alga *Halimeda* sp. and *Caulerpa* sp., the red alga *Laurencia* sp. and various cyanobacteria species.

Resistance, Resilience, Sensitivity and Confidence score criteria

Resistance

Resistance is scored according to the below criteria.

Resistance	Description
None (N)	Key functional, structural, characterizing species severely decline and/or the physico-chemical parameters are also affected (e.g. removal of habitats causing change in habitats type). A severe decline/reduction relates to the loss of 75% of the extent, density or abundance of the selected species or habitat component (e.g. loss of 75% substratum - where this can be sensibly applied).
Low (L)	Significant mortality of key and characterizing species with some effects on physico-chemical character of habitat. A significant decline/reduction relates to the loss of 25–75% of the extent, density, or abundance of the selected species or habitat component (e.g. loss of 25–75% of the substratum).
Medium (M)	Some mortality of species (can be significant where these are not keystone structural/functional and characterizing species) without change to habitats relates to the loss
High (H)	No significant effects to the physico-chemical character of habitat and no effect on population viability of key/characterizing species but may affect feeding, respiration and reproduction rates

Resilience

Resilience is scored according to the below criteria.

Resilience	Description
Very low (VL)	Negligible or prolonged recovery possible; at least 25 years to recover structure and function
Low (L)	Full recovery within 10–25 years
Medium (M)	Full recovery within 2–10 years
High (H)	Full recovery within 2 years

Sensitivity

Sensitivity is determined by a combination of the resistance and resilience score.

	Resistance			
Resilience	**None**	**Low**	**Medium**	**High**
Very low	High	High	Medium	Low
Low	High	High	Medium	Low
Medium	Medium	Medium	Medium	Low
High	Medium	Low	Low	Not sensitive

Confidence

The criteria for the three measures of confidence are displayed below.

Confidence level	Quality of evidence (QoE)	Applicability of evidence (AoE)	Degree of concordance (DoC)
High (H)	Based on peer reviewed papers (observational or experimental) or grey literature reports by established agencies on the feature (habitat, its	Assessment based on the same pressures acting on the same type of feature (habitat, its component species, or	Agree on the direction and magnitude (of impact or recovery).

	component species, or species of interest).	species of interest) in the UK.	
Medium (M)	Based on some peer reviewed papers but relies heavily on grey literature or expert judgement on feature (habitat, its component species, or species of interest) or similar features.	Assessment based on similar pressures on the feature (habitat, its component species, or species of interest) in other areas.	Agree on direction but not magnitude (of impact or recovery).
Low (L)	Based on expert judgement.	Assessment based on proxies for pressures (e.g. natural disturbance events).	Do not agree on direction or magnitude (of impact or recovery).

Recovery/ resilience rates

Green alga of *Caulerpa* are large single-celled organisms which can reproduce asexually through fragmentation or sexually via biflagellate gametes (Phillips 2009). Several *Caulerpa* species are invasive to areas such as Florida and the Mediterranean (Lapointe & Bedford 2010). *Caulerpa* are fast growing species and *Caulerpa taxifolia* and *Caulerpa racemosa* were recorded as possessing stolon growth rates of 0.97 ± 0.84 and 2.03 ± 1.75 cm/day respectively (Piazzi *et al.* 2001).

Halimeda are calcareous green alga found widely in the Caribbean. *Halimeda opuntia* has a relative growth rate of 0.011 ± 0.001 %/day (Teichberg *et al.* 2013). *Halimeda tuna* has a recorded growth rate of 0.025 g/day dry weight (Vroom *et al.* 2003) from samples taken in the Florida Quays. Species of *Halimeda* are known to reproduce asexually by fragmentation (Walters *et al*. 2002). These species may benefit from the actions of herbivorous fish which bite plants but subsequently reject the biomass leading to fragmentation.

Species of *Laurencia* have been observed to reproduce asexually by fragmentation (Herren *et al*. 2013) which plays a vital role in their ability to spread across benthic habitats. *Laurencia poiteaui* fragments in the Florida Quays were recorded to have a dispersal rate of 3.6 ± 0.3 cm/day over sand and almost all fragments attached to a host or sand within seven days (Herren *et al*. 2013). Fragments have survived in laboratory conditions for greater than six months which would allow for a large dispersal distance (Adames & Ballantine 1996). Josselyn (1977) recorded growth rates for *Laurencia poiteaui* of 2–5% weight increase/day during autumn and spring, which fell to 0–2% at other times of year. This resulted in an annual production of 21 g dry weight/m^2/year.

Cyanobacteria are ubiquitous throughout the Caribbean and benthic cyanobacterial mats have seen an increase in cover on coral reefs from 0.1% to 22.2% between 1973 and 2013 (Cissell *et al.* 2019)

Resilience Assessment

Where resistance is assessed as 'None' or 'Low' and there is significant mortality to species or significant changes to the habitat, resilience is assessed as 'Medium'. The characterising genera of this habitat possess fast growth rates and the ability to reproduce asexually by fragmentation. These life history traits would therefore likely result in fast recovery of lost biomass and abundance.

Where resistance is assessed as 'Medium', resilience is assessed as 'High'. The fast growth rates of these genera would likely result in the rapid recovery of the habitat if only some mortality occurred due to the impact of the pressure.

The confidences associated with the resilience scores are 'High' for Quality of Evidence (QoE), 'Medium' for Applicability of Evidence (AoE) (studies are from other Caribbean islands rather than Turks and Caicos Islands) and 'High' for Degree of Concordance (DoC).

Pressure Theme	Pressure	Revised Benchmark	Sensitivity Assessment											
			Resistance	Confidence Assessment			Resilience	Confidence Assessment			Sensitivity	Confidence Assessment		
				QoE	AoE	DoC		QoE	AoE	DoC		QoE	AoE	DoC
Physical pressures	Physical loss (to land or freshwater habitat)	Permanent loss of existing saline habitat within site	**N**	H	H	H	**VL**	H	M	H	**H**	H	H	H
			Evidence base - *i.e. evidence and citations for the given resistance and resilience scores:*											
			The permanent physical loss of a marine habitat to land or freshwater would cause an irreversible change to that habitat, to which marine species would have no resistance and be unable to recover. Resistance is therefore '**None'**, resilience is '**Very low'** and overall sensitivity is '**High'**. Due to the nature of this pressure, confidence is considered 'High'.											
	Physical change (to another seabed type)	Change from sedimentary or soft rock substrata to hard rock or artificial substrata or vice-versa.	**N**	H	H	H	**VL**	H	M	H	**H**	H	H	H
			Evidence base - *i.e. evidence and citations for the given resistance and resilience scores:*											
			A replacement from low relief sand, which characterises the habitat, to a hard or artificial substrate would result in a loss to the characterising feature. The permanent nature of this pressure means there would be no recovery. Resistance is therefore '**None'**, resilience '**Very low'** and overall sensitivity is '**High'**. Due to the nature of this pressure, confidence is considered to be 'High'.											
		Change in 1 Folk class (based on UK SeaMap simplified classification (Long, D. 2006. BGS detailed explanation of seabed sediment modified Folk classification))	**N**	H	H	H	**VL**	H	M	H	**H**	H	M	H
			Evidence base - *i.e. evidence and citations for the given resistance and resilience scores:*											
			A change in Folk class from sand to either mud, gravel, or mixed sediment would constitute a major change in the characterising feature of this habitat. Replacing the sand of this environment with another soft substrate would likely dramatically change the habitat and any associated species. As a permanent change to the substrate, resistance and resilience are assessed as '**None'** and '**Very low'**, giving a '**High'** sensitivity.											
	Abrasion/ disturbance of the substrate on the surface of the seabed	Damage to seabed surface features (species and habitats)	**H**	M	M	H	**H**	H	M	H	**NS**	M	M	H
			Evidence base - *i.e. evidence and citations for the given resistance and resilience scores:*											
			Caulerpa sp. appear to experience increases in population when exposed to surface abrasion. The ability to reproduce asexually by fragmentation resulted in an increase in the spread of *Caulerpa taxifolia* in the Ligurian Sea, where the algae is caught as bycatch during bottom trawling and fragments are distributed across the trawl path (Relini *et al.* 2000). Similarly, invasive *Caulerpa ramosa* in the Mediterranean Sea was recorded in greater densities in trawled areas than untrawled sites (Kiparissis *et al.* 2011).											

<table>
<tr><th rowspan="2">Pressure Theme</th><th rowspan="2">Pressure</th><th rowspan="2">Revised Benchmark</th><th colspan="12">Sensitivity Assessment</th></tr>
<tr><th>Resistance</th><th colspan="3">Confidence Assessment</th><th>Resilience</th><th colspan="3">Confidence Assessment</th><th>Sensitivity</th><th colspan="3">Confidence Assessment</th></tr>
<tr><th></th><th></th><th></th><th></th><th>QoE</th><th>AoE</th><th>DoC</th><th></th><th>QoE</th><th>AoE</th><th>DoC</th><th></th><th>QoE</th><th>AoE</th><th>DoC</th></tr>
<tr><td rowspan="7"></td><td></td><td></td><td colspan="12">Experimental disturbance of Halimdea kanaloana meadows in Hawaii recorded the recovery of plants which were cut, but the holdfast remained intact, or when the entire plant was removed. The cut meadows recovered canopy height and densities equal to the control within 110 days and 327 days respectively. Treatments where the entire plant was removed (excavating around 5–10 cm into the sediment) took longer to recover, with 327 days for both density and canopy height to reach that of the control. There were no significant differences between the densities of all three treatments after 606 days (Spalding 2012). This study also observed a nearby area of the same Halimeda kanaloana meadow which was impacted by an anchor. This area took 734 days to recover to pre-disturbance conditions where there was no discernible difference to the surrounding undisturbed area.
Sensitivity assessment
The available evidence for Caulerpa and Halimeda indicates that trawling can increase abundance by stimulating propagation by fragmentation and spreading those fragments across trawl paths. Reductions to Halimeda abundance by experimental disturbance or anchor scars had recovered in less than two years. Resistance and recovery are therefore both assessed as ‘High’, and the habitat is considered ‘Not sensitive’ at the pressure benchmark.</td></tr>
<tr><td rowspan="3">Penetration and/or disturbance of the substrate below the surface of the seabed, including abrasion</td><td rowspan="3">Damage to sub-surface seabed</td><td>H</td><td>M</td><td>M</td><td>H</td><td>H</td><td>H</td><td>M</td><td>H</td><td>NS</td><td>M</td><td>M</td><td>H</td></tr>
<tr><td colspan="12">Evidence base - i.e. evidence and citations for the given resistance and resilience scores:</td></tr>
<tr><td colspan="12">See above for evidence for abrasion.</td></tr>
<tr><td rowspan="3">Smothering and siltation changes (depth of vertical sediment overburden)</td><td rowspan="3">‘Light’ deposition of up to 5 cm of fine material added to the seabed in a single, discrete event</td><td>M</td><td>H</td><td>M</td><td>H</td><td>H</td><td>H</td><td>M</td><td>H</td><td>L</td><td>H</td><td>M</td><td>H</td></tr>
<tr><td colspan="12">Evidence base - i.e. evidence and citations for the given resistance and resilience scores:</td></tr>
<tr><td colspan="12">Laboratory experiments on samples of Caulerpa taxifolia observed that 35% of samples buried in 5 cm of sediment for 17 days survived and then recovered once the sediment was removed (Glasby et al. 2005). In situ observations and experimentation on Caulerpa sp. in the US Virgin Islands by Williams et al. (1985) recorded that while sedimentation decreased growth, plants were often able to survive single or daily (for six days) additions of 250 cm^3 (369 g dry) sediment with only 6% and 7% of plants dying in the treatments when sediment was applied once or daily respectively.
In situ experiments on Caulerpa racemosa in the Mediterranean found that in addition to the natural rate of sediment deposition</td></tr>
</table>

<table>
<tr><th rowspan="3">Pressure Theme</th><th rowspan="3">Pressure</th><th rowspan="3">Revised Benchmark</th><th colspan="12">Sensitivity Assessment</th></tr>
<tr><th rowspan="2">Resistance</th><th colspan="3">Confidence Assessment</th><th rowspan="2">Resilience</th><th colspan="3">Confidence Assessment</th><th rowspan="2">Sensitivity</th><th colspan="3">Confidence Assessment</th></tr>
<tr><th>QoE</th><th>AoE</th><th>DoC</th><th>QoE</th><th>AoE</th><th>DoC</th><th>QoE</th><th>AoE</th><th>DoC</th></tr>
<tr><td rowspan="4"></td><td rowspan="4"></td><td></td><td colspan="12">(between 3.1–52.4 g/m^2/day depending on time of year), 200 g/m^2/day of sediment added on 10 occasions over a 14 month period caused no significant differences in the percentage cover of Caulerpa racemosa between control and experimental sites (Piazzi et al. 2005).

A study on Halimeda sp. in situ in the Florida Quays looked at the survivability of algal fragments after 14 weeks (Walters et al. 2002). At one site at 7 m depth, fragments were buried under 20.7 ± 2.4 mm of accumulated sediment. Of these, 33.3% of Halimeda opuntia fragments (8 mm in size) and 20% of Halimeda goreaui fragments (12 mm in size) regained pigment and had new rhizoids once the sediment was removed. However, Halimeda tuna fragments did not show recovery of rhizoids, with only 13.3% (4 mm in size) regaining pigment. A different site at 21 m depth accumulated 5.8 ± 0.2 mm sand and, here, a greater percentage of the same sized fragments regained pigmentation and grew rhizoids: 93.3 and 40% for Halimeda opuntia and Halimeda goreaui respectively, with Halimeda tuna regaining 13.3% (Walters et al. 2002).

Sensitivity assessment

The evidence for Halimeda sp. and Caulerpa sp. focuses on the effects of sedimentation on algal fragments with little evidence of impacts on adults. However, if the smaller fragments can withstand this pressure, it is likely that larger plants will be able to do so. Effects at the benchmark level were not available for both genera, however at lower levels (2 cm and 0.5 cm) within the Halimeda genus, the effect appears to vary within species (Walters et al. 2002). At the benchmark level (5 cm), Caulerpa sp. plants were found to be largely resistant to sedimentation (Williams et al. 1985). Resistance is therefore assessed as ‘Medium’, resilience is ‘High’, and overall sensitivity is ‘Low’.</td></tr>
<tr><td rowspan="3">‘Heavy’ deposition of up to 30 cm of fine material added to the seabed in a single discrete event</td><td>M</td><td>M</td><td>M</td><td>H</td><td>H</td><td>H</td><td>M</td><td>H</td><td>L</td><td>M</td><td>M</td><td>H</td></tr>
<tr><td colspan="12">Evidence base - i.e. evidence and citations for the given resistance and resilience scores:</td></tr>
<tr><td colspan="12">Effects of siltation at the benchmark level of 30 cm were limited within the literature. However, in situ observations and experimentation on Caulerpa sp. in the US Virgin Islands by Williams et al. (1985) recorded that while sedimentation decreased growth, plants were often able to survive single or daily (for six days) additions of 250 cm^3 (369 g dry) sediment with only 6% and 7% of plants dying in the treatments when sediment was applied once or daily respectively.

In situ experiments on Caulerpa racemosa in the Mediterranean found that in addition to the natural rate of sediment deposition (between 3.1–52.4 g/m^2/day depending on time of year), 200 g/m^2/day of sediment added on 10 occasions over a 14 month</td></tr>
</table>

Pressure Theme	Pressure	Revised Benchmark	Sensitivity Assessment											
			Resistance	Confidence Assessment			Resilience	Confidence Assessment			Sensitivity	Confidence Assessment		
				QoE	AoE	DoC		QoE	AoE	DoC		QoE	AoE	DoC
			period caused no significant differences in the percentage cover between control and experimental sites (Piazzi *et al.* 2005). Evidence on *Halimeda* sp. was only found at the lower benchmark level (see above). **Sensitivity assessment** Assuming similar responses to both light and heavy deposition levels, resistance is assessed as '**Medium'**, resilience is '**High'**, and overall sensitivity is '**Low'**.											
Pollution and other chemical changes	Organic enrichment	Total Organic Carbon (TOC) greater than 1.67 mg/L	**H**	H	L	M	**H**	H	M	H	**NS**	H	L	M
			Evidence base - *i.e. evidence and citations for the given resistance and resilience scores:*											
			There is limited evidence of the effects of organic enrichment of the characterising species of this habitat. After a Sargassum brown tide event, where large quantities of Sargassum seaweed decomposed in nearshore environments in Mexico, the abundance of seagrass decreased while the densities of *Halimeda wrightii* and *Caulerpa* sp. increased (van Tussenbroek *et al.* 2017). The Sargassusm brown tide event caused an increase in organic carbon, but also caused a number of related pressures such as decrease in illuminance, decreased dissolved oxygen and decreased pH. As such, the increase in *Halimeda wrightii* and *Caulerpa* spp. could not be solely attributed to an increase in organic carbon. It does, however, suggest that they can survive in areas with an increased organic carbon content. In a study by Brocke *et al.* (2015), benthic cyanobacterial mats (BCMs) were found to grow faster when seeded onto sediment enriched with organic matter. The *in situ* experiment on reefs on Curacao observed that when sediment was enriched with an additional 0.7 ± 0.2 SEM % C_{org} of sediment dry weight, BCM growth was significantly increased (Brocke *et al.* 2015). **Sensitivity assessment** This habitat is characterised by a sparse cover of macroalga and cyanobacteria species. There is limited evidence of any impacts on these species and the little evidence available indicates that additional organic matter is beneficial for growth. Resistance and resilience are both therefore assessed as '**High'**, and overall, the habitat is '**Not sensitive'** to this pressure.											
Biological pressures	Introduction of microbial pathogens	The introduction of relevant microbial pathogens or metazoan disease vectors to an	**NEv**	NR	NR	NR	**NEv**	NR	NR	NR	**NEv**	NR	NR	NR
			Evidence base - *i.e. evidence and citations for the given resistance and resilience scores:*											
			No Evidence was available for this pressure											

Pressure Theme	Pressure	Revised Benchmark	Sensitivity Assessment											
			Resistance	Confidence Assessment			Resilience	Confidence Assessment			Sensitivity	Confidence Assessment		
				QoE	AoE	DoC		QoE	AoE	DoC		QoE	AoE	DoC
		area where they are currently not present (e.g. *Martelia refringens* and Bonamia, Avian influenza virus, Haemorrhagic Septicaemia virus).												

References

Adames, V.M.C. & Ballantine, D.L. (1996). *Asexual Reproduction in* Laurencia poiteaui *(Rhodomelaceae, Rhodophyta)*. *39*(1–6), 75–78. https://doi.org/10.1515/botm.1996.39.1-6.75

Brocke, H.J., Polerecky, L., de Beer, D., Weber, M., Claudet, J. & Nugues, M.M. (2015). Organic Matter Degradation Drives Benthic Cyanobacterial Mat Abundance on Caribbean Coral Reefs. *PLOS ONE*, *10*(5), e0125445. https://doi.org/10.1371/journal.pone.0125445

Cissell, E.C., Manning, J.C. & McCoy, S.J. (2019). Consumption of benthic cyanobacterial mats on a Caribbean coral reef. *Scientific Reports*, *9*(1), 12693. https://doi.org/10.1038/s41598-019-49126-9

Glasby, T.M., Gibson, P.T. & Kay, S. (2005). Tolerance of the invasive marine alga *Caulerpa taxifolia* to burial by sediment. *Aquatic Botany*, *82*(2), 71–81. https://doi.org/10.1016/j.aquabot.2005.02.004

Herren, L.W., Walters, L.J. & Beach, K.S. (2013). Fragment production and recruitment ecology of the red alga *Laurencia poiteaui* in Florida Bay, USA. *Journal of Experimental Marine Biology and Ecology*, *440*, 192–199. https://doi.org/10.1016/j.jembe.2013.01.001

Josselyn, M.N. (1977). Seasonal changes in the distribution and growth of *Laurencia poitei* (rhodophyceae, ceramiales) in a subtropical lagoon. *Aquatic Botany*, *3*, 217–229. https://doi.org/10.1016/0304-3770(77)90024-9

Kiparissis, S., Fakiris, E., Papatheodorou, G., Geraga, M., Kornaros, M., Kapareliotis, A. & Ferentinos, G. (2011). Illegal trawling and induced invasive algal spread as collaborative factors in a *Posidonia oceanica* meadow degradation. *Biological Invasions*, *13*(3), 669–678. https://doi.org/10.1007/s10530-010-9858-9

Lapointe, B.E. & Bedford, B.J. (2010). Ecology and nutrition of invasive *Caulerpa brachypus* f. Parvifolia blooms on coral reefs off southeast Florida, U.S.A. *Harmful Algae*, *9*(1), 1–12. https://doi.org/10.1016/j.hal.2009.06.001

Phillips, J.A. (2009). Reproductive ecology of *Caulerpa taxifolia* (Caulerpaceae, Bryopsidales) in subtropical eastern Australia. *European Journal of Phycology*, *44*(1), 81–88. https://doi.org/10.1080/09670260802343640

Piazzi, L., Balata, D., Ceccherelli, G. & Cinelli, F. (2001). Comparative study of the growth of the two co-occurring introduced green algae *Caulerpa taxifolia* and *Caulerpa racemosa* along the Tuscan coast (Italy, western Mediterranean). *Cryptogamie Algologie*, *22*(4), 459–466.

Piazzi, L., Balata, D., Ceccherelli, G. & Cinelli, F. (2005). Interactive effect of sedimentation and *Caulerpa racemosa* var. Cylindracea invasion on macroalgal assemblages in the Mediterranean Sea. *Estuarine, Coastal and Shelf Science*, *64*(2), 467–474. https://doi.org/10.1016/j.ecss.2005.03.010

Relini, G., Relini, M. & Torchia, G. (2000). The role of fishing gear in the spreading of allochthonous species: The case of *Caulerpa taxifolia* in the Ligurian sea. *ICES Journal of Marine Science*, *57*(5), 1421–1427.

Spalding, H. L. (2012). *Ecology of mesophotic macroalgae and* Halimeda kanaloana *meadows in the main Hawaiian islands* [Thesis, [Honolulu]: [University of Hawaii at Manoa], [August 2012]]. http://scholarspace.manoa.hawaii.edu/handle/10125/101030

Teichberg, M., Fricke, A. & Bischof, K. (2013). Increased physiological performance of the calcifying green macroalga *Halimeda opuntia* in response to experimental nutrient enrichment on a Caribbean coral reef. *Aquatic Botany*, *104*, 25–33. https://doi.org/10.1016/j.aquabot.2012.09.010

van Tussenbroek, B.I., Hernández Arana, H.A., Rodríguez-Martínez, R.E., Espinoza-Avalos, J., Canizales-Flores, H.M., González-Godoy, C.E., Barba-Santos, M.G., Vega-Zepeda, A. & Collado-Vides, L. (2017). Severe impacts of brown tides caused by *Sargassum* spp. On near-shore Caribbean seagrass communities. *Marine Pollution Bulletin*, *122*(1), 272–281. https://doi.org/10.1016/j.marpolbul.2017.06.057

Vroom, P.S., Smith, C.M., Coyer, J.A., Walters, L.J., Hunter, C.L., Beach, K.S. & Smith, J. E. (2003). Field biology of Halimeda tuna (Bryopsidales, Chlorophyta) across a depth gradient: Comparative growth, survivorship, recruitment, and reproduction. *Hydrobiologia*, *501*(1), 149–166. https://doi.org/10.1023/A:1026287816324

Walters, L. J., Smith, C. M., Coyer, J. A., Hunter, C. L., Beach, K. S., & Vroom, P.S. (2002). Asexual propagation in the coral reef macroalga *Halimeda* (Chlorophyta, Bryopsidales): Production, dispersal and attachment of small fragments. *Journal of Experimental Marine Biology and Ecology*, *278*(1), 47–65. https://doi.org/10.1016/S0022-0981(02)00335-0

Williams, S.L., Breda, V.A., Anderson, T.W. & Nyden, B.B. (1985). Growth and sediment disturbances of *Caulerpa* spp. (Chlorophyta) in a submarine canyon. *Marine Ecology Progress Series*, *21*(3), 275–281.