



IPCC AR5: Key Findings – Projected Climate Change Impacts

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Some Findings from AR5 WG1

- Human influence on the climate system is clear.
- It is *extremely likely* that human influence has been the dominant cause of the observed warming since the mid-20th century

Temperature Projections



From WG1 AR5 Fig SPM.7

-Will continue beyond 2100 except for RCP2.6 -Will continue to exhibit interannualto-decadal variability -Will not be regionally uniform





More Findings from AR5 WG1

- The contrast between wet and dry regions and wet and dry seasons will increase, although there may be regional exceptions.
- Global mean sea level rise relative to 1986-2005 :
 - for RCP8.5 will be 0.52 to 0.98m by 2100(medium confidence
 - for RCP2.5 will *likely* be in the range of 0.26 to 0.55 m for 2081-2100
- Further uptake of carbon by the ocean will increase ocean acidification
- Cumulative emissions of CO2 largely determine global mean surface ∆T by the late 20th century & beyond. Most aspects of climate change will persist for many centuries even if emissions of CO2 are stopped







Technical Report – sea level rise observations & projections

Observed and projected relative sealevel change near the Cook Islands

RCP4.5: 2090

cm

50 51







pH Scale Alkaline (14) **Acidification** 8.16 Historical level of pH 8.08 Current level of pH 7.76 Projected lower level of Neutral (7) pH Oceans take up 25% of extra CO₂

Acidic (0)











Global ocean acidification



- •Reduces viability of coral reefs and shell fish
- Affects food security and pearl industries



Seawater pH exhibits considerable temporal and spatial variability in coastal areas compared to open ocean due to additional natural and human influences (*very high confidence*).

Coastal acidification is projected to continue but with large and uncertain regional and local variations (*high confidence*); *e.g.* pH ranged from 6 to 9 in 24 estuaries (Borges and Abril, 2011) and short-term (hours to weeks) changes of up to 0.5 pH units are not unusual in coastal ecosystems (Hofmann *et al., 2011*).









Walter Starck

Average surface ocean pH has decreased by more than 0.1 units below the preindustrial average of 8.17.

By 2100 average surface pH is expected to change by -0.13, -0.22, -0.28, -0.42 pH units, under RCP 2.6, 4.5, 6.0 and 8.5 respectively (WGI).

The rate of acidification in surface waters varies regionally but is 50% higher in the northern North Atlantic than in the subtropical Atlantic (Olafsson, 2009).

b. Surface pH in 2090s (RCP8.5, changed from 1990s)



Working Group II Impacts, Adaptation, and Vulnerability



Taxon	No. of	No. of	Total	pCO ₂ where the most	Assessment of	Assessment of
	studies	para-	no. of	vulnerable species is	tolerance to	tolerance to
		meters	species	negatively affected or	RCP 6.0	RCP 8.5
		studied	studied	investigated pCO2 range*	(confidence)	(confidence)
				(µatm)		
Cyanobacteria	17	5	9+	180-1250*	Beneficial	Beneficial
					(low)	(low)
Coccolithophores	35	6	7+	740	Tolerant	Vulnerable
					(low)	(medium)
Diatoms	22	5	28+	150-1500*	Tolerant	Tolerant
					(low)	(low)
Dinoflagellates	12	4	11+	150-1500*	Beneficial	Tolerant
					(low)	(low)
Foraminifers	11	4	22	588	Vulnerable	Vulnerable
					(low)	(medium)
Seagrasses	6	6	5	300-21000*	Beneficial	Beneficial
					(medium)	(low)
Macroalgae	21	5	21+	280-20812*	Beneficial	Beneficial
(non-calcifying)					(medium)	(low)
Macroalgae	38	10	36+	365	Vulnerable	Vulnerable
(calcifying)					(medium)	(high)
Warm-water	45	13	31	467	Vulnerable	Vulnerable
corals					(medium)	(high)
Cold-water corals	10	13	6	445	Vulnerable	Vulnerable
					(low)	(medium)
Annelids	10	6	17+	1200	Tolerant	Tolerant
					(medium)	(medium)
Echinoderms	54	14	35	510	Vulnerable	Vulnerable
					(medium)	(high)
Mollusks	72	20	38+	508	Vulnerable	Vulnerable
(benthic)					(medium)	(high)
Mollusks (pelagic)	7	8	8	550	Vulnerable	Vulnerable
					(low)	(medium)
Mollusks	10	8	5	2200 (850 for trace	Tolerant	Tolerant
(cephalopods)				elements)	(medium)	(medium)
Bryozoans	7	3	8+	549	Tolerant	Vulnerable
					(low)	(low)
Crustaceans	47	27	44+	700	Tolerant	Tolerant
					(medium)	(low)
Fish ⁺	51	16	40	700	Vulnerable	Vulnerable
					(low)	(low)

Tolerances to ocean acidification in marine taxa, assessed from laboratory and field studies of species in the *pCO2* range from <650 to >10 000 µatm, compared to present day atmospheric levels (400 µatm).

Variables studied include growth, survival, calcification, metabolic rate, immune response, development, abundance, behavior and others.

Confidence is based on the number of studies, the number of species studied and the agreement of results within one group. WGII Ch 6















Planktonic foraminifera are single-celled calcite-secreting organisms that represent between 25 and 50% of the total open-ocean marine carbonate flux. The comparison of shell weights of the modern foraminifer Globigerina bulloides collected from the Southern Ocean with the weights of shells preserved in the underlying Holocene-aged sediments, show that modern shell weights are 30–35% lower than those from the preindustrial sediments. (Moy *et al.*, 2009)









, (ppmv

























The Pacific Ocean Observing System



From Science to Management









Stafford Smith et al, *PhilTransRoySoc* 2011 (after Jones & McInnes 2004) **Decision-focussed adaptation**



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More Acidic Ocean

- Gaps in our understanding and our responses
- OA need to be considered together with SLR and Temperature change
- Other sources of CO2 (coastal areas)
- Coral Ecosystems
 - Branching corals are more affected than massive corals (similar to bleaching)
 - Reduces biological habitat for reef fish
- Open Ocean
 - Impacts on physiology of tuna
 - Could reduce plankton food supply to tuna

Fabricius et. al. Nature 2011.