Overview comment (to all referees)

We would like to acknowledge the helpful comments received by the referees. Here we address two of the main concerns expressed by the referees. We note that the referees expressed a recommendation that while the manuscript contained a large amount of valuable information, it should focus on the main factors influencing CO_2 efflux. In addition the referees asked for a more detailed description of the methods. We have addressed these concerns and suggestions by:

- Omitted the tidal flat data to concentrate on CO_2 efflux from intact and cleared mangrove forest sites and the main factors influencing the sediment CO2 efflux.
- Removed the macrofaunal data
- We have reassessed the criteria for including flux data. In the revised version only fluxes where the r^2 of the linear regression (increase of CO_2 concentration vs time) exceeds 0.8. In general, r^2 values of less than 0.8 occurred at sites where there was minimal change in CO_2 efflux, typically less than ± 0.4 μmol m^{-2} s^{-1}. While it is possible that the flux at these sites exhibits a non-linear trend, we have removed them to in order to strengthen the interpretation of the remaining dataset.
- This resulted in a decline in the number of clearance sites from 40 to 23, and intact mangrove forest sites from 18 to 13.
- While working on the calculations we identified an error in the CO_2 efflux calculation script (the chamber volume was overestimated by about 40 %) and we re-calculated all sediment CO_2 efflux values, re-did all related statistical tests, corrected the tables and figures.

The second point raised by referee#3 was in regards to the procedure of the CO_2 flux measurements, i.e. the possible continuation of photosynthesis if measurements were made immediately after the chamber deployment. Based on this we undertook additional measurements to test the impact of pre shading the sediment for > 30 minutes prior to dark CO_2 efflux measurements. We selected an existing location (Hatea 1) where CO_2 uptake had previously been measured. The manuscript has been modified to include the results of this experiment.

We compared control and biofilm removed measurements using identical methodology to that described in the manuscript. Relevant sections are included below:

> *2.3.1 Pre-shading the sediment*
>
> *Frames (0.5 m^2) were located approximately 20 cm above the sediment surface. The frame was completely covered by layered cloth to exclude light penetration. At site Hatea 1, three frames were deployed throughout the mangrove forest, at least 10 m from each other and the mangrove edge. After 30 minutes of shading, two CO_2 efflux measurements using a dark*

respiration chamber were conducted at different locations within the 0.5 m^2 area, before and after the removal of the surface biofilm. The biofilm (top ~2 mm of surface sediment) was scraped off using a spatula. Biofilm removed measurements were collected immediately following biofilm intact measurements in the identical location. Corresponding dark CO_2 efflux measurements were also conducted at locations that had not been pre-shaded (control) adjacent to each shaded measurement, as well as corresponding biofilm removed measurements to account for heterogeneity in sediment conditions.

2.3.2 Sediment CO_2 efflux from intact and cleared temperate mangrove

Sediment CO_2 efflux was measured in the centre of the cleared sites at three randomly selected locations. Locations in the intact mangrove forest were > 10 m from the cleared areas. No pre-shading of the sediment was undertaken prior to measurements.

The sediment CO_2 efflux was measured at low tide, between 8 am and 6 pm local time, using an infrared CO_2 analyser (Environmental Gas Monitor (EGM-4) with a dark sediment respiration chamber (SRC-1, PP Systems Ltd., Amesbury, MA, USA). Using a dark chamber prevents the photosynthetic activity of benthic microbial communities which results in the uptake of CO_2. A PVC collar (10 cm height) was attached to the base of the respiration chamber to protect the chamber from potential flooding. The collar was inserted approximately 5 mm into the sediment, avoiding damage to surface roots. Sediment within the chamber included crab burrows and pneumatophores < 7 cm which fit within the respiration chamber. The sediment area covered by each chamber was 0.00785 m^2. Chamber height was measured during each measurement as collar insertion varied based on sediment characteristics. Total chamber volume varied between 1.72 and 1.98 l depending on the depth of collar insertion. The CO_2 concentration in the chamber was measured at 5 second intervals over a 90 second period. Air and sediment temperature (Novel Ways temperature probe) and moisture (CS620, Campbell Scientific, Logan, UT, USA) to a depth of 12 cm was measured with each CO_2 efflux measurement.

In addition to measuring CO_2 efflux in intact (undisturbed) sediment, sediment CO_2 efflux was re-measured at the same location after the removal of the surface biofilm. Measurements were made within 30 seconds following the removal of the surface biofilm.

Sediment CO_2 efflux was calculated from linear regression of the CO_2 concentration within the chamber over time. Only regressions with r^2 values ≥ 0.8 were used for flux calculations.

The sediment CO_2 efflux rate was calculated as follows.

$$CO_2 \text{ flux } (\mu mol\ m^{-2}\ s^{-1}) = (\Delta CO_2/\Delta t) \times (P \times V/R \times T \times A) \qquad (1)$$

Where $\Delta CO_2/\Delta t$ is the change in CO_2 concentration over time, based on the slope of the linear regression (µmol mol^{-1}), t is time (s), P is the atmospheric pressure (Pa), V is the volume of the chamber including collar (m^3), A is the surface area covered by each chamber (0.007854 m^2), T is the temperature (K), R is the ideal gas constant, 8.20528 m^3 PaK^{-1} mol^{-1}).

We note that as part of a separate study we also undertook similar testing within intact mangrove at a new location (Whangateau 2), with similar results which we include in the response to referees but not the manuscript. A total of 18 measurements were collected for each treatment at Whangateau 2 (control biofilm intact, and control biofilm removed, shaded biofilm intact, shaded biofilm removed).

Statistical analysis used:

A Shapiro-Wilk test was used to test normality. As data conformed to normality, paired t-tests were used to determine significant differences ($p < 0.05$) in shaded and control measurements of sediment CO_2 efflux within intact mangrove at Hatea 1.

Results of the additional testing at Hatea 1:

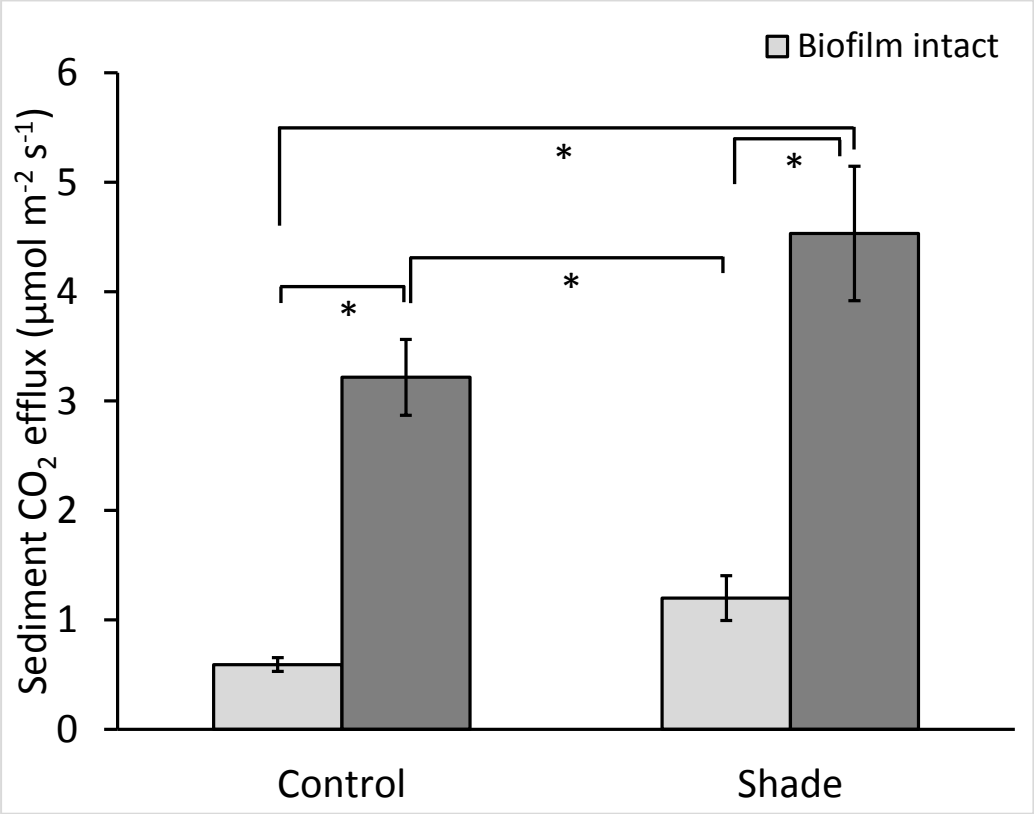

Figure 1. Mean sediment (± SE) CO_2 efflux (µmol m^{-2} s^{-1}) before and after surface biofilm was removed, from control (n = 6), and pre-shaded sediment (n = 6) at intact mangrove site Hatea 1. **significant difference ($p < 0.05$)*

No significant difference (p > 0.05) was detected in mean CO2 efflux between shaded and control treatments (Figure 2). Removing the surface biofilm resulted in significantly higher CO2 efflux (p < 0.05) for both shaded and control treatments (Figure 2).

Results of the additional testing at Whangateau 2:

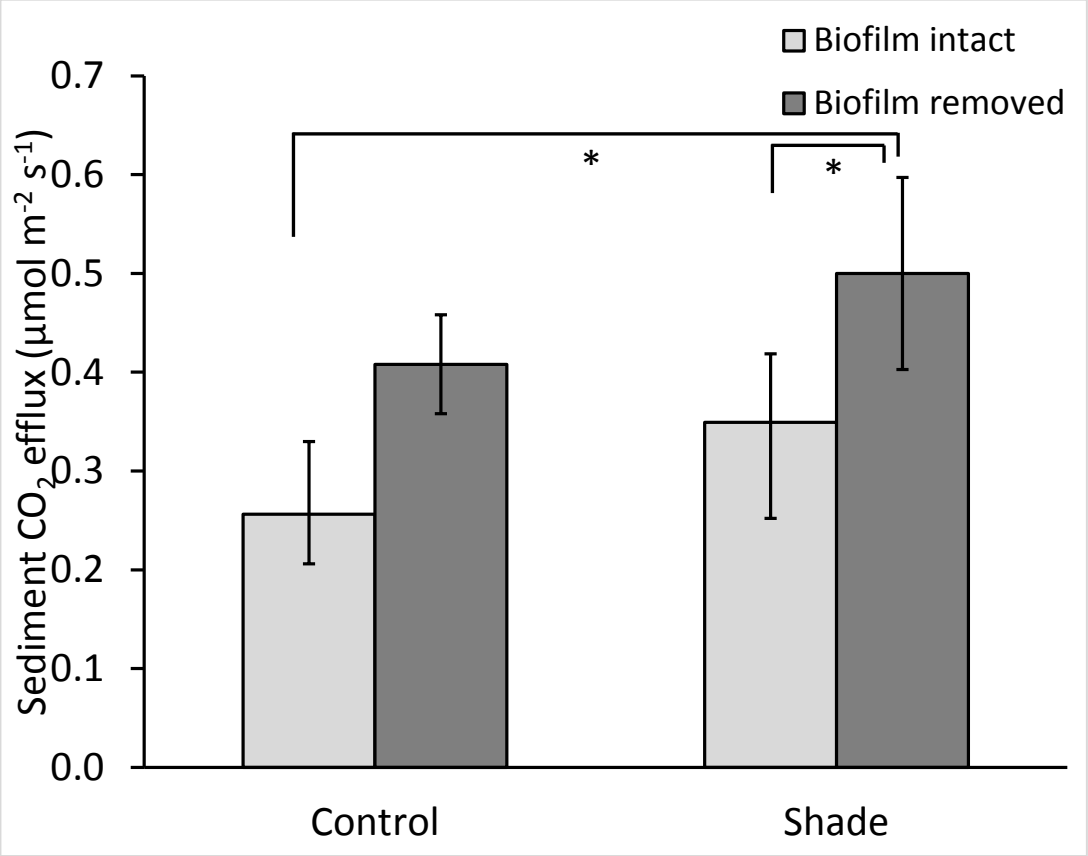

Figure 2. Mean sediment (± SE) CO_2 efflux (µmol m^{-2} s^{-1}) before and after surface biofilm was removed, from control (n = 18), and pre-shaded sediment (n = 18) at intact mangrove site Whangateau 2. **significant difference (p < 0.05)*

No significant difference was detected in mean CO_2 efflux between shaded and control treatments at Whangateau 2 (p > 0.05). Removing the surface biofilm resulted in significantly higher CO_2 efflux for shaded treatments (Figure 2), (p < 0.05).

Based on these results we derive the following conclusions.

- Our procedure to measure dark CO_2 efflux (which do not include > 30 minutes of pre shading) are valid.
- Lagged photosynthetic processes within the sediment of the dark incubation chamber are unlikely to be resulting in the CO_2 uptake observed at certain sites, or the significant increase in CO_2 efflux following biofilm removal.

We have included the following in the discussion as a potential explanation of the CO_2 uptake observed at certain sites in our study.

> *Sediment CO_2 uptake (negative flux) was observed at one intact (Hatea 1) and three cleared (Tairua 3, Whangamata 1, Hatea 1) mangrove forest sites. CO_2 uptake has also been reported in other mangrove efflux studies (Leopold et al., 2015; Lovelock, 2008; Lovelock et al., 2014). CO_2 uptake has been explained by the presence of biofilm microbial communities, as CO_2 uptake changed to efflux following biofilm removal (Leopold et al. (2015). In other habitats, CO_2 uptake from terrestrial shrub sediment has been attributed to sediment effusion-dissolution processes driven by sediment pH and moisture (Ma et al., 2013). CO_2 uptake from wetland sediment has been attributed to the drawdown of CO_2 into the sediment during large ebbing or very low tides (Krauss and Whitbeck, 2012).*
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> *Microphytobenthos have been shown to be significant contributors to benthic primary productivity (Bouillon et al., 2008; Kristensen and Alongi, 2006; Oakes and Eyre, 2014). Due to the short duration of our measurements (90 seconds), CO_2 uptake might be explained by the continuation of photosynthetic activity by surface biofilm communities at the onset of dark measurements until coenzymes were depleted (NADPH, ATP) (Leopold et al. (2015). However, the results from our shading results suggest that this was not the case, as we did not see significantly higher CO_2 efflux from sediment that was pre-shaded compared to sediment which had not been pre shaded.*
>
> *Another possibility is that the decrease in CO_2 concentration within the chamber observed at these sites is driven by the leakage of CO_2 from dark chamber measurements, via cracks, fissures or burrows in the surface sediment. The removal of the surface biofilm resulted at CO_2 emission even at the sites where CO_2 uptake was previously observed. This is possibly related to homogenising the sediment surface following biofilm removal, with cracks or burrows covered by scraped sediment, minimising CO_2 leakage to adjacent non-shaded microphytobenthos. Other studies have suggested that the biofilm may also act as a barrier to the flow of CO_2 from deeper sediment, which when removed results in a rapid increase in CO_2 efflux (Leopold et al., 2015; Leopold et al., 2013).*
>
> *Chemoautotrophs have also been shown to fix carbon in intertidal sediment under dark conditions (Boschker et al., 2014; Lenk et al., 2011). In particularly at the interface of aerobic and anaerobic zones where large amounts of reduced compounds, such as sulphur, accumulate (Boschker et al., 2014; Lenk et al., 2011; Santoro et al., 2013; Thomsen and Kristensen, 1997)). This is consistent with what is observed in mangrove sediment, where aerobic to anaerobic transitions typically occur close to the sediment surface, with sulphur driven processes likely to dominate in anaerobic conditions (Kristensen et al., 2008).*

Below is the response to individual referee's feedback.

Referee #2

Comment from referee: This paper measured sediment to air CO2 fluxes from a large number of mangrove dominated, cleared mangrove, and intertidal sites in New Zealand. Mangrove coverage is increasing in temperate areas, and the importance of these mangroves in carbon cycling is well known. Therefore the research question of what happens to this carbon when the mangroves are cleared is a valuable one to explore.

Author's response: We thank the referee for the detailed and constructive comments. We agree that research investigating the fate of carbon when mangrove forests are cleared is valuable, as well as the relative contribution to the atmosphere.

My general feeling with this paper is that it suffering a little bit from an identity crisis, is it an ecology or biogeochemistry paper. For example the inclusion of macrofauna data seems to have no relevance, particularly in light of the fact that this parameter was not measured in the "control" treatments (i.e. the undisturbed mangrove sites). While the importance of macrofauna in sediment respiration rates is well established in previous studies, in this paper there is really no exploration of the relationship between macrofauna and CO2 fluxes. For example – were any of the flux incubations carried out over crab burrows? If so was there a relationship between burrow size/density with the flux rate (for example see Kristensen et al. 2008)? Does the loss of crab burrows = lower CO2 fluxes? On the same note, what about pneumatophores? Similarly, tree biomass, root mass etc are not really adequately explored to warrant inclusion. There is a lot of data that is just thrown into the manuscript with little consideration as to how it fits into the CO2 flux story.

Author's response: Based on the referee's comment we removed the macrofaunal data. We kept the tree biomass, root mass, and pneumatophore abundance data and described their role in influencing sediment CO_2 efflux in more detail in the discussion.

Changes to manuscript:

Higher sediment CO_2 efflux observed within our study may partly be explained by the inclusion of crab burrows and short pneumatophores within flux measurements. The omission of crab burrows and pneumatophores has previously been proposed as a potential explanation of why global estimates may be underestimated (Bouillon et al., 2008). Crab burrows have been shown to increase CO_2 efflux by increasing the surface area for sediment-air exchange of CO_2 (Kristensen et al., 2008) and enhancing carbon decomposition processes (Pülmanns et al., 2014). Pneumatophores have been associated with increased CO_2 emissions by efficient translocation of CO_2 exchange from deeper sediments (Bouillon et al., 2008; Kristensen et al., 2008).

Comment from referee: There needs to be a greater detailing of methodology. For example there needs to be the inclusion of equations for CO2 flux measurements, criteria for inclusion/exclusion of fluxes (i.e. the linearity of the fluxes), what are the empirical equations used to determine biomass, did the use of different equations for biomass depending on tree height induce any differences."

Author's response: We substantially revised the methods section. Equations for CO_2 flux measurements, criteria for inclusion of fluxes, and the equations used to determine biomass have been included. No changes in the significance of the relationship between biomass and CO_2 efflux was observed using diameter rather than height for the two sites where height exceeded the range of the allometric equation.

Please see the earlier comments regarding changes to the fluxes.

Other changes to manuscript:

Within intact mangrove forests the tree height of the closest 5 mangrove trees to each measurement/sampling point and the density (number of mangroves within a 2 m x 2 m area) was recorded. Above ground biomass was estimated using the allometric equations developed for Avicennia marina in New Zealand (Woodroffe, 1985):

$$\text{Total above ground biomass}^{-1/3}\ \text{(g dry weight)} = -4.215 + 0.121 \times \text{Height (cm)} \quad (3)$$

At two sites, Mangere 1 (Auckland) and Hatea 1 (Northland) mangrove height exceeded the range the allometric equation was designed for (determined from trees ranging in height from 40 to 248 cm) and measures of trunk diameter were instead used to estimate biomass (based on the trunk diameter at 30 cm height of the closest 5 mangrove trees to each sampling point):

$$\text{Total above ground biomass}^{-1/3}\ \text{(g dry weight)} = 0.264 + 2.597 \times \text{Diameter (cm)} \quad (4)$$

At each clearance site a quadrat (0.5 m x 0.5 m) was sampled at three haphazardly placed locations (within a 10 m radius). The following metrics were recorded within each quadrat, the proportion of surface covered by mangrove leaf litter, proportion of surface covered by macroalgae, number of mangrove seeds and seedlings, and number of pneumatophores. Further, three randomly located root biomass cores (13 cm diameter, 15 cm depth) were collected at each clearance site. After sorting, all vegetative material was air dried for one week on aluminium trays, and then oven dried at 70 ºC for approximately 4 days until dry weight stabilised. Weights for each mangrove constituent were then recorded (fine root mass = root diameter ≤ 2 mm, thick root and pneumatophore mass > 2 mm, and total root mass). No cores were collected from intact mangrove forest sites.

Comment from referee: Further, some of the geochemical interpretations are a little bit too qualitative to be included in any kind of analysis (e.g. redox depth charecterization and compaction). For example, looking at the redox depth by change of sediment color is fine in a 2 dimensional system, however when you have biogenic structures such as crab burrows, roots, pneumatophores etc. this analysis is not appropriate.

Author's response: Measures of oxic depth and sediment compaction have been removed from the manuscript. We note that no significant correlation or regression was observed between these sediment properties and sediment CO_2 efflux.

Comment from referee: Looking at the influence of biofilm removal on CO2 fluxes is an interesting aspect, however without undertaking "light incubations" the interpretation is limited. Most of the CO2 uptake is likely to be by photosynthetic organisms, rather than chemosynthetic. While the reference of Leopold et al 2013 is used to justify the lack of light incubations, I would like to see a better explanation considering the Leopold study was in New Caledonia (Latitude 20 S with a very high mangrove density and therefore low light penetration to the sediments), as opposed to this study at 35 S with low mangrove density (and presumably higher light penetration). Also, considering that 2 of the treatments are free of mangroves (i.e. cleared and tidal flats), one would assume that the importance of photosynthetic organisms in these sites would be even higher.

Author's response: We modified the discussion to address these aspects, including a considerable expansion to potential causes of CO_2 uptake. Please refer to earlier comments for further details.

Comment from referee: Some more details on the biofilm removal procedure would also assist the reader, for example how long after the removal was the incubation started (i.e. was time given for the sediment to reach a steady state).

Author's response: Further information on the biofilm removal procedure has been included in the manuscript. Measurements were made within 30 seconds following the removal of the surface biofilm on the identical location to the corresponding biofilm intact measurement. Only flux measures with an r^2 greater than 0.8 were included. Typically the r^2 values of the biofilm removed flux values exceeded 0.95.

Changes to manuscript: In addition to measuring CO_2 efflux in intact (undisturbed) sediment, sediment CO_2 efflux was re-measured at the same location after the removal of the surface biofilm. Measurements were made within 30 seconds following the removal of the surface biofilm.

Comment from referee: I am not convinced the normalization procedure used (i.e. the calculation of the CO2prop value) is suitable for such small sample sizes (i.e. n=3 for each of the paired sites). For example do all the "cleared" sites have similar vegetation, are all the tidal flats, mangrove sites and cleared sites at the same height, and experience the same hydrodynamics? This is important because you are using the fluxes from these sites to normalise your data, therefore there needs to be some consistency there. Also it is unclear whether the n=3 relates to 3 incubations over the same sediment, or 3 separate incubations. Either way there is not enough replication there, I would think at each site a bare minimum would be triplicate incubations at 3 sub-sites (n=9). My experience with these incubations is that the spatial variability is quite large, and therefore replication is important. Particularly when looking at the mangrove sites where biogenic structures (e.g. crab burrows and pneumatophores) play such a large role. My feeling as that the authors have focused too much on sampling as many sites as possible, at the expense of adequate within site replication (spatial and temporal).

Author's response: The CO_2 proportion value was used in an attempt to control for the factors which may confound the relationship between CO_2 efflux and time since clearing. However, we acknowledge that a number of assumptions are made in this calculation. We removed the CO_2prop calculation from the analysis and focused the discussion on factors which may be influencing efflux within intact and cleared mangrove forest, rather than the relationship between CO_2 efflux and time since mangrove forests were cleared.

Additional information regarding where the three CO_2 efflux measures were collected at each site has been included in the manuscript. Measurements were haphazardly located at least 1 m apart. We acknowledge that spatial variation in measurements is quite large, both within and between sites. However, the mean variability within a site (CV = 0.55 for intact mangrove and 1.1 for cleared mangroves) was lower than among sites (CV = 0.99 for intact mangroves and CV = 1.34 for cleared mangroves). While increased replication in fewer sites would improve individual site estimates, we feel there is benefit to demonstrating that CO_2 efflux also varies significantly between different sites. By sampling at a large number of sites we are able to provide an overall estimate of CO_2 efflux from intact and cleared mangrove forest that better accounts for this difference than if fewer sites were included.

Comment from referee: I would like to see more figures to illustrate your key points, for example a few simple plots of CO2 flux rates vs drivers (e.g. sediment organic C, chlorophyll a, temperature etc.) would add significant value to this paper. It would be also good to put some of these fluxes into context with other mangrove carbon cycling processes, such as NPP, burial and lateral tidal export. While not specifically measured in this study, these factors are key components and should at least rate a mention in the intro.

Author's response: Figures of significant linear relationships between CO_2 efflux and mangrove biomass, and CO_2 efflux and sediment organic carbon concentration have been included in the manuscript. A section where the fluxes are put into the context of other mangrove carbon cycling processes has been included in the introduction.

Changes to manuscript:

Included in the introduction:

Carbon (C) cycling and storage are important ecosystem services provided by mangrove forests (Alongi, 2014; Bouillon et al., 2008; Kristensen et al., 2008; Twilley et al., 1992). Global net primary productivity in mangrove forest has been estimated at 218 ± 72 Tg C a^{-1}, which includes the rate of litterfall, above- and below-ground biomass production (Bouillon et al., 2008). An important component of the carbon cycle is the efflux of carbon dioxide (CO_2) from the sediment into the atmosphere (Raich and Schlesinger, 1992). Sediment CO_2 efflux (also called soil/sediment respiration) is the total of CO_2 released through root/mycorrhizae respiration (autotrophic respiration) and microbial respiration (heterotrophic respiration) associated with the decomposition of organic matter (Bouillon et al., 2008).

Included in the results:

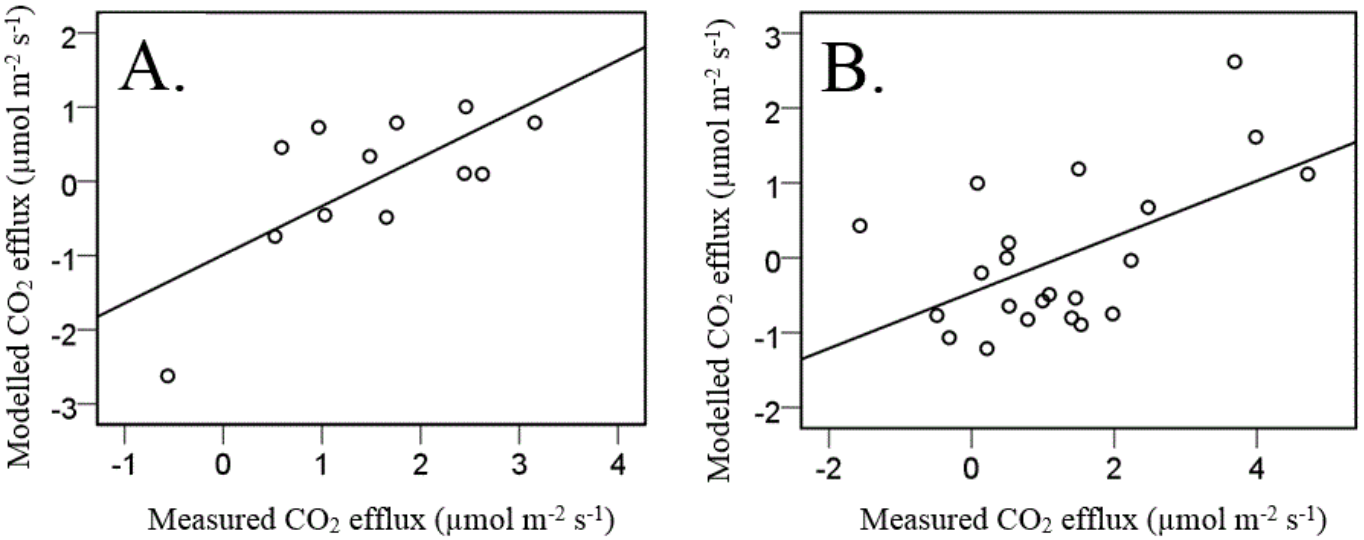

Figure 4: Model A. Modelled values of mangrove forest CO_2 efflux (based on mangrove biomass) compared to measured CO_2 efflux ($y = -0.73 + 0.59 * x$, $r^2 = 0.49$, $p < 0.01$). Model B. Modelled values of cleared mangrove forest CO_2 efflux (based on sediment organic carbon concentration) compared to measured CO_2 efflux ($y = -0.47 + 0.37 * x$, $r^2 = 0.32$, $p < 0.01$).

Comment from referee: Some specific comments are listed below: Page 3550 Line 7 – CO2 efflux is due to heterotrophic processes (in both autotrophs and heterotrophs), CO2 uptake is due to chemoautotrophic and photosynthetic processes. This sentence needs a rewrite

Author's response: This sentence has been modified.

Changes to manuscript:

Sediment CO_2 efflux (also called soil/sediment respiration) is the total of CO_2 released through root/mycorrhizae respiration (autotrophic respiration) and microbial respiration (heterotrophic respiration) associated with the decomposition of organic matter (Bouillon et al., 2008).

Comment from referee: Page 3552 Line 10 Nothing in the supplementary table about hydrodynamics – this would be welcomed though

Author's response: The supplementary table has been modified to include whether the site is exposed or sheltered.

Comment from referee:

Page 3552 Line 24 What are the dimensions of the chamber

Page 3553 Need to include the equations used for CO2 flux calculations along with acceptance/rejection criteria for fluxes

Author's response: The methods section was revised. Please refer to earlier comments.

Comment from referee: Page 3553 Line 15 There is a big difference between mangroves and climate in New Caledonia and New Zealand, can the authors justify the use of dark chambers only based on some of their own data? Looking at those high chlorophyll a concentrations I would expect a lot of photosynthetic activity in these sediment.

Author's response: Our aim was to investigate the losses of CO_2 from the sediment following clearing of temperate mangroves. Thus we measured CO_2 efflux using dark respiration chambers. We acknowledge that transparent chambers are critical to study the difference between photosynthesis and respiration (ecosystem) CO_2 fluxes.

Comment from referee: Page 3554 Line 2 As mentioned above, I am not convinced you can use this normalization procedure with such a small sample size in the paired sites

Author's response: The normalization procedure has been removed.

Comment from referee: Page 3555 Chl a analysis needs a few more refs – what equations wavelengths etc were used.

Author's response: The wavelengths and equation for the chlorophyll α analysis procedure has been included in the methodology.

The following modifications were made to the manuscript:

Chlorophyll α concentration was calculated based on the following equation:

$$Chlorophyll\ \alpha\ (\mu g\ g-1\ sediment) = \big((750a - 665a) - (750 - 665)\big) x\ Abs\ x\ \frac{Ethanol\ in\ extraction\ (l)}{Sediment\ analysed\ (ug)} \quad (2)$$

Where 750 and 665 is the absorption at wavelengths 750 and 665 nm, 750a and 665a is the absorption at wavelengths 750 and 665 nm after acidification with 0.05 mL 1 mol HCl and Abs is the absorbance correction for chlorophyll in ethanol (28.66)

Comment from referee: Page 3555 Tree biomass section needs some fleshing out, what were the allometric equations, was there a difference between the diameter vs height equations etc. Also only one 2 x 2m quadrant per site for density and only 5 trees per site for biomass seems too small a sample size. There are a number of protocols out there for measuring C stocks in mangroves (e.g. see the blue carbon initiative) I would recommend that the authors look closely and refer to these resources.

Author's response: The allometric equations for the tree biomass equations and differences between the diameter vs height equations have been included in the methodology. We acknowledge the referees comment that the measures used to measure C stocks in mangrove sites were based on small sample sizes. Still, we feel the tree based information provides useful information to understanding the processes influencing sediment CO_2 efflux

Comment from referee: Page 3556 Line 1 – See comment above re. redox depth in 3D sediments structure.

Author's response: The measurements of oxic depth and sediment sink have been removed from the manuscript.

Comment from referee: Page 3556 Line 10 If no macrofauna were collected analysed at "mangrove" sites then I feel it is not worth including as no cross comparisons can be made. The macrofauna data is not explored in any detail so I would recommend removal.

Author's response: The macrofauna data has been removed from the manuscript as suggested by the referee.

Comment from referee: Page 3557 Line 16 – This analysis does not add anything to the CO2 flux story.

Author's response: The manuscript has been modified with this line removed.

Comment from referee: Page 3558 Line 4 – Hard to believe that chemosynthetic CO2 uptake exceeded all respiratory processes in the tidal flats! No light therefore no photosynthesis, but plenty of OC and Chl a therefore one would expect in the dark that respiration would exceed fixation.

Author's response: The manuscript has been modified to focus on CO_2 efflux from intact and cleared sediment, with tidal flat data removed. We note that the r^2 of the linear regression of the change in CO_2 efflux at many of the tidal flat sites was less than 0.8, originally included due to minimal change in flux at many of locations leading to poor r^2 values. An expansion of the possible reasons for CO_2 uptake has been included in the manuscript discussion as well as additional testing of pre-shaded sediments.

Comment from referee: Page 3558 Line 13. The whole paragraph bares little relevance to the CO2 story. Perhaps a separate paper on changes in macrofauna abundance could be written, but in its current form it seems this data is just an added extra with no relevance.

Author's response: We have removed the data/discussion on macrofauna abundance

Comment from referee: Page 3558 line 24 – Would be good to have some figures showing these relationships, and those on the next page. One thing to consider is that a lot of this factors are likely covariates, e.g. OC, N and sediment composition are likely all driven by hydrodynamics and organic matter supply. Therefore teasing apart what is actually driving the CO2 flux story is a little more complicated than simple correlation analysis.

Author's response: The manuscript has been modified to include figures of the significant linear regressions. The influence of site hydrodynamics and organic matter supply has been expanded on within the discussion.

Comment from referee: Page 3560 Line 2 and 4 – the Figure states $p < 0.05$, need to be consistent

Author's response: These values have been updated

Comment from referee: Page 3560 Line 2 and 4 – the Figure states p

Author's response: This values has been updated

Comment from referee: Page 3560 Line 17 What about mangrove NPP and hydrology?

Author's response: The manuscript has been modified to include consideration of mangrove NPP and hydrology. Please refer to earlier response

Comment from referee: Page 3561 Line 6 to 12 No light incubations to test this!

Author's response: We acknowledge that no light chamber measurements were collected, however we infer that higher chlorophyll a concentrations measured in the sediment may be used as a proxy for increased photosynthetic activity (Bishop, 2007).

Comment from referee:Page 3562 Line 1 and 2 – no statistical difference between mangroves and cleared (previous sentence and Figure 2), yet talk about why the flux is lower in cleared in these sentences.

Author's response: The manuscript has been revised.

Changed to the discussion:

We did not find a significant difference in sediment CO_2 efflux between intact and cleared mangrove forest sites. Further, we did not find a relationship between time since clearing and sediment CO_2 efflux. In contrast, sediment CO_2 efflux from cleared peat mangrove forests in Belize declined logarithmically over a 20 year period (Lovelock et al., 2011). Two months after the clearing of mangroves in Kenya, sediment CO_2 efflux increased approximately two fold before returning to comparable levels to adjacent intact mangrove forests approximately five months after clearance (Lang'at et al., 2014). It is likely that a number of factors (such as differences in site sediment characteristics, size, exposure, and method of clearance) are confounding the effect of time since clearing on sediment CO_2 efflux in our study.

Comment from referee: Page 3563 Line 2 - 9 Elaborate on this some more

Author response: The manuscript has been revised. Macrofaunal data has been removed from the analysis based on referee recommmendations.

Comment from referee: Page 3564 Line 11 – 20 Did you do incubations over crab burrows? If so is there arelationship between flux and burrow size/density?

Author response: Yes, however no significant relationship was observed between crab burrow abundance and CO2 efflux. However, we have expanded on the potential impact of including crab burrows and pneumatophores within flux chambers in the discussion.

Comment from referee: Page 3565 Line 1 – 9 I think the biofilm discussion is a little weak without accounting for the influence of phototrophic CO2 uptake (i.e. light incubations). I would like to see some discussion about this, or at least an acknowledgement.

The manuscript has been modified to include greater consideration of phototrophic CO_2 uptake.

Please refer to earlier comments.

Thank you for your valuable suggestions on this manuscript.

References cited:

Alongi, D. M.: Carbon Cycling and Storage in Mangrove Forests, Annu. Rev. Marine. Sci., 6, 195-219, 2014.

Boschker, H. T. S., Vasquez-Cardenas, D., Bolhuis, H., Moerdijk-Poortvliet, T. W. C., and Moodley, L.: Chemoautotrophic carbon fixation rates and active bacterial communities in intertidal marine sediments, PLoS ONE, 9, 1-12, 2014.

Bouillon, S., Borges, A. V., Castañeda-Moya, E., Diele, K., Dittmar, T., Duke, N. C., Kristensen, E., Lee, S. Y., Marchand, C., Middelburg, J. J., Rivera-Monroy, V. H., Smith Iii, T. J., and Twilley, R. R.: Mangrove production and carbon sinks: A revision of global budget estimates, Global Biogeochem. Cy., 22, 2008.

Krauss, K. and Whitbeck, J.: Soil greenhouse gas fluxes during wetland forest retreat along the lower Savannah river, Georgia (USA), Wetlands, 32, 73-81, 2012.

Kristensen, E. and Alongi, D. M.: Control by fiddler crabs (*Uca vocans*) and plant roots (*Avicennia marina*) on carbon, iron, and sulfur biogeochemistry in mangrove sediment, Limnol. Oceanog., 51, 1557-1571, 2006.

Kristensen, E., Bouillon, S., Dittmar, T., and Marchand, C.: Organic carbon dynamics in mangrove ecosystems: A review, Aquat. Bot., 89, 201-219, 2008.

Lang'at, J. K. S., Kairo, J. G., Mencuccini, M., Bouillon, S., Skov, M. W., Waldron, S., and Huxham, M.: Rapid losses of surface elevation following tree girdling and cutting in tropical mangroves, PLoS ONE, 9, e107868, 2014.

Lenk, S., Arnds, J., Zerjatke, K., Musat, N., Amann, R., and Mußmann, M.: Novel groups of Gammaproteobacteria catalyse sulfur oxidation and carbon fixation in a coastal, intertidal sediment, Environ. Microbiol., 13, 758-774, 2011.

Leopold, A., Marchand, C., Deborde, J., and Allenbach, M.: Temporal variability of CO_2 fluxes at the sediment-air interface in mangroves (New Caledonia), Sci. Total Environ., 502, 617-626, 2015.

Leopold, A., Marchand, C., Deborde, J., Chaduteau, C., and Allenbach, M.: Influence of mangrove zonation on CO_2 fluxes at the sediment-air interface (New Caledonia), Geoderma, 202-203, 62-70, 2013.

Lovelock, C. E.: Soil respiration and belowground carbon allocation in mangrove forests, Ecosystems, 11, 342-354, 2008.

Lovelock, C. E., Feller, I. C., Reef, R., and Ruess, R. W.: Variable effects of nutrient enrichment on soil respiration in mangrove forests, Plant Soil, 379, 135-148, 2014.

Lovelock, C. E., Ruess, R. W., and Feller, I. C.: CO_2 efflux from cleared mangrove peat, PLoS ONE, 6, 2011.

Ma, J., Wang, Z.-Y., Stevenson, B. A., Zheng, X.-J., and Li, Y.: An inorganic CO_2 diffusion and dissolution process explains negative CO_2 fluxes in saline/alkaline soils, Scientific Reports, 3, 2025, 2013.

Oakes, J. M. and Eyre, B. D.: Transformation and fate of microphytobenthos carbon in subtropical, intertidal sediments: potential for long-term carbon retention revealed by 13C-labeling, Biogeosciences, 11, 1927-1940, 2014.

Santoro, A. L., Bastviken, D., Gudasz, C., Tranvik, L., and Enrich-Prast, A.: Dark carbon fixation: An important process in lake sediments, PLoS ONE, 8, e65813, 2013.

Thomsen, U. and Kristensen, E.: Dynamics of sigma CO_2 in a surficial sandy marine sediment: the role of chemoautotrophy, Aquat. Microb. Ecol., 12, 165-176, 1997.

Twilley, R. R., Chen, R. H., and Hargis, T.: Carbon sinks in mangroves and their implications to carbon budget of tropical coastal ecosystems, Water Air Soil Pollut, 64, 265-288, 1992.

Woodroffe, C. D.: Studies of a mangrove basin, Tuff Crater, New Zealand: I. Mangrove biomass and production of detritus, Estuar. Coast Shelf. S., 20, 265-280, 1985.