Senate Standing Committee on
Environment and Communications

Inquiry into

Recent trends in and preparedness for extreme weather events

Submission by

L.I.V.E.
Locals into Victoria's Environment

LIVE (Locals into Victoria's Environment)

and

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14 January 2012

Key points

Prudent risk management demands an analysis of the full range of possible future events, and the costs and benefits associated with each outcome.

The more extreme outcomes at the edges of the range of possibilities may be considered less likely, but are often associated with very high costs and – in the case of climate change – catastrophic outcomes.

Our coasts and coastal assets are vulnerable to storm surges and erosion. As a result of rising sea levels caused by global warming, the risk of severe flooding and storm damage to property will increase, beaches and bluffs will suffer increased erosion, low-lying areas will be inundated, with potential for saltwater to infiltrate into surface waters and aquifers, and sewage and septic systems, transportation and water treatment infrastructure will be at risk from flooding and erosion.

There is a broad body of scientific work which estimates that sea level could rise this century by as much as 2 metres. But the government's work is based on three scenarios, none of which exceeds 1.1 metres.

In relation to Terms of Reference (b)(i), the Australian Government has ignored basic, sound risk-management practices in assessing future sea-level rises and the impacts of extreme storm surge events by discounting the more recent, upper-range, scientific projections.

Small increases in the sea level can have devastating impact when combined with storm surges and high tides. The difference between a 1-metre and a 2-metre sea-level rise at such events will be in the tens to hundreds of billions of dollars for Australia, but this cost cannot be accurately quantified [Terms of Reference (b)(ii)], because the assessment work has not been done.

The Australian people have a right to know how extreme coastal impacts could affect their lives, so that they can make fully-informed choices.

Who we are

LIVE - Locals Into Victoria's Environment

LIVE is a group of over 3000 Victorians who have come together to address detrimental human impacts on the planet, especially the threat of climate change. Our organization is independent, non-partisan and non-profit. We are based in Melbourne’s City of Port Phillip, an inner Melbourne suburb just south of the Yarra River.

LIVE's goals are to raise awareness of the need to protect our world’s vulnerable ecosystems, to halt climate change, to encourage our society’s transition to a more healthy and sustainable economy, and to motivate and support others in our community to collectively minimise our carbon footprint.

LIVE applies polite pressure to all levels of government and industry to demand that meaningful, effective measures be taken immediately to ensure that all environmental costs are accounted for and that Victoria’s unacceptable greenhouse gas emissions, a major contributor to climate change, are reduced starting now. LIVE supports and works with environmental groups and community based groups who are working for a future that is healthy and best for all.

LIVE believes that when many people join together, our voices become louder and stronger. Local grassroots action can make a difference and is needed now!

David Spratt

David Spratt is the co-author of *Climate Code Red: The case for emergency action* (Scribe 2008) and is published by print and online publications, including ReNewEconomy, Climate Spectator, New Matilda, Crikey and The Age.

Risk management and climate change

Prudent risk management demands an analysis of the full range of possible future events, and the costs and benefits associated with each outcome.

The more extreme outcomes at the edges of the range of possibilities may be considered less likely, but are often associated with very high costs and – in the case of climate change – catastrophic outcomes. We ignore them at our peril.

The inquiry into Victoria's Black Saturday bush fires found a lack of preparedness for the conditions that occurred on that day, in part because those conditions had not previously been experienced, or fully anticipated. On that day, the McArthur Forest Fire Danger Index – originally on a scale of 0 to 100, based on the 1939 Black Friday fires – reached unprecedented levels, ranging from 120 to over 200.

This is one example of the type of extreme event we must now anticipate, and for which government must plan, as the climate becomes hotter. Global warming means that extreme events — such as heat, fire, drought, storm intensity and storm surge — which are currently unlikely will become more common, and extreme events never before experienced by human civilisation will occur at an increasing frequency.

In a report for the Australian Government, Professor Will Steffen notes:

> One of the more dramatic consequences of modest increases in sea level is the disproportionately large increase in the frequency of extreme sea-level events associated with high tides and storm surges. A 0.5 m rise in mean sea level could cause such extreme events to occur hundreds of times more frequently by the end of the century; **an event that now happens once every hundred years would be likely to occur two or three times per year**. (emphasis added) (Steffen 2009).

Meteorologist Dr Jeff Masters observes:

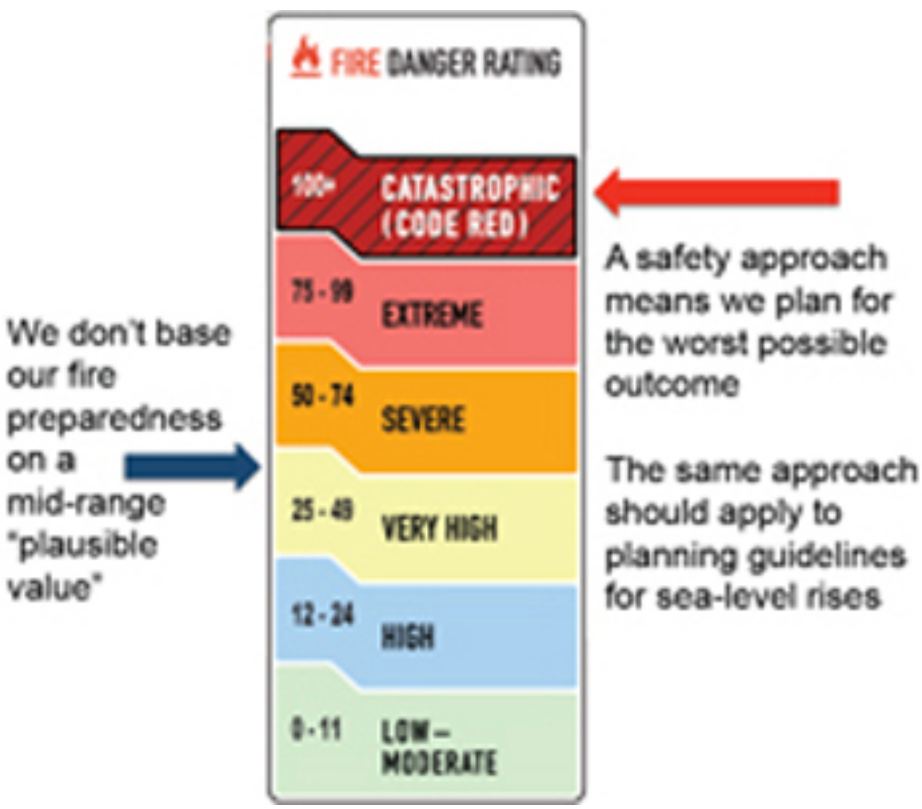
> Climate is what you expect; weather is what you get. I like to think of the weather as a game of dice. Mother Nature rolls the dice each day

to determine the weather, and the rolls fall within the boundaries of what the climate will allow. The extreme events that happen at the boundaries of what are possible are what people tend to notice the most. When the climate changes, those boundaries change. Thus, **the main way people will tend to notice climate change is through a change in the extreme events that occur at the boundaries of what is possible**. (emphasis added) (Shearer 2012).

Only the most rigorous risk management approach will allow us to assess and be prepared for such events, in so far as it is possible to be prepared.

It is the contention of this submission that in regard to global-warming-caused sea-level rises and the impacts of extreme storm surge events on coastal inundation, the Australian Government has failed in its risk management responsibilities by discounting the more recent, upper-range, scientific projections.

Figure 1: What is prudent risk management?



Instead, the Australian Government is basing research and adaptation initiatives on nothing more extreme than mid-range ”plausible value” projections. This is analogous to basing bushfire preparation plans on the assumption that no fire will ever exceed the mid-range orange scale, and that the “extreme” red-scale events will never occur.

This could become a very expensive and disruptive policy failure for those who live, work and play in vulnerable conditions around Australia’s coast. It is a failure that can be avoided, and this inquiry can take a leading role in ensuring that it is avoided.

Coasts at risk

Our coasts and coastal assets are vulnerable to storm surges, when rising water is pushed on shore by a combination of factors that may include severe low-pressure systems (including cyclones) and associated heavy precipitation, strong winds, and high or king tides.

> It is rarely a "wall of water" as often claimed, but rather a rise of water that can be as rapid as several feet in just a few minutes. The storm surge moves with the forward speed of the hurricane, typically 10–15 mph. This wind-driven water moving at 10–15 mph has tremendous power. A cubic yard of sea water weighs 1,728 pounds — almost a ton. A one-foot deep storm surge can sweep your car off the road, and it is difficult to stand in a six-inch surge. Compounding the destructive power of the rushing water is the large amount of floating debris that typically accompanies the surge. (Masters 2012)

How could we ever forget the images from Japan as the tsunami charged inland on 11 March 2011?

The impacts of storm surges are being exacerbated by rising sea levels. The devastating impacts of Superstorm Sandy on the United States’ north-east coast late in 2012 were made worse by a sea-level rise in the area of approximately 250mm over the last century. Dr Ben Strauss estimates that the extra height of the storm surge caused by higher sea levels affected an additional 70,000 people and 30,000 more homes were flooded. (Mandia 2012)

As a result of rising sea levels, the risk of severe flooding and storm damage will increase, beaches and bluffs will suffer increased erosion, low-lying areas will be inundated, with potential for saltwater to infiltrate into surface waters and aquifers, and sewage and septic systems, transportation and water treatment infrastructure will be at risk from flooding and erosion.

An Australian Government's assessment of the risks of climate change for the whole of Australia's coast found that:

> Up to $63 billion (replacement value) of existing residential buildings are potentially at risk of inundation from a 1.1 metre sea-level rise, with a lower and upper estimate of risk identified for between 157,000 and 247,600 individual buildings…
> With a mid range sea-level rise of 0.5 metres in the 21st century, events that now happen every 10 years would happen about every 10 days in 2100. The current 1-in-100 year event could occur several times a year. For illustration, a current 1-in-100 year event is equivalent to the intensity of storms along the New South Wales central coast in June 2007 when more than 200,000 homes lost power, thousands of people were forced to evacuate their properties, and insured losses exceeded $1.3 billion. An even larger increase in the frequency of high sea level events would occur around Sydney, with smaller increases around Adelaide and along parts of the Western Australian coast. The 1-in-100 year event is used in current planning guidelines as a benchmark for assessing extreme risk. (Australian Government 2009)

A question for this inquiry is whether this assessment, and subsequent work on which it is based, is rigorous in taking into account the full range of scientific projections and whether it is a exercise in prudent risk management, or otherwise.

Flaws in current approach to sea levels

There is a broad body of scientific work which estimates that the sea level by the end of this century could be as much as 2 metres higher (see following sections).

This has been recognised by the government on several occasions:

> Recent research, presented at the Copenhagen Climate Congress in March 2009, projected sea-level rise from 0.75 to 1.9 metres relative to 1990, with 1.1–1.2 metres the mid-range of the projection. (Australian Government 2009)

And:

> Current estimates of sea-level rise range from 0.50 m to over 2 m by 2100" (CSIRO/BoM/DCC 2009)

A prudent risk management approach would demand that this full range of possible outcomes — including those with the most extreme impacts at the high end of the range at 2 metres — be incorporated into the government's assessment and adaptation work. But it has not, and this should be of great concern to the Inquiry.

Instead, the government's work is based on three scenarios, none of which exceed 1.1 metres, a height which is little more than half that which the scientists are telling us could occur. In releasing an update in 2010, Minister Combet explained:

> The indundation maps show the potential long-term effects of climate change, highlighting three simple sea level rise scenarios for the period around the year 2100: low (0.5m), medium (0.8m) and high (1.1m).
>
> - The low scenario represents future sea-level rise which is likely to be unavoidable.
> - The medium scenario is in line with recent global emissions and observations of sea-level rise.
> - The high scenario considers the possible high-end risk identified in the Intergovernmental Panel on Climate Change 4th Assessment Report and more recent research. (Combet 2010)

This inquiry could ask a question of the government: why has it set a "high scenario" of 1.1 metres for sea-level rise when it has already recognised that it could be as high as 2 metres? The confusion is evident in the 2009 "first pass" assessment report:

> A recent assessment that used statistical approaches informed by the observed relationship between temperature and sea level was presented at the Copenhagen climate congress in March 2009. This

> analysis projected sea-level rise from 75 centimetres to 190 centimetres relative to 1990, with 110 to 120 centimetres the mid-range of the projection.
>
> The purpose of a national risk assessment is to ascertain the extent and magnitude of risk to identify the implications for decision making. Reasonable worse-case scenarios need to be considered to do this. A sea-level rise value of 1.1 metres by 2100 was selected for this assessment based on the plausible range of sea-level rise values from post IPCC research and that nearly all of the uncertainties in sea-level rise projections operate to increase rather than lower estimates of sea-level rise. (Australian Government 2009)

In just two paragraphs, the language shifts from “worse case scenarios” to “mid-range” to “plausible range of sea-level rise values” without a coherent explanation.

Adding to the confusion, Climate Minister Wong told ABC “Insiders” on 15 November 2009 that:

> 1.1-metre ….is about the upper end of the risk. (Wong 2009)

And in June 2011 Climate Change Minister Combet told ABC News that:

> The sea level rise of up to 1.1 metre…. is at the high end of the scenarios.

A “mid-range” projections has morphed in the government’s mind into the “upper end of the risk”. The politics behind this is not clear, but it demonstrates a risk assessment failure.

International comparisons

Whilst Australia’s high-end scenario stands at just 1.1 metres, others including the United States’ Government and the European Union are taking a different approach in recognising that more extreme events are possible, and need to be assessed.

A new report published last month by the US Department of Commerce and the National Oceanic and Atmospheric Administration (Parris et al 2012) notes that:

> Scientists have very high confidence (greater than 90% chance) that global mean sea level will rise at least 8 inches (0.2 meter) and no more than 6.6 feet (2.0 meters) by 2100.

The report says that "identifying global mean SLR estimates is a critical step in assessing coastal impacts and vulnerabilities" and recommends four scenarios:

- The lowest sea level change scenario (8 inch rise) is based on historic rates of observed sea level change. This scenario should be considered where there is a high tolerance for risk (e.g. projects with a short lifespan or flexibility to adapt within the near-term)
- The intermediate-low scenario (1.6 feet) is based on projected ocean warming
- The intermediate-high scenario (3.9 feet) is based on projected ocean warming and recent ice sheet loss
- **The highest sea level change scenario (6.6 foot rise) [2 metres] reflects ocean warming and the maximum plausible contribution of ice sheet loss and glacial melting. This highest scenario should be considered in situations where there is little tolerance for risk**. (emphasis added) (Parris et al 2012)

The previous month, in November 2012, the European Environment Agency released "Global and European sea-level rise (CLIM 012) Assessment" which concluded that:

> Projections of global mean sea-level rise in the 21st century range between 20 cm and about 2 m. Modelling uncertainty contributes at least as much to the overall uncertainty as uncertainty about future GHG emissions scenarios. It is likely that 21st century sea-level rise will be greater than during the 20th century. It is more likely to be less than 1 m than to be more than 1 m…
> The major conclusion from recent studies is that it is still not possible to rule out GMSL increases during the next century of up to approximately 2 m…

> In summary, the highest projections available in the scientific literature should not be treated as likely increases in 21st century sea level, but they are **useful for vulnerability tests against flooding in regions where there is a large risk aversion to flooding, or the consequences of flooding are particularly catastrophic.** (emphasis added) (EEA 2011)

What the science says about a 2-metre projection

Recent peer-reviewed research on projected sea-level rises to 2100 includes:

> On the basis of calculations presented here, we suggest that an improved estimate of the range of SLR to 2100 including increased ice dynamics **lies between 0.8 and 2.0 m.** … these values give a context and starting point for refinements in SLR forecasts on the basis of clearly defined assumptions and offer a more plausible range of estimates than those neglecting the dominant ice dynamics term. (Pfeffer et al 2008)

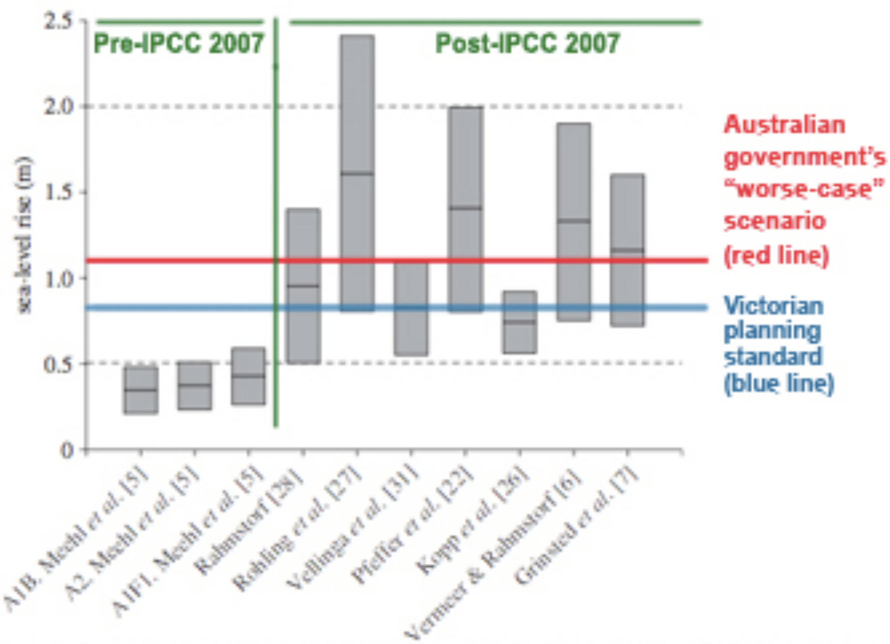
> For future global temperature scenarios of the Intergovernmental Panel on Climate Change's Fourth Assessment Report, the relationship projects **a sea-level rise ranging from 75 to 190 cm** for the period 1990–2100. (Vermeer and Rahmstorf 2009)

> The range of future climate-induced sea-level rise remains highly uncertain with continued concern that large increases in the twenty-first century cannot be ruled out. The biggest source of uncertainty is the response of the large ice sheets of Greenland and west Antarctica. Based on our analysis, a pragmatic estimate of sea-level rise by 2100, for a temperature rise of 4 degree C or more over the same time frame, **is between 0.5m and 2m**— the probability of rises at the high end is judged to be very low, but of unquantifiable probability… Climate-induced rise of relative sea level during the twenty-first century could be larger than the widely reported absolute numbers published by the IPCC AR4, **and a rise of up to 2m is not implausible but of unquantifiable probability**. (Nicholls and Marinova 2011)

A note on IPCC 2007: The 2007 ICC Fourth Assessment Report projections on sea-level rise of 18-59 centimetres to 2100 were far too low because they did not make any allowance for melting of the polar icecaps. The IPCC report contained the following qualification: “Because understanding of some important effects driving sea-level rise is too limited, this report does not assess the likelihood, nor provide a best estimate or an upper bound for sea level rise.” It added that the official projected sea-level rise of 18–59 centimetres this century did “not include uncertainties in climate-carbon cycle feedbacks nor the full effects of changes in ice sheet flow, therefore the upper values of the ranges are not to be considered upper bounds for sea level rise”.

The relationship between the IPCC projections and more recent research is illustrated in Figure 2, adapted from Nicholls et al (2011).

Figure 2: Projected sea-level rise ranges to 2100 compared to Australian Governments “worst-case” scenario



Projected sea-level rise ranges to 2100 (from Nicholls and Marinova 2012)with Australian government “worst-case” scenario (red line), Victorian planning standrard (blue line) and pre- and post-2007 research (green)

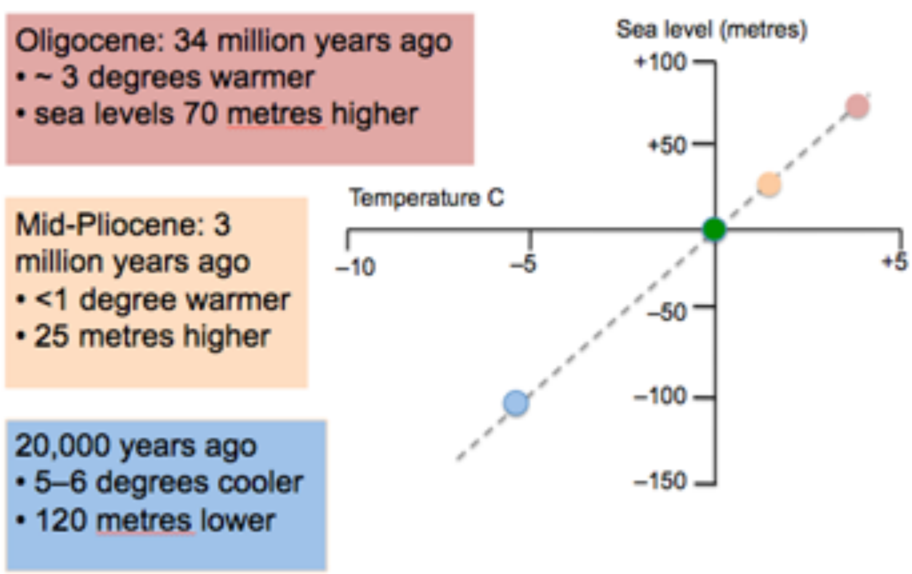
How high could sea levels go?

Managing risk for rising sea levels is a process that is rarely extended beyond 2100. But our society is making some very long-term decisions (new urban developments, infrastructure corridors) whose effects will flow well past that time. So it would be prudent for decision-makers to understand the long-term implications of climate change for sea-level rises and the future of our coasts.

Global temperature and sea-levels are intimately related: in warmer conditions ice sheets melt and global sea levels rise; in cooler conditions, more ice accumulates and sea levels fall. Research into past climates finds that:

- During the Oligocene, 34 million years ago, temperatures were ~3 degree C warmer than today and sea levels were 70 metres higher than today.
- During the early-Pliocene, 3 million years ago, temperatures were ~1 degree C warmer and sea levels were 25 metres higher than today
- During the last ice age, 20,000 years ago, temperatures were 5–6 degrees C cooler than today and sea levels were 120 metres lower.

Figure 3: Relationship between temperature and sea level (after D. Archer)



As Figure 3 graphically demonstrates, the conclusion to be drawn is that "equilibrium (eventual) sea level change in response to global temperature change is about 20 meters for each degree Celsius global warming". (Hansen and Sato 2012)

To be clear: **in the long term, over several-to-many centuries, each 1 degree C of global warming will raise the global sea level by around 20 metres.**

Three questions may be relevant to this enquiry.

<u>Question 1: How far would sea levels rise given the emissions trajectory the world is now heading along?</u>

It is now widely recognised by organisations as diverse as the International Energy Agency, the World Bank and PriceWaterhouse Coopers — as well as the climate science research community — that with the present policy settings the world is heading for 4 degrees C or more of warming by the end of this century, or earlier. (Schellnhuber et al 2011; Sokolov et al 2012, IEA 2011, PriceWaterhouse Coopers 2012)

The last time there were no ice sheets on the planet – 34 million years ago – sea levels were 70 metres higher than today, yet the global temperature was no more than 3 degrees C warmer than today. (Hansen and Sato 2012)

That we may, through systemic failure to reduce emissions quickly enough, be on the way to melting the great ice-sheets at both poles and raise sea levels by 70 metres over the long term is a bitter truth revealed by study of our past climates.

<u>Question 2: What would be the eventual sea-level rise for the **current level** of greenhouse gases?</u>

Speaking at the release of new and significant research, Aradhna Tripati (2009) said:

> "The last time **carbon dioxide levels were apparently as high as they are today** – and were sustained at those levels – global temperatures were 5 to 10 degrees Fahrenheit higher than they are today, **the sea level was approximately 75 to 120 feet higher than today**, there was no permanent sea ice cap in the Arctic and very little ice on Antarctica and Greenland." (emphasis added)

This is consistent with Rohling et al (2009) who find that:

> Even if we would curb all CO2 emissions today, and stabilise at the modern level (387 parts per million by volume), then our natural relationship suggests that sea level would continue to rise to about 25 metres above the present.

By comparing reconstructions of atmospheric CO2 concentrations and sea level over the past 40 million years, researchers based at the National Oceanography Centre, Southampton have found that atmospheric greenhouse gas concentrations similar to the present (almost 400 parts per million carbon dioxide) were systematically associated with sea levels at least nine metres above current levels, and as much as 31 metres. (Eureka Alert 2013)

And work by Raymo and Mitroca (2012), Hansen and Sato (2012) and others concludes than 400,000 years ago — when greenhouse gas levels were lower than today and the temperature less than 1 degree warmer — sea levels were 6–13 metres higher.

<u>Question 3: How fast could sea levels rise this century?</u>

A final question is whether a maximum sea-level rise projection of 2 metres by 2100 is robust.

Human action is adding greenhouse gases to the atmosphere at a rate of change unprecedented in the last 20 million years. It is therefore likely that impacts and events will also occur at rate for which there is no historical precedent. In the Arctic, 80 per cent by volume of the floating sea-ice in summer has been lost in the last 30 years, and there are forecasts of an Arctic free of sea-ice in summer as early as 2015. This is an astounding event which most scientists until recently did not think would occur for another century. This is but one example of the speed of climate change exceeding the general scientific expectation.

The rate of melt of the Greenland ice-sheeting is accelerating, but the climate models as yet are unable to fully resolve and project how fast that acceleration will be. It should be noted, however, that recent research found the tipping point for the Greenland ice sheet to be 1.6±0.8 degrees C. Recent work has found that there is a relatively short time lag between warming at the poles and the response of sea level rise – which implies the disintegration of the ice sheets. In the case of Antarctica, large ice reductions occur within 400-700 years, and for

Greenland, ice reductions occur very quickly – within 100 years**.**

Past events may provide some guide as to speed of sea-level increase. The head of the US Government's NASA Goddard Institute for Space Studies, Dr James Hansen, wrote in 2004 that:

> The peak rate of deglaciation following the last Ice Age was … about **one meter [39 inches] of sea-level rise every 20 years**, which was maintained for several centuries. (Hansen 2004)

A study of sea-level rises during the last interglacial period 119–124 thousand years ago — when the climate was similar to today's — found average rates of sea-level rise of 1.6 m per century with "**a full potential range for the rates of rise between 2.5 and 0.6 m per century**". It concludes that:

> As global mean temperatures during (this period) were comparable to projections for future climate change under the influence of anthropogenic greenhouse-gas emissions, these observed rates of sea-level change inform the ongoing debate about high versus low rates of sea-level rise in the coming century. (Rohling et al 2008)

And another study of the same period shows rises of **2–3 metres in 50 years** due to rapid melting of ice sheets 120,000 years ago. (Blanchon et al 2009)

This research demonstrates historical precedents for sea levels in the next period to rise by more than 2 metres per century.

Conclusion

Small increases in the sea level can have devastating impact when combined with storm surges and high tides. The difference between a 1-metre and a 2-metre sea-level rise at such events will be in the tens to hundreds of billions of dollars for Australia, but this cost cannot be accurately quantified because the assessment work has not been done

By restricting assessment of sea-level rises in Australia to a maximum of 1.1 metres by 2100 — when the body of evidence clearly demonstrates that a figure of at least 2 metres should be used to determine the impact of extreme events — the government has done the community a great disservice. Basic, sound risk-management practices have been ignored.

It is imperative that this inquiry right this wrong. The Australian people have a right to know how extreme coastal impacts could affect them, so that they can make fully-informed choices. At the moment, they have been left at sea.

Duty of care: A personal note

I am not a scientist, or a professor at a university. I am just a normal person who takes an interest in what is going on in the world. Every day, for the past two years, I have posted a list of environmental news articles on the LIVE website at www.live.org.au. These articles are collected every day from Australia's major daily newspapers, and the ABC. You can see each day's list here www.live.org.au/home/daily-news.

I read these articles, I understand them, and frankly I am very afraid of what awaits us in the future. Perhaps the one advantage of being 65 is that I will be dead before the worst of it happens. But my children, and grandchildren, and their descendants, for countless generations to come, will live miserable lives because of this generation's failure to act on climate change.

It seems to me that any reasonable person recognises that climate change is a reality. Its effects are being felt now. The longer we delay taking serious action to seriously mitigate carbon dioxide emissions, the greater the cost, and the less likely we will be able to avert disasters caused by extreme weather in the future.

The Australian Government has a duty of care to protect its citizens in time of war. Well, climate change will become never-ending war of unimaginable horror. Climate change is a creeping cancer that will progressively consume our civilisation.

Australia, acting alone, will not avert this disaster. But on a per-capita basis Australia is amongst the world's worst carbon-dioxide-emitting countries. If you add the carbon dioxide emitted when the coal we export is burnt, we are the worst.

Surely Australia must lead in doing whatever it can do, whatever the economic and political cost, in setting an example for other countries in how it acts on climate change.

David Robinson
LIVE

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