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Growth of three species of Mediterranean cold-water corals exposed to ocean acidification

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ABSTRACT

Increasing pCO_2 in the atmosphere results in ocean acidification. The changes in ocean chemistry posed by such phenomenon pose an imminent threat to calcifying organisms such as cold-water waters corals. Very little information is available on the effect such a threat poses on cold-water corals. Three species of Mediterranean cold water corals (*Lophelia pertusa*, *Madrepora oculata* and *Desmophyllum sp*) were exposed to ocean acidification conditions. Four separate pCO_2 levels were represented: 412 ± 73 ppm, 497 ± 117 ppm, 665 ± 100 ppm, and 866± 191 ppm. Coral response was measured using several methods of assessing growth: buoyant weight, colour (area) projection, new polyp development, and skeletal density. Response to ocean acidification was shown to be species specific with *Lophelia pertusa* being generally more affected (a reduction of over 40% buoyant weight per day on higher pCO_2 compared to lowest pCO_2) than *Madrepora oculata*. Growth rate was not clearly influenced by ocean acidification in *Desmophyllum sp*. After 9 months of experiment, polyp development and skeletal density were not significantly altered by ocean acidification. A reduction in projected colour (area) was observed for both *Madrepora oculata* and *Lophelia pertusa* area under medium and high ocean acidification scenarios (*Madrepora oculata* over 50% colour (area) per day on higher pCO_2 compared to lowest pCO_2 ; *Lophelia pertusa* nearly 50% colour (area) per day on higher pCO_2 compared to lowest pCO_2). Response of the three species assessed was not linear, possibly due to several sources of variation interacting with acidification. That *Lophelia pertusa* consistently performs better at lower acidification scenarios has implications for the future of the deep-sea coral community and species associated.

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LIST OF ABBREVIATIONS

pCO_2	-Partial pressure of carbon dioxide
fCO_2,	-Fugacity of carbon dioxide
H^+	-Hydrogen ion
H_2CO_3	-Carbonic Acid

HCO_3^-,	-Bicarbonate
CO_3^{-2}	-Carbonate
Ca^{+2}	-Calcium
$CaCO_3$	-Calcium Carbonate
$HgCl_2$	-Mercury Chloride
^{45}Ca	-Radioactive calcium isotope
Ωa	-Aragonite saturation state
Ωc	-Calcite saturation state
A_T	-Total alkalinity
TA	-Total alkalinity
C_T	- Dissolved Inorganic Carbon
DIC	- Dissolved Inorganic Carbon
mS/cm	-miliSiemens per centimetre
ppm	-Part Per Million
µatm	-microatmospheres (equivalent to ppm)
G	- Growth rate (% increase in buoyant weight/day)
Wd	-Final weight (g)
Wo	- Initial weight (g)
d	-Interval of time (days)
χ^2	-Chi Square test statistic
H-F	- Huyhn-Feldt adjusted test statistic
LUT	-Look up tables (a feature of Fiji, image software)
ROV	-Remotely Operated Vehicle
RM ANOVA	-Repeated Measurements Analysis of Variance

1 **Introduction** ....

1.1 Cold water corals ....

Cold-water, or deep-sea corals receive such denomination due to the temperatures of 4-12°C and depths of ~50-3000m they inhabit (Rogers, 1999; Murray-Roberts et al, 2006). At such depths these corals are unable to host photosynthetic zooxanthellae, and thus rely nutritionally on zooplankton predation (Duineveld et al, 2004; Tsounis et al, 2010), and bacteria and detritus to a lesser extent (Murray-Roberts et al, 2006). Due to this type of nutrition and the cold waters they inhabit, their growth rate is considered slow compared to shallow water corals (linear skeletal extension rate of deep-sea *Lophelia sp* ~26mm/y (Bell and Smith, 1999), linear skeletal extension rate of shallow water *Acropora sp* ~10cm/yr (Charucinda and Hylleberg, 1984)). Despite their relatively low growth rates, some species of cold-water corals are able to form bioherms which are reef-like structures comparable to shallow-water reefs (Rogers, 1999).

Because of the difficulties in accessing cold-water coral habitat, these corals have been much less studied than their shallow-water counterparts. Early literature on cold water corals is mainly limited to their taxonomy, distribution, and palaeontology (e.g. Rossi, 1961; Squires, 1961; Cairns, 1994 and references therein; Taviani et al, 2005 and references therein). However recent development of deep-sea exploration (e.g. submersibles, remote videoing, and sonars) has helped improved mapping of cold water corals distribution; understanding their biology and ecology better; and allow extraction of live samples for experiments.

1.1.1 Taxonomy, Global and Mediterranean Distribution ....

Cold-water corals are members of the scleractinian (hard skeleton) order.

Distribution of cold-water corals around the world is determined by a combination of salinity, temperature (Guinotte et al, 2006), biogeography (Rogers, 1999), topography (e.g. availability of hard substrata) (Rogers, 1999) and hydrographic features (Murray-Roberts et al, 2006). Corals rely on currents of sufficient speed to prevent smothering by falling sediments, whilst allowing feeding on zooplankton (Rogers, 1999; Murray-Roberts et al, 2006).

Mapping of cold-water corals global distribution is still a work in progress. What is currently known is that at low latitudes, preferred conditions for cold-water coral growth occur below warmer waters (i.e. 4000m); on the other hand at high latitudes these conditions are met within the first 50-1000m (Murray-Roberts et al, 2006). The centre of cold-water corals species diversity is located around the Philippines (Murray-Roberts et al, 2006). However in terms of cold-water coral coverage, the north Atlantic ranks first (Rogers, 1999; Murray-Roberts et al, 2006).

The Mediterranean waters are characterised by their oligotrophic nature, high temperature and high salinity (Carlier et al, 2009). Under such characteristics, Mediterranean cold-water corals are believed to be at the limit of their thermal tolerance (Freiwald et al, 2004). The three species studied in this experiment are among the most common species in the Mediterranean mounds: *Lophelia pertusa* (Linné, 1758), *Madrepora oculata* (Linné, 1758) and *Desmophyllum sp* (Esper, 1794) (Tursi et al, 2004; Taviani et al, 2005)

Lophelia pertusa (Family: Carophylliidae)

Also known as “white coral”, this species forms tree-like colonies which can in turn form large stony mounds, or bioherms, of up to 100km^2 long (Freiwald et al, 2004) and 45m high (Rogers, 1999). Bioherms are said to act in many ways as shallow water corals reefs (Rogers, 1999).

Occurrences of *Lophelia pertusa* have been reported in all major oceans (Zibrowius, 1980a; Freiwald et al, 2004; Tursi et al, 2004) usually at depths of 50-1000m, and up to 3000m in some locations (Rogers, 1999; Murray-Roberts et al, 2006). Largest coverage of this species has been observed off the coast of Norway (Freiwald et al, 2004). While initially living samples of this species were rarely found in the Mediterranean (Zibrowius, 1980b; Rogers, 1999; Tursi et al, 2004), recent explorations have discovered flourishing populations at the East Mediterranean (Tursi et al, 2004; Taviani et al, 2005). This species is believed to be particularly vulnerable to changes in salinity and temperature (Rogers, 1999).

Madrepora oculata (Family: Oculinidae)

Commonly known as "zigzag coral", this species grows in thin branching fan-shaped structures of up to 50cm high (Tsounis et al, 2010). While not on the same scale as *Lophelia pertusa*; *Madrepora oculata* is also a bioherm constructor (Freiwald et al, 2004). It generally occurs at 50- 1000m (Schroeder et al, 2005; Murray-Roberts et al, 2006), but there are records of specimens occurring at more than 1900m (Zibrowius, 1980a; Freiwald, 2004).

While this species is more commonly recorded in the North Atlantic (Tursi et al, 2004), it has also been found in the Gulf of Mexico (Schroeder et al, 2005), along the Brazilian coast (Zibrowius 1980a), and in the Pacific and Indian oceans (Tursi et al, 2004).

In the Mediterranean this species occurs more commonly than *Lophelia pertusa* (Freiwald et al, 2004; Taviani et al, 2005), where its depth range is 80-1500m (Zibrowius, 1980b).

Desmophyllum sp (Family: Caryophyllidae)

Species of this genus are also commonly known as "cockscomb cup coral". This genus is characterized by solitary large polyps. Taxonomy within the family Caryophillidae is still being elucidated (Le Goff-Vitry and Rogers, 2005), and thus there are difficulties distinguishing species within the *Desmophyllum* genus (Addamo et al, 2010). The common size of most species within this genus is 3-10cm diameter and about 40cm (e.g. *Desmophyllum dianthus*) long (Försterra et al, 2005). The usual depth range of this species is 35-2460m (Försterra et al, 2005), but can extend down to 4km (Risk et al, 2002).

Desmophyllum sp in association with *Lophelia pertusa* and *Madrepora oculata* is also considered a frame-builder (Remia and Taviani, 2005; Taviani et al, 2005). High densities of *Desmophyllum sp* (1500 individuals per m^2) have been found on overhangs (Försterra et al, 2005)

The genus *Desmophyllum sp* has a cosmopolitan distribution (Sorauf and Jell, 1977; Zibrowius 1980). It has been recorded in the North (Sorauf and Jell, 1977) and West (Cogswell et al, 2009) Atlantic, the Chilean (Försterra et al, 2005), South African and Australian coasts (Zibrowius, 1980a).

This genus is also widespread in the Mediterranean. Records include live samples from the Balearic Sea in Spain (Taviani et al, 2005), Banyuls and Marseille in France, Santa Maria di Leuca in Italy (Tursi et al, 2004); and as far as Cyprus in the East Mediterranean (Taviani et al, 2005).

1.1.2 Biology ....

Feeding

Knowledge of cold-water coral nutrition is relatively poor (Freiwald et al, 2004). Being azooxanthellate, cold-water corals are hypothesized to rely on zooplankton (e.g. copepods), bacteria and detritus for their nutrition (Rogers, 1999; Kiriakoulis et al, 2005; Murray-Roberts et al, 2006). Recent studies confirm this hypothesis for all of the species assessed in our experiment (Carlier et al, 2009; Tsounis et al, 2010). Rates of zooplankton ingestion and preferred prey- types and sizes differ among species (Tsounis et al, 2010). Rates of ingestion for *Lophelia pertusa* were comparable to those commonly found in tropical corals (Tsounis et al, 2010). Feeding rates of *Lophelia pertusa*, *Madrepora oculata* and *Desmophyllum sp* in their natural habitat are determined by factors such as zooplankton vertical migration (Carlier et al, 2009) and seasonal surface productivity (Murray-Roberts et al, 2006).

Reproduction

Reproduction in cold-water corals has so far been one of the least studied and most difficult to investigate topics. Contrary to most shallow-water corals, most species of cold-water corals have separate sexes (gonochorist) (Waller and Tyler, 2005). Asexual reproduction has been confirmed as a common means of reproduction (Rogers, 1999; Waller et al, 2002), particularly in patches of isolated ecological conditions (Le Goff-Vitry and Rogers, 2005). Among the few studied cold-water corals, broadcast spawning is common (Waller et al, 2002; Waller and Tyler, 2005). What triggers such broadcast is still unknown but it is hypothesized that a pulse in phytodetritus may well be responsible for the periodicity in reproduction (Waller et al, 2002; Waller and Tyler, 2005). Lecithotrophic rather than planktotrophic development has been suggested as the development mode of deep-sea coral larvae (Waller et al, 2002; Le Goff-Vitry and Rogers, 2005; Waller, 2005). Because of the difficulties in finding suitable hard substrata on which cold-water corals can settle, it has been suggested that deep-sea coral larvae have long competency (Waller and Tyler, 2005). However, until more data help backup this theory, relatively poor energetic sources at deep-sea would render such suggestion somewhat implausible (Waller and Tyler, 2005).

1.1.3 Ecology...

Supporting biodiversity

Lophelia pertusa has been recognized for its ability to transform an otherwise life-impoverished environment into a thriving deep-sea community (Costello et al, 2005; Turley et al, 2007). Its physical structure is what confers such ability to this species (Rogers, 1999). As previously mentioned, the so-called "*Lophelia* reefs" in many cases include also *Madrepora oculata* and *Desmophyllum sp*. About 1000 species have been found co-occuring with *Lophelia* reefs (Rogers, 1999). Whether they are obligate or facultative inhabitants of *Lophelia* reefs is not yet fully known (Rogers 1999; Murray-Roberts et al, 2006). However it is plausible cold-water corals act as refugia and feeding ground (Carlier et al, 2009) of many of the species they are associated with. This list of species found includes sponges, molluscs, cnidarians, annelids, crustaceans and bryozoans (Tursi et al, 2004; Mastrototaro et al, 2010). From these many are new to science (Rogers, 1999; Mastrototaro et al, 2010). Several species of fish, including more than 60% of commercial interest (Costello et al, 2005) have been found on *Lophelia* reefs.

Functionality in the ecosystem

Besides increasing habitat complexity (Rogers, 1999; Fossa et al, 2002), there are other ecological roles of cold-water corals. Presence of corals alters the trophic relationships (Carlier et al, 2009) and chemistry of the surrounding waters (Gattuso et al, 1998; Palmer and Totterdell, 2001). For example the impact of cold-water corals on the population dynamics of zooplankton (Tsounis et al, 2010) and bacteria (Hansson et al, 2009) has only started to be investigated. The effect of parasites although identified, has not been assessed (Freiwald et al, 2004). Coral predators have also been identified and include gastropods, and echinoderms; however we have little knowledge about the rates of predation and in general the trophic dynamics of this association (Freiwald et al, 2004). A large bioeroding community (bacteria, fungi, sponges, bryozoans) has been described in association with cold-water corals (Beuck and Freiwald, 2005). Through abrasion, corrosion and in cases calcifying; bioeroders actively modify reef structure (Rogers, 1999; Beuck et al, 2010). Bioeroders interact with local hydrodynamics and temperature changes to yield a reef's final physical structure (Manzello et al, 2008). Given their close association with corals, as bioeroder communities are identified and quantified (Beuck et al, 2010), their use as health indicators for corals is facilitated (Beuck and Freiwald, 2005).

Furthermore corals, as other calcifying organisms, play an important role in the global carbon cycle and budget of the ocean (Barker et al, 2003; Broecker, 2009; Doney et al, 2009). Such role has been recently highlighted as climate change awareness has risen. Besides temperature changes ocean acidification (Chapter 1.3) is now recognized as "the other" global threat posed by increasing emission of greenhouse gases (Doney et al, 2009; Veron et al, 2009). Coral's vulnerability to ocean acidification is only started to be understood. The effect of ocean acidification on corals is most likely to affect other organisms, ultimately including humans.

Coral skeletons as paleoarchives

Being long-lived and of wide distribution, deep-sea corals represent an invaluable source of palaeographic information (Murray-Roberts et al, 2006). Well-preserved coral fossil samples help us characterize past bodies of water (their temperature, salinity, etc.) (Lutringer et al, 2005; Risk et al, 2005); infer about the formation and structure of ancient cold-water coral communities (Buddemeier and Kinzie, 1976; Stanley and Cairns, 1988; Greenstein and Pandolfi, 1997), and in combination with modern techniques; predict changes in coral community structure (Jackson and Erwin, 2006)

1.1.4 Threats to Cold water corals ....

Cold-water corals are said to be at “multiple jeopardy” (Hofmann, 2008), that is, their existence is simultaneously threatened by several factors (Buddemeier and Smith, 1999; Veron et al, 2009). They are menaced physically by deep-sea trawling as well as the search and exploitation of energy reserves in the ocean. Besides these fairly localized threats; deep-sea corals are at the mercy of changes in water chemistry caused by increasing levels of greenhouse gases in the ocean (Chapter 1.3). Such changes, because of the consequential reduced pH, have come under the umbrella name of “ocean acidification”.

Deep-sea fisheries and trawling

Deep-sea trawling is considered one of the most destructive anthropogenic activities on corals (Rogers, 1999; Hall-Spencer et al, 2002; Fossa et al, 2002). In some areas up to 50% of coral habitat has been damaged by this activity (Fossa et al, 2002). With the collapse of more accessible fisheries, deep-sea fisheries have been growing (Freiwald et al, 2004; Morato et al, 2006). The three species assessed in this study are all vulnerable to deep-sea trawling (Rogers, 1999; Hall-Spencer et al, 2002; Fossa et al, 2002). Destruction of deep-sea corals is particularly devastating given the slow rate at which most of these species grow (Reyes-Bonilla, 2010). Furthermore frequent destruction of deep-sea habitat adds to the damaging effect on deep-sea corals by impeding recruitment (Hall-Spencer et al, 2002; Waller, 2005) and reattachment. Deep-sea fisheries not only directly destroy corals and coral habitat, but also influence community structure and trophic relationships at deep-sea (Morato et al, 2006). Ultimately a reduction in catch of deep-sea species is expected as a consequence of reduced coral habitat (Fossa et al, 2002; Reyes-Bonilla, 2010).

Hydrocarbon industry threat

An increasing human demand for energy sources has been translated into growing efforts to find and exploit oil and gas reserves at sea. Drilling destroys corals and potential coral habitat.

Effluents disposal and oil leaks alter physic-chemical conditions, for example creating an anoxic environment (Rogers, 1999); potentially smothering live corals (Freiwald et al, 2004) and preventing recruitment (Rogers, 1999). The full extent of physiological and behavioural consequences such as clogging of respiratory structures by increase sedimentation (Rogers, 1999) or excessive mucus production to cope with unfavourable chemical environment (Brown and Bythell, 2005) produced by the activities of the industry, are yet to be better understood.

Interestingly, *Lophelia pertusa* specimens and other scleractinians have been found growing on top of oil rig structures and other man-made structures (Bell and Smith, 1999; Freiwald et al, 2004). While this has to be kept in mind for the conservation and fisheries potential of oil rigs' decommissioning (Soldal et al, 2002; Ponti et al, 2002; Freiwald et al, 2004); caution is advised in promoting rigs as artificial recruitment structures. This is because among other reasons, whether these structures genuinely imitate the deep-sea natural habitat in terms of species diversity and functionality is not yet fully known (Seaman, 2007).

The threats mentioned are likely to scale with global increase in human population and demands (Langdon et al, 2000; Veron et al, 2009). To endanger deep-sea corals is to threat the ecosystem services they provide to humans too (Guinotte et al, 2006). Thus it is an urgent scientific task to better understand the basic biology and ecology of deep-sea coral communities, as well as their potential response to multiple threats.

1.2 **Coral growth**..

Coral growth is generally defined as the net accretion of calcium carbonate (Buddemeier and Kinzie, 1976). Despite the relative simpleness of this definition, assessing coral growth is not as straightforward. Firstly corals are colonial modular organisms. This means individual polyps or groups of polyps need not add the same quantity of skeleton or/and at the same rate (Buddemeier and Kinzie, 1976; Edmunds, 2006; Brooke and Young, 2009; Maier et al, 2009). Secondly, growth can be assessed based on various parameters which may not necessarily yield the same results (Buddemeier and Kinzie, 1976; Rodolfo-Metalpa et al, 2010b). To illustrate, if one is to measure growth based on linear extension, the results might be different to those of skeletal weight as the coral might invest more energy into sturdiness as opposed to elongation.

An additional difficulty to measure coral growth is that it does not seem to be related to any one environmental factor strongly, but rather a combination of environmental influences (Buddemeier and Kinzie, 1976; Buddemeier, 1978; Kleypas et al, 2006; Holcomb et al, 2010). Furthermore, coral physiology is poorly known so that the microcosm which the organism inhabits might not closely relate to the oceanographic conditions (Buddemeier and Kinzie, 1976; Pörtner, 2008) measured by field sampling. Colony size and life-stage are also potential sources of variation in coral growth measurements (Buddemeier and Kinzie, 1976; Langdon et al, 2010). Despite these difficulties, development of new technologies, establishing theoretical and analytical basis of calcification, and increased collaboration between scientists, have resulted in considerable improvements of coral growth measuring methods.

1.2.1 Methods to measure coral growth..

Table 1 summarizes some of the most commonly used methods to assess coral growth, their advantages, disadvantages, and a non-exhaustive list of references. As it becomes apparent, none of these methods is a panacea for measuring coral growth. Non-destructive methods (alkalinity anomaly, buoyant weight, polyp addition, linear extension and photographing) for example enable repeated measurements of the same individual (Jokiel et al, 1978). This is advantageous as it provides information on growth variability over various temporal periods. Caution however is advised, as frequent measuring of corals or lack of an adequate recovery period, has been found to alter calcification rates obtained (Dodge et al, 1984; Davies, 1989). Retrospective techniques despite their relatively high cost and expertise needed; are the closer thing we have to a time-machine (Gibbons, 2010). They enable inferences of coral growth over temporal scales which the other methods are unable to. Another factor to consider in methods assessing coral growth is that dissolution rates, if not accounted for, possibly result in underestimation of calcification rates (Langdon et al, 2010). Because of the pitfalls involved in using different methods, it is recommended to use more than one method were possible and that carbon chemistry is closely monitored whether in field or laboratory experiments (Langdon et al, 2010).

Table 1: Summary of methods to measure coral growth.

Method	Basis	Advantages	Disadvantages	References
Buoyant weight	Submerged weight can be translated into dry weight by use of a formula derived from Archimedes principle (see Jokiel 1978)	Non-destructive, inexpensive, easy to use, able to detect changes over various temporal scales, relatively insensitive to tissue and mucus weight. Can be safely performed on species of different growth form	Biofouling, calcification by cryofauna, and formation of bubbles as a source of error. Bias can occur in perforate (species where tissue goes deep into skeleton) corals	Buddemeier and Kinzie, 1976; Jokiel et al, 1978; Dodge et al, 1984; Davies, 1989; Jokiel et al, 2008; Langdon et al, 2010; present study
Alkalinity Anomaly	Calcification (precipitation of 1 mole of $CaCO3$) reduces total alkalinity by 2 molar equivalents	Non-destructive. Applicable to specimens of various sizes, over various periods	Potential bias from ammonia liberation, nutrients, respiration, protein metabolism, microbial decomposition and development of anaerobic conditions. Such bias can be estimated and in some cases corrected. Fast production of counteracting ions producing bias estimates of total alkalinity	Smith and Key, 1975; Buddemeier and Kinzie, 1976; Smith, 1978; Chisholm and Gattuso, 1991; Langdon et al, 2000; Pörtner, 2008; Langdon et al, 2010
^{45}Ca	Coral incubated with radioactive ^{45}Ca. Radioactive material incorporation taken as a proxy of calcification (Calcium deposited per milligram of Nitrogen)	Suitable for studying Ca^{+2} pathways. Very sensitive, thus short measuring periods suffice. Able to extract information on growth at different parts of a colony	Need to sacrifice coral, involve handling of dangerous radioactive material, expensive, requires specialized equipment. Sensitive to skeletal porosity	Goreau, 1959; Marshall and Wright, 1998; Maier et al, 2009; Langdon et al, 2010
Polyp addition	Counting new polyps developed over a period	Non-destructive, minimal handling	Accurate counting difficult in colonies with many polyps. Requires long time intervals to	Buddemeier and Kinzie, 1976; Orejas et al, 2008;

Method	Basis	Advantages	Disadvantages	References
	to look for Calcium content of a specimen		correction formulas which can potentially introduce bias. Expensive, requires specialized equipment.	

1.3 **Increased levels of pCO_2 in the ocean -Ocean acidification**.....................

1.3.1 Changes to oceanic water chemistry ....

The ocean plays a vital role in controlling the climate via several processes. One of them is the so-called carbonate buffering system which allows considerable amounts of carbon dioxide to enter the ocean before acidic conditions are reached. A series of equations are involved in this process:

First carbon dioxide combines with water to form carbonic acid:

$$[CO_2] + [H_2O] \leftrightarrow [H_2CO_3]$$

Then carbonic acid dissociates into hydrogen protons and bicarbonate:

$$[H_2CO_3] \leftrightarrow [H^+] + [HCO^-{}_3]$$

Finally, some carbonate ions combine with available hydrogen protons to form bicarbonate:

$$[H^+] + [CO^{-2}{}_3] \leftrightarrow [HCO^-{}_3]$$

As it becomes apparent, increasing amounts of carbon dioxide entering the ocean ultimately result in increasing amounts of carbonate ions taken up by this buffering system.

Thus increasing pCO_2 increases H^+, H_2CO_3 and HCO_3^- while decreasing CO_3^{-2} (The Royal Society, 2005). Because such situation results in a net reduction in pH, such change in oceanic chemistry is denominated “acidification”.

During the last couple of centuries carbon dioxide and other greenhouse gases have been released to the atmosphere at unprecedented levels (Kleypas et al, 1999; Barker et al, 2003; Hoegh-Guldberg et al 2007; Veron et al, 2009). Such a release has already been translated into a pH decrease of 0.1 compared to pre-industrial times. It is projected that by the year 2100 atmospheric pCO_2 could reach up to 1000ppm depending on IPCC scenarios, which is more than twice its current (380ppm) value (Barker et al, 2003). Furthermore it is believed that the ocean’s capacity as a buffer is becoming more and more limited with over 30% of it being already taken up till day (Sabine et al, 2004; Fabry et al, 2008; Veron et al, 2009). The previous group of equations attempted to illustrate how ocean acidification occurs, however what is of equal interest is the impact of such phenomenon.

1.3.2 Influence of ocean acidification on calcifying organisms........................

Among the organisms most likely to be affected by such changes are the calcifiers. Such organisms are characterized by the production of an internal or external structure made of calcium carbonate. An equation relevant to calcifiers is:

$$CaCO_3 \leftrightarrow [Ca^{+2}] + [CO^{-2}{}_3]$$

Calcification (formation of a calcareous structure) occurs when calcium and carbonate ions are combined. The reversed equation, dissolution of calcareous structures occurs when these two ions dissociate. Because increasing amounts of carbon dioxide demand carbonate ions, the previous equation is shifted to the right, favouring dissolution (The Royal Society, 2005; Stanley, 2008). Calcium carbonate is expected to dissolve below a critical concentration of carbonate ions; such concentration is denominated “saturation state”. The saturation state of aragonite, the more readily soluble cristalline form of calcium carbonate, is expressed as Ωa, while that of calcite, a less soluble form of calcium carbonate is Ωc. Recent studies estimate Ωa has been higher in the past, and drops with increasing pCO_2 (Kleypas et al, 1999; Stanley, 2008).

By the time atmospheric pCO_2 rises to 560 ppm, undersaturated conditions are expected in many of the ocean's surface waters (Veron et al, 2009).

Another concept along the same lines as the saturation state is the saturation horizon. This is the critical depth above which calcification is favoured and below which dissolution takes place. The solubility of calcium carbonate increases with increasing pressure and lowering temperatures. Because of the effect of ocean acidification on calcium carbonate, a shallowing of the saturation horizon is expected (Gattuso et al, 1998; Kleypas et al, 1999; Barker et al, 2003; Doney et al, 2009; Veron et al, 2009). Nevertheless such shallowing and changes in Ωa would probably not take place at the same time or with the same magnitude across the globe (Stanley, 2008; Tyrrell, 2008). This is among other reasons because of the naturally occurring low Ωa areas (Tyrrell, 2008), as well as the variation in thermal configuration of the ocean (Stanley, 2008).

While the theoretical basis of ocean acidification has been fairly established, how exposure to such chemical changes influences marine biota is receiving increasing attention. Calcifying organisms span several taxa, however the most widely studied are coccolithophores (Riebesell et al, 2000; Iglesias-Rodriguez et al, 2008), and tropical corals (Leclercq et al 2000; Hoegh-Guldberg et al, 2007). Nevertheless studies on pteropods (Comeau et al, 2009), foraminifera (Dias et al, 2010), temperate- (Holcomb et al, 2010; Rodolfo-Metalpa et al, 2010b) and cold-water corals (Maier et al, 2009; Chapter 1.3.2); echinoderms (Kurihara and Shirayama, 2004; Dupont, 2010), crustaceans (Small et al, 2010; Walther et al, 2010), and fish (Frommel et al, 2010; Pörtner et al, 2010; Munday et al, 2009), are becoming part of literature on ocean acidification. Even for the most studied species, there are wide gaps of knowledge (Chapter 1.3.3). From studies collected till 2006, evidence suggests a calcification reduction between 3 and 60% (Kleypas et al, 2006). The wide range observed need is not surprising, given the variety of taxa, experiment designs, and geographical locations were such studies took place. Increasing scientific collaboration as well as standardizing methodology for ocean acidification studies (Fabry, 2008; Riebesell et al, 2010) is expected to help increase the efficiency of ocean acidification research.

It is important to establish what a calcareous structure provides an organism with, to understand the potential consequences of its demise. Kleypas et al (2006) and Doney et al (2009) suggested such structure provides an organism with: anchoring, increase competiveness, attainability of alternative environmental conditions, and protection; among others. Beyond the organism and into the community level, lack of calcifiers potentially alter food webs (Turley et al, 2007; Tyrrell 2008), habitat (Kleypas et al, 2006; Veron et al, 2009), and oceanic productivity (Tyrrell 2008; Doney et al 2009).

An important point is that even if acidification was to cause reduction and even demise of calcifiers, such a situation could go undetected due to the lack of baseline information (Doney et al, 2009). Thus it is urgent to obtain basic biological and ecological data including mapping of calcifiers' abundance and distribution, population dynamics of such species, etc.

What follows is a brief review of the response of some calcifiers to ocean acidification to date. To be kept in mind is that calcification is not an isolated process in the life of an organism. This means that it interacts with several other physiological processes (Pörtner, 2008; Ries et al, 2009; Todgham and Hofmann, 2009) as well as ecological factors (Kleypas et al, 2006; Turley et al, 2007; Doney et al, 2009), and thus it would be erroneous to consider that a change in an organism's calcification rate is the only process affected by ocean acidification.

Coccolithophores

Interest on this planktonic species arises from its recognized key role in the food web and the global carbon budget (Riebesell et al, 2000; Iglesias-Rodriguez et al, 2008). These organisms are covered by calcareous plates, and because of their numbers they play important roles in ocean calcification. Early studies on two coccolithophore species exposed to 750 ppm, revealed a decrease in calcification rate of more than 15% and 44% for *Emiliania huxleyi* and *Gephyrocapsa oceanica* respectively (Riebesell et al, 2000). Later studies however showed the response of coccolithophores to be more complex than expected. Based on laboratory cultures and field evidence, Iglesias-

Rodriguez et al (2008) concluded several physiological processes of *E huxleyi* to be unaffected by acidification to 750 ppm and coccolithophore volume to actually increase under such circumstances. Furthermore Iglesias-Rodriguez et al (2008) venture to suggest that perhaps this planktonic species is already adapting to ocean acidification. Along similar lines, a recent study looking at molecular level expression of genes related to calcification in *E huxleyi*, also failed to report significant changes in calcification under acidification conditions (Richier et al, 2011). Besides experimental differences, it is suggested that discrepancy between Iglesias-Rodriguez et al (2008) and Riebesell et al (2000) results could also be related to unresolved taxonomic issues, meaning that *E huxleyi* specimens used in each experiment could in fact represent two or more separate species (Fabry, 2008; Müller et al, 2010). Whatever the reasons, differential calcification itself has consequences, and more studies are encouraged to further understand calcification in this planktonic organisms and their response under ocean acidification scenarios (Fabry, 2008; Iglesias-Rodriguez et al, 2008; Müller et al, 2010).

Tropical, shallow-water corals

The range of Ωa that favours growth and conservation of coral reefs is estimated to be around 4 (Kleypas et al, 1999). Under increased ocean acidification, saturation state is expected to reach ~3 by 2065 and less by 2100 (Langdon et al, 2000). Based on a study looking at several tropical scleractinians and associated fauna, calcification of coral communities is expected to reduce about 70% by 2065 compared to pre-industrial levels (Leclercq et al, 2000). Importantly, such a reduction need not be geographically or taxonomically uniform. A collection of several studies looking at the effects of acidification on zooxanthellate scleractinians, showed 0-84% reduction in calcification depending on species and study (Kleypas et al, 2006).

From the physiological point of view, acidification effects on shallow-water corals can only be understood by considering the effects of this process on their zooxanthellate symbionts too. At the moment evidence suggest zooxanthellae is only involved in calcification mainly as an stimulant providing the coral with energy to perform such task, but other hypotheses for the role of zooxanthellae in coral calcification are possible (Gattuso et al, 1999). Nevertheless a coral stressed by the combination of increased temperatures and acidification or one of these stresses by itself, is likely to release zooxanthellae (bleach) and thus reduce or even stop calcification due to insufficient energy (Hoegh-Guldberg et al, 2007; Anthony et al, 2008).

At ecological scales, the effect of acidification is likely to affect shallow-water corals directly and indirectly by influencing habitat complexity, altering macroalgal grazer populations; and by reducing crustose coralline algae thus hampering larval recruitment (Langdon et al, 2000; Kleypas et al, 2006; Hoegh-Guldberg et al, 2007; Doney et al, 2009; Nakamura et al, 2011). Furthermore global warming is expected to interact in turn with these and other processes relevant to coral organism and reef community survival (Kleypas et al, 2006; Hoegh-Guldberg et al, 2007; Doney et al, 2009; Veron et al, 2009)

Besides observation of coral calcification decline over short-term experiments, a couple of retrospective studies provide evidence from wider spatial and temporal scale reductions in calcification. De'ath et al (2009) found that since 1990, a decline in calcification of ~14% was observed based on more than 300 specimens taken from several sites within the Great Barrier Reef. The authors suggest that such decline is at least partially due to a reduction in Ωa. In another study also in the Great Barrier Reef, Cooper et al (2008) reported a decrease of ~21% in calcification of massive colonies during the last couple of decades. While the possibility that such reduction is related to changes in temperature and pCO_2, the authors recommend more studies on the chemistry of the GBR before obtaining definite conclusions.

Temperate corals

Many species of temperate corals have features to share with tropical corals, such as being zooxanthellate, and some features with cold-water corals, such as slow growth rates (Rodolfo-Metalpa et al, 2010b). A long-term (1-year) experiment assessing the effects of acidification on Mediterranean *Cladocora caespitosa* showed no evidence for reduction of calcification rates at 700ppm. Temperature on the other hand was shown to be a more important driver of calcification in such species (Rodolfo-Metalpa et al, 2010b).

Off the American coast, Holcomb et al (2010) studied the performance (calcification) of temperate *Astrangia poculata* under nutrient-enriched and ambient-nutrient conditions. After observing calcification rates to vary with both nutrient-level and pCO_2 levels, the authors suggested a model where the negative effects of acidification on calcification can be ameliorated by a nutrient-enriched environment (Holcomb et al, 2010).

Pteropods

Just as coccolithophores, pteropods are also considered a key element of several food webs and because of their numbers; they also play an important role in recycling of carbon (Doney et al, 2009; Comeau et al, 2009; Comeau et al, 2010a, Comeau et al, 2010b, Comeau et al, 2011). Arctic pteropods reduced calcification by 28% at 760ppm compared to current (350ppm) pCO_2 levels. A change in pteropod distributions towards lower latitudes and depths is expected as a result of shallowing of aragonite saturation horizon (Doney et al, 2009). However recent studies performed on pteropod species from warmer and cold environments show marked calcification reduction regardless of environment (Comeau et al, 2011). Thus while differential susceptibility to acidification could result species shift, ultimately it appears that most if not all pteropod species will suffer from acidification.

There is also available evidence showing early stages of pteropod larvae are also affected by acidification. Larvae of a Mediterranean pteropod species were unable to produce a shell under very high ~1700ppm acidification conditions, and suffered shell malformation even at lower pCO_2 levels (Comeau et al, 2010b).

Foraminifera

An 8-14% reduction in shell weight across several foram species was observed as a result of acidification (Kleypas et al, 2006). Retrospective and present species distribution analysis showed foram species assemble in different ways along a pH

Method	Basis	Advantages	Disadvantages	References
	of time		record growth increments	Brooke and Young, 2009; present study
Linear Extension by means of Alizarin red staining	Incubation of coral into Alizarin red dye. Subsequent growth marked by measuring stained versus non-stained skeleton	Non-destructive, simple use, relatively inexpensive	Staining stresses the coral, observed limited growth after staining. Variable stain incorporation rates according to species. Of limited use in ocean acidification experiments as dye tends to fade under very low pH (~5).	Lamberts, 1978; Jokiel et al, 2008; Brooke & Young, 2009
Linear Extension, direct measurements	Length measurements by means of rulers, callipers or image analysis over time	Non-destructive, inexpensive, easily conducted, use simple equipment	Limited accuracy increase potential for even small biases to under/overestimate growth rates; particularly in slow-growing species. Difficulties choosing a relevant point of measurement in colonies with variable growth rates across colony	Buddemeier and Kinzie, 1976; Langdon et al, 2010
Photograph based	Obtaining of linear extension, projected area, diameter, etc. Using image analysis software that compares series of photos taken over time	Non-destructive, relatively inexpensive, minimal handling depending on design	Limited accuracy increase potential for even small biases to under/overestimate growth rates; particularly in slow-growing species. Extremely sensitive to poor quality photographing. Relatively time consuming	Purser et al, 2009; Langdon et al, 2010; Polder et al, 2010; present study
Retrospective	Analyse skeletal structure using X-ray to look for banding patterns or spectroscopy	No experimental bias, provide information on a much wider temporal scale,	Limited to species with clear and conserved growth patterns carved into skeletal structure. Difficult interpretation of growth band formation. Needs calibration and	Buddemeier and Kinzie, 1976; Buddemeier, 1978; Langdon et al, 2010

gradient. A predominantly calcareous foraminiferan community occurred at higher pH (8.2–8.14) compared to a reduced-diversity, non-calcareous community at lower pH (7.6) (Dias et al, 2010). Another study also showed two species of cosmopolitan forams reduced their calcification rates under acidification conditions (Lombard et al, 2010). Nevertheless it appears that influence of acidification on foraminiferan calcification need not be linear in all cases. A recent study assessing acidification effects on large benthic forams showed lack of linearity in response (Kuroyanagi et al, 2009). However under a pH threshold of 7.7 forams performance continuously declined (Kuroyanagi et al, 2009). Despite shown reduction in calcification as a result of acidified conditions, the physiological mechanisms of this process are only started to be understood (Lombard et al, 2010).

Echinoderms

Assessment of several parameters of development of laboratory-raised sea urchins revealed a negative effect of acidification conditions either via HCl acidification and more pronounced by pCO_2 gassing (Kurihara and Shirayama, 2004; Kurihara, 2008). In consequence, Kurihara (2008) suggests that a reduction in recruits, and poorly developed echinoid larvae would be reflected in reduced viability of sea urchin populations exposed to ocean acidification.

Looking also at development, Dupont et al (2008) found increased larval mortality, malformed skeleton and reduced size of a common Atlantic species of brittlestars (ophiuroidea), under acidic conditions.

Later studies attempting to involve life-history strategies in ocean acidification research, showed lecithotrophic starfish larvae to be more tolerant than planktotrophic starfish larvae to acidified conditions (Dupont et al, 2010a). Although only a handful of echinoderms have so far been studied, a few patterns and questions have been outlined: species-specific response, whether short-term response to acidified conditions is similar to long-term response; and early life-stages shaping population viability (Dupont et al, 2010b).

Crustaceans

In addition to echinoids, bottlenecks in population defined by early life stages have also been observed in high latitude crabs (Walther et al, 2010). Similarly, acidification had a negative effect on development and metamorphosis of barnacles (Findlay et al, 2010). However another study assessing various parameters of physiological performance in another species of crab, show robustness to ocean acidification over a relatively long period of exposure (Small et al, 2010). Nevertheless the authors observe a trade-off of such robustness is expressed for example in altered metabolic rates (Small et al, 2010).

Others

Furthermore, acidification has been shown to negatively influence early development of mussels (Gazeau et al, 2010); had no effect on sperm or fertilization rates of cod fish (Frommel et al, 2010), nor oysters (Havenhand and Schelegel, 2009); had mixed effects on the few so-far assessed microbes (Liu et al, 2010); and enhanced negative effects of temperature changes on mortality of bryozoans (Rodolfo-Metalpa et al, 2010a) and reef fish larvae (Munday et al, 2009).

1.3.3 Cold water corals exposed to ocean acidification..................................

About 70% of currently known cold-water coral areas are expected to undergo aragonite undersaturation by 2099 (Guinotte et al, 2006), and some even by 2020 (Turley et al, 2007). The impact of such a change in water chemistry is expected to happen early in the North Atlantic where pCO_2 is already seeping in large amounts to ocean depths (Tyrrell, 2008). The Mediterranean sea-bottom as well, is likely to be particularly susceptible to acidification due to its relatively high temperatures (Carlier et al, 2009) –as Ωa decreases with depth and temperature.

Studies documenting cold-water corals response to ocean acidification are very recent. Such situation is mainly due to our only recently acquired ability to carefully extract live deep-sea corals from their habitat in order to subject them to projected acidification conditions. To date, this operation is still relatively expensive and logistically challenging thus only a handful of experiments have been conducted.

A short-term study conducted on specimens of the cosmopolitan *Lophelia pertusa* from the North Atlantic and the North Sea (Maier et al, 2009) found that lowering pH by 0.15 (equivalent to 1054ppm) and 0.3 (equivalent to 1389ppm) resulted in reduced calcification by 30% and 56% respectively. This study also put in evidence differential calcification rates according to polyp rank (age), with younger, faster growing polyps appearing more affected by acidification (Maier et al, 2009). Interestingly, *Lophelia pertusa* continued to calcify even at undersaturated aragonite levels. While this suggests a degree of adaptation to low Ωa waters; reduced growth rates most probably have negative consequences for overall species fitness (Maier et al, 2009; Doney et al, 2009).

Although no studies were documented to date about the effect of acidification on cold-water coral prey (i.e. zooplankton), if these were to alter food availability, corals would have to cope with acidified conditions and poor nutrition simultaneously. Such situation is plausible for example by a reduction in survival of zooplanktonic larvae under acidified conditions, as has been observed for other crustaceans (Walther et al, 2010).

1.3.3.1 Knowledge gaps..

One of the readily apparent observations of the short review on the effect of acidification on calcifiers is the very poor knowledge we have of cold-water corals response to such phenomena. There are several reasons to stimulate research on this topic. Some of them include:

- Growth and maintenance of cold-water bioherms, just as that of tropical reefs, requires calcification rates to exceed those of dissolution (Kleypas et al, 2006). Thus we are interested in finding such tipping points were coral calcification rates become unable to exceed dissolution rates and bioherm structure is compromised.
- Does acidification response of cold-water corals resemble that of tropical and temperate species?

- Because of the Mediterranean' oligotrophic and high salinity, high temperature characteristics, insights on cold-water corals from this region are particularly informative in reference to a global environmental gradient.
- Obtaining information on reference growth performance (that at ambient pCO_2 conditions) is necessary to disentangle effects from anthropogenic influences such as deep-sea trawling (Rogers, 1999). Given few published growth rates of cold-water corals and their disparity, increasing baseline information and information of performance under altered chemistry is valuable.
- Long-term (months to years) studies provide insights into chronic rather than acute exposure to acidification; which better mimics the nature of the acidification threat (Pörtner, 2008; Rodolfo-Metalpa et al, 2010b). Thus assessing cold-water corals response to acidification over long-term periods while closely monitoring experimental environmental conditions is recommended
- Studies on cold-water corals were acidification is induced via pCO_2 bubbling rather than via acid addition are missing, and can better resemble the altered chemistry of acidification scenarios (Rodolfo-Metalpa et al, 2010b; Riebesell et al, 2010)
- Assessment of more than one species, in more than one habitat is recommended as this can provide interesting ecological information. For example a species-specific response to acidification is possible, and together with geographical information, and molecular techniques, this can help predict species shifts in the future (Pörtner, 2008).

1.4 **Objectives**..

1.4.1 General ....

The main aim of this experiment was to determine whether imminent conditions of ocean acidification would influence growth rate of three species of cold Mediterranean water corals.

1.4.2 Specific..

To answer such question there are several aspects to look for:

I. What is the influence of experimental maintenance time on growth rate?
    a. Does acclimation interact with levels of ocean acidification?
        i. Can this trend reflect potential differences in short versus long term exposure experiments?
II. Is response of corals to ocean acidification species specific?
    a. If so, which species are more vulnerable than others?
        i. What would be potential ecological changes (e.g. species dominance shifts, functionality of deep-sea community) expected in the future considering a gradient of vulnerability among species
III. Would different methods of measuring coral growth rate under ocean acidification conditions yield similar results?
    a. Which method is more precise?
    b. Which method provides a better cost-efficiency ratio?

2 **Material & Methods** ....

2.1 [Samples collection]..

All *Madrepora oculata* and *Lophelia pertusa* samples were obtained during the MedSeaCan campaign of June 2009, at the Canyon Lacaze-Duthiers, Golfe du Lion, France (Appendix –Figure 36). Collection took place using a remotely operated vehicle (ROV) at depths of 260m (43°35.07'N, 03°24.14'E); 267m (42°34.98'N, 03°24.15'E); and 500m (42°32.98'N, 03°25.21'E). Samples of *Desmophyllum sp* were kindly donated by B. Vendrell and C. Orejas from the Insitut de Ciències del Mar (ICM-CSIC) in Barcelona, Spain.

2.2 Experimental design ....

Four aquaria with a different pCO_2 level were installed: 280µatm, 390 µatm, 750 µatm, 1000 µatm. Such levels attempted to follow the guidelines (Barry et al, 2010) for setting up experiments spanning realistic and comparable values in ocean acidification research (Figure 1).

Within each aquaria fragments or whole colonies of the three species of Mediterranean cold water corals: *Lophelia pertusa*, *Madrepora oculata* and *Desmophyllum sp* were placed (Table 2Table 1). Fragments were distributed so that each treatment would contain corals with corresponding size range, number of each species and potential genetic variability, meaning that sub-fragments from one bigger branch were distributed into different treatments. Each fragment or colony was placed into either a 1000ml or a 300ml vial. In addition to vials containing corals, there were at least 3 control vials ("blank" with only seawater and no corals) within each pCO_2 treatment.

Corals were maintained over circa 10 months (September 2009 – July 2010) at the four different pCO_2 treatments, with repeated determinations of skeletal growth (Chapter 2.5).

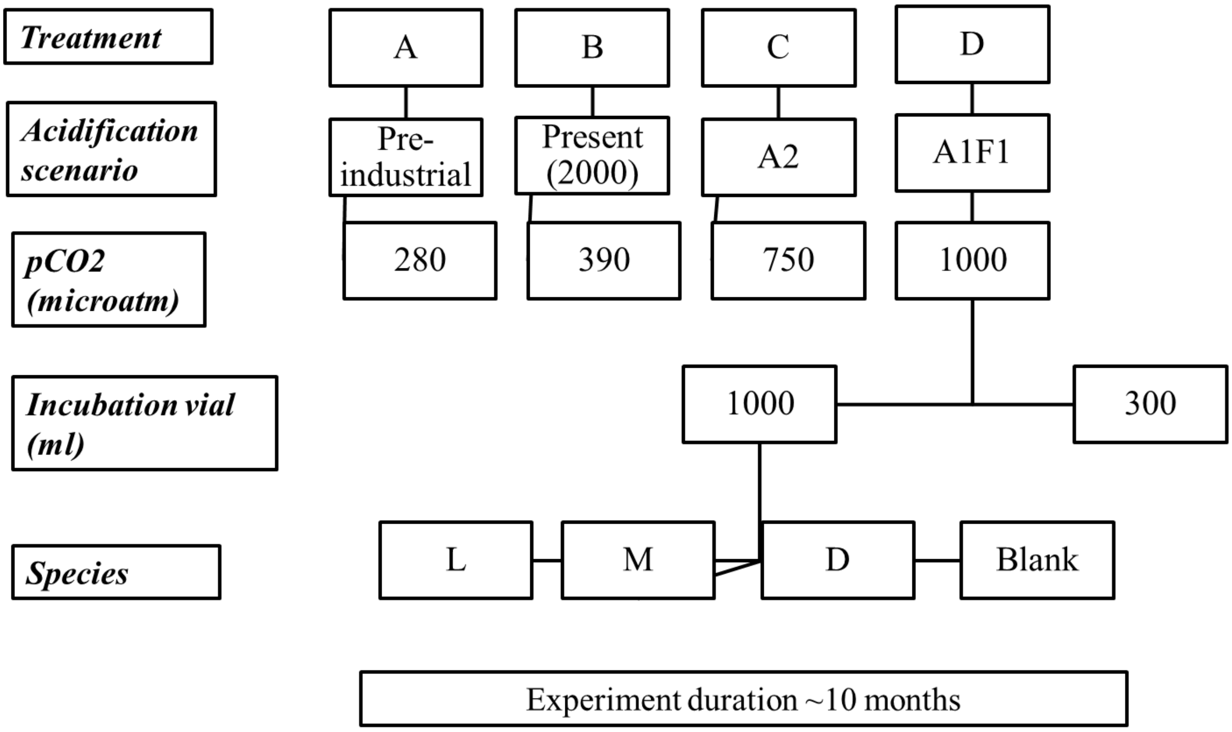

Figure 1: Experimental design of ocean acidification experiment performed on three species of deep-sea corals. L (*Lophelia pertusa*), M (*Madrepora oculata*), D (*Desmophyllum sp*). Acidification scenarios based on (Special Report on Emissions Scenarios (SRES) developed by the Intergovernmental Panel on Climate Change (IPCC)[1]

Table 2: Distribution of coral samples and blanks across treatments

	A	B	C	D	TOTAL
Madrepora	7	9	8	8	32
Lophelia	6	5	5	5	21
Desmophyllum	3	1	3	3	10
Blanks	3	6	5	5	19
TOTAL	16	15	16	16	63

2.3 Aquaria setup & maintenance...

The experiment was carried out inside a cold room set to 10°C where a flow-through (open) circulation system with four aquaria (one for each pCO_2 treatment) was installed. Each aquarium served as water-bath containing the different vials with corals

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[1] IPCC SPECIAL REPORT EMISSIONS SCENARIOS: Summary for Policymakers: A Special Report of IPCC Working Group III. Published by the Intergovernmental Panel on Climate Change (2000).

and blanks (15 vials of 300ml and 6 vials of 1L capacity) belonging to any one treatment (Figure 2). Seawater supply came from surface water of the bay of Villefranche-sur-mer and was slowly flowing through coral vials after passing a large tank in which the surface water was cooled down by the room temperature. The large tank also contained 2 big filter bags of 5 and 1 µm mesh size to filter the incoming surface water. Inside each aquarium a heater was placed for maintaining the water at 13°C, which is the ambient temperature for Mediterranean cold-water corals. In addition, temperature loggers (STAR-ODDI© DST centi-T) were also kept in aquaria to closely monitor any changes in temperature at an interval of 10 minutes. To provide aeration, a pump (JBL Pro Flow© 500) with a capacity of 500lh^{-1}, and an air diffusor (HOBBY©) of 150mm length were placed in each aquarium. Two thin tubes were placed inside each vial; one of an outer/inner diameter of 2.5/0.5mm for dripping water at a rate of 32 ± 14 ml/h (± S.D.) (Schubert, 2010); and another of 3/.8 mm outer/inner diameter for aerating with the desired pCO_2. The latter tube ended in a small tube within the vial and with the upward flow of air generating seawater circulation (Figure 3).

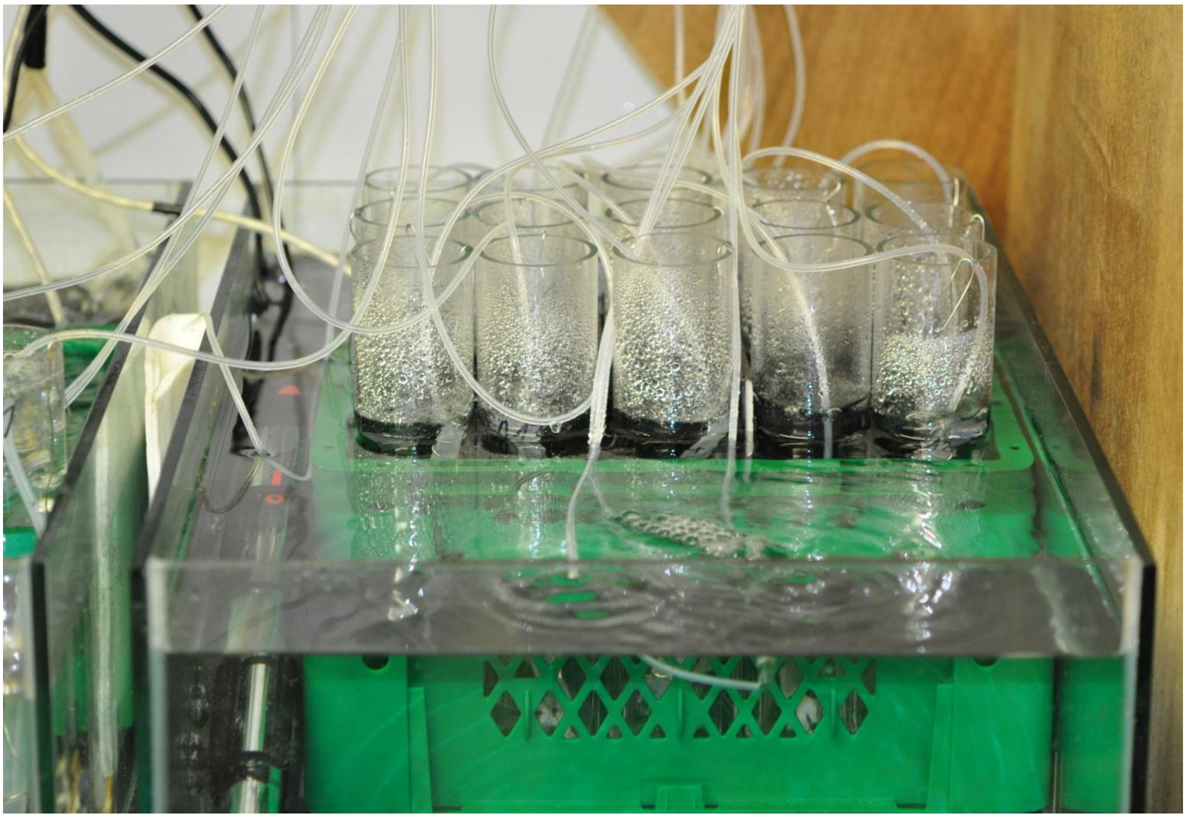

Figure 2: Sample aquaria showing 700ml vials and two thin tubes per vial. One distributing water and the other pCO_2 gas at relevant concentration. There were four such aquaria (one per pCO_2 treatment) in this study[2]

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[2] Photo courtesy of A. Schubert and F. Bils

Figure 3: Example of 1L vial containing a *Madrepora oculata* colony. Observe plastic tube containing thin tube bubbling pCO_2. Such design aided gas distribution and circulation within vial

To achieve the desired concentration of pCO_2 a gas mixing panel was used (Figure 4). The panel held eight mass flow controllers: four for pure CO_2 with a flow rate of 0-10ml/min; and four for ambient air with a flow rate of 0-10 L/min. By mixing ambient air with pCO_2 of each desired concentration, 3 L of air-CO_2 mix was generated for each aquarium.

Cleaning was performed three times per week (Monday, Wednesday, and Friday). Each vial was cleaned by flooding it with the seawater from the aquarium surrounding the vials and which contained the seawater overflowing from the vials with respective pCO_2 level. When flooding the vials, the seawater was filtered using a Tetratec® EX 1200, 1200 L/hr filters which had been placed in each treatment's water-bath for approximately two hours prior to cleaning to adjust to respective pCO_2 level.

Feeding was also was carried out three times per week after cleaning. Preis-Aquaristik© Coral-V-powder containing aminoacids and phagocyte stimulants; and freshly hatched *Artemia sp* nauplii were added equally to all treatments every time. Pacific Krill (*Euphausia pacifica*) and minced mussel were added once a week to all treatments.

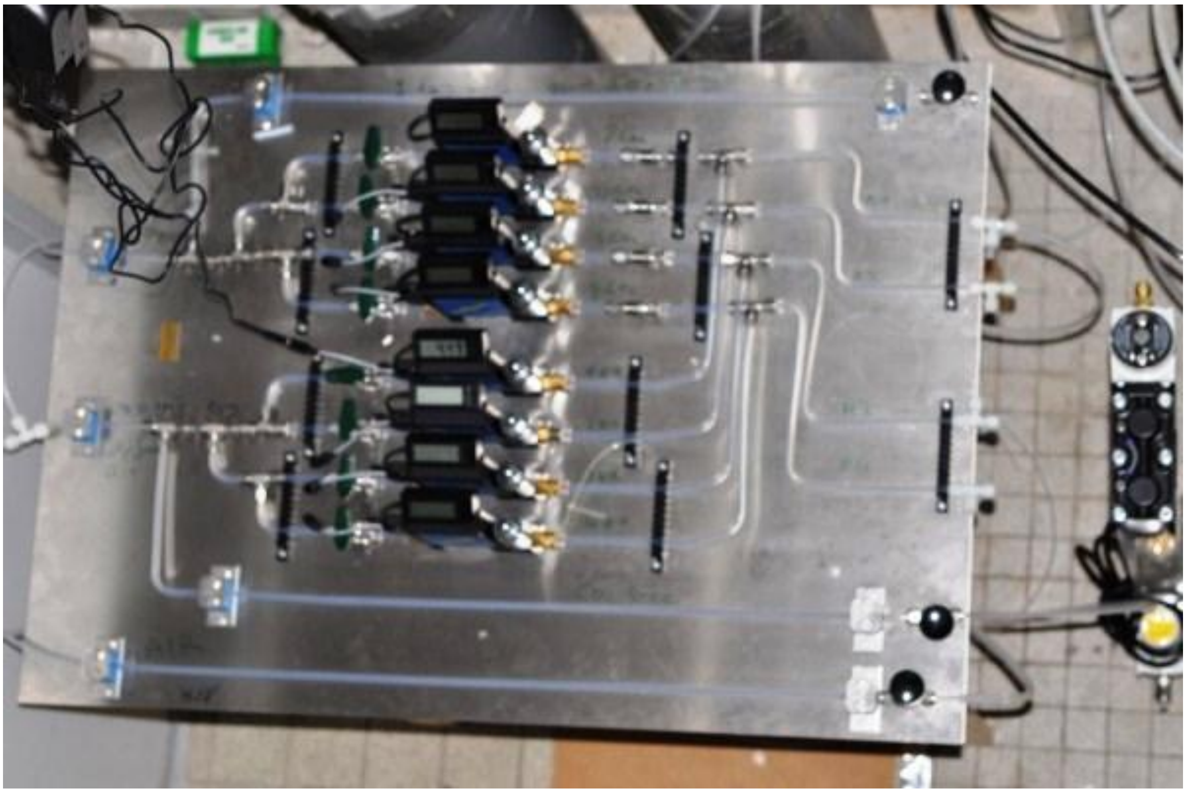

Figure 4: Panel with mass flow controllers to mix pure CO_2 and air and distribute air/CO_2 mix to aquaria[3]

2.4 Aquarium monitoring ....

Rather than assuming stability within the experimental setup, we regularly tested several environmental parameters the corals were exposed to, in order to get a "feeling" for their variability in their microcosms. In addition to the previously

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[3] Photo courtesy of A. Schubert and F. Bils

mentioned temperature loggers, an IKS Aquastar® V. 2.XX computer was connected to the aquaria in order to record temperature and salinity, Interval for Aquastar computer records was 15 minutes. Only one probe for each parameter was available, and thus treatment wise comparisons of the performance of these parameters with the computer are not possible.

2.4.1 Salinity recording..

To monitor possible fluctuation in salinity of the water in the flow-through system, this parameter was weekly measured. Salinity measurements started in June 2010 (i.e. 8 months after initial incubation). Each week 14 samples from each treatment were taken: 3 from big (1L) vials, 3 from small (300ml) vials, 5 from blanks, and 3 from different locations within the water-bath. Samples were measured using a S30 SevenEasy™ conductivity meter. Before measuring aquaria samples, the conductivity meter probe was calibrated using the supplier's buffer solution at 12.88 mS/cm. Samples were also incubated at 25°C prior to salinity measurements. In addition, the salinity of water coming directly from the bay to the large tank was measured.

2.4.2 Aquarium chemistry ....

To assess *in situ* carbon chemistry at the aquaria, samples from each vial and large supply tanks were taken monthly for the first 5 months, and twice over the last 3 months of the experiment. If not measured directly after sampling, samples were poisoned with mercury chloride ($HgCl_2$) to prevent biological activity (Dickson et al, 2007)

Prior to measuring Dissolved Inorganic Carbon (C_T) and Total Alkalinity (A_T) samples were incubated at 25°C in a water-bath.

2.4.2.1 Measurement of Dissolved Inorganic Carbon (C_T)...............................

Dissolved Inorganic Carbon was determined using the method of: Acidification-gas stripping-infrared detection (Dickson, 2010). This method was available by means of software that controls an Automated Infra-Red Inorganic Carbon Analyser (AIRICA) (Marianda, www.marianda.com), which was coupled to a CO_2 analyser (Li-COR ® 6252).

At least 4 subsamples of 1300 µl were measured by the machine, and at least three values were used to obtain an average C_T measurement (rejection of value deviating most from common mean) . To calculate the CO_2 concentrations of a sample from the area peaks generated by the AIRICA software, we utilised 3 volumes (1200, 1300 and 1400 µl) of certified reference material (Batches: 93, 94, 99 and 102) from the Scripps Institution of Oceanography, San Diego (http://andrew.ucsd.edu/co2qc/batches.html) for calibration.

2.4.2.2 Measurement of Total Alkalinity (A_T)..

To measure total alkalinity, open-cell acidimetric titration (Dickson et al 2007, Dickson 2010) was the method of choice. Samples of approximately 25ml were weighted and then titrated similarly to the standard operation procedure (SOP) 3b outlined in Dickson et al (2007) guide to best practices for ocean CO_2 measurements. Titration was controlled by Metrohm © Tiamo™ titration software 1.3, using Metrohm equipment (5ml burette “888 Titrando”; “801 stirrer”, pH electrode and temperature sensor). At least three replicate samples were titrated to determine the average. The titrated volume displayed by the Tiamo™ software was typed as an input into an R script (S. Comeau and F. Gazeau, unpublished), that calculates alkalinity based on parameters including salinity, temperature, and acid normality.

To calibrate the total alkalinity titration system, we utilized samples of certified reference material (Batches: 93, 94, 99 and 102) from the Scripps Institution of Oceanography, San Diego (http://andrew.ucsd.edu/co2qc/batches.html)

Additional parameters of the carbon system in aquaria (pH, pCO_2, fCO_2, HCO_3^-, CO_3^{-2}, aragonite saturation, calcite saturation and pH) were obtained from A_T, C_T, temperature, salinity and hydrostatic pressure using the software package seacarb under R (Lavigne and Gattuso, 2010).

2.5 Growth Measurements ....

2.5.1 Buoyant weight……………………………………………………………………………

To assess coral growth, buoyant weight was recorded twice during the first 7 months of the experiment and monthly thereafter. We followed the buoyant weighing technique described by Jokiel et al (1978) in the manual of research methods for coral reefs (Stoddart and Johannes, 1978)

Calcification rate was reported as percentage growth (% increase in buoyant weight over time). The initial buoyant weight was taken to be the absolute and coral growth was measured in reference to these first values utilizing the formula:

$$\mathrm{G} = \left(\left(\frac{Wd}{\mathrm{Wo}} \right)^{\frac{1}{\mathrm{d}}} - 1 \right) * 100$$

Where: G= Growth rate (% increase in weight/day)

Wd= Final weight (g)

Wo= Initial weight (g)

d= Interval of time (days)

To assess coral growth in our experiment we chose the exponential over the linear growth formula. This formula takes into account that daily growth increments are not uniform, but change with the daily addition of new skeleton. A simple linear formula on the other hand, would assume same values for new daily growth increments as function of the original weight, neglecting the newly accreted skeleton.

Negative values were excluded from analysis as dilution of coral skeleton was not assumed to occur in this experiment.

2.5.2 Polyp count………………………………………………………………………………

To estimate the rate of polyp addition, polyp number was recorded once in September 2009, and monthly after April 2010. It must be noted that polyp counts were performed to the best of our practices, but bias possibly exists originating from at least two sources. First of all corals grow in more than one direction, so there can be confusion as to whether a polyp has already been counted or not. Secondly, in order to minimize stress, handling of the corals to count polyps was kept to a minimum. Mucus production was observable in some cases, indicating coral stress. In view of this, the amount of time that could be devoted to conducting a detailed polyp count was limited.

Besides physical counting of polyps, photographs of corals at different times were also compared to help indicate growth of new polyps.

2.5.3 Image analysis –colour projection...

2.5.3.1 Photographing...

Corals were photographed using a Nikon© D90 camera. Photographing was done three times during the experiment: initial photographing (September 2009); after 5 months (February 2010), and after 9-10 months (July/August 2010) of incubation.

2.5.3.2 Measuring growth rate based on photographs ....

Image processing took place using Fiji (http://pacific.mpi-cbg.de/wiki/index.php/Fiji). Fiji is a software based on Java programming language, considered an extension of Image J (http://rsbweb.nih.gov/ij/index.html) for special use in life sciences. In addition to Fiji's general platform, image analysis in this study was performed using Color Inspector 3D © (Interaktive Visualisierung von Farbräumen) v.2.3, developed by Kai Uwe Barthel at the FHTW, Berlin.

A macro was created to speed up image analysis. Depending on the quality of the photo, adjustment of brightness and contrast, as well as image cropping was performed prior to running the macro.

To measure growth each image went through the following procedure in the macro:

- Split channels: this is done in order to obtain three images (red, blue, green) from the original image. Corals are best projected in the red area of the spectrum (Purser et al, 2009), and so this sub-image was selected for further analysis. (Figure 5)

- Lookup Tables→ green/red: Fiji gives an option to divide the image on red and green pixels only. Here the coral is highlighted in green pixels and the background image becomes red. (Figure 6)
- Analyse→ colour inspector 3D: this function allowed categorization of red/green image. In here, green tab was maximized and red tab minimized in order to get a colour simplified image. Changing tabs resulted in a green (coral)/black (background) image (Figure 7). Display mode was changed from “all colours” to “histogram”. In histogram display the option “LUT” (Lookup tables) was available. Selecting this option displayed the number and frequency of green pixels (Figure 8).

Coral area was deduced from the number of green (coral) pixels divided by the total number of pixels in the image (coral + background). Such ratio provided a proxy of how many pixels the coral projects per unit space. The ratio obtained from this exercise at Time zero (initial photographing of corals) was then compared to the ratio obtained at Time 1 (after 5 months). Then the ratio obtained in Time 1 was compared to the ratio obtained in Time 2 (after 9 months). This process resulted in two growth rates. Values were reported in % increase per day. Negative values were excluded from analysis as dilution of coral skeleton was not considered in this experiment.

Image analysis was performed only on *Madrepora oculata* and *Lophelia pertusa*. *Desmophyllum sp* had to be excluded from this analysis as Images of this coral were not sufficiently compatible between measuring periods.

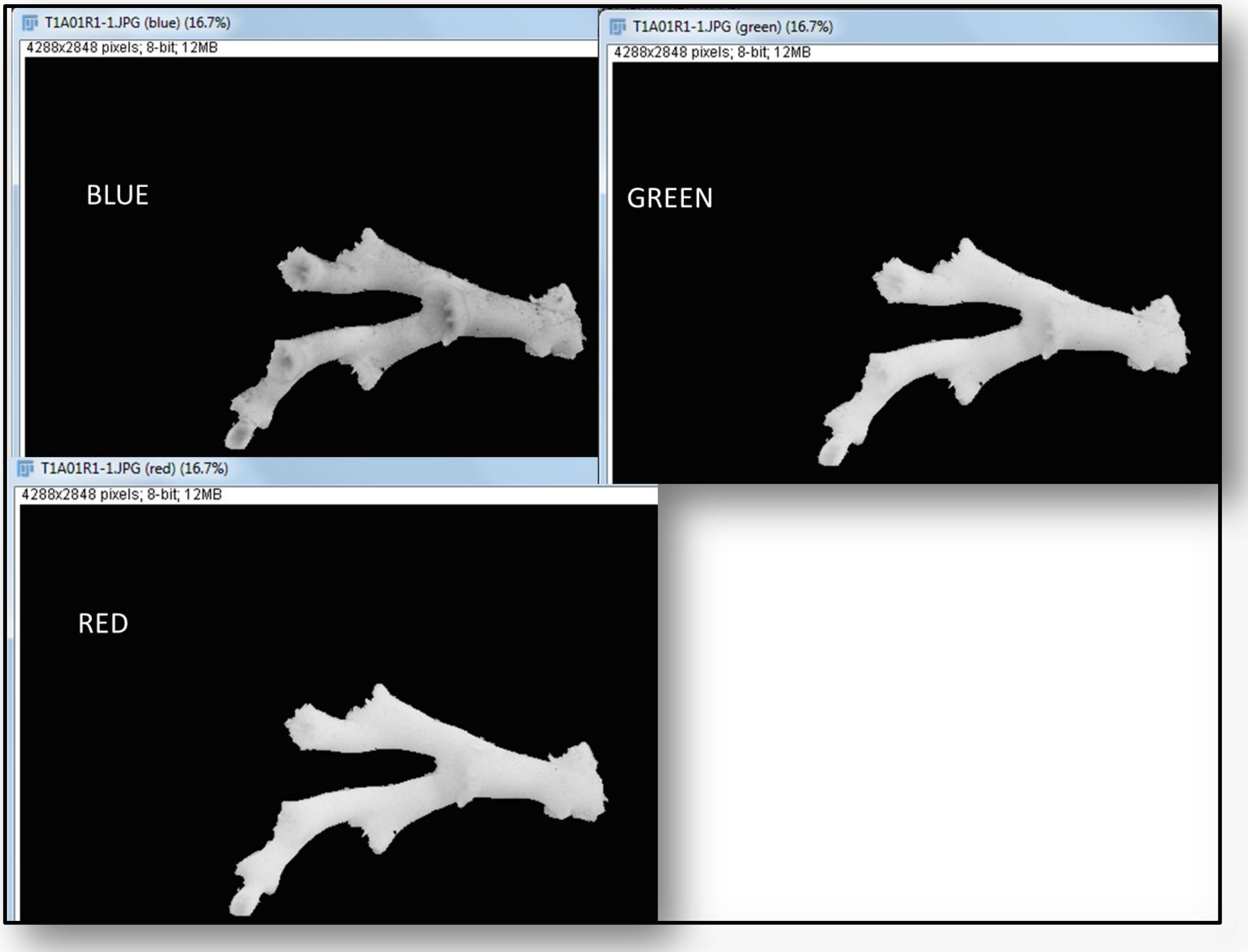


Figure 5: Three sub-images created with "split channels" function in Fiji. Observe clearer coral projection in red channel.

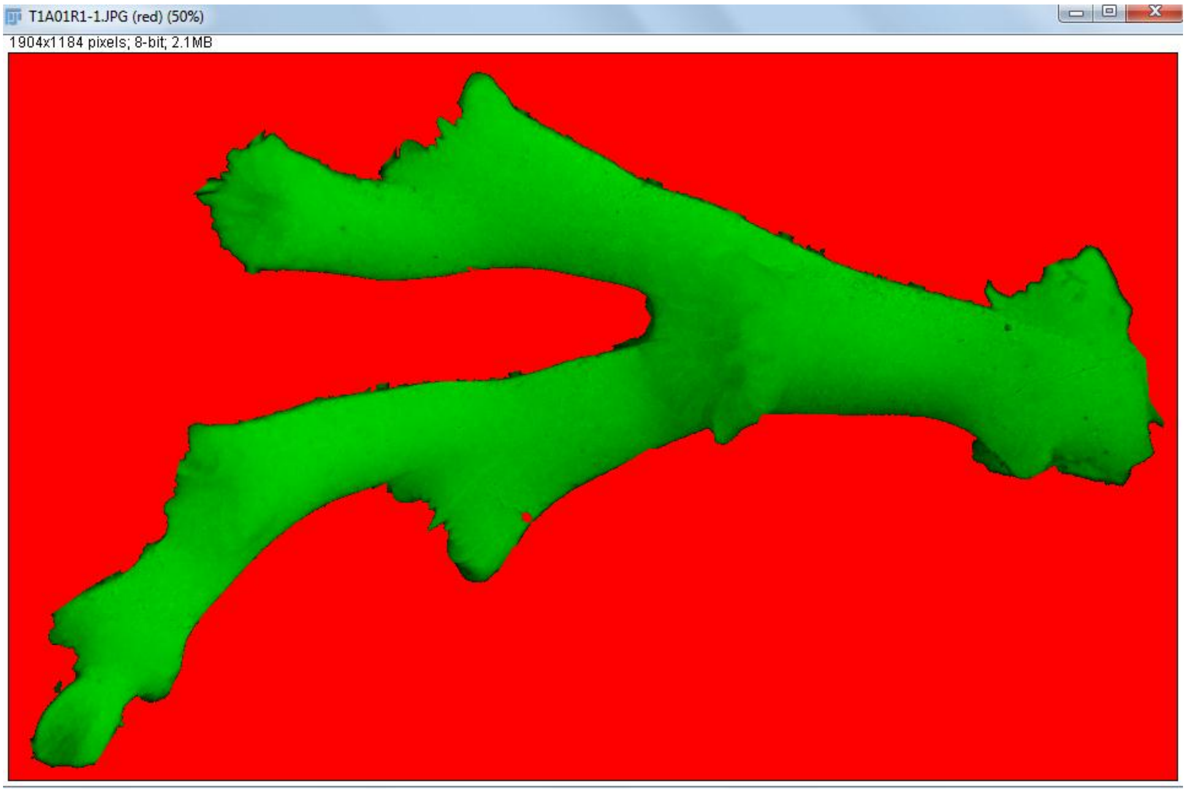
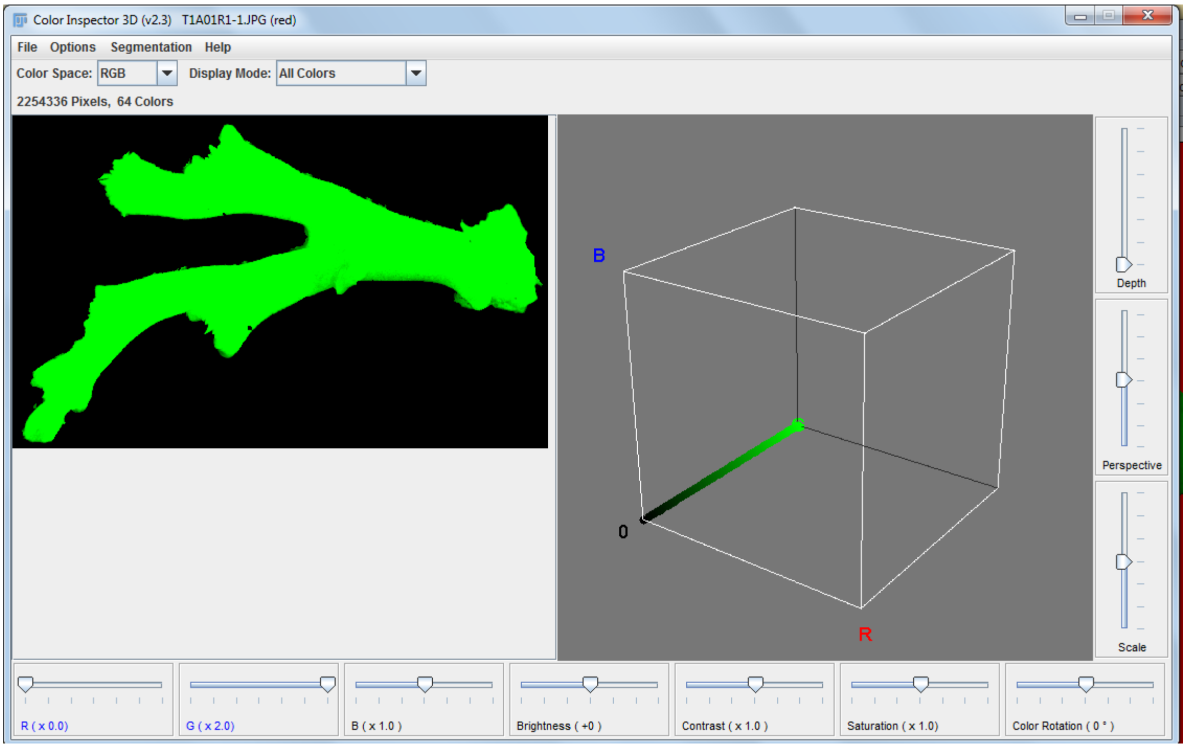


Figure 6: Red/green image after performing "lookup tables" --> red/green function



Color Space: RGB

Display Mode: All Colors

2254336 Pixels, 64 Colors

R (x 0.0)

G (x 2.0)

B (x 1.0)

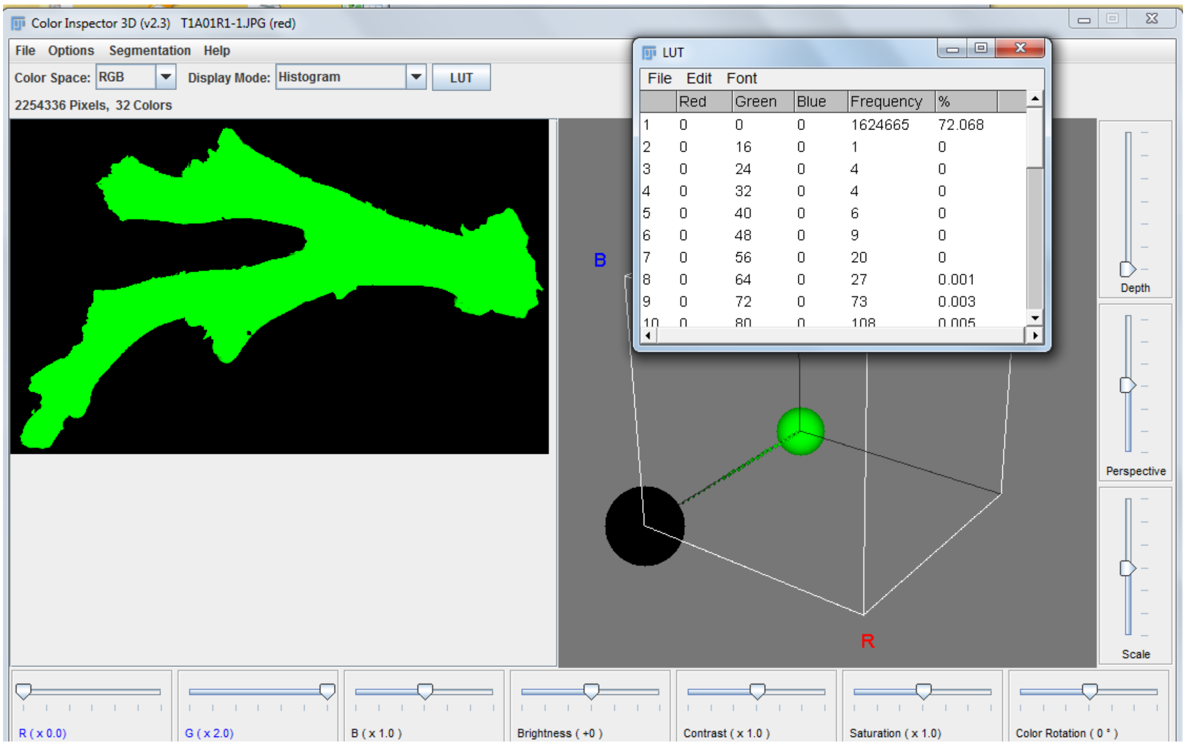
Brightness (+0)

Contrast (x 1.0)

Saturation (x 1.0)

Color Rotation (0 °)

Figure 7: Simplified colour image as visualized in "Colour inspector 3D" function of Fiji. Observe maximized "G" tab and minimized "R" tab at the bottom



Color Space: RGB
Display Mode: Histogram
2254336 Pixels, 32 Colors

	Red	Green	Blue	Frequency	%
1	0	0	0	1624665	72.068
2	0	16	0	1	0
3	0	24	0	4	0
4	0	32	0	4	0
5	0	40	0	6	0
6	0	48	0	9	0
7	0	56	0	20	0
8	0	64	0	27	0.001
9	0	72	0	73	0.003
10	0	80	0	108	0.005

Figure 8: Sample of Lookup table (LUT) as visualized in Color Inspector 3D. Number and Frequency of green pixels visible from this table

2.5.4 Skeletal density changes……………………………………………………………

The ratio of growth based on buoyant weight to that of growth based on colour projection served as a proxy of skeletal density. I.e. indication of the amount of effort the coral was putting into either expanding itself (greater denominator; lighter weight) or becoming sturdier (greater numerator; heavier weight). Since my main interest was on whether such ratio would be significantly altered by ocean acidification; I plotted such ratios as a function of pCO_2 treatment.

2.5.5 Calibration of growth measuring parameters……………………………………

To assess which method of obtaining growth rates performed better, buoyant weight and colour projection –based methods were compared. The assessment criteria included whether these methods provided:

- growth rates of similar magnitude and variation
- similar trends as a function of increasing ocean acidification

2.6 General housekeeping……………………………………………………………………

In addition to general aquarium monitoring parameters, behavioural and general observations such as "tentacles out", "hydrozoan attachment", "visible calcification against the vial wall" and others were recorded. Such observations helped to obtain a qualitative idea of the corals health.

2.7 Data analysis...

Descriptive statistics, frequency tables and plots were generated using STATISTICA © v. 7 (StatSoft Inc.).

The median was chosen as a measure of central distribution, due to its robustness to abnormal distributions, quite common given the very high variability found naturally in coral growth rates. Thus choosing the mean would likely give undue importance to extreme and outlier values.

Normality was defined in this study as the ratio of skewness to standard error of skewness. The distribution of the response variable was then considered normal, if such ratio was equal or minor to 3.29 (SPSS).

The effect of variance on a response variable (growth rate) was also assessed based on the mathematical property of Jensen's inequality (Ruel and Ayres, 1999). This property states that variance has the potential for suppressing, accelerating or causing no effect on the response variable; according to its shape. Linear shape (variance has no effect), concave up (accelerating effect), concave down (decelerating effect) (Ruel and Ayres, 1999).

The community level response, labeled "deep-sea coral community" hereafter; is obtained by putting together the response of the three species: *Madrepora oculata*, *Lophelia pertusa* and *Desmophyllum sp.*

2.7.1 Polyp count...

To assess whether there was a significantly different proportion of new polyps in any given ocean acidification treatment at the end of the experiment, a Chi-square test was performed.

Growth rates based on polyp development were also calculated (No. of new polyps per year) for comparison with available literature.

2.7.2 Buoyant weight……………………………………………………………………………

To observe whether experimental maintenance time and/or pCO_2 level were able to significantly explain some of the variability in growth rate; a General Linear Model, Repeated Measurements Analysis of Variance (RM ANOVA) was carried out using SPSS © v. 16 (SPSS Inc.). Such analysis was performed four times: one for each species (*Desmophyllum sp, Lophelia pertusa, Madrepora oculata*), and one for the whole deep-sea community. An Additional RM ANOVA was utilized to see whether a species specific response to pCO_2 level existed.

Whenever the sphericity assumption was violated, results from RM ANOVA were interpreted based on the Huyhn-Feldt adjusted statistic.

The questions to be answered by the RM ANOVA (acclimation*treatment) analysis were:

- *Within-subjects main effects*: Does acclimation (experimental maintenance time) influence coral growth rate?
- *Between-subjects main effects*: Does ocean acidification treatment (pCO_2 level) influences coral growth rate?
- *Within-subjects by between-subjects*: Does the influence of pCO_2 on growth rate depend upon acclimation? (Does the pattern of differences between growth rates for pCO2 levels change with acclimation?)

The questions to be answered by the RM ANOVA (treatment*species) analysis were:

- *Within-subjects main effects*: Does treatment influence coral growth rate?
- *Between-subjects main effects*: Does species influence coral growth rate?
- *Within-subjects by between-subjects*: Does the influence of species on growth rate depend upon treatment? (Does the pattern of differences between growth rates for species change with treatment?)

2.7.3 Image analysis –colour projection…………………………………………………

To observe whether experimental maintenance time and/or pCO_2 level were able to significantly explain some of the variability in growth rate; a General Linear Model, Repeated Measurements Analysis of Variance (RM ANOVA) was carried out using SPSS © v. 16 (SPSS Inc.). Due to restricted number of available values after deletion of incompatible images and negative values, only a single RM ANOVA, performed at the community level was performed. An Additional RM ANOVA was utilized to see whether a species specific response to pCO2 level existed.

Whenever the sphericity assumption was violated, results from RM ANOVA were interpreted based on the Huyhn-Feldt adjusted statistic.

The questions to be answered by the RM ANOVA (acclimation*treatment) analysis were:

- *Within-subjects main effects*: Does acclimation (experimental maintenance time) influence coral growth rate?
- *Between-subjects main effects*: Does ocean acidification treatment (pCO_2 level) influences coral growth rate?
- *Within-subjects by between-subjects*: Does the influence of pCO_2 on growth rate depend upon acclimation? (Does the pattern of differences between growth rates for pCO_2 levels change with acclimation?)

The questions to be answered by the RM ANOVA (treatment*species) analysis were:

- *Within-subjects main effects*: Does treatment influence coral growth rate?
- *Between-subjects main effects*: Does species influence coral growth rate?
- *Within-subjects by between-subjects*: Does the influence of species on growth rate depend upon treatment? (Does the pattern of differences between growth rates for species change with treatment?)

2.7.4 Skeletal density changes..

In order to assess whether treatment had a significant effect on skeletal density, a one-way ANOVA or Kruskal-Wallis test (in the case were ANOVA assumptions were violated) was performed.

3 **Results** ....

3.1 Aquaria chemistry..

Summary of selected physic-chemical parameters values is available in Table 3.

3.1.1 Salinity ....

Average salinity across treatments was 37.66± 1.04 S.D in the period June-August 2010 (Table 4). Over 70% of the records were between 35-38 (Appendix- Table 12). There was a tendency of increasing salinity with time. Water in the large supplying tanks had the lowest fluctuation (37.00± 0.33) whereas treatment D (1000ppm) appeared to have the highest variation (mean= 38.19± 1.3.) and salinity values (Max= 41.95). Treatment's A and B generally had lower salinity than C and D.

Variation across vials of different water volume was similar except for the big (1000ml) vials (Appendix-Table 13) It became apparent that evaporation was taking place in vials if compared to the supplying tanks.

Table 3: Selected parameters of physic-chemical conditions in aquaria

	Temperature (°C)		**Salinity (ppt)**		**pCO2 (ppm)**		**pH**		**Ω aragonite**	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
A	12.930	1.127	37.271	0.637	412.192	73.671	8.075	0.062	2.767	0.332
B	12.322	0.516	37.375	0.695	497.187	117.504	8.018	0.032	2.488	0.191
C	12.946	0.518	37.865	1.050	665.454	100.012	7.880	0.044	1.888	0.200
D	12.904	0.502	38.193	1.368	866.001	191.199	7.767	0.048	1.500	0.183

Table 4: Salinity values over measurement period June-August 2010

Treatment	Salinity Means	Confidence -95,000%	Confidence +95,000%	Salinity N	Salinity Std.Dev.	Salinity Minimum	Salinity Maximum
A	37.271	37.086	37.456	48	0.637	36.2	39.2
B	37.375	37.196	37.554	60	0.695	36.1	39.5
C	37.865	37.582	38.149	55	1.050	36.2	40.3
D	38.193	37.827	38.559	56	1.368	36.6	42
Bulk water	37.000	36.721	37.279	8	0.334	36.6	37.7
All Groups	37.660	37.524	37.796	227	1.040	36.1	42

3.1.2 Temperature..

Based on temperature loggers, mean temperature across treatments and time was 12.776 ± 0.076 °C (± S.D.) (Table 5). There was a significant difference in temperature according to treatment [Kruskal-Wallis, H (3, N= 58756) =23838.07 $p<0.05$]. Highest temperature was recorded in treatment C, (mean 12.94± 0.087 °C (± S.D.)), followed by A (mean 12.94± 1.127 °C (± S.D.)), D (mean 12.90± 0.502 °C (± S.D.)), and finally B (mean 12.32± 0.516 °C (± S.D.)).

Overall, temperature remained constant (Figure 9) for the duration of the experiment. There were however two temperature disrupting episodes experienced by all treatments due to breakdown of the cooling system of the climate room and the time for re-adjustment to experimental temperature (30-31 July 2010 and 5/6 August 2010) which means, these temperature anomalies were not related to external (Villefranche bay) temperature changes. Such episodes can be observed in the later portion of the temperature profile (**Figure 5**)

Table 5: Temperature (in °C) observed over 9-month ocean acidification experiment on Mediterranean cold water corals

Treatment	temp Means	Confidence -95,000%	Confidence +95,000%	temp N	temp Std.Dev.	temp Minimum	temp Maximum
A	12.930	12.912	12.948	14692	1.127	9.433	25.535
B	12.322	12.314	12.330	14686	0.517	8.487	14.613
C	12.947	12.939	12.955	14687	0.519	8.582	24.493
D	12.905	12.897	12.913	14691	0.502	8.801	25.487
All Groups	12.776	12.770	12.782	58756	0.764	8.487	25.535

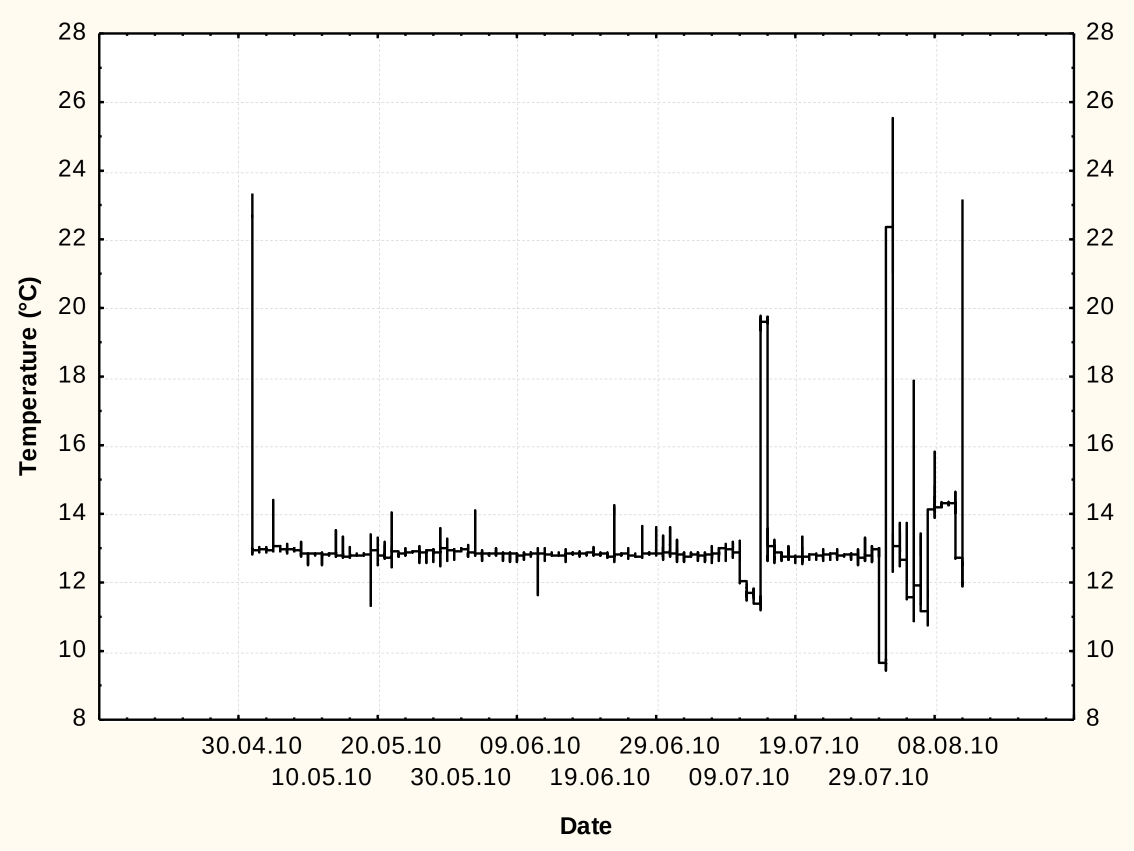


Figure 9: Temperature profile of ocean acidification experiment. N=14,691 logs

3.1.3 Aquastar computer monitoring: salinity and temperature.....................

Values displayed by the IKS aquastar © computer differed slightly from those obtained with temperature loggers and weekly measurements of salinity (Figure 10). Mean temperature in the aquastar computer was 12.97 ± 0.087 °C (± S.D.) (N=3501) and mean salinity 38.12± 0.405 ppt ± S.D. (Figure 10). Nevertheless both measuring methods (aquastar, manual) confirmed that values observed in aquaria, indeed approximate values of temperature and salinity aimed for.

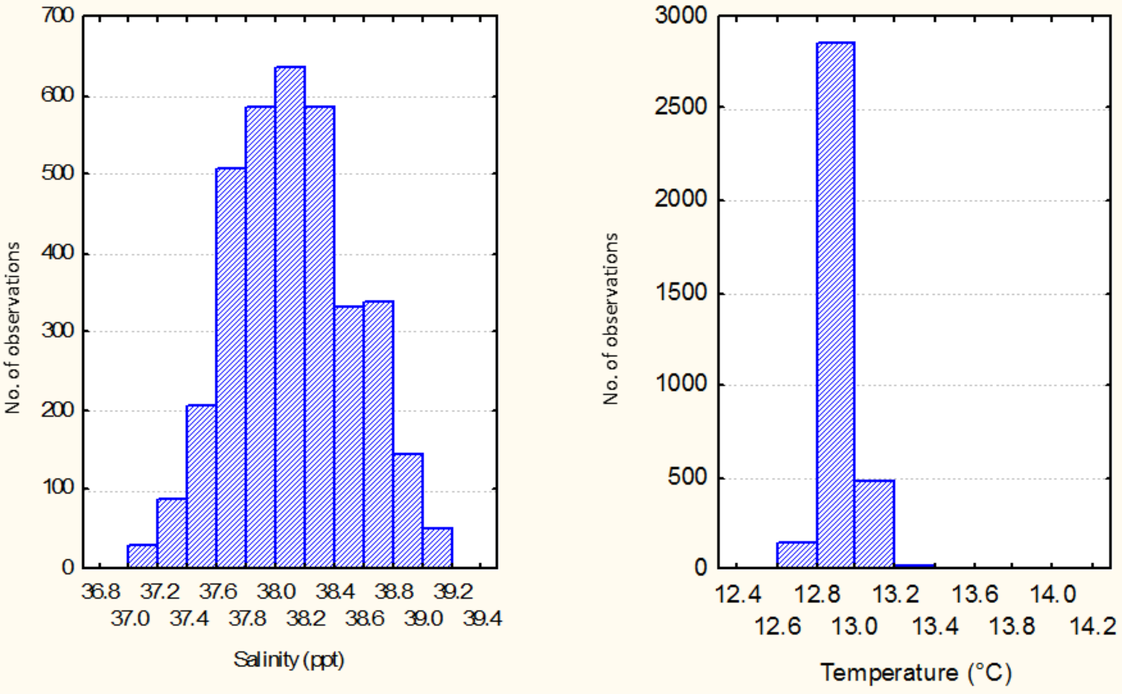


Figure 10: Salinity and temperature values obtained from IKS Aquastar computer in Aquaria. Measurements took place at intervals of 30 minutes

3.1.3 Carbon system ....

A summary of the carbon chemistry parameters for the whole experiment is available in Table 6. There was a deviation from the values we attempted to achieve and the values measured using TA and DIC during incubation and from monthly sampling in aquaria. In particular, treatment A which was aimed to represent pre-industrial pCO_2 levels, was closer to ambient conditions than desired with a mean determined by TA/DIC of 412 ± 73 ppm (± S.D.) (Table 6, Figure 11). Nevertheless, each treatment represented a discrete scenario as shown by Kruskal-Wallis test (H (3, 575) =375.766), $p<0.05$). For treatment B, over 50% of values determined by TA/DIC were between

450-500 ppm (Appendix –Table 16), with a mean of 497 ± 117 ppm. Over 50% of all values for treatment C were between 600-800ppm (mean= 665 ± 100 ppm). Highest variation was present in treatment D (866 ± 191 ppm) with over 70% of values lying between 800-1000 ppm.

Excluding the measurement period of September when the experiment was started, pattern of pCO_2 levels remained fairly constant (Figure 12).

Table 6: Descriptive Statistics for Carbon system in ocean acidification experiment. Parameters obtained using R script "seacarb" developed by Lavigne and Gattuso (2010). Estimated parameters: pCO_2, fCO_2, HCO3, CO3, Ωaragonite, Ωcalcite were calculated based on total alkalinity, dissolved inorganic Carbon, salinity 38ppt, temperature 13 °C, pressure 0 atm. Smallest N for any variable: 574.

Treatment	**pCO2 Means (µatm)**	**pCO2 Std.Dev.**	**fCO2 Means (µatm)**	**fCO2 Std.Dev.**	**HCO3 Means (mol/kg)**	**HCO3 Std.Dev.**	**CO3_ Means (mol/kg)**	**CO3_ Std.Dev.**
A	412.19162	73.67072	410.68464	73.40138	0.002102	0.000066	0.000184	0.000023
B	497.18731	117.50371	495.36959	117.07411	0.002166	0.000054	0.000163	0.000020
C	665.45439	100.01225	663.02149	99.64660	0.002242	0.000064	0.000130	0.000019
D	866.00084	191.19856	862.83473	190.49953	0.002297	0.000096	0.000108	0.000027
All Groups	614.58776	216.43620	612.34083	215.64490	0.002204	0.000103	0.000146	0.000037
	DIC Means (mol/kg)	**DIC Std.Dev.**	**TA_ Means (mol/kg)**	**TA_ Std.Dev.**	**Ω Aragonite Means**	**Ω Aragonite Std.Dev.**	**Ω Calcite Means**	**Ω Calcite Std.Dev.**
A	0.002303	0.000057	0.002556	0.000053	2.760737	0.339691	4.305019	0.531042
B	0.002349	0.000054	0.002568	0.000061	2.441692	0.301853	3.806004	0.470515
C	0.002398	0.000063	0.002562	0.000067	1.945639	0.289282	3.032777	0.450921
D	0.002439	0.000093	0.002563	0.000095	1.620942	0.402992	2.526653	0.628166
All Groups	0.002373	0.000086	0.002562	0.000071	2.180747	0.553160	3.398087	0.862541

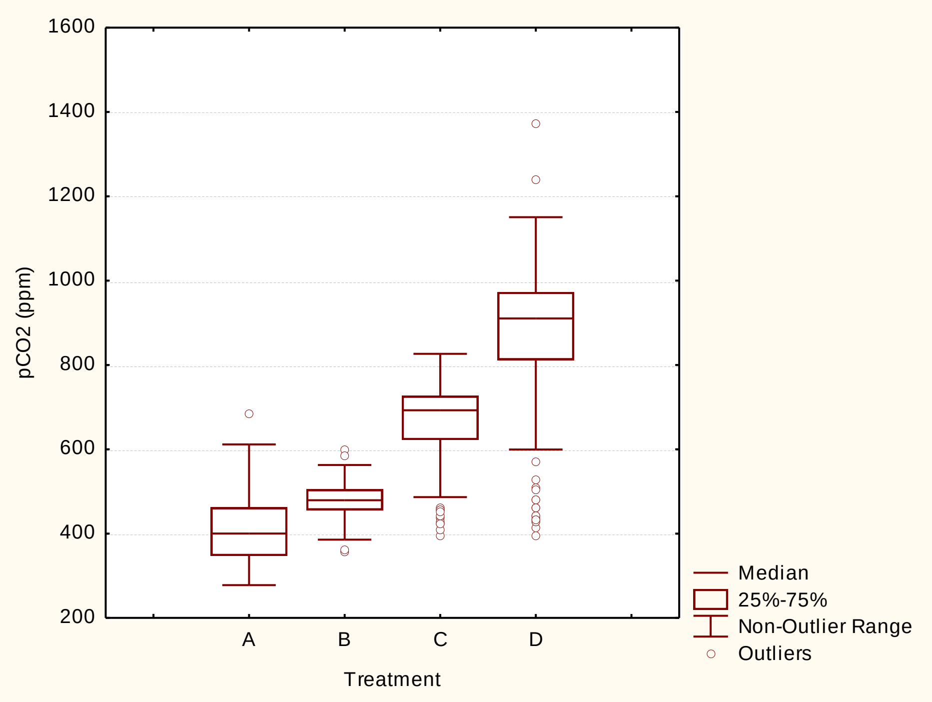


Figure 11: Variation of pCO_2 observed during ocean acidification experiment. September 2009-August 2010

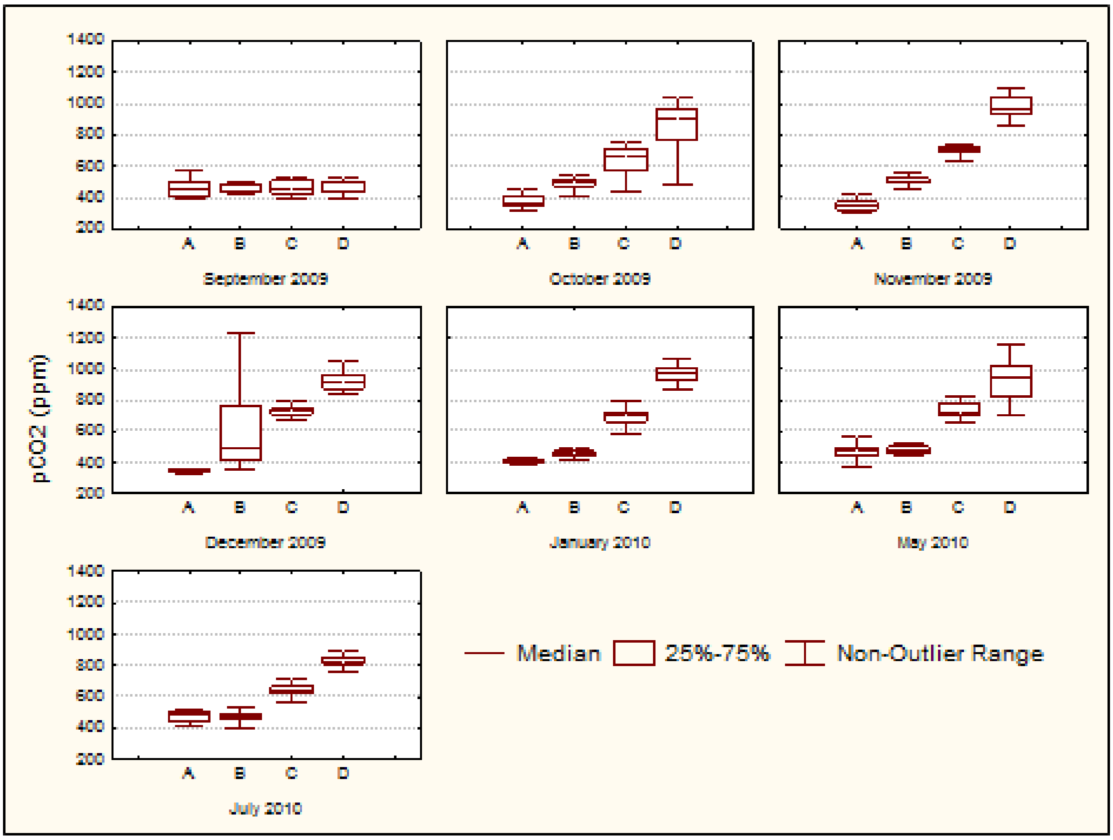


Figure 12: pCO_2 levels observed for ocean acidification experiment over time

3.1.4 Maintenance……………………………………………………………………………

Some issues related to maintenance aroused during the experiment. Some of them were reflected in salinity, temperature and carbon chemistry trends. For example cooling system breakdowns were reflected in temperature disruption episodes. These tended to be more common towards the summer period (June-August). Fluctuation in salinity was sometimes the result of increased rain, excessive evaporation, or recent cleaning. Besides changes in water quality of Villefranche bay's, occasional clogging of water tubes also contributed to observed variation in salinity. Changes in pCO_2 were at least partially related to clogging of pCO_2 delivering tubes. An additional element of fluctuation for this parameter was the problem of sealing soda lime tube. This tube was in charge of eliminating pCO_2 for treatment A; however regular check-ups with CO_2 analyser (Li-COR© 6252) revealed leakages. Thus levels of pCO_2 in such treatment were in several cases above pre-industrial scenario.

3.2 Growth under different pCO_2 levels ....

3.2.1 [Based on polyp addition] ....

All treatments presented at least one specimen developing new polyps (Table 7). Such new polyps belonged either to *Lophelia pertusa* or *Madrepora oculata;* since no new polyps were readily visible in our experimental samples of *Desmophyllum sp*. Average rate of polyp addition was 5.6 polyps per year in *Lophelia pertusa* and 4.0 polyps per year in *Madrepora oculata*.

There was no significant influence of treatment on new polyp development of *Lophelia pertusa* ($\chi^2=0.355$, df=3, $p>0.05$); *Madrepora oculata* ($\chi^2=0.756$, df=3, $p>0.05$) or the deep-sea coral community ($\chi^2=0.053$, df=3, $p>0.05$) after 9 months of experimental maintenance time.

Polyp development was already visible at least from the fifth month of experimental maintenance time in some cases (Figure 13). However gradual growth of new polyps; as well as difficulties in counting polyps –particularly in large colonies, impeded a more precise estimation of polyp addition in reference to experimental maintenance time.

Table 7: Number of new polyps developed in aquaria. In brackets total number of corals for each category.

	A	B	C	D	TOTAL
Lophelia pertusa	5 (11)	3 (8)	5 (10)	4 (10)	17 (29)
Madrepora oculata	4 (7)	3 (9)	3 (8)	2 (8)	12 (22)
Total	9 (25)	6 (21)	8 (24)	6 (22)	29 (92)

Figure 13: Example of polyp development over time in *Lophelia pertusa* exposed to treatment A

3.2.2 Based on buoyant weight...

Desmophyllum sp

Highest growth rates for *Desmophyllum sp* were recorded in treatment B (0.032 ± 0.006) (% buoyant weight per day ± S.D.) followed by D (0.026 ± 0.018 % buoyant weight per day) (± S.D), A (0.013 ± 0.047 % buoyant weight per day) (± S.D), and finally C (0.012 ± 0.064% buoyant weight per day) (± S.D) (Table 8 Figure 14). The 90 percentile was highest in treatment A (0.154% buoyant weight per day), indicating that a larger amount of fast growth rates belong to such treatment. Treatment C also reported a high 90 percentile (0.138% buoyant weight per day).

There was no reduction in calcification based on growth rate differences between treatments for this species. However there was a significant interaction between experimental maintenance time and treatment (RM ANOVA, F_{12}= 2.415, $p<0.05$) (Figure 15) (Table 9: Summary of RM ANOVA results. Significant effects were determined at $p<0.05$. Whenever sphericity was significant, Huyhn-Feldt (H-F) adjusted statistic was used.). Such result shows that influence of treatment on growth rate of this species depends upon experimental maintenance time. Largest median growth rate was observed for specimens in treatment C, after 8 months of experimental maintenance time (0.169 ± 0.043 % buoyant weight per day) (± S.D.); whereas the lowest median growth rate was recorded in treatment A, also after 8 months of incubation (0.002 ± 0.003 % buoyant weight per day) (± S.D.).

Table 8: Summary of descriptive statistics showing growth rate based on buoyant weight of three species of Mediterranean deep-sea corals exposed to ocean acidification

Table 8: Summary of descriptive statistics showing growth rate based on buoyant weight of three species of Mediterranean deep-sea corals exposed to ocean acidification.

Species	**Treatment**	**Valid N**	**Mean**	**Median**	**Minimum**	**Maximum**	**Percentile 20.00000**	**Percentile 90.00000**	**Std.Dev.**	**Standard Error**	**Skewness**	**Std.Err. Skewness**	**Kurtosis**	**Std.Err. Kurtosis**	**Normality**
Desmophyllum	A	9	0.029	0.013	0.000	0.155	0.005	0.155	0.048	0.016	2.787	0.717	8.047	1.400	3.887
	B	2	0.032	0.032	0.027	0.037	0.027	0.037	0.007	0.005					
	C	11	0.047	0.013	0.003	0.199	0.007	0.139	0.064	0.019	1.863	0.661	2.729	1.279	2.820
	D	9	0.034	0.027	0.015	0.072	0.017	0.072	0.019	0.006	1.145	0.717	1.060	1.400	1.597
Madrepora	A	26	0.022	0.017	0.000	0.060	0.003	0.049	0.018	0.004	0.524	0.456	-1.070	0.887	1.150
	B	35	0.034	0.025	0.000	0.133	0.007	0.081	0.033	0.006	1.318	0.398	1.367	0.778	3.314
	C	30	0.040	0.020	0.000	0.286	0.008	0.096	0.058	0.011	3.154	0.427	11.356	0.833	7.388
	D	25	0.059	0.036	0.000	0.287	0.010	0.183	0.072	0.014	2.122	0.464	4.272	0.902	4.577
Lophelia	A	20	0.037	0.013	0.003	0.162	0.006	0.128	0.048	0.011	1.826	0.512	2.476	0.992	3.565
	B	15	0.019	0.008	0.002	0.090	0.005	0.041	0.023	0.006	2.343	0.580	6.433	1.121	4.040
	C	16	0.028	0.009	0.001	0.219	0.003	0.047	0.053	0.013	3.495	0.564	13.014	1.091	6.194
	D	16	0.027	0.007	0.000	0.119	0.003	0.114	0.040	0.010	1.713	0.564	1.601	1.091	3.036
Community	A	55	0.029	0.015	0.000	0.162	0.005	0.060	0.037	0.005	2.462	0.322	6.209	0.634	7.651
	B	52	0.030	0.024	0.000	0.133	0.006	0.079	0.030	0.004	1.539	0.330	2.160	0.650	4.659
	C	57	0.038	0.013	0.000	0.286	0.007	0.123	0.057	0.008	2.759	0.316	7.841	0.623	8.722
	D	50	0.044	0.020	0.000	0.287	0.007	0.101	0.057	0.008	2.563	0.337	7.511	0.662	7.615

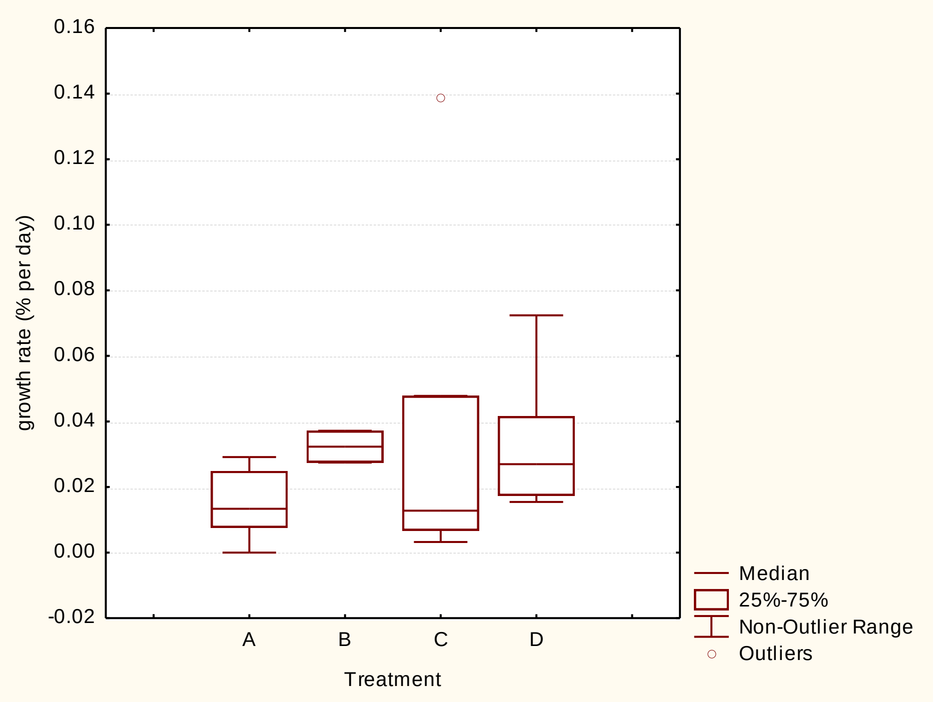


Figure 14: Growth rate (% buoyant weight per day) of *Desmophyllum sp* exposed to ocean acidification according to buoyant weight technique

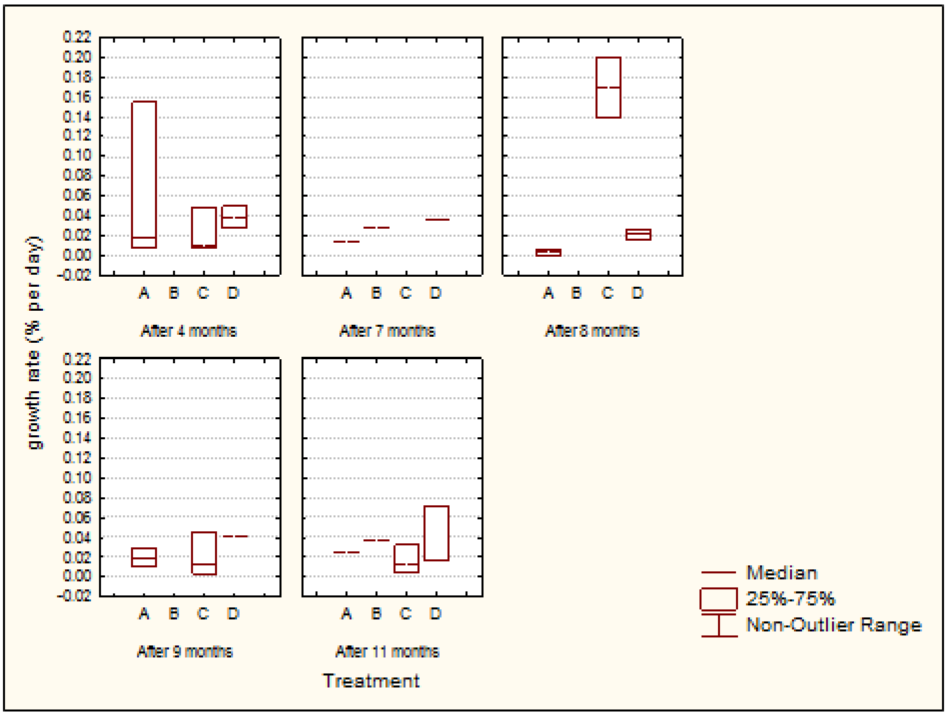


Figure 15: Growth rate (% buoyant weight per day) of *Desmophyllum sp* over time. According to buoyant weight technique

Table 9: Summary of RM ANOVA results. Significant effects were determined at $p<0.05$. Whenever sphericity was significant, Huyhn-Feldt (H-F) adjusted statistic was used.

		Sphericity	Within	Interaction	Between
GLM_ttment*time_BW (within: time; between: ttment)					
	Desmo	ns	ns	s	ns
	Madre	s	ns	ns	ns
	Loph	s	s (H-F)	ns	ns
	Community	s	s (H-F)	s (H-F)	ns
GLM_ttment*spp_BW (within: treatment; between: spp)					
	Community	s	s (H-F)	s (H-F)	s [post-hoc subsets: Madrepora different from Lophelia]
GLM_ttment*time_colour (within: time; between: ttment)					
	Community	s	s (H-F)	s (H-F)	s (A-B one subgroup; C-D another subgroup)
GLM_ttment*spp_colour (within: treatment; between: spp)					
	Community	s	s (H-F)	ns	ns

Lophelia pertusa

Median growth rate of *Lophelia pertusa* in treatment A was an order of magnitude larger than in any other treatment (0.013 ± 0.048 % buoyant weight per day) (± S.D.) (Table 8 Figure 16). This treatment had also the largest proportion of fast growth rates, as observed by highest 90 percentile compared to other treatments. At the other end, lowest median growth rate was observed in treatment D (0.007 ± 0.040 % buoyant weight per day) (± S.D.). Reduction in calcification based on growth rate differences between treatments was 46% buoyant weight per day on higher pCO_2 compared to lowest $pCO_{2.}$ However statistically there was no conclusive evidence that treatment had an effect on growth rates of this species (RM ANOVA, $F_3= 0.504$, $p>0.05$). Acclimation on the other hand did play a role in growth rate of *Lophelia pertusa* (RM ANOVA, Huynh-Feldt corrected, $F_{3.028}= 3.186$, $p<0.05$) (Figure 17). Growth rate pattern is similar at the 4th 9th and 11th month of experimental maintenance time, but appears quite dissimilar at the 7th and 8th months where treatments C and D are unusually high.

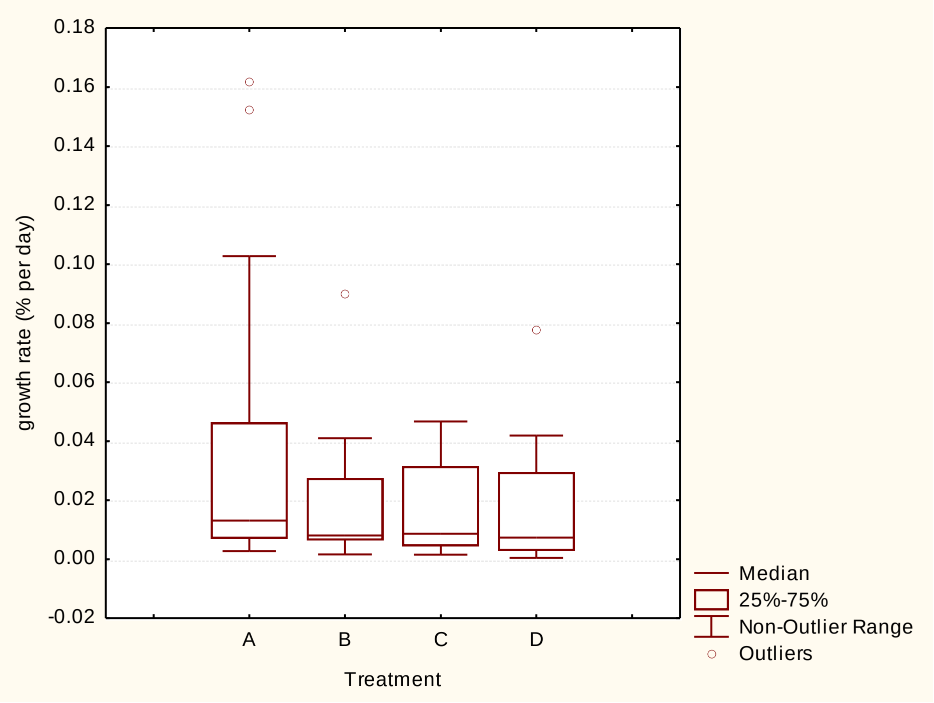


Figure 16: Growth rate ((% buoyant weight per day) of *Lophelia pertusa* exposed to ocean acidification according to buoyant weight technique

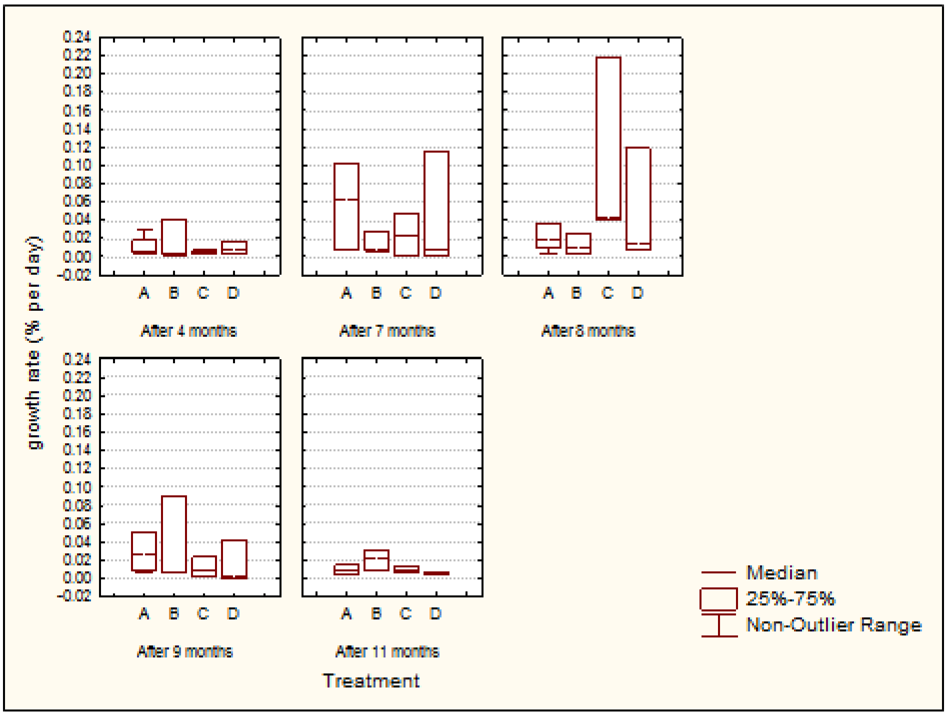


Figure 17: Growth rate (% buoyant weight per day) of *Lophelia pertusa* over time. According to buoyant weight technique

Madrepora oculata

Largest median growth rate and variance for *Madrepora oculata* was recorded for treatment D (0.036 ± 0.071 % buoyant weight per day) (± S.D.) (Table 8 Figure 18). Within this treatment we also observed the greatest amount of fast growth rates, an order of magnitude higher than the rest of the treatments (90 percentile: 0.183 % buoyant weight per day). There was no reduction in calcification based on growth rate differences between treatments for this species. A RM ANOVA test confirmed no significant effect of treatment on growth rate (F_3=2.49, p>0.05)

Regarding the influence of experimental maintenance time on growth rate, there was also no significant effect (RM ANOVA, Huynh-Feldt corrected, $F_{3.882}$= 1.033, p<0.05) (Figure 19).

Relationship of growth rate with increasing pCO_2 in this species had a concave up shape (Figure 20). According to Jensen's inequality (Ruel and Ayres, 1999), increasing variation in this species would have the effect of accelerating growth rates more than expected, since variance elevates the response of coral to increasing pCO_2.

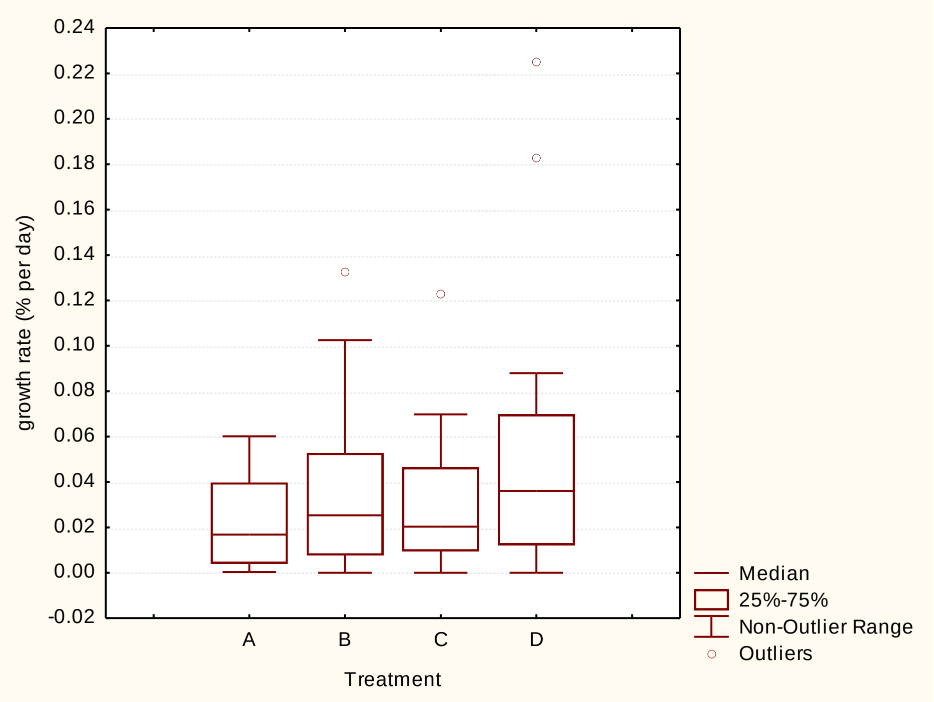


Figure 18: Growth rate (% buoyant weight per day) of *Madrepora oculata* exposed to ocean acidification according to buoyant weight technique

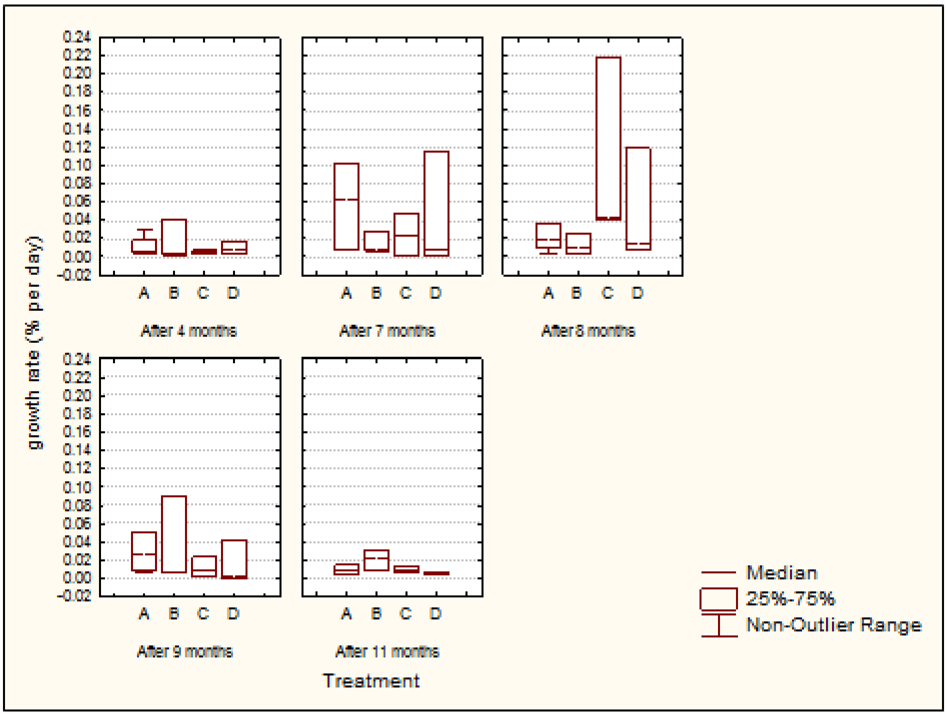


Figure 19: Growth rate (% buoyant weight per day) of *Madrepora oculata* over time. According to buoyant weight technique

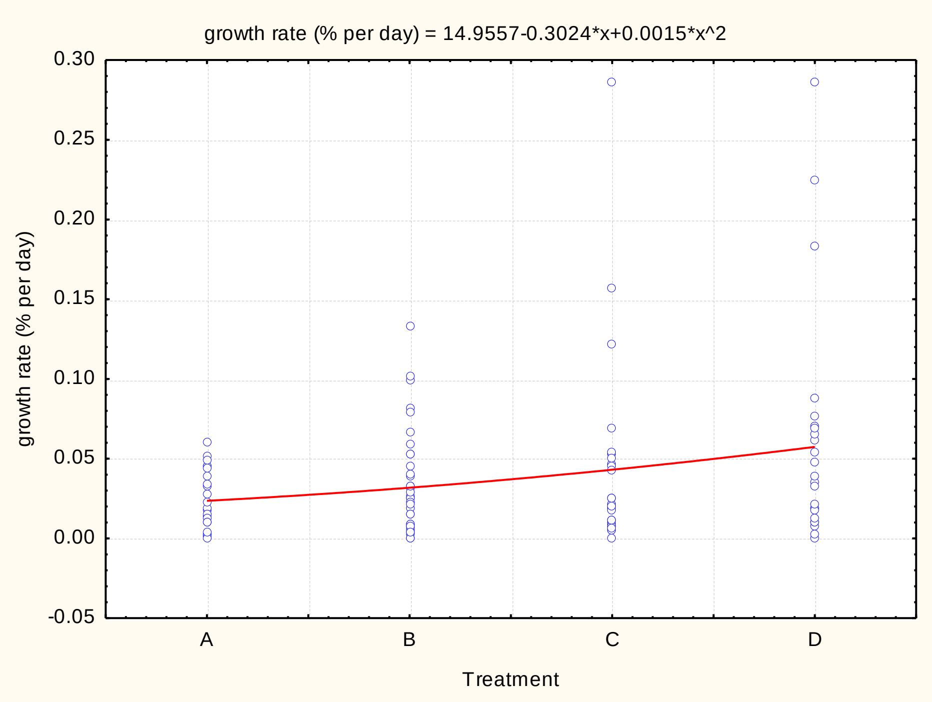


Figure 20: Relationship of *Madrepora oculata* growth rate with increasing ocean acidification based on buoyant weight.

Deep-sea coral community

Median growth rate for deep-sea coral community was highest for treatment B (0.023 ± 0.030 % buoyant weight per day) (± S.D.) (Table 8 Figure 21). This was followed closely by treatment D (0.019 ± 0.057 % buoyant weight per day) (± S.D.). Lowest median growth rate at the community level was recorded for treatment C (0.013 ± 0.057 % buoyant weight per day) (± S.D.). A larger proportion of fast growth rates were recorded in treatment C (90 percentile: 0.122 % buoyant weight per day). There was no reduction in calcification based on growth rate differences between treatments at the coral community level.

There was a significant interaction between experimental maintenance time and treatment (RM ANOVA, Huynh-Feldt corrected, $F_{11.107}$= 3.979, $p<0.05$) (Figure 22), indicating that influence of treatment on growth rate depends upon experimental maintenance time. Largest median growth rate was recorded in treatment C during the 8th month of experimental maintenance time (0.138 ± 0.096 % buoyant weight per day) (± S.D.). A median growth rate of such magnitude was not registered any other time during the whole experiment. Fast growth rates were recorded mainly during the 8th and 9th experimental maintenance months in treatments' C (90 percentile: 0.2864 %

buoyant weight per day) and D (90 percentile: 0.2865 % buoyant weight per day) respectively.

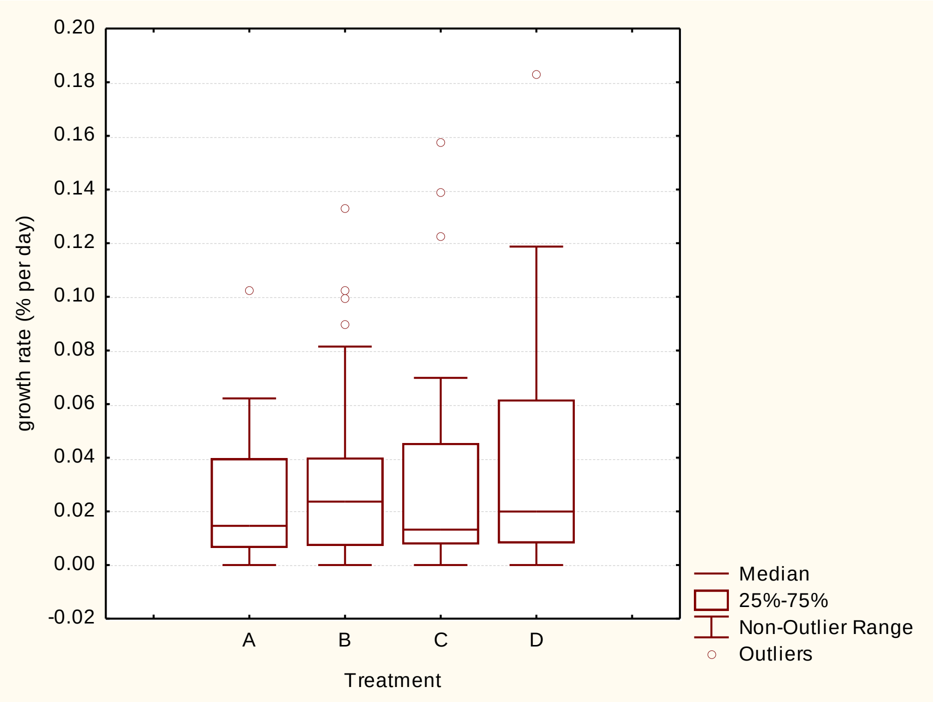


Figure 21: Growth rate (% buoyant weight per day) of deep-sea coral community exposed to ocean acidification according to buoyant weight technique

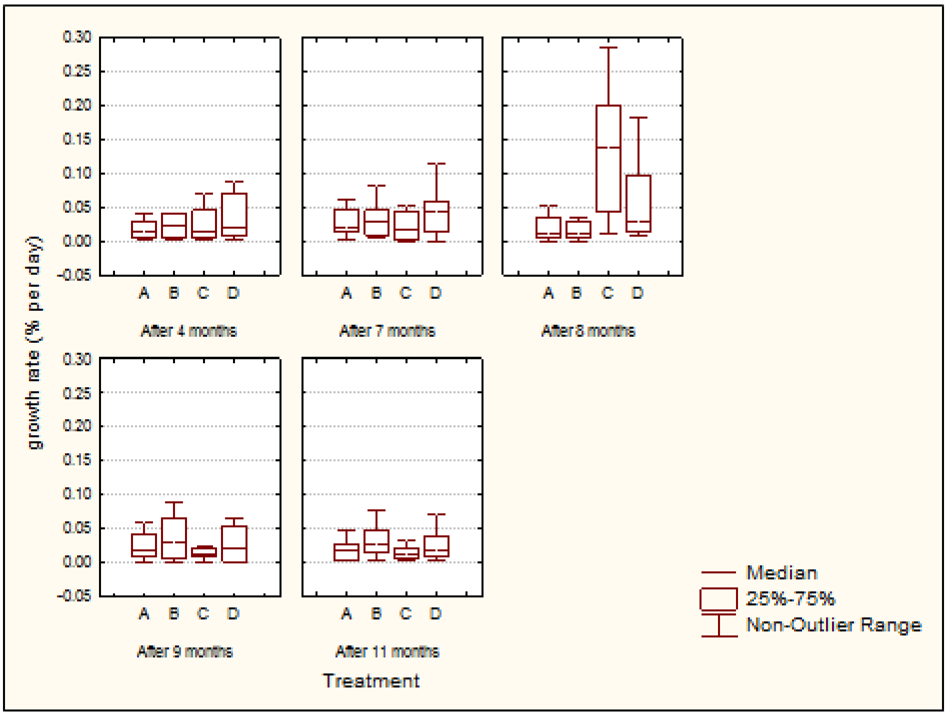


Figure 22: Growth rate (% buoyant weight per day) of deep-sea coral community over time. According to buoyant weight technique

Comparison of growth rates between species

A RM ANOVA revealed a significant interaction effect between treatment and species (Huynh-Feldt corrected, $F_{4.869}$= 3.675, $p<0.05$) (Table 9). Such result highlights a species specific response (growth rate) to increased pCO_2. A post-hoc multiple comparisons test with equal variances not assumed (Tahmane's 2), created two subgroups. The first subgroup was constituted by *Lophelia pertusa* and *Desmophyllum sp*; and the second by *Madrepora oculata* and *Desmophyllum sp*, thus excluding a similar response between *Lophelia pertusa* and *Madrepora oculata*.

On average *Madrepora oculata* had higher growth rates than *Desmophyllum sp*, which in turn had larger median growth rates than *Lophelia pertusa* (Figure 23). *Lophelia pertusa* reached its highest median growth rate in Treatment A (0.013 ± 0.048 % buoyant weight per day) (± S.D.), *Madrepora oculata* in treatment D (0.036 ± 0.071 % buoyant weight per day) (± S.D.), and *Desmophyllum sp* in treatment B (0.032 ± 0.006 % buoyant weight per day) (± S.D.).

Only the variance of *Madrepora oculata* had an accelerating effect influencing the relationship between growth rates and increasing pCO_2.

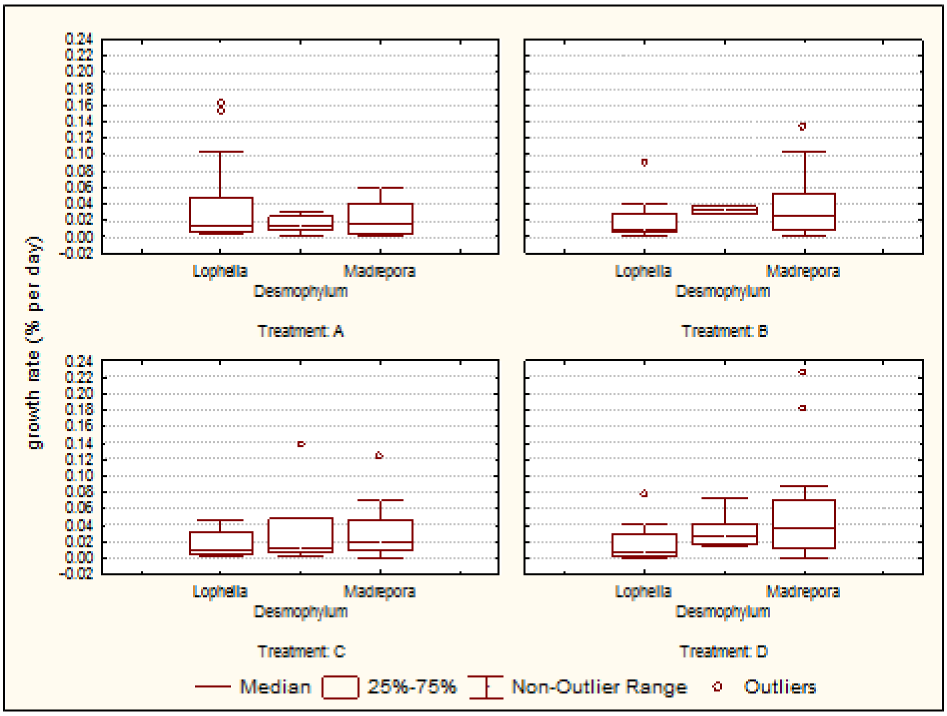


Figure 23: Comparison of three species of deep-sea corals growth rates (% buoyant weight per day) exposed to ocean acidification. Based on buoyant weight technique

3.2.3 Based on image analysis ....

Lophelia pertusa

Consistent with buoyant weight results, median growth rate of *Lophelia pertusa* in treatment A was larger than in any other treatment (0.059± 0.028 % colour area per day) (± S.D.) (Table 10, Figure 24). Treatment's A and B had also the largest proportion of fast growth rates, as observed by their high 90 percentile compared to other treatments. Lowest median growth rate was observed in treatment C (0.009 ± 0.013 % colour area per day) (± S.D.). Reduction in calcification based on growth rate differences between treatments was 49% colour area per day on higher pCO_2 (treatment C) compared to lower pCO_2 (treatment A).

Decline of growth rate in relation to ocean acidification for this species was steeper after 5 months than after 9 (Figure 25).

Table 10: Summary of descriptive statistics showing growth rate based on color projection (% colour area per day) of three species of Mediterranean deep-sea corals exposed to ocean acidification

Table 10: Summary of descriptive statistics showing growth rate based on color projection (% colour area per day) of three species of Mediterranean deep-sea corals exposed to ocean acidification

Species	Treatment	Valid N	Mean	Median	Min.	Max.	Percentile 20.00000	Percentile 90.00000	S. D.	Standard Error	Skewness	Std.Err. Skewness	Kurtosis	Std.Err. Kurtosis	Normality
Lophelia	A	4	0.056	0.059	0.019	0.086	0.019	0.086	0.028	0.014	-0.659	1.014	1.384	2.619	-0.650
	B	3	0.041	0.029	0.014	0.080	0.014	0.080	0.034	0.020	1.382	1.225			1.129
	C	5	0.013	0.010	0.001	0.034	0.001	0.034	0.014	0.006	0.970	0.913	0.034	2.000	1.062
	D	2	0.030	0.030	0.019	0.040	0.019	0.040	0.015	0.010					
Madrepora	A	4	0.063	0.027	0.004	0.192	0.004	0.192	0.089	0.044	1.722	1.014	2.898	2.619	1.698
	B	4	0.077	0.053	0.005	0.197	0.005	0.197	0.088	0.044	1.105	1.014	0.107	2.619	1.089
	C	3	0.010	0.006	0.002	0.022	0.002	0.022	0.011	0.006	1.447	1.225			1.182
	D	4	0.011	0.011	0.001	0.023	0.001	0.023	0.010	0.005	0.182	1.014	-1.364	2.619	0.180
Community	A	8	0.059	0.051	0.004	0.192	0.007	0.192	0.061	0.022	1.676	0.752	3.364	1.481	2.229
	B	7	0.062	0.029	0.005	0.197	0.014	0.197	0.068	0.026	1.539	0.794	2.281	1.587	1.939
	C	8	0.012	0.008	0.001	0.034	0.002	0.034	0.012	0.004	0.939	0.752	-0.161	1.481	1.249
	D	6	0.018	0.017	0.001	0.040	0.007	0.040	0.014	0.006	0.699	0.845	0.799	1.741	0.827

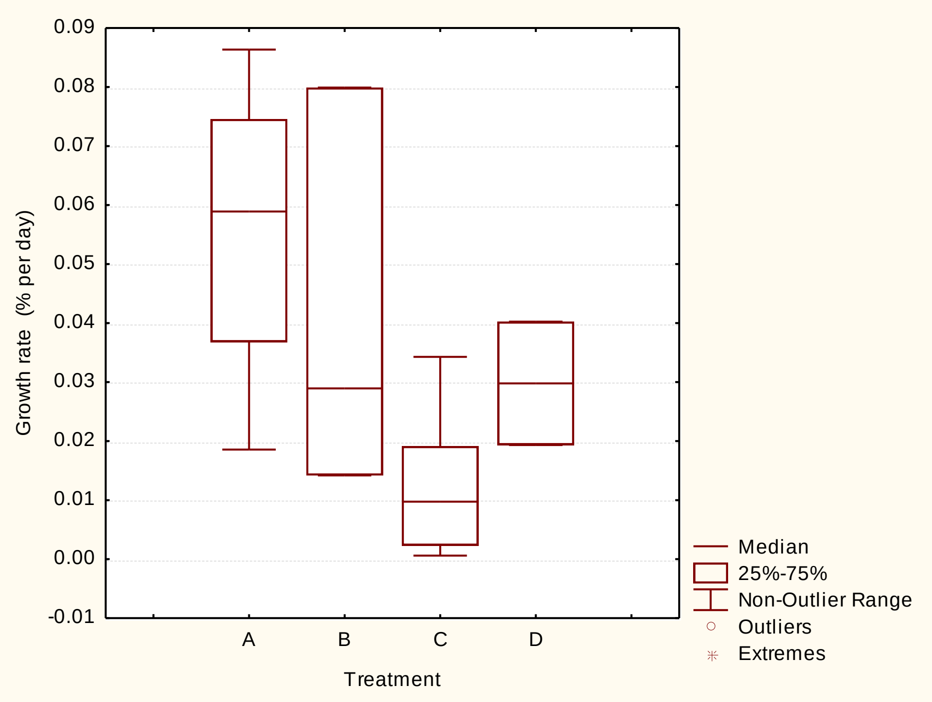


Figure 24: Growth rate (% colour area per day) of *Lophelia pertusa* exposed to ocean acidification based on colour projection

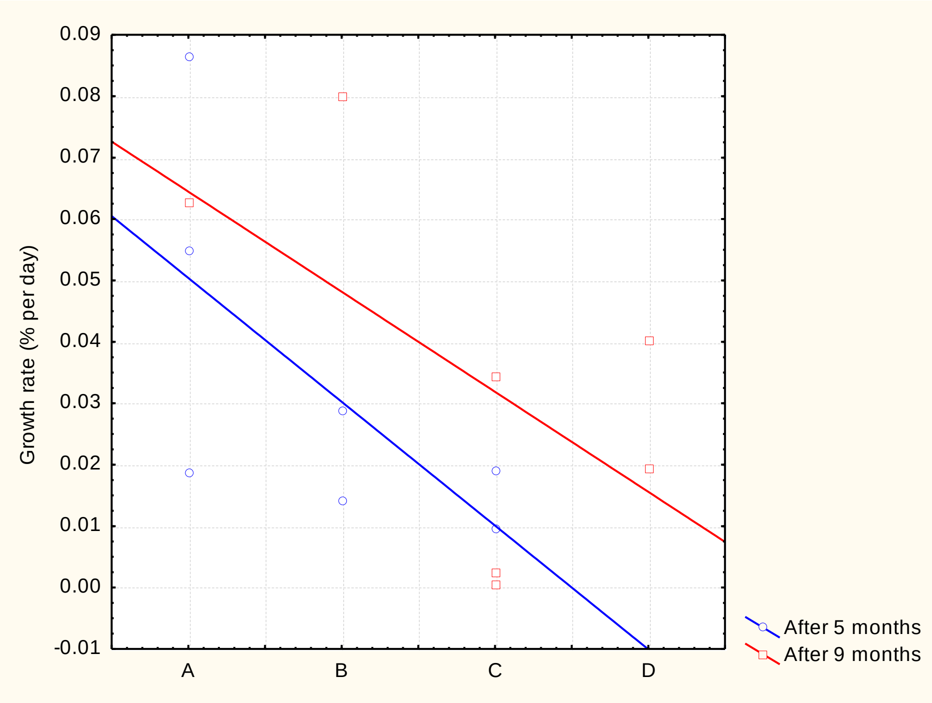


Figure 25: Evolution of growth rate of *Lophelia pertusa* based on colour projection

Madrepora oculata

Largest median growth rate for *Madrepora oculata* was recorded for treatment B (0.053 ± 0.087 % colour area per day) (± S.D.) (Table 10, Figure 26). Both treatment A and B presented an order of magnitude faster growth rates (A: 0.192 % colour area per day; B: 0.196 % colour area per day), than the other two treatments (C: 0.022 % colour area per day; D: 0.022 % colour area per day). Reduction in calcification based on growth rate differences between treatments was 88% buoyant weight per day on higher pCO_2 (treatment C) compared to lower pCO_2 (treatment B).

A decline in growth rate for this species only became apparent towards 9 months after incubation (Figure 27).

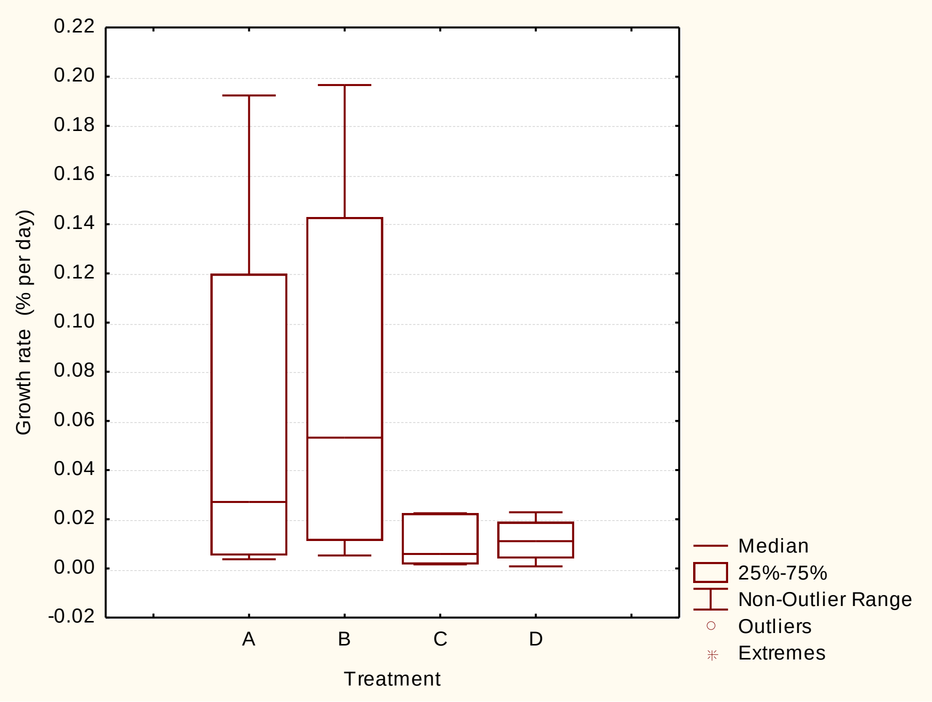


Figure 26: Growth rate (% colour area per day) of *Madrepora oculata* exposed to ocean acidification based on colour projection

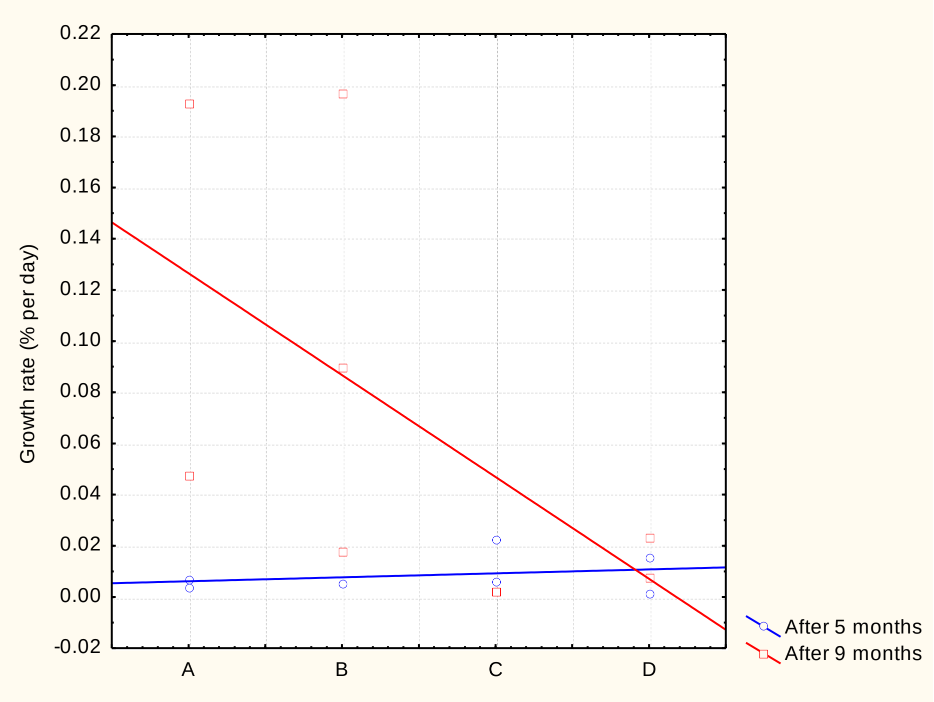


Figure 27: Evolution of growth rate of *Madrepora oculata* based on colour projection

Deep-sea coral community

Median growth rate for the deep-sea coral community was highest for treatment A (0.051 ± 0.061 % colour area per day) (± S.D.) (Table 10, Figure 28). At the other end, lowest median growth rate at the community level was recorded for treatment C (0.007 ± 0.012 % colour area per day) (± S.D.). A larger proportion of fast growth rates were recorded in treatment's A and B. Reduction in calcification based on growth rate differences between treatments was 84% buoyant weight per day on higher pCO_2 (treatment C) compared to lower pCO_2 (treatment A).

There was a significant interaction between experimental maintenance time and treatment (RM ANOVA, Huynh-Feldt corrected, F_3= 9.708, $p<0.05$), indicating that influence of treatment on growth rate depends upon experimental maintenance time. Largest median growth rate was recorded in treatment B after 8 months of incubation (0.085 ± 0.074 % colour area per day) (± S.D.) (Table 11). Treatment A also registered a median growth rate of similar magnitude during the same period (0.062 ± 0.079 % colour area per day) (± S.D.). Treatment's C and D registered an order of magnitude lower growth rate after 9 and after 5 months respectively. A larger proportion of fast growth rates in treatment A was consistently recorded regardless of incubation time.

Growth decline for treatment's C and D was much steeper in the later part of the experiment compared to earlier months (Figure 29).

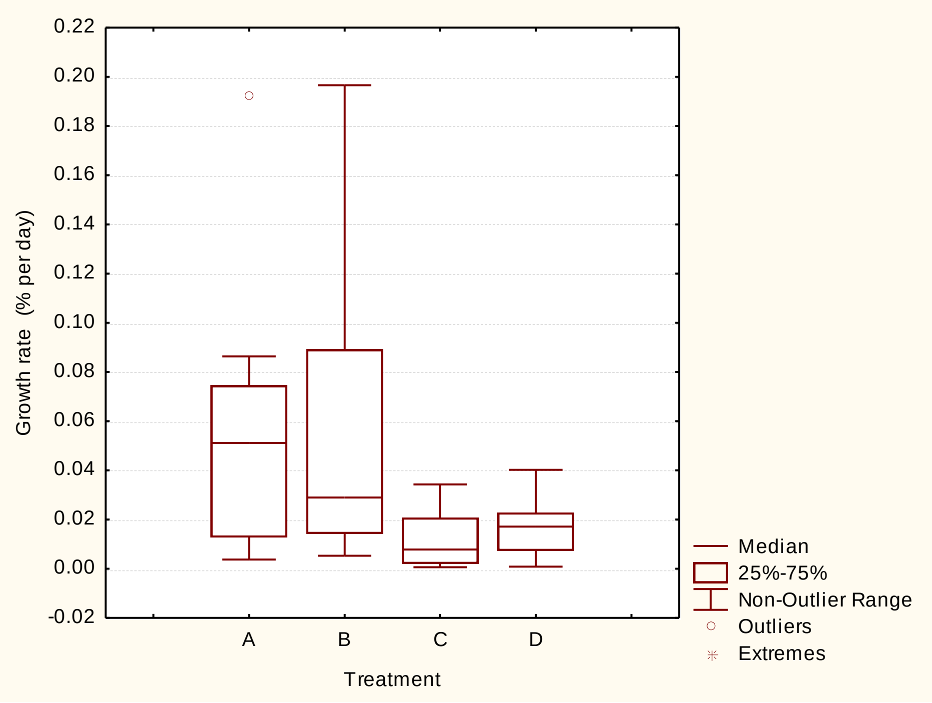


Figure 28: Growth rate (% colour area per day) of deep-sea coral community exposed to ocean acidification based on colour projection

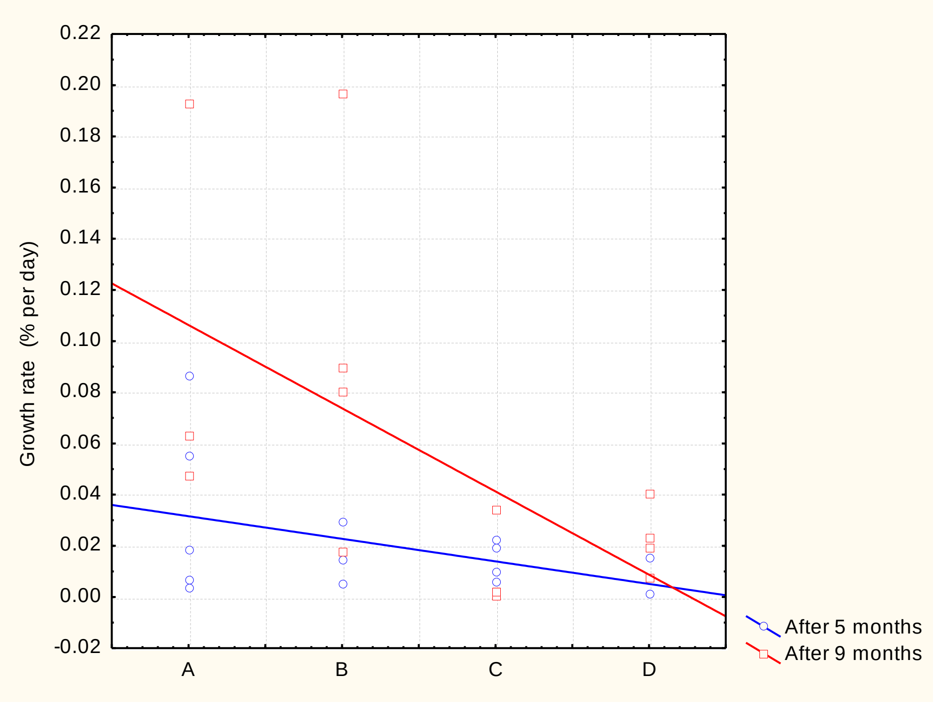


Figure 29: Evolution of deep-sea community growth rate based on colour projection

Table 11: Summary statistics of deep-sea community growth rate (% colour area per day) based on colour projection

Treatment	**Incubation time**	**Valid N**	**Mean**	**Median**	**Minimum**	**Maximum**	**Percentile 20.00000**	**Percentile 90.00000**	**Std.Dev.**	**Standard Error**	**Skewness**	**Std.Err. Skewness**	**Kurtosis**	**Std.Err. Kurtosis**	**Normality**
A	5 months	5	0.034	0.019	0.004	0.086	0.005	0.086	0.036	0.016	0.920	0.913	-0.926	2.000	0.992
	9 months	3	0.101	0.063	0.047	0.192	0.047	0.192	0.080	0.046	1.658	1.225			0.739
B	5 months	3	0.016	0.014	0.005	0.029	0.005	0.029	0.012	0.007	0.715	1.225			1.713
	9 months	4	0.096	0.085	0.017	0.197	0.017	0.197	0.074	0.037	0.869	1.014	1.855	2.619	1.167
C	5 months	4	0.014	0.014	0.006	0.022	0.006	0.022	0.008	0.004	-0.053	1.014	-4.042	2.619	-19.188
	9 months	4	0.010	0.002	0.001	0.034	0.001	0.034	0.016	0.008	1.989	1.014	3.964	2.619	0.510
D	5 months	2	0.008	0.008	0.001	0.015	0.001	0.015	0.010	0.007					
	9 months	4	0.022	0.021	0.007	0.040	0.007	0.040	0.014	0.007	0.565	1.014	1.363	2.619	1.796

Comparison of growth rates between species

Being exposed to a particular treatment (pCO_2 level) significantly influenced a species growth rate (RM ANOVA, Huynh-Feldt corrected, F_3= 9.708, $p<0.05$). *Lophelia pertusa* performed better than *Madrepora oculata* in all but the B Treatment (Figure 30). Nevertheless, both species present considerably lower growth rates in treatment C and D, compared to A and B. *Lophelia pertusa* reached its best median growth rate in Treatment A (0.058 ± 0.028 % colour area per day) (± S.D.), *Madrepora oculata* in treatment B (0.053 ± 0.087 % colour area per day) (± S.D.). Growth rate of *Lophelia pertusa* displayed smaller variation in treatment A and B and larger in C and D.

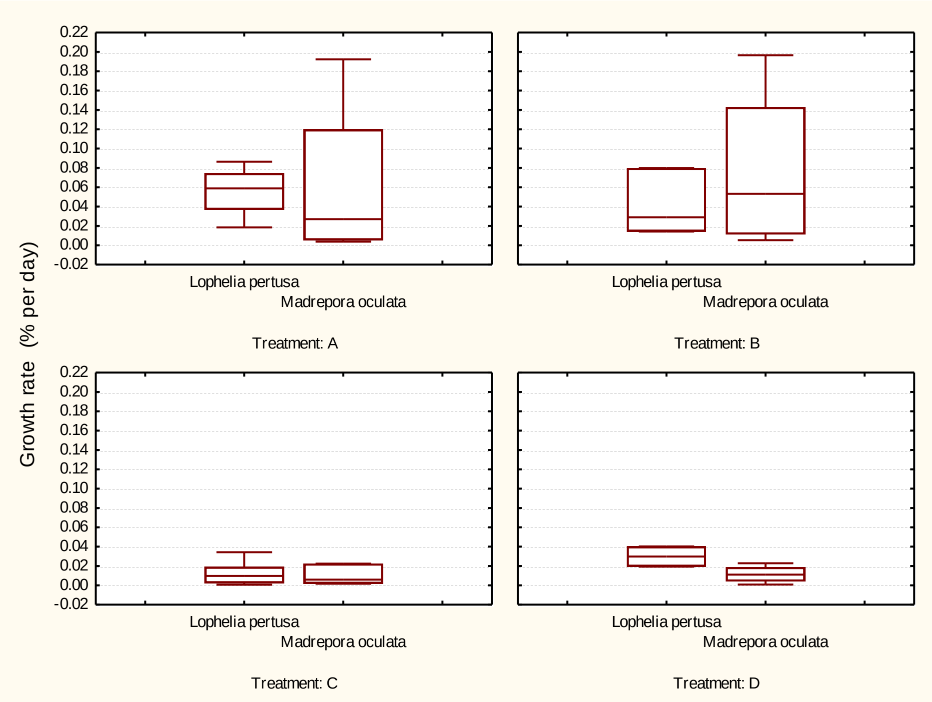


Figure 30: Comparison of two species of deep-sea corals growth rates (% colour area per day) exposed to ocean acidification. Based on colour projection

3.2.4 Skeletal density..

Skeletal density of corals was defined as ratio of growth rate based on buoyant weight to ratio of growth rate based on colour projection. Constructing such a ratio was problematic due to several reasons. First of all buoyant weight and colour projection, both had negative values which were excluded from the analyses. This resulted in quite a restricted number of replicates matching in both parameters. In extreme cases there was only one value per treatment. Under such circumstances, a comparative analysis was only performed at the deep-sea community level where there was enough replication.

Variation in skeletal density was high in all but the A treatment. Treatment C presented an unusually high median skeletal density compared to other treatments (Figure 31). However there was no significant effect of treatment on skeletal density of deep-sea coral community (1-way ANOVA, $F_{3,19}$= 0.58, p>0.05). Treatment had also no significant effect on skeletal density of *Madrepora oculata* (1-way ANOVA, $F_{3,7}= 0.83$, $p>0.05$) or *Lophelia pertusa* (Kruskal-Wallis, $H_3= 2.54$, $p>0.05$)

Relationship of growth rate with increasing pCO_2 in this species had a concave down shape (Figure 32). According to Jensen's inequality (Ruel and Ayres, 1999), increasing variation in this species would have the effect of decelerating growth rates more than expected, since variance depresses the response of coral to increasing pCO_2.

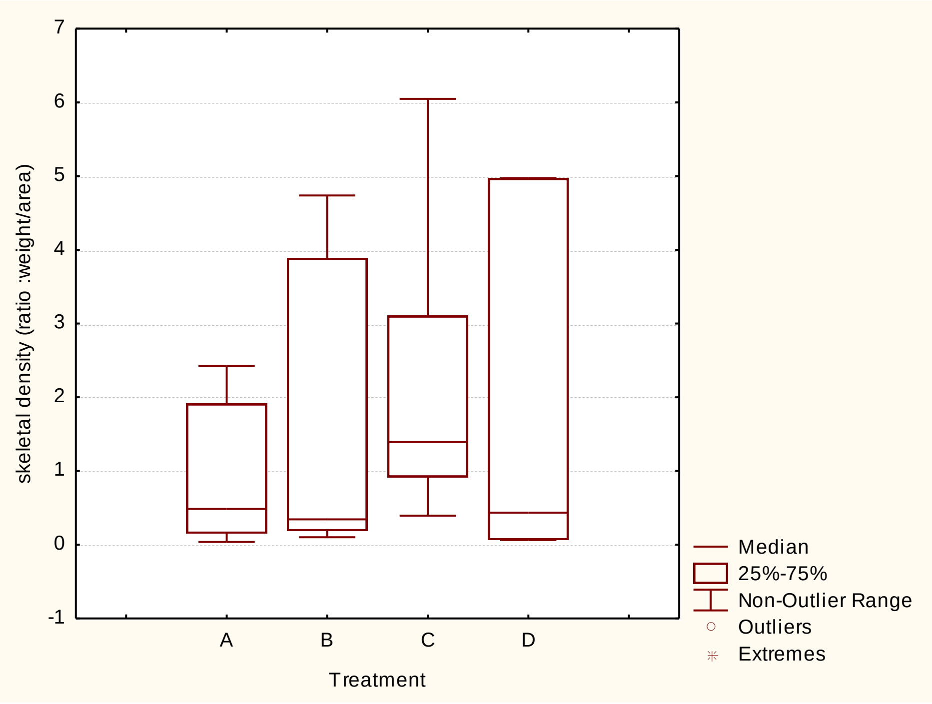


Figure 31: Skeletal density of corals exposed to ocean acidification treatments.

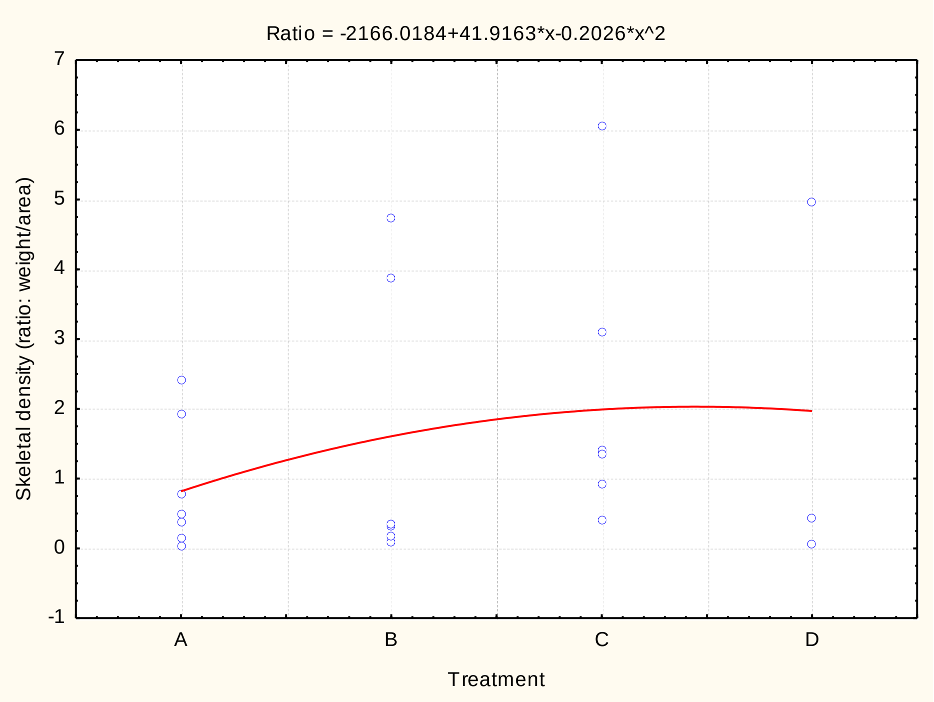


Figure 32: Relationship of deep-sea coral community skeletal density with increasing ocean acidification.

3.3 Calibration of growth measuring parameters...

Generally buoyant weight and colour projection provided growth rates of similar magnitude (Figure 33). However patterns of change in growth rates obtained with buoyant weight and colour projection were not necessarily similar (Figure 34). This is illustrated for example by treatment D were *Madrepora oculata* was the best grower based on buoyant weight and the worst based on colour projection; *Lophelia pertusa* on the other hand performed best according to colour projection; and worst according to buoyant weight compared to other species. Colour projection produced a clearer separation of growth rates obtained with A and B (larger) and C and D (smaller). On the other hand growth rates obtained with buoyant weight produced a narrower range of change between treatments (Figure 35)

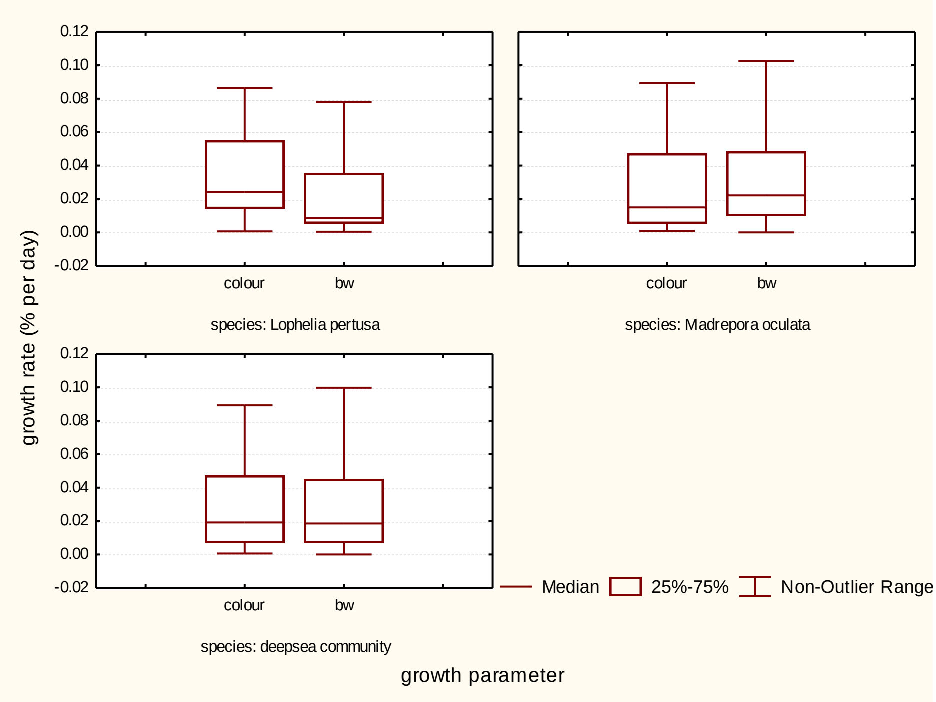


Figure 33: Comparison between growth rates estimated with buoyant weight and growth rates estimated with colour projection

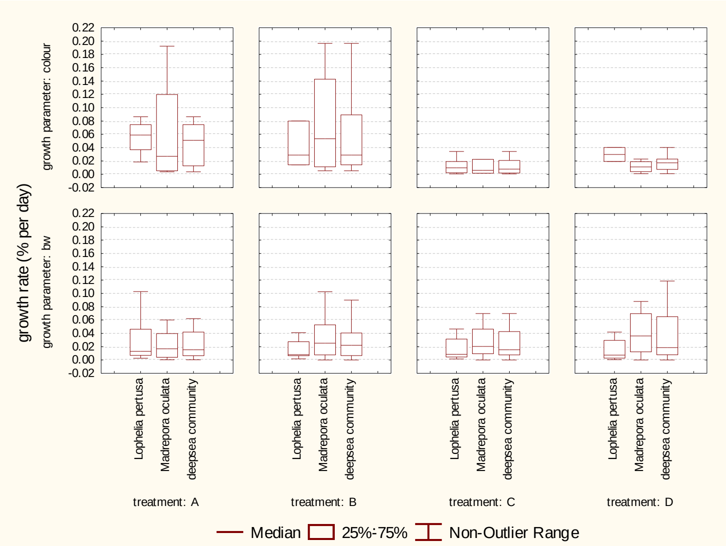


Figure 34: Treatment wise comparison of growth rates based on two measuring techniques: buoyant weight and colour projection

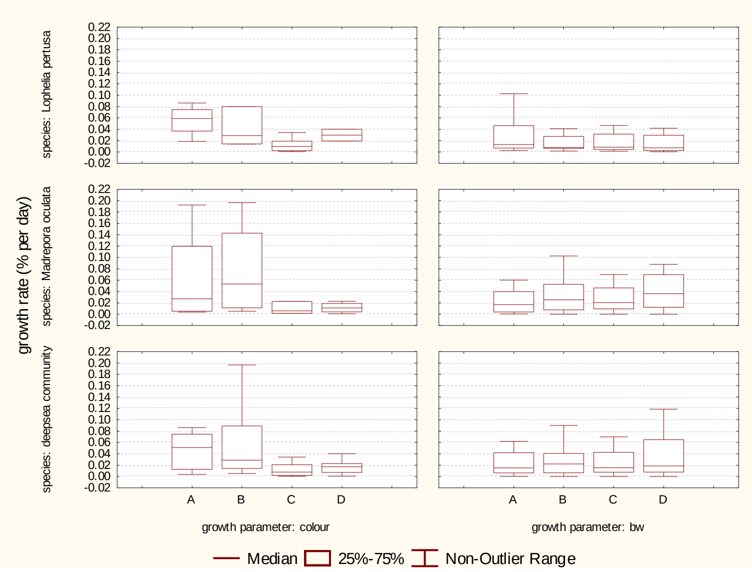


Figure 35: Species wise comparison of growth rates as a function of ocean acidification treatments obtained with two growth parameters

4 **Discussion**...

4.1 Growth under ocean acidification scenarios..

4.1.1 Acclimation to laboratory conditions..

Increasing pCO_2 had variable effects on coral growth according to experimental maintenance time. Particularly after 8 months, regardless of species, corals exhibited unusual growth rates compared to measurement periods before and after. There are several reasons for this observation. One of them is the notion that coral growth is not linear (Buddemeier and Kinzie, 1976; Hamel et al, 2010; Ries et al, 2010). It can spur, it can be arrested, and it can resume at different times. What triggers the pace at which growth takes place, is still not fully understood. Externally, slight variations in physico-chemical environment besides pCO_2 could be responsible (Buddemeier and Kinzie, 1976; Holcomb et al, 2010; Brooke and Young, 2009; Hamel et al, 2010; Chapter 4.1.2.2). Internally, biological changes related to nutritional status (Rodolfo-Metalpa et al, 2010b; Tsounis et al, 2010) or reproduction (Waller et al, 2005) could also be manifested in such rates. The length of our experiment allowed us to capture some of the variation in growth response that could have been produced by variations in any of these factors along the experiment.

Along similar lines of thinking; at least part of the variability observed in published growth rates of cold water corals arises from the duration of each study, and thus potential for acclimation. Short-term studies act in many ways as toxicity tests (Dupont et al, 2010b) where an individual is subjected to various levels of a toxin (in this case acidified waters) followed by assessment of a sharp response in the form of survival or growth for example. Because ocean acidification is expected to be gradual, and chronic (Pörtner, 2008), longer-term studies are potentially more realistic in reproducing ocean acidification conditions to be encountered by calcifiers, than short-term, acute response experiments. This was clear for example in the evolution of *Madrepora oculata*'s growth rates based on area in our experiment. After 5 months, there was no clear trend of this species growth rates as a function of pCO_2. However measurements performed 9 months after, displayed a clear negative trend in growth rates with increasing pCO_2. It is possible that factors such as initial differences in lipid content (Rodolfo-Metalpa et al, 2010b) were evened out after a few months, and thus response to acidification was evident in the long-term. Whether this trend is permanent is difficult to know, and longer studies are recommended where possible. Nevertheless the notion that long term exposure has different effects to short term exposure (Pörtner, 2008, Rodolfo-Metalpa et al, 2010b) is confirmed.

4.1.2 General growth trends ....

Besides acclimation, coral growth rates exhibited great variation according to acidification treatment, species, and measuring method.

Desmophyllum sp

Since neither colour (area) projection nor skeletal density of *Desmophyllum sp* were possible to obtain, growth rate of this species was only based on buoyant weight increases. Although a larger amount of fast growth rates were registered in treatment A, *Desmophyllum sp* was not clearly influenced by ocean acidification as shown by similar growth rates between treatment's B and D, and between treatment's A and C.

Regular observation in aquaria showed this species to be generally healthy, with tentacles out and feeding in all treatments. Nevertheless a degree of biofouling on the side of the skeletons, was also seen even from early months (5^{th} month-onwards) regardless of treatment. It is possible that such biofouling could have biased buoyant weights. Thus the lack of clear response of this species to ocean acidification could at least be partially due to such erroneous readings. Nevertheless, the nearly monthly measuring of corals towards the end of the experiment had the potential to even out such biases.

Lophelia pertusa

Lophelia pertusa did appear to benefit from pre-industrial ocean chemistry as it consistently perform better in treatment A (lowest pCO_2), regardless of measuring method. Despite this, the species did not follow a linear trajectory of decline with increasing acidification. This makes it difficult to assert that 497±117 provide a threshold beyond which this species will inevitably be driven to poor calcification or dissolution. However it is possible to say that conditions below 497±117 are optimal for the species, while further increases in pCO_2 move the species to suboptimal conditions where other factors, such as nutritional status, size, temperature or salinity changes interact with acidification to push a species towards faster or slower growth rates. Such was the case for example of a temperate coral species subjected to various treatments that combined levels of acidification and temperature (Holcomb et al, 2010). The species performed better or worse according not only to acidification, but also to nutrient-enrichment levels (Holcomb et al, 2010). Another possibility for the lack of linear decline with increasing acidification is that intra-treatment variability exceeded response to acidification. Great variability within a colony, as well as between colonies of *Lophelia pertusa* appears to be quite common (Rogers, 1999; Brooke and Young, 2009). Thus while we did attempt for all our treatments to have a fair representation of sizes and genetic variability, the low number of corals available, perhaps made such attempt insufficient to surpass internal variability to show a common, higher-level response to acidification.

The reduction in calcification rates observed here (40% based on buoyant weight, and 50% based on area reduction) for *Lophelia pertusa* growing under high acidification (866±191ppm) is somewhat higher than the 30% observed by Maier et al (2009) at 1054ppm acidification scenario. First of all one must consider that *Lophelia pertusa*'s samples in Maier et al's (2009) experiment were taken in colder Atlantic or North Sea waters. Secondly, acidification was induced by means of acid addition instead of pCO_2 bubbling. Finally means of measuring calcification in both studies differ. Nevertheless both studies confirm a negative effect of acidification on calcification rates for this species.

Madrepora oculata

Madrepora oculata was the most sensitive species to measuring method. Based on buoyant weight this species did not present a clear growth trend as a function of acidification. However based on projected colour (area), this species performed better in the pre-industrial and present-day scenarios than in higher acidification treatments. Reasons for this discrepancy are unknown. Again the causes that resulted in lack of linearity in *Lophelia pertusa*'s growth rate, as well as the biofouling that could have altered *Desmophyllum sp* buoyant weight readings; are possibly also present in *Madrepora oculata*. Nevertheless, *Madrepora oculata* had higher number of replicates so that bias due to biofouling was possibly not so significant; and while *Madrepora oculata* does exhibit variability within and between colonies, it is perhaps not to the same extent as in *Lophelia pertusa*. Discrepancy in results obtained using different measuring methods can arise for a number of reasons. For example a coral might grow on one branch tip, while it might become more brittle at another branch tip. The net effect of this would be an increase in area but not necessarily in weight since the older branch area is still present, although not with the same skeletal density as before. Further studies are highly advised to see whether the observed 50% reduction in growth rates based on area at a pCO_2 above 497±117 S.D. µatm or similar results can be confirmed in future experiments assessing the effect of acidification on calcification.

An interesting observation for *Madrepora oculata* is that variation appears to increase with increasing acidification. This trend was only observed with growth rates obtained based on buoyant weight. More studies could help to confirm whether this trend was casual or it actually forms part of *Madrepora oculata*'s response to acidification. If so, this could mean that variation within this species would accelerate the response (in this case growth rates) of *Madrepora oculata* to acidification.

Deep-sea coral community

Largest median growth rates for the deep-sea coral community based on buoyant weight were recorded in treatment B. This indicates perhaps a dominant influence of *Madrepora oculata* and *Desmophyllum sp*. However based on projected colour (area), and considering the absence of *Desmophyllum sp* from growth rates obtained based on this parameter, *Lophelia pertusa* was dominant and thus treatment A presented the highest median growth rates. Regardless of measuring method, growth rates at the deep-sea coral community level presented no clear trend with respect to acidification. The disparity between species growth rates was sufficient for such pattern. While the deep-sea coral community category here is totally artificial, it gives hints as to how these commonly together species might behave as a community (Chapter 4.1.3). A triad of Lophelia-Madrepora-Desmophyllum would also be influenced by colony size, and the various physiological and coping mechanisms each species has to acidification and other stresses. It is possible that at lower pCO_2 acidification scenarios, *Lophelia pertusa* would particularly promote calcification while the other two species will also perform well. As acidification gets higher, calcification of the triad would be dominated by *Madrepora oculata* and *Desmophyllum sp* and the few *Lophelia pertusa* colonies that prove strong enough (for example via high nutritional status) to cope with acidification.

Polyp development

It is probable that the 11-month time frame if this study was simply not long enough to allow for differences in polyp development to become apparent as a function of pCO_2. While changes in area and weight are perhaps more tangible, new polyp development requires longer time to be fully visible (Brooke and Young, 2009). This was particularly clear for our *Desmophyllum sp* samples, in which changes in weight were apparent, but no new polyps in any treatment could be visualised at the end of the 9-month experiment. Such results is likely due to the fact that although budding can take place in solitary corals, this might be a very sporadic process (Maier, unpublished).

Rates of polyp addition in our study for both *Lophelia pertusa* and *Madrepora oculata* were similar to those of Orejas et al (2008) with samples from another Mediterranean site. However, for *Lophelia pertusa* in particular, rates observed in this study are higher than those found by Brooke and Young (2009) in the Gulf of Mexico. Besides the obvious geographical factor as a potential explanation for this discrepancy, lack of linearity in growth rates (Brooke and Young 2009; Buddemeier and Kinzie, 1976; Ries et al, 2010) again has to be considered. Furthermore, the fact that Brooke's observations were performed *in situ* while Orejas et al (2008) and the present study were performed under laboratory conditions; could point for example to the effect of lab nutrition as opposed to field nutrition, on observed polyp addition rate. Similarly to Brooke and Young's (2009) study; polyps in our study budded usually from tip branches, but occasionally from lateral polyps as well.

Skeletal density

Better quality photographing, increased number of replicates, and closer match between measuring times; could perhaps have enhanced the possibilities to assess skeletal density at the species. At the community level, skeletal density was not significantly influenced by pCO_2 in our study. This however does not exclude the possibility of changes towards brittleness or sturdiness at the species level. In addition, studies looking at the microstructure of a coral's skeleton are encouraged as they can shed some light on ocean acidification effects not visible to the naked eye. Evidence for such an effect exists in other calcifying species (Dupont et al, 2008, O'Donell, 2010) and is currently being studied for coral larvae (Albright, unpublished.).

4.1.2.1 Comparison with tropical and temperate corals ....

The Ωa 2.8 threshold at which Langdon et al (2000) proposed a 40% decline in calcification rates, based on a shallow-water coral reef mesocosms, is not applicable to cold-water corals. Similarly, the Ωa 3.3, pCO_2 levels of 480ppm, threshold proposed by Hoegh-Guldberg et al (2007) for the maintenance and growth of tropical coral reefs appears inappropriate to cold-water corals. In this experiment, all of the acidification treatments had lower aragonite saturation states than both thresholds mentioned. The fact that the three species of cold-water corals continued growing under these conditions does provide evidence for adaptation to the naturally low saturation these corals inhabit. The physiological or behavioural mechanisms by which cold-water corals regulate calcification are perhaps different to those of tropical corals, s they can cope with the naturally lower Ωa waters they inhabit (Pörtner, 2008; Rodolfo-Metalpa et al, 2010b).

More appropriate thresholds for cold-water corals need to be obtained, although probably not solely based on aragonite saturation; since a lot of variation in calcification rates around this parameter has been found (Holcomb et al, 2010). Furthermore cold-water corals have been observed to calcify even under Ωa 1.0 (Maier et al, 2009). Similarly, temperate corals have also been found to continue calcification at low Ωa (Holcomb et al, 2010; Ries et al, 2010; Rodolfo-Metalpa et al, 2010b).

The great variation across taxa observed in calcification studies on tropical corals appears to be present in cold-water corals too, at least for the three species assessed in this study. Lack of linearity in calcification rates has also been observed at least for one tropical species (Leclercq et al, 2000) and one temperate species (Ries et al, 2010).

4.1.2.2 Additional sources of variation ....

In addition to acidification, there are several factors potentially influencing variation in growth rates observed in this experiment. These include age, nutritional status, mucus production and physiological regulation.

Age (size) is considered another important factor in producing the wide range of variation present in published coral growth rates (Jokiel et al, 1978; Davies, 1989; Brooke and Young, 2009; Buddemeier and Kinzie, 1976; Maier et al, 2009). It is hypothesized that as a coral gets older, the proportion of productive to non-productive polyps decreases (Buddemeier and Kinzie, 1976; Hamel et al, 2010 and references therein). Thus it is easily understood that a “younger” coral will score faster growth rates than an older specimen from the same species. In the present study, specimens of various ages were represented in each treatment; so we do not consider our samples to be biased towards a particular age group. Nevertheless, it has to be considered that all of our samples are of a size ultimately limited by sampling procedures and experimental settings.

Initial condition of coral as well as nutritional status might have to do with great variation in growth rates (Holcomb et al, 2010). However the duration of our experiment hopefully allowed acclimation to such levels where initial-status discrepancies were no longer producing “noise” (variation) to tell apart effects of OA.

Mucus production has been found to send a coral into growth arrest (Davies, 1989). Although it was not directly tested in our experiment, it is possible that part of the variability observed in growth rates comes from stress inflicted during weighting, polyp counting or photographing. While such a situation would add noise to coral growth profiles, it is likely that this was evenly distributed, since coral handling was similar across experiments.

Finally the range of calcification responses to acidification are believed to be influenced by the ability for an organism to regulate pH at calcification sites (Ries et al, 2009). Corals have mechanisms to create different physico-chemical conditions promoting favourable gradients for calcification (Buddemeier and Kinzie, 1976; Gattuso et al, 1999). Most research describing calcification has been done on zooxanthellate scleractinians, thus it is recommendable to assess to what extent comparable mechanisms are available in cold-water corals, and how they might be influenced by acidification.

4.1.3 Gradient of vulnerability to ocean acidification among species.............

Growth rate among species can vary in relation to growth form (Jackson, 1979; Buddemeier and Kinzie, 1976), physiological constrains (Pörtner, 2008; Anthony et al, 2008), and ultimately to the combined characteristics that define a species tolerance to an external stressor such as ocean acidification.

Out of the three species studied in this experiment, *Desmophyllum sp* appeared to be the least affected by changes in chemistry related to ocean acidification. A note of caution has to be added for this species, considering the unfortunate low number of replicates available in this study. Nevertheless a long fossil record (Taviani et al, 2005; Risk et al, 2002) and existing literature (Stanley and Cairns, 1988) add support to the presumed robustness of this genus.

At the moment, evidence for the effects of ocean acidification on *Madrepora oculata* in this study remains inconclusive. Using growth rates obtained with buoyant weight point to a lack of influence, while growth rates based on colour area indicate a reduction with increasing ocean acidification. Because unfortunately skeletal density analysis could not be performed at the species level, it is not possible to conclude that this species presents a tendency towards sturdiness. This would be the case if a small skeletal density ratio (% buoyant weight per day/ % colour (area) per day) was observed. Nonetheless a significant reduction in area of 50% colour (area) per day on higher pCO_2 treatment compared to lowest pCO_2 treatment does point to an adverse effect of ocean acidification.

That *Lophelia pertusa* was the only species to consistently perform at its best on our lowest pCO_2 treatment and worst on higher treatments suggests a higher vulnerability for this species to ocean acidification than *Madrepora oculata* and *Desmophyllum sp*. The very same species has been regularly associated with high biodiversity and fish abundance (Husebo et al, 2002; Costello et al, 2005). Thus its projected reduction in growth rates under imminent ocean acidification scenarios could be translated into a potential reduction in diversity and fish abundance of the deep-sea mounds this species usually inhabits.

Consequences of a gradient in vulnerability, species versus community trends

The community effects level assessed in this study could provide an indication of net effects to ocean acidification, but it does not exhaustively indicate all possible ecological consequences. This was evident in our study observing that some trends evident at species level were masked at the community level while simultaneously; some trends evident at the community level were not visible at the species level. These discrepancies could serve as a guidance of the role each species has to community resilience. For example net community calcification might not be altered while individual species could be. To put an example, one can think of a scenario where *Desmophyllum sp* increases growth rates while *Lophelia pertusa* decreases them.If calcification was to be our only proxy for community health with respect to ocean acidification, there would be no net chemical change (since carbonate precipitation rates would remain similar). Nevertheless a net reduction in functionality of the community may be present given that *Lophelia pertusa*'s ecological role (for example as a bioherm builder) is not the same as that of *Desmophyllum sp*'s. As a result, community resilience would be reduced with its ultimate consequences for coral and non-coral members of the deep-sea community and the production of ecosystem services (Kleypas et al, 2006; Fine and Tchernov, 2007).

Corals have a long evolutionary history in which there is evidence of adaptation to various types and degrees of disturbances at different time scales (Pandolfi, 2002; Turley et al, 2007; Veron et al, 2009). The question of whether they will adapt fast enough to keep up with changes in ocean chemistry brought about by ocean acidification is however debatable. This debate has grown with discrepancies in results assessing the response of corals to ocean acidification. While part of these discrepancies are the result of different experimental conditions, spatio-temporal scales, or genetic composition; for the larger part, there is consensus that corals will not adapt fast enough (Hoegh-Guldberg et al, 2007; Veron et al, 2009).

Corals in treatments B to D of our experiment continued to calcify even under 172 µmol/kg carbonate concentration which defines a threshold where calcification is supposed to practically stop (Langdon et al, 2000). Similar results have been found in other recent studies with temperate and cold water species (Ries et al, 2009; Maier et al, 2009; Rodolfo-Metalpa et al, 2010b). It is believed that such species may be already adapted to low aragonite saturation waters. While this could superficially represent a cause for optimism, the reality is that a species physiological tolerance is not unlimited. In addition to stress caused by ocean acidification, temperature changes will further drive a species towards adaptation or extinction (Pörtner, 2008). Besides climate change (in the form of acidification or temperature increases), several threats of anthropogenic origin and more localized effects (e.g. trawling and hydrocarbon exploration) further exacerbate the situation for these corals (Turley et al, 2007). The main reason not to rely on a species potential for adaptation is that an organism of naturally slow growth and relatively strict habitat requirements, is most unlikely to keep up with the upcoming rapid changes of carbon chemistry in the ocean (Gattuso et al, 1998). Even over larger spatio-temporal scales, a recent study suggests unprecedented reductions in calcification (Cooper et al, 2008; De'ath et al, 2009).

It is hypothesized that coral tolerance to stress inflicted for example by ocean acidification is a product of physiological coping mechanisms rather than geographical shifts (Fine and Tchernov, 2007). Physiological studies are needed to fine-tune thresholds at which coral calcification processes are hampered; how recovery operates at the cellular level; and how calcification interacts with other processes such as metabolism (Pörtner, 2008; Nakamura et al, 2011; Doney et al, 2009) that could in turn be affected by ocean acidification *per se*. Furthermore physiological studies are believed to have a key role in understanding the difference tolerances of deep-sea and shallow-water corals to ocean acidification (Turley et al, 2007, Rodolfo-Metalpa et al, 2010b).

4.2 Setting up acidification experiments with cold-water corals.....................

4.2.1 Lessons from experience...

Maintaining an ocean acidification setup with cold-water corals can be challenging while not impossible due to several reasons. Any design has to be "fit for purpose", that is, what might be useful to one experiment need not be fully reproducible in another. Each design has to adopt only those elements that cost-efficiently address the research in question. The Guide to best practices for ocean acidification research and data reporting (Riebesell et al, 2010) has quite extensive suggestions for setting up ocean acidification experiments. It is advocated that such guide is used were possible, as a means of standardizing ocean acidification research from its beginnings and thus reduce the difficulties in comparing results from ocean acidification experiments.

A brief list of recommendations to improve the setup and maintenance of aquaria such as the one used in this experiment follows:

- If one is to clearly separate temperature from pCO_2 effects, temperature must be kept at a constant level, which resembles natural conditions as close as possible. In our case this proved to be particularly challenging towards the summer when air-temperature conditions exerted too much pressure on the cooling system for the climate room. This would not be such a problem in areas where air-temperature is already closer to deep-sea temperatures (e.g. Norway). However in our case two, instead of one cooling system, would be more recommendable. If costs were to forbid such addition; locating the climate room at a naturally cooler place, could perhaps help.

- Keeping a close eye on water- and CO_2 gas- delivering tubes is important to minimize variation within a treatment.

- Where possible, having at least one pH probe connected to each treatment is recommendable to have a closer monitoring of carbonate chemistry *in situ* using pH proxy in addition to temperature and salinity meters.

- Minimizing handling of corals during buoyant weighting and photographing

- Attempt for aquarium water to mimic water flow in natural environment as close as possible (Holcomb et al, 2010)

- Increasing the number of replicates would be quite useful in increasing statistical power, particularly given the naturally high variability in coral growth (Buddemeier and Kinzie, 1976).

- A systematic way of weighing and photographing corals on the same day can help reduce some variation and minimize handling of live samples.

4.2.2 Methods to assess coral growth..

Both buoyant weight and colour projection provide relatively inexpensive methods to obtain coral growth rates. Polyp addition is perhaps more useful with fast-growing species, and/or long term (over a year) experiments. Each method's convenience can be reviewed in terms of the time necessary to obtain measurements, the precision obtained, equipment and expertise necessary, potential biases, and the economic cost.

In terms of time, equipment and expertise needed; the buoyant weight is perhaps more efficient. This method requires mainly a bucket and a scale and there is little "after-processing" of the data. An excel sheet and analytical software will suffice. The colour projection technique on the other hand requires a good camera, good lighting and a computer. This method has a rather extensive after-processing period, where coral images have to be labelled, edited and run through a macro on specialized image software.

Biofouling is a potential bias to both methods. It adds non-coral buoyancy to the buoyant weight method; and it adds non-coral area to the colour projection technique. More frequent sampling would perhaps help improve precision despite biofouling however it will not increase accuracy. In the colour projection method, it is possible to isolate and delete biofouling from the image in some cases, but not always.

Both methods provide growth rates of comparable magnitude; thus under- or over-estimation by either method was not observed. Comparison with other methods (Chapter 1.2.1) would be able to tell whether both these methods still provide similar magnitude growth rates or as observed in comparison to alkalinity anomaly, buoyant weight will provide higher growth rates (Rodolfo-Metalpa et al, 2010b). In terms of precision, the buoyant weight method seems to provide a smaller range of variation.

Buoyant weight and colour projection can be considered complementary when it comes to producing a measure of skeletal density. A better option to obtain skeletal density estimates is to use the ratio of linear extension to buoyant weight

4.3 The road ahead... ………………………

This is among the early studies of the effect of acidification on cold-water corals. Thus there remains a lot to build upon in terms of exploring not only calcification, but also physiological and behavioural responses to acidification. Experiments performed on various life-stages are also important to detect for example effect of acidification on population dynamics caused by early life-stages mortality. Additionally, translating what reduced calcification rates would be translated to the ecosystem level (Kleypas et al, 2006; Doney et al, 2009) is still an important challenge to solve. Finally scenarios where acidification is combined with levels of temperature, nutrients and other variables likely to be encountered in the future; can provide a more realistic and comprehensive prognosis of cold-water corals.

Since acidification is a global, large-scale, and in many ways delocalized threat, it is nearly impossible to prevent cold-water corals from exposure to such threat. Protection of cold-water corals can however come in the form of reducing deep-sea trawling; and careful management of deep-sea hydrocarbon exploration for example. Such measures could perhaps confer resilience to the corals to cope better with acidification (Veron et al, 2009).

5 **Conclusion**

Cold-water corals are ecologically and economically important. Their difficult accessibility has unfortunately resulted in poor knowledge about them. Oceanic chemistry changes prompted by increasing atmospheric pCO_2 (ocean acidification) pose a threat to cold-water corals as calcifying organisms. The present study subjected Mediterranean specimens from three species of common cold-water corals to four scenarios of acidification conditions. Growth rates were the response parameter of choice in this study. It appears the response of cold-water corals to acidification is species specific, with bioherm-forming *Lophelia pertusa* being more vulnerable than *Madrepora oculata* or *Desmophyllum sp*. Consequences at the community level are thus expected from different species vulnerability. Acclimation to experimental conditions does come up as a relevant factor in shaping the response of corals to acidification. It is likely that acidification conditions interact with several external factors such as temperature and salinity changes; as well as internal such as nutritional or reproduction status; to yield an overall, and in many cases non-linear response to acidification. It is important to test cold-water coral specimens from other sites and species; as well as broadening the methods and response parameters assessed to have a better grasp of the prognosis cold-water corals have under acidification.

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APPENDIX

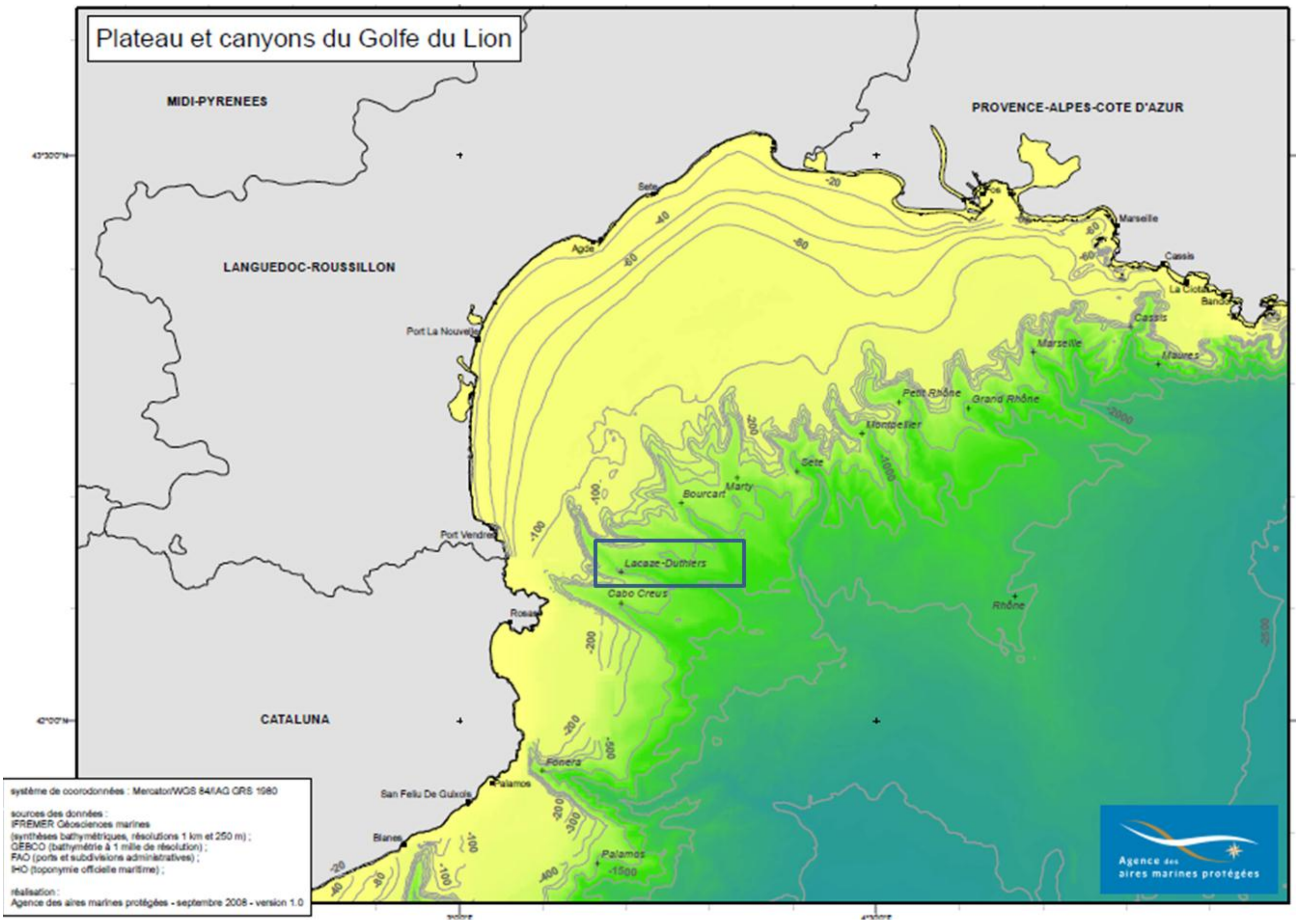

Figure 36: Golfe du Lion including the Canyon Lacaze-Duthiers where coral samples for this study were taken. (Agence des aires marines protégées http://www.aires-marines.fr/c-en-campagne-dans-les-vallees-sous-marines-de-mediterranee.html)

Table 12: Frequency of salinity (in ppt) values over June-August 2010

Frequency category	Count	Cumulative count	Percent of valid cases	Cumulative % of valid cases	% of all cases	Cumulative % of all cases
35 > x ≥ 36	0	0	0.000	0.000	0.000	0.000
36 > x ≥ 37	68	68	29.956	29.956	25.092	25.092
37 > x ≥ 38	97	165	42.731	72.687	35.793	60.886
38 > x ≥ 39	40	205	17.621	90.308	14.760	75.646
39 > x ≥ 40	13	218	5.727	96.035	4.797	80.443
40 > x ≥ 41	6	224	2.643	98.678	2.214	82.657
41 > x ≥ 42	3	227	1.322	100.000	1.107	83.764

Table 13: Salinity (in ppt) values according to vial type. Measurement period June-August 2010

type	Salinity Means	Salinity N	Salinity Std.Dev.
big blank	38.057	28	1.434
big colony	37.785	48	1.148
blank vial	37.554	48	0.919
small colony	37.638	48	0.952
waterbath	37.540	47	0.860
bulk water	37.000	8	0.334
All Groups	37.660	227	1.040

Table 14: Frequency of temperature (in °C) values from April-August 2010.

Frequency category	Count	Cumulative count	% of all cases	Cumulative % of all cases
5 > x ≥ 10	553	553	0.844	0.844
10 > x ≥ 15	57905	58458	88.356	89.200
15 > x ≥ 20	215	58673	0.328	89.528
20 > x ≥ 25	57	58730	0.087	89.615
25 > x ≥ 30	26	58756	0.040	89.655

Table 15: Frequency of pCO_2 (in ppm) values in treatment A

From To	Count	Cumulative Count	Percent	Cumulative Percent
200.0000<x<=300.0000	1	1	0.685	0.685
300.0000<x<=400.0000	67	68	45.890	46.575
400.0000<x<=500.0000	54	122	36.986	83.562
500.0000<x<=600.0000	13	135	8.904	92.466
600.0000<x<=700.0000	3	138	2.055	94.521
700.0000<x<=800.0000	0	138	0.000	94.521
Missing	8	146	5.479	100.000

Table 16: Frequency of pCO_2 (in ppm) values in treatment B

From To	Count	Cumulative Count	Percent	Cumulative Percent
350.000<x<=400.000	1	1	0.741	0.741
400.0000<x<=450.000	26	27	19.259	20.000
450.0000<x<=500.0000	68	95	50.370	70.370
500.0000<x<=550.0000	34	129	25.185	95.556
550.0000<x<=600.0000	2	131	1.481	97.037
600.0000<x<=650.0000	0	131	0.000	97.037
Missing	4	135	2.963	100.000

Table 17: Frequency of pCO_2 (in ppm) values in treatment C

From To	Count	Cumulative Count	Percent	Cumulative Percent
400.0000<x<=500.0000	3	3	2.239	2.239
500.0000<x<=600.0000	15	18	11.194	13.433
600.0000<x<=700.0000	49	67	36.567	50.000
700.0000<x<=800.0000	64	131	47.761	97.761
800.0000<x<=900.0000	3	134	2.239	100.000
900.0000<x<=1000.000	0	134	0.000	100.000
Missing	0	134	0.000	100.000

Table 18: Frequency of pCO_2 (in ppm) values in treatment D

From To	Count	Cumulative Count	Percent	Cumulative Percent
400.0000<x<=600.0000	1	1	0.794	0.794
600.0000<x<=800.0000	12	13	9.524	10.318
800.0000<x<=1000.000	92	105	73.016	83.333
1000.000<x<=1200.000	21	126	16.667	100.000
1200.000<x<=1400.000	0	126	0.000	100.000
Missing	0	126	0.000	100.000

Table 1: Colour projection raw data

Treatment	ID	coral spp	photo_ID	Time_photo	Scale (pixels/cm)	Nikkon date	Interval (days)	Fiji code	Width	Length	Total # pixels	Red total	Green total	Proporcion	percentage ((t2*100)/t1)
A	A1	Lophelia	T1A01R1	1	426.17	07/09/2009		1	1904	1184	2254336	1624665	629671	0.2793155	100
A	A1	Lophelia	T2A01R1	2	360.00	10/02/2010	156.00	1	1428	756	1079568	737409	342159	0.3169407	113.4704872
A	A1	Lophelia	T3A01R2	3	380.02	10/06/2010	120.00	1	1617	861	1392237	950983	441254	0.3169389	99.99942871
A	A2	Lophelia	T1A02R1	1	337.34	07/09/2009		1	2308	1136	2621888	1652254	969634	0.3698228	100
A	A2	Lophelia	T2A02R1	2	330	10/02/2010	156	1	2312	1088	2515456	1558248	957208	0.3805306	102.8953846
A	A2	Lophelia	T3A02R1	3	420.04	10/06/2010	120	1	3018	1446	4364028	2804477	1559551	0.3573650	93.91229603
A	A3	Lophelia	T1A03R2	1	360.2	07/09/2009		1	1680	879	1476720	1178617	298103	0.2018683	100
A	A3	Lophelia	T3A03R9	3	666.03	10/06/2010	276	1	2964	1386	4108104	3135065	973039	0.2368584	117.3331224
A	A4	Lophelia	T1A04R2	1	403.61	07/09/2009		1	1788	2133	3813804	2382653	1431151	0.3752555	100
A	A4	Lophelia	T2A04R1	2	402.4	10/02/2010	156	1	1644	1968	3235392	1917100	1318292	0.4074597	108.581946
A	A4	Lophelia	T3A04R2	3	336.02	10/06/2010	120	1	1400	1780	2492000	1538959	953041	0.3824402	93.85962985
A	A7	Madrepora	T1A07R3	1	486.04	07/09/2009		1	3186	1080	3440880	2396995	1043885	0.3033773	100
A	A7	Madrepora	T2A07R4	2	529.67	10/02/2010	156	1	2790	1002	2795580	1976037	819543	0.2931567	96.63104813
A	A7	Madrepora	T3A07R9	3	426	10/06/2010	120	1	2376	856	2033856	1423921	609935	0.2998909	102.2971499
A	A8	Madrepora	T1A08R1	1	330.00	07/09/2009		1	1350	2214	2988900	2152819	836081	0.2797287	100
A	A8	Madrepora	T2A08R1	2	444.36	10/02/2010	156	1	1568	2576	4039168	2897194	1141974	0.2827251	101.0711786
A	A8	Madrepora	T3A08R1	3	282	10/06/2010	120	1	996	1612	1605552	1159790	445762	0.2776378	98.20065132
A	A9	Madrepora	T1A09R2	1	360.8	07/09/2009		1	1290	2130	2747700	2212522	535178	0.1947731	100
A	A9	Madrepora	T2A09R3	2	398.22	10/02/2010	156	1	1290	2178	2809620	2259197	550423	0.1959066	100.5819495
A	A9	Madrepora	T3A09R8	3	303.73	10/06/2010	120	1	1012	1692	1712304	1377831	334473	0.1953351	99.70827596
A	A10	Lophelia	T2A10R1	2	367.3	10/02/2010		1	1098	2010	2206980	1378264	828716	0.3754977	100
A	A10	Lophelia	T2A10R1	2	367.3	10/02/2010		2	540	1278	690120	362634	327486	0.4745349	
A	A10	Lophelia	T2A10R1	2	367.3	10/02/2010		1_al_2						0.8500326	100
A	A10	Lophelia	T3A10R1	3	285	10/06/2010	120	1	864	1560	1347840	862375	485465	0.3601800	95.92068188
A	A10	Lophelia	T3A10R1	3	285	10/06/2010		2	468	1026	480168	267452	212716	0.4430033	
A	A10	Lophelia	T3A10R1	3	285	10/06/2010		1_al_2						0.8031833	94.48852568
A	A16	Lophelia	T2A16R4	2	331.66	10/02/2010		1	3444	1704	5868576	4031206	1837370	0.3130862	100
A	A16	Lophelia	T3A16R3	3	294.14	10/06/2010	120	1	3150	1530	4819500	3338755	1480745	0.3072404	98.13284784
A	A18	Madrepora	T2A18R1	2	328.31	10/02/2010		1	3180	2412	7670160	5792595	1877565	0.2447882	100
A	A18	Madrepora	T3A18R2	3	200	10/06/2010		1	1916	1324	2536784	1826810	709974	0.2798717	
A	A18	Madrepora	T3A18R2	3	200	10/06/2010		2	1916	1324	2536784	2482452	54332	0.0214177	
A	A18	Madrepora	T3A18R2	3	200	10/06/2010	120	1 y 2						0.3012893	123.0816251
A	A19	Madrepora	T2A19R3	2	324.96	10/02/2010		1	3708	2190	8120520	5853486	2267034	0.2791735	100
A	A19	Madrepora	T3A19R3	3	165	10/06/2010	120	1	1948	1296	2524608	1825831	698777	0.2767863	99.14491724
B	B2	Lophelia	T1B02R1	1	366.05	07/09/2009		1	1408	852	1199616	811143	388473	0.3238311	100
B	B2	Lophelia	T2B02R1	2	378.43	10/02/2010	156	1	1278	858	1096524	725401	371123	0.3384541	104.5156049
B	B2	Lophelia	T3B02R1	3	300	07/07/2010	147	1	975	609	593775	399693	194082	0.3268612	96.57475656

Treatment	ID	coral spp	photo_ID	Time_photo	Scale (pixels/cm)	Nikkon date	Interval (days)	Fiji code	Width	Length	Total # pixels	Red total	Green total	Proporcion	percentage ((t2*100)/t1)
B	B3	Lophelia	T1B03R4	1	360	07/09/2009		1	2886	1530	4415580	3101096	1314484	0.2976923	100
B	B3	Lophelia	T2B03R1	2	388	10/02/2010	156	1	2592	1374	3561408	2477732	1083676	0.3042830	102.2139516
B	B3	Lophelia	T3B03R3	3	321.6	07/07/2010	147	1	2250	1116	2511000	1773160	737840	0.2938431	96.56900521
B	B4	Lophelia	T1B04R1	1	282	07/09/2009		1	1248	1728	2156544	1603258	553286	0.2565614	100
B	B4	Lophelia	T2B04R1	2	384.05	10/02/2010	156	1	1424	1812	2580288	1931783	648505	0.2513305	97.96113052
B	B4	Lophelia	T3B04R4	3	290.8	07/07/2010	147	1	1059	1350	1429650	1035451	394199	0.2757311	109.7085925
B	B6	Madrepora	T1B06R5	1	426.68	07/09/2009		1	2334	1542	3599028	2882815	716213	0.1990018	100
B	B6	Madrepora	T2B06R2	2	456.86	10/02/2010	156	1	2286	1428	3264408	2659240	605168	0.1853837	93.15679697
B	B6	Madrepora	T3B06R6	3	216.67	07/07/2010	147	1	1040	602	626080	502738	123342	0.1970068	106.2697439
B	B7	Madrepora	T1B07R5	1	357.82	07/09/2009		1	1656	1244	2060064	1576645	483419	0.2346621	100
B	B7	Madrepora	T2B07R3	2	416	10/02/2010	156	1	1676	1316	2205616	1683772	521844	0.2365978	100.8248972
B	B7	Madrepora	T3B07R3	3	272	07/07/2010	147	1	1137	930	1057410	808612	248798	0.2352900	99.4472277
B	B8	Madrepora	T1B08R1	1	264.27	07/09/2009		1	495	891	441045	359185	81860	0.1856046	
B	B8	Madrepora	T1B08R1	1	264.27	07/09/2009		2	400	688	275200	199464	75736	0.2752035	
B	B8	Madrepora	T1B08R1	1	264.27	07/09/2009		3	440	900	396000	314565	81435	0.2056439	
B	B8	Madrepora	T1B08R1	1	264.27	07/09/2009		4	420	750	315000	235149	79851	0.2534952	
B	B8	Madrepora	T1B08R1	1	264.27	07/09/2009		5	375	597	223875	173770	50105	0.2238079	
B	B8	Madrepora	T1B08R1	1	264.27	07/09/2009		1_al_5					0	1.1437552	100
B	B8	Madrepora	T2B08R1	2	385.02	10/02/2010		1	552	1080	596160	487889	108271	0.1816140	
B	B8	Madrepora	T2B08R1	2	385.02	10/02/2010		2	444	816	362304	263125	99179	0.2737453	
B	B8	Madrepora	T2B08R1	2	385.02	10/02/2010		3	544	1048	570112	459073	111039	0.1947670	
B	B8	Madrepora	T2B08R1	2	385.02	10/02/2010		4	480	888	426240	320707	105533	0.2475906	
B	B8	Madrepora	T2B08R1	2	385.02	10/02/2010		5	411	723	297153	229039	68114	0.2292220	
B	B8	Madrepora	T2B08R1	2	385.02	10/02/2010	156	1_al_5					0	1.1269388	98.52971573
B	B8	Madrepora	T3B08R7	3	295.24	07/07/2010		1	422	808	340976	280145	60831	0.1784026	
B	B8	Madrepora	T3B08R7	3	295.24	07/07/2010		2	338	572	193336	138926	54410	0.2814272	
B	B8	Madrepora	T3B08R7	3	295.24	07/07/2010		3	381	831	316611	249065	67546	0.2133407	
B	B8	Madrepora	T3B08R7	3	295.24	07/07/2010		4	370	666	246420	188029	58391	0.2369572	
B	B8	Madrepora	T3B08R7	3	295.24	07/07/2010		5	316	520	164320	126726	37594	0.2287853	
B	B8	Madrepora	T3B08R7	3	295.24	07/07/2010	147	1_al_5					0	1.1389129	101.0625368
B	B9	Madrepora	T1B09R3	1	308.23	07/09/2009		1	1884	1548	2916432	2368316	548116	0.1879406	100
B	B9	Madrepora	T2B09R3	2	400.18	10/02/2010	156	1	2094	1662	3480228	2864259	615969	0.1769910	94.17389525
B	B9	Madrepora	T3B09R2	3	186.60	07/07/2010	147	1	1500	1340	2010000	1572172	437828	0.2178249	123.0711661
B	B10	Madrepora	T1B10R1	1	304.66	07/09/2009		1	414	747	309258	221003	88255	0.2853766	
B	B10	Madrepora	T1B10R1	1	304.66	07/09/2009		2	294	861	253134	185389	67745	0.2676251	
B	B10	Madrepora	T1B10R1	1	304.66	07/09/2009		3	512	432	221184	161938	59246	0.2678584	
B	B10	Madrepora	T1B10R1	1	304.66	07/09/2009		4	1029	810	833490	660406	173084	0.2076618	
B	B10	Madrepora	T1B10R1	1	304.66	07/09/2009		1_al_4						1.0285219	100
B	B10	Madrepora	T2B10R1	2	420.00	10/02/2010		1	564	932	525648	391555	134093	0.2551004	

Treatment	ID	coral spp	photo_ID	Time_photo	Scale (pixels/cm)	Nikkon date	Interval (days)	Fiji code	Width	Length	Total # pixels	Red total	Green total	Proporcion	percentage ((t2*100)/t1)
B	B10	Madrepora	T2B10R1	2	420.00	10/02/2010		2	352	1080	380160	277773	102387	0.2693261	
B	B10	Madrepora	T2B10R1	2	420.00	10/02/2010		3	609	498	303282	217336	85946	0.2833864	
B	B10	Madrepora	T2B10R1	2	420.00	10/02/2010		4	1240	992	1230080	965975	264105	0.2147055	
B	B10	Madrepora	T2B10R1	2	420.00	10/02/2010	156	1_al_4						1.0225184	99.41630349
B	B10	Madrepora	T3B10R7	3	245.52	07/07/2010		1	308	524	161392	114959	46433	0.2877032	
B	B10	Madrepora	T3B10R7	3	245.52	07/07/2010		2	208	648	134784	98936	35848	0.2659663	
B	B10	Madrepora	T3B10R7	3	245.52	07/07/2010		3	398	303	120594	88131	32463	0.2691925	
B	B10	Madrepora	T3B10R7	3	245.52	07/07/2010		4	828	648	536544	433858	102686	0.1913841	
B	B10	Madrepora	T3B10R7	3	245.52	07/07/2010	147	1_al_4						1.0142461	99.19098982
B	B16	Lophelia	T2B16R1	2	331.660	10/02/2010		1	3246	2286	7420356	4956846	2463510	0.3319935	100
B	B16	Lophelia	T3B16R2	3	181.750	07/07/2010	147	1	1695	1284	2176380	1534387	641993	0.2949820	88.85174847
B	B18	Madrepora	T2B18R3	2	308.210	10/02/2010		1	2082	2544	5296608	3910521	1386087	0.2616933	100
B	B18	Madrepora	T3B18R3	3	182.163	07/07/2010	147	1	1128	1480	1669440	1266130	403310	0.2415840	92.31568938
B	B19	Madrepora	T2B19R1	2	339.480	10/02/2010		1	2298	1854	4260492	3330663	929829	0.2182445	100
B	B19	Madrepora	T3B19R3	3	185.270	07/07/2010	147	1	1173	945	1108485	868801	239684	0.2162267	99.07541276
C	C1	Lophelia	T1C01R1	1	291.550	07/09/2009		1	1828	1076	1966928	1195787	771141	0.3920535	100
C	C1	Lophelia	T2C01R1	2	426.170	10/02/2010	156	1	2220	1300	2886000	1737359	1148641	0.3980045	101.5179071
C	C1	Lophelia	T3C01R10	3	156.180	07/07/2010	147	1	828	504	417312	248139	169173	0.4053873	101.8549618
C	C2	Lophelia	T1C02R5	1	332.660	07/09/2009		1	1602	1062	1701324	1063038	638286	0.3751702	100
C	C2	Lophelia	T3C02R6	3	262.990	07/07/2010	303	1	1172	800	937600	585201	352399	0.3758522	100.181788
C	C3	Lophelia	T2C03R1	2	368.090	10/02/2010		1	1110	1176	1305360	842345	463015	0.3547029	100
C	C3	Lophelia	T3C03R1	3	195.000	07/07/2010	147	1	616	588	362208	227259	134949	0.3725732	105.0381036
C	C4	Lophelia	T1C04R1	1	328.020	07/09/2009		1	936	1596	1493856	967829	526027	0.3521270	100
C	C4	Lophelia	T2C04R1	2	390.000	10/02/2010	156	1	1016	1756	1784096	1137098	646998	0.3626475	102.987714
C	C4	Lophelia	T3C04R2	3	198.730	07/07/2010	147	1	564	867	488988	322478	166510	0.3405196	93.89822889
C	C6	Madrepora	T1C06R4	1	375.010	07/09/2009		1	2676	1842	4929192	4097648	831544	0.1686978	100
C	C6	Madrepora	T2C06R1	2	402.020	10/02/2010	156	1	2454	1632	4004928	3305656	699272	0.1746029	103.5003758
C	C6	Madrepora	T3C06R9	3	208.390	07/07/2010	147	1	1296	868	1124928	951439	173489	0.1542223	88.32747003
C	C7	Madrepora	T1C07R5	1	348.210	07/09/2009		1	2100	1404	2948400	2223000	725400	0.2460317	100
C	C7	Madrepora	T2C07R1	2	389.390	10/02/2010	156	1	2148	1412	3032976	2279892	753084	0.2482987	100.9214074
C	C7	Madrepora	T3C07R3	3	216.000	07/07/2010	147	1	1227	774	949698	740348	209350	0.2204385	88.77956134
C	C8	Madrepora	T1C08R1	1	284.180	07/09/2009		1	798	1245	993510	744550	248960	0.2505863	
C	C8	Madrepora	T1C08R1	1	284.180	07/09/2009		2	687	390	267930	198834	69096	0.2578883	
C	C8	Madrepora	T1C08R1	1	284.180	07/09/2009		3	544	331	180064	131719	48345	0.2684879	
C	C8	Madrepora	T1C08R1	1	284.180	07/09/2009		1_al_3						0.7769624	100
C	C8	Madrepora	T2C08R1	2	456.000	10/02/2010		1	1128	1844	2080032	1575020	505012	0.2427905	
C	C8	Madrepora	T2C08R1	2	456.000	10/02/2010		2	1011	552	558072	405198	152874	0.2739324	
C	C8	Madrepora	T2C08R1	2	456.000	10/02/2010		3	792	436	345312	257305	88007	0.2548623	
C	C8	Madrepora	T2C08R1	2	456.000	10/02/2010	156	1_al_3						0.7715852	99.30791124

Treatment	ID	coral spp	photo_ID	Time_photo	Scale (pixels/cm)	Nikkon date	Interval (days)	Fiji code	Width	Length	Total # pixels	Red total	Green total	Proporcion	percentage ((t2*100)/t1)
C	C8	Madrepora	T3C08R2	3	232.720	07/07/2010		1	532	872	463904	348333	115571	0.2491270	
C	C8	Madrepora	T3C08R2	3	232.720	07/07/2010		2	458	279	127782	97760	30022	0.2349470	
C	C8	Madrepora	T3C08R2	3	232.720	07/07/2010		3	381	208	79248	57838	21410	0.2701645	
C	C8	Madrepora	T3C08R2	3	232.720	07/07/2010	147	1_al_3						0.7542385	97.75182037
C	C9	Madrepora	T2C09R1	2	420.000	10/02/2010		1	3468	1296	4494528	3598183	896345	0.1994303	
C	C9	Madrepora	T3C09R3	3	215.410	07/07/2010	147	1	1659	657	1089963	881425	208538	0.1913258	
C	C16	Lophelia	T2C16R5	2	304.870	10/02/2010		1	4128	2124	8767872	6742182	2025690	0.2310355	100
C	C16	Lophelia	T3C16R2	3	212.150	07/07/2010	147	1	2484	1320	3278880	2535196	743684	0.2268104	98.17120734
C	C18	Madrepora	T2C18R1	2	351.760	10/02/2010		1	2040	1716	3500640	2876619	624021	0.1782591	100
C	C18	Madrepora	T3C18R5	3	202.250	07/07/2010	147	1	1203	927	1115181	925829	189352	0.1697949	95.25170998
C	C19	Madrepora	T2C19R1	2	304.860	10/02/2010		1	3012	2394	7210728	6046202	1164526	0.1614991	100
C	C19	Madrepora	T3C19R2	3	167.140	07/07/2010	147	1	1644	1324	2176656	1824261	352395	0.1618974	100.2466489
D	D1	Lophelia	T2D01R1	2	396.050	10/02/2010		1	956	844	806864	564307	242557	0.3006170	
D	D1	Lophelia	T2D01R1	2	396.050	10/02/2010		2	1312	1176	1542912	1211945	330967	0.2145080	
D	D1	Lophelia	T2D01R1	2	396.050	10/02/2010		1_al_2						0.5151250	100
D	D1	Lophelia	T3D01R6	3	262.860	18/07/2010		1	717	597	428049	303571	124478	0.2908032	
D	D1	Lophelia	T3D01R6	3	262.860	18/07/2010		2	902	770	694540	527809	166731	0.2400596	
D	D1	Lophelia	T3D01R6	3	262.860	18/07/2010	158	1_al_2						0.5308628	103.0551393
D	D2	Lophelia	T1D02R4	1	349.290	07/09/2009		1	2224	1272	2828928	1826605	1002323	0.3543120	100
D	D2	Lophelia	T2D02R3	2	396.010	10/02/2010	156	1	2322	1440	3343680	2225289	1118391	0.3344791	94.40242578
D	D2	Lophelia	T3D02R7	3	274.370	18/07/2010	158	1	1652	1004	1658608	1099621	558987	0.3370218	100.7601942
D	D3	Lophelia	T2D03R1	2	417.000	10/02/2010		1	1062	1674	1777788	1240412	537376	0.3022723	
D	D3	Lophelia	T2D03R1	2	417.000	10/02/2010		2	852	1728	1472256	983142	489114	0.3322208	
D	D3	Lophelia	T2D03R1	2	417.000	10/02/2010		1_al_2						0.6344930	100
D	D3	Lophelia	T3D03R1	3	217.950	18/07/2010		1	591	891	526581	375052	151529	0.2877601	
D	D3	Lophelia	T3D03R1	3	217.950	18/07/2010		2	522	902	470844	333158	137686	0.2924238	
D	D3	Lophelia	T3D03R1	3	217.950	18/07/2010	158	1_al_2						0.5801839	91.44055171
D	D4	Lophelia	T2D04R2	2	444.020	10/02/2010		1	1422	1572	2235384	1413164	822220	0.3678205	
D	D4	Lophelia	T2D04R2	2	444.020	10/02/2010		2	1460	1408	2055680	1189111	866569	0.4215486	
D	D4	Lophelia	T2D04R2	2	444.020	10/02/2010		1_al_2						0.7893691	136.0549714
D	D4	Lophelia	T3D04R10	3	267.400	18/07/2010		1	768	963	739584	460439	279145	0.3774352	
D	D4	Lophelia	T3D04R10	3	267.400	18/07/2010		2	942	909	856278	492010	364268	0.4254086	
D	D4	Lophelia	T3D04R10	3	267.400	18/07/2010	158	1_al_2						0.8028437	101.7070169
D	D7	Madrepora	T1D07R1	1	328.020	07/09/2009		1	2496	1168	2915328	2258862	656466	0.2251774	100
D	D7	Madrepora	T2D07R1	2	438.410	10/02/2010	156	1	2742	1488	4080096	3160153	919943	0.2254709	100.1303475
D	D7	Madrepora	T3D07R15	3	232.720	18/07/2010	158	1	1425	741	1055925	826675	229250	0.2171082	96.29100833
D	D8	Madrepora	T1D08R1	1	288.060	07/09/2009		1	642	222	142524	96035	46489	0.3261837	
D	D8	Madrepora	T1D08R1	1	288.060	07/09/2009		2	291	666	193806	135157	58649	0.3026171	
D	D8	Madrepora	T1D08R1	1	288.060	07/09/2009		3	291	813	236583	164347	72236	0.3053305	

Treatment	ID	coral spp	photo_ID	Time_photo	Scale (pixels/cm)	Nikkon date	Interval (days)	Fiji code	Width	Length	Total # pixels	Red total	Green total	Proporcion	percentage ((t2*100)/t1)
D	D8	Madrepora	T1D08R1	1	288.060	07/09/2009		4	357	738	263466	184895	78571	0.2982206	
D	D8	Madrepora	T1D08R1	1	288.060	07/09/2009		5	666	591	393606	317012	76594	0.1945956	
D	D8	Madrepora	T1D08R1	1	288.060	07/09/2009		1_al_5						1.4269474	100
D	D8	Madrepora	T2D08R1	2	402.550	10/02/2010		1	792	276	218592	150908	67684	0.3096362	
D	D8	Madrepora	T2D08R1	2	402.550	10/02/2010		2	357	816	291312	204203	87109	0.2990230	
D	D8	Madrepora	T2D08R1	2	402.550	10/02/2010		3	316	1008	318528	215845	102683	0.3223673	
D	D8	Madrepora	T2D08R1	2	402.550	10/02/2010		4	390	930	362700	242139	120561	0.3323987	
D	D8	Madrepora	T2D08R1	2	402.550	10/02/2010		5	820	744	610080	490028	120052	0.1967808	
D	D8	Madrepora	T2D08R1	2	402.550	10/02/2010	156	1_al_5						1.4602059	102.3307452
D	D8	Madrepora	T3D08R4	3	312.000	18/07/2010		1	566	202	114332	78506	35826	0.3133506	
D	D8	Madrepora	T3D08R4	3	312.000	18/07/2010		2	252	590	148680	109275	39405	0.2650323	
D	D8	Madrepora	T3D08R4	3	312.000	18/07/2010		3	206	522	107532	77606	29926	0.2782986	
D	D8	Madrepora	T3D08R4	3	312.000	18/07/2010		4	322	612	197064	139755	57309	0.2908142	
D	D8	Madrepora	T3D08R4	3	312.000	18/07/2010		5	600	510	306000	251222	54778	0.1790131	
D	D8	Madrepora	T3D08R4	3	312.000	18/07/2010	158	1_al_5						1.3265087	90.84394258
D	D9	Madrepora	T1D09R1	1	378.050	07/09/2009		1	2092	484	1012528	678542	333986	0.3298536	100
D	D9	Madrepora	T2D09R1	2	468.000	10/02/2010	156	1	2340	520	1216800	848322	368478	0.3028254	91.8060161
D	D9	Madrepora	T3D09R3	3	265.630	18/07/2010	158	1	1317	315	414855	298080	116775	0.2814839	92.95252355
D	D10	Madrepora	T1D10R1	1	336.000	07/09/2009		1	2820	1152	3248640	2411563	837077	0.2576700	100
D	D10	Madrepora	T2D10R1	2	426.000	10/02/2010	156	1	2892	1194	3453048	2576792	876256	0.2537631	98.48374785
D	D10	Madrepora	T3D10R5	3	211.700	18/07/2010	158	1	1521	576	876096	657519	218577	0.2494898	98.31603921
D	D16	Lophelia	T2D16R3	2	289.220	10/02/2010		1	3774	1728	6521472	4937621	1583851	0.2428671	
D	D16	Lophelia	T3D16R3	3	192.000	18/07/2010	158	1	2536	1108	2809888	2139240	670648	0.2386743	
D	D18	Madrepora	T2D18R2	2	251.810	10/02/2010		1	3174	2514	7979436	6378429	1601007	0.2006416	100
D	D18	Madrepora	T3D18R3	3	232.160	18/07/2010	158	1	3090	2250	6952500	5626023	1326477	0.1907914	95.09062274
D	D19	Madrepora	T2D19R1	2	280.890	10/02/2010		1	3042	1902	5785884	3887592	1898292	0.3280902	100
D	D19	Madrepora	T3D19R6	3	198.820	18/07/2010	158	1	2116	1256	2657696	1754259	903437	0.3399324	103.6094278

Table 1: Buoyant weight and polyp count raw data

Treatment	ID	Incubation volume (ml)	coral spp	photo_ID	ROV	Collection depth (m)	BW Date	BW label	BW (g)	polyp count	polyp count label
A	A1	300	Lophelia	172-174	LDACHP_10	267	31/08/2009	T1	1.017	7	T1
A	A2	300	Lophelia	308-315	LDACHP_10	267	02/09/2009	T1	5.346	16	T1
A	A3	300	Lophelia	168-171	on board	267	31/08/2009	T1	0.431	4	T1
A	A4	300	Lophelia	238-246	LDACHP_12	200	01/09/2009	T1	5.759	12	T1
A	A5	300	Desmophylum	342-345	D17	-	02/09/2009	T1	0.611	1	T1
A	A6	300	Desmophylum	194		-	31/08/2009	T1	1.339	2	T1
A	A7	300	Madrepora	144-146	LDACHP_9	500	31/08/2009	T1	0.934	17	T1
A	A8	300	Madrepora	211-215	LDACHP_9	500	01/09/2009	T1	2.785	32	T1
A	A9	300	Madrepora	283-287	LDACHP_10	267	02/09/2009	T1	0.775	31	T1
A	A10	300	Lophelia	378-384	LDACHP_9	500	07/09/2009	T1	4.149	7	T1
A	A11	300	Madrepora				23/11/2009	T1	0.957	32	T1
A	A12	300	Madrepora				23/11/2009	T1	1.372	43	T1
A	A16	1000	Lophelia		LDACHP_9	500	03/10/2009	T1	8.593	28	T1
A	A17	1000	Desmophylum		FA5 (SE_1)	-	05/10/2009	T1	1.034	1	T1
A	A18	1000	Madrepora		LDACHP_12	200	03/10/2009	T1	5.082	129	T1
A	A19	1000	Madrepora		LDACHP_12	200	03/10/2009	T1	11.593	185	T1
B	B1	300	Lophelia	356-377	LDACHP_9	500	07/09/2009	T1	4.631	12	T1
B	B2	300	Lophelia	316-324	LDACHP_10	267	02/09/2009	T1	1.051	5	T1
B	B3	300	Lophelia	175-178	LDACHP_10	267	31/08/2009	T1	3.372	17	T1
B	B4	300	Lophelia	247-252	LDACHP_12	200	01/09/2009	T1	1.742	10	T1
B	B5	300	Desmophylum	346-348		-	02/09/2009	T1	0.429	1	T1
B	B6	300	Madrepora	147-153	LDACHP_12	200	31/08/2009	T1	0.607	18	T1
B	B7	300	Madrepora	216-221	LDACHP_9	500	01/09/2009	T1	1.531	22	T1
B	B8	300	Madrepora	400-402	LDACHP_9	500	07/09/2009	T1	0.42	34	T1
B	B9	300	Madrepora	288-291	LDACHP_10	267	02/09/2009	T1	1.134	31	T1
B	B10	300	Madrepora	385-388	LDACHP_9	500	07/09/2009	T1	0.513	36	T1
B	B11	300	Madrepora				23/11/2009	T1	1.054	30	T1
B	B12	300	Madrepora				23/11/2009	T1	0.993	24	T1
B	B16	1000	Lophelia		LDACHP_9	500	03/10/2009	T1	12.221	31	T1
B	B18	1000	Madrepora		LDACHP_12	200	03/10/2009	T1	5.98	77	T1
B	B19	1000	Madrepora		LDACHP_12	200	03/10/2009	T1	2.923	35	T1
C	C1	300	Lophelia	349-352	LDACHP_12	200	07/09/2009	T1	4.665	17	T1
C	C2	300	Lophelia	325-334	LDACHP_10	267	02/09/2009	T1	3.151	18	T1
C	C3	300	Lophelia	179-187	LDACHP_12	200	31/08/2009	T1	2.034	15	T1
C	C4	300	Lophelia	253-259	LDACHP_12	200	01/09/2009	T1	2.859	7	T1
C	C5	300	Desmophylum	275		-	01/09/2009	T1	0.191	1	T1
C	C6	300	Madrepora	154-158	LDACHP_12	200	31/08/2009	T1	0.81	32	T1
C	C7	300	Madrepora	222-231	LDACHP_12	200	01/09/2009	T1	1.593	38	T1
C	C8	300	Madrepora	393-399	LDACHP_9	500	07/09/2009	T1	0.749	18	T1

Treatment	ID	Incubation volume (ml)	coral spp	photo_ID	ROV	Collection depth (m)	BW Date	BW label	BW (g)	polyp count	polyp count label
C	C9	300	Madrepora	292-294	LDACHP_10	267	02/09/2009	T1	1.53	30	T1
C	C10	300	Desmophylum	403	LDACHP_9	-	07/09/2009	T1	1.256	1	T1
C	C11	300	Madrepora				23/11/2009	T1	0.266	18	T1
C	C12	300	Madrepora				23/11/2009	T1	1.419	48	T1
C	C16	1000	Lophelia		LDACHP_12	200	03/10/2009	T1	13.017	46	T1
C	C17	1000	Desmophylum		FA11	-	06/10/2009	T1	6.031	1	T1
C	C18	1000	Madrepora		LDACHP_9	500	03/10/2009	T1	1.953	42	T1
C	C19	1000	Madrepora		LDACHP_10	267	03/10/2009	T1	3.31	83	T1
D	D1	300	Lophelia	353-355	LDACHP_9	500	07/09/2009	T1	0.906	13	T1
D	D2	300	Lophelia	335-341	LDACHP_10	267	02/09/2009	T1	5.261	10	T1
D	D3	300	Lophelia	188-193	LDACHP_9	500	31/08/2009	T1	2.702	7	T1
D	D4	300	Lophelia	260-274	LDACHP_12	200	01/09/2009	T1	8.771	20	T1
D	D5	300	Desmophylum	276-278		-	01/09/2009	T1	0.237	1	T1
D	D6	300	Desmophylum	404	LDACHP_9	-	07/09/2009	T1	0.825	1	T1
D	D7	300	Madrepora	232-237	LDACHP_12	200	01/09/2009	T1	1.319	41	T1
D	D8	300	Madrepora	389-392	LDACHP_9	500	07/09/2009	T1	0.346	30	T1
D	D9	300	Madrepora	295-307	LDACHP_10	267	02/09/2009	T1	0.373	14	T1
D	D10	300	Madrepora	159-167	LDACHP_10	267	31/08/2009	T1	1.493	33	T1
D	D11	300	Madrepora		1.719		23/11/2009	T1	0.973	38	T1
D	D12	300	Madrepora				23/11/2009	T1	1.224	48	T1
D	D16	1000	Lophelia		LDACHP_9	500	03/10/2009	T1	11.943	25	T1
D	D17	1000	Desmophylum		FA6	-	06/10/2009	T1	0.582	2	T1
D	D18	1000	Madrepora		LDACHP_10	267	03/10/2009	T1	11.133	132	T1
D	D19	1000	Madrepora		LDACHP_10	267	03/10/2009	T1	14.246	117	T1
A	A1	300	Lophelia	172-174	LDACHP_10	267	27/01/2010	T2	0.983		T2
A	A2	300	Lophelia	308-315	LDACHP_10	267	27/01/2010	T2	5.388		T2
A	A3	300	Lophelia	168-171	on board	267	27/01/2010	T2	0.416		T2
A	A4	300	Lophelia	238-246	LDACHP_12	200	27/01/2010	T2	5.823		T2
A	A5	300	Desmophylum	342-345	D17	-	27/01/2010	T2	0.628		T2
A	A6	300	Desmophylum	194		-	27/01/2010	T2	1.686		T2
A	A7	300	Madrepora	144-146	LDACHP_9	500	27/01/2010	T2	0.991		T2
A	A8	300	Madrepora	211-215	LDACHP_9	500	27/01/2010	T2	2.859		T2
A	A9	300	Madrepora	283-287	LDACHP_10	267	27/01/2010	T2	0.762		T2
A	A10	300	Lophelia	378-384	LDACHP_9	500	27/01/2010	T2	4.168		T2
A	A11	300	Madrepora				27/01/2010	T2	0.978		T2
A	A12	300	Madrepora				27/01/2010	T2	1.375		T2
A	A16	1000	Lophelia		LDACHP_9	500	27/01/2010	T2	8.883		T2
A	A17	1000	Desmophylum		FA5 (SE_1)	-	27/01/2010	T2	1.043		T2
A	A18	1000	Madrepora		LDACHP_12	200	27/01/2010	T2	5.163		T2
A	A19	1000	Madrepora		LDACHP_12	200	27/01/2010	T2	11.635		T2

Treatment	ID	Incubation volume (ml)	coral spp	photo_ID	ROV	Collection depth (m)	BW Date	BW label	BW (g)	polyp count	polyp count label
B	B1	300	Lophelia	356-377	LDACHP_9	500	27/01/2010	T2	4.63		T2
B	B2	300	Lophelia	316-324	LDACHP_10	267	27/01/2010	T2	1.114		T2
B	B3	300	Lophelia	175-178	LDACHP_10	267	27/01/2010	T2	3.39		T2
B	B4	300	Lophelia	247-252	LDACHP_12	200	27/01/2010	T2	1.616		T2
B	B5	300	Desmophylum	346-348		-	27/01/2010	T2	0.416		T2
B	B6	300	Madrepora	147-153	LDACHP_12	200	27/01/2010	T2	0.642		T2
B	B7	300	Madrepora	216-221	LDACHP_9	500	27/01/2010	T2	1.587		T2
B	B8	300	Madrepora	400-402	LDACHP_9	500	27/01/2010	T2	0.507		T2
B	B9	300	Madrepora	288-291	LDACHP_10	267	27/01/2010	T2	1.18		T2
B	B10	300	Madrepora	385-388	LDACHP_9	500	27/01/2010	T2	0.591		T2
B	B11	300	Madrepora				27/01/2010	T2	1.067		T2
B	B12	300	Madrepora				27/01/2010	T2	0.995		T2
B	B16	1000	Lophelia		LDACHP_9	500	27/01/2010	T2	12.244		T2
B	B18	1000	Madrepora		LDACHP_12	200	27/01/2010	T2	6.018		T2
B	B19	1000	Madrepora		LDACHP_12	200	27/01/2010	T2	2.949		T2
C	C1	300	Lophelia	349-352	LDACHP_12	200	27/01/2010	T2	4.722		T2
C	C2	300	Lophelia	325-334	LDACHP_10	267	27/01/2010	T2	3.167		T2
C	C3	300	Lophelia	179-187	LDACHP_12	200	27/01/2010	T2	1.706		T2
C	C4	300	Lophelia	253-259	LDACHP_12	200	27/01/2010	T2	2.882		T2
C	C5	300	Desmophylum	275		-	27/01/2010	T2	0.205		T2
C	C6	300	Madrepora	154-158	LDACHP_12	200	27/01/2010	T2	0.868		T2
C	C7	300	Madrepora	222-231	LDACHP_12	200	27/01/2010	T2	1.653		T2
C	C8	300	Madrepora	393-399	LDACHP_9	500	27/01/2010	T2	0.827		T2
C	C9	300	Madrepora	292-294	LDACHP_10	267	27/01/2010	T2	1.589		T2
C	C10	300	Desmophylum	403	LDACHP_9	-	27/01/2010	T2	1.273		T2
C	C11	300	Madrepora				27/01/2010	T2	0.274		T2
C	C12	300	Madrepora				27/01/2010	T2	1.424		T2
C	C16	1000	Lophelia		LDACHP_12	200	27/01/2010	T2	13.062		T2
C	C17	1000	Desmophylum		FA11	-	27/01/2010	T2	6.077		T2
C	C18	1000	Madrepora		LDACHP_9	500	27/01/2010	T2	1.829		T2
C	C19	1000	Madrepora		LDACHP_10	267	27/01/2010	T2	3.388		T2
D	D1	300	Lophelia	353-355	LDACHP_9	500	27/01/2010	T2	1.012		T2
D	D2	300	Lophelia	335-341	LDACHP_10	267	27/01/2010	T2	5.278		T2
D	D3	300	Lophelia	188-193	LDACHP_9	500	27/01/2010	T2	2.772		T2
D	D4	300	Lophelia	260-274	LDACHP_12	200	27/01/2010	T2	8.81		T2
D	D5	300	Desmophylum	276-278		-	27/01/2010	T2	0.255		T2
D	D6	300	Desmophylum	404	LDACHP_9	-	27/01/2010	T2	0.8		T2
D	D7	300	Madrepora	232-237	LDACHP_12	200	27/01/2010	T2	1.335		T2
D	D8	300	Madrepora	389-392	LDACHP_9	500	27/01/2010	T2	0.392		T2
D	D9	300	Madrepora	295-307	LDACHP_10	267	27/01/2010	T2	0.519		T2

Treatment	ID	Incubation volume (ml)	coral spp	photo_ID	ROV	Collection depth (m)	BW Date	BW label	BW (g)	polyp count	polyp count label
D	D10	300	Madrepora	159-167	LDACHP_10	267	27/01/2010	T2	1.535		T2
D	D11	300	Madrepora		1.719		27/01/2010	T2	1.019		T2
D	D12	300	Madrepora				27/01/2010	T2	1.253		T2
D	D16	1000	Lophelia		LDACHP_9	500	27/01/2010	T2	12.053		T2
D	D17	1000	Desmophylum		FA6	-	27/01/2010	T2	0.6		T2
D	D18	1000	Madrepora		LDACHP_10	267	27/01/2010	T2	11.269		T2
D	D19	1000	Madrepora		LDACHP_10	267	27/01/2010	T2	14.411		T2
A	A1	300	Lophelia	172-174	LDACHP_10	267	20/04/2010	T3	1.035	7	T3
A	A2	300	Lophelia	308-315	LDACHP_10	267	20/04/2010	T3	5.425	16	T3
A	A3	300	Lophelia	168-171	on board	267	20/04/2010	T3	0.453	3	T3
A	A4	300	Lophelia	238-246	LDACHP_12	200	20/04/2010	T3	5.812	10	T3
A	A5	300	Desmophylum	342-345	D17	-	20/04/2010	T3	0.635	1	T3
A	A6	300	Desmophylum	194		-	20/04/2010	T3		1	T3
A	A7	300	Madrepora	144-146	LDACHP_9	500	20/04/2010	T3	1.007	20	T3
A	A8	300	Madrepora	211-215	LDACHP_9	500	20/04/2010	T3	2.897	31	T3
A	A9	300	Madrepora	283-287	LDACHP_10	267	20/04/2010	T3	0.791	29	T3
A	A10	300	Lophelia	378-384	LDACHP_9	500	20/04/2010	T3	4.108	11	T3
A	A11	300	Madrepora				20/04/2010	T3	1.016	33	T3
A	A12	300	Madrepora				20/04/2010	T3	1.377	40	T3
A	A16	1000	Lophelia		LDACHP_9	500		T3		20-27	T3
A	A17	1000	Desmophylum		FA5 (SE_1)	-		T3		1	T3
A	A18	1000	Madrepora		LDACHP_12	200		T3		~80	T3
A	A19	1000	Madrepora		LDACHP_12	200		T3		~102	T3
B	B1	300	Lophelia	356-377	LDACHP_9	500	15/04/2010	T3	4.627	14	T3
B	B2	300	Lophelia	316-324	LDACHP_10	267	15/04/2010	T3	1.121	6	T3
B	B3	300	Lophelia	175-178	LDACHP_10	267	15/04/2010	T3	3.407	17	T3
B	B4	300	Lophelia	247-252	LDACHP_12	200	15/04/2010	T3	1.651	10	T3
B	B5	300	Desmophylum	346-348		-	15/04/2010	T3	0.425	1	T3
B	B6	300	Madrepora	147-153	LDACHP_12	200	15/04/2010	T3	0.665	20	T3
B	B7	300	Madrepora	216-221	LDACHP_9	500	15/04/2010	T3	1.618	23-24	T3
B	B8	300	Madrepora	400-402	LDACHP_9	500	07/05/2010	T3	0.55	36	T3
B	B9	300	Madrepora	288-291	LDACHP_10	267	15/04/2010	T3	1.218	31	T3
B	B10	300	Madrepora	385-388	LDACHP_9	500	07/05/2010	T3	0.623	37	T3
B	B11	300	Madrepora				15/04/2010	T3	1.08	32	T3
B	B12	300	Madrepora				15/04/2010	T3	1.002	22	T3
B	B16	1000	Lophelia		LDACHP_9	500		T3		20	T3
B	B18	1000	Madrepora		LDACHP_12	200		T3		60	T3
B	B19	1000	Madrepora		LDACHP_12	200		T3		30	T3
C	C1	300	Lophelia	349-352	LDACHP_12	200	22/04/2010	T3	4.728	21	T3
C	C2	300	Lophelia	325-334	LDACHP_10	267	22/04/2010	T3	3.142	20	T3

Treatment	ID	Incubation volume (ml)	coral spp	photo_ID	ROV	Collection depth (m)	BW Date	BW label	BW (g)	polyp count	polyp count label
C	C3	300	Lophelia	179-187	LDACHP_12	200	22/04/2010	T3	1.775	10	T3
C	C4	300	Lophelia	253-259	LDACHP_12	200	22/04/2010	T3	2.866	8	T3
C	C5	300	Desmophylum	275		-	22/04/2010	T3	0.199	1	T3
C	C6	300	Madrepora	154-158	LDACHP_12	200	22/04/2010	T3	0.877	34	T3
C	C7	300	Madrepora	222-231	LDACHP_12	200	22/04/2010	T3	1.714	38	T3
C	C8	300	Madrepora	393-399	LDACHP_9	500	07/05/2010	T3	0.843	22	T3
C	C9	300	Madrepora	292-294	LDACHP_10	267	22/04/2010	T3	1.662	32-33	T3
C	C10	300	Desmophylum	403	LDACHP_9	-	22/04/2010	T3	0.315	1	T3
C	C11	300	Madrepora				22/04/2010	T3	0.274	17	T3
C	C12	300	Madrepora				22/04/2010	T3	1.43	45	T3
C	C16	1000	Lophelia		LDACHP_12	200		T3		40	T3
C	C17	1000	Desmophylum		FA11	-		T3		1	T3
C	C18	1000	Madrepora		LDACHP_9	500		T3		30	T3
C	C19	1000	Madrepora		LDACHP_10	267		T3		80	T3
D	D1	300	Lophelia	353-355	LDACHP_9	500	21/04/2010	T3	1.114	13	T3
D	D2	300	Lophelia	335-341	LDACHP_10	267	21/04/2010	T3	5.274	13	T3
D	D3	300	Lophelia	188-193	LDACHP_9	500	21/04/2010	T3	2.773	9 or 10	T3
D	D4	300	Lophelia	260-274	LDACHP_12	200	21/04/2010	T3	8.859	27	T3
D	D5	300	Desmophylum	276-278		-	21/04/2010	T3	0.263	1	T3
D	D6	300	Desmophylum	404	LDACHP_9	-	21/04/2010	T3	0.798	2	T3
D	D7	300	Madrepora	232-237	LDACHP_12	200	21/04/2010	T3	1.406	37	T3
D	D8	300	Madrepora	389-392	LDACHP_9	500	07/05/2010	T3	0.609	31	T3
D	D9	300	Madrepora	295-307	LDACHP_10	267	21/04/2010	T3	0.402	14	T3
D	D10	300	Madrepora	159-167	LDACHP_10	267	21/04/2010	T3	1.598	31	T3
D	D11	300	Madrepora		1.719		21/04/2010	T3	1.035	36	T3
D	D12	300	Madrepora				21/04/2010	T3	1.311	44	T3
D	D16	1000	Lophelia		LDACHP_9	500		T3			T3
D	D17	1000	Desmophylum		FA6	-		T3		2	T3
D	D18	1000	Madrepora		LDACHP_10	267		T3			T3
D	D19	1000	Madrepora		LDACHP_10	267		T3			T3
A	A1	300	Lophelia	172-174	LDACHP_10	267	17/05/2010	T4	1.045		T4
A	A2	300	Lophelia	308-315	LDACHP_10	267	17/05/2010	T4	5.429		T4
A	A3	300	Lophelia	168-171	on board	267	17/05/2010	T4	0.472		T4
A	A4	300	Lophelia	238-246	LDACHP_12	200	17/05/2010	T4	5.826		T4
A	A5	300	Desmophylum	342-345	D17	-	17/05/2010	T4	0.635		T4
A	A6	300	Desmophylum	194		-	17/05/2010	T4			T4
A	A7	300	Madrepora	144-146	LDACHP_9	500	17/05/2010	T4	1.019		T4
A	A8	300	Madrepora	211-215	LDACHP_9	500	17/05/2010	T4	2.905		T4
A	A9	300	Madrepora	283-287	LDACHP_10	267	17/05/2010	T4	0.802		T4
A	A10	300	Lophelia	378-384	LDACHP_9	500	17/05/2010	T4	4.038		T4

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Treatment	ID	Incubation volume (ml)	coral spp	photo_ID	ROV	Collection depth (m)	BW Date	BW label	BW (g)	polyp count	polyp count label
A	A11	300	Madrepora				17/05/2010	T4	1.002		T4
A	A12	300	Madrepora				17/05/2010	T4	1.382		T4
A	A16	1000	Lophelia		LDACHP_9	500	12/05/2010	T4	9.068		T4
A	A17	1000	Desmophylum		FA5 (SE_1)	-	12/05/2010	T4	1.049		T4
A	A18	1000	Madrepora		LDACHP_12	200	12/05/2010	T4	5.222		T4
A	A19	1000	Madrepora		LDACHP_12	200	12/05/2010	T4	11.654		T4
B	B1	300	Lophelia	356-377	LDACHP_9	500	18/05/2010	T4	4.624		T4
B	B2	300	Lophelia	316-324	LDACHP_10	267	18/05/2010	T4	1.125		T4
B	B3	300	Lophelia	175-178	LDACHP_10	267	18/05/2010	T4	3.411		T4
B	B4	300	Lophelia	247-252	LDACHP_12	200	18/05/2010	T4	1.665		T4
B	B5	300	Desmophylum	346-348		-	18/05/2010	T4	0.419		T4
B	B6	300	Madrepora	147-153	LDACHP_12	200	18/05/2010	T4	0.667		T4
B	B7	300	Madrepora	216-221	LDACHP_9	500	18/05/2010	T4	1.626		T4
B	B8	300	Madrepora	400-402	LDACHP_9	500	18/05/2010	T4	0.552		T4
B	B9	300	Madrepora	288-291	LDACHP_10	267	18/05/2010	T4	1.231		T4
B	B10	300	Madrepora	385-388	LDACHP_9	500	18/05/2010	T4	0.625		T4
B	B11	300	Madrepora				18/05/2010	T4	1.08		T4
B	B12	300	Madrepora				18/05/2010	T4	1.004		T4
B	B16	1000	Lophelia		LDACHP_9	500	13/05/2010	T4	12.195		T4
B	B18	1000	Madrepora		LDACHP_12	200	13/05/2010	T4	5.986		T4
B	B19	1000	Madrepora		LDACHP_12	200	13/05/2010	T4	2.96		T4
C	C1	300	Lophelia	349-352	LDACHP_12	200	19/05/2010	T4	4.726		T4
C	C2	300	Lophelia	325-334	LDACHP_10	267	19/05/2010	T4	3.178		T4
C	C3	300	Lophelia	179-187	LDACHP_12	200	19/05/2010	T4	1.883		T4
C	C4	300	Lophelia	253-259	LDACHP_12	200	19/05/2010	T4	2.897		T4
C	C5	300	Desmophylum	275		-	19/05/2010	T4	0.21		T4
C	C6	300	Madrepora	154-158	LDACHP_12	200	19/05/2010	T4	0.915		T4
C	C7	300	Madrepora	222-231	LDACHP_12	200	19/05/2010	T4	1.703		T4
C	C8	300	Madrepora	393-399	LDACHP_9	500	20/05/2010	T4	0.907		T4
C	C9	300	Madrepora	292-294	LDACHP_10	267	19/05/2010	T4	1.643		T4
C	C10	300	Desmophylum	403	LDACHP_9	-	19/05/2010	T4	0.327		T4
C	C11	300	Madrepora				19/05/2010	T4	0.296		T4
C	C12	300	Madrepora				19/05/2010	T4	1.451		T4
C	C16	1000	Lophelia		LDACHP_12	200	13/05/2010	T4	13.007		T4
C	C17	1000	Desmophylum		FA11	-	13/05/2010	T4	6.062		T4
C	C18	1000	Madrepora		LDACHP_9	500	13/05/2010	T4	1.083		T4
C	C19	1000	Madrepora		LDACHP_10	267	13/05/2010	T4	3.427		T4
D	D1	300	Lophelia	353-355	LDACHP_9	500	20/05/2010	T4	1.153		T4
D	D2	300	Lophelia	335-341	LDACHP_10	267	20/05/2010	T4	5.27		T4
D	D3	300	Lophelia	188-193	LDACHP_9	500	20/05/2010	T4	2.784		T4

Treatment	ID	Incubation volume (ml)	coral spp	photo_ID	ROV	Collection depth (m)	BW Date	BW label	BW (g)	polyp count	polyp count label
D	D4	300	Lophelia	260-274	LDACHP_12	200	20/05/2010	T4	8.854		T4
D	D5	300	Desmophylum	276-278		-	20/05/2010	T4	0.265		T4
D	D6	300	Desmophylum	404	LDACHP_9	-	20/05/2010	T4	0.797		T4
D	D7	300	Madrepora	232-237	LDACHP_12	200	20/05/2010	T4	1.38		T4
D	D8	300	Madrepora	389-392	LDACHP_9	500	20/05/2010	T4	0.482		T4
D	D9	300	Madrepora	295-307	LDACHP_10	267	20/05/2010	T4	0.411		T4
D	D10	300	Madrepora	159-167	LDACHP_10	267	20/05/2010	T4	1.574		T4
D	D11	300	Madrepora		1.719		20/05/2010	T4	1.045		T4
D	D12	300	Madrepora				20/05/2010	T4	1.264		T4
D	D16	1000	Lophelia		LDACHP_9	500	14/05/2010	T4	12.154		T4
D	D17	1000	Desmophylum		FA6	-	14/05/2010	T4	0.61		T4
D	D18	1000	Madrepora		LDACHP_10	267	14/05/2010	T4	11.233		T4
D	D19	1000	Madrepora		LDACHP_10	267	14/05/2010	T4	14.367		T4
A	A1	300	Lophelia	172-174	LDACHP_10	267	29/06/2010	T5	1.064	7	T5
A	A2	300	Lophelia	308-315	LDACHP_10	267	29/06/2010	T5	5.456	16	T5
A	A3	300	Lophelia	168-171	on board	267	29/06/2010	T5	0.506	4	T5
A	A4	300	Lophelia	238-246	LDACHP_12	200	29/06/2010	T5	5.847	13	T5
A	A5	300	Desmophylum	342-345	D17	-	29/06/2010	T5	0.643	1	T5
A	A6	300	Desmophylum	194		-	29/06/2010	T5		1	T5
A	A7	300	Madrepora	144-146	LDACHP_9	500	29/06/2010	T5	1.034	21	T5
A	A8	300	Madrepora	211-215	LDACHP_9	500	29/06/2010	T5	2.918	33?	T5
A	A9	300	Madrepora	283-287	LDACHP_10	267	29/06/2010	T5	0.823	27	T5
A	A10	300	Lophelia	378-384	LDACHP_9	500	29/06/2010	T5	4.127	10	T5
A	A11	300	Madrepora				29/06/2010	T5	1.012	31?	T5
A	A12	300	Madrepora				29/06/2010	T5	1.38	39?	T5
A	A16	1000	Lophelia		LDACHP_9	500	29/06/2010	T5	9.096	25?	T5
A	A17	1000	Desmophylum		FA5 (SE_1)	-	29/06/2010	T5	1.054	1	T5
A	A18	1000	Madrepora		LDACHP_12	200	29/06/2010	T5	5.23		T5
A	A19	1000	Madrepora		LDACHP_12	200	29/06/2010	T5	11.656		T5
B	B1	300	Lophelia	356-377	LDACHP_9	500	27/06/2010	T5	4.578	15	T5
B	B2	300	Lophelia	316-324	LDACHP_10	267	27/06/2010	T5	1.128	6	T5
B	B3	300	Lophelia	175-178	LDACHP_10	267	27/06/2010	T5	3.376	18	T5
B	B4	300	Lophelia	247-252	LDACHP_12	200	27/06/2010	T5	1.726	11	T5
B	B5	300	Desmophylum	346-348		-	27/06/2010	T5	0.411	1	T5
B	B6	300	Madrepora	147-153	LDACHP_12	200	27/06/2010	T5	0.667	18	T5
B	B7	300	Madrepora	216-221	LDACHP_9	500	27/06/2010	T5	1.661	22	T5
B	B8	300	Madrepora	400-402	LDACHP_9	500	27/06/2010	T5	0.567	36	T5
B	B9	300	Madrepora	288-291	LDACHP_10	267	27/06/2010	T5	1.202	32	T5
B	B10	300	Madrepora	385-388	LDACHP_9	500	27/06/2010	T5	0.609	37	T5
B	B11	300	Madrepora				27/06/2010	T5	1.054	32	T5

Treatment	ID	Incubation volume (ml)	coral spp	photo_ID	ROV	Collection depth (m)	BW Date	BW label	BW (g)	polyp count	polyp count label
B	B12	300	Madrepora				27/06/2010	T5	0.977	20	T5
B	B16	1000	Lophelia		LDACHP_9	500	27/06/2010	T5	12.23	34	T5
B	B18	1000	Madrepora		LDACHP_12	200	27/06/2010	T5	5.936	?	T5
B	B19	1000	Madrepora		LDACHP_12	200	27/06/2010	T5	2.943	37?	T5
C	C1	300	Lophelia	349-352	LDACHP_12	200	28/06/2010	T5	4.77	20	T5
C	C2	300	Lophelia	325-334	LDACHP_10	267	28/06/2010	T5	3.177	18	T5
C	C3	300	Lophelia	179-187	LDACHP_12	200	28/06/2010	T5	1.837	10	T5
C	C4	300	Lophelia	253-259	LDACHP_12	200	28/06/2010	T5	2.907	7	T5
C	C5	300	Desmophylum	275		-	28/06/2010	T5	0.211	1	T5
C	C6	300	Madrepora	154-158	LDACHP_12	200	28/06/2010	T5	0.918	40	T5
C	C7	300	Madrepora	222-231	LDACHP_12	200	28/06/2010	T5	1.711	32	T5
C	C8	300	Madrepora	393-399	LDACHP_9	500	30/06/2010	T5	0.851	28	T5
C	C9	300	Madrepora	292-294	LDACHP_10	267	28/06/2010	T5	1.657	34	T5
C	C10	300	Desmophylum	403	LDACHP_9	-	28/06/2010	T5	0.333	1	T5
C	C11	300	Madrepora				28/06/2010	T5	0.302	18	T5
C	C12	300	Madrepora				28/06/2010	T5	1.401	36	T5
C	C16	1000	Lophelia		LDACHP_12	200	28/06/2010	T5	13.018	37?	T5
C	C17	1000	Desmophylum		FA11	-	28/06/2010	T5	6.071	1	T5
C	C18	1000	Madrepora		LDACHP_9	500	28/06/2010	T5	1.822	28?	T5
C	C19	1000	Madrepora		LDACHP_10	267	28/06/2010	T5	3.442	77?	T5
D	D1	300	Lophelia	353-355	LDACHP_9	500	26/06/2010	T5	1.171	13	T5
D	D2	300	Lophelia	335-341	LDACHP_10	267	26/06/2010	T5	5.275	11	T5
D	D3	300	Lophelia	188-193	LDACHP_9	500	26/06/2010	T5	2.78	8	T5
D	D4	300	Lophelia	260-274	LDACHP_12	200	26/06/2010	T5	8.856	23	T5
D	D5	300	Desmophylum	276-278		-	26/06/2010	T5	0.258	1	T5
D	D6	300	Desmophylum	404	LDACHP_9	-	26/06/2010	T5	0.795	1	T5
D	D7	300	Madrepora	232-237	LDACHP_12	200	26/06/2010	T5	1.377	39	T5
D	D8	300	Madrepora	389-392	LDACHP_9	500	30/06/2010	T5	0.542	33	T5
D	D9	300	Madrepora	295-307	LDACHP_10	267	26/06/2010	T5	0.421	14	T5
D	D10	300	Madrepora	159-167	LDACHP_10	267	26/06/2010	T5	1.572	31	T5
D	D11	300	Madrepora		1.719		26/06/2010	T5	1.04	34	T5
D	D12	300	Madrepora				26/06/2010	T5	1.264	41	T5
D	D16	1000	Lophelia		LDACHP_9	500	26/06/2010	T5	12.118	35?	T5
D	D17	1000	Desmophylum		FA6	-	26/06/2010	T5	0.621	2	T5
D	D18	1000	Madrepora		LDACHP_10	267	26/06/2010	T5	11.245	102?	T5
D	D19	1000	Madrepora		LDACHP_10	267	26/06/2010	T5	14.335	156?	T5
A	A1	300	Lophelia	172-174	LDACHP_10	267	06/08/2010	T6	1.058	7	T6
A	A2	300	Lophelia	308-315	LDACHP_10	267	06/08/2010	T6	5.453	15	T6
A	A3	300	Lophelia	168-171	on board	267	06/08/2010	T6	0.504	4	T6
A	A4	300	Lophelia	238-246	LDACHP_12	200	06/08/2010	T6	5.827	16	T6

Treatment	ID	Incubation volume (ml)	coral spp	photo_ID	ROV	Collection depth (m)	BW Date	BW label	BW (g)	polyp count	polyp count label
A	A5	300	Desmophylum	342-345	D17	-	06/08/2010	T6	0.621	1	T6
A	A6	300	Desmophylum	194		-	06/08/2010	T6		1	T6
A	A7	300	Madrepora	144-146	LDACHP_9	500	06/08/2010	T6	1.015	22	T6
A	A8	300	Madrepora	211-215	LDACHP_9	500	06/08/2010	T6	2.908	34	T6
A	A9	300	Madrepora	283-287	LDACHP_10	267	06/08/2010	T6	0.814	28	T6
A	A10	300	Lophelia	378-384	LDACHP_9	500	06/08/2010	T6	4.15	13	T6
A	A11	300	Madrepora				06/08/2010	T6	1.031	31?	T6
A	A12	300	Madrepora				06/08/2010	T6	1.395	41?	T6
A	A16	1000	Lophelia		LDACHP_9	500	06/08/2010	T6	9.112	27	T6
A	A17	1000	Desmophylum		FA5 (SE_1)	-	06/08/2010	T6	1.064	1	T6
A	A18	1000	Madrepora		LDACHP_12	200	06/08/2010	T6	5.238	126	T6
A	A19	1000	Madrepora		LDACHP_12	200	06/08/2010	T6	11.562	95	T6
B	B1	300	Lophelia	356-377	LDACHP_9	500	05/08/2010	T6	4.617	13	T6
B	B2	300	Lophelia	316-324	LDACHP_10	267	05/08/2010	T6	1.118	5	T6
B	B3	300	Lophelia	175-178	LDACHP_10	267	05/08/2010	T6	3.416	17	T6
B	B4	300	Lophelia	247-252	LDACHP_12	200	05/08/2010	T6	1.69	11	T6
B	B5	300	Desmophylum	346-348		-	05/08/2010	T6	0.417	1	T6
B	B6	300	Madrepora	147-153	LDACHP_12	200	05/08/2010	T6	0.669	18	T6
B	B7	300	Madrepora	216-221	LDACHP_9	500	05/08/2010	T6	1.644	21	T6
B	B8	300	Madrepora	400-402	LDACHP_9	500	05/08/2010	T6	0.572	36	T6
B	B9	300	Madrepora	288-291	LDACHP_10	267	05/08/2010	T6	1.251	28	T6
B	B10	300	Madrepora	385-388	LDACHP_9	500	05/08/2010	T6	0.628	36	T6
B	B11	300	Madrepora				05/08/2010	T6	1.063	29	T6
B	B12	300	Madrepora				05/08/2010	T6	1.000	23	T6
B	B16	1000	Lophelia		LDACHP_9	500	05/08/2010	T6	12.268	36	T6
B	B18	1000	Madrepora		LDACHP_12	200	05/08/2010	T6	6.012	69?	T6
B	B19	1000	Madrepora		LDACHP_12	200	05/08/2010	T6	2.948	34?	T6
C	C1	300	Lophelia	349-352	LDACHP_12	200	04/08/2010	T6	4.085	21?	T6
C	C2	300	Lophelia	325-334	LDACHP_10	267	04/08/2010	T6	3.192	20	T6
C	C3	300	Lophelia	179-187	LDACHP_12	200	04/08/2010	T6	1.846	13?	T6
C	C4	300	Lophelia	253-259	LDACHP_12	200	04/08/2010	T6	2.914	9	T6
C	C5	300	Desmophylum	275		-	04/08/2010	T6	0.212	1	T6
C	C6	300	Madrepora	154-158	LDACHP_12	200	04/08/2010	T6	0.925	35?	T6
C	C7	300	Madrepora	222-231	LDACHP_12	200	04/08/2010	T6	1.716	35?, 39?	T6
C	C8	300	Madrepora	393-399	LDACHP_9	500	04/08/2010	T6	0.846	28	T6
C	C9	300	Madrepora	292-294	LDACHP_10	267	04/08/2010	T6	1.673	29?	T6
C	C10	300	Desmophylum	403	LDACHP_9	-	04/08/2010	T6	0.337	1	T6
C	C11	300	Madrepora				04/08/2010	T6	0.316	18	T6
C	C12	300	Madrepora				04/08/2010	T6	1.405	45?	T6
C	C16	1000	Lophelia		LDACHP_12	200	04/08/2010	T6	13.051	51?	T6

Treatment	ID	Incubation volume (ml)	coral spp	photo_ID	ROV	Collection depth (m)	BW Date	BW label	BW (g)	polyp count	polyp count label
C	C17	1000	Desmophylum		FA11	-	04/08/2010	T6	6.082	1	T6
C	C18	1000	Madrepora		LDACHP_9	500	04/08/2010	T6	1.83	33	T6
C	C19	1000	Madrepora		LDACHP_10	267	04/08/2010	T6	3.45	74?	T6
D	D1	300	Lophelia	353-355	LDACHP_9	500	02/08/2010	T6	1.165	14	T6
D	D2	300	Lophelia	335-341	LDACHP_10	267	02/08/2010	T6	5.283	11	T6
D	D3	300	Lophelia	188-193	LDACHP_9	500	02/08/2010	T6	2.787	8	T6
D	D4	300	Lophelia	260-274	LDACHP_12	200	02/08/2010	T6	8.85	24	T6
D	D5	300	Desmophylum	276-278		-	02/08/2010	T6	0.265	1	T6
D	D6	300	Desmophylum	404	LDACHP_9	-	02/08/2010	T6	0.8	1	T6
D	D7	300	Madrepora	232-237	LDACHP_12	200	02/08/2010	T6	1.397	28-38	T6
D	D8	300	Madrepora	389-392	LDACHP_9	500	02/08/2010	T6	0.535	32	T6
D	D9	300	Madrepora	295-307	LDACHP_10	267	02/08/2010	T6	0.432	14	T6
D	D10	300	Madrepora	159-167	LDACHP_10	267	02/08/2010	T6	1.578	25-26	T6
D	D11	300	Madrepora		1.719		02/08/2010	T6	1.047	32-33	T6
D	D12	300	Madrepora				02/08/2010	T6	1.274	33-35	T6
D	D16	1000	Lophelia		LDACHP_9	500	02/08/2010	T6	12.085	29	T6
D	D17	1000	Desmophylum		FA6	-	02/08/2010	T6	0.625	2	T6
D	D18	1000	Madrepora		LDACHP_10	267	02/08/2010	T6	11.296	127?	T6
D	D19	1000	Madrepora		LDACHP_10	267	02/08/2010	T6	14.317	118?	T6
A	A4	300	Lophelia	238-246	LDACHP_12					14	T7
A	A7	300	Madrepora	144-146	LDACHP_9					21	T7
A	A8	300	Madrepora	211-215	LDACHP_9					31	T7
A	A9	300	Madrepora	283-287	LDACHP_10					26	T7
A	A10	300	Lophelia	378-384	LDACHP_9					10	T7
A	A11	300	Madrepora							32	T7
A	A12	300	Madrepora							42	T7
A	A16	1000	Lophelia		LDACHP_9					27-28	T7
A	A19	1000	Madrepora		LDACHP_12					118	T7
B	B18	1000	Madrepora		LDACHP_12					77	T7
C	C2	300	Lophelia	325-334	LDACHP_10					19	T7
C	C3	300	Lophelia	179-187	LDACHP_12					10	T7
C	C4	300	Lophelia	253-259	LDACHP_12					8	T7
C	C6	300	Madrepora	154-158	LDACHP_12					35	T7
C	C8	300	Madrepora	393-399	LDACHP_9					28	T7
C	C9	300	Madrepora	292-294	LDACHP_10					31	T7
C	C12	300	Madrepora							43	T7
C	C16	1000	Lophelia		LDACHP_12					44	T7
C	C18	1000	Madrepora		LDACHP_9					41	T7
C	C19	1000	Madrepora		LDACHP_10					85	T7
D	D2	300	Lophelia	335-341	LDACHP_10					12	T7

Treatment	ID	Incubation volume (ml)	coral spp	photo_ID	ROV	Collection depth (m)	BW Date	BW label	BW (g)	polyp count	polyp count label
D	D3	300	Lophelia	188-193	LDACHP_9					8	T7
D	D4	300	Lophelia	260-274	LDACHP_12					24	T7
D	D8	300	Madrepora	389-392	LDACHP_9					34	T7
D	D10	300	Madrepora	159-167	LDACHP_10					32	T7
D	D11	300	Madrepora		1.719					35	T7
D	D12	300	Madrepora							43	T7
D	D16	1000	Lophelia		LDACHP_9					27	T7
D	D18	1000	Madrepora		LDACHP_10					123	T7
D	D19	1000	Madrepora		LDACHP_10					118	T7

Table 1: Carbonate chemistry raw data. Salinity: 38 ppt, Temperature: 13 C, Hydrostatic pressure: 0 atm

Treatment	ID	coral spp	Collection date	pH	CO2	pCO2	fCO2	HCO3	CO3	DIC	ALK	ΩAragonite	ΩCalcite
X	/	bulk 02.09.2009	08/2009	8.168	0.0000123	315.585	314.431	0.00203	0.00022	0.00226	0.00257	3.285	5.120
X	/	bulk 02.09.2009	08/2009	8.158	0.0000126	323.745	322.562	0.00203	0.00021	0.00226	0.00256	3.213	5.008
X	/	bulk 02.09.2009	08/2009	8.151	0.0000129	330.499	329.291	0.00204	0.00021	0.00227	0.00256	3.176	4.950
X	/	bulk 03.09.2009	08/2009	8.171	0.0000121	310.962	309.825	0.00201	0.00022	0.00225	0.00256	3.288	5.125
X	/	bulk 03.09.2009	08/2009	8.168	0.0000122	313.297	312.152	0.00202	0.00022	0.00225	0.00255	3.267	5.093
X	/	bulk 03.09.2009	08/2009	8.171	0.0000122	311.700	310.560	0.00202	0.00022	0.00225	0.00256	3.289	5.127
X	/	bulk 04.09.2009	09/2009	8.175	0.0000120	308.728	307.599	0.00202	0.00022	0.00225	0.00256	3.321	5.176
X	/	bulk 04.09.2009	09/2009										
X	/	bulk 04.09.2009	09/2009	8.170	0.0000123	314.163	313.015	0.00203	0.00022	0.00226	0.00257	3.294	5.135
A	A7	Madrepora	09/2009	8.001	0.0000194	497.666	495.846	0.00218	0.00016	0.00236	0.00258	2.406	3.750
B	B6	Madrepora	09/2009	8.061	0.0000168	429.556	427.985	0.00216	0.00018	0.00236	0.00260	2.727	4.251
C	C6	Madrepora	09/2009	8.069	0.0000160	408.764	407.270	0.00209	0.00018	0.00229	0.00254	2.695	4.201
D	D10	Madrepora	09/2009	8.022	0.0000180	460.846	459.161	0.00211	0.00016	0.00230	0.00252	2.445	3.811
A	A3	Lophelia	09/2009										
A	A1	Lophelia	09/2009										
B	B3	Lophelia	09/2009	8.055	0.0000168	431.186	429.610	0.00214	0.00018	0.00233	0.00257	2.666	4.156
C	C3	Lophelia	09/2009	8.036	0.0000180	460.100	458.418	0.00218	0.00017	0.00237	0.00261	2.607	4.064
D	D3	Lophelia	09/2009	7.997	0.0000198	507.583	505.728	0.00220	0.00016	0.00238	0.00260	2.406	3.750
A	A6	Desmophylum	09/2009	8.074	0.0000163	416.739	415.216	0.00216	0.00019	0.00236	0.00262	2.808	4.378
A	A11	blank	09/2009	8.030	0.0000182	467.411	465.702	0.00219	0.00017	0.00238	0.00261	2.580	4.021
A	A12	blank	09/2009	8.100	0.0000153	390.850	389.421	0.00215	0.00020	0.00237	0.00264	2.982	4.648
A	A13	blank	09/2009	8.010	0.0000192	492.578	490.777	0.00220	0.00017	0.00238	0.00261	2.475	3.857
A	A14	blank	09/2009	8.053	0.0000172	440.316	438.707	0.00217	0.00018	0.00237	0.00262	2.705	4.216
A	A15	blank	09/2009	8.042	0.0000178	454.846	453.183	0.00219	0.00018	0.00238	0.00262	2.650	4.131
B	B11	blank	09/2009	8.060	0.0000168	429.865	428.293	0.00216	0.00018	0.00236	0.00260	2.727	4.251
B	B12	blank	09/2009	8.053	0.0000172	440.943	439.331	0.00218	0.00018	0.00237	0.00262	2.706	4.218
B	B13	blank	09/2009	8.052	0.0000172	439.637	438.029	0.00216	0.00018	0.00236	0.00260	2.679	4.176
B	B14	blank	09/2009										
B	B15	blank	09/2009	8.074	0.0000162	416.137	414.616	0.00215	0.00019	0.00236	0.00261	2.807	4.376
A	A8	Madrepora	09/2009										
B	B7	Madrepora	09/2009	8.020	0.0000183	468.077	466.365	0.00214	0.00016	0.00232	0.00255	2.467	3.846
C	C7	Madrepora	09/2009	8.055	0.0000166	424.253	422.702	0.00210	0.00018	0.00230	0.00254	2.631	4.101
D	D7	Madrepora	09/2009	8.047	0.0000168	429.388	427.818	0.00209	0.00017	0.00228	0.00251	2.563	3.996
A	A4	Lophelia	09/2009	8.035	0.0000180	462.047	460.357	0.00219	0.00017	0.00238	0.00262	2.610	4.068
B	B4	Lophelia	09/2009	8.014	0.0000187	479.690	477.936	0.00216	0.00016	0.00235	0.00257	2.458	3.831

Treatment	ID	coral spp	Collection date	pH	CO2	pCO2	fCO2	HCO3	CO3	DIC	ALK	ΩAragonite	ΩCalcite
C	C4	Lophelia	09/2009	7.981	0.0000206	528.997	527.063	0.00221	0.00016	0.00239	0.00260	2.332	3.635
D	D4	Lophelia	09/2009	7.985	0.0000205	525.582	523.660	0.00222	0.00016	0.00239	0.00260	2.353	3.668
C	C5	Desmophylum	09/2009	8.003	0.0000194	496.799	494.983	0.00218	0.00016	0.00236	0.00258	2.417	3.768
D	D5	Desmophylum	09/2009	8.046	0.0000168	430.320	428.746	0.00209	0.00017	0.00228	0.00251	2.552	3.978
D	D11	blank	09/2009	8.054	0.0000170	436.530	434.934	0.00216	0.00018	0.00235	0.00260	2.687	4.188
D	D12	blank	09/2009	8.046	0.0000173	444.318	442.693	0.00216	0.00018	0.00235	0.00259	2.635	4.108
D	D13	blank	09/2009	8.034	0.0000179	459.202	457.523	0.00217	0.00017	0.00236	0.00259	2.581	4.023
D	D14	blank	09/2009	8.075	0.0000161	413.433	411.922	0.00214	0.00019	0.00235	0.00260	2.803	4.369
D	D15	blank	09/2009	8.059	0.0000168	431.360	429.783	0.00216	0.00018	0.00236	0.00260	2.717	4.235
A	A9	Madrepora	09/2009	8.091	0.0000153	390.993	389.564	0.00210	0.00019	0.00231	0.00257	2.856	4.451
B	B9	Madrepora	09/2009	7.997	0.0000192	492.344	490.544	0.00214	0.00016	0.00231	0.00252	2.337	3.642
C	C9	Madrepora	09/2009	8.027	0.0000178	455.023	453.359	0.00211	0.00017	0.00230	0.00252	2.475	3.857
D	D9	Madrepora	09/2009	8.054	0.0000170	434.621	433.032	0.00215	0.00018	0.00234	0.00259	2.671	4.164
A	A2	Lophelia	09/2009	8.072	0.0000158	404.728	403.248	0.00209	0.00018	0.00229	0.00254	2.714	4.231
B	B2	Lophelia	09/2009	8.012	0.0000187	479.260	477.508	0.00215	0.00016	0.00233	0.00255	2.432	3.791
C	C2	Lophelia	09/2009	8.077	0.0000154	393.667	392.228	0.00205	0.00018	0.00225	0.00250	2.697	4.203
D	D2	Lophelia	09/2009	8.088	0.0000154	395.506	394.060	0.00212	0.00019	0.00232	0.00258	2.850	4.443
A	A5	Desmophylum	09/2009	7.945	0.0000221	565.468	563.401	0.00218	0.00014	0.00234	0.00253	2.112	3.292
B	B5	Desmophylum	09/2009	8.057	0.0000170	436.327	434.731	0.00217	0.00018	0.00237	0.00262	2.724	4.247
X	/	bulk 09.09.2009	09/2009	8.198	0.0000113	289.927	288.867	0.00200	0.00023	0.00224	0.00257	3.469	5.408
X	/	bulk 09.09.2009	09/2009	8.194	0.0000115	293.435	292.363	0.00200	0.00023	0.00225	0.00257	3.452	5.381
X	/	bulk 09.09.2009	09/2009	8.191	0.0000115	295.468	294.388	0.00200	0.00023	0.00224	0.00256	3.418	5.328
C	C11	blank	09/2009	7.992	0.0000199	509.840	507.976	0.00218	0.00016	0.00236	0.00257	2.359	3.676
C	C12	blank	09/2009	7.993	0.0000199	508.915	507.054	0.00219	0.00016	0.00237	0.00258	2.370	3.694
C	C13	blank	09/2009	8.051	0.0000171	438.985	437.380	0.00215	0.00018	0.00235	0.00259	2.665	4.154
C	C14	blank	09/2009	8.064	0.0000165	422.239	420.695	0.00214	0.00018	0.00234	0.00259	2.728	4.253
C	C15	blank	09/2009	8.063	0.0000167	427.517	425.954	0.00216	0.00018	0.00236	0.00261	2.749	4.285
C	C1	Lophelia	09/2009	7.855	0.0000281	719.042	716.413	0.00225	0.00012	0.00239	0.00254	1.768	2.755
D	D1	Lophelia	09/2009	8.044	0.0000173	443.359	441.738	0.00214	0.00017	0.00233	0.00257	2.609	4.066
B	B1	Lophelia	09/2009										
A	A10	Lophelia	09/2009	7.873	0.0000268	686.245	683.736	0.00224	0.00012	0.00239	0.00254	1.837	2.863
B	B10	Madrepora	09/2009	8.017	0.0000184	470.609	468.889	0.00214	0.00016	0.00232	0.00254	2.446	3.812
D	D8	Madrepora	09/2009	7.994	0.0000196	502.815	500.977	0.00217	0.00016	0.00234	0.00255	2.350	3.663
C	C8	Madrepora	09/2009	8.000	0.0000195	498.540	496.717	0.00218	0.00016	0.00236	0.00257	2.395	3.732
B	B8	Madrepora	09/2009	7.952	0.0000216	553.825	551.801	0.00217	0.00014	0.00233	0.00252	2.136	3.329
C	C10	Desmophylum	09/2009	8.023	0.0000178	454.957	453.293	0.00209	0.00016	0.00227	0.00249	2.425	3.779
D	D6	Desmophylum	09/2009	7.839	0.0000291	746.665	743.935	0.00225	0.00011	0.00239	0.00253	1.705	2.658

Treatment	ID	coral spp	Collection date	pH	CO2	pCO2	fCO2	HCO3	CO3	DIC	ALK	ΩAragonite	ΩCalcite
X	/	bulk 05.10.2009	10/2009	8.161	0.0000125	320.554	319.383	0.00203	0.00022	0.00226	0.00256	3.232	5.037
X	/	bulk 05.10.2009	10/2009	8.124	0.0000138	352.763	351.474	0.00205	0.00020	0.00227	0.00255	3.004	4.682
X	/	bulk 05.10.2009	10/2009	8.152	0.0000128	328.476	327.275	0.00204	0.00021	0.00226	0.00256	3.184	4.964
A	A17	blank	10/2009										
A	A20	blank	10/2009	8.043	0.0000177	453.555	451.897	0.00219	0.00018	0.00238	0.00262	2.661	4.148
A	A21	blank	10/2009	8.073	0.0000164	419.844	418.309	0.00217	0.00019	0.00238	0.00263	2.826	4.405
B	B17	blank	10/2009	8.089	0.0000161	411.797	410.292	0.00221	0.00020	0.00242	0.00269	2.978	4.642
B	B20	blank	10/2009	8.073	0.0000167	428.260	426.694	0.00221	0.00019	0.00242	0.00268	2.877	4.484
B	B21	blank	10/2009	8.092	0.0000158	403.920	402.443	0.00218	0.00020	0.00239	0.00266	2.965	4.622
C	C17	blank	10/2009	8.054	0.0000173	443.818	442.196	0.00219	0.00018	0.00240	0.00264	2.735	4.264
C	C20	blank	10/2009	8.044	0.0000177	453.867	452.208	0.00219	0.00018	0.00239	0.00263	2.674	4.168
C	C21	blank	10/2009	7.994	0.0000202	516.686	514.797	0.00223	0.00016	0.00241	0.00262	2.417	3.768
D	D17	blank	10/2009	8.020	0.0000188	482.717	480.952	0.00220	0.00017	0.00239	0.00262	2.537	3.955
D	D20	blank	10/2009	8.038	0.0000179	459.390	457.711	0.00219	0.00018	0.00238	0.00262	2.631	4.102
D	D21	blank	10/2009	8.021	0.0000187	479.709	477.955	0.00220	0.00017	0.00238	0.00261	2.533	3.949
A	A16	Lophelia	10/2009	7.920	0.0000239	611.479	609.243	0.00222	0.00014	0.00238	0.00256	2.037	3.175
B	B16	Lophelia	10/2009	7.971	0.0000212	542.511	540.528	0.00222	0.00015	0.00239	0.00259	2.285	3.562
C	C16	Lophelia	10/2009	8.014	0.0000190	486.538	484.759	0.00219	0.00017	0.00238	0.00260	2.492	3.884
D	D16	Lophelia	10/2009	7.947	0.0000222	569.104	567.023	0.00220	0.00014	0.00236	0.00255	2.141	3.337
A	A18	Madrepora	10/2009	7.963	0.0000212	543.529	541.541	0.00218	0.00015	0.00235	0.00254	2.199	3.428
A	A19	Madrepora	10/2009	7.913	0.0000238	609.094	606.867	0.00218	0.00013	0.00233	0.00250	1.959	3.054
B	B18	Madrepora	10/2009	7.975	0.0000208	531.933	529.988	0.00219	0.00015	0.00236	0.00256	2.273	3.543
B	B19	Madrepora	10/2009	7.989	0.0000207	529.277	527.342	0.00225	0.00016	0.00244	0.00265	2.420	3.772
C	C18	Madrepora	10/2009	8.041	0.0000179	458.698	457.021	0.00220	0.00018	0.00239	0.00263	2.656	4.139
C	C19	Madrepora	10/2009	7.920	0.0000235	601.570	599.371	0.00219	0.00013	0.00234	0.00252	2.001	3.120
D	D18	Madrepora	10/2009	7.907	0.0000234	599.536	597.344	0.00211	0.00013	0.00226	0.00242	1.875	2.923
D	D19	Madrepora	10/2009	7.870	0.0000267	684.862	682.358	0.00222	0.00012	0.00237	0.00252	1.811	2.822
X	/	bulk 07.10.2009	10/2009	8.099	0.0000149	381.559	380.164	0.00209	0.00019	0.00230	0.00257	2.890	4.505
X	/	bulk 07.10.2009	10/2009	8.111	0.0000144	368.207	366.861	0.00208	0.00020	0.00229	0.00256	2.956	4.607
X	/	bulk 07.10.2009	10/2009	8.090	0.0000152	389.974	388.549	0.00210	0.00019	0.00230	0.00256	2.841	4.429
X	/	bulk 07.10.2009	10/2009	8.001	0.0000192	490.760	488.966	0.00215	0.00016	0.00233	0.00254	2.372	3.697
X	/	bulk 07.10.2009	10/2009	7.963	0.0000212	543.900	541.911	0.00218	0.00015	0.00235	0.00254	2.199	3.428
X	/	bulk 07.10.2009	10/2009	7.954	0.0000217	555.607	553.575	0.00218	0.00014	0.00235	0.00254	2.163	3.371
X	/	bulk 08.10.2009	10/2009	7.803	0.0000322	824.365	821.351	0.00229	0.00011	0.00243	0.00255	1.598	2.490
X	/	bulk 08.10.2009	10/2009	7.739	0.0000377	967.193	963.657	0.00232	0.00009	0.00245	0.00255	1.398	2.180
X	/	bulk 08.10.2009	10/2009	7.752	0.0000366	937.554	934.126	0.00231	0.00010	0.00245	0.00255	1.438	2.242
X	/	bulk 08.10.2009	10/2009	7.669	0.0000451	1,155.455	1,151.231	0.00235	0.00008	0.00248	0.00255	1.209	1.884

Treatment	ID	coral spp	Collection date	pH	CO2	pCO2	fCO2	HCO3	CO3	DIC	ALK	ΩAragonite	ΩCalcite
X	/	bulk 08.10.2009	10/2009	7.674	0.0000445	1,140.907	1,136.736	0.00235	0.00008	0.00248	0.00256	1.224	1.907
X	/	bulk 08.10.2009	10/2009	7.655	0.0000466	1,195.224	1,190.854	0.00236	0.00008	0.00248	0.00255	1.173	1.829
A	A11	blank	10/2009	8.155	0.0000130	333.752	332.532	0.00208	0.00022	0.00231	0.00262	3.271	5.099
A	A12	blank	10/2009	8.138	0.0000135	346.596	345.329	0.00208	0.00021	0.00230	0.00260	3.144	4.900
A	A13	blank	10/2009	8.168	0.0000125	321.272	320.097	0.00207	0.00022	0.00230	0.00261	3.347	5.218
A	A14	blank	10/2009	8.152	0.0000131	334.954	333.729	0.00207	0.00022	0.00230	0.00260	3.235	5.043
A	A15	blank	10/2009	8.131	0.0000138	354.111	352.816	0.00209	0.00021	0.00231	0.00260	3.107	4.843
A	A20	blank	10/2009	8.130	0.0000139	357.299	355.993	0.00211	0.00021	0.00233	0.00262	3.126	4.872
A	A21	blank	10/2009	8.105	0.0000149	381.193	379.800	0.00212	0.00020	0.00233	0.00260	2.965	4.622
A	A1	Lophelia	10/2009	8.126	0.0000134	342.645	341.392	0.00200	0.00020	0.00221	0.00248	2.934	4.574
A	A2	Lophelia	10/2009	8.121	0.0000139	355.295	353.996	0.00205	0.00020	0.00226	0.00254	2.983	4.650
A	A3	Lophelia	10/2009	8.091	0.0000152	388.814	387.392	0.00209	0.00019	0.00230	0.00256	2.839	4.426
A	A4	Lophelia	10/2009	8.126	0.0000137	350.060	348.780	0.00204	0.00020	0.00226	0.00254	2.999	4.674
A	A5	Desmophylum	10/2009	8.134	0.0000135	345.599	344.335	0.00205	0.00021	0.00227	0.00256	3.079	4.799
A	A6	Desmophylum	10/2009	8.143	0.0000132	338.202	336.965	0.00205	0.00021	0.00228	0.00257	3.140	4.895
A	A7	Madrepora	10/2009	8.132	0.0000135	346.167	344.901	0.00205	0.00020	0.00227	0.00255	3.054	4.761
A	A8	Madrepora	10/2009	8.127	0.0000135	345.782	344.518	0.00202	0.00020	0.00223	0.00251	2.978	4.642
A	A9	Madrepora	10/2009	8.160	0.0000126	323.113	321.932	0.00204	0.00022	0.00227	0.00258	3.250	5.065
A	A10	Lophelia	10/2009	8.138	0.0000133	341.083	339.836	0.00205	0.00021	0.00227	0.00256	3.095	4.825
A	A16	Lophelia	10/2009	8.076	0.0000158	406.039	404.555	0.00211	0.00018	0.00231	0.00257	2.766	4.312
A	A17	Desmophylum	10/2009	8.131	0.0000139	355.958	354.657	0.00210	0.00021	0.00232	0.00261	3.123	4.868
A	A18	Madrepora	10/2009	8.061	0.0000163	416.999	415.474	0.00210	0.00018	0.00229	0.00254	2.658	4.143
A	A19	Madrepora	10/2009	8.103	0.0000146	373.318	371.953	0.00206	0.00019	0.00227	0.00254	2.876	4.483
B	B11	blank	10/2009	7.994	0.0000199	510.804	508.936	0.00220	0.00016	0.00238	0.00259	2.385	3.717
B	B12	blank	10/2009	8.042	0.0000176	451.335	449.685	0.00217	0.00018	0.00237	0.00260	2.633	4.104
B	B13	blank	10/2009	8.031	0.0000181	464.464	462.766	0.00218	0.00017	0.00237	0.00260	2.575	4.015
B	B14	blank	10/2009	8.025	0.0000185	473.878	472.145	0.00219	0.00017	0.00238	0.00261	2.551	3.976
B	B15	blank	10/2009	8.021	0.0000187	480.279	478.523	0.00220	0.00017	0.00239	0.00262	2.547	3.969
B	B17	blank	10/2009	8.010	0.0000192	490.875	489.080	0.00219	0.00017	0.00238	0.00260	2.472	3.854
B	B20	blank	10/2009	7.992	0.0000202	517.489	515.597	0.00222	0.00016	0.00240	0.00261	2.393	3.730
B	B21	blank	10/2009	8.000	0.0000197	504.410	502.566	0.00220	0.00016	0.00239	0.00260	2.427	3.783
B	B1	Lophelia	10/2009	8.003	0.0000190	486.278	484.500	0.00214	0.00016	0.00231	0.00253	2.366	3.688
B	B2	Lophelia	10/2009	7.968	0.0000201	514.346	512.465	0.00208	0.00014	0.00225	0.00244	2.127	3.316
B	B3	Lophelia	10/2009	7.977	0.0000203	519.553	517.653	0.00215	0.00015	0.00232	0.00252	2.245	3.500
B	B4	Lophelia	10/2009	7.998	0.0000194	497.179	495.362	0.00216	0.00016	0.00234	0.00255	2.368	3.691
B	B5	Desmophylum	10/2009	8.016	0.0000188	481.140	479.381	0.00218	0.00017	0.00236	0.00259	2.485	3.873
B	B6	Madrepora	10/2009	7.980	0.0000205	524.169	522.253	0.00219	0.00015	0.00236	0.00257	2.301	3.587

Treatment	ID	coral spp	Collection date	pH	CO2	pCO2	fCO2	HCO3	CO3	DIC	ALK	ΩAragonite	ΩCalcite
B	B7	Madrepora	10/2009	7.978	0.0000202	517.026	515.136	0.00214	0.00015	0.00232	0.00252	2.242	3.495
B	B8	Madrepora	10/2009	8.029	0.0000179	458.461	456.785	0.00214	0.00017	0.00233	0.00255	2.517	3.923
B	B9	Madrepora	10/2009	7.984	0.0000199	509.040	507.179	0.00214	0.00015	0.00231	0.00252	2.270	3.539
B	B10	Madrepora	10/2009	8.003	0.0000192	492.143	490.344	0.00216	0.00016	0.00234	0.00256	2.399	3.739
B	B16	Lophelia	10/2009	7.987	0.0000202	517.387	515.496	0.00219	0.00016	0.00237	0.00258	2.343	3.652
B	B18	Madrepora	10/2009	7.995	0.0000197	503.656	501.815	0.00217	0.00016	0.00235	0.00256	2.363	3.684
B	B19	Madrepora	10/2009	7.987	0.0000202	517.387	515.496	0.00219	0.00016	0.00237	0.00258	2.343	3.652
C	C11	blank	10/2009	7.853	0.0000289	741.236	738.526	0.00231	0.00012	0.00246	0.00261	1.812	2.825
C	C12	blank	10/2009	7.898	0.0000258	661.213	658.795	0.00228	0.00013	0.00244	0.00261	1.987	3.097
C	C13	blank	10/2009	7.883	0.0000269	688.692	686.174	0.00229	0.00013	0.00245	0.00261	1.926	3.002
C	C14	blank	10/2009	7.847	0.0000294	753.656	750.901	0.00231	0.00012	0.00246	0.00260	1.786	2.784
C	C15	blank	10/2009	7.851	0.0000291	745.193	742.468	0.00231	0.00012	0.00246	0.00261	1.803	2.811
C	C20	blank	10/2009	7.943	0.0000230	590.509	588.350	0.00226	0.00015	0.00243	0.00262	2.177	3.393
C	C21	blank	10/2009	7.952	0.0000225	576.600	574.491	0.00226	0.00015	0.00243	0.00262	2.224	3.467
C	C1	Lophelia	10/2009	7.830	0.0000292	748.184	745.449	0.00221	0.00011	0.00235	0.00248	1.645	2.564
C	C2	Lophelia	10/2009	7.864	0.0000271	695.571	693.028	0.00222	0.00012	0.00237	0.00251	1.783	2.780
C	C3	Lophelia	10/2009	7.858	0.0000270	692.606	690.074	0.00218	0.00012	0.00232	0.00247	1.731	2.698
C	C4	Lophelia	10/2009	7.848	0.0000292	747.761	745.027	0.00230	0.00012	0.00245	0.00259	1.781	2.776
C	C5	Desmophylum	10/2009	7.892	0.0000262	670.519	668.067	0.00228	0.00013	0.00244	0.00260	1.959	3.053
C	C6	Madrepora	10/2009	7.858	0.0000277	710.707	708.109	0.00224	0.00012	0.00238	0.00253	1.772	2.763
C	C7	Madrepora	10/2009	7.865	0.0000272	697.537	694.987	0.00223	0.00012	0.00238	0.00253	1.798	2.802
C	C8	Madrepora	10/2009	7.890	0.0000260	665.556	663.122	0.00226	0.00013	0.00241	0.00257	1.929	3.007
C	C9	Madrepora	10/2009	7.852	0.0000280	717.008	714.387	0.00223	0.00012	0.00237	0.00251	1.741	2.714
C	C10	Desmophylum	10/2009	7.903	0.0000249	639.213	636.876	0.00223	0.00013	0.00239	0.00256	1.965	3.063
C	C16	Lophelia	10/2009	7.950	0.0000224	573.417	571.320	0.00223	0.00015	0.00240	0.00259	2.183	3.403
C	C17	Desmophylum	10/2009	7.912	0.0000245	628.886	626.586	0.00224	0.00013	0.00240	0.00258	2.017	3.144
C	C18	Madrepora	10/2009	7.953	0.0000222	568.711	566.632	0.00223	0.00015	0.00240	0.00259	2.203	3.433
C	C19	Madrepora	10/2009	7.878	0.0000261	669.245	666.798	0.00221	0.00012	0.00236	0.00251	1.833	2.857
D	D11	blank	10/2009	7.786	0.0000344	881.500	878.277	0.00235	0.00011	0.00249	0.00261	1.581	2.465
D	D12	blank	10/2009	7.743	0.0000383	981.885	978.295	0.00237	0.00010	0.00251	0.00261	1.446	2.255
D	D13	blank	10/2009	7.741	0.0000385	987.706	984.095	0.00237	0.00010	0.00251	0.00261	1.438	2.242
D	D14	blank	10/2009	7.743	0.0000384	983.463	979.868	0.00238	0.00010	0.00251	0.00261	1.448	2.256
D	D15	blank	10/2009	7.751	0.0000375	962.103	958.585	0.00237	0.00010	0.00250	0.00261	1.469	2.290
D	D20	blank	10/2009	7.806	0.0000328	839.331	836.263	0.00234	0.00011	0.00249	0.00261	1.647	2.567
D	D21	blank	10/2009	7.842	0.0000298	764.086	761.293	0.00232	0.00012	0.00247	0.00261	1.770	2.759
D	D7	Madrepora	10/2009	7.714	0.0000399	1,022.725	1,018.986	0.00231	0.00009	0.00244	0.00253	1.315	2.050
D	D1	Lophelia	10/2009	7.750	0.0000373	954.726	951.235	0.00234	0.00010	0.00248	0.00258	1.451	2.262

Treatment	ID	coral spp	Collection date	pH	CO2	pCO2	fCO2	HCO3	CO3	DIC	ALK	ΩAragonite	ΩCalcite
D	D2	Lophelia	10/2009	7.759	0.0000355	908.428	905.106	0.00228	0.00010	0.00241	0.00252	1.441	2.246
D	D3	Lophelia	10/2009	7.770	0.0000349	894.444	891.174	0.00230	0.00010	0.00244	0.00255	1.492	2.326
D	D4	Lophelia	10/2009	7.770	0.0000350	896.472	893.195	0.00231	0.00010	0.00244	0.00255	1.494	2.328
D	D5	Desmophylum	10/2009	7.776	0.0000352	902.375	899.076	0.00235	0.00010	0.00249	0.00261	1.548	2.413
D	D6	Desmophylum	10/2009	7.731	0.0000380	974.411	970.849	0.00229	0.00009	0.00242	0.00251	1.354	2.111
D	D8	Madrepora	10/2009	7.750	0.0000365	936.404	932.980	0.00230	0.00010	0.00243	0.00254	1.425	2.221
D	D9	Madrepora	10/2009	7.763	0.0000360	921.412	918.043	0.00233	0.00010	0.00247	0.00258	1.488	2.319
D	D10	Madrepora	10/2009	7.760	0.0000353	904.830	901.522	0.00227	0.00010	0.00240	0.00251	1.438	2.242
D	D16	Lophelia	10/2009	7.714	0.0000406	1,039.781	1,035.980	0.00235	0.00009	0.00248	0.00257	1.339	2.088
D	D17	(Desmophylum)	10/2009	7.786	0.0000344	882.494	879.268	0.00235	0.00011	0.00249	0.00261	1.582	2.466
D	D18	Madrepora	10/2009	7.744	0.0000361	925.643	922.259	0.00224	0.00009	0.00237	0.00247	1.368	2.132
D	D19	Madrepora	10/2009	7.759	0.0000356	910.999	907.668	0.00228	0.00010	0.00242	0.00252	1.443	2.249
X	/	bulk-water 750ox	10/2009	7.807	0.0000321	821.792	818.787	0.00230	0.00011	0.00244	0.00257	1.620	2.526
X	/	bulk-water 1000ox	10/2009	7.707	0.0000412	1,055.812	1,051.952	0.00235	0.00009	0.00248	0.00256	1.314	2.048
X	/	bulk-water 250ox	10/2009	8.094	0.0000151	385.654	384.244	0.00209	0.00019	0.00230	0.00256	2.859	4.457
X	/	bulk-water 420ox	10/2009	8.016	0.0000186	476.880	475.136	0.00216	0.00016	0.00234	0.00257	2.467	3.845
X	/	250?	10/2009	8.068	0.0000165	424.054	422.504	0.00216	0.00019	0.00237	0.00262	2.782	4.336
X	/	bulk 05.11.2009	11/2009										
X	/	bulk 05.11.2009	11/2009										
X	/	bulk 05.11.2009	11/2009										
X	/	bulk 05.11.2009	11/2009	7.971	0.0000208	533.266	531.317	0.00218	0.00015	0.00235	0.00254	2.237	3.487
X	/	bulk 05.11.2009	11/2009	7.981	0.0000202	518.700	516.803	0.00217	0.00015	0.00234	0.00254	2.282	3.557
X	/	bulk 05.11.2009	11/2009	7.991	0.0000197	505.711	503.862	0.00216	0.00016	0.00234	0.00255	2.328	3.629
X	/	bulk 06.11.2009	11/2009	7.793	0.0000330	844.449	841.362	0.00229	0.00010	0.00243	0.00255	1.564	2.438
X	/	bulk 06.11.2009	11/2009	7.772	0.0000348	892.241	888.979	0.00231	0.00010	0.00244	0.00255	1.503	2.343
X	/	bulk 06.11.2009	11/2009	7.765	0.0000355	909.645	906.320	0.00231	0.00010	0.00245	0.00255	1.479	2.305
X	/	bulk 06.11.2009	11/2009	7.666	0.0000456	1,168.552	1,164.280	0.00236	0.00008	0.00249	0.00256	1.205	1.878
X	/	bulk 06.11.2009	11/2009	7.685	0.0000433	1,109.158	1,105.103	0.00235	0.00008	0.00247	0.00255	1.252	1.951
X	/	bulk 06.11.2009	11/2009	7.644	0.0000478	1,225.766	1,221.285	0.00236	0.00008	0.00248	0.00255	1.144	1.783
A	A11	blank	11/2009	8.170	0.0000125	319.598	318.429	0.00206	0.00022	0.00230	0.00261	3.356	5.232
A	A12	blank	11/2009	8.157	0.0000128	328.379	327.178	0.00206	0.00022	0.00229	0.00259	3.248	5.062
A	A13	blank	11/2009	8.192	0.0000118	302.217	301.112	0.00205	0.00023	0.00230	0.00263	3.510	5.471
A	A14	blank	11/2009	8.182	0.0000121	310.972	309.835	0.00206	0.00023	0.00231	0.00263	3.453	5.382
A	A15	blank	11/2009	8.168	0.0000125	319.172	318.005	0.00205	0.00022	0.00228	0.00259	3.318	5.171

Treatment	ID	coral spp	Collection date	pH	CO2	pCO2	fCO2	HCO3	CO3	DIC	ALK	ΩAragonite	ΩCalcite
A	A20	blank	11/2009	8.156	0.0000130	331.969	330.755	0.00207	0.00022	0.00231	0.00261	3.267	5.093
A	A21	blank	11/2009	8.179	0.0000122	312.744	311.601	0.00206	0.00023	0.00231	0.00263	3.431	5.348
A	A1	Lophelia	11/2009	8.151	0.0000127	325.296	324.107	0.00201	0.00021	0.00223	0.00253	3.128	4.875
A	A2	Lophelia	11/2009	8.128	0.0000133	341.783	340.533	0.00200	0.00020	0.00221	0.00249	2.958	4.611
A	A3	Lophelia	11/2009	8.084	0.0000154	395.843	394.395	0.00210	0.00019	0.00230	0.00256	2.800	4.365
A	A4	Lophelia	11/2009	8.083	0.0000145	371.612	370.253	0.00196	0.00017	0.00215	0.00240	2.610	4.069
A	A5	Desmophylum	11/2009	8.131	0.0000135	345.409	344.146	0.00204	0.00020	0.00225	0.00254	3.028	4.720
A	A6	Desmophylum	11/2009	8.148	0.0000128	328.870	327.668	0.00202	0.00021	0.00224	0.00253	3.122	4.867
A	A7	Madrepora	11/2009	8.094	0.0000146	374.206	372.838	0.00203	0.00019	0.00223	0.00249	2.777	4.329
A	A8	Madrepora	11/2009	8.148	0.0000126	322.091	320.913	0.00198	0.00020	0.00219	0.00248	3.058	4.767
A	A9	Madrepora	11/2009	8.134	0.0000133	340.070	338.827	0.00202	0.00020	0.00224	0.00252	3.030	4.723
A	A10	Lophelia	11/2009	8.131	0.0000135	346.722	345.454	0.00205	0.00020	0.00226	0.00255	3.043	4.743
A	A16	Lophelia	11/2009	8.028	0.0000165	423.716	422.167	0.00197	0.00015	0.00215	0.00236	2.319	3.614
A	A17	Desmophylum	11/2009	8.115	0.0000143	367.155	365.813	0.00209	0.00020	0.00230	0.00258	2.992	4.663
A	A18	Madrepora	11/2009	8.101	0.0000146	373.704	372.338	0.00206	0.00019	0.00227	0.00253	2.864	4.465
A	A19	Madrepora	11/2009	8.079	0.0000154	393.609	392.170	0.00206	0.00018	0.00226	0.00251	2.721	4.242
B	B11	blank	11/2009	8.010	0.0000192	491.556	489.758	0.00220	0.00017	0.00238	0.00260	2.473	3.855
B	B12	blank	11/2009	7.998	0.0000197	505.143	503.296	0.00219	0.00016	0.00238	0.00259	2.403	3.745
B	B13	blank	11/2009	8.034	0.0000179	459.202	457.523	0.00217	0.00017	0.00236	0.00259	2.581	4.023
B	B14	blank	11/2009	8.012	0.0000191	490.396	488.603	0.00220	0.00017	0.00238	0.00261	2.484	3.873
B	B15	blank	11/2009	8.016	0.0000190	486.295	484.517	0.00220	0.00017	0.00239	0.00262	2.517	3.923
B	B17	blank	11/2009	8.007	0.0000193	495.272	493.461	0.00220	0.00016	0.00238	0.00260	2.453	3.824
B	B20	blank	11/2009	8.019	0.0000188	480.477	478.721	0.00219	0.00017	0.00238	0.00261	2.522	3.931
B	B21	blank	11/2009	8.006	0.0000194	496.644	494.828	0.00220	0.00016	0.00238	0.00260	2.455	3.826
B	B1	Lophelia	11/2009	7.977	0.0000203	521.360	519.454	0.00216	0.00015	0.00233	0.00253	2.248	3.504
B	B2	Lophelia	11/2009	7.961	0.0000204	522.756	520.845	0.00209	0.00014	0.00225	0.00244	2.100	3.274
B	B3	Lophelia	11/2009	7.947	0.0000220	562.701	560.644	0.00218	0.00014	0.00234	0.00253	2.121	3.306
B	B4	Lophelia	11/2009	7.970	0.0000208	533.998	532.046	0.00218	0.00015	0.00235	0.00255	2.238	3.488
B	B5	Desmophylum	11/2009	7.979	0.0000205	525.536	523.614	0.00219	0.00015	0.00236	0.00256	2.290	3.570
B	B6	Madrepora	11/2009	7.989	0.0000197	505.111	503.264	0.00215	0.00015	0.00232	0.00253	2.303	3.589
B	B7	Madrepora	11/2009	7.950	0.0000214	548.705	546.699	0.00213	0.00014	0.00230	0.00248	2.093	3.262
B	B8	Madrepora	11/2009	8.017	0.0000183	468.031	466.319	0.00212	0.00016	0.00231	0.00253	2.430	3.787
B	B9	Madrepora	11/2009	7.986	0.0000192	491.294	489.498	0.00208	0.00015	0.00224	0.00244	2.211	3.446
B	B10	Madrepora	11/2009	7.996	0.0000195	499.813	497.985	0.00216	0.00016	0.00234	0.00255	2.359	3.676
B	B16	Lophelia	11/2009	7.972	0.0000207	529.977	528.039	0.00217	0.00015	0.00234	0.00254	2.233	3.481
B	B18	Madrepora	11/2009	8.000	0.0000196	503.210	501.371	0.00220	0.00016	0.00238	0.00259	2.413	3.761
B	B19	Madrepora	11/2009	7.989	0.0000201	515.369	513.485	0.00219	0.00016	0.00237	0.00258	2.353	3.668

Treatment	ID	coral spp	Collection date	pH	CO2	pCO2	fCO2	HCO3	CO3	DIC	ALK	ΩAragonite	ΩCalcite
C	C11	blank	11/2009	7.861	0.0000282	723.781	721.134	0.00230	0.00012	0.00245	0.00260	1.834	2.859
C	C12	blank	11/2009	7.897	0.0000258	659.969	657.556	0.00227	0.00013	0.00243	0.00260	1.973	3.076
C	C13	blank	11/2009	7.877	0.0000272	696.419	693.873	0.00229	0.00013	0.00244	0.00260	1.896	2.955
C	C14	blank	11/2009	7.872	0.0000275	705.017	702.439	0.00229	0.00013	0.00245	0.00260	1.879	2.929
C	C15	blank	11/2009	7.872	0.0000275	705.017	702.439	0.00229	0.00013	0.00245	0.00260	1.879	2.929
C	C20	blank	11/2009	7.928	0.0000240	614.830	612.582	0.00227	0.00014	0.00244	0.00262	2.115	3.297
C	C21	blank	11/2009	7.903	0.0000255	653.333	650.945	0.00228	0.00013	0.00244	0.00261	2.004	3.124
C	C1	Lophelia	11/2009	7.821	0.0000283	726.425	723.769	0.00210	0.00010	0.00223	0.00235	1.528	2.381
C	C2	Lophelia	11/2009	7.856	0.0000277	711.003	708.403	0.00223	0.00012	0.00237	0.00252	1.760	2.744
C	C3	Lophelia	11/2009	7.826	0.0000279	715.539	712.923	0.00209	0.00010	0.00222	0.00235	1.543	2.405
C	C4	Lophelia	11/2009	7.856	0.0000287	734.179	731.494	0.00230	0.00012	0.00245	0.00260	1.819	2.835
C	C5	Desmophylum	11/2009	7.859	0.0000284	728.959	726.294	0.00230	0.00012	0.00245	0.00260	1.826	2.847
C	C6	Madrepora	11/2009	7.861	0.0000273	700.674	698.112	0.00222	0.00012	0.00237	0.00252	1.776	2.768
C	C7	Madrepora	11/2009	7.844	0.0000286	733.930	731.246	0.00224	0.00011	0.00238	0.00252	1.719	2.679
C	C8	Madrepora	11/2009	7.868	0.0000271	695.342	692.799	0.00224	0.00012	0.00239	0.00254	1.820	2.837
C	C9	Madrepora	11/2009	7.694	0.0000412	1,056.879	1,053.015	0.00228	0.00008	0.00241	0.00249	1.240	1.933
C	C10	Desmophylum	11/2009	7.876	0.0000268	686.786	684.275	0.00225	0.00012	0.00240	0.00256	1.862	2.903
C	C16	Lophelia	11/2009	7.886	0.0000260	666.174	663.738	0.00224	0.00013	0.00239	0.00255	1.892	2.949
C	C17	Desmophylum	11/2009	7.879	0.0000268	685.634	683.127	0.00227	0.00013	0.00242	0.00258	1.886	2.940
C	C18	Madrepora	11/2009	7.912	0.0000249	637.116	634.787	0.00227	0.00014	0.00243	0.00260	2.038	3.177
C	C19	Madrepora	11/2009	7.860	0.0000273	700.494	697.933	0.00221	0.00012	0.00236	0.00251	1.763	2.748
D	D11	blank	11/2009	7.765	0.0000359	920.630	917.264	0.00234	0.00010	0.00248	0.00259	1.500	2.338
D	D12	blank	11/2009	7.762	0.0000363	929.102	925.705	0.00235	0.00010	0.00248	0.00259	1.494	2.329
D	D13	blank	11/2009	7.760	0.0000365	936.096	932.674	0.00235	0.00010	0.00249	0.00259	1.487	2.317
D	D14	blank	11/2009	7.729	0.0000393	1,006.306	1,002.627	0.00236	0.00009	0.00249	0.00258	1.390	2.166
D	D15	blank	11/2009	7.759	0.0000368	942.279	938.834	0.00236	0.00010	0.00250	0.00261	1.491	2.325
D	D20	blank	11/2009	7.753	0.0000377	964.794	961.267	0.00238	0.00010	0.00252	0.00263	1.483	2.312
D	D21	blank	11/2009	7.798	0.0000333	854.031	850.909	0.00234	0.00011	0.00249	0.00261	1.622	2.528
D	D7	Madrepora	11/2009	7.690	0.0000411	1,052.594	1,048.745	0.00225	0.00008	0.00237	0.00245	1.213	1.891
D	D1	Lophelia	11/2009	7.750	0.0000365	935.884	932.462	0.00230	0.00010	0.00243	0.00254	1.425	2.221
D	D2	Lophelia	11/2009	7.708	0.0000378	968.913	965.371	0.00216	0.00008	0.00228	0.00237	1.216	1.895
D	D3	Lophelia	11/2009	7.714	0.0000381	975.014	971.449	0.00220	0.00008	0.00233	0.00241	1.257	1.959
D	D4	Lophelia	11/2009	7.710	0.0000405	1,036.744	1,032.954	0.00232	0.00009	0.00245	0.00254	1.313	2.046
D	D5	Desmophylum	11/2009	7.641	0.0000484	1,239.571	1,235.039	0.00237	0.00008	0.00249	0.00256	1.140	1.777
D	D6	Desmophylum	11/2009	7.727	0.0000379	971.493	967.941	0.00226	0.00009	0.00239	0.00248	1.328	2.069
D	D8	Madrepora	11/2009	7.777	0.0000340	870.440	867.258	0.00227	0.00010	0.00241	0.00252	1.498	2.335
D	D9	Madrepora	11/2009	7.768	0.0000356	911.207	907.876	0.00233	0.00010	0.00247	0.00258	1.505	2.346

Treatment	ID	coral spp	Collection date	pH	CO2	pCO2	fCO2	HCO3	CO3	DIC	ALK	ΩAragonite	ΩCalcite
D	D10	Madrepora	11/2009	7.583	0.0000535	1,371.687	1,366.672	0.00229	0.00006	0.00241	0.00245	0.965	1.504
D	D16	Lophelia	11/2009	7.708	0.0000396	1,014.049	1,010.342	0.00226	0.00008	0.00239	0.00247	1.272	1.983
D	D17	Desmophylum	11/2009	7.755	0.0000370	947.661	944.196	0.00235	0.00010	0.00249	0.00259	1.471	2.292
D	D18	Madrepora	11/2009	7.693	0.0000407	1,044.151	1,040.333	0.00225	0.00008	0.00237	0.00245	1.219	1.901
D	D19	Madrepora	11/2009	7.673	0.0000426	1,092.229	1,088.236	0.00225	0.00008	0.00237	0.00244	1.166	1.818
X	/	bulk 03.12.2009	11/2009	8.141	0.0000132	337.407	336.173	0.00204	0.00021	0.00226	0.00255	3.101	4.833
X	/	bulk 03.12.2009	11/2009	8.141	0.0000132	337.930	336.695	0.00204	0.00021	0.00226	0.00255	3.102	4.835
X	/	bulk 03.12.2009	11/2009	8.129	0.0000136	348.353	347.079	0.00205	0.00020	0.00226	0.00255	3.033	4.728
X	/	bulk 03.12.2009	11/2009	8.012	0.0000187	478.922	477.171	0.00215	0.00016	0.00233	0.00255	2.432	3.791
X	/	bulk 03.12.2009	11/2009	8.012	0.0000187	479.260	477.508	0.00215	0.00016	0.00233	0.00255	2.432	3.791
X	/	bulk 03.12.2009	11/2009	8.005	0.0000190	487.330	485.548	0.00215	0.00016	0.00233	0.00255	2.393	3.730
X	/	bulk 04.12.2009	12/2009	7.824	0.0000304	778.147	775.302	0.00226	0.00011	0.00240	0.00254	1.658	2.585
X	/	bulk 04.12.2009	12/2009	7.804	0.0000319	818.558	815.566	0.00227	0.00011	0.00241	0.00254	1.593	2.483
X	/	bulk 04.12.2009	12/2009	7.814	0.0000311	796.829	793.916	0.00227	0.00011	0.00241	0.00253	1.624	2.532
X	/	bulk 04.12.2009	12/2009	7.684	0.0000431	1,104.329	1,100.291	0.00233	0.00008	0.00245	0.00253	1.236	1.927
X	/	bulk 04.12.2009	12/2009	7.699	0.0000416	1,066.744	1,062.844	0.00233	0.00009	0.00246	0.00254	1.284	2.002
X	/	bulk 04.12.2009	12/2009	7.702	0.0000412	1,056.808	1,052.944	0.00233	0.00009	0.00245	0.00254	1.290	2.010
A	A13	blank	12/2009	8.149	0.0000131	335.408	334.182	0.00206	0.00021	0.00229	0.00259	3.198	4.985
A	A14	blank	12/2009	8.144	0.0000133	340.038	338.795	0.00207	0.00021	0.00229	0.00259	3.169	4.940
A	A15	blank	12/2009	8.154	0.0000130	332.930	331.713	0.00207	0.00022	0.00230	0.00260	3.244	5.057
A	A20	blank	12/2009	8.139	0.0000136	347.379	346.109	0.00209	0.00021	0.00231	0.00260	3.158	4.922
A	A21	blank	12/2009	8.139	0.0000135	346.852	345.583	0.00208	0.00021	0.00231	0.00260	3.157	4.921
A	A1	Lophelia	12/2009	8.125	0.0000135	345.577	344.314	0.00201	0.00020	0.00222	0.00250	2.953	4.602
A	A2	Lophelia	12/2009	8.129	0.0000133	340.688	339.443	0.00200	0.00020	0.00222	0.00249	2.969	4.627
A	A3	Lophelia	12/2009	8.132	0.0000135	345.368	344.105	0.00205	0.00020	0.00226	0.00255	3.053	4.759
A	A4	Lophelia	12/2009	8.096	0.0000138	353.960	352.666	0.00193	0.00018	0.00212	0.00237	2.643	4.119
A	A5	Desmophylum	12/2009	8.127	0.0000136	348.949	347.673	0.00204	0.00020	0.00226	0.00254	3.009	4.691
A	A6	Desmophylum	12/2009	8.128	0.0000134	342.561	341.309	0.00201	0.00020	0.00222	0.00250	2.972	4.633
A	A7	Madrepora	12/2009	8.122	0.0000136	347.274	346.004	0.00201	0.00020	0.00222	0.00249	2.931	4.568
A	A8	Madrepora	12/2009	8.105	0.0000138	352.853	351.563	0.00196	0.00018	0.00216	0.00242	2.753	4.291
A	A9	Madrepora	12/2009	8.118	0.0000136	349.363	348.086	0.00200	0.00019	0.00221	0.00248	2.884	4.496
A	A10	Lophelia	12/2009	8.125	0.0000137	351.411	350.126	0.00205	0.00020	0.00226	0.00254	3.001	4.678
A	A11	Madrepora	12/2009	8.060	0.0000159	407.451	405.961	0.00204	0.00017	0.00223	0.00247	2.581	4.022
A	A12	Madrepora	12/2009	8.217	0.0000108	277.748	276.732	0.00200	0.00024	0.00225	0.00260	3.631	5.660
A	A16	Lophelia	12/2009										
A	A17	Desmophylum	12/2009										
A	A18	Madrepora	12/2009										

Treatment	ID	coral spp	Collection date	pH	CO2	pCO2	fCO2	HCO3	CO3	DIC	ALK	ΩAragonite	ΩCalcite
A	A19	Madrepora	12/2009										
B	B13	blank	12/2009	7.656	0.0000478	1,225.197	1,220.718	0.00242	0.00008	0.00255	0.00262	1.205	1.879
B	B14	blank	12/2009	7.614	0.0000532	1,363.311	1,358.327	0.00245	0.00007	0.00258	0.00263	1.107	1.726
B	B15	blank	12/2009	8.011	0.0000189	484.894	483.121	0.00217	0.00016	0.00236	0.00258	2.452	3.822
B	B17	blank	12/2009										
B	B20	blank	12/2009	8.098	0.0000151	385.728	384.318	0.00211	0.00019	0.00232	0.00259	2.910	4.536
B	B21	blank	12/2009										
B	B1	Lophelia	12/2009	7.833	0.0000287	734.302	731.617	0.00218	0.00011	0.00232	0.00245	1.633	2.545
B	B2	Lophelia	12/2009	8.060	0.0000161	413.117	411.606	0.00207	0.00017	0.00226	0.00250	2.614	4.075
B	B3	Lophelia	12/2009	8.002	0.0000190	485.755	483.979	0.00213	0.00016	0.00231	0.00252	2.353	3.668
B	B4	Lophelia	12/2009	8.014	0.0000185	474.528	472.793	0.00214	0.00016	0.00232	0.00254	2.426	3.781
B	B5	Desmophylum	12/2009	7.812	0.0000308	788.224	785.342	0.00223	0.00011	0.00237	0.00250	1.592	2.482
B	B6	Madrepora	12/2009	7.924	0.0000228	585.232	583.092	0.00215	0.00013	0.00230	0.00248	1.984	3.093
B	B7	Madrepora	12/2009	8.000	0.0000188	482.124	480.361	0.00210	0.00015	0.00228	0.00249	2.311	3.602
B	B8	Madrepora	12/2009	7.734	0.0000354	906.041	902.729	0.00215	0.00009	0.00227	0.00236	1.280	1.995
B	B9	Madrepora	12/2009	8.109	0.0000142	363.306	361.978	0.00204	0.00019	0.00225	0.00252	2.884	4.495
B	B10	Madrepora	12/2009	8.011	0.0000186	475.788	474.049	0.00213	0.00016	0.00231	0.00253	2.403	3.745
B	B11	Madrepora	12/2009	8.127	0.0000139	356.356	355.054	0.00208	0.00021	0.00230	0.00259	3.073	4.791
B	B12	Madrepora	12/2009	7.923	0.0000234	600.292	598.097	0.00220	0.00014	0.00236	0.00253	2.025	3.156
B	B16	Lophelia	12/2009	8.063	0.0000164	420.265	418.729	0.00212	0.00018	0.00232	0.00257	2.700	4.209
B	B18	Madrepora	12/2009	7.992	0.0000197	505.488	503.640	0.00217	0.00016	0.00234	0.00255	2.341	3.649
B	B19	Madrepora	12/2009	7.822	0.0000296	757.876	755.105	0.00220	0.00011	0.00233	0.00246	1.604	2.500
C	C13	blank	12/2009	7.855	0.0000286	734.058	731.375	0.00229	0.00012	0.00244	0.00259	1.806	2.815
C	C14	blank	12/2009	7.868	0.0000277	709.363	706.770	0.00229	0.00012	0.00244	0.00259	1.858	2.897
C	C15	blank	12/2009	7.842	0.0000295	756.301	753.536	0.00229	0.00012	0.00244	0.00258	1.751	2.729
C	C20	blank	12/2009	7.871	0.0000274	701.724	699.159	0.00228	0.00012	0.00243	0.00258	1.864	2.905
C	C21	blank	12/2009	7.883	0.0000266	681.099	678.609	0.00227	0.00013	0.00242	0.00258	1.906	2.972
C	C1	Lophelia	12/2009	7.794	0.0000286	733.017	730.337	0.00199	0.00009	0.00211	0.00222	1.363	2.125
C	C2	Lophelia	12/2009	7.828	0.0000297	761.201	758.418	0.00224	0.00011	0.00238	0.00251	1.656	2.581
C	C3	Lophelia	12/2009	7.788	0.0000299	767.185	764.380	0.00206	0.00009	0.00218	0.00229	1.391	2.169
C	C4	Lophelia	12/2009	7.865	0.0000277	709.384	706.791	0.00227	0.00012	0.00242	0.00257	1.833	2.858
C	C5	Desmophylum	12/2009	7.852	0.0000286	732.496	729.818	0.00227	0.00012	0.00242	0.00257	1.780	2.774
C	C6	Madrepora	12/2009	7.830	0.0000290	743.137	740.420	0.00219	0.00011	0.00233	0.00246	1.628	2.538
C	C7	Madrepora	12/2009	7.841	0.0000289	739.815	737.110	0.00224	0.00011	0.00239	0.00252	1.712	2.668
C	C8	Madrepora	12/2009	7.837	0.0000289	739.323	736.620	0.00222	0.00011	0.00236	0.00249	1.674	2.610
C	C9	Madrepora	12/2009	7.805	0.0000308	789.731	786.844	0.00220	0.00010	0.00233	0.00246	1.544	2.407
C	C10	Desmophylum	12/2009	7.835	0.0000292	748.527	745.790	0.00224	0.00011	0.00238	0.00251	1.682	2.622

Treatment	ID	coral spp	Collection date	pH	CO2	pCO2	fCO2	HCO3	CO3	DIC	ALK	ΩAragonite	ΩCalcite
C	C11	Madrepora	12/2009	7.844	0.0000291	744.437	741.715	0.00227	0.00012	0.00241	0.00255	1.741	2.713
C	C12	Madrepora	12/2009	7.847	0.0000290	742.264	739.550	0.00228	0.00012	0.00243	0.00257	1.764	2.749
C	C16	Lophelia	12/2009	7.881	0.0000261	668.583	666.139	0.00222	0.00012	0.00237	0.00253	1.857	2.895
C	C17	Desmophylum	12/2009	7.859	0.0000280	717.245	714.622	0.00227	0.00012	0.00241	0.00256	1.803	2.811
C	C18	Madrepora	12/2009	7.881	0.0000266	680.355	677.868	0.00226	0.00013	0.00241	0.00257	1.893	2.951
C	C19	Madrepora	12/2009	7.838	0.0000285	731.065	728.393	0.00220	0.00011	0.00234	0.00248	1.667	2.598
D	D13	blank	12/2009	7.732	0.0000388	994.941	991.303	0.00235	0.00009	0.00248	0.00258	1.394	2.173
D	D14	blank	12/2009	7.768	0.0000355	909.681	906.355	0.00233	0.00010	0.00247	0.00258	1.504	2.344
D	D15	blank	12/2009	7.740	0.0000380	974.550	970.987	0.00234	0.00009	0.00247	0.00257	1.416	2.208
D	D20	blank	12/2009	7.749	0.0000375	961.506	957.991	0.00236	0.00010	0.00249	0.00260	1.456	2.270
D	D21	blank	12/2009	7.789	0.0000341	872.551	869.361	0.00234	0.00011	0.00248	0.00260	1.587	2.473
D	D1	Lophelia	12/2009	7.677	0.0000408	1,044.659	1,040.839	0.00217	0.00008	0.00229	0.00236	1.134	1.768
D	D2	Lophelia	12/2009	7.713	0.0000403	1,032.529	1,028.754	0.00233	0.00009	0.00246	0.00255	1.322	2.061
D	D3	Lophelia	12/2009	7.713	0.0000369	945.747	942.290	0.00213	0.00008	0.00225	0.00234	1.211	1.888
D	D4	Lophelia	12/2009	7.704	0.0000378	969.666	966.121	0.00214	0.00008	0.00226	0.00234	1.192	1.858
D	D5	Desmophylum	12/2009	7.754	0.0000358	918.372	915.014	0.00228	0.00010	0.00241	0.00251	1.424	2.219
D	D6	Desmophylum	12/2009	7.803	0.0000327	836.623	833.564	0.00232	0.00011	0.00246	0.00259	1.620	2.525
D	D7	Madrepora	12/2009	7.750	0.0000360	921.727	918.357	0.00226	0.00009	0.00239	0.00250	1.402	2.185
D	D8	Madrepora	12/2009	7.767	0.0000350	895.871	892.596	0.00228	0.00010	0.00242	0.00253	1.469	2.289
D	D9	Madrepora	12/2009	7.761	0.0000356	912.240	908.905	0.00230	0.00010	0.00243	0.00254	1.456	2.270
D	D10	Madrepora	12/2009	7.853	0.0000284	728.004	725.342	0.00226	0.00012	0.00241	0.00256	1.776	2.768
D	D11	Madrepora	12/2009	7.699	0.0000362	927.351	923.961	0.00202	0.00007	0.00214	0.00221	1.114	1.736
D	D12	Madrepora	12/2009	7.769	0.0000326	835.512	832.458	0.00214	0.00009	0.00227	0.00237	1.385	2.159
D	D16	Lophelia	12/2009	7.787	0.0000336	861.180	858.032	0.00230	0.00010	0.00244	0.00256	1.553	2.420
D	D17	Desmophylum	12/2009	7.795	0.0000330	846.470	843.375	0.00230	0.00011	0.00244	0.00256	1.578	2.460
D	D18	Madrepora	12/2009	7.753	0.0000352	902.006	898.708	0.00223	0.00009	0.00236	0.00246	1.387	2.162
D	D19	Madrepora	12/2009	7.759	0.0000350	896.903	893.623	0.00225	0.00009	0.00238	0.00248	1.420	2.213
X	/	bulk 04.01.2010	01/2010	8.135	0.0000134	342.695	341.442	0.00204	0.00020	0.00226	0.00254	3.060	4.771
X	/	bulk 04.01.2010	01/2010	8.169	0.0000122	313.360	312.214	0.00202	0.00022	0.00225	0.00256	3.280	5.113
X	/	bulk 04.01.2010	01/2010	8.158	0.0000126	322.482	321.303	0.00203	0.00021	0.00225	0.00256	3.210	5.004
X	/	bulk 04.01.2010	01/2010	8.016	0.0000185	473.629	471.897	0.00215	0.00016	0.00233	0.00255	2.450	3.819
X	/	bulk 04.01.2010	01/2010	8.027	0.0000180	460.489	458.805	0.00214	0.00017	0.00233	0.00255	2.507	3.908
X	/	bulk 04.01.2010	01/2010	8.045	0.0000172	440.814	439.202	0.00213	0.00017	0.00233	0.00256	2.605	4.061
X	/	bulk 05.01.2010	01/2010	7.869	0.0000273	700.383	697.822	0.00226	0.00012	0.00241	0.00256	1.837	2.864
X	/	bulk 05.01.2010	01/2010	7.875	0.0000269	688.517	685.999	0.00226	0.00012	0.00241	0.00256	1.864	2.905
X	/	bulk 05.01.2010	01/2010	7.838	0.0000296	759.514	756.738	0.00228	0.00012	0.00243	0.00257	1.729	2.695
X	/	bulk 05.01.2010	01/2010	7.699	0.0000418	1,070.065	1,066.153	0.00234	0.00009	0.00247	0.00255	1.286	2.005

Treatment	ID	coral spp	Collection date	pH	CO2	pCO2	fCO2	HCO3	CO3	DIC	ALK	ΩAragonite	ΩCalcite
X	/	bulk 05.01.2010	01/2010	7.739	0.0000379	971.419	967.868	0.00232	0.00009	0.00246	0.00256	1.402	2.185
X	/	bulk 05.01.2010	01/2010	7.710	0.0000408	1,045.494	1,041.672	0.00234	0.00009	0.00247	0.00256	1.319	2.056
A	A13	blank	01/2010	8.092	0.0000155	397.677	396.223	0.00215	0.00019	0.00236	0.00262	2.917	4.547
A	A14	blank	01/2010	8.100	0.0000152	390.111	388.685	0.00214	0.00020	0.00236	0.00263	2.968	4.626
A	A15	blank	01/2010	8.104	0.0000148	379.599	378.211	0.00211	0.00020	0.00232	0.00259	2.950	4.598
A	A20	blank	01/2010	8.089	0.0000155	395.938	394.490	0.00212	0.00019	0.00233	0.00259	2.864	4.464
A	A21	blank	01/2010	8.086	0.0000156	400.188	398.725	0.00213	0.00019	0.00234	0.00260	2.858	4.455
A	A1	Lophelia	01/2010	8.069	0.0000156	400.931	399.465	0.00205	0.00018	0.00224	0.00249	2.645	4.124
A	A2	Lophelia	01/2010	8.073	0.0000155	397.621	396.168	0.00206	0.00018	0.00225	0.00250	2.678	4.174
A	A3	Lophelia	01/2010	8.085	0.0000153	391.013	389.583	0.00208	0.00019	0.00228	0.00254	2.780	4.333
A	A4	Lophelia	01/2010	8.060	0.0000161	412.194	410.687	0.00207	0.00017	0.00226	0.00250	2.613	4.073
A	A5	Desmophylum	01/2010	8.073	0.0000159	406.330	404.845	0.00210	0.00018	0.00230	0.00255	2.729	4.254
A	A6	Desmophylum	01/2010	8.082	0.0000154	393.688	392.248	0.00208	0.00018	0.00228	0.00253	2.759	4.301
A	A7	Madrepora	01/2010	8.068	0.0000158	403.653	402.177	0.00206	0.00018	0.00225	0.00250	2.650	4.130
A	A8	Madrepora	01/2010	8.053	0.0000162	414.961	413.444	0.00205	0.00017	0.00223	0.00247	2.542	3.962
A	A9	Madrepora	01/2010	8.069	0.0000160	410.366	408.866	0.00210	0.00018	0.00230	0.00255	2.710	4.225
A	A10	Lophelia	01/2010	8.068	0.0000161	412.184	410.677	0.00211	0.00018	0.00230	0.00255	2.713	4.229
A	A11	Madrepora	01/2010	8.054	0.0000168	430.837	429.262	0.00213	0.00018	0.00232	0.00257	2.653	4.136
A	A12	Madrepora	01/2010	8.094	0.0000151	387.096	385.680	0.00210	0.00019	0.00230	0.00257	2.862	4.461
A	A16	Lophelia	01/2010	8.045	0.0000170	435.402	433.810	0.00211	0.00017	0.00230	0.00253	2.572	4.009
A	A17	Desmophylum	01/2010	8.087	0.0000154	395.659	394.213	0.00211	0.00019	0.00232	0.00258	2.838	4.424
A	A18	Madrepora	01/2010	8.060	0.0000166	425.433	423.878	0.00213	0.00018	0.00233	0.00258	2.696	4.202
A	A19	Madrepora	01/2010	8.075	0.0000156	400.038	398.576	0.00208	0.00018	0.00228	0.00253	2.719	4.239
B	B13	blank	01/2010	8.046	0.0000176	450.362	448.716	0.00218	0.00018	0.00238	0.00262	2.669	4.160
B	B14	blank	01/2010	8.065	0.0000169	433.293	431.709	0.00220	0.00019	0.00240	0.00266	2.808	4.377
B	B15	blank	01/2010	8.028	0.0000188	481.094	479.335	0.00224	0.00018	0.00243	0.00267	2.623	4.089
B	B17	blank	01/2010	8.024	0.0000184	470.725	469.004	0.00217	0.00017	0.00236	0.00258	2.521	3.930
B	B20	blank	01/2010	8.029	0.0000181	464.577	462.878	0.00217	0.00017	0.00236	0.00259	2.550	3.976
B	B21	blank	01/2010	8.035	0.0000179	458.839	457.162	0.00217	0.00017	0.00236	0.00260	2.593	4.042
B	B1	Lophelia	01/2010	8.037	0.0000176	451.750	450.098	0.00215	0.00017	0.00234	0.00257	2.570	4.007
B	B2	Lophelia	01/2010	8.013	0.0000185	473.972	472.239	0.00213	0.00016	0.00231	0.00253	2.413	3.761
B	B3	Lophelia	01/2010	8.030	0.0000175	448.751	447.110	0.00210	0.00017	0.00228	0.00251	2.478	3.863
B	B4	Lophelia	01/2010	8.077	0.0000162	414.638	413.122	0.00216	0.00019	0.00237	0.00263	2.843	4.431
B	B5	Desmophylum	01/2010	8.048	0.0000173	444.016	442.393	0.00216	0.00018	0.00236	0.00260	2.660	4.146
B	B6	Madrepora	01/2010	8.070	0.0000162	414.564	413.048	0.00213	0.00018	0.00233	0.00258	2.755	4.294
B	B7	Madrepora	01/2010	8.007	0.0000186	475.850	474.110	0.00211	0.00016	0.00229	0.00250	2.365	3.687
B	B8	Madrepora	01/2010	8.049	0.0000169	432.287	430.707	0.00211	0.00017	0.00231	0.00254	2.605	4.061

Treatment	ID	coral spp	Collection date	pH	CO2	pCO2	fCO2	HCO3	CO3	DIC	ALK	ΩAragonite	ΩCalcite
B	B9	Madrepora	01/2010	8.040	0.0000173	443.061	441.441	0.00212	0.00017	0.00231	0.00254	2.558	3.987
B	B10	Madrepora	01/2010	8.030	0.0000179	458.407	456.731	0.00215	0.00017	0.00233	0.00256	2.529	3.943
B	B11	Madrepora	01/2010	8.051	0.0000172	440.894	439.282	0.00217	0.00018	0.00236	0.00261	2.681	4.178
B	B12	Madrepora	01/2010	8.038	0.0000180	462.268	460.578	0.00220	0.00018	0.00240	0.00264	2.648	4.128
B	B16	Lophelia	01/2010	8.001	0.0000192	491.106	489.310	0.00215	0.00016	0.00233	0.00254	2.373	3.698
B	B18	Madrepora	01/2010	8.032	0.0000179	457.985	456.310	0.00215	0.00017	0.00234	0.00257	2.554	3.981
B	B19	Madrepora	01/2010	8.004	0.0000192	491.978	490.179	0.00217	0.00016	0.00235	0.00257	2.411	3.758
C	C13	blank	01/2010	7.855	0.0000286	733.163	730.482	0.00229	0.00012	0.00244	0.00259	1.805	2.814
C	C14	blank	01/2010	7.862	0.0000281	719.350	716.720	0.00229	0.00012	0.00244	0.00259	1.830	2.853
C	C15	blank	01/2010	7.836	0.0000300	767.801	764.994	0.00230	0.00012	0.00245	0.00259	1.736	2.706
C	C20	blank	01/2010	7.936	0.0000233	596.927	594.745	0.00225	0.00014	0.00241	0.00260	2.134	3.326
C	C21	blank	01/2010	7.950	0.0000225	575.618	573.513	0.00224	0.00015	0.00241	0.00260	2.198	3.426
C	C1	Lophelia	01/2010	7.815	0.0000312	798.514	795.595	0.00228	0.00011	0.00242	0.00255	1.638	2.553
C	C2	Lophelia	01/2010	7.855	0.0000281	719.042	716.413	0.00225	0.00012	0.00239	0.00254	1.768	2.755
C	C3	Lophelia	01/2010	7.856	0.0000281	720.961	718.325	0.00226	0.00012	0.00241	0.00255	1.782	2.777
C	C4	Lophelia	01/2010	7.866	0.0000274	701.263	698.699	0.00225	0.00012	0.00240	0.00255	1.813	2.827
C	C5	Desmophylum	01/2010	7.863	0.0000277	708.557	705.967	0.00225	0.00012	0.00240	0.00255	1.808	2.818
C	C6	Madrepora	01/2010	7.871	0.0000264	675.465	672.996	0.00219	0.00012	0.00234	0.00249	1.789	2.789
C	C7	Madrepora	01/2010	7.863	0.0000269	689.202	686.682	0.00220	0.00012	0.00234	0.00249	1.765	2.751
C	C8	Madrepora	01/2010	7.845	0.0000287	736.252	733.561	0.00225	0.00012	0.00240	0.00254	1.733	2.702
C	C9	Madrepora	01/2010	7.867	0.0000273	700.160	697.600	0.00225	0.00012	0.00240	0.00255	1.825	2.844
C	C10	Desmophylum	01/2010	7.863	0.0000275	705.467	702.887	0.00225	0.00012	0.00240	0.00255	1.805	2.813
C	C11	Madrepora	01/2010	7.897	0.0000255	653.712	651.322	0.00225	0.00013	0.00241	0.00257	1.955	3.047
C	C12	Madrepora	01/2010	7.891	0.0000260	666.772	664.334	0.00227	0.00013	0.00242	0.00259	1.943	3.028
C	C16	Lophelia	01/2010	7.892	0.0000259	663.401	660.975	0.00226	0.00013	0.00242	0.00258	1.939	3.023
C	C17	Desmophylum	01/2010	7.878	0.0000267	684.049	681.548	0.00225	0.00013	0.00241	0.00256	1.872	2.918
C	C18	Madrepora	01/2010	7.941	0.0000229	586.908	584.762	0.00224	0.00014	0.00240	0.00259	2.148	3.348
C	C19	Madrepora	01/2010	7.916	0.0000237	607.314	605.094	0.00219	0.00013	0.00234	0.00251	1.982	3.090
D	D13	blank	01/2010	7.766	0.0000364	931.611	928.205	0.00237	0.00010	0.00251	0.00262	1.521	2.370
D	D14	blank	01/2010	7.757	0.0000368	942.629	939.183	0.00235	0.00010	0.00249	0.00260	1.479	2.306
X				7.608	0.0000519	1,330.064	1,325.201	0.00235	0.00007	0.00248	0.00253	1.050	1.636
X				7.675	0.0000442	1,132.953	1,128.811	0.00234	0.00008	0.00247	0.00254	1.218	1.899
X				8.125	0.0000137	350.600	349.318	0.00204	0.00020	0.00226	0.00254	3.000	4.676
X				8.037	0.0000178	454.953	453.290	0.00216	0.00017	0.00235	0.00259	2.587	4.033
D	D15	blank	01/2010	7.758	0.0000369	946.405	942.945	0.00237	0.00010	0.00251	0.00261	1.495	2.330
D	D20	blank	01/2010	7.774	0.0000356	911.114	907.783	0.00236	0.00010	0.00250	0.00261	1.542	2.404
D	D21	blank	01/2010	7.790	0.0000341	875.021	871.822	0.00236	0.00011	0.00250	0.00262	1.601	2.496

Treatment	ID	coral spp	Collection date	pH	CO2	pCO2	fCO2	HCO3	CO3	DIC	ALK	ΩAragonite	ΩCalcite
D	D1	Lophelia	01/2010	7.504	0.0000620	1,588.830	1,583.021	0.00221	0.00005	0.00233	0.00234	0.776	1.210
D	D2	Lophelia	01/2010	7.721	0.0000393	1,007.711	1,004.027	0.00232	0.00009	0.00245	0.00254	1.341	2.091
D	D3	Lophelia	01/2010	7.718	0.0000382	978.789	975.210	0.00223	0.00009	0.00236	0.00245	1.284	2.001
D	D4	Lophelia	01/2010	7.728	0.0000376	962.401	958.882	0.00225	0.00009	0.00237	0.00247	1.321	2.059
D	D5	Desmophylum	01/2010	7.763	0.0000356	911.956	908.622	0.00231	0.00010	0.00244	0.00255	1.468	2.289
D	D6	Desmophylum	01/2010	7.735	0.0000386	990.036	986.416	0.00235	0.00009	0.00248	0.00258	1.403	2.187
D	D7	Madrepora	01/2010	7.759	0.0000356	910.999	907.668	0.00228	0.00010	0.00242	0.00252	1.443	2.249
D	D8	Madrepora	01/2010	7.719	0.0000395	1,011.768	1,008.069	0.00231	0.00009	0.00244	0.00253	1.332	2.076
D	D9	Madrepora	01/2010	7.712	0.0000397	1,017.097	1,013.379	0.00229	0.00009	0.00242	0.00250	1.299	2.024
D	D10	Madrepora	01/2010	7.692	0.0000412	1,056.957	1,053.093	0.00227	0.00008	0.00239	0.00247	1.228	1.914
D	D11	Madrepora	01/2010	7.692	0.0000402	1,029.743	1,025.978	0.00221	0.00008	0.00233	0.00241	1.197	1.866
D	D12	Madrepora	01/2010	7.719	0.0000387	990.957	987.334	0.00227	0.00009	0.00239	0.00248	1.305	2.034
D	D16	Lophelia	01/2010	7.725	0.0000387	991.867	988.240	0.00230	0.00009	0.00243	0.00252	1.342	2.092
D	D17	Desmophylum	01/2010	7.731	0.0000387	990.812	987.189	0.00233	0.00009	0.00246	0.00256	1.379	2.149
D	D18	Madrepora	01/2010	7.741	0.0000366	937.686	934.258	0.00225	0.00009	0.00238	0.00248	1.364	2.127
D	D19	Madrepora	01/2010	7.781	0.0000340	870.763	867.579	0.00229	0.00010	0.00243	0.00255	1.523	2.374
A	A1	Lophelia	05/2010	8.030	0.0000186	476.262	474.521	0.00223	0.00018	0.00242	0.00266	2.626	4.094
A	A2	Lophelia	05/2010	8.059	0.0000165	423.923	422.373	0.00212	0.00018	0.00232	0.00256	2.674	4.169
A	A3	Lophelia	05/2010	8.123	0.0000139	357.280	355.974	0.00207	0.00020	0.00228	0.00257	3.019	4.706
A	A4	Lophelia	05/2010	8.106	0.0000147	377.744	376.363	0.00210	0.00020	0.00232	0.00259	2.952	4.601
A	A5	Desmophylum	05/2010	8.055	0.0000166	426.595	425.036	0.00211	0.00018	0.00231	0.00255	2.642	4.118
A	A6	Desmophylum	05/2010	7.996	0.0000196	501.009	499.177	0.00217	0.00016	0.00234	0.00255	2.360	3.679
A	A7	Madrepora	05/2010	8.039	0.0000174	445.480	443.851	0.00213	0.00017	0.00232	0.00255	2.561	3.992
A	A8	Madrepora	05/2010	7.969	0.0000222	569.295	567.214	0.00231	0.00016	0.00249	0.00270	2.367	3.690
A	A9	Madrepora	05/2010	7.993	0.0000196	502.761	500.923	0.00216	0.00016	0.00234	0.00255	2.342	3.651
A	A10	Lophelia	05/2010	8.022	0.0000182	466.072	464.368	0.00214	0.00017	0.00233	0.00255	2.479	3.865
A	A11	Madrepora	05/2010	7.998	0.0000194	497.607	495.787	0.00216	0.00016	0.00234	0.00255	2.366	3.688
A	A12	Madrepora	05/2010	8.004	0.0000201	515.204	513.320	0.00227	0.00017	0.00246	0.00268	2.518	3.925
A	A13	blank	05/2010	8.000	0.0000198	506.345	504.494	0.00221	0.00016	0.00240	0.00261	2.436	3.797
A	A14	blank	05/2010	8.002	0.0000193	494.908	493.099	0.00217	0.00016	0.00235	0.00257	2.403	3.745
A	A15	blank	05/2010	8.011	0.0000187	479.995	478.240	0.00215	0.00016	0.00233	0.00255	2.427	3.783
A	A16	Lophelia	05/2010	8.001	0.0000190	488.126	486.342	0.00214	0.00016	0.00231	0.00253	2.358	3.675
A	A17	Desmophylum	05/2010	8.033	0.0000178	454.853	453.190	0.00214	0.00017	0.00233	0.00256	2.544	3.966
A	A18	Madrepora	05/2010	8.025	0.0000180	461.985	460.296	0.00213	0.00017	0.00232	0.00254	2.486	3.874
A	A19	Madrepora	05/2010	8.053	0.0000167	427.817	426.253	0.00211	0.00018	0.00230	0.00254	2.620	4.083
A	Arcadia1	Madrepora	05/2010	8.019	0.0000186	476.144	474.403	0.00217	0.00017	0.00235	0.00258	2.491	3.883
A	Arcadia2	Madrepora	05/2010	8.019	0.0000193	494.271	492.464	0.00225	0.00017	0.00245	0.00268	2.590	4.037

Treatment	ID	coral spp	Collection date	pH	CO2	pCO2	fCO2	HCO3	CO3	DIC	ALK	ΩAragonite	ΩCalcite
B	B1	Lophelia	05/2010	8.044	0.0000178	455.328	453.664	0.00220	0.00018	0.00240	0.00264	2.681	4.178
B	B2	Lophelia	05/2010	8.058	0.0000180	462.222	460.532	0.00231	0.00019	0.00252	0.00278	2.901	4.522
B	B3	Lophelia	05/2010	8.011	0.0000187	478.689	476.939	0.00214	0.00016	0.00233	0.00254	2.422	3.775
B	B4	Lophelia	05/2010	8.001	0.0000191	489.236	487.447	0.00214	0.00016	0.00232	0.00253	2.358	3.676
B	B5	Desmophylum	05/2010	8.079	0.0000180	460.536	458.853	0.00241	0.00021	0.00264	0.00292	3.182	4.960
B	B6	Madrepora	05/2010	8.045	0.0000180	461.761	460.073	0.00223	0.00018	0.00243	0.00268	2.724	4.246
B	B7	Madrepora	05/2010	8.009	0.0000189	483.833	482.065	0.00216	0.00016	0.00234	0.00255	2.420	3.773
B	B8	Madrepora	05/2010	8.035	0.0000176	449.828	448.183	0.00213	0.00017	0.00232	0.00255	2.540	3.959
B	B9	Madrepora	05/2010	7.992	0.0000196	502.379	500.543	0.00215	0.00016	0.00233	0.00254	2.326	3.626
B	B10	Madrepora	05/2010	6.777	0.0003283	8,411.812	8,381.058	0.00220	0.00001	0.00253	0.00222	0.144	0.225
B	B11	Madrepora	05/2010	6.983	0.0002030	5,202.774	5,183.752	0.00218	0.00002	0.00240	0.00222	0.231	0.360
B	B12	Madrepora	05/2010	8.013	0.0000186	477.565	475.819	0.00215	0.00016	0.00233	0.00255	2.441	3.804
B	B13	blank	05/2010	7.997	0.0000197	505.789	503.940	0.00219	0.00016	0.00237	0.00259	2.397	3.736
B	B14	blank	05/2010	8.024	0.0000182	466.708	465.001	0.00215	0.00017	0.00234	0.00256	2.500	3.897
B	B15	blank	05/2010	8.037	0.0000179	457.947	456.273	0.00218	0.00017	0.00237	0.00261	2.609	4.067
B	B16	Lophelia	05/2010	7.981	0.0000206	527.386	525.458	0.00220	0.00016	0.00238	0.00259	2.323	3.620
B	B17	blank	05/2010	8.034	0.0000176	451.029	449.380	0.00213	0.00017	0.00231	0.00254	2.530	3.944
B	B18	Madrepora	05/2010	7.994	0.0000196	500.959	499.128	0.00216	0.00016	0.00233	0.00254	2.341	3.650
B	B19	Madrepora	05/2010	8.013	0.0000196	503.293	501.453	0.00226	0.00017	0.00245	0.00268	2.564	3.997
B	B20	blank	05/2010	8.014	0.0000185	473.281	471.551	0.00214	0.00016	0.00232	0.00254	2.428	3.785
B	B21	blank	05/2010	8.031	0.0000177	452.699	451.044	0.00212	0.00017	0.00231	0.00254	2.511	3.914
C	C1	Lophelia	05/2010	7.816	0.0000312	800.658	797.731	0.00229	0.00011	0.00243	0.00256	1.648	2.569
C	C2	Lophelia	05/2010	7.828	0.0000304	779.312	776.463	0.00229	0.00011	0.00243	0.00257	1.693	2.639
C	C3	Lophelia	05/2010	7.804	0.0000322	826.234	823.213	0.00229	0.00011	0.00243	0.00256	1.606	2.504
C	C4	Lophelia	05/2010	7.819	0.0000308	789.586	786.699	0.00227	0.00011	0.00241	0.00255	1.650	2.571
C	C5	Desmophylum	05/2010	7.810	0.0000318	815.229	812.248	0.00230	0.00011	0.00244	0.00257	1.631	2.542
C	C6	Madrepora	05/2010	7.819	0.0000311	797.211	794.296	0.00230	0.00011	0.00244	0.00257	1.665	2.596
C	C7	Madrepora	05/2010	7.853	0.0000284	726.562	723.906	0.00226	0.00012	0.00241	0.00255	1.772	2.761
C	C8	Madrepora	05/2010	7.896	0.0000280	717.795	715.170	0.00246	0.00014	0.00264	0.00281	2.132	3.324
C	C9	Madrepora	05/2010	7.879	0.0000265	679.325	676.841	0.00225	0.00013	0.00240	0.00255	1.872	2.917
C	C10	Desmophylum	05/2010	7.860	0.0000279	714.690	712.077	0.00226	0.00012	0.00241	0.00256	1.801	2.807
C	C11	Madrepora	05/2010	7.883	0.0000263	673.510	671.047	0.00224	0.00013	0.00240	0.00255	1.885	2.939
C	C12	Madrepora	05/2010	7.855	0.0000284	727.677	725.017	0.00228	0.00012	0.00243	0.00257	1.796	2.799
C	C13	blank	05/2010	7.880	0.0000273	700.665	698.103	0.00232	0.00013	0.00248	0.00264	1.940	3.024
C	C14	blank	05/2010	7.842	0.0000294	753.726	750.970	0.00229	0.00012	0.00243	0.00258	1.750	2.728
C	C15	blank	05/2010	7.841	0.0000294	753.113	750.360	0.00228	0.00012	0.00242	0.00256	1.736	2.706
C	C16	Lophelia	05/2010	7.888	0.0000271	695.360	692.818	0.00235	0.00013	0.00251	0.00267	1.994	3.108

Treatment	ID	coral spp	Collection date	pH	CO2	pCO2	fCO2	HCO3	CO3	DIC	ALK	ΩAragonite	ΩCalcite
C	C17	Desmophylum	05/2010	7.896	0.0000268	687.466	684.952	0.00236	0.00014	0.00253	0.00270	2.049	3.194
C	C18	Madrepora	05/2010	7.893	0.0000277	710.080	707.484	0.00242	0.00014	0.00259	0.00276	2.086	3.252
C	C19	Madrepora	05/2010	7.909	0.0000257	658.535	656.128	0.00233	0.00014	0.00250	0.00267	2.081	3.244
C	C20	blank	05/2010	7.888	0.0000261	667.767	665.325	0.00226	0.00013	0.00241	0.00257	1.919	2.992
C	C21	blank	05/2010	7.889	0.0000277	710.662	708.063	0.00240	0.00014	0.00257	0.00274	2.050	3.196
D	D1	Lophelia	05/2010	7.673	0.0000449	1,150.515	1,146.309	0.00237	0.00008	0.00249	0.00257	1.228	1.914
D	D2	Lophelia	05/2010	7.723	0.0000395	1,012.082	1,008.382	0.00234	0.00009	0.00247	0.00256	1.359	2.118
D	D3	Lophelia	05/2010	7.749	0.0000402	1,031.128	1,027.358	0.00253	0.00010	0.00267	0.00278	1.560	2.431
D	D4	Lophelia	05/2010	7.725	0.0000425	1,088.827	1,084.846	0.00252	0.00010	0.00266	0.00276	1.473	2.296
D	D5	Desmophylum	05/2010	7.777	0.0000347	889.387	886.135	0.00232	0.00010	0.00246	0.00257	1.529	2.383
D	D6	Desmophylum	05/2010	7.733	0.0000420	1,076.082	1,072.148	0.00254	0.00010	0.00268	0.00279	1.512	2.357
D	D7	Madrepora	05/2010	7.760	0.0000389	997.236	993.590	0.00251	0.00011	0.00265	0.00277	1.589	2.476
D	D8	Madrepora	05/2010	7.775	0.0000373	955.342	951.849	0.00248	0.00011	0.00263	0.00275	1.625	2.533
D	D9	Madrepora	05/2010	7.743	0.0000374	959.368	955.860	0.00232	0.00009	0.00245	0.00255	1.409	2.196
D	D10	Madrepora	05/2010	7.802	0.0000369	945.874	942.416	0.00262	0.00012	0.00277	0.00291	1.823	2.841
D	D11	Madrepora	05/2010	7.746	0.0000399	1,022.056	1,018.319	0.00249	0.00010	0.00263	0.00274	1.526	2.378
D	D12	Madrepora	05/2010	7.854	0.0000314	803.423	800.486	0.00251	0.00013	0.00267	0.00283	1.971	3.073
D	D13	blank	05/2010	7.738	0.0000378	967.925	964.386	0.00231	0.00009	0.00245	0.00254	1.394	2.173
D	D14	blank	05/2010	7.818	0.0000311	796.989	794.075	0.00229	0.00011	0.00243	0.00256	1.657	2.584
D	D15	blank	05/2010	7.883	0.0000277	709.686	707.091	0.00237	0.00013	0.00253	0.00269	1.992	3.104
D	D16	Lophelia	05/2010	7.788	0.0000355	909.763	906.437	0.00244	0.00011	0.00258	0.00270	1.643	2.561
D	D17	Desmophylum	05/2010	7.889	0.0000272	696.045	693.500	0.00235	0.00013	0.00251	0.00268	2.001	3.119
D	D18	Madrepora	05/2010	7.815	0.0000321	821.611	818.607	0.00234	0.00011	0.00249	0.00262	1.684	2.625
D	D19	Madrepora	05/2010	7.808	0.0000338	865.259	862.096	0.00243	0.00011	0.00258	0.00271	1.720	2.681
D	D20	blank	05/2010	7.868	0.0000290	743.527	740.809	0.00240	0.00013	0.00255	0.00271	1.946	3.033
D	D21	blank	05/2010	7.821	0.0000344	880.228	877.009	0.00255	0.00012	0.00270	0.00285	1.856	2.893
/	bulk left		05/2010	8.140	0.0000131	335.133	333.907	0.00202	0.00020	0.00224	0.00252	3.062	4.773
/	bulk right		05/2010	8.163	0.0000123	316.007	314.851	0.00201	0.00021	0.00224	0.00254	3.216	5.012
A	A1	Lophelia	07/2010	8.042	17.2865900	442.945	441.325	0.00213	0.00017	0.00232	0.00256	2.587	4.033
A	A2	Lophelia	07/2010	7.985	20.0804300	514.533	512.652	0.00217	0.00015	0.00235	0.00255	2.308	3.598
A	A3	Lophelia	07/2010	8.073	15.8550600	406.264	404.779	0.00210	0.00018	0.00230	0.00255	2.735	4.264
A	A4	Lophelia	07/2010	8.037	17.4484500	447.092	445.458	0.00212	0.00017	0.00231	0.00254	2.545	3.966
A	A5	Desmophylum	07/2010	8.061	16.4506600	421.525	419.984	0.00212	0.00018	0.00231	0.00256	2.677	4.173
A	A6	Desmophylum	07/2010	8.037	17.4824100	447.962	446.325	0.00213	0.00017	0.00232	0.00255	2.553	3.980
A	A7	Madrepora	07/2010	8.004	19.0657500	488.533	486.747	0.00215	0.00016	0.00233	0.00255	2.391	3.727
A	A8	Madrepora	07/2010	7.990	19.7044800	504.900	503.054	0.00215	0.00015	0.00233	0.00253	2.311	3.603
A	A9	Madrepora	07/2010	8.058	16.5449200	423.940	422.391	0.00211	0.00018	0.00231	0.00255	2.654	4.138

Treatment	ID	coral spp	Collection date	pH	CO2	pCO2	fCO2	HCO3	CO3	DIC	ALK	ΩAragonite	ΩCalcite
A	A10	Lophelia	07/2010	8.006	18.9956800	486.738	484.958	0.00215	0.00016	0.00233	0.00255	2.399	3.739
A	A11	Madrepora	07/2010	7.998	19.3001300	494.539	492.731	0.00215	0.00016	0.00232	0.00253	2.350	3.663
A	A12	Madrepora	07/2010	7.921	23.6258700	605.380	603.167	0.00220	0.00013	0.00236	0.00253	2.018	3.145
A	A13	blank	07/2010	8.019	18.3513700	470.228	468.509	0.00214	0.00016	0.00233	0.00255	2.462	3.838
A	A14	blank	07/2010	8.015	18.5404900	475.074	473.337	0.00214	0.00016	0.00233	0.00255	2.440	3.804
A	A15	blank	07/2010	8.034	17.6695200	452.757	451.102	0.00214	0.00017	0.00232	0.00255	2.541	3.960
A	A16	Lophelia	07/2010	7.982	20.1406200	516.075	514.188	0.00216	0.00015	0.00233	0.00254	2.279	3.553
A	A17	Desmophylum	07/2010	7.977	20.3351500	521.060	519.155	0.00216	0.00015	0.00233	0.00253	2.248	3.504
A	A18	Madrepora	07/2010	7.992	19.5321700	500.485	498.655	0.00215	0.00015	0.00232	0.00253	2.318	3.613
A	A19	Madrepora	07/2010	7.990	19.6750000	504.145	502.301	0.00215	0.00015	0.00232	0.00253	2.310	3.601
A	Arcadia1	Madrepora	07/2010	8.004	19.0373600	487.806	486.022	0.00215	0.00016	0.00233	0.00255	2.392	3.729
A	Arcadia2	Madrepora	07/2010	8.033	17.6197400	451.481	449.831	0.00213	0.00017	0.00231	0.00254	2.521	3.930
B	B1	Lophelia	07/2010	8.022	18.3022700	468.970	467.256	0.00215	0.00017	0.00234	0.00256	2.494	3.887
B	B2	Lophelia	07/2010	7.974	20.5453600	526.446	524.521	0.00216	0.00015	0.00233	0.00253	2.241	3.493
B	B3	Lophelia	07/2010	8.013	18.6215500	477.151	475.407	0.00215	0.00016	0.00233	0.00255	2.439	3.802
B	B4	Lophelia	07/2010	8.024	18.1314400	464.593	462.894	0.00214	0.00017	0.00233	0.00255	2.488	3.878
B	B5	Desmophylum	07/2010	8.015	18.5579900	475.523	473.784	0.00215	0.00016	0.00233	0.00255	2.451	3.820
B	B6	Madrepora	07/2010	7.996	19.5203700	500.182	498.354	0.00216	0.00016	0.00234	0.00255	2.357	3.674
B	B7	Madrepora	07/2010	7.991	19.7249000	505.423	503.575	0.00216	0.00016	0.00234	0.00254	2.329	3.631
B	B8	Madrepora	07/2010	8.018	18.4001800	471.479	469.755	0.00214	0.00016	0.00233	0.00255	2.458	3.831
B	B9	Madrepora	07/2010	8.024	18.0542000	462.614	460.922	0.00214	0.00017	0.00232	0.00255	2.486	3.876
B	B10	Madrepora	07/2010	8.001	19.2746200	493.885	492.080	0.00216	0.00016	0.00234	0.00255	2.379	3.708
B	B11	Madrepora	07/2010	8.013	18.6492400	477.861	476.114	0.00215	0.00016	0.00233	0.00255	2.434	3.795
B	B12	Madrepora	07/2010	7.989	19.8318200	508.163	506.305	0.00217	0.00016	0.00234	0.00255	2.325	3.625
B	B13	blank	07/2010	7.998	19.3707000	496.347	494.532	0.00216	0.00016	0.00233	0.00255	2.363	3.684
B	B14	blank	07/2010	8.015	18.5569400	475.496	473.757	0.00215	0.00016	0.00233	0.00255	2.447	3.815
B	B15	blank	07/2010	8.012	18.6600200	478.137	476.389	0.00215	0.00016	0.00233	0.00255	2.427	3.783
B	B16	Lophelia	07/2010	8.056	16.6670900	427.071	425.510	0.00212	0.00018	0.00232	0.00256	2.657	4.142
B	B17	blank	07/2010	8.075	15.8110700	405.137	403.655	0.00210	0.00018	0.00230	0.00255	2.749	4.285
B	B18	Madrepora	07/2010	8.062	16.3794200	419.700	418.165	0.00211	0.00018	0.00231	0.00255	2.680	4.178
B	B19	Madrepora	07/2010	8.032	17.6661600	452.671	451.016	0.00213	0.00017	0.00232	0.00254	2.524	3.934
B	B20	blank	07/2010	8.073	15.9148700	407.796	406.306	0.00210	0.00018	0.00230	0.00255	2.736	4.265
B	B21	blank	07/2010	8.079	15.6405600	400.767	399.302	0.00210	0.00018	0.00230	0.00255	2.767	4.314
C	C1	Lophelia	07/2010	7.902	24.8545000	636.862	634.534	0.00222	0.00013	0.00237	0.00254	1.948	3.036
C	C2	Lophelia	07/2010	7.914	24.2866200	622.311	620.036	0.00223	0.00013	0.00239	0.00256	2.015	3.141
C	C3	Lophelia	07/2010	7.869	27.6246900	707.844	705.256	0.00228	0.00012	0.00243	0.00259	1.856	2.893
C	C4	Lophelia	07/2010	7.861	27.7571600	711.239	708.638	0.00225	0.00012	0.00240	0.00255	1.798	2.803

Treatment	ID	coral spp	Collection date	pH	CO2	pCO2	fCO2	HCO3	CO3	DIC	ALK	ΩAragonite	ΩCalcite
C	C5	Desmophylum	07/2010	7.868	27.6475000	708.429	705.838	0.00228	0.00012	0.00244	0.00259	1.855	2.892
C	C6	Madrepora	07/2010	7.911	24.2678300	621.829	619.556	0.00221	0.00013	0.00237	0.00254	1.980	3.087
C	C7	Madrepora	07/2010	7.907	24.6570700	631.803	629.493	0.00223	0.00013	0.00239	0.00255	1.981	3.088
C	C8	Madrepora	07/2010	7.882	25.5662300	655.099	652.704	0.00218	0.00012	0.00233	0.00248	1.826	2.846
C	C9	Madrepora	07/2010	7.948	22.0916500	566.068	563.998	0.00219	0.00014	0.00236	0.00255	2.145	3.343
C	C10	Desmophylum	07/2010	7.940	22.6344700	579.977	577.856	0.00221	0.00014	0.00237	0.00255	2.114	3.296
C	C11	Madrepora	07/2010	7.933	23.1329000	592.748	590.581	0.00222	0.00014	0.00238	0.00256	2.090	3.258
C	C12	Madrepora	07/2010	7.917	24.0394000	615.976	613.724	0.00222	0.00013	0.00238	0.00255	2.018	3.146
C	C13	blank	07/2010	7.910	24.5297400	628.540	626.242	0.00223	0.00013	0.00239	0.00256	1.995	3.110
C	C14	blank	07/2010	7.898	25.3519500	649.608	647.233	0.00225	0.00013	0.00240	0.00257	1.955	3.048
C	C15	blank	07/2010	7.913	24.4808200	627.287	624.994	0.00224	0.00013	0.00240	0.00257	2.016	3.143
C	C16	Lophelia	07/2010	7.916	24.2212000	620.634	618.365	0.00223	0.00014	0.00239	0.00257	2.026	3.157
C	C17	Desmophylum	07/2010	7.900	25.2970800	648.202	645.833	0.00225	0.00013	0.00241	0.00257	1.966	3.065
C	C18	Madrepora	07/2010	7.884	26.5805100	681.088	678.598	0.00228	0.00013	0.00243	0.00259	1.916	2.986
C	C19	Madrepora	07/2010	7.885	26.0441400	667.345	664.905	0.00223	0.00013	0.00239	0.00254	1.884	2.937
C	C20	blank	07/2010	7.935	23.1030600	591.984	589.819	0.00223	0.00014	0.00239	0.00257	2.110	3.288
C	C21	blank	07/2010	7.877	27.4446700	703.231	700.660	0.00231	0.00013	0.00247	0.00263	1.919	2.992
D	D1	Lophelia	07/2010	7.800	32.1602300	824.061	821.048	0.00227	0.00011	0.00240	0.00253	1.572	2.451
D	D2	Lophelia	07/2010	7.777	34.2239200	876.940	873.734	0.00229	0.00010	0.00243	0.00254	1.511	2.355
D	D3	Lophelia	07/2010	7.845	29.6271700	759.155	756.379	0.00232	0.00012	0.00247	0.00261	1.786	2.783
D	D4	Lophelia	07/2010	7.784	33.6410600	862.005	858.854	0.00229	0.00010	0.00243	0.00254	1.534	2.392
D	D5	Desmophylum	07/2010	7.826	30.4079200	779.160	776.312	0.00228	0.00011	0.00242	0.00256	1.683	2.624
D	D6	Desmophylum	07/2010	7.818	31.7758700	814.212	811.236	0.00234	0.00011	0.00248	0.00262	1.692	2.638
D	D7	Madrepora	07/2010	7.801	32.2678700	826.819	823.796	0.00229	0.00011	0.00242	0.00255	1.592	2.482
D	D7		07/2010	7.898	25.1785700	645.166	642.807	0.00223	0.00013	0.00238	0.00255	1.941	3.026
D	D8	Madrepora	07/2010	7.798	32.9547500	844.419	841.332	0.00232	0.00011	0.00246	0.00258	1.601	2.495
D	D9	Madrepora	07/2010	7.903	24.7919600	635.259	632.937	0.00222	0.00013	0.00237	0.00254	1.952	3.043
D	D10	Madrepora	07/2010	7.803	32.2762500	827.034	824.010	0.00229	0.00011	0.00243	0.00256	1.604	2.500
D	D11	Madrepora	07/2010	7.794	32.7637800	839.526	836.457	0.00228	0.00010	0.00242	0.00254	1.560	2.432
D	D12	Madrepora	07/2010	7.776	34.8658500	893.389	890.123	0.00233	0.00010	0.00246	0.00258	1.527	2.381
D	D13	blank	07/2010	7.757	36.4619800	934.287	930.872	0.00233	0.00010	0.00246	0.00257	1.462	2.280
D	D14	blank	07/2010	7.810	31.5565400	808.592	805.636	0.00228	0.00011	0.00242	0.00254	1.618	2.522
D	D15	blank	07/2010	7.832	29.9318100	766.961	764.157	0.00227	0.00011	0.00242	0.00255	1.697	2.645
D	D16	Lophelia	07/2010	7.817	31.5768600	809.113	806.155	0.00232	0.00011	0.00246	0.00259	1.671	2.604
D	D17	Desmophylum	07/2010	7.797	33.2155100	851.101	847.989	0.00233	0.00011	0.00247	0.00259	1.605	2.501
D	D18	Madrepora	07/2010	7.812	31.5677900	808.881	805.923	0.00229	0.00011	0.00243	0.00256	1.631	2.542
D	D19	Madrepora	07/2010	7.802	32.6425100	836.419	833.361	0.00231	0.00011	0.00245	0.00258	1.614	2.515

Treatment	ID	coral spp	Collection date	pH	CO2	pCO2	fCO2	HCO3	CO3	DIC	ALK	ΩAragonite	ΩCalcite
D	D20	blank	07/2010	7.824	31.5360400	808.067	805.113	0.00235	0.00012	0.00250	0.00263	1.722	2.684
D	D21	blank	07/2010	7.757	37.2716800	955.035	951.543	0.00238	0.00010	0.00252	0.00263	1.499	2.336
/	bulk left		07/2010	8.132	13.4374500	344.316	343.057	0.00204	0.00020	0.00225	0.00254	3.040	4.739
/	bulk right		07/2010	8.136	13.3907400	343.119	341.865	0.00205	0.00021	0.00227	0.00256	3.081	4.803
X	?			7.864	0.0000277	710.511	707.913	0.00227	0.00012	0.00242	0.00257	1.822	2.840

EIDESSTATTLICHE ERKLÄRUNG

Hiermit erkläre ich, dass ich die vorliegende Arbeit selbständig und ohne fremde Hilfe angefertigt und keine anderen als die angegebenen Quellen und Hilfsmittel werwendet habe.

Die eingereichte schriftliche Fassung der Arbeit entspricht der auf dem elektronischen Speichermedium.

Weiterhin versichere ich, dass diese Arbeit noch nicht als Abschlussarbeit an anderer Stelle vorgelegen hat.

2-Mai-2011

Maria M Berzunza Sanchez