



7.4 CLIMATE CHANGE IMPLICATIONS FOR THE ROYAL AUSTRALIAN NAVY

Commander Stephen Cole

My objective today is to provide a perspective from someone who lives in the South Pacific. This is a photo of Sydney, and I live not far from there, but that is our main fleet base right in the heart of Sydney. What I would like to talk to you about are some of the key challenges posed by climate change to the Royal Australian Navy and to those who reside in the Pacific region.

We have already heard several presentations on climate change, so I will go over this fairly quickly. One of the issues that I bring to my people at home when I speak to them is that we are talking about fossil fuels here. We are talking about sequestration of carbon that occurred over a period of 60 million years, some 300 million years ago, and we are digging up this material and we are burning it. It was stored as coal, oil, gas, etc., and that accumulated CO₂ is being released rapidly into the atmosphere by human activities. And Australians are the source of some of that activity.

Commander Stephen Cole is a Reserve officer in the Royal Australian Navy with 25 years service as a seaman officer on Navy landing craft and patrol boats, and as a diving officer. Steve then worked as Port Services Manager at Darwin Naval Base for some years and led the organization during the East Timor crisis in 1999. Steve joined Navy Headquarters as Navy Environment Manager in 2001 to help guide environmental policy and compliance of the service. Key areas of focus include disposal of obsolete vessels, compliance with international conventions, and mitigation measures to manage potential environmental impacts. Before his Defense service, Steve was a lecturer in the Science faculty at Charles Darwin University, having previously completed a B.Sc. (Hons.) in marine biology and a Ph.D. in eco-physiology. An ongoing interest is to understand the impacts of climate change on the Australian environment.

Some 85% of our electrical energy is provided by coal. In my lifetime, I have been involved with climate change research. I started doing my undergraduate studies around 1980, and at that time I had an infrared gas analyzer that I used to measure plant photosynthesis. In the early 1980s, when I zeroed out the gas analyzer at the start of my measurements, it showed an atmospheric CO_2 concentration of about 338 parts per million. Figure 1 shows an almost lineal increase in CO_2 levels; currently it is up around 380 parts per million. So in the time that I have been involved in the science of climate change, we have seen about a 20–25% increase in CO_2 levels.

Figure 1 is an interesting graph, for those of you who have not seen it before, because the black line is the South Pacific increase, and, in the Northern Hemisphere locations, you can see a distinct sawtooth pattern. And I find it really interesting. You can look at these graphs and you can see that the Northern Hemisphere has most of the land in the world. The Southern Hemisphere is mostly oceans. And so the Northern Hemisphere pattern is superimposed with the summer–winter cycle of productivity.

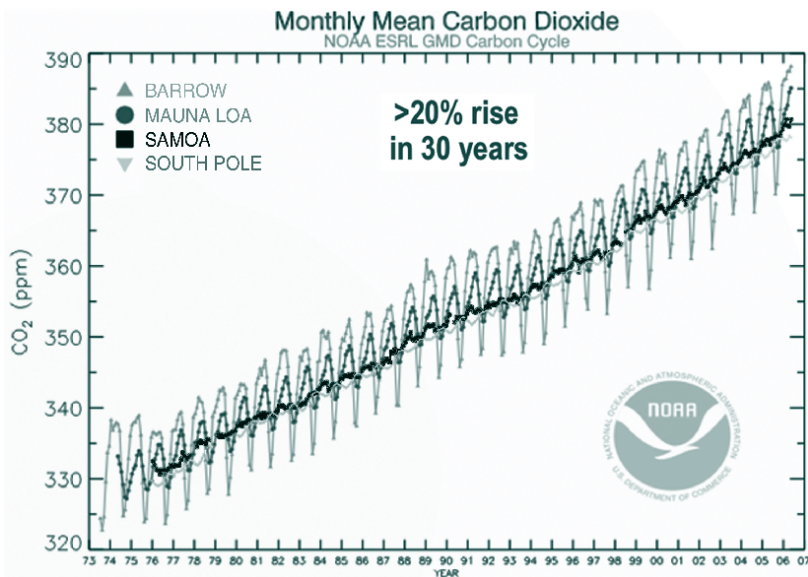


Figure 1. Carbon Dioxide and the Atmosphere

As for climate change challenges, the fourth Intergovernmental Panel on Climate Change report stated, “Warming of the climate system is unequivocal, as is now evident from observations of increases in global average air and ocean temperatures, widespread melting of snow and ice, and rising global average sea level.” [1] Note that the statement uses the word “unequivocal.” We are seeing changes to air and ocean temperatures. The vast majority of glaciers in the world are retreating. We are also seeing reductions in ice caps and rising sea level.

I am now going to discuss some of the regional impacts that are likely from climate change. The west Pacific and the Pacific region differ substantially from the Northern Hemisphere, and I will talk a little bit about that. I will talk about some of the vulnerabilities that the Royal Australian Navy faces and some of the challenges they face. And I will talk about some of the strategies that we might be able to use to avoid those vulnerabilities becoming serious.

So first, the primary effects of climate change that we are likely to see include coastal inundation, more frequent and heavier precipitation events, and more intense and longer droughts (Figure 2). Those of you who know a little bit about Australia will know that Australia is often referred to rather poetically as “the land of drought and flooding rain.” Well, what climate change is telling us is that this is going to become a lot worse.

- **Coastal inundation**
- **More frequent heavy precipitation events (rainstorms, floods or snowstorms) in many areas**
- **More intense and longer droughts over wide areas**
- **Higher sea states and wind speeds**
- **Water and resource scarcity**
- **Degradation/changes to natural habitat and species resilience/distributions**
- **Increasing temperatures**

Figure 2. Primary Effects of Climate Change

I currently live in Canberra, the capital of Australia, not far from Sydney. Over the last 10 years, Canberra has had its three hottest years on record. We have had 9 years of substandard rainfall, and, in one of those years, we received about 20% of our annual rainfall. The one year that we did have average rainfall, it only just met the average. So over the last 10 years, Canberra is about 4 feet short of the cumulative amount of rainfall that it should have had in that period. When I speak to people in Canberra, I tell them that what we are seeing is the effects of 2°C of climate change because that is what the model predictions for Southern Australia are, about a 25% decrease in rainfall. Some of the issues include higher sea states and wind speeds as well as resource scarcity, particularly water.

As I said, Australia is a dry continent. In fact, it is the driest inhabited continent on the planet. Large parts of Australia are already experiencing a serious water shortage. We will see degradations to natural habitat and a reduction in the resilience of species to cope with these changes, and so there will be changes to distributions of species. Many of these things that we are seeing here are critical for countries of the southwest Pacific in particular. We will see increasing temperatures; in fact, we are already seeing those increasing temperatures in Australia with these record-setting years over in the last decade.

The implication for rising sea level in Australian waters is a bit of a tricky thing. Most of you will understand that sea level has a contribution from thermal expansion. As the water gets hotter, it expands. And there is also a contribution from the polar ice cap, melting of ice caps and glaciers, etc. In Australia it is about half and half: the two are causing the sea-level rise. Thus far, we have seen about 6–7 inches of sea-level rise; the Australian Antarctic Division's latest studies predict an additional sea level rise of between 1.0 and 1.2 meters (around 40 inches) by 2100. [2] Those estimates, however, are probably still conservative.

As I have said, the primary causes of sea-level rise are ice melt and thermal expansion of the ocean. As a result, in some locations you will get a larger sea-level rise rate than in another location.

The iceberg shown in Figure 3 broke off from Antarctica earlier this year. It is about twice the size of the Australian capital territory or, for you Americans, about four times the size of Rhode Island. As you may be aware, Antarctica is an unusual continent in that a significant portion of West Antarctica is actually well below sea level. The ground there is covered by an ice cap that is roughly 3 kilometers thick. Between the ice cap and the bedrock beneath is a layer of water that is between 100 and 500 meters deep. One of the many climate unknowns is how quickly that system will become unstable. There is a lot of research going on in the Antarctic Division in Australia in an attempt to understand what the implications are for sea-level rise if there is an instability in the west Antarctic ice sheet.

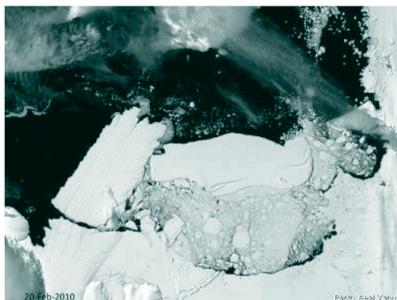
As shown in Figure 4, measured sea-level rise at Sydney currently stands at about 10 millimeters per year, although the rate is accelerating. The problem that we have and that I foresee is that this temperature that we are expecting over this century is unusual in at least the previous 1300 years. One has to go back around 125,000 years ago to find a time that was warmer than it is now.

■ **Rising sea level in Australian waters**

- About 6-7 inches (150 mm) in the 20th century
- Predicted 40 inches (1.0-1.2 m) by 2100 (AAD estimates)

■ **Primary causes: Ice melt and thermal expansion**

■ **Thinning ice caps in west Antarctica**



2500-km² iceberg calved
February 2010
Photo courtesy of AAD [2]

Figure 3. Regional Effects of Climate Change

0.5m sea level rise by 2050, ca. 1.2 m by 2100 (ACE CRC Report 2010)

- Sea level rise for Sydney currently 10 mm per year and is accelerating.
- Paleoclimate information supports the interpretation that the warmth of the last half century is unusual in at least the previous 1300 years.
- The last time the polar regions were significantly warmer than present for an extended period (about 125,000 years ago), reductions in polar ice volume led to 4 to 6 metres (of sea level rise.

Figure 4. Coastal Inundation Facts [3]

At that time, sea level stabilized 4–6 meters higher than it is today. Given our predilection as a species for living on the coast and the incredible density of infrastructure on the coast, I find it difficult to understand how, as a society, we can cope with 4–6 meters of sea-level rise, if that eventuates.

It is quite clear that temperatures are increasing. You can see it on the graph provided as Figure 5. This is one of many graphs

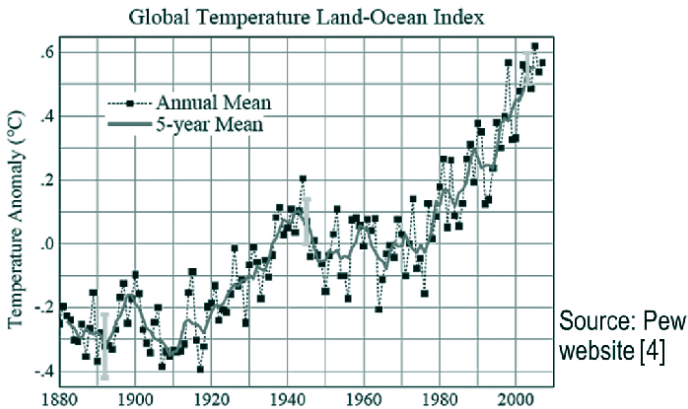


Figure 5. Rate of Energy Consumption with Increased Temperature

available that show this increase in temperature that is being caused by climate change impacts. That will only lead to higher energy consumption. Already in Australia we are seeing an explosion in the numbers of air-conditioning systems fitted to houses. So it is difficult to see how we can constrain our energy consumption in a situation in which we are getting significant temperature increases.

Figure 6 shows the storm incidence in the North Atlantic, but I can assure you it is exactly the same in the area in which I live. The problem that it creates for us is that because there is more energy coming into the system, the storms are liable to be more violent, with higher wind speeds and great sea states. And that creates real challenges for operating and also increased responsibilities for search and rescue and aid to the civil community.

I would also like to point out some of the key issues that I feel are a little underestimated with regard to climate change. The most important impact for the Australian Navy is liable to be related to infrastructure. We have roughly the same value of infrastructure in our shore establishments as we do in our 60 ships and aircraft. But there is not as much focus on the infrastructure because it just is

- Severe storm incidence will increase
- More energy in system

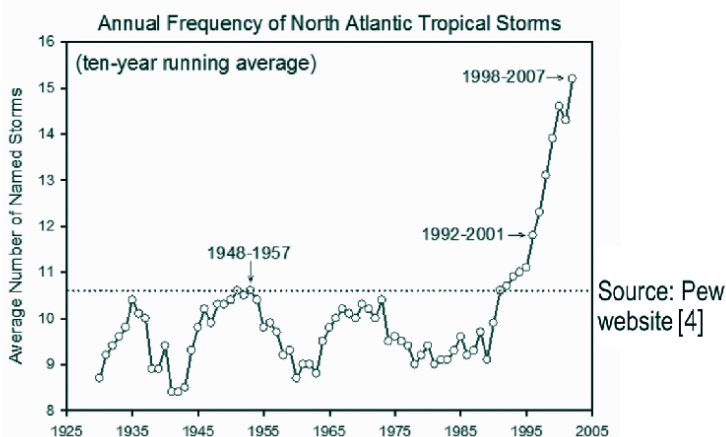


Figure 6. Number of Severe Storms in the North Atlantic

not as interesting. Because all of our infrastructure is on the coast, it is vulnerable to sea-level rise. It is vulnerable to changes in intensity of storms. And so we will see the types of problems outlined in Figure 7.

The first example of sea-level-rise impact will be through storm water drainage-type systems, which require a head to allow the water to flow. And once you lose that head, or part of it, these systems break down. And having spoken to other navies, they have similar issues with infrastructure that is aged and at the limits of its capability. Coping with increased stresses will require that money be spent to repair the systems. There are liable to be issues related to the performance of breakwaters and other sea mitigation devices. Depth clearance will be an issue. Wave action can pop the wharf off its footing, so we are going to have to start looking at these issues. So there is a propensity for more maintenance, which will drive up the costs for these systems. There will likely be loss of some coastal facilities simply because they do not have enough height above sea level.

As I have said, the problems in the South Pacific, and in the Pacific in general, are very different from those in the Northern Hemisphere. We have to remember that many of the people who live in these countries are subsistence farmers or subsistence fishers.

Infrastructure impacts:

- **Reduced performance of stormwater drainage systems**
- **Reduced performance of breakwaters**
- **Reduced wharf deck clearances**
- **More maintenance, greater costs**
- **Increased energy requirements**
- **Loss of some coastal facilities**



Figure 7. Climate Change Infrastructure Implications

They rely on a lot of foreign exchange coming from tourism. So the health of their coral reefs and the health of their ecosystem are fundamental to their survival. Climate change predictions include bleaching of coral reefs as well as damage to fishery stocks, movements of some fishery stocks, and loss of others. Many of these countries are not currently managing their fisheries in particularly sustainable ways. So there is potential for loss of fisheries. There is potential for loss of coral reefs. Such issues are very much at the heart of the problem for many of these nations that rely on tourism for the majority of their foreign exchange.

It also seems likely that climate change will have a destabilizing influence on regional security (Figure 8). There is even the potential for loss of some sovereign nations, one of which is the tiny island country of Kiribati. Kiribati is pretty easy to find on a globe. Look for the equator and then find the spot where the equator meets 180 degrees of longitude—the International Dateline. The island of Kiribati occupies that spot. It is home to a few thousand people who rely on subsistence agriculture. Unfortunately, their land is only a couple of feet above sea level. Once they are inundated, they have nowhere to live. So, if you want to think about the nations that will be the first to be impacted and lost as a result of climate change, the Pacific is where you have to look, and Kiribati is probably the most vulnerable of all of those nations.

Impacts on regional countries:

- High proportion of population in coastal areas
- Some countries very low lying
- Loss of fisheries
- Less developed countries lack resilience
- Destabilising influence on regional security
- Potential loss of some sovereign nations
- Climate refugees from SW Pacific and elsewhere
- Increased Defence civil community aid requirements



Kiribati Flag

Figure 8. Impact of Climate Change on Regional Countries

This will lead inevitably to the appearance of climate refugees in this region. It is interesting to note that New Zealand has already offered to take the entire nation of Kiribati when their country goes under. When that happens, I think it will be a walk-up call for all of us, alerting us that we need to do something about this issue. I hope that it will serve as a catalyst to get further action on climate change. It is quite clear, also, that increased defense civil community aid will be required. Those people will need to be evacuated. They will need support.

In terms of operational impacts on the Royal Australian Navy, I believe it is very similar to all of the statements that have been made with regard to the U.S. Navy. We have particular vulnerabilities because we have a smaller Navy, and most of our platforms are significantly smaller than those used by the U.S. Navy. Figure 9 shows helicopter operations on the left and replenishment at sea on the right. Both of those activities are limited by sea state and wind speed. All of the predictions for our region are that sea states and wind speeds will get higher. If that happens, it has the potential to impose limits on when these activities can be undertaken.

Second, in terms of operational impacts, illegal fishing is already a large issue for Australia. We manage our fisheries resources very

Operational impacts:

■ Challenges to maintaining capability at sea



Maritime helicopter and RAS operations are sea state limited, and sea states may increase in many areas.

Figure 9. Operational Impacts as a Result of Climate Change

closely, and so we tend to get other nations' fishermen coming into our Economic Exclusion Zone to take fish. We typically have to bring in 600–800 illegal fishing vessels each year. But I expect that those numbers will increase because the effects of climate change mean that fishing will become less predictable and there will be more pressure on the system, so less fish.

Search and rescue is bound to increase. You have probably seen this photo of the *MS Explorer*, which hit ice and foundered a year or so ago (Figure 10). Australia is responsible for providing search-and-rescue capability over about one-seventh of the world's ocean area—a huge area. We already anticipate that the increase in tourism that will come as ice diminishes in the Southern Ocean, and the increased fishing access that will go on as conditions become more mild in the Southern Ocean, will mean that there will be more ships and more aircraft and more fishing vessels operating there. As a result, it is more likely that you will have problems like this occurring.

In terms of resilience to climate change, I think it is fairly easy to say that we need to get bigger platforms. One of the challenges to operating in high sea states and high wind speeds in small vessels is that it is pretty uncomfortable. As you can see on the

Operational impacts:

- Increased Defence civil community aid requirements
- Search and rescue obligations will expand from more extreme weather events and increased access to the Southern Ocean



MS Explorer
Source: *The Age* [5]

Figure 10. Additional Operational Impacts as a Result of Climate Change

left in Figure 11, we have been using LPA ships that are ex-U.S. Navy ships. They are soon to be replaced in the next few years by a Spanish-designed landing helicopter dock (shown in the right panel of Figure 11). That represents about a threefold increase in the size of the vessel.

Although climate change has not motivated that change, it will assist us in meeting some of the challenges that we can foresee from climate change. Something similar is happening with our patrol boats. In the time that I have been involved in the Navy, we have had three classes of ships that have paid off. Figure 12 shows two museum ships alongside our latest patrol boat and gives you a fairly good snapshot of how, as the problem of illegal fishing and maritime patrol has expanded, the capability requirement that we have needed has also expanded and we have gone up about four to five times in terms of the size of platform.

Again, that process means that we have more capable platforms to assist with the types of impacts we expect from climate change. In terms of shore infrastructure, one of the things that I have started to initiate is a review of that infrastructure because I think that the largest cost for the Royal Australian Navy will inevitably be that for

- **We will need bigger, more seaworthy and more capable ships to cope with projected operational requirements and limitations imposed by climate change.**
- **Most current ships are being replaced with larger vessels.**
- **Eg from LPA (8550 t) to LHD (27,000 t).**



Figure 11. Ways to Build Resilience to Climate Change

- Patrol boats: more flexible capability and larger to meet increased surveillance and interdiction requirements



Figure 12. Latest RAN Patrol Boat (Left) with Older Versions

our infrastructure (Figure 13). What I have been asked to do is get a panel of people together to look at all of our sites and do a risk analysis that will allow us to identify the locations that are most likely to be impacted by sea-level rise.

- Improving shore infrastructure resilience is challenging
- Likely this will be the largest cost imposition on Defence

Key issues:

Wharf decks/hardstands
Buildings
Drainage systems
Wave mitigation devices
Berthing and wind/wave action

Key attributes:

Location
Elevation
Substrate
Infrastructure value
Cost of modifications



HMAS Stirling
(Fleet Base West)

Figure 13. Shore Infrastructure Issues and Climate Change

We will be looking at wharf deck heights, the height of hard stands above sea level, the effectiveness of drainage systems, and the impacts that you are going to get from changes to wind speed on the ability of large ships to berth alongside the wharfs. As shown in Figure 13, HMAS *Stirling*, which is near Perth on the southwest corner of Australia, is situated in low-lying country. We already have afternoon wind-speed problems with berthing ships. With climate change, those types of problems are likely to continue.

Finally, I would just like to show you an example. When I travel each year from Sydney to Adelaide to visit with my sister, about halfway across I pass Lake Boga in outback New South Wales. The image on the right in Figure 14 shows what Lake Boga looks like today, after 10 years of extended drought. Because the predictions for the southwest corner of Australia are rather dire, I expect that it will be some time before we again see the view shown on the left.



Figure 14. Lake Boga in the Past (Left) and After 10 Years of Drought (Right)

REFERENCES

1. IPCC, *Fourth Assessment Report: Climate Change 2007*, IPCC, 2007.
2. Australia Antarctic Division, <http://www.antarctica.gov.au/>.
3. Antarctic Climate and Ecosystems Cooperative Research Centre, *Large Iceberg Breaks off the Mertz Glacier in the Australian*

Antarctic Territory, 26 Feb 2010, http://www.acecrc.org.au/drawpage.cgi?pid=news&sid=news_media&aid=797707.

4. Pew Center on Global Climate Change, www.pewclimate.org.
5. The Age, *The Sinking of the MS Explorer in Antarctica*, 5 Dec 2008, <http://www.theage.com.au/photogallery/travel/the-sinking-of-the-ms-explorer-in-antarctica/20081205-6s8l.html?selectedImage=5>.