Seagrass assessment for Pōrangahau Estuary, Hawkes Bay

Prepared for Hawkes Bay Regional Council

October 2018

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NIWA CLIENT REPORT No: 2018301HN
Report date: October 2018
NIWA Project: ELF19205

Quality Assurance Statement		
	Reviewed by:	Mary de Winton
	Formatting checked by:	Alison Bartley
	Approved for release by:	David Roper

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Contents

Tables

Figures

Executive summary

Pōrangahau Estuary, located at the mouth of the Pōrangahau River in southern Hawke's Bay is a nationally significant wildlife area and of great cultural importance to Ngāti Kere. It is a long, narrow estuary occupying about 14 km of the coastline.

In March 2018, Hawke's Bay Regional Council (HBRC) identified several patches of seagrass (*Zostera muelleri*) in the estuary. The last record of seagrass in estuaries within the Region is from the Ahuriri Estuary in 1978 and there are no prior records of seagrass in Pōrangahau Estuary. HBRC sought advice from NIWA to help protect the newly discovered patches of seagrass. In particular, HBRC wished to scope work to identify (1) the drivers behind the degradation of seagrass in this estuary (assuming it is a remnant population), (2) planning provisions in order to maintain or enhance this habitat, and (3) potential options for restoration.

HBRC and NIWA visited Pōrangahau Estuary on 26 July 2018 to assess the present state of the seagrass patches, and view the wider estuary and contributing catchment. The patches were relocated and samples for plant biomass and water quality were taken. Past and present aerial images and reports for the estuary were collated. Water quality data for HBRC's Pōrangahau River monitoring site, 1 km upstream of the seagrass patches was examined.

Five small (1 to 2 m^2) seagrass patches were relocated, occurring together in the upper river-dominated part of the estuary. The patches remained submerged, just below the water surface, at low tide. Plant biomass in the patches was relatively low (mean 79 g dry weight/m^2). Water quality data suggest that the patches are subjected to highly variable salinity (<2 to 31 ppt), probably just within their range of tolerance, and water turbidity and nitrate concentrations are elevated.

Seagrass could not be identified in aerial images of the estuary dating back to 1978. However, similar tidal lagoon estuaries in New Zealand are known to support seagrass, so it seems likely that it has been formerly present in the estuary. Exploring the cultural knowledge of Ngāti Kere might provide further information about historical seagrass presence in the estuary.

Comparisons of conditions at the Pōrangahau site with other seagrass locations (current and historical) indicate that inputs of fine sediments (silt and clay particles) are of particular concern for seagrass persistence, while excessive sediment loading has been confirmed by studies in the catchment. The seagrass patches may be persisting in their present location because the moderate flow of water prevents excessive sediment deposition that would smother the plants. Further downstream, at HBRC's estuary monitoring site the mud (silt plus clay) content of the substrate (40-50%) is well above levels suggested to support seagrass (<13%).

In order to establish trends in seagrass presence, the patches should be mapped annually to document extent and condition (cover and biomass). Ongoing monitoring of contaminants, especially fine sediments, in water and substrate is important. To protect and enhance the seagrass habitat in Pōrangahau Estuary, we recommend that initiatives to reduce sediment and nutrient loads to the estuary including land retirement, stock exclusion from waterways, including the estuary, and riparian planting should be pursued.

1 Introduction

Pōrangahau Estuary is located at the mouth of the Pōrangahau River in southern Hawke's Bay. It is a long, narrow estuary formed behind a low, longshore bar. It has a variety of estuarine habitats including saltmarsh, intertidal sand and mudflats, and shallow tidal channels. At around 750 ha it is the largest estuary on the North Island's east coast south of Ohiwa Harbour, dominating about 14 km of coastline. The estuary is a wildlife area of national significance. It provides roosting, feeding and breeding areas for common and rare coastal bird species including migratory waders. The estuary is also an important spawning and nursery habitat and feeding ground for native fish and is an area of great significance to Ngāti Kere. Twenty customary fishing sites exist between Pōrangahau township and the sea and the estuary continues to be an important source of flatfish, kahawai, eels and whitebait (HBRC 2018). The catchment is dominated by high producing exotic grassland supporting sheep and beef cattle.

The seagrass *Zostera muelleri* is a native, flowering, marine plant that occurs as patches or meadows in estuaries or sheltered coastal bays. It often grows in the intertidal zone but also below the low tide mark (i.e., in the subtidal zone) where waters are sufficiently clear. Seagrass provides important habitat for many marine species. It is likely to have been more widespread in the past with available studies suggesting substantial losses from some New Zealand estuaries associated with human activities (Inglis 2003; Matheson et al. 2011).

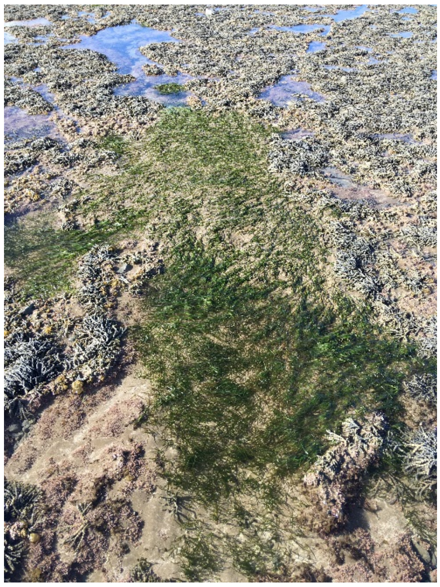

Figure 1-1: Location of Pōrangahau Estuary in Southern Hawkes Bay (left) and a patch of *Zostera muelleri* on an intertidal reef platform along the coast at Blackhead (right).

Until recently it was thought that seagrass persisted in the Hawke's Bay Region only on the intertidal reef platforms of the Southern Coast and Mahia Peninsula. The last record of seagrass in estuaries within the Region is from the Ahuriri Estuary in 1978 (Akroyd & Kilner 1978; Madarasz-Smith et al. 2016). However, in March 2018, Hawkes Bay Regional Council (HBRC) identified several patches of seagrass in Pōrangahau Estuary. There are no prior records of seagrass from this estuary. Seagrass was not recorded when the vegetation of Pōrangahau Estuary was mapped in 2006 (Stevens and Robertson 2006).

Advice was sought from NIWA to help protect the newly discovered patches of seagrass in Pōrangahau Estuary. In particular, HBRC wished to scope work to identify (1) the drivers behind the degradation of seagrass in this estuary (assuming it was present historically), (2) planning provisions in order to maintain or enhance this habitat, and (3) potential options for restoration. This report summarises relevant information and provides recommendations for future work.

2 Methods

HBRC and NIWA visited Pōrangahau Estuary on 26 July 2018. The field visit was carried out to assess the seagrass patches, and view the wider estuary and contributing catchment. During the field visit, seagrass patches were relocated and position coordinates recorded. Photographs were taken of the patches, a single core (10 cm diameter x 10 cm depth) was collected from four of the five seagrass patches to quantify seagrass biomass and a water sample was collected to gather some basic indicative data on water salinity, turbidity and nutrient concentrations from the area occupied by the patches. Plant biomass was washed from sediment cores in the field. In the laboratory, above-ground and below-ground biomass in each sample was separated and all samples dried at 60°C for 48 hours before the sample dry weight (DW) was measured.

Relevant reports and aerial photographs for the estuary were collated. Aerial photographs from 1976-78 and 1996-97 were acquired from Retrolens and Land Information New Zealand databases to scope whether seagrass was formerly present in the estuary. In addition, a series of more recent Google Earth images from 21 September 2004, 30 December 2010, 31 January 2013, 28 March 2013, 19 April 2015 to 3 February 2017 were examined. In addition, HBRC provided NIWA with water quality data for the nearest Pōrangahau River monitoring site.

3 Results

3.1 Present condition

The seagrass patches were located in the upper, river-dominated part of the estuary, just over 1 km downstream of the Beach Rd boat ramp (Figure 3-1). The patches are located in an area with a moderate flow velocity.

Figure 3-1: Location of seagrass patches in riverine section of the estuary. Beach Rd bridge and boat ramp is in the lower left corner of the photo. Aerial image sourced from Google Earth.

Five seagrass patches were located. All patches were relatively small (ca. 1 to 2 m^2 area) and remained submerged, just below the water surface, at low tide. Plant density was lower than observed in March 2018 (O. Wade, pers. obs. and see Figure 3-2). Some reduction in biomass was expected due to seasonal senescence of plants during autumn and winter. However, it is likely that winter storms bringing flushing flows and sediment down the Pōrangahau River had also recently disturbed the patches. The substrate associated with the patches was predominantly gravel and mud (See Table A-1).

Figure 3-2: Seagrass patch in Pōrangahau Estuary in March 2018 (partially exposed at low tide) and July 2018 (submerged at low tide). (Photos: O. Wade).

The biomass of seagrass in the patches ranged from 1.1 to 7.4 gDW/m^2 for above-ground shoots and 60 to 102 gDW/m^2 for below-ground roots and rhizomes (See Table A-1). These values are relatively low compared to measurements made during the winter months in other New Zealand estuaries (Table 3-1). Biomass data for other estuaries in other seasons is provided in Table A-2.

Table 3-1: Seagrass biomass measured in Pōrangahau Estuary compared to other NZ locations. All data from winter months. Values are means ± standard error.

Estuary or embayment	Above-ground biomass (gDW/m^2)	Below-ground Biomass (gDW/m^2)	Reference
Pōrangahau	4 (± 1)	75 (± 9)	This study
Porirua	6 (± 2) to 60 (± 26)	24 (± 8) to 250 (± 102)	Matheson & Wadhwa 2012
Whangamata	48 (± 4) to 58 (± 5)	120 (± 12) to 133 (± 14)	Turner & Schwarz 2006
Whangapoua	47 (± 4) to 123 (± 9)	479 (± 83) to 587 (± 123)	Turner & Schwarz 2006

At the time of sampling on 26 July 2018, water immediately adjacent to the seagrass patches had a relatively low salinity of 6.7 ppt. This is consistent with their location in the river-dominated part of the estuary. Salinity varies through time in response to the cycle of tides and variable river inflows. The monthly sampling records for HBRC's nearest water quality monitoring site (Pōrangahau at Estuary Bridge) provide an indication of the variation in salinity that is likely to be experienced by the seagrass patches. These records for the period from June 2017 to June 2018 (13 samples) show that salinity varied from <2 to 31 ppt with a median value of 9 ppt. Slightly higher salinity values would generally be expected downstream at the seagrass site.

Table 3-2: Water quality parameters measured at sites in Pōrangahau Estuary and other New Zealand seagrass sites. The data range is shown with median in parentheses if available. Other seagrass sites include current or former sites for which similar data was available. Note that these are only indicative data because water quality is variable through time.

Estuary	Season	Salinity (ppt)	Turbidity (NTU)	NO_3-N (µg/L)	NH_4-N (µg/L)	DRP (µg/L)	Chla (µg/L)	Reference	Comment
Pōrangahau seagrass	Winter	6.7	8.4	226	32	12	-	This study	One-off samples
Pōrangahau at Estuary Bridge	All seasons	<2-31 (9)	13.2-196 (28)	<1-600 (20)	<1-610 (22)	4-95 (18)	1-27 (2)	HBRC data	Monthly samples from June 2017 to June 2018
Bay of Islands	Spring-Summer	34.9-35.5	0.39-1.33	-	-	-	0.6-2.2	Matheson et al. 2010	Data from six existing seagrass sites
Whangarei	All seasons	15.1-36.0	0.29-5.29	0.5-12	3-62	2-13	0.5-1.9	Matheson et al. 2017	Data from two existing seagrass sites
Porirua (existing)	All seasons	22-35 (32)	1.6-15.6 (5.5)	2-220 (2)	<10-38 (<10)	4-14 (5)	<3-7 (<3)	Matheson & Wadhwa 2012	Data from an existing seagrass site closest to historical site
Porirua (existing)	All seasons	22-35 (34)	1.2-19.5 (2.4)	2-130 (3)	<10-26 (<10)	4-12 (6)	<3 (<3)	Matheson & Wadhwa 2012	Data from an existing seagrass site furthest from historical site
Porirua (historical)	All seasons	11-35 (31)	2.1-169 (3.8)	<2-650 (7)	<10-74 (<10)	4-17 (8)	<3-16 (<3)	Matheson & Wadhwa 2012	Data from historical pre-1980 seagrass site

Most seagrasses grow best where salinity is > 10 ppt (see Touchette 2007). *Zostera muelleri* has been shown to have maximum rates of photosynthesis at salinities between 25 and 46 ppt (at 16°C), but is able to maintain photosynthesis at a salinity of 5 ppt (Kerr and Strother 1983). Furthermore, seeds of this species have been shown to germinate most prolifically at lower salinities (0-8 ppt) (Conacher et al. 1994; Stafford-Bell et al. 2016). Therefore, it appears that the Pōrangahau seagrass patches are located where the salinity is tolerable, perhaps even favourable for seed germination, but probably not ideal for robust growth and long-term persistence.

Water turbidity at the Pōrangahau seagrass site at the time of sampling was 8.4 NTU and bioavailable nutrient concentrations were 226 µg/L for nitrate-nitrogen (NO_3-N), 32 µg/L for ammoniacal-nitrogen (NH_4-N) and 12 µg/L for dissolved reactive phosphorus (DRP) (Table 3-2). Turbidity, nutrient and chlorophyll *a* (chla) concentrations at the upstream HBRC monitoring site from June 2017 to June 2018 ranged from 13.2 to 196 NTU (median 28), <1 to 600 µg/L NO_3-N (median 20), <1 to 610 µg/L NH_4-N (median 22), 4 to 95 µg/L DRP (median 18) and 1 to 27 µg/L chla (median 2). Therefore, the July 2018 concentrations for nitrogen measured at the Pōrangahau seagrass site were above the median values measured for the upstream monitoring site, but turbidity and DRP concentrations were not. Chla was not measured at the Pōrangahau seagrass site. In comparison to other New Zealand seagrass sites for which data is available, the concentrations of turbidity, NH_4-N and DRP at the Pōrangahau seagrass site are within the range reported. However, the concentration of NO_3-N was slightly higher and within the range of values for a former site in Porirua Harbour from which seagrass was lost. In addition, the median turbidity for the nearby HBRC monitoring is relatively high at 28 NTU. This provides an indication that the conditions for longer-term seagrass persistence at the Pōrangahau site are probably marginal under current water quality conditions. The moderate flow velocity at the site is likely supporting plant persistence in this area by limiting the deposition of fine sediments and smothering of plants.

3.2 Historical records

No published reports of seagrass occurring in Pōrangahau Estuary could be located. Inspection of the historical aerial images did not suggest the presence of any large, dense beds of seagrass as far back as 1978 (Figure 3-3). However, image quality and resolution is not ideal especially for the earlier images and it is inherently difficult to distinguish seagrass from other features in aerial images without supporting evidence for their presence. Moreover, the mapping of estuary vegetation done in 2006 (Stevens and Robertson 2006) was done at broad-scale so it is possible that small seagrass patches immersed in turbid water may have been present but not detected at this time (L. Stevens, pers. comm.). Consequently, it is not possible to discount the past occurrence of seagrass in the estuary, especially if growth was sparse or patches were small. Dark patches in the channel close to the tidal entrance in the most recent images have been identified as growths of the macroalga, *Gracilaria* spp. (O. Wade, pers. comm.).

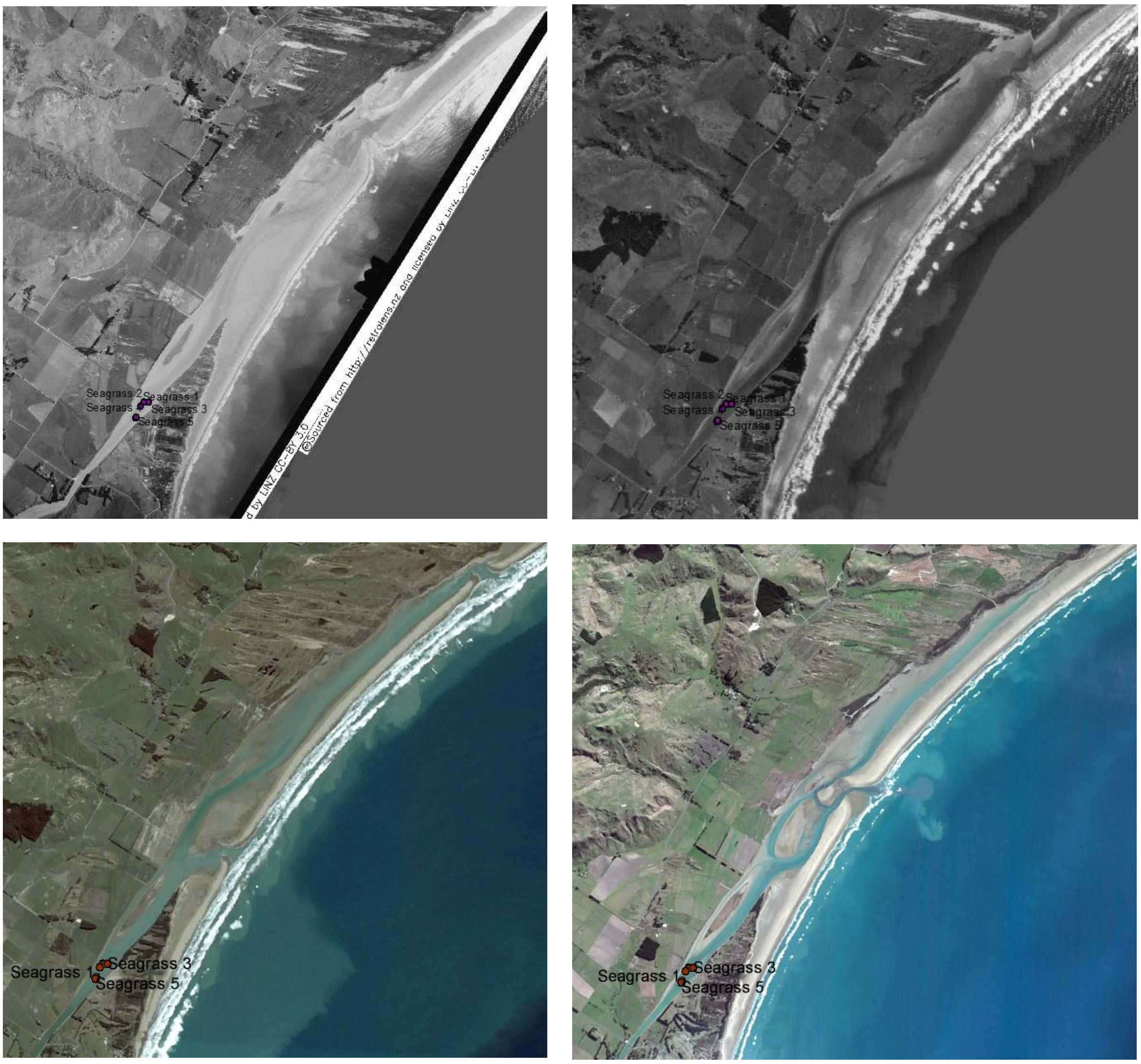

Figure 3-3: Aerial images of the Pōrangahau Estuary from ca. 1978 (top left), ca. 1997 (top right), 2004 (bottom left) and 2015 (bottom right). Present day seagrass patch locations are indicated.

For the area where seagrass was found in 2018, patches or beds of seagrass could not be identified in the recent time-series of available images dating from 2004 (Figure 3-4). Areas more darkly shaded in and around the 2018 seagrass locations in the images from 2010 onwards are suggestive of seagrass (particularly in the 2015 image) but they could also be other features such as areas of darker coloured sediment, or growths of macroalgae.

Figure 3-4: Time-series of Google Earth images showing location of the seagrass patches found in 2018. In sequence from top left, left to right: 21 September 2004, 30 December 2010, 31 January 2013, 28 March 2013, 19 April 2015, 3 February 2017.

4 Discussion

It is unclear whether the seagrass patches recently discovered in Pōrangahau Estuary represent a remnant population, an entirely new population or one that has re-established after an absence. No evidence was found to suggest that seagrass was formerly present in the estuary. However, there are few published reports available that describe the ecology of the estuary. A future avenue to explore for information on past occurrence is the cultural knowledge of Ngāti Kere.

Pōrangahau Estuary is a permanently open tidal lagoon with 26% intertidal area (IA) (New Zealand Classification of Coastal Hydro Systems; Hume et al. 2016). Other permanently open tidal lagoons that have, or have had, seagrass include the Ahuriri (9% IA), Avon-Heathcote (66% IA), Wharekawa (86% IA) and Jacobs River estuaries (66% IA). Consequently, it seems likely that Pōrangahau Estuary has supported at least some seagrass in the past, given the area of available habitat.

HBRC's monitoring data and recent reports for the estuary and catchment suggest that inputs of sediment, especially, but also nutrients, are likely to have impacted upon the estuary. A recent analysis suggests that almost 30% of land in the catchment is highly erodible with around 10% of this land (ca. 25,600 ha) considered likely to deliver silt and clay sized particles to the river and stream network (Palmer et al. 2017). The Turaekaitai, Mangaorapa, and Lower Pōrangahau subcatchments transport the greatest sediment loads to the estuary (Palmer et al. 2017).

At the sole monitoring site within the estuary (ca. 4 km downstream of the seagrass patches), an analysis by Smith (2009) showed that substrates had a high percentage of mud (silt and clay, 40-50%), with values higher than those for monitoring sites in the Ahuriri Estuary. Studies in Tauranga Harbour have suggested that seagrass is lost from areas where substrate mud content exceeds 13% (Park 1994; Park 1999). In addition, the redox discontinuity layer was very shallow at a mean depth of 3mm, indicating anoxic conditions.

Fine sediments also transport nutrients, particularly phosphorus, into receiving environments. Both sediment and nutrient inputs affect the growing conditions for seagrass, mainly through direct and indirect effects on light availability for photosynthesis (Ralph et al. 2006). These contaminants have likely contributed to losses of seagrass from other New Zealand estuaries (e.g., Whangarei, Tauranga, Avon-Heathcote, Porirua - see Park 1999; Inglis 2003; Matheson et al. 2011) and consequently they threaten the existing seagrass patches in Pōrangahau Estuary. However, the analysis by Smith (2009) suggests that nutrient enrichment is less of an issue in the Pōrangahau catchment compared to inputs of fine sediments. Smith (2009) also found that concentrations of trace metals in the estuary sediments were relatively low and below ANZECC sediment quality guidelines.

5 Recommendations

To monitor, protect and enhance the existing patches the following actions are recommended:

1. Annual mapping of seagrass patch locations, patch extents and percent plant cover and biomass within patches, in summer.

   This will help to gauge patch condition and determine whether expansion or contraction is occurring. If growing conditions are suitable seagrass patches should expand gradually on their own. However, careful transplanting could be considered as an option to help speed up this process (see Matheson et al. 2017).

2. Stock exclusion from waterways, targeted land retirement (if required) and riparian planting within the catchment, and the estuary surrounds, to reduce sediment and nutrient loads into the estuary.

   Recent SedNet modelling suggests that 100% stream bank fencing and planting in the catchment would reduce the sediment load to the estuary substantially (by 76% from 32,000 to 7,800 tonnes per annum) (Palmer et al. 2017). HBRC are implementing catchment actions (O. Wade, HBRC, pers comm.) and ongoing monitoring at the estuary, including sensitive biota such as seagrass, would provide evidence of the success of sediment load mitigation methods.

3. Monitoring of conditions near/at the seagrass site.

   Monitoring upstream at the Pōrangahau River Estuary Bridge site provides an indication of the water quality experienced by the seagrass patches. However, it would also be useful to periodically collect water samples from the seagrass patch site as a comparison and to annually monitor sediment grain size and deposition rates. Deploying a submersible light logger (with biowiper to remove biofouling) would help to ascertain directly the light climate at the site – a critical parameter for long-term seagrass persistence and growth.

6 Acknowledgements

Oliver Wade from Hawkes Bay Regional Council initiated this work, provided background information and facilitated the visit to Pōrangahau Estuary. Sanjay Wadhwa (NIWA) sourced and geo-rectified historical aerial images in ArcGIS. Leigh Stevens from Salt Ecology Ltd was consulted about the broad-scale vegetation mapping undertaken in 2006.

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Appendix A Supplementary data

Table A-1: Details of the seagrass patches located and sampled on 29 July 2018.

Patch No.	Coordinates (NZTM)		Substrate	Seagrass biomass (gDW/m²)		Comment
	Northing	Easting		AG	BG	
1	5533633	1911206	Gravel mud sand	1.1	101.9	Covered in sandy mud.
2	5533680	1911251	Gravel mud sand	2.8	60.0	Really depleted from last time.
3	5533679	1911314	Gravel mud	2.7	67.9	Very sparse.
4	5533496	1911155	Gravel mud	No sample taken		Very sparse.
5	5533477	1911145	Mud gravel	7.4	68.9	Slightly better condition compared to other patches. Green stems but still very sparse.

AG = above-ground, BG = below-ground.

Table A-2: Seagrass biomass measured in spring, summer and autumn in other NZ locations. Values are range in means ± standard error.

Estuary or embayment	Above-ground biomass (gDW/m²)	Below-ground Biomass (gDW/m²)	Reference
Bay of Islands[1]	ca. 150	ca. 1150	Matheson et al. 2010
Raglan[2]	15 ± 9 to 85 ± 22	2 ± 2 to 112 ± 42	Matheson & Schwarz 2007
Tauranga[2]	13 ± 4 to 84 ± 14	27 ± 12 to 268 ± 30	Matheson & Schwarz 2007
Tauranga[2]	59 ± 6 to 228 ± 80	367 ± 82 to 701 ± 113	Dos Santos & Matheson 2016
Whangamata[2]	49 ± 16 to 51 ± 8	165 ± 32 to 168 ± 23	Turner & Schwarz 2006
Whangapoua[2]	85 ± 10 to 101 ± 20	638 ± 97 to 665 ± 110	Turner & Schwarz 2006
Whangapoua[2]	60 ± 25 to 254 ± 85	126 ± 35 to 590 ± 212	Matheson & Schwarz 2007
Wharekawa[2]	65 ± 11 to 69 ± 6	256 ± 30 to 260 ± 52	Turner & Schwarz 2006
Otago[3]	93 to 97	180 to 235	Ismail 2001
Tauranga[3]	84 ± 11	187 ± 12	Dos Santos et al. 2012
Whangarei[3]	7 ± 2 to 71 ± 11	51 ± 21 to 581 ± 110	Matheson et al. 2017

[1] = spring, [2] = summer, [3] = autumn.