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 4: Sensitivity Assessment for the Turks and Caicos Islands seagrass habitats

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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 4. Sensitivity Assessment for Turks and Caicos Islands seagrass 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

Seagrass

Description (taken from The Nature Conservancy benthic class description)

Found in shallow lagoons or relatively sheltered zones at a depth of 2–10m, characterized by a low relief, sand substrate with dense living community cover (greater than 50% cover). Living cover is dominated by a mix of seagrass species: *Thalassia testudinum, Syringodium filiforme, Halodule wrightii* and *Halophila decipiens*; and commonly associated with green algae genera: *Ulva spp*., *Chaetomorpha spp, Caulerpa* and *Avrainvillea* or some coral rubble habitat. There may also be some brown algae (e.g. benthic *Sargassum spp., Dictyota spp*.).

Sensitivity characteristics/ features

Seagrass communities serve as habitats for a wide range of organisms, and provide food for species such as parrotfish, surgeonfish, queen conch, sea urchins and green turtles. The seagrass leaves carry epiphytic algae and animals, which are grazed by invertebrates and fish (Kennedy & Björk 2009). The seagrass blades also enhance sedimentation and reduce erosion by slowing down waves and currents, while the roots and rhizomes bind and stabilise the sediment surface. The meadows play a vital role in the marine food chain as a result of the high rate at which they convert carbon dioxide dissolved in the water into organic matter, through the process of photosynthesis (high net productivity) (Duarte *et al.* 2010). Seagrass habitats also act as a nursery for the young of many commercial species of fish, crustaceans and molluscs (Heck Jr. *et al*. 2003). In TCI, Nassau Grouper, Tiger shark and Barracuda have been observed foraging on the abundant small fish and invertebrates present in seagrass. Although a wide range of species are associated with seagrass beds, these species occur in a range of other biotopes and were therefore not considered by to characterise the sensitivity of this biotope.

Accounting for the health of seagrass meadows, three species were recorded throughout TCI: *Thalassia testudinum*, *Syringodium filiforme* and *Halodule wrightii*. Meadows are spatially expansive, occupying a high proportion of the shallow waters of the Caicos Bank with average cover of 40% (Baker *et al*. 2015). Lagoon sites on the West Coast of South Caicos have low seagrass cover (~ 9%) likely due to the shallow nature high sediment composition. Reef seagrass meadows are dominated by *Thalassia* and lagoon seagrasses dominated by *Halodule wrightii*. Seagrass meadows in TCI (e.g. South Caicos and Leeward marina) were found to have declined as a result of tourism development (Zuidema *et al.* 2011). Dredging for shipping channels, marinas and cruise liner ports, hotel construction and nutrient run-off from hotel landscaping are key stressors. Baker *et al.* (2015) also reported that there is extensive seagrass burning throughout the TCI suggesting climate related impacts.

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 component species, or species of interest).	Assessment based on the same pressures acting on the same type of feature (habitat, its component species, or species of interest) in the UK.	Agree on the direction and magnitude (of impact or recovery).
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

Generally, seagrass species are fast-growing and relatively short-lived but can take a significant amount of time to recover from damaging events (d'Avack *et al.* 2014). The response of seagrasses to pressures depends on the magnitude or duration of exposure pressure and the nature of the environments and is different for every seagrass population.

Seagrasses are marine submerged angiosperms that reproduce sexually via pollination of flowers and resultant sexual seed but can also reproduce and colonise sediment asexually via rhizomes. Seagrass species use pollen, seed, floating reproductive structures, and biotic vectors such as wildfowl, fish and turtles, to disperse and colonise new areas (Kendall *et al.* 2004; Tol *et al.* 2017; van Tussenbroek & Muhlia-Montero 2013). Once established, seagrass meadows can expand through vegetative (clonal) growth by rhizome extensions. Vegetative growth from adjacent perennial seagrass beds is the most significant factor for the recovery of damaged seagrass beds, whereas sexual production and seeds are more important for recruitment (Boese *et al*. 2009). Genetic analysis has revealed that long-distance dispersal of floating fruits (up to 400 km) maintains high connectivity and high genetic diversity of the seagrass populations across the Caribbean (Bijak *et al*. 2018; van Dijk *et al.* 2018). Because of their extensive below ground roots and rhizomes, seagrasses have among the highest light requirements of all plants, requiring 10–30% of full surface-incident sunlight (Duarte *et al.* 1997). In the Caribbean, the reproductive season usually starts in late winter to early spring, when small floral buds are formed. Male and female flowers emerge almost simultaneously during late April and May, and the fruits reach maturity during August-September. Mature fruits emerge above the sediment and their green colour indicate that they are photosynthetic.

T.testudinum consist of horizontal rhizomes that branch at regular intervals and erect short shoots (vertical rhizomes) bearing foliage leaves and roots. Leaf growth of *T. testudinum* exhibit a seasonal pattern with monthly production ranged from 8 to 95 g dry weight m^{-2} mo^{-1}, equivalent to 614 g dry weight m^{-2} mo^{-1}. Rhizome growth is also seasonal, and areal below-ground production range between 14 and 40 g dry weight m^{-2} mo^{-1}, equivalent to 339 g dry weight m^{-2} mo^{-1} (Kaldy & Dunton 2000). On an annual basis, rhizome production account for 10–35% of total plant production (Gallegos *et al.* 1993). Naturally, seasonal leaf and rhizome growth patterns are highly correlated with underwater irradiance, daylength and temperature. Below-ground tissues account for 80 to 90% of the total plant biomass (Kaldy & Dunton 2000). Seasonal fluctuations in environmental parameters are the primary factors controlling seagrass growth rates and production.

Thalassia testudinum maintains its vertical meristem near the sediment surface, to the extent that sediment accretion leads to increased vertical stem growth (Marbà *et al.* 1994). Sediment erosion has a negative relationship with vertical stem growth and overall plant survival. Approximately 90% of *T. testudinum* fruits dehisce (burst open) when still attached to the mother plant with seeds dispersing one to several meters.

Syringodium filiforme has highly differentiated rhizome structure and a relatively fast horizontal and vertical growth compared to other seagrass species in the Caribbean. *S. filiforme* meadows stabilise sediment and initiate the formation of elevated mudbanks, providing protection for coral reefs (Kenworthy & Schwarzschild 1998). *S. filiforme* short-shoots produce approximately nine leaves per short-shoot per year. The internodes on the vertical stems of individual short-shoots ranged in size from 0.1 to 7.5 cm with an average internode lengths measured at 2.09 ± 0.05 cm. The average vertical stem growth is 28.7 ± 1.3 cm per year during the first year of growth and drops to ~ 17 cm per year during the second year (Kenworthy & Schwarzschild 1998). New leaves are formed every 40–60 days (Gallegos *et al.* 1994; Kenworthy & Schwarzschild 1998). Unlike *Thalassia testudinum* and *Halodule wrightii* short-shoots, which produce distinct flowering stalks branching from the main vertical axis, entire *S. filiforme* short-shoots transform from vegetative short-shoots to sexual flowering short shoots. Unbranched short-shoots which flower have been observed to die soon after release of pollen or after the seeds dropped. *Syringodium filiforme* seeds are oriented towards short-term dormancy with germinations occuring in the salinity range of 20–50‰ (McMillan 1981).

Halodule wrightii is the smallest and fastest growing seagrass species found in TCI and is considered a pioneer species taking over the community after disturbance events. Rhizome growth rates for the species were 2- to 4-fold greater than those of *Thalassia testudinum* (Gallegos *et al*. 1994). *H. wrightii* does not have highly differentiated meristems and grow on small prostrate stems elevated only 3 to 5 cm above the sediment surface. The lack of differentiated meristems does not necessarily constrain vertical growth. The average shoot life expectancy was estimated to be three months and the leaf turnover as 8.5 yr^{-1}. The leaf growth is about twice as fast as rhizome turnover (Gallegos *et al*. 1994). *Halodule* seeds are suited to long-term dormancy (years) and germination occurs in the salinity range 5–50‰ (McMillan 1981).

Resilience assessment

The local environmental (water currents, exposure, temperature, etc.) conditions, growth rates, seed supply, population homogeneity and connectivity are all important factors that will influence the resilience of seagrass beds and their ability to recover from anthropogenic pressures. Changes in community structure of mixed meadows after disturbance can impact not only the resilience of individual seagrass species but the overall community as well. An expansion of smaller and faster growing seagrass species like *Halodule wrightii* and *Halophila stipulacea* over larger and more robust species like *Thalassia* and *Syringodium,* for example, can increase the vulnerability of meadows to disturbances and prolong recovery (Williams 1987, 1988). The removal of seagrass plants can induce a negative feedback loop inhibiting recovery. The removal of plants can cause loss of organic nutrients and chronic turbidity due to continual resuspension of unconsolidated sediments, which in turns reduces the light availability necessary for photosynthesis and growth. Recovery of seagrass beds may not occur at all when the water quality conditions remain poor for a prolonged time (Erftemeijer & Robin Lewis 2006). Fragmentation of existing meadows may also increase their vulnerability to further disturbance (Cunha & Santos 2009; Fonseca & Bell 1998). Considering all of this, recovery may take several decades. Therefore, where resistance is assessed as ‘Medium’ or ‘Low’, resilience is probably **‘Medium’** and where resistance is ‘None’, resilience is probably **‘Very low’**, depending on the effects of the pressure on the habitat.

The confidences associated with the resilience scores are ‘High’ for Quality of Evidence (QoE), ‘High’ for Applicability of Evidence (AoE) and ‘Medium’ 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	H	H	**H**	H	H	H
			Evidence base - *i.e. evidence and citations for the given resistance and resilience scores:*											
			Thalassia testudinum and *Syringodium filiforme* are obligate marine species, while *Halodule wrightii* is more freshwater tolerant seagrass and often can be found in lower estuarine environments (Ridler *et al.* 2006). Seagrasses thrive in salinities between 22–35‰ and are able to survive salinities below 17‰ only for a short period of time (Lirman & Cropper 2003; Thorhaug *et al*. 2006). Therefore, resistance to permanent loss of existing saline habitat is ‘**None**’. Recovery from the pressure’s benchmark is unlikely, resulting in ‘**Very Low’** resilience. The overall sensitivity to this pressure is therefore ‘**High**’. Although no specific evidence is described from the TCI, confidence in this pressure is ‘High’ due to the inconvertible nature to this pressure.											
	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	H	H	**H**	H	H	H
			Evidence base - *i.e. evidence and citations for the given resistance and resilience scores:*											
			A change from sediment to hard rock will result in a permanent loss of suitable habitat for seagrass species. Resistance is thus assessed as ‘**None**’. As this pressure represents a permanent change, recovery will not occur due to lacking suitable substratum for seagrasses. Therefore, resilience is assessed as ‘**Very Low**’ and the overall sensitivity as ‘**High**’. Although no specific evidence is described, confidence in this assessment is ‘High’, due to the inconvertible nature of this pressure.											
		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	H	H	**H**	H	H	H
			Evidence base - *i.e. evidence and citations for the given resistance and resilience scores:*											
			Seagrass beds occur almost exclusively in sandy and muddy substrates. Coarser sediments reduce the vegetative spreading of seagrasses and inhibit seedling colonization (Gray & Elliot 2009). A change towards a coarser sediment type would inhibit seagrasses from becoming established due to a lack of adequate anchoring substratum. Similarly, a change towards more mud dominated habitat, will cause an increased sediment re-suspension and exclude seagrasses due to unfavourable light conditions. **Sensitivity assessment.** The resistance was assessed as ‘**Low**’. As this pressure represents a permanent change, recovery will not occur without intervention due to lacking suitable substratum for seagrasses. Therefore, resilience is assessed as ‘**Very low’** and the overall sensitivity as ‘**High**’. Although no specific											

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
			evidence is described, confidence in this assessment is 'High', due to the incontrovertible nature of this pressure.											
	Abrasion/ disturbance of the substrate on the surface of the seabed	Damage to seabed surface features (species and habitats)	**L**	H	M	H	**M**	H	H	M	**M**	H	M	M
			Evidence base - *i.e. evidence and citations for the given resistance and resilience scores:*											
			Seagrasses are not physically robust due to their leaves and stems rising above the surface and the roots being shallowly buried. This makes them vulnerable to surface abrasion. Activities such as trampling, anchoring, power boating, dredging for shipping channels, marinas and cruise liner ports and potting are likely to remove leaves and damage rhizomes. The removal of above-ground biomass would result in a loss of productivity, whilst the removal of roots would cause the death of plants. Seagrasses are limited to shallow, sheltered waters and soft sediments, areas often open to public access and widely used in commercial and recreational activities. Boating activities: the physical impact of the engine's propellers, shearing of leaves and cutting into the bottom can have damaging effect on seagrass communities. In severe cases, propellers cutting into the bottom may completely denude an area resulting in narrow dredged channels through the vegetation called propeller scars. Scars might expand and merge to form larger denuded areas. A study in Florida looking at the seagrasses *T. testudinum*, *Syringodium filiforme* and *Halodule wrightii* determined that recovery of seagrass to propeller impact depends on the species (Kenworthy *et al.* 2002). *S. filifrome* recovered within 1.4 years, *H. wrightii* within 1.7 years, and the recovery of *T. testudinum* was estimated to require 9.5 years. Variations in recovery time were explained by different growth rates. Furthermore, Hammerstrom *et al.* (2007) examined the impact of boat-induced damage on *T. testudinum* and *S. filiforme* dominated seagrass communities in Marathon Key, Florida. Sediment excavation disturbances that exceeded 10 cm in depth were found to have a significant effect on short-shoot counts of *T. testudinum* and *S. filiforme*. In the deepest excavations (40 cm), *T. testudinum* short-shoot counts were significantly reduced for up to 2 years but shoot density increased to control levels between the second- and third years following disturbance. The response of *S. filiforme* to experimental dredging caused by boat propellers was different from the response of *T. testudinum*. *S. filiforme* has faster growing rates than *T. testudinum* which can lead to short term competitive advantage in areas where all seagrass above and below ground biomass was removed – *S. filiforme* shoot densities exceeded those of surrounding undisturbed bed by 4- to 10-fold within two years after the disturbance event. Bourque *et al.* (2015) assessed the disturbance effects of vessel grounding (mean depth of disturbance of 0.5 m) on seagrass											

<table>
<tr><th>Pressure Theme</th><th>Pressure</th><th>Revised Benchmark</th><th colspan="12">Sensitivity Assessment</th></tr>
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<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></td><td></td><td colspan="12">communities in southern Biscayne Bay, Florida which are dominated by dense <i>T. testudinum</i> and lower abundance of <i>S. filiforme</i> and <i>H. wrightii</i>. Initial effects included loss of above ground cover of seagrass and below ground removal of rhizome and root biomass. Seagrass cover in disturbed sites was three to four times lower than in reference meadows in the first year after disturbance and remained lower even after five years after disturbance. Furthermore, it was observed that in disturbed sites, there was a long-term change in sediment properties, organic content and porewater nutrients which did not return to reference levels within five years. The slow recovery of seagrass meadows was attributed to disruption of nutrients caused by the loss of plant cover which in turn led to loss of organic matter from surficial sediments (Bourque <i>et al.</i> 2015).
Sensitivity assessment: The resilience and recovery of seagrass beds to abrasion of the seabed surface depends on the frequency, persistence and extent of disturbance, and the seagrass species. Factors such as the size and shape of the impact will also influence the sensitivity of seagrass to this pressure. Overall, studies suggest little resistance to abrasion resulting in ‘Low’ resistance. Physical disturbance and removal of plants can lead to increased patchiness and destabilisation of the seagrass bed, which in turn can lead to reduced sedimentation within the seagrass bed, increased erosion, and loss of larger areas of plants. Recovery will, however, be fairly rapid resulting in ‘Medium’ resilience. Overall, this biotope, therefore, has a ‘Medium’ sensitivity to this pressure.</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>L</td><td>H</td><td>M</td><td>H</td><td>M</td><td>H</td><td>H</td><td>M</td><td>M</td><td>H</td><td>M</td><td>M</td></tr>
<tr><td colspan="12">Evidence base - <i>i.e. evidence and citations for the given resistance and resilience scores:</i></td></tr>
<tr><td colspan="12">See above evidence for surface abrasion.</td></tr>
<tr><td rowspan="3"></td><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>L</td><td>H</td><td>M</td><td>M</td><td>M</td><td>H</td><td>H</td><td>M</td><td>M</td><td>H</td><td>M</td><td>M</td></tr>
<tr><td colspan="12">Evidence base - <i>i.e. evidence and citations for the given resistance and resilience scores:</i></td></tr>
<tr><td colspan="12">Seagrasses are vulnerable to burial under sediment caused by coastal development, bioturbation, and tropical storms. Excessive sedimentation can cause serious deterioration of seagrass meadows, but the consequences depend on several factors such as the species, life history stage as well as depth and timing of burial.
Early life stages of seagrass, smaller in size than adult plants, are most vulnerable to this pressure as even a small load of added</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
			sediment will lead to complete burial. Cabaço *et al.* (2008) studied the response of 15 seagrass species to the effect of sediment burial and reported that the burial threshold for 50% mortality ranged from 2 cm to 19 cm but most species experienced 50% mortality within the 2–4 cm range. *Syringodium filiforme* showed 80% mortality under low burial levels of 4–5 cm and reached 100% mortality (total shoot loss) under 10 cm. For *Thalassia testudinum*, on the other hand, the 50% mortality threshold was reached at 5 cm and total shoot loss did not occur even at 10 cm burial. Overall, the authors concluded that the capacity of seagrass species to withstand sediment burial was strongly size-dependent and mortality was significantly related to the shoot mass, the rhizome diameter, the above ground biomass, the horizontal elongation rate, and the size of leaves. Large species, with high shoot mass, high above ground biomass, thick rhizomes, low horizontal rhizome elongation rates and long leaves, have a greater capacity to withstand sediment burial (Cabaço *et al.* 2008). In a mixed Philippine seagrass meadows, Duarte *et al.* (1997) studied the response of *Thalassia hemprichii*, *Halodule uninervis* and *Syringodium isoetifolium* to an experimental sediment loading (2:1 mixture of sand and mud) of 2, 4, 8 and 16 cm after 2, 4, and 10 months following disturbance. *T. hemprichii* showed a sharp decline in shoot density even at moderate burial treatments, whereas *S. isoetifolium* and *H. uninervis* showed an initial decline followed by recovery. *T.hemprichii* revealed a rapid response to burial through increased internodal length which was maintained over 8 months following the disturbance. In addition, burial had a more pronounced negative effect on young (less than 1 year) *T. hemprichii* shoots with a tendency towards a selective loss. However, there was increase in recruitment of young *S. isoetifolium* and *H. uninervis* shoots and a more complex age-dependent response to burial. Furthermore, the mortality of *T. hempechii* created large gaps in the canopy of the mixed seagrass community which increased in size with increasing burial. Small, fast-growing species such as *Halophila ovalis* and *H. uninervis* were able to increase densities in the high-burial treatment 4- to 5-fold more so than in the control treatment (no burial) suggesting that inter-specific competition controls the shaping of the mixed communities. Although the species in this study were not the same found in TCI, the impact of sediment burial can be expected to have similar effects on the mixed seagrass communities in TCI. **Sensitivity assessment**. The presented evidence suggests that the characterising seagrass species in this biotope would experience high initial mortality and biomass loss at the level of the benchmark (5 cm of added material). Therefore, resistance is assessed as '**Low**'. Some seagrass species have better chances of recovery and individual plants will successfully relocate rhizomes vertically closer to the sediment surface. With the benchmark set at 'material added to the seabed in a single event', the sensitivity will be greater if burial occurred in a continuous way. In areas, where											

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
			seagrass meadows are restricted to low energy environments, it is very likely that once deposited, the sediment will remain in place for a long period of time so habitat conditions will not reduce exposure. Resilience is therefore assessed as ‘**Medium**’ and overall sensitivity as ‘**Medium**’.											
		‘Heavy’ deposition of up to 30 cm of fine material added to the seabed in a single discrete event	**L**	H	M	M	**M**	H	H	M	**M**	H	M	M
			Evidence base - *i.e. evidence and citations for the given resistance and resilience scores:*											
			In addition to the information provided above for ‘light’ smothering and siltation, hurricane disturbances are common in the region and probably the most destructive single burial event that can affect a coastal seagrass population in the region. Hurricanes can cause extensive damage to seagrass meadows through heavy sediment deposition and burial, erosion of sediments and loss of seagrass above- and below-ground biomass caused by high winds, strong currents or wave energy, and changes in water quality resulting from excessive rainfall and turbid freshwater run-off. In Puerto Morelos coral reef lagoon, Mexico, Hurricane Gilbert (1988) caused *Thalassia testudinum* plants to disappear from the seagrass communities in the mid-lagoon and coastal sides of the lagoon, while *T. testudinum* populations at back-reef areas of the lagoon were not affected in terms of vegetative growth (van Tussenbroek 1994). The passage of Hurricane Georges in 1998 (category 4) caused an immediate loss of 3% of the density of *T. testudinum* and 19% of the *S. filiforme* in the back reef environment of the Florida Keys. In some places of the studied areas, sediment burial was the main cause for seagrass loss resulting in complete loss of *T. testudinum* cover. In areas that had little to moderate sediment deposition, remnant patches of *T. testudinum* were slowly expanding and their abundance recovered within 1 year, whilst areas buried by 50 cm of sediment had recovered very little during the three years after the storm (Fourqurean & Rutten 2004). **Sensitivity assessment**. Although the smaller seagrasses *Syringodium* and *Halodule* will likely experience 100% mortality at the pressure benchmark, evidence for *Thalassia* suggests that it might be able to withstand some sedimentation burial. Resistance to sedimentation at the pressure benchmark (up to 30 cm of added material) is therefore assessed as ‘**Low’**. Even though larger species such as *Thalassia* sp. and *Syringodium* sp. have a greater capacity to withstand sedimentation burial, full recovery of the biotope at the benchmark is expected to be slow. As this biotope is restricted to a relatively low energy environment, it is very likely that once deposited, the sediment will remain in place for a long period of time so habitat conditions will not reduce exposure, and therefore prolong recovery. Consequently, resilience is assessed as ‘**Medium**’. Sensitivity based on combined resistance and resilience is therefore assessed as ‘**Medium’**.											

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<tr><td rowspan="3">Pollution and other chemical pressures</td><td rowspan="3">Organic enrichment</td><td rowspan="3">Total Organic Carbon (TOC) greater than 1.67 mg/L</td><td>**M**</td><td>H</td><td>M</td><td>M</td><td>**M**</td><td>H</td><td>H</td><td>M</td><td>**M**</td><td>H</td><td>M</td><td>M</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">Organic enrichment may lead to eutrophication with adverse environmental effects including deoxygenation, algal blooms, and changes in community structure due to epiphyte overgrowth and/or light limitation.
Govers *et al.* (2014) studied the effect of eutrophication on seagrass beds with *Thalassia testudinum* and *Syringodium filiforme* on Curacao and Bonaire, Netherlands Antilles. *Thalassia* leaf nutrient concentrations (%N and %P) were commonly elevated (greater than 35% higher) in the close vicinity (0–200 m) of the eutrophication source (e.g. emergency overflow pipe in Piscadera Bay) than in plants further away from the eutrophication source. In contrast to *T. testudinum*, the fast-growing *S. filiforme* did not accumulate nutrients in the eutrophic bay but seem to have used the extra nutrients for growth. Although no specific impact on the seagrass population has been reported, the authors concluded that the seagrasses in the studied areas are under threat of complete disappearance with a further increase of nutrient loads.
Carruthers *et al*. (2005) also reported higher levels of leaf nutrients and chlorophyll-*a* in *T. testudinum* in Bocas del Toro archipelago, Panama, likely as a consequence of large volumes of runoffs from agriculture and land clearing. However, detrimental effect on the seagrass beds was not demonstrated.
Eutrophication stress in Kingston Harbour, Jamaica, was shown to cause lower productivity, turnover and leaf area, shoot density and total seagrass biomass of *T. testudinum* dominated seagrass meadow compared to meadows located in oligotrophic waters (Green & Webber 2003). Oligotrophic sites have favourable conditions for growth, storage and propagation of the meadow, hence the greater biomass and more shoots m^{-2} than at eutrophic sites. In the long term, the authors suggested that continuous eutrophication will lead to a predictable decline in both seagrass biomass and shoot density and therefore, negatively impact the seagrass population.
Unprecedented *Sargassum* spp. bloom was observed from 2011 to 2016 in the Caribbean Sea that resulted in the so called Sargassum-brown-tide (Sbt). van Tussenbroek *et al*. (2017) reported negatively affected seagrass communities along the Mexican Caribbean coastline by Sbt. The authors of the study reported that Sbt caused acute high loads of organic material and increased turbidity which caused a prolonged reduction of illuminance and dissolved oxygen. After the Sbt, the organic matter content of the sediment increased 15 to 35 times and the seagrass *Thalassia testudinum* had increased stable nitrogen isotopes (δ^{15}N) in their tissues. By 2016, a large section of the seagrass meadow</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
			formerly dominated by *T. testudinum*, ~ 5,700 m^2 in size (representing ~47% of the studied meadow) was completely lost and replaced by the algae *Halimeda incrassata*. The seagrass *Halodule wrightii* disappeared completely from this area, while significant reductions were also recorded for the seagrass *S. filiforme.* In almost all sites, the loss of the seagrasses caused 62% to 99.5% reduction of below-ground biomass, from 674.7 to 258.6 in Puerto Morelos site and from 1,236.4 to 6.1 dry g m^{-2} in Mirador Nizuc site, respectively (van Tussenbroek *et al*. 2017). Due to the relatively slow growth rates of *T. testudinum*, the recovery of the near-shore seagrass meadows is expected to be slow and take at least 5–10 years depending on the extent of loss. **Sensitivity assessment**. The organic enrichment of the marine environment increases turbidity and causes the enrichment of the sediment in organic matter and nutrients. In addition, the effects of the organic enrichment may accelerate the shifts in community composition towards fast-growing and less-deep rooting vegetation. If the frequency of periodic disturbances is higher than the time of recovery of the system, then the seagrass community will change permanently with detrimental consequences for coastal stability and other ecosystem services. Evidence suggests that seagrasses have some tolerance to organic enrichment, but significant biomass losses can be expected near sources of organic discharge. No evidence was found addressing the benchmark of this pressure. Therefore, resistance to this pressure is assessed as “**Medium**”, recovery as ‘**Medium**’, and overall sensitivity is assessed as ‘**Medium**’.											
Biological pressures	Introduction of microbial pathogens	The introduction of relevant microbial pathogens or metazoan disease vectors to an area where they are currently not present (e.g. *Martelia refringens* and Bonamia, Avian influenza virus, Haemorrhagic Septicaemia virus).	**L**	H	M	H	**L**	H	H	M	**H**	H	M	M
			Evidence base - *i.e. evidence and citations for the given resistance and resilience scores:*											
			Although specific evidence for microbial pathogens affecting seagrass communities in Turks and Caicos is scant, evidence is available from other areas within the Caribbean. In the tropical and sub-tropical Caribbean and Gulf of Mexico, pathogenic slime mould-like protist *Labyrinthula* spp. cause wasting disease in the seagrass *Thalassia testudinum* (Blakesley *et al.* 2000; Robblee *et al.* 1991). Environmental stressors such as reductions in light availability, climatic anomalies, and eutrophication can increase the susceptibility of *Thalassia testudinum* to infections with *Labyrinthula* (Duffin *et al.* 2020). Rapid and widespread mortality of *T. testudinum* was reported in Florida Bay, USA in the period of 1987–1990 which was partly attributed to wasting disease infection and partly to chronic hypoxia of below-ground *T. testudinum* tissue (Robblee *et al*. 1991). Successful infection is known to suppress plant photochemistry and lead to enhanced lesions (Bishop *et al.* 2017). Maximum photosynthetic rate in *T. testudinum* decreased to below zero when lesions covered 25% or more of the leaf tissue											

<table>
<tr><th>Pressure Theme</th><th>Pressure</th><th>Revised Benchmark</th><th colspan="12">Sensitivity Assessment</th></tr>
<tr><th rowspan="2"></th><th rowspan="2"></th><th rowspan="2"></th><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></td><td></td><td></td><td colspan="12">and respiration rates in infected leaves were up to three times greater that in adjacent unaffected tissue (Durako & Kuss 1994). Evidence for the effects of wasting disease on *Syringodium* spp. and *Halodule* spp. was not found.
Sensitivity assessment. Seagrasses are highly susceptible to microbial pathogens, which can be responsible for significant reductions in seagrass populations by reducing their ability to photosynthesise. The resistance is ‘**Low**’, and the resilience is also assessed as ‘**Low**’. Therefore, the overall sensitivity score is recorded as ‘**High**’.</td></tr>
</table>

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