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*Supplement of*

## **Sediment CO<sub>2</sub> efflux from cleared and intact temperate mangroves and tidal flats**

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## Supplementary material

Table 1: CO<sub>2</sub> efflux ( $\mu\text{mol m}^{-2} \text{s}^{-1}$ ) before and after surface biofilm was removed, at intact mangrove, mangrove clearance, and tidal flat sites (n = 3, mean  $\pm$  SE). (02/11/13, 04/11/13 - 06/11/13, 25/11/13, 29/11/13 - 01/12/13, 17/12/13, 18/12/13, 15/01/14). Small size < 1 ha, large size > 1 ha.

Region	Sub estuary	Longitude	Latitude	Clearance Age (Years)	Size of Clearance	Clearance Method	Carbon dioxide efflux: surface biofilm intact ( $\mu\text{mol m}^{-2} \text{s}^{-1}$ )			Carbon dioxide efflux: surface biofilm disturbed ( $\mu\text{mol m}^{-2} \text{s}^{-1}$ )		
							Mangrove	Clearance	Tidal flat	Mangrove	Clearance	Tidal flat
Northland	Hatea 2	35 43.261	174 19.512	0.10	Small	Unknown	-1.24 $\pm$ 0.46	-3.95 $\pm$ 0.40		9.60 $\pm$ 0.25	2.14 $\pm$ 0.90	
Northland	Hatea 1	35 43.569	174 19.743	0.10	Small	Unknown	-0.94 $\pm$ 1.10	-2.34 $\pm$ 0.60	16.11 $\pm$ 0.49	4.58 $\pm$ 1.20		
Northland	Mangawhai 1	36 7.706	174 34.927	3.00	Small	Unknown	0.92 $\pm$ 0.30	-0.41 $\pm$ 0.27	-0.45 $\pm$ 0.23	2.51 $\pm$ 0.67	1.45 $\pm$ 0.31	1.12 $\pm$ 0.28
Auckland	Weiti	36 38.711	174 43.554	2.00	Small	Natural death		0.04 $\pm$ 0.29	-0.57 $\pm$ 0.10		1.49 $\pm$ 0.05	0.21 $\pm$ 0.04
Auckland	Waiuku 3	37 14.545	174 43.716	3.00	Small	Mechanical		7.65 $\pm$ 2.17	1.01 $\pm$ 0.25		5.73 $\pm$ 1.75	3.08 $\pm$ 0.68
Auckland	Waiuku 2	37 14.653	174 43.793	3.00	Small	Mechanical		13.83 $\pm$ 5.06	1.57 $\pm$ 0.65		4.23 $\pm$ 0.53	2.28 $\pm$ 0.68
Auckland	Waiuku 1	37 14.756	174 43.823	7.00	Small	Mechanical		2.90 $\pm$ 1.26	0.67 $\pm$ 0.35		5.36 $\pm$ 1.17	3.30 $\pm$ 0.30
Auckland	Whangateau	36 20.634	174 45.676	5.00	Small	Manual	0.65 $\pm$ 0.40	0.09 $\pm$ 0.15	-0.16 $\pm$ 0.11	2.45 $\pm$ 0.04	1.95 $\pm$ 0.08	1.38 $\pm$ 0.46
Auckland	Airport 2	37 00.382	174 46.190	2.50	Large	Mechanical		0.12 $\pm$ 0.25	-0.19 $\pm$ 0.25		2.96 $\pm$ 0.31	0.06 $\pm$ 0.51
Auckland	Airport 1	37 00.444	174 46.268	2.50	Large	Mechanical		0.74 $\pm$ 0.39	-0.25 $\pm$ 0.18		3.98 $\pm$ 1.82	0.25 $\pm$ 0.13
Auckland	Mangere 1	36 55.934	174 47.222	0.10	Small	Manual	0.86 $\pm$ 0.21	3.48 $\pm$ 1.54	-0.27 $\pm$ 0.32	1.51 $\pm$ 0.30	1.89 $\pm$ 0.43	2.62 $\pm$ 0.39
Auckland	Mangere 2	36 56.163	174 47.263	1.00	Small	Manual	2.68 $\pm$ 0.29	1.42 $\pm$ 1.40	0.25 $\pm$ 0.67	3.11 $\pm$ 0.91	4.65 $\pm$ 0.45	0.27 $\pm$ 0.56
Auckland	Mangere 3	36 56.145	174 47.328	2.00	Small	Manual		1.42 $\pm$ 1.40			4.65 $\pm$ 0.45	
Auckland	Panmure 2	36 54.429	174 50.714	5.00	Small	Manual	1.15 $\pm$ 0.66	1.83 $\pm$ 0.60	0.53 $\pm$ 0.13	4.15 $\pm$ 0.43	3.42 $\pm$ 0.79	0.54 $\pm$ 0.27
Auckland	Panmure 1	36 54.486	174 50.909	5.00	Small	Manual		0.33 $\pm$ 0.54	-0.04 $\pm$ 0.31		3.90 $\pm$ 0.24	1.70 $\pm$ 0.28
Auckland	Puhurehure 1	37 02.638	174 54.335	1.00	Small	Manual	1.60 $\pm$ 0.10	0.29 $\pm$ 0.37	0.08 $\pm$ 0.05	3.89 $\pm$ 0.42	1.89 $\pm$ 0.31	1.47 $\pm$ 0.24
Auckland	Puhurehure 4	37 03.450	174 55.385	1.00	Large	Mechanical		6.65 $\pm$ 3.34	1.29 $\pm$ 0.41		5.25 $\pm$ 1.46	2.53 $\pm$ 0.26
Auckland	Puhurehure 3	37 03.280	174 55.556	1.50	Large	Mechanical		2.49 $\pm$ 0.28	1.27 $\pm$ 0.77		5.21 $\pm$ 0.66	2.28 $\pm$ 0.57
Auckland	Puhurehure 2	37 03.678	174 55.788	5.00	Large	Manual		0.88 $\pm$ 0.15	0.03 $\pm$ 0.30		4.52 $\pm$ 0.37	3.57 $\pm$ 0.32
Waikato	Tairua 1	37 00.260	175 50.556	3.00	Small	Manual	-0.13 $\pm$ 0.11	-0.42 $\pm$ 0.02	-0.24 $\pm$ 0.06	3.88 $\pm$ 0.62	1.24 $\pm$ 0.45	0.37 $\pm$ 0.23
Waikato	Tairua 2	37 00.762	175 50.812	3.00	Small	Manual	2.14 $\pm$ 0.88	1.24 $\pm$ 0.45	-0.40 $\pm$ 0.06	4.17 $\pm$ 0.59	6.43 $\pm$ 0.71	0.33 $\pm$ 0.16
Waikato	Tairua 3	37 01.754	175 50.976	3.00	Small	Manual	0.90 $\pm$ 0.00	-0.28 $\pm$ 0.26	-0.69 $\pm$ 0.07	2.90 $\pm$ 0.00	3.47 $\pm$ 0.36	0.51 $\pm$ 0.09
Waikato	Whangamata 3	37 11.526	175 51.523	13.00	Small	Manual		0.14 $\pm$ 0.08	0.07 $\pm$ 0.12		1.74 $\pm$ 0.59	0.16 $\pm$ 0.11
Waikato	Whangamata G	37 11.179	175 51.564	0.60	Large	Mechanical	2.91 $\pm$ 0.93	1.41 $\pm$ 0.18	0.12 $\pm$ 0.06	13.41 $\pm$ 1.41	5.46 $\pm$ 0.43	0.06 $\pm$ 0.13
Waikato	Whangamata E	37 12.163	175 51.672	0.60	Large	Manual	0.07 $\pm$ 0.26	1.66 $\pm$ 0.84		4.24 $\pm$ 0.06	5.32 $\pm$ 2.10	
Waikato	Whangamata E	37 12.093	175 51.722	0.60	Large	Mechanical	-0.16 $\pm$ 0.08	3.39 $\pm$ 1.73	-0.16 $\pm$ 0.17	2.38 $\pm$ 0.20	4.87 $\pm$ 0.80	3.20 $\pm$ 0.77
Waikato	Whangamata 2	37 12.043	175 51.839	6.00	Small	Manual		-0.48 $\pm$ 0.12			2.31 $\pm$ 0.85	
Waikato	Whangamata 1	37 11.983	175 51.898	6.00	Small	Mechanical		-0.63 $\pm$ 0.18			1.16 $\pm$ 0.38	
Bay of Plenty	Uretara 2	37 32.277	175 55.457	6.00	Large	Manual		0.77 $\pm$ 0.06	-0.20 $\pm$ 0.10		1.77 $\pm$ 0.74	-0.01 $\pm$ 0.10
Bay of Plenty	Uretara 1	37 32.262	175 55.528	3.00	Large	Mechanical	4.30 $\pm$ 1.25	0.16 $\pm$ 0.41		6.95 $\pm$ 0.87	3.91 $\pm$ 0.33	
Bay of Plenty	Welcome bay 2	37 43.298	176 10.866	10.00	Small	Manual		-0.34 $\pm$ 0.16			3.76 $\pm$ 0.15	
Bay of Plenty	Welcome bay 1	37 43.518	176 11.072	2.00	Large	Mechanical	4.39 $\pm$ 1.14	6.23 $\pm$ 1.02	-0.25 $\pm$ 0.04	7.06 $\pm$ 0.77	6.42 $\pm$ 1.79	2.22 $\pm$ 0.44
Bay of Plenty	Waikaraka 1	37 39.986	176 3.840	3.00	Large	Manual and	2.52 $\pm$ 0.75	-0.53 $\pm$ 0.17	-0.46 $\pm$ 0.20	2.99 $\pm$ 1.15	4.27 $\pm$ 1.54	0.79 $\pm$ 0.04
Bay of Plenty	Waikaraka 1	37 39.986	176 3.840	7.00	Large	Manual		-0.27 $\pm$ 0.15			1.52 $\pm$ 0.43	
Bay of Plenty	Waikaraka 3	37 39.902	176 3.890	3.00	Small	Mechanical		0.73 $\pm$ 0.29	-0.46 $\pm$ 0.23		5.02 $\pm$ 2.22	1.33 $\pm$ 0.42
Bay of Plenty	Waikaraka 3	37 39.902	176 3.890	7.00	Small	Manual		-0.17 $\pm$ 0.00			7.45 $\pm$ 0.00	
Bay of Plenty	Waikaraka 2	37 40.093	176 3.928	3.00	Large	Mechanical		0.71 $\pm$ 0.44	-0.02 $\pm$ 0.33		4.42 $\pm$ 1.37	0.89 $\pm$ 0.33
Bay of Plenty	Matua	37 40.322	176 7.540	3.00	Small	Mechanical	12.47 $\pm$ 2.78	-0.19 $\pm$ 0.23	-1.20 $\pm$ 0.20	20.82 $\pm$ 4.98	6.02 $\pm$ 1.03	2.74 $\pm$ 0.62
Bay of Plenty	Matua	37 40.322	176 7.540	9.00	Small	Manual		0.30 $\pm$ 0.56			3.17 $\pm$ 0.70	
Bay of Plenty	Waikareo	37 41.214	176 8.943	3.00	Large	Mechanical	5.29 $\pm$ 1.44	0.15 $\pm$ 0.13	-0.63 $\pm$ 0.16	12.56 $\pm$ 0.55	3.85 $\pm$ 0.24	1.39 $\pm$ 0.54
			<b>Mean</b>				<b>2.31 <math>\pm</math> 0.70</b>	<b>1.34 <math>\pm</math> 0.70</b>	<b>-0.12 <math>\pm</math> 0.24</b>	<b>6.39 <math>\pm</math> 0.80</b>	<b>4.01 <math>\pm</math> 0.75</b>	<b>1.43 <math>\pm</math> 0.36</b>

Table 2: SIMPER analysis showing the top 10 species contributing towards the dissimilarity observed between clearance and tidal flat sites

Species	Clearance Mean Abundance	Tidal flat Mean Abundance	Mean Dissimilarity	Dissimilarity/SD	Contribution %	Cumulative contribution %
<i>Potamopyrgus estuarensis</i>	4.24	0.99	6.67	0.73	9.33	9.33
Oligochaeta	5.31	2.84	6.04	1.15	8.45	17.78
<i>Paracorophium</i> sp.	2.11	2.03	4.42	0.8	6.18	23.96
<i>Ceratonereis</i> sp.	2.46	1.25	3.5	1.25	4.9	28.87
<i>Scolecopides benhami</i>	2.02	1.46	3.1	1.06	4.35	33.21
Capitellidae	2.16	0.95	2.71	0.92	3.79	37
<i>Zeacumantus lutulentus</i>	0.95	0.64	2.37	0.69	3.31	40.32
<i>Arthritica bifurca</i>	1	1.27	2.35	0.98	3.29	43.6
<i>Scoloplos cylindrifera</i>	0.86	0.92	2.12	0.99	2.97	46.57
<i>Prionospio aucklandica</i>	0.61	1.02	1.99	0.85	2.78	49.35

Table 3: Significant ( $p < 0.05$ ) correlations sediment CO<sub>2</sub> efflux (biofilm intact) and site characteristics for intact mangrove, mangrove clearance, and tidal flat sites. ns = not significant, na = not applicable

	CO <sub>2</sub> efflux			Organic carbon concentration		
	Mangrove (n = 18)	Clearance (n = 40)	Tidal flat (n = 30)	Mangrove (n = 18)	Clearance (n = 40)	Tidal flat (n = 30)
Mangrove density (trees m <sup>-2</sup> )	ns	na	na	<b>0.57</b>	na	na
Mangrove height (m)	<b>-0.54</b>	na	na	<b>-0.47</b>	na	na
Years since clearance	na	ns	na	na	<b>-0.39</b>	ns
Size of clearing	na	ns	na	na	ns	na
Mangrove root mass (g core <sup>-1</sup> )	no data	ns	na	no data	ns	na
CO <sub>2</sub> efflux (μmol CO <sub>2</sub> m <sup>-2</sup> s <sup>-1</sup> )	na	na	na	ns	<b>0.36</b>	<b>0.52</b>
CO <sub>2</sub> efflux: biofilm removed (μmol CO <sub>2</sub> m <sup>-2</sup> s <sup>-1</sup> )	<b>0.50</b>	<b>0.40</b>	ns	<b>0.55</b>	<b>0.32</b>	<b>0.60</b>
Organic carbon (%)	ns	<b>0.36</b>	<b>0.52</b>	na	na	na
Nitrogen (%)	ns	<b>0.39</b>	<b>0.42</b>	<b>0.80</b>	<b>0.62</b>	<b>0.52</b>
Gravel (%)	ns	ns	ns	ns	ns	ns
Coarse Sand (%)	ns	ns	<b>-0.40</b>	ns	<b>-0.44</b>	<b>-0.37</b>
Medium Sand (%)	ns	<b>-0.46</b>	<b>-0.48</b>	<b>-0.48</b>	<b>-0.62</b>	<b>-0.57</b>
Fine Sand (%)	ns	<b>-0.57</b>	<b>-0.40</b>	<b>-0.50</b>	<b>-0.68</b>	<b>-0.71</b>
Silt (%)	ns	<b>0.46</b>	<b>0.52</b>	<b>0.54</b>	<b>0.67</b>	<b>0.81</b>
Clay (%)	ns	<b>0.48</b>	<b>0.55</b>	<b>0.59</b>	<b>0.79</b>	<b>0.88</b>
Chlorophyll <i>a</i> (mg <sub>g</sub> <sup>-1</sup> g <sup>-1</sup> sediment)	ns	ns	ns	<b>0.67</b>	ns	ns
Phaeophytin (mg <sub>g</sub> <sup>-1</sup> g <sup>-1</sup> sediment)	ns	ns	<b>0.50</b>	<b>0.85</b>	<b>0.80</b>	<b>0.64</b>
Sediment compaction (cm)	no data	ns	<b>0.46</b>	no data	<b>0.35</b>	<b>0.78</b>
Air temp (°C)	ns	ns	ns	ns	na	<b>-0.58</b>
Soil Temp (°C)	ns	<b>-0.35</b>	<b>-0.40</b>	ns	ns	ns
Soil Moisture (PER μsec)	<b>0.50</b>	ns	<b>0.42</b>	ns	ns	<b>0.43</b>
# Crab burrows	no data	ns	<b>0.45</b>	no data	ns	<b>0.70</b>
<i>Top 10 macrofauna species</i>						
# <i>Arthritica bifurca</i>	no data	ns	ns	no data	ns	ns
# Capitellidae	no data	<b>0.60</b>	ns	no data	<b>0.36</b>	ns
# <i>Ceratonereis</i> sp.	no data	ns	<b>-0.55</b>	no data	ns	ns
# <i>Paracorphium</i> sp.	no data	ns	ns	no data	ns	ns
# Oligochaeta	no data	ns	ns	no data	ns	ns
# <i>Potamopyrgus estuarinsis</i>	no data	ns	ns	no data	<b>0.39</b>	ns
# <i>Prionospio aucklandica</i>	no data	<b>-0.36</b>	ns	no data	ns	ns
# <i>Scolecoides benhami</i>	no data	ns	ns	no data	ns	<b>0.53</b>
# <i>Scolecoides cylindrifer</i>	no data	ns	ns	no data	<b>-0.49</b>	<b>-0.73</b>
# <i>Zeacumantus lutulentus</i>	no data	<b>-0.41</b>	ns	no data	<b>-0.48</b>	<b>-0.41</b>
<b>FUNCTIONAL GROUPS</b>						
Feeding mode:						
Suspension feeders	no data	ns	ns	no data	<b>0.35</b>	ns
Deposit feeders	no data	ns	ns	no data	<b>0.36</b>	ns
Predators	no data	ns	ns	no data	<b>0.38</b>	ns
Scavengers	no data	ns	ns	no data	ns	ns
Grazers	no data	ns	ns	no data	<b>0.50</b>	<b>0.56</b>
Mobility:						
Epifauna	no data	ns	ns	no data	ns	ns
Attached	no data	ns	ns	no data	ns	ns
Active in top 2 cm	no data	ns	ns	no data	ns	ns
Deep	no data	ns	ns	no data	ns	ns
Permanent burrow	no data	ns	<b>-0.43</b>	no data	ns	ns
Simple hole or pit	no data	ns	ns	no data	ns	ns
Tube structure	no data	ns	<b>0.45</b>	no data	ns	ns