ADAPTIVE URBANISM

Sea Level Rise, Resilience & Urban Development

STEPHENSON &TURNER

Stephenson&Turner New Zealand Ltd. presents this booklet to provide an overview of the current information and discussion about sea level rise. Ensuring that our cities can withstand flooding and storm surge beyond the 21st Century will soon be a hot topic for local governments around the world. We at S&T think it will be helpful to contribute to the discussion by detailing possible response options.

The visions of an adaptive urbanism were created by Masters students at the University of Auckland's School of Architecture and Planning, led by S&T Principal, Bernd Gundermann. These show how we could improve both the resilience and the biodiversity of our cities; and how this would offer new lifestyle opportunities for residents.

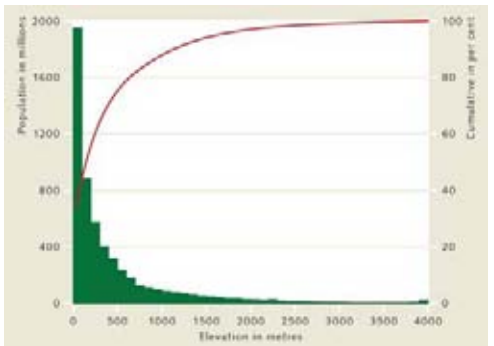
For more information please contact* Bernd Gundermann: *+64 9 914 6093 or bgundermann@stephensonturner.com.

Storm surge in Auckland in January, 2011.

INVITATION TO ADAPTIVE URBANISM

OUTSET

HUMANITY LIVES ON THE COASTS

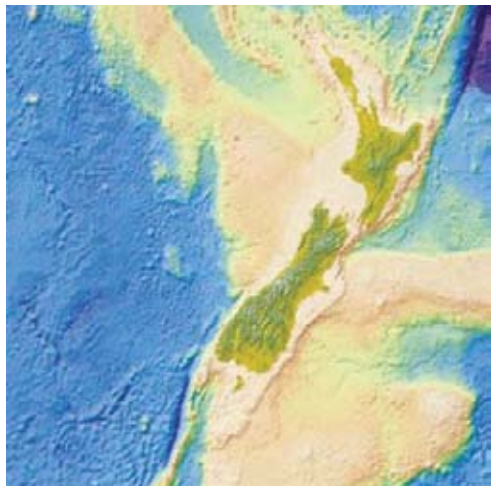


Coastal areas are hugely popular places to settle. Home to more than 45% of the world's population, 75% of the mega-cities (i.e. populations over 10 million) are located here, containing vital transport and industrial infrastructure. Though these areas account for only 20% of the world's surface, it is estimated that by the year 2025, 75% of the world's population (or 6 billion people) will live in coastal spaces.

Because of this, low-lying, sedimentary coastal zones are at significant risk of damage from both human activity and natural erosion. Within the urban areas, land reclamation has added to this natural fragility, leaving the majority of mankind vulnerable to the impact of natural forces.

75% of the world's population, or 6 billion people, will live in coastal areas by 2025.

FACTS & ESTIMATES ON SEA LEVEL RISE



The surface of our planet undergoes constant change. 20,000 years ago, the sea level was 120m lower, and consequently the land area of New Zealand far greater. Scientists' predictions vary significantly. Those of the Intergovernmental Panel on Climate Change (IPCC) are relatively conservative *(fig 1)*. Actual measured sea level rise over the past 15 years has been in the higher range of predicted levels. Other models, incorporating both the melting of the polar ice and the permafrost soils, predict a sea level rise of 1.8m relative to the current global average by the year 2100 *(fig 2)*. The Port of Auckland's estimates are based on the IPCC model and predict an 80 cm rise by 2100. Satellite observations have also shown that this rise may vary by region *(fig 4)*.

Given these facts and estimates, the uncertainty of science, the fragility of mankind's environment, and the timeframe, we should start taking action now.

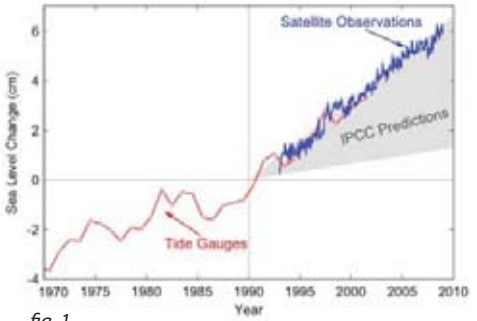


fig. 1

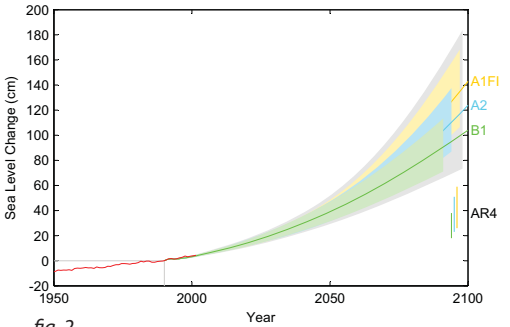


fig. 2

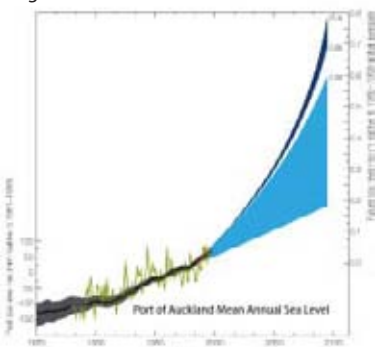


fig. 3

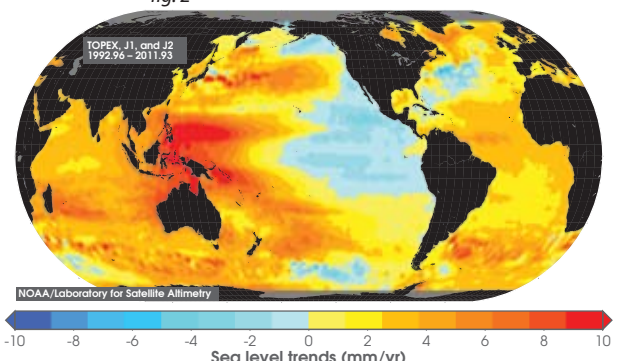


fig. 4

AUCKLAND'S PROBLEM

The map of Auckland's CBD below indicates sea level rise of 3, 5 and 10m. The photomontage on the right shows a water level five metres above the current level.

Like any other coastal city in the world, Auckland will face consequences of sea level rise. The most attractive areas of the CBD are built on reclaimed land, and currently new city quarters are being developed on converted land from the former port. These areas are facing serious threat.

Sea level rise itself is not the biggest problem; rather it is storm surges (which can be several times higher than the projected sea level rise itself) that can cause major damage. We must divide response options into those that address sea level increases of one to two metres by 2100, and those that break the wave energy of storm surges up to ten metres high.

Mankind has a long history of protecting buildings and cities against floods and such approaches can provide a starting point as we develop appropriate response options.

RESPONSE OPTIONS

BARRICADE

The seemingly simplest method is to barricade each single building in a flood prone area.

Bernd Gundermann led the design of the Hanseatic Trade Centre (outside the dykes) in his hometown of Hamburg in the early 1990s. The ground floor was designed with only a few openings protected by flood doors. The large image to the right also shows the elevated bridge-system that acts as an egress route to guide people to the safe hinterland. Currently Europe's largest urban development, "Hafen City", is underway; these buildings are designed on a plinth in order to create a safe plateau *(top left)*.

Barricading may work as an option for newly-built developments, but it disconnects people from the water. It is unlikely to be a preferred option for existing places; it is difficult to imagine Auckland's lower Queen St with barricaded shop windows.

CONCRETE

The majority of Dutch people live below sea level, as indicated by the light blue zones on the map to the left. Over centuries they have achieved a system for both reclaiming and draining new land, protecting it with dykes.

After the flooding disaster of 1952, Holland invested billions to create huge flood gates in the delta of the rivers Rhine, Schelde and Maas. However, the "Delta-works" have caused irreversible ecological damage. The disruption of the salt- and freshwater ecosystems led to increased erosion on the seaside and soil-salination on the land, among other effects.

Holland has moved away from this approach and now aims for a seamless transition between sea and land, retaining bulwarks for disaster-protection only.

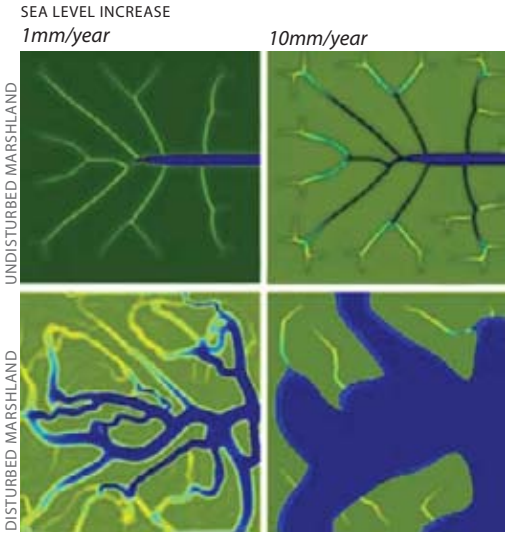
CONCRETE (CONT'D.)

London has been protected by the Thames barrier since 1984 but it is envisaged that, due to sea level rise, its working life will cease by 2060-70. Hence proposals are on the table for a new barrier further downstream.

Architect Lord Norman Foster, the author of this £50 billion vision, gave his view: *"If we are to establish a modern transport and energy infrastructure in Britain, we need to recapture the foresight and political courage of our 19th Century forebears and draw on our traditions of engineering, design and landscape."*

His reference to the heyday of grand engineering is driven by the belief in mankind as the "masters and possessors of nature," as Rene Descartes put it 1637. This concept has largely been replaced by accepting the environment as a third teacher; instead of trumping nature, we work with it as a partner.

RETREAT THEORY



Smart solutions currently under development aim to both understand how nature works and to apply this learning to future planning. **Duke University** in the United States is researching the capability of tidal salt-water marshes to absorb rising water levels.

The images to the left show the findings of model studies. The top images show an undisturbed marsh which may change little when the sea level rise increases from 1 millimeter a year *(top left)* to 10 *(top right)*. But disturbing half the vegetation *(bottom left)* or just 5 percent of the plants while reducing sediment supplies *(bottom right)* creates substantial changes with a 10 mm/year sea level increase.

Duke University's concept is to retreat from the coast and reverse-engineer former human structures into marshland as a natural buffer against sea level rise.

RETREAT

East Anglia (UK) is about to lose its battle against coastline erosion. Due to a lack of funding, sea defences have not been maintained properly and the battered wooden groynes and dunes are failing. A sea level rise of approximately 6mm per year and loss of sediment adds to the problem.

The *Shoreline Management Plan* allows for the demise of sea defences and commits large areas of the coastline to the sea. Over the next decades, dozens of villages and towns will be sacrificed and the population will need to relocate elsewhere.

The map on the left shows the expected coastline of East Anglia when the West Antarctica Ice Shelf melts due to global warming and the vital sea defences are no longer maintained. When even the UK cannot afford sea defence, New Zealand will certainly have to consider retreat as an option in many coastal areas.

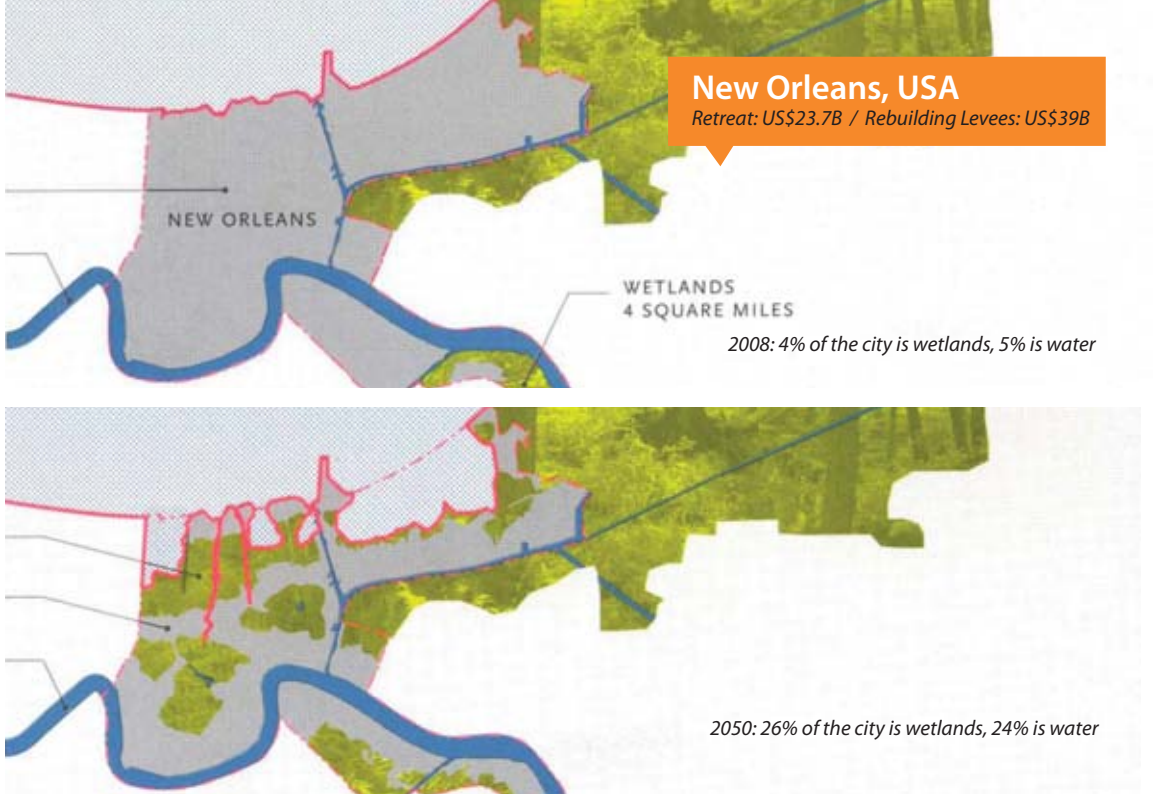
RETREAT (CONT'D.)

New Orleans Development Plan 2050

New Orleans (USA) paid a terrible price when its levee systems failed in 2005 during Hurricane Katrina, leaving 80% of the area below sea level flooded and claiming 1,500 lives. The city is currently sinking approximately 0.9 meters per century and sea level is estimated to rise by the same amount over that time. Meanwhile, hurricanes still batter the coast on average every 2.8 years.

Architects Thom Mayne and Morphosis produced an *Urban Development Plan* to reverse-engineer the low-lying areas and create wetlands. The displaced population will be accommodated in remaining areas, producing higher density zones. This process was scheduled to begin in 2008 and has three phases:

- By 2015 the lowest ground will be vacated
- By 2021 the lower ground will be vacated
- By 2050 the high ground will be densified



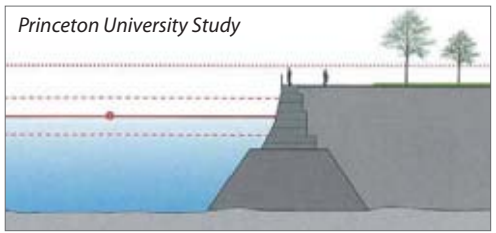
RESILIENCE THEORY

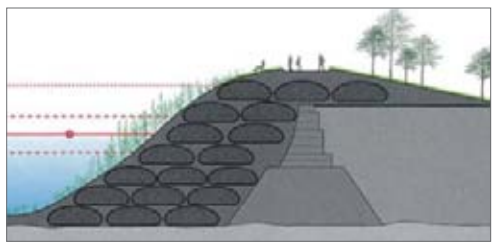
In 2010 the School of Architecture at **Princeton University** presented its study on boosting the resilience of Palisade Bay (shared by New York and New Jersey) against sea level rise.

Obviously neither city would consider retreat to be an option, as their buildings and infrastructure investment in the area is immense. After testing and discarding hard engineered "Dutch" options, they tested soft solutions and developed a variety of small-scale interventions. The advantage of this approach is that the initial financial commitment is far less and the project can be installed, monitored, and improved over time to be fully effective when sea level rise is visible at the end of the century.

On the following pages we describe this adaptive response option as published in the book *"On the Water"*.

RESILIENCE
SOFTENED COASTLINE

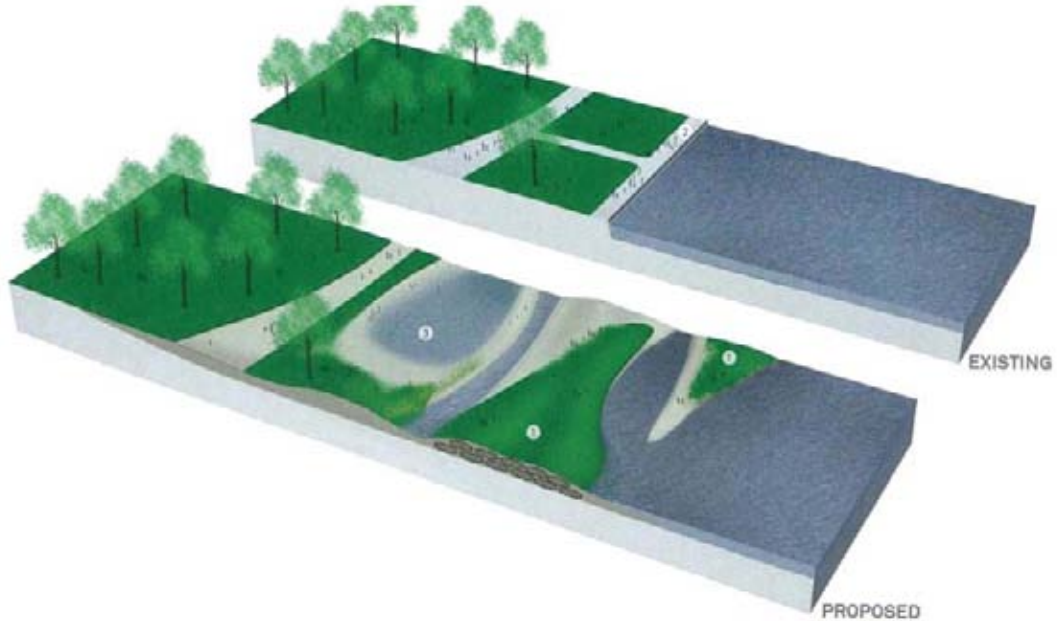




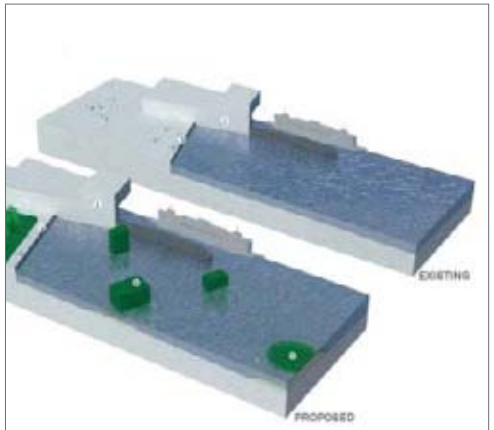
In the CBD, coastlines are usually comprised of hard quay walls, often no longer in use because of the re-location of the cities' ports. The opportunity exists to soften these walls by building a wide base within the water and creating a softly moulded coast line up to a height. These would absorb most of the energy in storm surges, mitigating the effect of sea level rise.

In recent decades urban areas adjacent to ports have been converted to commercial and residential use. A softened coast line will upgrade the look and feel of those precincts while also creating opportunities to enhance biodiversity with coastal estuaries or wetlands.

Earthwork is constructed with geotextile fabric containers filled with dredged sediment from the harbour.



RESILIENCE
BREAKWATER TOWERS



Princeton University Study

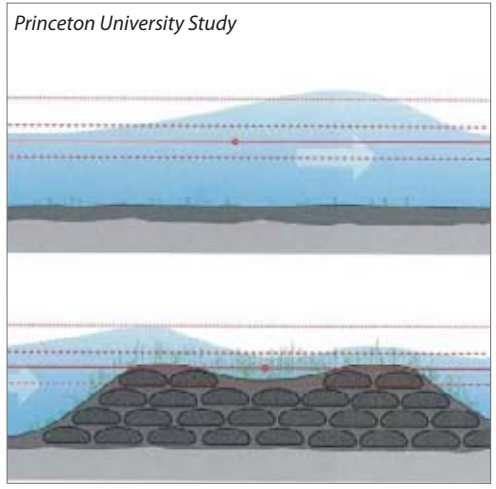
Smart solutions are often distinguished by the technique of breaking down a complex task into more manageable pieces and dealing with each separately and with uncompromised efficiency.

The proposed breakwater towers' main task is to help reduce the impact of storm surge, which is, as mentioned before, the biggest danger. The towers can be placed in shipping routes since the interstitial spaces allow for maneouverability. The porous structures obstruct waves and - above the water - they can work as sanctuaries for maritime life.

The architectonically composed shapes of the breakwater towers reflect the built environment of the surrounding city and, together with the other means, help to establish a visually seamless transition between land and sea.

RESILIENCE
ARTIFICIAL ISLANDS

Princeton University Study



Ports are continuously dredged in order to maintain or deepen shipping channels. The dredged spoil should be used to build up artificial islands. As storm surge waves can build up over kilometers, massive interventions are necessary to break their energy and protect the land.

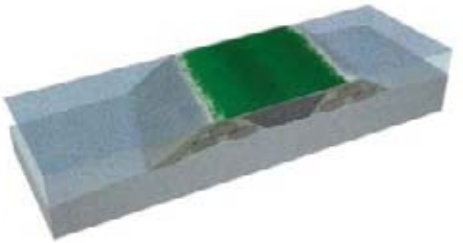
The dredged sediment first has to be decontaminated, then filled into geotextile tubes and placed in bundles in appropriate places. The final shape of the island is created by further infill of sediment. All of this can be done without disrupting the coastal mainland.

Wave barriers can substantially enrich coastal ecosystems by creating artificial islands.

Existing vacant sea bed sites

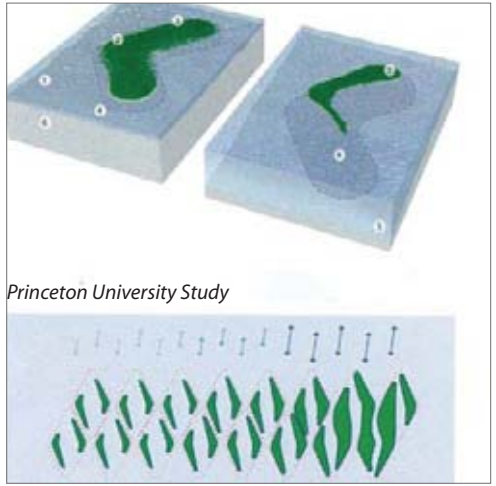
Positioning of geotextile tubes

Fill / island formation



Recycled rubble / debris as dry island foundation

RESILIENCE
ISLAND ARRAY TECHNIQUE



Princeton University Study

As a protective measure, artificial islands can be optimised by arranging them in patterns around the coast. In section, all islands are shaped like a pyramid. The decreasing water depth close to the shoreline will result in larger islands, reducing the effect of currents and waves on the shore while keeping shipping channels open.

The "island array" technique also offers opportunities to extend urban design over the water by developing island patterns that reflect the street pattern of the adjacent city. This fully-integrated urban design approach blurs the boundaries between man-made and natural features.

RESILIENCE
CONCLUSION

The measures described on the previous pages to protect the city from sea level rise offer exciting opportunities to improve both the urban life style and natural environment.

To fully assess the benefits of all response options, one needs the skill sets of architects and urban designers as well as those of scientists, engineers and environmentalists. Integrated results will come from integrated teamwork. We need a vision of the bigger picture and to think beyond our lifetimes. Consent procedures, currently focused on preserving the status quo, will instead need to accommodate a flexible, dynamic approach to improving coastal resilience. This requires informing, educating and engaging residents and councils, as well as exchanging ideas with coastal communities on a global level.

Princeton University Study

VISIONS FOR AUCKLAND

THE AUCKLAND PLAN

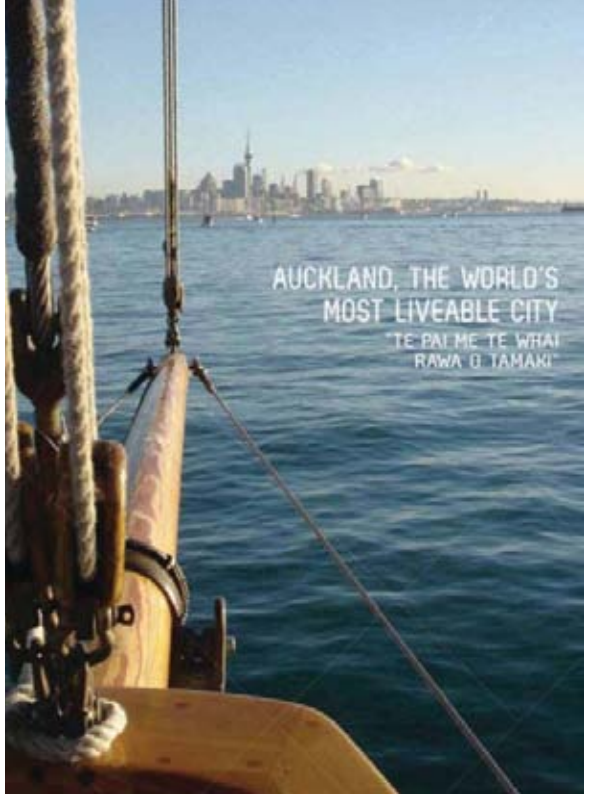
"Global climate change affects Auckland. How we engage with national and international efforts to mitigate climate change are important dimensions of Auckland's future."

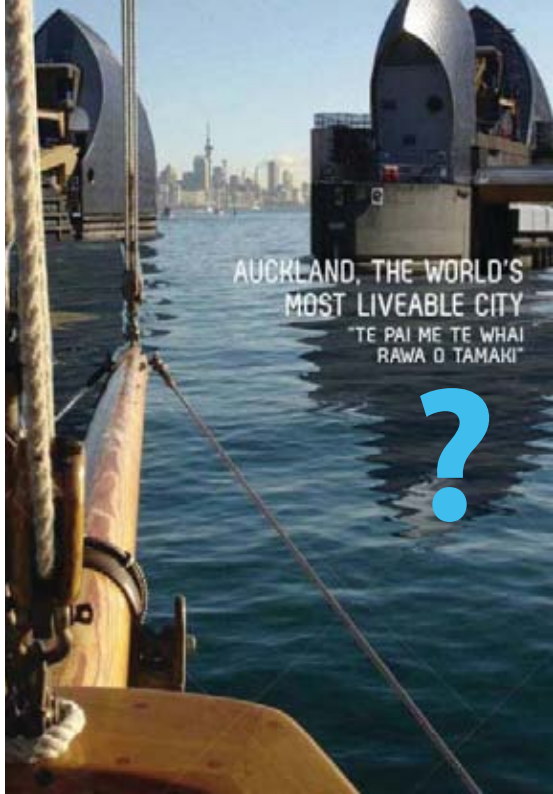
– The Draft Auckland Plan p19

Len Brown, Mayor of the recently-unified metropolis of Auckland, released the Draft Auckland Plan in September 2011. It is the first spatial plan in the history of our city and its ambitious goal is to make Auckland "the world's most liveable city" by 2040.

This timeline, however, is too short to tackle the issues of sea level rise as a result of climate change. It will take time to apply the appropriate measures to combat sea level rise and storm surge in the right way, and it will take even more time to implement them with the support of residents. In addition, all of this must be done *before* the effects of sea level rise are a reality.

This is why we should act soon. If Auckland takes the opportunity to fight sea level rise now, basic decisions can become a part of this plan and be gradually approved by the public to make this a truly livable city well beyond 2040.





THE AUCKLAND WATERFRONT PLAN

The Auckland Plan defines the very core of the metropolis surrounding the harbour, responding to the "amphibious" character of the city. Therefore the waterfront areas are dealt with in a separate Waterfront Plan document.

The sketch on the right illustrates how the tools described on the previous pages could be applied to Auckland's waterfront. In the water *(blue),* breakwater towers, islands and reefs are constructed to dampen powerful storm currents and to develop new estuarine habitats. The shore *(green)* could be softened and may combine wharves, marshes and parks for recreation and community development.

On the land, the highlighted zone *(brown)* may define potential impact areas needing increased resilience against natural disasters.

UNIVERSITY OF AUCKLAND
MASTERS SEMINAR

Masters Seminar at the University of Auckland's School of Architecture and Planning led by Bernd Gundermann

The worst effects of sea level rise are forecasted to happen after the mid-half of the century. Hence it is important to discuss the issue with the evolving current generation of university students.

In 2011 Bernd Gundermann mentored a Masters seminar about Auckland's urban response to sea level rise, which had exciting results. Students coped surprisingly well with the prospect of parts of the city they grew up in being submerged. They boldly applied soft interventions, combining these with the latest practices such as urban farming, and didn't hesitate to "abandon" major infrastructures like motorway viaducts or naval bases by the year 2100. Both the creative power and local sensitivity of the emerging talent led to results that might compel one to look forward with optimism as to how sea level rise might be experienced in Auckland.

DEVONPORT'S NEW WETLAND

By Mitchell Round

By the year 2100 Auckland (as a City for Peace) might no longer need a naval base in Devonport. Instead the low-lying foreland might be utilised to protect the cliff from erosion and extend the civic centre of the town.

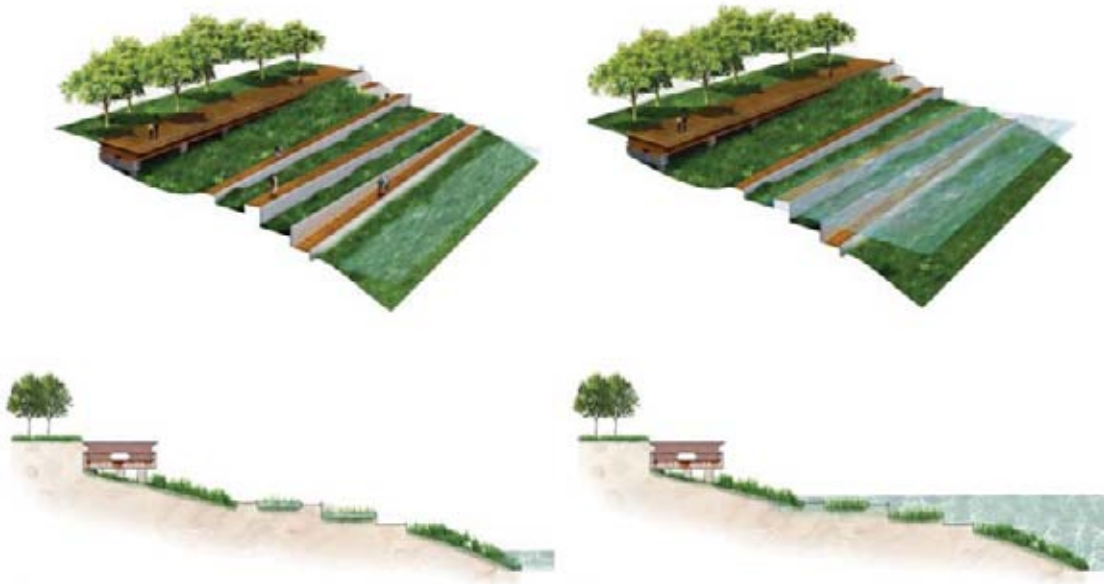
The analysis *(left)* shows how Auckland's Devonport peninsula would likely be divided into three areas as the sea level rises: Stanley Point, Devonport with the central area around Victoria Road, and North Head.

Significant structures on the current naval base, such as the big shed, could be preserved and converted into civic buildings. Clusters of floating homes, positioned with guard poles, might extend Kiwi lifestyle onto the water by using existing jetties. Preserved cranes, current landmarks of the site, could connect the clifftop with lower Devonport through lifting platforms.

DEVONPORT'S NEW WETLAND (CONT'D.)

Here, special attention has been given to the softened coastlines. The slopes are terraced and accessed by boardwalks. The slices of land in between display differentiated habitats - some are envisaged as "basins," retaining the tidal water. Tidal waterflows could be utilised for power generation.

This approach draws from Devonport's close connection to the sea. However, instead of the public being fenced out of this prime real estate facing the CBD, the people of the future could engage with the sea and even live on the water. This work presents a resilient version of coastal lifestyle including aspects of heritage preservation.



A TERRACED COAST

Hexagonal basalt formations at Giant's Causeway, Ireland

By Gabrielle Free

Inspired by New Zealand's landscape, this work applies the basalt formations, similar to those on the left, as guiding motifs for the underlying structure.

Hexagonal structures soften the coast and make areas of water accessible, even in the CBD. The greatest advantage of soft resilience against hard engineering is the possible multifunctionality of adaptive interventions. The current quay walls are monofunctional; they provide moorings for ships and nothing more.

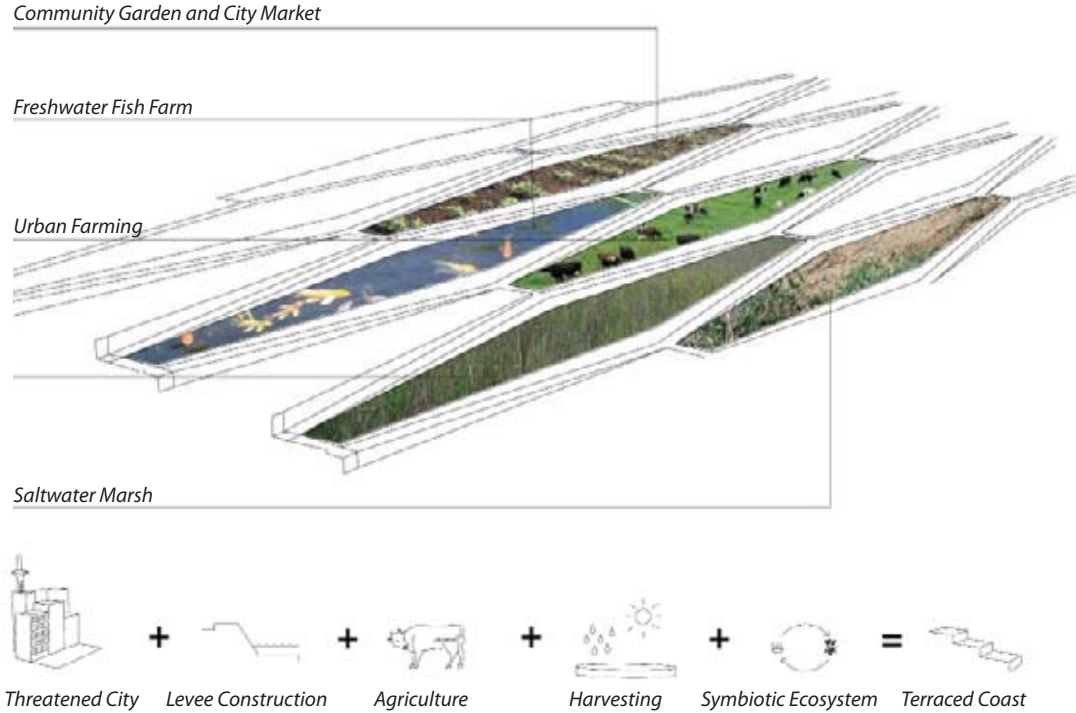
Heritage preservationists may disagree, but the advanced lifestyle that has emerged in the last decades and the abandonment of port functions needs to find its expression in an altered coastline. Sea level rise here works as a trigger to start a transition.

A TERRACED COAST (CONT'D.)

Auckland wants to attract tourists, in particular, because of its coastal richness: this is a way to achieve it.

The fascinating potential that the proposed terraced coast offers is displayed in the diagram on the right. The terraced coast comprises, beside the integrated levee and pedestrian walkways, a symbiotic ecosystem:

- Community gardens and city markets for food distribution.
- Freshwater fish farm with harvested rainwater.
- Urban farming nourished by run-off water and organic waste create a type of food-generating infrastructure.
- Saltwater marsh that takes advantage of the intertidal deposits and produces organic fertilizer for agricultural production.



FLOATING COMMUNITIES

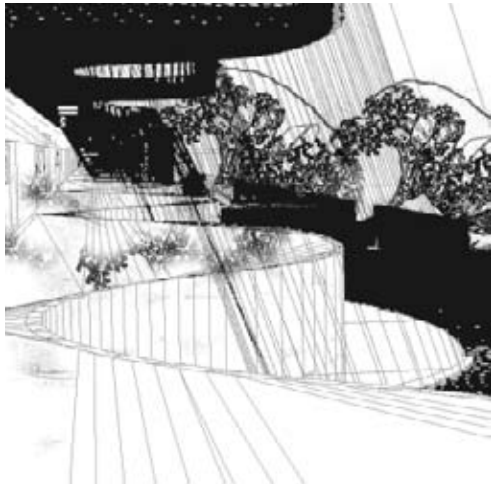
By Syed Ibrahim Ikram

Floating communities can work as breakwaters to weaken the wave energy of a storm surge. Historically, land was reclaimed to gain more usable area for the development of the city. Floating urban structures can enrich the variety of the urban tissue with a unique maritime lifestyle.

Standardised building types and plug-ins to connect with the infrastructure may provide a new level of mobility; coast to coast, city to city.

This project also presents housing for those, displaced from flood-prone, low-lying precincts. The challenge of sea level rise may lead to a new concept of home-ownership beyond strata-titled lots. If we are on the brink of a new urban nomadic lifestyle, this is a version in Auckland style.

A GIANT BREAKWATER



By Kai Qin

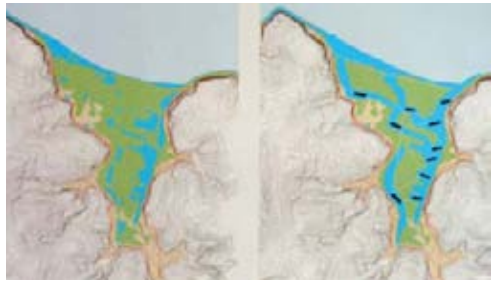
The classic engineering solution for coastal protection was the sea wall, which means commitment to long-term investment and execution, particularly because of the complicated offshore construction. This is an alternative, drawing inspiration from floating carpark structures pioneered in Asia.

A super wharf, floating parallel to Auckland's Tamaki Drive, might protect the coast from the impact of the powerful wave caused by storm surge. The structure accommodates a cruise terminal, a fishing port, moorings for yachts, markets and tourist infrastructure.

The envisaged model offers spatial richness inspired by the maritime environment. The wharf's design works with a long straight central spine that is set apart from undulating structures.

THE EASTERN BAYS
WETLANDS

From suburban to high density - the "quarter-acre Kiwi dream" rotated, densified and hung



By Jordon Saunders

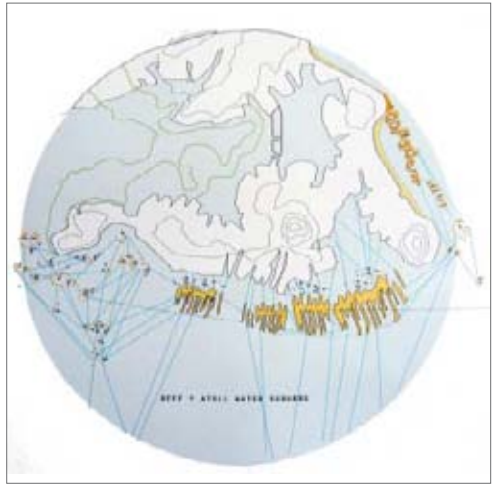
This project considered the question of where the line should be held against sea level, and where ground should be ceded. It posited that only the accumulated value of the CBD would justify elaborate protection.

The low-lying land of Auckland's eastern bays, which have been created by run-off sediments from the high hinterland, are extremely exposed to flooding. This project combines the concept of retreat with the creation of a denser version of classic suburban housing.

The design concept for residential housing is of shelf-like structures that are based on a set of variable pontoons. Housing units become floating communities, replacing the former land-based suburb.

DEVONPORT
3.0

Reef and atoll suburbs around the Devonport peninsula



By Esther Mecredy

The Draft Auckland Plan adds Devonport to the city fringe zone. This project cedes the land threatened by sea level rise. The result is a higher density community, mirroring the CBD across the harbour.

Artificial reef- and atoll suburbs protect the south and east of Devonport. The future Devonport would be defined by landscape features such as cliffs, beaches, mounts, mangrove marshes and the urban shore, where the civic centre is intricately engaged with the harbour. The dense population would share the nearby waterline.

Devonport and the east coast bays would be closely connected by a tight ferry network around its shores. Maritime connectivity replaces the current car-based commuting.

DEVONPORT 3.0 (CONT'D.)

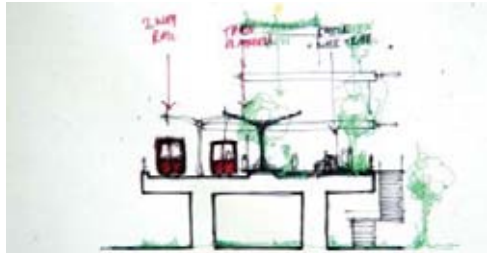
A Manufactured Lagoon

The low-lying land of the current golf course is seen as submerged. This manufactured lagoon serves as collector for run-off water. Integrated into the Lake Road bridge, which passes through this tidal mangrove marsh, are filters that clean the run-off before it enters the outer mangrove marsh, Ngataringa Bay.

The design approach of this project intends to create an entirely new urban fabric, delicately interwoven with the sea and resilient at the same time.

Drawing from this inherent potential Auckland might rise above its current state and become a truly maritime metropolis in the south Pacific and a model for other cities.

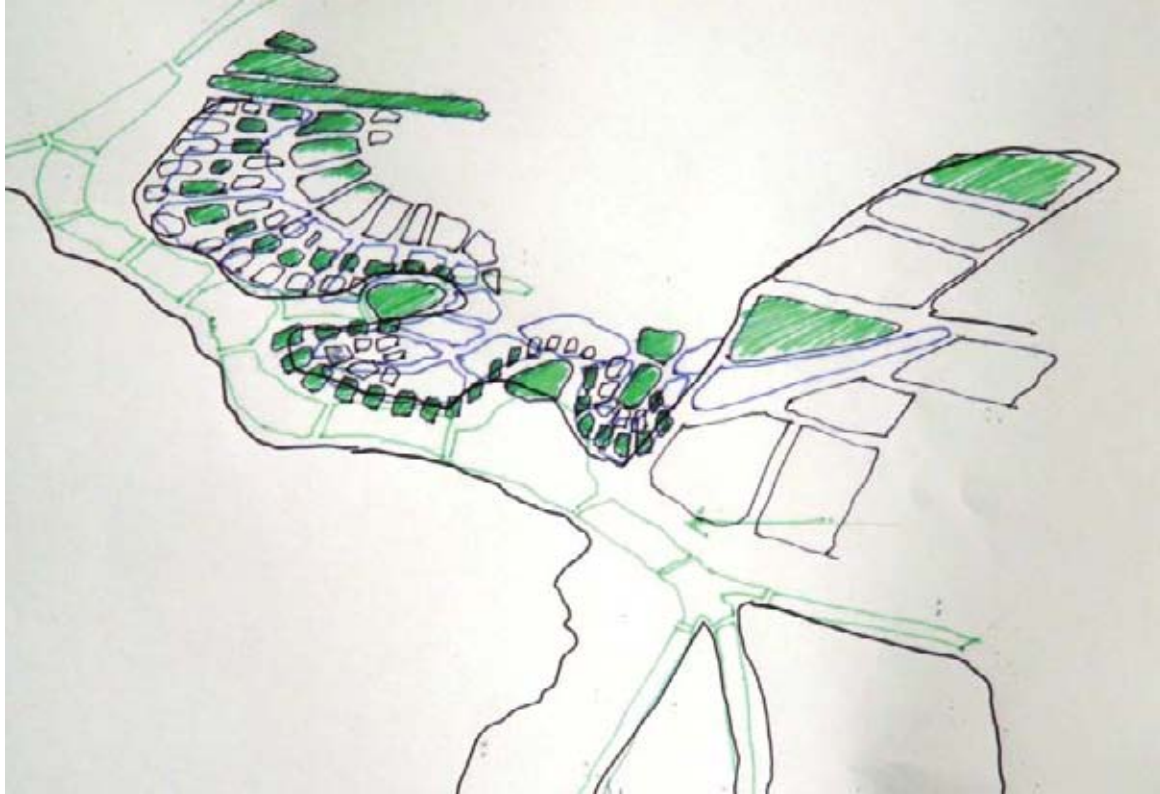
ST MARY'S
BACK ON THE BAY



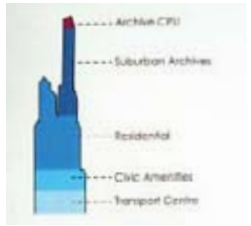
By Klaus Carson

Auckland created its motorways on the last remaining coherent strips of land along the shore, breaking the connection between residential areas and the coast.

This project assumes that the motorway through Saint Mary's Bay will be abandoned by the year 2100, and its remaining structure used as a stepping stone to the harbour. It would accommodate both civic and traffic infrastructure as well as additional housing in shipping containers to accommodate the growing population. This work exemplifies how ingenuity can take old, outdated buildings and reinvent them into something new and useful. Westhaven and Saint Mary's Bay would be poldered to create tidal marshland and additional housing on the landfill cells.



SCHEDULED ABANDONMENT



By Thomas Ward

Retreating from the coast and abandoning settlements is a painful and delicate process. This project creates a scheduled approach to guide the reverse-engineering and the renaturalising of the abandoned areas in the second half of the 21st Century.

Key points include the relocation of the population; the dismantling of building elements, which might harm the future green space; the preservation of historical landmarks that remain - and parallel - the monitored re-establishment of a coastal ecosystem; and the densification of the safe hinterland including new traffic solutions.

A new high-density accommodation zone, as a band-city structure comprised of an array of high rise building, provides everyone with a sea view.

VERTICAL RETREAT

Parasitic green balconies grow out of high rise buildings

Garden balconies spawn delta-robotic lifts, which start to fabricate plant material for extensions

Delta robot gardens flock producing a green network in the sky

By Adrian Kumar

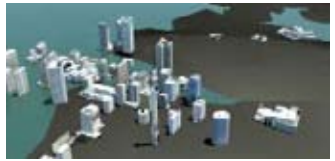
Usually the retreat from the coast in response to sea level rise involves horizontal movement - putting some distance between the sea and the city. This project, however, suggests a vertical retreat of the CBD.

The basic tool to fabricate the new city would be the delta robot, which is currently used in the packaging industry because of its rapid and precise movements.

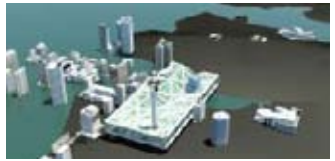
In order to create a self-replicating urban fabric, the existing high-rise office towers are used as structural pylons. In early stages the newly spawned green balconies would enrich the blandness and the uniformity of the buildings.

The concept combines digital fabrication with the robotic movable assembly of the manufactured components.

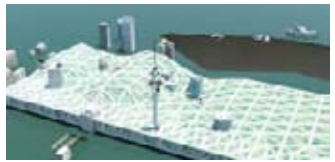
VERTICAL RETREAT (CONT'D.)



As people finally accept the reality of sea level rise, it's too late for sea walls or horizontal retreat



Creating a safe upper level above the existing CBD is the only option as the inundation begins

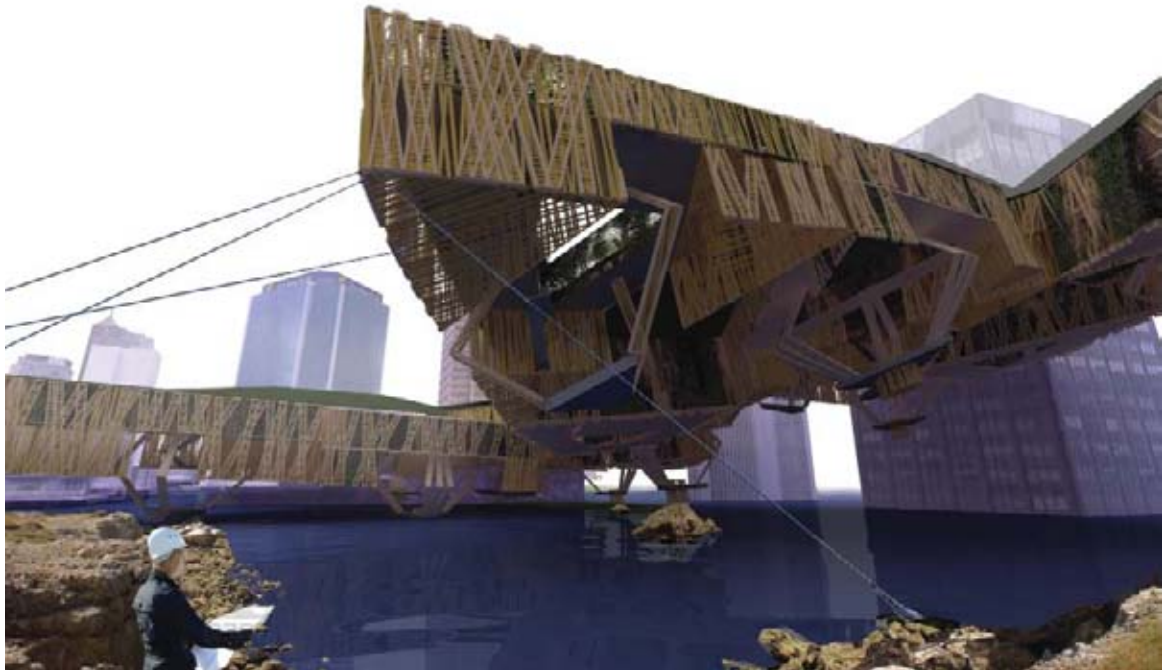


By the time polar ice caps have melted, the elevated landscaped city is complete

Over time landscaped decks would be the basis of city life as the land underneath is flooded. Between the vertical towers an ever-changing, horizontally layered urban fabric would emerge.

This approach may seem like science fiction, and it *is* partly inspired by Archigram's "walking city", a 1964 vision of bug-like gigantic cities moving over the globe. A School of Architecture, however, should be a laboratory, where (im)possible futures of the built environment are created and tested.

Huge challenges and substantial changes to our common lifestyle are around the corner. In times like this we need the creative input of projects that - right now - might be fantastic. Just as Paolo Soleri's visions of 50 years ago (of giant eco-tech structures taking shape in Asian mega-cities) seem the norm nowadays, perhaps too these ideas will seem modest by 2100.



CONCLUSION

"Crisis is only the perception of those who refuse to adapt."

Nobody is certain how quick or how disastrous sea level rise will be. We know, however, that the earlier we start taking action, the more potential we have to use these changes to beautify our communities by applying sensitive and adaptive measures.

Cities have always invested heavily in various building schemes - whether in fortifications or urban infrastructure to keep up with sprawl. Now may be the time to invest significant money in the resilience of our coastal areas.

If we consider the situation wisely and make the right decisions early, we will not have a "crisis" on our hands; we will have beautifully adapted, safe cities.

THANKS

2011 Masters Seminar Students "Coastal Challenge"
University of Auckland
School of Architecture and Planning:

Klaus Michael Carson
Gabrielle Courtney Free
Syed Ibrahim Ikram
Adrian Vincent Kumar
Esther Lauren Mecredy
Jong Min Park
Kai Qin
Mitchell Hamish Round
Jordon Tomas Saunders
Thomas William Ward

Scientific input:
Dr. Mark Dickson, Senior Lecturer
University of Auckland, School of the Environment

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One threat our entire civilisation is facing is climate change. While most mainstream discussion still focuses on topics like greenhouse gas reduction, Stephenson&Turner New Zealand Ltd. is initiating an exploration of the impact that sea level rise, caused by climate change, will have on coastal cities around the world and, in particular, Auckland. This booklet starts a discussion about urban response strategies that – when applied early – can lead to resilient and better living environments for mankind and nature.

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