Botany Bay Forum

University of NSW (UNSW) – Morning Session (Cont'd)

Speakers
Chairperson: Bruce Thom
Speaker 7: Bill Pearson
Speaker 8: Tony Underwood
Speaker 9: Paul Adams

Chairperson: **Bruce Thom**

In association with the tide, depending upon where you are in the Bay, you can get substantial movement or not so much movement. Up at the Cooks River, for example, there's little movement, because the water doesn't go anywhere. It simply sits there and goes up and down, whereas out towards the entrances, down towards Port Botany, there's substantial transport. That's a tidal simulation with no wind, but we can actually incorporate wind and that can make a substantial difference.

Let's try a southwesterly wind. Now the wind direction is indicated in the top right corner. Some of the particles now are able to move in significantly different directions. Down to the bottom area, particles that begin at Kurnell can move almost to the entrance and, indeed, had we put some particles in the entrance, they would have in fact disappeared on the tidal cycle.

A slightly different wind direction now from the south east, the predominant wind throughout a lot of the year. Up in the top right hand corner, for a number of dynamical reasons, there's now a flushing of the area around Cooks River. We haven't incorporated the Georges River here. That's something that can easily be done, of course.

Let me run back now to a couple of other matters that we can now think about. If we were to put tracers throughout the Bay and then wait and see whether the tracers would leave the Bay – once they've left the Bay they don't come back, by the way, in this model – then what would happen is that under conditions of north west wind, which is the bottom line, tracers will leave the Bay relatively quickly. In three to four days, you'll have 75% of tracers which were in the Bay have left the Bay. They have basically been blown out on the outgoing tide and don't come back in. On the other hand, in conditions of south east wind, the tracers are left in the Bay. They tend not to blow towards the entrance, and the tidal exchange has very very limited effect. The transport features of particles within the Bay and how they might escape and how they might flush are dependent very very much on the wind conditions as well as the tide conditions.

Here are some comparisons of particles under different wind conditions. The particles start on the cross and then depending upon the wind, whether it's north east or north west, the particles will move either on the red path or the green path on different winds. You can see that the end trajectory can be quite significantly different depending upon the winds and that was the point I was just making.

I won't talk too much more about the detail of the model. It's a hydro-dynamic model. It's used, obviously, for tracing particles, looking at circulation processes and we can do all the sorts of things that you might want. To this stage the model is developed to a level where it's useful and we're now asking the questions, what are the most important questions to answer with this model? We can answer a range of questions but there's got to be a priority put on these things.

Many thanks to my colleague, Patrick Tinco, for producing the simulations, and I'll leave you with those questions of what is most important? We can calculate where the groundwater plumes. Once they get into the water column, we can calculate where they go. We can calculate how long things will take to flush. We can identify if there is a spill of contaminants anywhere. We've cut off the model, almost self-evidently, at Captain Cook Bridge, but we can extend this further up the river. We can identify how long it would take to flush matters or contaminants from anywhere and a little later on Tony Underwood will tell us about some of the biology. We can track the biology, nutrients, Laval dispersal and so on. We are waiting excitedly to do some more research on some of the applied things.

I'll hand over now to Bill Pearson.

Seventh Speaker: **Bill Pearson**

I'm here representing the Water Research Laboratory. The School of Civil and Environmental Engineering has a laboratory out at Manly Vale which has a long history with the Botany Bay system and Georges River, which probably dates back something like 40 or 50 years, and I'd like to acknowledge the Director of the Water Research Laboratory, Associate Professor Norm Cox, and I'm doing the presentation on his behalf.

What I'd like to do is perhaps stand back and revisit some of the issues that Jason raised and Jerzy and Noel earlier, and just look at water and sediments in estuarine environments. In terms of fresh water, we're looking at terrestrial run off, usually manifested in terms of flood flows, because, as you know in Australia we have a fairly strong flood/drought cycle. We've got the groundwater component, of course, and that's been discussed earlier, as well, and I'll return to some of those issues in a short while. On the other side out in the open ocean we have our marine waters, of course, which are salty and therefore more dense. They have a forcing mechanism that is associated with tides and also with waves coming in through the entrance of Botany Bay. Jason has talked about some of the mixing processes that go in in terms of the Bay in terms of the wind-driven mixing. What I'd like to turn your attention to at the moment is some of the stratified flow issues.

Because we have fresh water and marine water which differ in density, what tends to happen is that, if the flow of the river is from right to left as you look at it here, what we tend to get is stratification of the flow of the water body, where we tend to have fresher waters flowing out over the top of the salty waters of marine origin. This is quite important as we'll see in our next slide when we start to talk about sediments. A number of us at the Water Research Laboratory have been having a look at stratified flows in open waters and, not only is it true in open waters, but it's also true in groundwater systems as well, and my colleague Ian Acworth out at Water Research Laboratory, has been looking at stratified flow systems in groundwater as well, particularly as they relate to jet fuel on the northern side of the Bay.

UNSW Water Research Laboratory

Water in estuarine environments...

Fresh waters

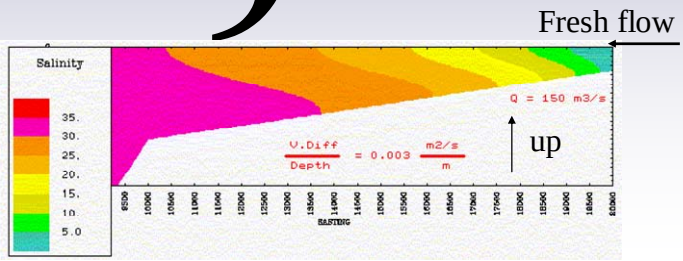
- •terrestrial runoff → flood flows
- •groundwater

Marine waters

- •salty → more dense
- •tides
- •waves

Stratified flow

- •open waters: Peirson, Miller, Cox
- •groundwater: Acworth



If you look at sediments in estuarine environments, they generally settle into a couple of different types, and Alberto referred to that earlier.

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Sediments in estuarine environments

Terrestrial sediments

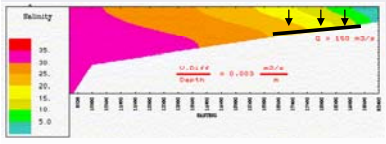
- •Fine water-borne particles → flocculation → deposition of mud beds

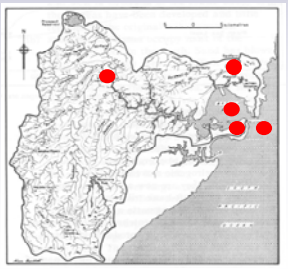
Marine sediments

- •Sand - non-cohesive

Cohesive sediment deposition - Ball, Peirson

Effects of dredging - WRL since 1960s, Cox





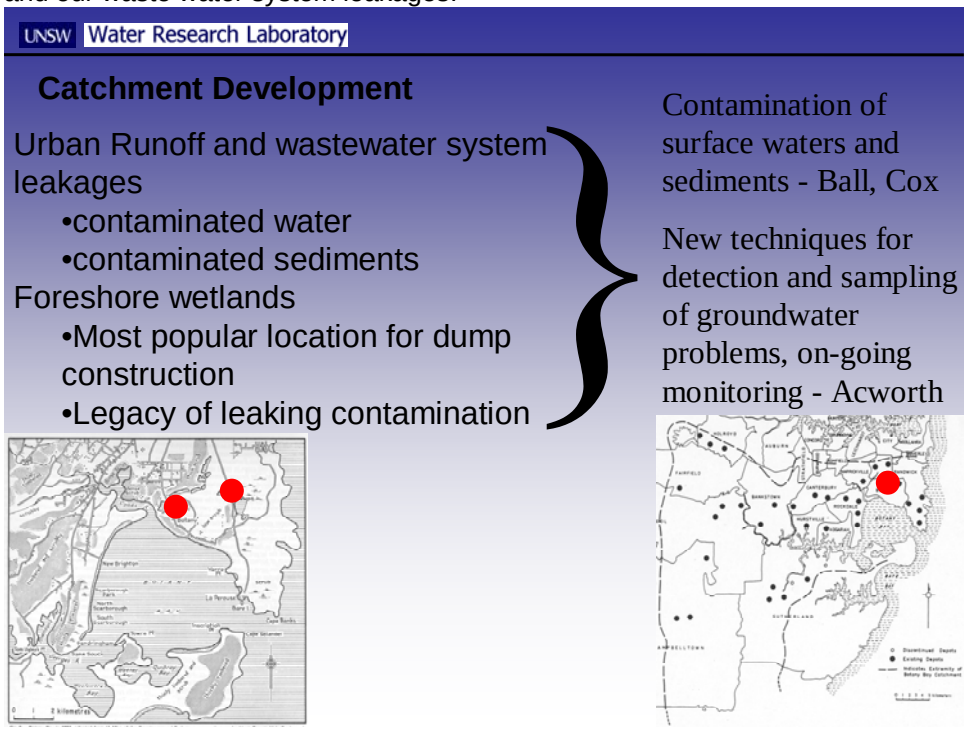
In terms of our terrestrial sediments, probably of greatest concern to us in this context are the fine water-borne particles. We do get coarser material, but in the environment we're talking about, it's these ones we need to focus on more. What tends to happen is that as the fresh water comes in and meets with these saltier waters of the ocean, we get an increase in electric conductivity of the water body overall. These little fellas tend to stick together and flocculate and then we deposit some sort of mud bed somewhere in our estuarine system. On the other hand, our marine sediments tend to be of a more sandy nature and a non-cohesive sort of nature, and so there

tend to be different sorts of characteristics between these two. I'll review some of the work WRL's done over the last 40 years in relation to this.

We've done a lot of engineering research on behaviour of sediments within the Botany Bay system, particularly relating to dredging impacts in Botany Bay itself relating to the extraction of marine sands up in the Georges River system - not always our advice has been taken, I might add - but we have done engineering research in that area. Down the Kurnell Peninsula, that's mostly to do with marine-type material. In terms of the finer material, some work that we've got going on - we've had some students working on this over the last little while; Jim Ball and myself have been looking at cohesive sediments and how they get carried down through these freshwater systems on the northern side.

You may also remember that there were proposed sand extractions offshore Sydney, offshore of Botany Bay as well in the last decade or so.

If we now look into the application of modelling in terms of catchment development, one of our key issues, if we turn back to our freshwater, we've got to try and characterise our urban run-off and our waste water system leakages.

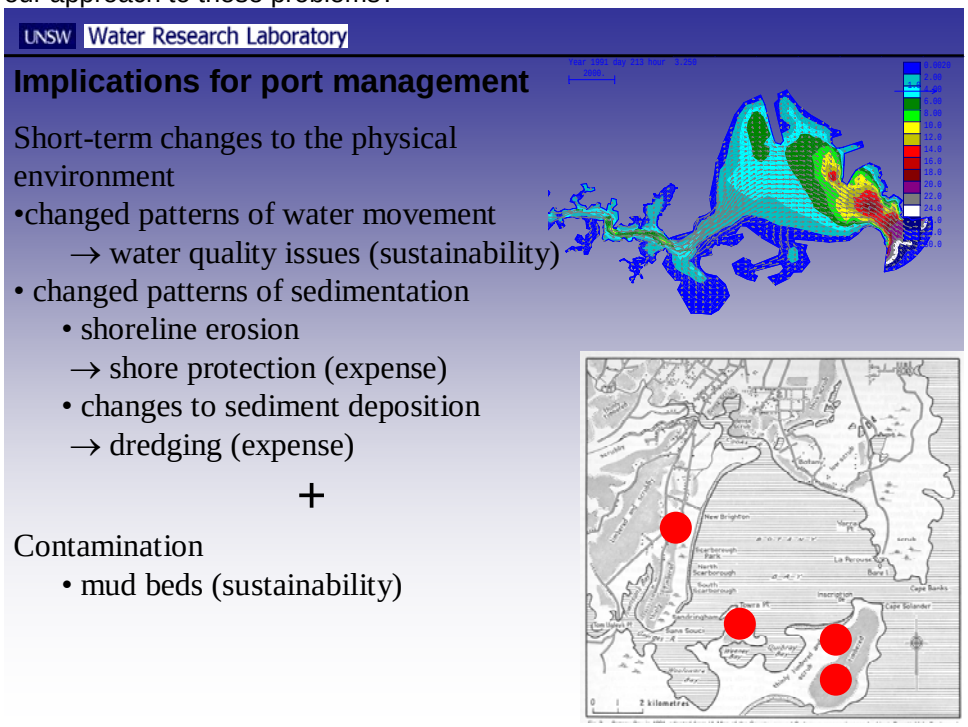


Particularly we're looking at contaminated water released by these materials and contaminated sediments that they might be bearing and there's been quite a bit of work done by Jim Ball and Norm Cox looking at contamination and trying to characterise these surface waters from the urban run-off and their impacts on the sediments. This has been particularly undertaken down in Centennial Park area, where there's a reasonably controlled catchment and we've been able to monitor flows and the quantity and quality going on there. I believe Ron's proposing in coming session to do some more sampling material. We're talking about this area here in the north of Botany Bay in terms of contamination of surface water and sediments.

Foreshore wetlands have been a lovely and popular place for the construction of dumps. Poor old Botany Bay has been no exception to that characteristic of dump construction and there are a lot of dump sites around here. I've actually pulled out some old pictures where various dump sites were around Botany Bay and Ian Acworth has, I guess, been working for about 15 years looking at characterising some of these dumps, particularly on the northern side. I've done some

perhaps less focused work on the southern side on the Kurnell Peninsula as well. There's a network of multi-level piezometer that's been installed there and some of our under graduate students have been involved in that, and a number of post graduate students have done some monitoring as well. Ian's been out at this groundwater work trying to develop some new techniques for detection and sampling of groundwater and looking at some ongoing monitoring issues.

What are the implications for port management, because we do take an engineering direction in our approach to these problems?



In terms of short term changes to the physical environment, what we're looking at is changed patterns of water movement inside the Bay and this is just reflecting some modelling similar to what Jason was showing you a short while ago, where we're looking at the movement of waters in and out of the Botany Bay system and, as Jason pointed out, where we close off areas - this map's not exact, ladies and gentlemen, as you'll be aware, but the principle's the same, this is an older configuration of Botany Bay – where we tend to close off areas of the Bay, the circulation patterns would tend to go down and we're then reliant on the wind mixing to allow water to flow out. We end up with water quality issues, particularly in areas where we start to enclose the embayments, and that raises questions of sustainability. Also, we tend to get changed patterns of sedimentation, as Alberto was talking about earlier. Where we've got lower energy, the finer particles tend to settle out. Also, our finer friends tend to be the ones that attract the most contaminated material, and so we get changed patterns of sedimentation within the water body. We'll come back to that in a moment.

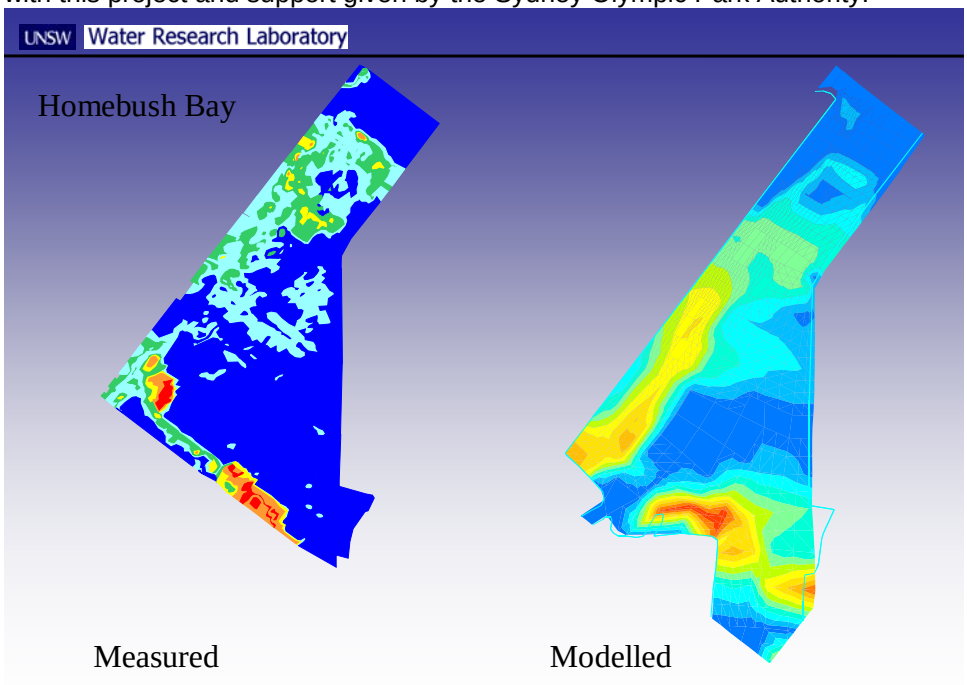
Let's stay with some of the marine, the coarser material for the moment. One particular issue we've seen in Botany Bay – and here's a lovely old picture of Botany Bay down here – If we start changing wave direction patterns due to dredging and that sort of thing, we change the wave energy at shore, we tend to get shoreline erosion, we then respond by constructing shore protection which tends to be a fairly expensive business - I'm not going to go into some of the social and economic issues associated with that but just to draw a circle around it – we also tend to get changes in the way sediments are deposited as we change the geometries of these bays, and then we're forced into some mode of actually dredging sediments, either for management of navigation or changed patterns of fine material deposition and if it's contaminated, we've got a

real problem on our hands in terms of how we actually dispose of that contaminated material. Further up the catchment here, there was actually a significant issue with Centennial Park, as to where they should put some of their dredged material from the bottom of the ponds.

While the coarser material doesn't seem to be too heavily contaminated – people like sand for buildings and things like that, it's usually easy to get rid of – the finer material can be a real headache in terms of planning its disposal.

Going back to our mud beds, if it is contaminated, we've not just got an expense issue; we also have a sustainability issue in terms of what are the downstream effects in terms that you've got a new composition of the bed of the water body. It will, in turn, have impacts for the marine biota and we've got a couple of hot spots around Sydney in that area.

I want to try and show you a little example of how this has been integrated together. On the next page – this is not Botany Bay, this is some work we've been doing at Homebush Bay and I'd like to acknowledge at this point the contribution that some of my colleagues at ANSTO have given with this project and support given by the Sydney Olympic Park Authority.



What we've been looking at here is the contaminated muds within Homebush Bay, we've been looking at the initiation of motion and the fate of those contaminants and what we've done as a first pass, we've revisited some of the patterns of deposition that have occurred in Homebush Bay and have been measured historically by some of the Ports Authorities and there is a creek flowing in here, another creek flowing in here and the Parramatta River system lies up here. What we've examined is the fate of the fine material coming off the catchments into Homebush Bay and over this side we've got our model result here and you can see some of the inputs here, and then we've got some sort of schematic of the sort of deposition that's occurred. We tend to get these deltas forming around the mouths of the creeks and then some settlement in the wider bay system and some small deposition up here near the point. What's been recorded is, again, these delta sort of behaviour around the creek entrances - we've managed to reproduce this pattern of deposition further into the Bay and again they've even got a signature up here. Why there's material here is missing, it's a little bit of a mystery for us. Why haven't we done this in Botany Bay? I guess the key issue is, if you're going to do modelling you need to verify it somehow and you need to put together some sort of package in terms of appropriate monitoring, appropriate

modelling so that we can check that the modelling is giving us the correct answers and we've got some confidence in terms of making predictions of future behaviour.

Thank you very much.

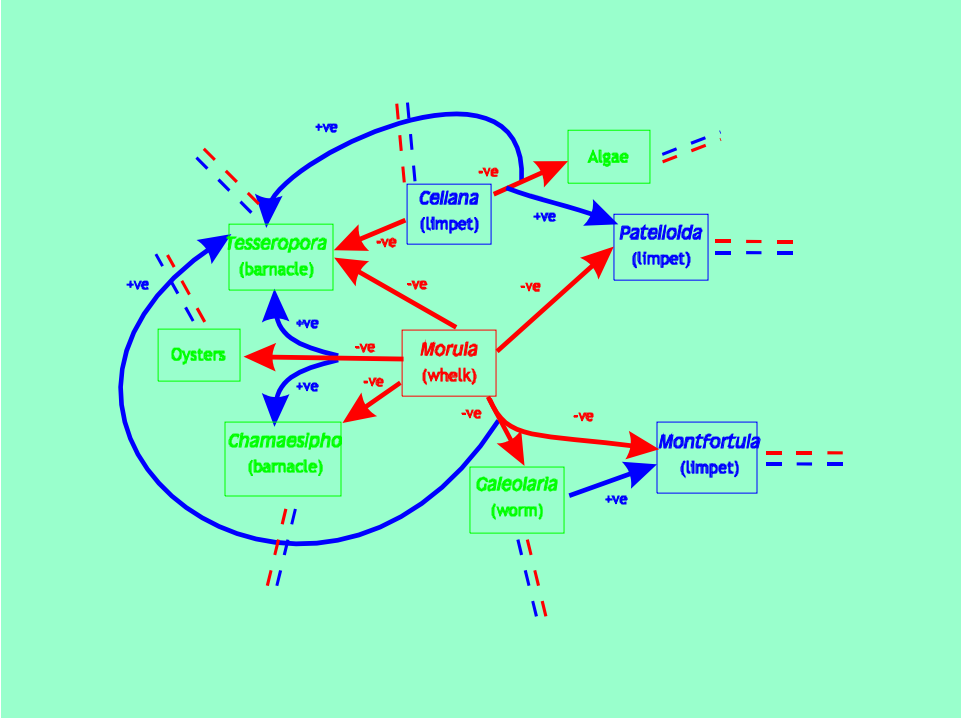
Chairperson: **Bruce Thom**

Thanks very much to both Jason and Bill and also by acknowledgement to Ron for his work there and leadership to that Centre. Now, to ecology, and we have two presentations to wrap up this morning's session. Firstly, Professor Tony Underwood from the University of Sydney and then Paul Adam from UNSW. Tony.

Eighth Speaker: **Tony Underwood**

One of the things that really puzzles me about how to address issues relative to such things as Botany Bay for a group such as yourselves, is whether to do as some of the speakers previously have done and focus on particular and important topics of ongoing problem solving, or whether to try and take some more overview approach. And I'm going to try and take an overview approach, because I looked last week and how many projects of ecological concern are currently going on in Botany Bay that would matter to any future management of development, and there are more than a hundred, so it's six seconds each in a ten minute presentation - I don't see much point in trying to address any of them. Instead, what I'm going to do, is try and give you some insights about what ecologists know about the way we need to progress and the first thing I want to point out is there are, in fact, numerous ecological processes. There isn't THE ecological process as Alberto tried to summarise in the timetable for today. I want to talk about understanding them, how to get control of the sort of research that's necessary, so that it is relevant to problem solving.

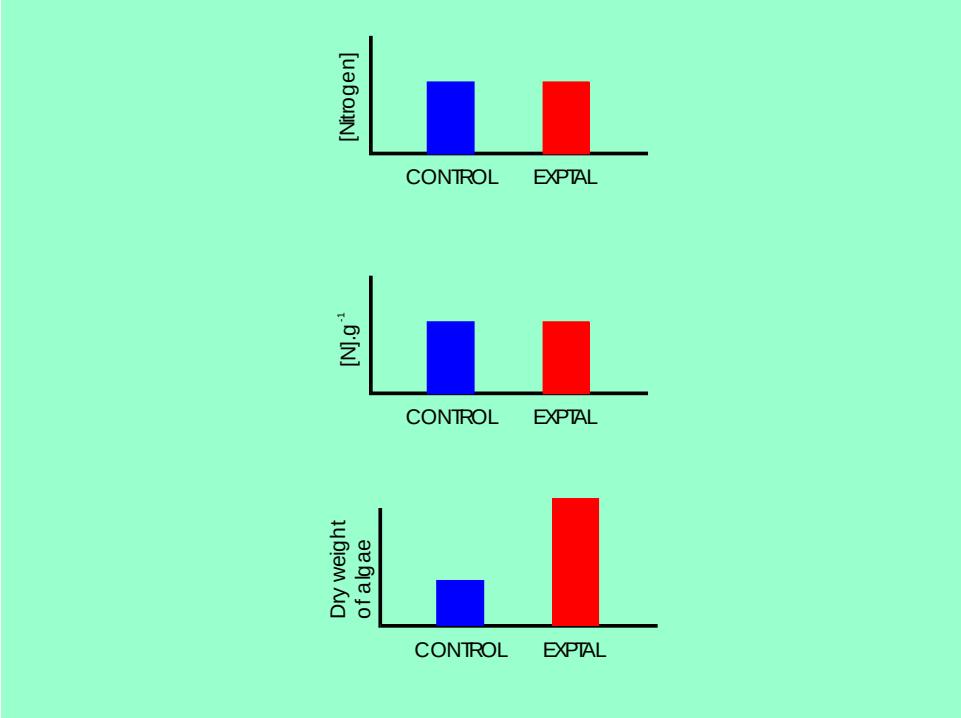
The numerous interactive processes are very complex. I'm just going to show you one small wiring diagram for the interactions among about eight or nine species on a rocky shore in Botany Bay - this work's actually done in Botany Bay - and it really doesn't matter which species you start with, there are complex ecological processes affecting arrivals, departures, interactions, consumption of food, responses to habitat, and so on.



These things are very complex. We know experimental analyses of the simpler parts of the system that there are enormous numbers of factors involved in controlling such things as ecological functions or biodiversity, two of the things which people wish to have some understanding of in areas like Botany Bay. That implies that any ecological analysis is itself going to be complex, it's going to be in control of things you've already heard about. But where the object of the exercise is to understand what is going on with ecology, we only need to do that directly and not try and look at things that are of no relevance at all.

Water quality for most ecological processes has relatively little relevance. That is not true when we're dealing with issues of human health concern and it's not true when there are major intrusions of contaminants, some of which we've just heard about.

By and large, it isn't useful to measure water quality if the object of the exercise is to understand ecology. In a small example of work done in Tuggerah Lakes, Wyong Council – it doesn't have axes – the top graph was supposed to be the Y axis actually says in the original this is the amount of nitrogen in the water.

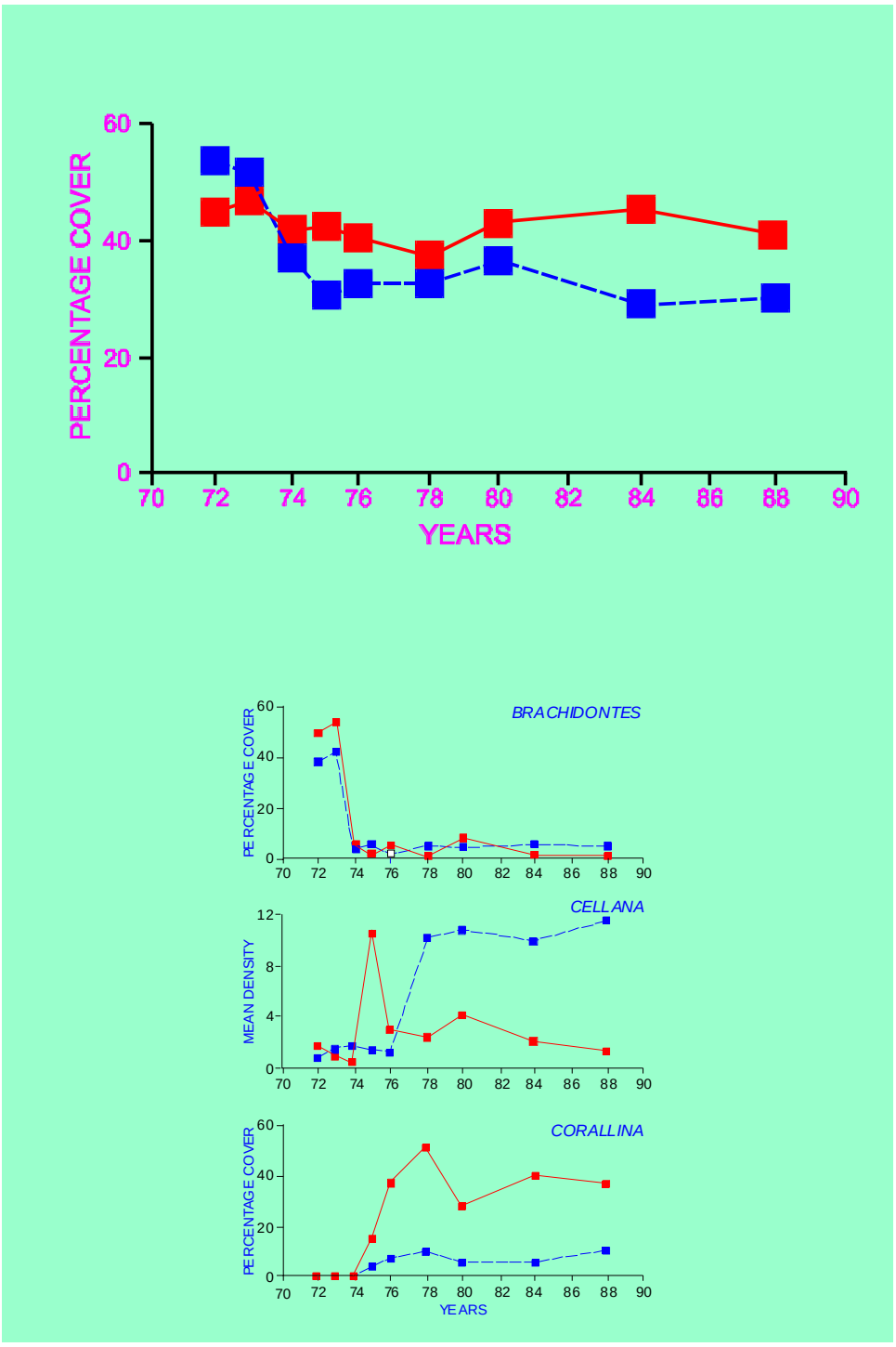


The blue and red referred to areas that were believed to be seriously over-nutrified and areas that were not. The water quality was absolutely the same between them.

The next issue was what is happening to the plants, and the issue here was actually large amounts of biomass of algae – algae blooms caused by, they thought, nitrogen entering the Lakes system.

The next measure was how much nitrogen was actually in the plants – and blue and red again referred to the amount of nitrogen per gram of plant in areas that were problematic and areas that weren't. You can see that neither of these is showing any difference whatsoever, so measuring them doesn't tell you anything. What you actually have to measure in this graph was the amount of plant, the actual ecological measure, and that was dramatically increased in problem areas. And no amount of stuffing around with the water quality is ever going to tell you anything. What happens is, you put in all this nitrogen and the plants promptly take it out of the water, so you can't measure it in the water at all. Then you try and measure it in the plants, but unless you actually measure the whole plant, you don't get it, because the amount per gram of plant doesn't change. I could use this as just one illustration. There are thousands of known, very well documented examples, where water quality does not change when ecology does, or when the ecology does not change when the water quality has.

Secondly, this one is very important. There is no (and there never was) a balance of nature. Professional ecologists have known this for now 84 years, roughly, since the first papers demonstrating this were published. We've known it for all sorts of parts of Botany Bay for about 30 years. All we have to do is get past the Teachers Federation and the special interest groups, the ABC journalists, and then you can know this too. It is a fact, there is, there never was a balance of nature, let's not try and restore one. Here's a small example.

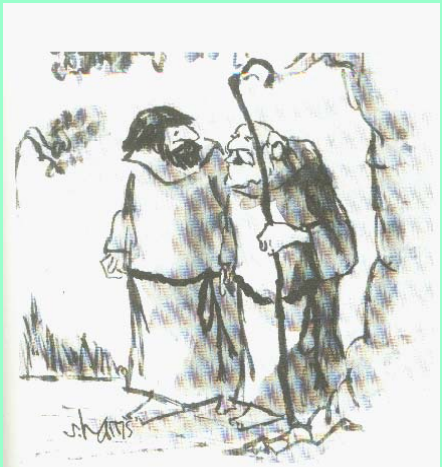


These are the percentage cover of mussels in Broken Bay and you can see if left to their own devices they're pretty boring, they do nothing. The blue and red lines simply plot how much mussel there was over many years. Those graphs go on now to the present day.

In the University of New South Wales they clearly have an unknown system of projecting that. This works in other universities. It also worked recently in Melbourne and Brazil, so it must be something here. However, these dots tell you nothing, so I'll just tell you the story anyway. In May of 1974, there was a one in a hundred year storm event in our coast and in the beginning of June there was another one. So there was a one in then thousand year event at about this time

and it removed mussel beds from large areas of coast. What these graphs are going to show you is they have not come back at all. This is now virtually 30 years later. In the middle of this year when I get the data, this will be 30 years of no recovery of mussels, a perfectly natural change. All sorts of other things have come and lived in the places instead and it is going to take a very long time for mussels to get back into this system for various ecological reasons. This is normal. Things change, things fluctuate, things are not static. There is no balance of nature.

The other problem we have as ecologists is that health is not a very good metaphor for anything that is going on ecologically. It comes from human concerns, where there are tightly regulated control systems to keep, for example, temperature within narrow bands. The temperature goes out of it, clearly there is something wrong with the system. You can go to the doctor and he will charge you a fairly substantial sum of money to say, "Oh, you have a pain in your kidney. I will diagnose nephritis." Now for that you agree to pay him. But basically these symptoms are very easy to determine for human systems, but health does not work as an ecological metaphor at all. I really don't know how to illustrate this – my graph won't work, anyway – so I won't illustrate it. I actually had a small thing there of two angels looking at the dead body of Methuselah, one of them saying, "I'm not surprised; he's been dying for 435 years."

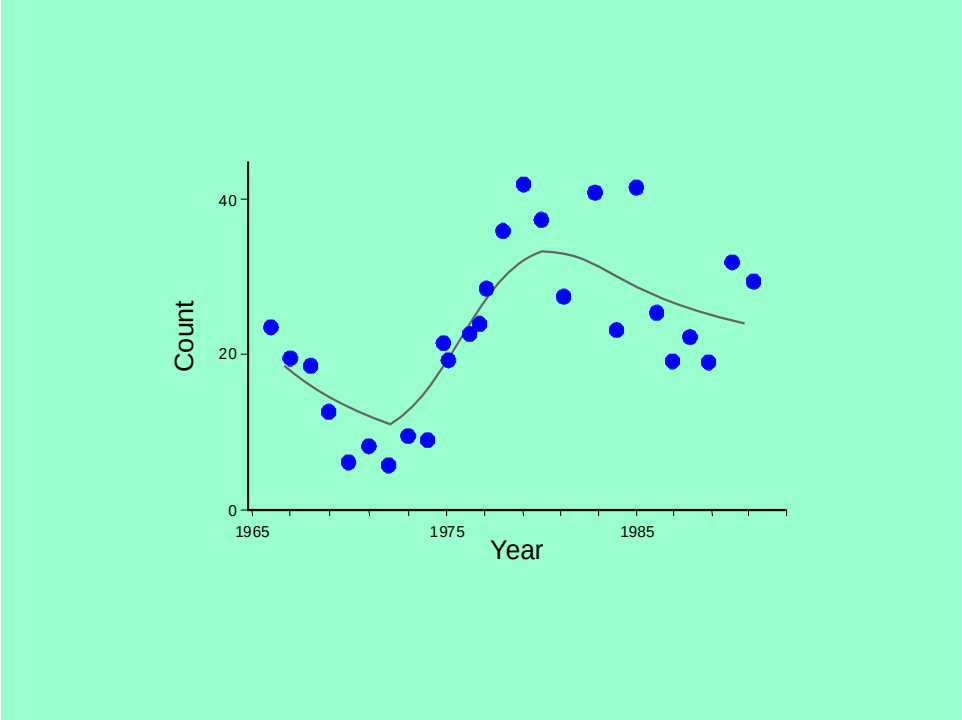


I'm not surprized about Methusaleh -
he was sick for over 350 years

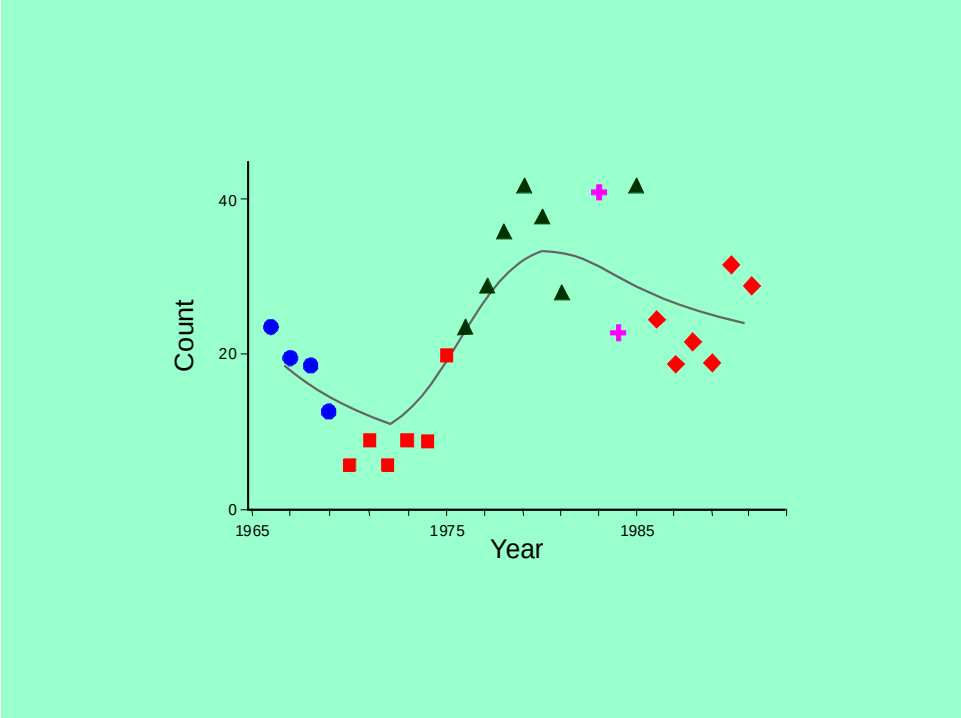
The problem is with ecological systems and health, it's a very poor metaphor and it leads to over-simplification and it has actually lead to all sorts of confusion in how to manage, predict, look after ecological processes.

Here's my advice for the way forward. First, be absolutely explicit about what you want. This is never going to be a natural system, even if we knew what a natural system was, given that there's nothing to tell us, because these systems are constantly in change. We've got to be a bit explicit about what the end points are that people are trying to get to and being very vague about 'we'd like a nice healthy eco system in the Bay' doesn't help anybody – it doesn't mean anything. We've got to translate this into real terms to allow scientists to actually help get you these goals achieved. It's not nonsense, it's reality and there are going to be four and a half million people here whatever you do with this Bay, so it will never be natural. Understand and accept what must be done to achieve whatever it is that you want. This is an important message too. You can't say you want X, but we're not going to allow the work to be done to achieve it. You have to understand what's necessary.

You also have to stop pretending that amateurs know better than professionals. I was going to illustrate this from the bird survey in the United States, one of the largest involvements of community data gathering that has ever been done in an area where people can make huge contributions, because amateur bird watchers are extraordinarily good observers. These are the data over two decades of results from this – the axes are not showing up so I can't show you the years - and would be interpreted to show quite marked trends in numbers of birds in mid-western states of the United States.



When, however, you plot the data according to which observer took them, you see a quite different pattern.



When you factor out observer differences and biases, there are no patterns in the data at all. One of the things that's been a really huge growth area for professional statisticians over the last 30 years, is taking community data and finding new ways to identify what's wrong with them. This is not the way forward. It is much better to decide what you want and get in partnership with people who can help you achieve it, rather than saying you'll do it without them, particularly when it's said we will do it better without them.

Finally, here are my pieces of advice for the way forward. Be very explicit about what the goals are. Vagueness will not help achieve anything at all. Understand and accept what you have to be involved in to get those goals achieved. If somebody says, I want there to be stability in degradative and productive processes in ecological systems in the Bay, and somebody from the Australian Museum tells you that would be hard to do unless we do an inventory and a taxonomy of the species that live there, accept that advice and help them get the funds to do the taxonomy. Make them explain why it's necessary, hold them to account for doing it efficiently, but do not just say, no we don't want to do that; we want to get on with managing the productive aspects of the ecology of the Bay. Stop pretending that amateurs know better than professionals. I doubt a single one of you would have stood up and said you could do some of the things we've heard in the previous presentations, but as soon as it comes to ecology everybody knows how to do it, apparently. Not good.

Control the objectives. Make sure that as communities, managers, developers, people in society, you know what it is you are trying to achieve and then control this by making sure that all the scientific research that ever gets done is absolutely and coherently and thoroughly reviewed by competent people, otherwise you will not get what you want.

I won't spend time talking about the major list of things we need to discover. There are three broad areas we need to discover enormously quickly in Botany Bay.
1. What is the diversity of this Bay? This comes as a surprise to people to discover that there are more species of fish in Botany Bay than in Jervis Bay. That's interesting, but why?
2. What on earth is going to happen under climatic change predictions? The whole Bay is going to change and if it changes the flushing that Jason has so eloquently explained to you, in any serious way, the whole thing is going to be very very different, but who knows?

3. As ecologists, we're terribly concerned about patchiness and fragmentation of habitats in the Bay. We don't know which are connected in various ways. We don't know which are sources of things. We don't know which are sinks. These are urgent tasks, they are not simple tasks and they involve research into the outside of the Bay as well in it and they've got to be started now. If you don't believe climatic change is on, watch the mangroves on the march. The sea level rise is already happening in many areas of the world.

My last point I think, if you will just allow me, is whoever it was who was interjecting, God knows what your problem is but I'll happily try and talk to you during coffee.

Chairperson: **Bruce Thom**

Thank you Tony. In typical Tony style, he's raised a number of issues which I'm sure over the workshops we'll be able to engage in, either with Tony or with others, particularly with some more interest, but knowing, of course, that this interactivity that we are trying to stress here in this natural environment session today is so important to come to grips with in terms of being able to better manage this wonderful Bay.

Our last speaker in this morning session is well known to many of you, Paul Adam, from the University of New South Wales, to talk about the ecology of foreshores.

Ninth Speaker: **Paul Adams**

Thank you. One of the problems that I face is that foreshores is a very vague and general term, which could mean different things to different people. What I'll discuss in the next few minutes is some of the things that it means to me, which means that I'll probably miss other things that other people here regard as important and that can come out later. There's also the problem of what is Botany Bay, how much does one consider Cooks River and Georges River are part of it, and that certainly in relation to some of the things that I'm interested in, one can add to the list of documents which haven't quite existed, but Jim referred to earlier, by adding to that the Georges River REP, for which extensive studies were done in the late 90s, including detailed mapping and recording of a range of foreshore communities, but all of that seems to be in some limbo in Macquarie Street.

I'm also a botanist and a terrestrial person and I don't swim particularly well, so my approach is terrestrial. Some of the issues in Botany Bay are generic, if you like, to a whole lot of other places; it's just that a whole lot of these get concentrated in Botany Bay. The heads of Botany Bay, better illustrated in Alberto's initial picture, still support vegetation which in a general sense is similar to what was first seen by Captain Cook. I have great difficulty in relating it to what Captain Cook says in his diary. The day that he came over to the northern side of Botany Bay he said that it reminded him of the North Yorkshire moors. I think he must have been having a bad day. Nevertheless, the heads of Botany Bay still support important areas of urban bushland. Also, here is rocky shore which is one of the habitats in Botany Bay which is the result of Tony's work over many years. It's probably better documented and understood than many of the other aspects of the foreshores of Botany Bay.

The issues affecting the terrestrial heathland and woodland of the headlands really relate to the fact that they are now isolated fragments within an urbanising environment and the problems of urban bushland are well known - issues of fire management, of feral species, both in terms of plants and animals, and interestingly and particularly concentrated there are the fact that there are endangered ecological communities for reasons which I at least don't understand. The northern headland of Botany Bay always appears to have been different from the southern. The northern headland marks the southern limit of distribution of banksia emula. The vegetation on the northern side is one endangered ecological community, *Banksia* scrub. The Kurnell dune

forest on the southern side is in quite a number of ways a different community. Why is there this difference? We don't know, but how do we manage, if that's what we wish to do, these communities for long term survival as they become increasingly fragmented, is an important issue which we need to address. One of the important issues is, because they're fragmented and because of urbanisation, increased recreational use and the possible incompatibility of that with some of the values we wish to keep.

Botany Bay has extensive beaches, a little bit more of a fore dune than a beach, but the issues of beach management that are of concern relate to issues of sand movement, of nourishment, of sandy beaches. The current questions to be asked as to whether the beach nourishment of Towra Beach is to be approved and around much of the Bay, recreational use. One of the things about beaches is that most people don't see it as a habitat, but in the interstices between sand grains there is a whole new world, the biodiversity about which we know almost nothing and how various activities effect that community which actually lives in beaches is very poorly known.

The strandline is a very important community in its own right. Around much of Botany Bay, a major component of the strandline is dead seagrass, and as the seagrass communities change in abundance of distribution in the Bay, presumably the nature of the strandline has changed, although we don't have any data. It is also the area where a great many pollutants accumulate. But again, what is the role of the strandline in the ecology of the bay? How much nutrient recycling occurs here? Questions that we don't know. Seagrass in the subtidal which gets washed up into the strandline; strandline encroachment. What are the issues? The issues of accumulating marine debris, range of feral species which also affect the strandline. With Australia Day approaching, one of the things that concerns me, not so much in Botany Bay, but in other places, is how eagerly people clean up the strandline without realising that it is actually an important component of the ecosystem and, of course, the effects of erosion and sand movement change where and how the strandline community can develop.

Dunes once occupied much of the shoreline of Botany Bay and they still do in parts of it, but other areas of sand dunes are now a shadow of their former self, occupied, for example, by much of Rockdale. Sand dunes in eastern Australia are natural colonies as regards spinifex. In fact, there's a very different growth pattern from dune forming grasses in other parts of the world and one of the general issues in southern Australia is that for a whole variety of reasons we have chosen to replace spinifex with an introduced grass which is much easier to grow but, nevertheless, has a completely different growth form and changes the due morphology of the dunes. Is that something of concern? What are the long term consequences of that? Subject of much speculation but remarkably little data.

The issues, again, for dunes are feral species, some of which we've deliberately put there others of which have just arrived; a great deal of disturbance by human activity; on the southern side of the Bay, sandmining and then the issues that follow from that of rehabilitation; in the foredunes now and during my time in the past 25 years there's definitely increased an abundance around Botany Bay and around much of southern Australia as well, the sea rocket, *Cakile edentula*, introduced from the northern hemisphere. One of the interesting issues with foredune species like *Cakile edentula* is that in many cases there seem to have been remarkably few native species there to be replaced, so we've in fact increased the diversity of dunes, but have we altered their function? Of course, the number one villain in the piece, bitu bush, for which there is now very active biological control. We still await to see how effective that's going to be in the long term. Again, if we get rid of bitu bush, we have to be able to replace it with something, unless we want blowing sand in places where it hasn't previously occurred.

Salt marshes and mangroves are popularly seen as very important parts of the ecosystem of Botany Bay, important in relation to fisheries, although it's very difficult to demonstrate in a quantitative form how important they actually are. Here in Penryn Estuary we see invading mangroves, and one of the major issues, not only in Botany Bay but the whole of the south east coast, is that certainly over the past few decades, and in Botany Bay it would seem probably for

most of the century, mangroves have been spreading at the expense of other communities. Do we see that as a problem? That's very largely a cycle issue, but if we do, unless we understand why the process is occurring, simply going out and removing mangroves is to embark on a ? task, because unless we know what the process is that's driving this mangrove expansion, we will be forced ever to continue to remove them without actually achieving a great deal. Saltmarsh *Sarcornia quinqueflora*, which is probably the most widespread saltmarsh plant around Botany Bay.

The issues we need to consider as to whether they should be on the management agenda and hence on the research agenda, is the whole issue of the expansion of the mangroves. Trampling and use of recreational vehicles is a major problem, particularly in the Georges River salt marshes, where construction of bicycle jumps and other obstacles occurs even within salt marshes which are supposedly parts of National Parks. One of the big unknowns is the influence of groundwater on salt marsh and mangrove ecosystems. Studies, particularly in Florida, have shown that the distribution and growth rate of mangroves on coasts there is very much influenced by how much groundwater they can tap. The groundwater isn't actually visible, if you like, in the salt marshes and mangroves, but the mangroves roots go down far enough to tap into it. We simply don't know in Australia the role of groundwater on salt marsh and mangrove ecology, and yes, as we've already heard, there have been a great many changes in groundwater around Botany Bay and it's something that we need to look at more.

One of the other issues that's increasingly important and will be an issue in relation to Port Botany, is whether or not we can enhance or create salt marshes and mangroves, and so why would we want to do that? Globally, salt marshes and mangroves have probably been subject to more restoration recreation exercises than any other ecosystem, but the jury would have to be out. Most of those exercises have been not monitored, or very badly monitored. The few that have been studied have certainly created wetlands of some sort, but very rarely that which was originally anticipated. If society demands that we do restore and recreate these habitats around Botany Bay, then a great deal of work is going to be needed, both to define exactly what it is we want, rather than some sort of vague, oh well, go and create a salt marsh and a great deal of work will then need to be done to work out whether or not we can achieve that objective.

This is Penryn Estuary as it is today. If you look at the EIS for expansion, the plans are to establish salt marsh over much of this area. Whether or not we can do that and whether or not it's really what we want to do are questions that we need to address.

Much of the shore of Botany Bay is now artificial. We have created concrete rocky shores around much of Botany Bay and these have habitat value in their own right, both sub-tidally in the creation of sub-tidal rocky shores and they clearly are important, and even in this picture there's a fisherman taking advantage of the life that's attracted to this rocky shore. From my perspective, above the high water mark, these mainly appear to be habitats for rats, which do very well in all those interstices. That is an issue. Feral issues attracted to these artificial habitats have influences beyond their immediate influences. Possibly we can design, in the future, these artificial shores, which we are continuing to create, to increase habitat value, but we also need to minimise the offside impact from providing habitat for feral species or from the changed way from current patterns that result from these artificial habitats.

The third runway, of course, is another example of a very extensive foreshore that's now an artificial habitat. If you go to Penryn Estuary today and other places around the Bay, you will see notification of the development proposal for Port Botany which is something which I think should focus the mind on what it is that society wants of Botany Bay and from that to decide how we actually achieve it. Thank you.

Chairperson: **Bruce Thom**

Thank you Paul and thank you very much to all the speakers this morning, because I think it's opened up a lot of questions for us, particularly this issue that's been raised by Paul and others of what society wants, how do we achieve it, what are the consequences, how do we, from the point of view of the University and research group and research community, how do we add value to those societal needs. How do we help maybe steer the societal needs as well as participate in and provide information on the consequences? Could you all join with me again in thanking our speakers for this morning.

End of Morning Session