Edited transcript of:

Prof Chris Battershill's presentation entitled:

Marine Reserves Biodiversity – More Than You Bargain For
Baselines, resilience and the blue economy

With the focus on Akaroa Harbour and the establishment of marine reserves in general, Chris will discuss a wide array of attributes of marine protection.

Monday 2nd March 2015
Akaroa Bowling Club

Tonight I'm going to talk about the biodiversity conservation with a focus on marine protected areas and also to try and broaden the focus a little and to present some of the elements where marine reserves are enormously important.

The blue economy is a term that describes aquaculture and bio-discovery which includes sourcing drugs from the sea. While these activities are juxtaposed with the idea of marine conservation, they are all in fact intertwined with our understanding of the marine estate.

It was about 25-30 years ago when I last dived in the Akaroa marine reserve area. I started off working in and around Flea Bay when I was doing a post-doctorate with the University of Canterbury with the cancer research group lead by Murray Munro and John Blunt. Flea Bay is an enormously important area and I'll talk about this a little later on in terms of what the biodiversity supports.

I photographed the intertidal area of Gisborne only a few years after the marine reserve was established and already in the inter-tidal zone you can see crayfish. In many marine protected areas they do well and in others they do not and we'll talk a little more about that.

I will talk more about the breast cancer active drug Halaven later. There is a connection between Halaven and Akaroa Harbour because of the way that it was advanced through the clinical trials. This was reliant in significant part to aquaculture linked into the salmon farm in Akaroa. Halaven was developed from the yellow slimy sponge which was identified in Akaroa Harbour.

Diving at the Akaroa Heads reveals a myriad of colours and marine life. To me as a sponge biologist/ecologist this is just beauty personified, particularly as this marine life is really starting to interact, and this is where interesting things are starting to happen in the chemistry. This is where the biodiversity is at, the algae and the marine encrusting organisms. It might surprise you to know that for a $10m^2$ area (this is a standard unit that I've been using just to compare the diversity of these bottom types of communities around the planet), there are about 50 species. At least 10% of them are unknown; that is they are either new to the area or new to New Zealand or haven't yet been described but potentially were new species when we looked at them. We had some of the best experts in the world when we were diving with the National Cancer Institute collection programme all those years ago. We had very high levels of new species being discovered all the time and at least 25% of them are endemic in that they are not found anywhere else. So that means over very short spatial scales as you move around the coast different things were being found.

I'll go out a little bit now to the scale of the planet and we'll come back to where Akaroa fits in in terms of the biodiversity stakes.

In 2010 the first phase of a census of marine life was undertaken. There was an international programme which was funded by entrepreneurial and philanthropic grants. All around the planet marine scientists endeavoured find out how many species there were on the planet. There are 250,000 species of the things you can see, sponges, seaweeds, crabs, marine mammals and things like that and we knew there's a lot more and that this was the tip of the iceberg. It is estimated there's about a million, or another 750,000 yet to be discovered.

Our patch of the world has the fourth or fifth largest EEZ (Exclusive Economic Zone) globally depending on whether you include some of the extension of the continental shelf. The continental shelf around NZ is about 1% of the earth's surface. In NZ we are officially listed in terms of encrusting marine life, plants and animals as having a little over 17,000 species so we have 14% of the known species complement on the planet for 1% of the earth's surface. For a country that does not have a Great Barrier Reef it is still doing incredibly well. Based on that, New Zealand is classified as a biodiversity hotspot. The important thing is that many of the species are unique and not found anywhere else. It is like our terrestrial fauna and quite significant really but can be highly patchy in places. So what appears in one space might not seen in another and that means if it's damaged in one space it's unlikely to return.

Marine scientists cut their teeth on an area measuring $10m^2$ in the Leigh marine reserve by recording how many species there are in an area of that size. New Plymouth surprisingly is very high and yet the New Plymouth coastline has breakers coming in, it's very murky and yet even just at 50m off most of that coastal area there is an enormous range of biodiversity.

Ross Island in Antarctica under the ice and biodiversity is very high here too.

In Gisborne the biodiversity is very low and it should be near New Plymouth's levels of biodiversity. We know the counts should have been high by the remnants of skeletal material, the sponges and spicules. These remnants last for a long time in the sediments, so something catastrophic has happened in the Gisborne area.

So biodiversity is patchy but we're losing it at an alarming rate. We're losing it through sedimentation which is the prime culprit but also marine invasions and pollution and all of this against a changing climate.

In some areas around the country after storms there is a pattern of massive land scouring. We are losing the sediment and it's coming in big plumes off the land.

Notably following Cyclone Bola the sediments flowed out over the continental shelf and the inshore area and the area was blanketed. The sediment covered important and diverse communities, particularly the sponge gardens.

After Cyclone Bola we dived in the area and there's a fine layer of sediment, it's only a couple of millimetres thick but it's enough to stop all of the sponge life coming back.

In the South Taranaki Bight which should have vibrant sponge gardens and communities on them but they don't. What's happened here is that muddy rivers have affected the entire South Taranaki Bight area as well as some benthic trawling.

We have a highly degraded environment around the country over very large spatial areas on our continental shelf and our near shore coastal zone. I emphasise we are losing biodiversity fast. The only organisms that can survive in the sediment are the little wispy sponges which are rather like gorse on the land.

During Cyclone Bola about a million tons of mud went out of one river every day. New Zealand is one of the worst countries on the planet with respect to sediment loss from the land. We can be compared to China. The Waipu River for instance loses 35 million tons of mud a year. Valuable top soil is being lost, the farmers' gold. It's roughly the equivalent of the area of eighty dairy farms and 25cm of top soil going out the river every single year.

This is having catastrophic effects on the marine estate. The deeper reef communities are being destroyed. There is a little bit of algae on the top but it is the sponge characterised communities that are important and not only because of the diversity but because of all of the little fishes.

These communities attract their own microcosm of productivity. They attract little shrimps which are eating productivity, carbon and other stuff that's been sequestered down by these sponges and of course juvenile fishes come in and feed off those so they are nursery grounds. These are the stepping stones in the whole ecosystem of connectivity. As scientists we are interested to know what the scale of the loss is and we think it is quite catastrophic in our country.

There is not a firm figure but it's at least 30% of the coastal area of this type is being destroyed and we do not know what the consequences may be. By looking at these organisms we know that they are very important and they exist even in coral reefs. In the Great Barrier Reef the corals start to wither out at about 10-15 metres and they are then replaced by sponge gardens.

For example there is a carnivorous sponge which was recently discovered called a Hart's sponge and it eats little fishes. But any sort of sediment is the kiss of death to this sponge and we are losing them fast. If they are left intact they live for certainly a decade of time but potentially sponges can be hundreds of not thousands of years old. They are highly stable and as it turns out they are important feeders.

To try and understand what these types of organisms do on the seabed we turn to biology and it transpires that they pump an enormous amount of water. If this room was filled up with seawater they could pump it in about three or four hours. They are eating all of the micro-organisms and bacteria and they'll eat and take the carbon out of the water column in certain particular forms. They are enormously efficient. The key figure here is that an average sponge garden might only have about three or four sponges per square metre but will be producing or turning around 4.3 tonnes of carbon per day per square kilometre.

Taking 10m or so of sponge gardens long a 100km of coastline, we know we are losing at least 30% of those gardens. That equates to between 50,000 to 100,000 thousand tonnes of carbon per year. That's carbon that's no longer being sucked out of the water column and being transferred down to the sea floor.

Not only are we losing that biodiversity but we are losing the carbon-generating mechanism that the juvenile fishes eat through the food chain. Thus we are losing those nursery grounds. This is a massive loss and is one of the reasons why we need significant protected areas, in particular with the land sea interface being connected, where the land is also being protected as well so we can start to restore the land and sea connection. Normally we think of protected areas for fishes, but there's an equal need to have protection of the entire inter-link of the food chain in this regard.

Overfished areas may also be destroying the nursery grounds as there is nowhere for the juvenile fishes to go and eat well. Again I emphasise the inter-connectedness and in the interests of vibrant fisheries we need to start thinking a bit more holistically about this and how it effects the environment.

Another massive pressure on biodiversity is marine invasions. This is becoming enormously acute, particularly in the far north. Years ago a Russian fishing vessel had 60 tonnes of black mussels on it which were just scraped off the side and washed into Lyttelton Harbour. The Harbour system now is full of invasives, particularly the Asian algae that is affecting not only fisheries but also the biodiversity of the Harbour. Undaria, once it invades, knocks out the native species rather like gorse knocking out the native trees on the land. It's quite significant especially in Wellington Harbour. Undaria forms a monoculture and grows very densely and produces mucous off the fronds which binds the sediments underneath the canopy. We are facing a massive assault on biodiversity and yet most of the time we don't know it's happening because it's hard to see under the water. Also we are losing all of our benchmarks.

This is the key message of the theme of this talk is *"how do you know what's changed if you can't compare it to what was there originally?"* This is where marine protected areas come in as very important features. They are a benchmark by which we can measure change or recovery.

So the age-old question – do marine protected areas work?

I'll give you some insight into some work that we did over twelve years in Australia which was a massively interesting experience. The Great Barrier Reef Marine Park has led the world in a sense by stipulating that 30% of its area would be protected. This caused an enormous outcry as you can imagine with very angry fishers, who thought they just couldn't make a living any more.

They certainly have a right to think that way as the creator of businesses. The politicians who were promoting this were nervous. The fishers were constantly asking the politicians – *"is it working yet?"* They were desperate to find out whether changes or improvements were happening. One of the ways we researched that was with stereo-cameras, baited underwater camera systems to identify and measure fishes without dive influence. This was a big project.

At the same time we were doing this we also had a look at whether there were the same numbers of fishes seen in a diver-type swim compared to just using a baited camera. Prior to the dive we only saw a sea snake but once we put the remote camera down with a little bag of bait on it all sorts of things turned up. For example the tiger shark came up to the bait, had a little sniff and then went away before returning from a different direction.

The Torres Strait islanders will tell you that you have two chances with a tiger shark because they come up and nudge you a couple of times and then the third time they will come up out of a totally different direction and if you are still there it's all over!

This research delivered some interesting results. In a lot of areas there seemed to be no change. To the dismay of the politicians the evidence was not looking compelling for a marine reserve because only two out of the major areas appeared to be actually working.

The realisation transpired that that those northern reefs in particular were so fished out that there was no viable adult population to reseed even with protection of other populations. Whereas in the reefs with connectivity, including the sponge gardens, there was this flow of progeny coming in. So there was a very important message that the connectivity of these systems had to be considered as well. You couldn't just put in a reserve, although you would get some benefit from it certainly, but it was going to take a long time. It has since transpired that most of these systems are now actually starting to increase.

Another interesting exercise was done with the Great Barrier Reef Marine Park Authority, the James Cook Union and the fishers. We got the fishers themselves involved in the tagging and recapture programmes. So the fishers could see the same adult fish that they were catching each time and they suddenly realised that they weren't moving far.

So a great deal of awareness was built into the whole community about the vulnerability of some reefs and the resilience of others and the need for all the reserves. Following this there was eventually a great deal of acceptance of the whole idea once the reasons were demonstrated.

We've just resurveyed Kapiti Island. I did a survey there twenty something years ago before the reserve was established and I can assure you there were no paua there then unlike now which is showing a very different picture.

Paua like to munch on driftweed that's coming in and a lot modify their environment by moving the shell around. The fishes in the marine reserve are more numerous now and what's interesting is that they are all bigger. Some communities had been so unstable that when they come back they do so in a quite unpredictable manner.

So what can reserves do about sedimentation? One would wonder how on earth can a marine reserve do anything about this all-encompassing sedimentation effect that originates on the land. We have had an opportunity to test that.

At the Te Angiangi marine reserve in central Hawke's Bay near Aramoana in 2011-2012 we had some storm events and there were catastrophic sedimentation events occurring. There is the marine reserve here but it became totally inundated. 150,000 m^3 of coastal inundation and about 1.5m m^2 of regional scour occurred after that storm.

What was presented was an interesting situation because there had been beforehand monitoring of this entire area, and we had an opportunity where there was some before-marine reserve information, after-marine reserve information and then of course we had the sedimentation event into the marine reserve.

We were able to also look at outside the reserve, inside the reserve and then outside again and this time with huge amounts of mud all over the place. It was a natural experiment to see whether there was any inherent resilience within the marine reserve.

To cut a very long story short, it transpired surprisingly that inside the reserve the size of paua and kina were bigger and the numbers greater.

We knew there was still poaching going on and so it's not as if the reserve was totally devoid of human predation. Some poachers were caught as we were working with the tides early in the morning. The additional predation pressure from humans was that much lower inside the reserve and we were seeing higher resilience because there were more juveniles left in the area. So even under this catastrophic sedimentation event and even though it's a tiny reserve it looked like the reserve was effective.

I don't want to go too far with this point because we need to return and re-establish those surveys and see what the trends are doing. We also want to get into the sub-tidal zone and see what the fish might be doing. So some interesting insights have been developed even out of small reserves and the extra resilience that might be afforded to some areas.

This is returns to the theme *"how do you know what you've got until it's gone and if there's been some impact then how do you know if it's recovered or not if you don't have anything to benchmark it against?"*

Let's look at the Rena situation just very briefly. Looking at the shipping routes around New Zealand it's surprising we haven't had a Rena-type event before this. This ship took a short cut, hit the rock at 17 knots and had it been just three or four metres either side it would have missed it.

By world standards the oiling event wasn't that huge as most of the oil was actually recovered. By our standards however it was catastrophic and we haven't seen anything like this before. It is now the second-most expensive shipwreck in the world and has cost $US600m so far. They estimate that to pull the entire ship up is going to be extremely difficult and would cost about $US1 billion. It is comparable to the Costa Concordia. It is arguably the most complex shipwreck in the world because it had heavy fuel oil and then a massive container loss but is in shallow waters with extremely violent seas. Container ships are lost often but usually in really deep water and it sinks in entirety but the Rena is a container ship that has literally been shredded. There are still 300 containers on board and these with the contents are the cause of some of the complexities now. Around the Astrolabe Reef there's a debris field.

The Rena had been starting to benchmark our thinking about other ship incidents, should they happen in the future, bearing in mind that we are a maritime nation. It has also benchmarked our thinking about oil and gas exploration and what would happen if we got a leak of oil in deep water similar to the Rena situation. What would be the impact and how long would it take to recover?

To answer those questions we need to have some comparative benchmarks and sadly we don't tend to have that in this country. We don't really know what's out there in much of the marine area apart from the few marine protected areas that exist.

There is a marine reserve at Mayor Island and we do have that as a potential benchmark for Astrolabe Reef where the Rena is now. It transpired that on the beaches and on the rocky shores there was significant recovery over very short time frames and this was really unpredicted.

It is very difficult indeed to find any effect now even by digging down metres into the sand. On the previously blackened beaches there are no remnants of oil. Around the Reef itself we have a ship that is largely breaking up and we need to understand how the environment will recover. How do you do that if you don't have the beforehand information on this particular reef?

One way is to benchmark it against areas that we know about and we can do that in this situation. We are able to have a look at the speed of recovery and how it might be hastened through removing the debris field. So that's the situation up there at the moment in a nutshell.

The final part of this talk will be looking back again at the biodiversity and this is the 'blue economy' component. I've talked about the need to have integrated communities connected and the importance of even some of the more boring looking organisms that represent repositories of genetic information which can lead to all sorts of interesting discoveries.

In the past there was the thought that by prospecting, someone's going to want to grab tonnes of material to pop it into a drug screening programme.

Fortunately those days are now long gone due to the sophistication of synthesis. About 90% of the synthetic drugs occur in nature, most of them from plants. Indeed chimpanzees have for years consumed medicinal plants. So if the chimpanzee has an infestation of parasites or is feeling sick for some reason, he/she will go and eat a particular plant type. Ethnobotanists have identified some 60% of the chimpanzee's diet is medicinal in one form or another and they have been doing this for a long time.

Many leads have come from the land, mainly the rainforest, but if you look to the sea that's where the diversity is. 90% of the known phyla on the planet have representation in the sea. That diversity represents a chemical complexity and that's where we have an exciting future to explore, particularly in the medicinal area.

There is now new realisation that the microbial realm is even more important than we originally thought. It has been calculated that there are about 38,000 microbes in just one litre of seawater and microbiologists have calculated that there are 100 x 1billion x 1billion x 1billion cells in the ocean. But what is interesting about the dinoflagellates is that they have a lot of genetic material inside them but just why we don't know.

One microbiologist wanted to know just what the biomass of all those bugs in the seawater was, so he virtually calculated how much it would weigh if you filtered the entire globe's oceans and got all the bacteria out. The answer is a staggering weight equivalent to 240 billion elephants. So in Akaroa Harbour there would be about 40 – 100 elephants in bacteria weight depending on whether there's a plankton bloom or not.

We are not certain what all this bacteria does. Certainly the chemistry is complex and we know the bacteria interacts with all the things on the seabed, but also what is important is the connection within the food chain.

Another microbiologist who works on viruses estimates that there are 50 million marine viruses in 1ml of seawater. A virus looks like just a little sprig of chemical material, is highly bioreactive, probably a ball, basically atoms strung together. If you were to stack each of the viruses from the planet's oceans end on end there would be so many of them that they would extend 60 galaxies out into space. These viruses, also biomass, are interacting with bacteria and in turn with all the sponges and they are the origin of a lot of the interesting chemistry seen on the seabed. But the point is that no-one really knows how these masses of biologically reactive components are actually working together. There are big question marks about this.

We are in the situation where we need to understand the productivity of our oceans and fisheries and how the coastal estate works and yet there are big question marks there because we don't know what's normal and what's not any more. We need marine protected areas as reference areas.

One sea squirt presents an example of chemistry in action and this is touching on where the blue economy comes in. The sea squirt keeps the soft coral at bay by manufacturing enormously complex chemicals and it does that by harnessing some of the chemistry of the bacteria and viruses that it's feeding on, so it will munch up the carbon but it will also steal some of the chemistry so it can make these really weird compounds. The chemistry is very potent because there's a lot of water whisking across it yet there is no death along the squirt's membrane. It's enormously potent because the water is getting into the really thick cells but there's no death along the membrane along the leading edge of that soft coral. Relating this to a cancer drug and what is needed for that, we want something that gets into the cells it needs to get into and that's not cytotoxic,

In the sea squirt we can see this huge myriad of microbial, viral and sponge chemistry all coming together resulting in the manufacture of chemistry which has super-subtle activities.

For us to take advantage of that we need to see those interactions and see all that biodiversity working together. The planet is moving to natural products now and not manipulated synthetically, but grown through aquaculture in a mechanism that's sustainable.

In Flea Bay there is an anti-inflammatory compound called pseudopterosin in a little sea fan. It has been used by Estee Lauder in a product called Resilience. This compound has been worth $US7 billion a year to Estee Lauder but is actually synthesised now as it is cheaper to do that.

This is just an example of what might be in the marine estate. 30% of the leads on the US National Cancer Drug Leads are from Australasia and most of those are from New Zealand despite there being hardly any work done in the last few years.

Halaven (Eribulin), a late phase breast cancer drug, was developed after clinical trials and came significantly from the yellow slimy sponge found in Akaroa Harbour and the Marlborough Sounds. Also Peloruside A is another chemical that is found at Akaroa Heads that could be developed as an effective cancer therapeutic.

This is just a brief fly over of a number of targets that are linked to the conservation ethic, that is preserving biodiversity not only because we are losing it rapidly but also to emphasise the importance of having marine protected areas as these reference areas. They are enormously important in their own right to rebuild the ecological interconnectedness. We also need them to benchmark how the rest of the country is changing and believe me it's changing very fast.

We certainly need these networks of protected areas and they need to be quite considerably more prevalent.

I've talked to you about refugia and resilience, a little bit about the spill-over benefits because they are starting to see those, the biodiversity and living biolibraries and the need for benchmarks to check change.

Thank you very much.

Professor Chris Battershill
Chair, Coastal Science, University of Waikato