**DISCUSSION OUTLINE**

Coral fertilisation success and larval survivorship were affected by multiple water quality factors. Our approach allowed us to estimate the relative importance of these factors (Table 2 and 3). Suspended sediment, phosphate, ammonium, copper and salinity significantly reduced fertilisation success, illustrating the sensitivity of larvae to their environment. Larval survivorship was most affected by the presence of the heavy metals copper and lead, but was also affected by temperature.

* Discus the use of the combined model and location based data

Our research demonstrates the use of a single model to combine and estimate the relative importance of a range of environmental factors in estimating the success of early life history stages in corals.

* Heavy metals including copper and lead are known to have widespread negative impacts on marine invertebrates ([Reichelt-Brushett and Harrison 2004](#_ENREF_51" \o "Reichelt-Brushett, 2004 #13); [Rivera-Duarte et al. 2005](#_ENREF_55" \o "Rivera-Duarte, 2005 #6); [Wang et al. 2009](#_ENREF_66" \o "Wang, 2009 #14); [Fitzpatrick et al. 2008](#_ENREF_22" \o "Fitzpatrick, 2008 #8); [Caldwell et al. 2011](#_ENREF_12" \o "Caldwell, 2011 #11)).
  + Copper, which significantly affects both life history stages occurs naturally within the marine environment however, is in excess due to its use in anti-fouling agents on vessels ([Reichelt-Brushett and Harrison 2004](#_ENREF_51" \o "Reichelt-Brushett, 2004 #13); [Negri and Heyward 2001](#_ENREF_43" \o "Negri, 2001 #3)).
  + Lead was also found to significantly reduce larval survivorship and is of concern as it can be found in high levels in nearshore reef environments as a result of industrial activities.
* Suspended sediment was also shown to significantly reduce fertilisation success in corals.
* Natural and anthropogenic disturbances ranging from storms to seafloor dredging increase the amount of suspended sediment within marine environments, especially in shallower or nearshore habitats ([Humphrey et al. 2008](#_ENREF_35" \o "Humphrey, 2008 #46); [Erftemeijer et al. 2012](#_ENREF_19" \o "Erftemeijer, 2012 #69); [Styan and Rosser 2012](#_ENREF_62" \o "Styan, 2012 #63)).
* Similar to the suspended sediment response, the introduction of nutrients including phosphate and ammonium reduced fertilisation success.
* These nutrients are common in run-off from agricultural land uses and has been shown to severely diminish water quality and in some cases lead to anoxic surface waters ([Correll 1998](#_ENREF_15" \o "Correll, 1998 #17); [Harrison and Ward 2001](#_ENREF_31" \o "Harrison, 2001 #43)).
* Water temperature and salinity both affected coral early life stages with temperature changes decreasing fertilisation and changes in salinity decreasing larval survivorship.
* Increased water temperatures as a result of climate change threaten marine environments and therefore coral reefs ([Solomon et al. 2007](#_ENREF_60" \o "Solomon, 2007 #83)).
* Episodic increases in freshwater influxes, decreasing salinity as a result of increase storms and runoff from urban areas is also a significant threat to coral larval survival (Knutson et al. 2010; Scott et al., 2013).

To be successful, an individual needs to survive both stages of development (fertilisation and larval survivorship).

* To demonstrate our models use in a real-world scenario, we incorporated episodic data collected from three locations. Water was collected from inside and outside Sydney Harbour (Chowder Bay and Mona Vale, respectively) to highlight the difference between water qualities within the harbour compared to water collected outside the heads.
* Discuss results
* Results were not what we expected – mainly as a result of differing salinity and low levels of salinity at Mona Vale
* This analysis is an example only based on a one-off single water sample. This example was used to

As an example we conducted a joint probability analysis for each of the three locations Chowder Bay and Mona Vale in Sydney as well as Lizard Island to determine the likelihood of a single egg at any location surviving through fertilisation, as well as up to 14 days within the plankton

* While larvae can survive for longer than this within the surface waters, this model was created to include larvae within their peak competency period who are most likely to settle within their natal reef ([Richmond 1997](#_ENREF_54); [Connolly and Baird 2010](#_ENREF_13)).
* Combined model is just an example – again not what we expected to see but show’s it use
* Model can incorporate more than a single factor and can be based on actual water quality at different sites, to determine the effect of pollutants on larval development.

Our study is significant because it estimates the relative importance of various environmental factors on the early life history stages of corals. However, there were several issues that might have influenced the predictive capacity of the models.

* Based on few papers - ~20 papers
* Variation in species and
* Interactions between factors?

While this analysis is small in scale it does highlight the practical applications of generalised linear models. Within the changing global environment the ability to predict success and particular in the early life history stages of sensitive sessile adult species is imperative for their survival and proliferation in novel environments.

* Future studies
  + Focus on next life history
  + Identify bottleneck and develop pollution level thresholds
  + Dispersal and recruitment success at any location
  + Coral success in novel environments – climate change and range shifts