Ocean As Place For Urban Life:

Building on Water to Combat Urban Congestion & Climate Change

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Abstract

Coastal cities form some of the largest and most important cities in the world. The unique character of these cities has been shaped and moulded by the coastal environment. As powerful as these cities seem they have became vulnerable. Coastal cities face the need to expand with rapidly growing populations, also, sea level rise has been increased by climate change, which threatens this expansion and the city itself.

This thesis explores how the effects of climate change and urban congestion can be mitigated through architectural development, incorporating a flexible framework for housing and the adaption of the urban fabric to living on water. It seeks to change the perception of buildable space and adapt to the changing face of the coastal city and its environment.

The research finds that responses to the coastal city problem exist only as separate projects independent of one another. A unified solution is needed to mitigate these issues between all coastal cities. This can be resolved by combining strategies within further inner city developments.

The project responds to coastal city issues as well as adapting to current city inhabitation. Modern city life is one of change and movement. Travel between cities is frequent due to changing lifestyles and job opportunities. Developing on this lifestyle, the project successfully investigates a solution to help protect and improve the life of the coastal city, addressing the problems of tomorrow, today.

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Introduction

Coastal cities face the need to expand with rapidly growing populations. From global warming and sea level rise to extreme weather events, the waterfront boundary needs to address the threat to the front of the city. Through exploring the possibility of living on or within water the city could answer both these problems, extending the urban fabric into the ocean.

To understand the demand for water based housing and communities it is important to be aware of the environment that drives the need for this change from land to water. The introduction will identify the main two drivers: urban congestion and rising water levels.

Urban Congestion

The world's population is increasing in number faster than ever. Currently the total population is estimated at around 6.9 billion, predicted to reach 7 billion in the year 2012. In the 1800s less than 3% of the total world's population lived in cities. Today in the 21st century for the first time more than half the world's population live in cities (Brand, 2007). A large number of cities are located in coastal areas. The four most populated cities in the world are located on the coast: Shanghai, Mumbai, Istanbul and Karachi. Urban congestion is now a pressing issue facing cities with continuing migration from rural settlements to urban centres. Problems are created in these urban areas as a result of the increasing population.

With increasing numbers of people moving to cities one of the obvious problems caused is overcrowding. When a city is overcrowded it means that the increasing number of people in the city puts a strain on existing available infrastructure and services to the point were they no longer cope with the demand. Additional problems have also developed because of overcrowding.

With increasing numbers of people moving to cities, the demand for land and property is put under pressure. An example of this situation can be seen in the coastal city Beihai in Southern China that has an average population growth of 10.58%, and is the fastest growing city in the world (Telegraph, 2010). Like many large established cities Beihai has increasing slum areas as well as zones of inadequate housing.

In many of these fast growing cities through an increasing population, land surrounding the city is developed expanding the outer limits of the city creating urban sprawl. This effect can lead to decreasing density in city centres. In order to retain and improve the infrastructure, and in doing so, safe guard prosperity with all its accompanying services, a minimum number of consumers is required (Keuning & Olthuis, 2010). Urban sprawl can draw the density away from the urban centre reducing the city's character and identity.

While in some cities have room to grow, others have a lack of suitable land to expand. Coastal cities such as Cape Town and Wellington are restricted by the coastal boundary in the front of the city and steep terrain at the back of the city. Little room for expansion in the city can add to the overcrowding problem. Reasons for



Figure 1: Traffic on Auckland Harbour Bridge. Auckland has the greatest car ownership ratio after the U.S.A.

Image retrieved 18/11/2011, from: http://allworldcars.com/wordpress/?p=11866 this can be the waterfront itself or steep and unbuildable terrain surrounding the city. Depending on these characteristics the density required to provide for the increasing population may not be able to be achieved.

A problem contributing to cities needing to expand is the outdated perception of buildable space. With an increasing knowledge in technology and construction, buildable space within the city is no longer restricted to land. Coastal cities have large areas of water within the city centre that offers space to develop. How this water space is developed is very important in regard to the increasing success of coastal cities.

The top four most populated cities in the world are waterfront cities. The size of these cities and many other coastal cities are growing, increasing the importance of coastal cities both as assets to the countries they inhabit but also globally. These cities like hundreds around the world not only face the growing problem of urban congestion they are also subject to a rising sea level.

Rising Water Levels

Sea level rise is thought to be one of the main possible effects from global warming. Junyong Chen (1997) identifies three main ways in which sea level rise is created:

- Water expands when heated. As the global temperature increases water expands forming a bigger mass the warmer it gets. Accelerated melting of the ice caps in Greenland and Antarctica contributes to 50% of sea level rise.
- Roughly 20% sea level rise is from the expanding volume of water flowing from lakes and rivers unloading an increasing amount of water into the ocean.
- 10% of sea level rise is pure expansion of water in the ocean as it increases in temperature.

However, pure water mass is not the only aspect that will affect coastal cities. Chen (1997, p. 926) states "the real impact on a coastal areas comes from the relative sea rise of the area in global change". Relative sea level

rise is the combination of rising sea levels and crustal vertical movement in the area. In New Zealand this poses a significant threat to cities as New Zealand has frequent seismic activity. Wellington itself is on a fault line and has in the past experienced large uplift, such as the 1855 Wellington earthquake that drained the Basin Reserve and created land uplift along the harbour coast that State Highway 2 now runs along. Rising sea levels means less land to use for building as well as forcing the city to retreat from the waters edge.

Many coastal countries are low lying and loss of land is an immediate issue facing them with sea level rise. A large number of these countries are in the Pacific and Indian Oceans. Rising sea levels therefore have a much larger impact on these countries as opposed to countries with higher terrain. In a few of these countries the sea level rise is extreme enough to force the inhabitants to move. One such country is the Maldives. The Maldives is a collection of islands in the Indian Ocean. It is home to around 350,000 people. The average height above sea level is 1.5m with the highest point in the country being 2.3m above sea level. In 2009 the president of the Maldives issued a statement that he was obliged by rising sea levels to buy land in Sri Lanka and relocate his people (Keuning & Olthuis, 2010). This highlights the urgent need for solutions to this rising water threat level, not only to create space for people to live, but also to create place, as culture can be lost through loss of place. Although sea level rise may seem very minimal such as 10 to 20mm per year the affects are much larger. This highlights the level of urgency caused from sea level rise.

Kiribati is another country in the Pacific Ocean in which the ocean is already consuming their atoll archipelago along the equator (Field, 2011). Much like the Maldives the country is very close to sea level and is suffering from loss of land and widespread damage to housing throughout the country.

Loss of land is a large problem caused by sea level rise, but is only one of the many hazards that can occur. The rise of water triggers a range of other natural occurrences that can affect structures in low-lying coastal cities. These include an increase in storm surges, flooding and water-logging (Chen, 1997). With rising sea levels the balance of fresh water and salt water is disturbed. Increasing salt water can spoil many water systems that are used in low-lying regions for agriculture that can then have negative effects on crops.



Figure 2: Male: Maldives. Male located on a small atoll and is the largest city in the Maldives and has a population density of 479 people per hectre. This population and city is threatened by sea level rise.

Image retrieved 18/11/2011, from: http:// travelworld.thecheers.org/Maldives/Male/ photos.html

The ocean accounts for 70% of the earth's surface. With landmass slowly being reduced, coastal cities need

to use the most available space to expand, develop or to create density. The ocean provides this space, but extending the urban fabric onto the water and forming communities also presents problems.

Forming Communities

Coastal cities are an encompassing identity created from a variety of districts, cultural zones and neighbourhoods. Each of there aspects of the city form a type of community that defines and maintains the character of the coastal city. How these communities are currently being formed is an issue facing the coastal city.

Monotonous housing growth within suburbs, and bland inner city developments are increasing due to various elements that are perceived as favourable to both developers and buyers. Examples are building time and overall cost including design and construction. The popularity of the waterfront environment increases the amount of development within coastal cities. However, these developments do not all form communities that maintain the character of the city.

Communities built on water inherently have a identifiable character. Developments on the water could shape this character into an identity that benefits the city. However, unlike building and forming communities on land there are no established guidelines to doing so on water. There is a strong difference between building on land and water and this distinct difference should be displayed through the community.

Future developments within the coastal city need to identify elements that contribute not just to the success of the community, but how the community also contributes to the city. Each community must respond to its unique environment to foster a social atmosphere with respect the growing issues of urban congestion throughout coastal cities.

Transportation

How a community as a combined whole, or as the individual houses that make it up, can move from city to city is an issue that needs to be addressed. A housing community on water should make the most of its environment, as a house or building that floats can also move easily on water. An entire community that can move as a whole or as individual elements has many issues to consider in regard to how it would move, such as powering movement and the transport mediums that would be used.

However, having established hierarchies, connections and infrastructure in place at each destination, eases the process of disengaging from one community and plugging into another. A community that can be broken down into individual elements such as single houses or buildings has flexibility and ease of movement over a whole community that is permanently joined together, or joined to its environment.

If these individual elements all need to have individual power sources to move, there are issues of where this power comes from as well as how to deal with the by products of power, such as waste and pollution. How the community's movement is powered is an area of concern. Most waterfront developments and marinas have polluted the surrounding water to a degree, through the use of petrol powered machines. This is not economic for the owners of these homes to move such a long way in such a large, possibly bulky structure, as well as not using renewable energy.

Also once these individual housing modules have reached a new destination they must all re-connect to form a functioning community once again. This can take time in both physical connection as well as organizational commitments.

Building On Water

There are both urban and physical issues to be addressed with a water community. The physical issues that are essential to supporting a water community is the need for durable materials to last within the harsh environment of the ocean. In keeping with developing trends these materials need to be sustainable and effective. Sustainable materials will not only help reduce negative effects on the planet but also help promote water communities as a friendly inviting place to live.

Well-built structures may function well alone but may fail when placed in an urban context. How the water community is organized is of huge importance to its success. As discussed coastal cities are among the largest in the world. There are many problems that occur in these cities that the water community should work towards reducing. One such negative effect is urban sprawl. This effect can lead to decreasing density in city centres. In order to retain and improve the infrastructure, and in doing so, safe guard prosperity with all its accompanying services, a minimum number of consumers is required (Koen Olthuis, 2010).

Urban sprawl can draw the density away from the urban centre of the city reducing improvement and development. It is widely accepted that denser living and building conditions in compact cities have more intrinsic potentials to become less resource consuming than more sprawling cities with sparser living and building patterns (Shelton, Karakiewicz, & Kvan, 2011). These large coastal cities have both large land and sea areas. Building on the water must also take care, like building on land, to maintain compact and contribute to the city centre.

Literature Review

This literature review covers a range of topics from a variety of disciplines related to building on water to combat urban congestion and climate change. This is because the coastal city and its waterfront are not issues that can be isolated from their environment. Like any city the success and growth of the coastal city must address and examine all the factors that affect and influence it. Therefore this review will examine firstly what a coastal city is, then examine the influencing factors of urban density, community formation, nomadic architecture and sea level rise to inform building on water.

Coastal Cities

Coastal cities have a growing significance in the world as 17 out of the top 25 megacities in the world are coastal cities (Timmerman, 1997). To fully understand the issues surrounding coastal cities we must first understand what it means to be a coastal city. The coastal city has been described as one of the most astonishing meetings of land and water on earth (Nordenson, Seavitt, & Yarinsky, 2010). Eric Homberger (Homberger, 2003) further describes a city next to the water as one charged with variety and endless possibility.

Peter Timmerman (Timmerman, 1997) develops the definition of the coastal city as a meeting of two ecosystems, "A conurbation of more than 100,000 people contiguous with, significantly oriented towards, and/or actually or potentially affected hydrodynamically by an extensive body of surface fresh or salt water".

From these definitions it can be understood that coastal cities offer a diverse range of possible developments through their unique connection between land, water and urban life. Some of the world's greatest cities such as New York have been shaped by the physical relationship of the city to the sea (Homberger, 2003).

The character of a coastal city is one that is fundamental to the life of its inhabitants. Coastal cities have inspired and encouraged their inhabitants to be artful about their rough co-existence with the sea in the past. With the growing threats of climate change, to help protect themselves these cities have the option of being creative once again (Nordenson, et al., 2010). In this way the character of the coastal city is fundamental to the life of its inhabitants. The climate of the waterfront is vastly different to inland areas through cooler temperatures and different rainfall and wind patterns, which forms an identity of place. For example Wellington, New Zealand, is renowned for being the windy city. In turn people will associate themselves with this identity of place. Each unique identity will create a different response to changing conditions within the city.

The city's main connection to the sea is through the waterfront. Historically coastal cities focused on trading through the port, with many kinds of ships. Essential to these ships was a waterfront that accommodated them as well as providing an unbroken connection to the city for easy transport and delivery of goods. This connection provided a direct relationship between city and sea. In expanding coastal cities it could be argued that the cities



Figure 3: Coastal Clty: Sydney, Australia. Photo courtesy of Rodney Haywood.

old port and waterfront area has been the last industrial space to be redeveloped. This has been helped by gentrification becoming popular in previous industrial areas. For example London's docklands were forced to close between 1960 and 1980, as they were unable to cope for the new standardized shipping container. This disused area provided the opportunity for a new young demographic to renovate and move to this previously industrial area. This development is also seen in Auckland as a gentrification trend emerged as young tertiary educated New Zealanders began moving into the inner city regions, including the waterfront (Murphy, 2008). It is argued that these young professionals, following their time at university associated the excitement of this new lifestyle with the city, and it was this that drove the process of inner city gentrification (Butler, 2007). This development saw the waterfronts of cities as adding a new character and identity by becoming revitalized by new styles and ideas that came with these young professionals.

Reasons for more recent development of the waterfront have been due to city council's growing awareness of tourism and that the possibility of intervening on the waterfront could modify the very image of the city as well as socio-cultural reforms within the city (Bruttomesso, 1993). Today cities such as New York and Hong Kong are recognized by their waterfront skyline. This waterfront view becomes the attractive face of the city encouraging tourists to visit. The waterfront and the water itself provide the possibility to continue contributing to the coastal city.



Figure 4: Coastal Clty: New York, U.S.A.

Image retrieved 18/11/2011, from: http://images.google.com/hosted/life/ f?imgurl=7f32067959add0a7 However, the waterfront is not just made up from buildings, many other elements contribute to it. Brand (2007) has identified types of spaces that exist within the cities water edge that can be defined as 'bluespace'. This author also uses this idea of bluespace to distinguish nine different instances where urban and sea spaces combine to produce a very individual public space, such as wharfs, piers and even boats themselves. This highlights the ability of the waterfront and water itself to provide a connection between the land and sea. This ability of spaces to connect is also supported by Melanie Gidel who claims that communities on the water can act in the same way as bluespace, to link the sea, waterfront and city. Gidel goes on to compares these communities to mangroves that develop at the point of contact between land and water (Desfor, Laidley, Stevens, & Schubert, 2011). By doing so these water communities take part in the vitality and natural equilibrium of the coastal city.

Urban Density

Throughout the world there is a trend of movement from rural settlements to urban centres. This trend is in response to urban centres offering better education, having a higher standard of living and more job opportunities. These urban centres continue to develop and expand. Richard Florida explains that these centres keep on growing, they practically never reduce in size (Florida, Gulden, & Mellander, 2007). Urban regions that continue to grow form mega-regions. According to Florida these urban centres can become more economically important than the countries in which they exist (Florida, et al., 2007). Therefore these urban centres are of great importance to not only their surrounding environments but also at national scale. These urban centres contain within themselves vital customs, culture and history (Keuning & Olthuis, 2010). When one thinks of New York, London or Hong King a great variety of images and thoughts come to mind, highlighting the importance of the character to each of these places.

To help maintain the character of the central city the urban fabric needs to be of a certain density. The effects of urban sprawl can diminish the character and identity of the central city by reducing urban density. For example Atlanta's population grew by 80% from 1960 to 2000. However the growth was predominantly through expanding suburbs which actually resulted in a loss of population in central Atlanta (Lewyn, 2003). This trend is mirrored in Toronto, a city that developed over 9,100 acres per year of boarding rural land. In comparison Portland in Oregon consumed land at a rate of 1,700 acres per year (Green Belt Ontario, 2009). This move out of the city reduces the continuing development of customs and culture within the city (Alexander, Ishikawa, & Silverstein, 1977). In contrast, the benefits of urban density offer more than contributing to the culture of the city. It is widely accepted that denser living and building conditions in compact cities have more intrinsic potentials to become less resource consuming than more sprawling cities with sparser living and building patterns (Jenks & Dempsey, 2005). This urban density in the central city is essential to maintain as a minimum number of consumers is required to preserve and develop the character of the city (Keuning & Olthuis, 2010).

When these growing urban centres are coastal cities they have a considerable advantage over inland cities as the focus of the city is around the waterfront, which without existing buildings provides a huge opportunity for the city to improve itself. As much as 90% of the 100 largest cities in the world are located on water. The

majority of these cities have a large expanse of water in the city themselves in the form of lakes, rivers, canals, harbours, bays or open sea. If assumed water can support foundations and buildings it is in effect like a land extension of the city. When observed like this, a substantial amount of the ground area in these cities is therefore water (Keuning & Olthuis, 2010). These coastal cities can then achieve urban density in the central city with ease. The city centre on water provides the opportunities to develop the city from the inside that inland cities cannot achieve without extensive deconstruction, removal or demolition. The significant advantage of building within this central water space is the location. This space contributes to the identity of the central city through developing the area while maintaining the density without overcrowding. Unlike urban sprawl that develops on the edge of the city, this water development is created within the city itself.

In these constantly changing urban centres the need to develop the central city is paramount to create a centralized identity that people can associated themselves with and belong to. In the last 100 years cities have had to cope with more changes than before, as well as the speed at which these changes take place (Keuning & Olthuis, 2010). The existing consumer lifestyle means that the demand for different things is constantly changing. It is clear that there is an area of tension between the long lifespan of the built urban environment and the quickly fluctuating demands of the city dwellers (Keuning & Olthuis, 2010). So the need for an urban environment that is readily changeable is urgently required. Current urban planning looks at creating new spaces that are flexible to accommodate for this change.

On solid sites this flexibility is limited. However building on water means building on a site that can move. Coastal cities with expansive ground area of water can create in their central city, a perfectly flexible urban environment that can keep up with the demands of city dwellers. Building on water and then moving the structures means that the site left is exactly the same as before the structure was built. This type of development is also highly reusable. Parts of the city where buildings are in disuse may be in demand elsewhere in the city. Because water offers ease of transport, this facilitates quick relocation to areas of demand where these buildings life rejuvenated. However the scale of how these reusable spaces are developed must be addressed. Flexibility by itself will not create a successful space, so people must associate with and enjoy these places.

Evidence shows communities or neighbourhoods that people identify with, have small populations as well

as having a small area, and without any major roads thoroughfares (Alexander, et al., 1977). Elements such as too much traffic or over-sized roads can make a community feel isolated and restricts social interaction. Therefore a community on water must be of a scale that encourages pedestrian movement throughout. It should also develop on its inherent unique identity of a neighbourhood on water. The balance of density is key to a community's diversity. Too little density and the 'magic' or identity of an urban space is lost. Alternatively if the density is too great then overcrowding also destroys the space. In a community making the most of its public space on water density must be maintained. Within the community, public space should form areas for gathering and activity to create a sense of diversity. Most of all, a community on water must accept that water is a public space and through this develop a social atmosphere of togetherness will emerge, forming a community.

Forming Communities

When forming a community its context is essential. In New Zealand culture, a large amount of activity occurs outside within the backyard. As the behind house is effectively an extension of the backyard, perhaps this element should be kept on. As water is public space, it could be perceived that with a house on water, any behind area is a backyard, however this is a dauntingly large space. As you cannot shrink the ocean to make your backyard smaller, it must be the way in which these housing clusters are organized to control the size of the backyard.

Inner city apartments are built side by side to create density. This forms a liner line of sight and movement within an apartment. Therefore when incorporating this style of apartment living into a water community flaws start to appear. A city apartment building can be located to face the best light conditions. But a community on water can face any direction depending on how the community forms. So building side-by-side reduces the ability to gain quality light if not taking advantage of quality light, such as North facing windows.

Christopher Alexander explains that within cities there should be a belt of common land next to the water

(Alexander, et al., 1977). This belt of land forms a green space in the city for people to enjoy as well as creating diversity between the city and sea connection. By connecting the community to this belt of land, a middle ground is formed to ease the change between spaces, integrating the community seamlessly with the city.

Living on water requires the support of a community to be viable for a large number of people. Forming a community on water faces many different challenges to those urban spaces on land. A distinct difference is that unlike land, water is constantly in a state of change. Because of this floating communities can be considered a nomadic type, and as a community they can take advantage of the ease of movement through living on water.

The community must be connected, both through physical connections and atmosphere. These connections need to be at different scales within the community creating a sense of diversity, avoiding the possibility of a monotone urban space. As well as the community connecting within itself it also needs to connect to the permanent coastal cities it migrates to.

An issue with floating communities is that they are effectively modifying the underwater environment through the loss of light, particularly in shallow areas adjoining land. This can negatively affect aquatic life such are marine plants and fish that rely on this light. This is an issue that needs to be addressed, especially in large water communities. This issue can be modified by the use of temporary or nomadic communities that reduces this effect.

The nomadic community is a flexible urban space on water that has no fixed aspects to a particular site it inhabits temporarily. For a community of this nature the connection to the city is paramount. A temporary suburb or urban area that can commute between cities will have no established interaction with the city it is currently docked with. To be successful and inviting as a place to live water communities must have an inherent character and pleasant atmosphere that contributes to the cities the community connects to.

Essential to keep any community functioning smoothly is a sufficient grade of quality infrastructure. One of the main challenges with infrastructure in a water community is the need for continual change, requiring flexibility. One of the benefits of living on water is flexibility of space and the ease of transportation as a whole community.

Nomadic Architecture

The ocean as a place of living offers the potential for flexibility of movement and therefore place. This possibility of changing place could dissolve the established conditions that we associated with the permanence of shelter and dwelling. Deleuze and Guattari associate this change of conditions with those of the nomad (Deleuze & Guattari, 1986). The nomadic life however does not degrade our social norms; it is a life that offers huge potential to create them. Alberto Perez-Gomez has described nomadic life as one that has offered humanity real possibilities for fulfillment, revealing to the individual a sense of participation in the cultural order and natural world (Kronenburg & Klassen, 2006). The aborigines of Australia are a nomadic, not through architecture but through culture. Traveling to them offers this fulfillment of life through weaving together their story of travelling. Nomadic architecture offers the possibility to create a unique story through using the fluidity and movement of the ocean as a place of change, to enrich both architecture and inhabitants lives resulting from this nomadic lifestyle.

Architecture that is moveable or transportable offers an exciting new experience of place. Through nomadic architecture people can perceive space differently and through movement can connect space and cities. The journey between places perceives space not as a void but as a link between every object, both of natural and man made (Kiesler, 1996). Movement and change of place is highly beneficial for a person's development, through this sense of discovery. This sense of discovery can be both through architecture and through the environment. To help enhance this sense in design, perhaps sacrificing immediate visual clarity and order may be a welcome price to pay for the overall appeal of indeterminacy and discovery (Berleant, 2005).

Heinrich Tessenow explains that when designing any structure you must lay foundations, as this is the base for any building, the starting block (Tessenow, 1989). When this starting block is water, an element that itself moves, it greatly changes our perception of what it means to have house or home in a place, rather than a space. The foundations have always been an aspect of building that has created permanence to create a home. But, Mathew Allen explains a home is only a place we occupy for a period of time, as we may change homes many times during our life (Allen, 2005). Alternatively living on water could create the perception that it is only place we occupy for a period of time but our home we could take with us. Therefore making the home a permanent space is a variety of places.

It is therefore understood that people gain meaning from a place in a stable environment, as they feel safe through a sense of attachment and belonging. This stable environment can relate to both surrounding terra firma as well as structures that are built into this environment, in a permanent setting. Architecture that moves through an environment that is in a state of constant change can create a sense of losing meaning in each change. However it is not the architect who builds meaning into the design of a building, it is the users who imbue the design with meaning (Prussin, 1995). Therefore, to gain a sense of home we must accept that it can change. Allen concludes that finding a home in the world must rely, ultimately, on a nomadic sensibility that is willing to experiment with life (Allen, 2005).

Sea Level Rise

The literature surrounding sea level rise is extensive. This literature and current events both highlight the need for water architecture. Sea level rise deals with issues that include loss of land, but also more subtle effects from the ocean. These effects include an increase in extreme weather such as storm surges and fresh water salination. Sea level rise in some places is so wide spread that it affects whole countries, and through this many political issues are created in how to deal with this increasing problem facing many countries.

Loss of land and in some cases the flooding of a country results in many radical political decisions. As explained earlier the people of the Maldives face such a choice in terms of how to react to the flooding of their country by rising sea levels. Instead of building within their country they are exploring moving to a different one. The Maldivian President Nasheed has proposed Sri Lanka as a place for his people to move as their culture is the most similar and therefore more likely to support the culture of the Maldives to continue (Zoomers, 2011).

Alternatively in Kiribati they have chosen to stay within their country. With no close neighboring countries to move to, their president Anote Tong is considering building floating barges for his people to live on. He



Figure 5: Sea level rise in Kiribati.

Image retrieved 18/11/2001, from: http://www. greenpeace.org/international/en/campaigns/ climate-change/impacts/sea_level_rise/ identifies that this is not the most ideal solution and may destroy his people's way of life. This also highlights the need for a more developed solution to meet the needs of these differing peoples.

Therefore, sea level rise has forced coastal cities to create many responses to the changing climate. These adaptions to the city are varied. Jane Bicknell, David Dodman and David Satterthwaite define this adaptation to climate change as actions to reduce the vulnerability of a system or population group to the adverse impacts of anticipated climate change. These authors also point out that often adaption to climate change will also result in adaptation to climate variability (Bicknell, Dodman, & Satterthwaite, 2009).

The immediate response by most major cities is to create a barricade against sea level rise. The most well known example of this is the Thames Barrier, considered one of the best flood defenses in the world (Barker, 2008). There are many other examples of barriers and sea walls to help block out water, such as the Maeslantkering Barrier in Holland (Nordenson, et al., 2010). However this response of creating barriers is now considered an out dated solution. 'Rising Currents', an exhibition at the Museum of Modern Art in New York in 2010 promoted a response to accept the rise in water level rather than blocking it out. The exhibition aimed to create public awareness and to encourage different solutions to sea level rise (Ouroussoff, 2009). Other projects like 'On the Water: Palisade Bay' in New York highlights this new approach of letting water into the city contributing to an increase in interaction between land and water along the shoreline throughout the city (Nordenson, et al., 2010).

Barricading, or blocking the water out is only one of many solutions. Some countries perceive the rise of the ocean to be too great to keep out and therefore have looked to other means of protection against this problem. In response to increased effects such as storm surges the idea of managing and reducing the affects of sea level rise has been put in place in many countries. The Netherlands has reformed flood management approaches to accommodate the changing perception of how to deal with rising water levels. That is, to see water level as an inevitable change that is to be embraced by design. English firm Baca Architects won a design competition in the Netherlands that addresses these issues (Thompson, 2008). The design is a mix of 80-100 floating, amphibious and flood resistant homes. The diversity in design of these homes means that they can be integrated into existing communities, allowing for a progression of land based dwellings to purely independent floating houses.

One noticeable absence in literature is an accepted theory on urban implications of sea level rise, as most theories focus on effects on the environment or project statistical data. (Oakley, 2010). This absence is explained through the lack of cross-disciplinary collaboration between designers and climate change specialists. The literature suggests that climate change specialists lack an understanding in relation to urban effects because they have a simplistic often stereotyped 'urban population explosion' or 'rural push/urban pull' view of urban change. This often fails to consider why urbanization is taking place, what drives people to concentrate in specific urban locations, and what particular processes make the population of each urban centre vulnerable to environmental hazards (Bicknell, et al., 2009). Because of this there is a need for further research that includes and combines both environmental and urban issues to create a more developed solution.

Building On Water

There is an increasing amount of building on water. Global attention has been seen in Dubai with the floating islands and suburbs like Palm Island created off the coast of the United Arab Emirates. There are many other examples of floating structures, such as floating prisons, floating high rise buildings, floating airports and roads (Keuning & Olthuis, 2010). In terms of individual housing Canada and the Netherlands have the most developed buildings. Examples of big housing developments in Holland are De Draai in Heerhugowaard and projects like Waterstudio's 'New Water Project' and Baca Architects Amphibious homes.

The majority of these floating houses are relatively small homes that are of lightweight timber frame construction built on buoyant platforms (Thompson, 2008). Water is a very fluid material and needs a type of structure that can move with it. Using lightweight materials combine well with living on water because of the need for flexibility in terms of movement. These lightweight houses need to find a balance between movement with water and stability for living.

These Dutch floating houses address this issue of movement and can be moved along waterways to different

destinations. Amphibious houses float on concrete buoyancy decks. These structures rest on solid land but in the case of rising water float with the water level. They are restricted to pure vertical movement, as they stay connected to their foundations. As water level rise is a gradual process, most resources are investigating the amphibious homes as a step in the adaptation of living on water. This is enforced by the Dutch pioneering in the investigation of amphibious housing that Brand (Brand, 2007) explains is due to predictions of hundreds of millions to become refugees of global warming.

To date development of concrete type floatation is limited in the Netherlands because a depth of 1.5 meters is needed to form the base for a single house. This is because most Dutch canals and surface waters are shallow, less than two meters deep. As the Dutch have focused on the interior fresh water of the country and little on the ocean front there has been few development with sea ready buoyancy devices. This gap in knowledge could be useful to explore. However these larger concrete decks could be explored further as they are more practical for deeper ocean environments. Also the concrete buoyancy blocks are useful in forming communities as they can be easily connected to form large platforms (De Graaf, 2009).

Other construction options currently being explored are a Canadian invented floatation system of a polystyrene foam core with a concrete shell. This reduces the density of the floating device. This system needs less water to work which works with in dykes in Holland (De Graaf, 2009). Basic versions of these systems have been in place in the Netherlands and Canada for sometime. However these designs have been custom built by individuals and not suitable for mass production standards. The reason for this is the demand for this type of housing has not been enough to warrant commercial scale construction and therefor these houses have been privately built and cannot access the savings and building techniques that more commercial scale operation can. By standardizing components essential to living on water such as floating foundations, this type of living can be more readily available to both private and commercial projects.

Precedent Review

This chapter will review selected case studies that will inform the design ideas and development of the proposed design. Case studies explored will start from the largest scale to the smallest projects. The range of projects provides an insight into differing responses at different scales on how to address living around and near water. This insight will create an understanding of what elements are successful from each project to then inform the design case study of living on water.

Victoria Harbour Hong Kong

Hong Kong is a city split between the Kowloon Peninsula and Hong Kong Island by the harbour. The habour is a critical part of the identity of this coastal city as the name Hong Kong literally means 'fragrant harbour'. The ocean in the city with the harbour and the boats connecting the two land masses has become the life blood of this urban centre (Shelton, Karakiewicz, & Kvan, 2011).

Hong Kong in one of the densest cities in the world. With steep terrain much like Wellington, Hong Kong has little room for the expansion the city population require, so has instead resorted to creating high density living through taller buildings and smaller spaces. From very early on the harbour lying between the divided halves of the city was seen as a place to expand. The city has now reclaimed over half of the 6500 hectares of Victoria Harbour. The distance from Kowloon Peninsula to Hong Kong Island has been reduced from 2300m to 920m.

This coastal city's response to its increasing population growth has been to expand onto the water through land reclamation. Reducing the ocean and harbour within the city has also meant reducing the unique elements that contribute to its identity and make the coastal city so appealing.

The Victoria Harbour case studies identify both the problems of many coastal cities and the advantages, such as the water itself. For example Victoria Harbour is at the heart of Hong Kong's global identity and the source of its competitive advantage in the Pearl River delta (Glassman, 2005). Victoria Harbour illustrates that reclamation is not the answer for extending the urban fabric. While it provides more available land to build on it however physically reduces the character of the city that made it desirable to build on in the first place. This would suggest a more flexible solution is required. Hong Kong needs now to consider a solution that respects and enhances the cities waterfront. This supports the idea that a form living both with and on the water is required. This concept will be explored in my design case study.

Figure 6, 7, 8, 9, 10: View of Victoria Harbour splitting the Kowloon Peninsula and Hong Kong Island by day.t

Image from: Wing (2011) Retrieved 08/006/11, http://en.wikipedia.org/wiki/File:Hong_ Kong_Victoria_Harbour_Pano_View_from_ ICC_201105.jpg

Traditional Junk, one of the many boats that transverse Victoria Harbour.

Image from: FriendlyPlant (2009) Retrieved 13/11/11, http://www.friendlyplanet.com/media/ gallery/asia/china/hong-kong-victoria-harborjunk-big.jpg?title=Victoria%20Harbor,%20 Hong%20Kong

View of the entrance to Victoria Harbour from Hong Kong Island.

Image from Wing (2011) Retrieved 13/11/11, http://en.wikipedia.org/wiki/File:International_ Commerce_Centre_%26_International_ Finance_Centre_201007.jpg

Star Ferry crossing Victoria Harbour from Kowloon Peninsula.

Image retrieved 13/11/11, from http:// en.wikipedia.org/wiki/File:Hong_Kong_at_night. jpg

View of Victoria Harbour and Hong Kong Island at night.

Image retrieved 13/11/11, from http:// en.wikipedia.org/wiki/File:Hong_Kong_at_night. jpg







Palisade Bay Project New York

Palisade Bay is a project designed for New York that integrates the idea of soft infrastructure to the city's New York – New Jersey Upper Bay. The idea of soft infrastructure is part of adaptive design solutions to cope with rising sea levels and effects associated with climate change like storm surges. In the next fifty years the sea level around New York is likely to rise by as much as a foot above the average current sea level (Nordenson, Seavitt, & Yarinsky, 2010). The Upper Bay is home to some of New Yorks most valuable real estate, most of which lies just above sea level, covering Manhattan, Brooklyn, Staten Island and New Jersey.

To help protect this essential and vital part of New York city the integration of soft infrastructure aims to synthesize solutions for storm defense, sea level rise and environment enrichment (Nordenson, et al., 2010). This is achieved using a series of green zones along the waters edge throughout the Upper Bay. These green zones consist of wetlands, piers and slips and numerous islands.

The word palisade has a various meanings associated with protection and defense and captures how these green zones aim to protect the shoreline in the bay. However unlike flood barriers and sea walls that aim to shut out the water completely, these green zones act as a means of absorbing the water. The damage caused in storm surges or floods is taken into the city and reduced dramatically through the resilience of these green areas.

The unique idea of green zones as a defense against climate change is that they are incorporated into the city and become the city, rather than separate structures that serves no other function. By bringing the green zones into the city the resistance to damage caused by climate change is increased. However, as the Upper Bay is such an essential part of New York, the valuable real estate cannot be just handed over for protection. Here the Palisade Bay project really excels, in that all the green zones provide a variety of functions. These resilient areas have been designed to provide a great number of recreational areas within the central city to improve and create a diverse ecology through both plant and animal life that enhances the cities vibrancy and way of life.

The Palisade Bay project demonstrates a thorough understanding of the different systems in play within a

Figure 11, 12, 13, 14: New York Upper Bay zones of soft infrastructure implementation.

Example of recreation opportunities within developed green zones.

Integration of soft infrastructure into the urban fabric.

Proposal for sea level rise defence on Manhattan island, New York.

All images from Rising Currents: Projects for New York's Waterfront 2010, Retrieved 23/05/11 http://www.moma.org/visit/calendar/ exhibitions/1031




coastal city. It realizes the importance of the need for protection as well as economic development and forms a balanced solution between the two. Although the project only focuses on a part of a single city, the principles and ideas behind the moves to create an adaptable solution can be applied to other coastal cities to help both improve and protect our much loved urban environments.

This idea of the environment successfully working to improve the quality of the city while also helping reducing negative effects associated with sea level rise is a quality that should be incorporated into the design case study. This study highlights that the water community should view the built and natural environment equally so they can work together to create a better solution.

Cua Van Village Halong Bay

Cua Van is a fishing village located in Halong Bay in Vietnam. It is one of four villages that are part of the Halong Bay world heritage site. Cua Van is made up of about 200 floating homes with roughly 800 residents. The village also has its own floating school and community centre.

The village has existed for over one hundred years and is recognized as a culture icon of Vietnam. Because the village floats on the ocean rather than built into the earth it has developed a unique character that contributes to the Halong Bay environment.

The organisation of the community is established through a set of hierarchies. The houses focus and cluster around a chief, or headman in the village. This person can change and the community rearranges itself with this change. Other elements such a weather conditions and neighbouring land formations contribute to this cluster hierarchy community.

Cua Van is a village without power or infrastructure. It could be considered a community of the most basic form, all the houses and buildings are completely separated and have no relation to one another. There is no waste disposal, all of which is dumped into the ocean next to the floating houses.

This village reflects the cultural diversity of communities living on water and demonstrates how living on water can exist and continue without all the essentials of modern life. What Cua Van indicates is that living on water is successful at this small scale. It shows that a community can exist without a connection to land. By showing this on such a basic level it proves that a modern water community developed from these basic aspects can greatly improve the quality of life of water.

Figure 15: Cua Van floating village, Halong Bay, Vietnam.

Image retrieved 06/07/2011, from: http://www. buildingonwater.blogspot.com/



Chong Khenas, Tonle Sap Lake, Cambodia & Semporna Coast, Sabah, Malaysia

These areas have a range of different structures built for living on water. Chong Khenas and the Semporna coast have structures built on slits that are sunk into the lake or seabed. While on Tonle Sap Lake there are a large number of independent floating homes, including the majority that are physically tied to the ground. These areas and housing describes a way of life on the water.

The villages off the Semporna Coast, unlike the floating villages in Halong Bay, are situated a long way from the coast and are not dependent on land. This area is home to sea nomads. These residents are so in tune with life on the ocean that they suffer from land sickness when they visit the mainland.

Chong Khenas is located on a part of Tonle Sap Lake and during the dry season is completely drained. All the structures are designed and built to function both on dry and wet land when the water level rises to over three metres. It is interesting to see a community layout that functions through conventional street layouts in the dry season yet is still connected just as well when the ground is submerged.

Chong Khenas is a poor area and its housing is below any quality grade standard but it demonstrates the continuing success off a community that is resilient to extreme flooding, creating a system of living that is adaptable to both water and land.

Like Cua Van, Chong Khenas and Semporna are cultural icons and attract tourism that economically benefits the surrounding towns and villages. It is this identity that binds the community together giving inhabitants a sense of place and belonging. This form of identity has and uniqueness is a quality that is incorporated into the design case study, creating a sense of place through identity.

Figure 16, 17, 18, 19: Chong Khenas Village street during dry season.

Houses in Chong Khenas on stilts in the wet season.

Community on stilts, Semporna Coast.

http://www.southeastasia.org/index.php /seaawards/photos/the-paradise/

Houses on the edge of the reef, Semporna Coast.

http://photography.nationalgeographic.com/ photography/enlarge/semporna-coast_pod_ image.html



Kampong Ayer

Kampong Ayer has developed from a village that has been dated back 1300 years. Today it is a large community of 39,000 residents. It is located in an area that is part of Brunei's capital Bandar Seri Begawan and because of its location on the water and various channels and waterways that have been created it has been nicknamed the Venice of the East. Similar to Chong Khenas and the Semporna coast all the structures are built on stilts.

What Kampong Ayer demonstrates, that Cua Van and Chong Khneas don't, is the capability of water communities to be integrated into the urban fabric. What is interesting with Kampong Ayer is that the capital Bandar Seri Begawan developed from the water village, rather than the village being a result of the urban sprawl pushing the city onto the water. This shows that living on water can be equal to living on land in terms of size. Kampong Ayer relates to current practice through demonstrating the complete compatibility between water communities and coastal cities. Bandar Seri Begawan recognized the importance of Kampong Ayer to the city, both through its cultural and historical importance but also through its ability to attract tourism.

Kampong Ayer is connected through a series of wooden walkways that connect all the buildings in the village. There are also main waterways that act as the main roads through the village. The majority of the houses are accessible by boat, however the main method of movement throughout the village is through walking.

It is interesting that walking is the main method of getting around in a village on water. It highlights that living on water does not need to be restricted to water transport and that it can be pedestrian friendly. However an issue with this is if that buildings were floating and could move apart a permanent walkway would be difficult and this is an area that needs exploring.

Figure 20, 21, 22, 23: Pathway along the edge of the village.

Laneway between houses above the water.

View down onto Kampong Ayer village.

http://www.columbusmagazine.nl/azie_en_ midden-oosten/brunei/reisreporter/fotos/12542. html

Example of founation stilts exposed.

http://myprintsolutions.com.au/Blenheim-serdimicro-2000-valve-seat-cutter/









Nijmegen Peninsula Baca Architects

The Nijmegen Peninsula is a project to create a new peninsula in Holland that is to house a dyke relocation program as well as an integrated community development.

The project aims to promote itself as an environmentally aware development that is designed to deal with rising water levels and floods that are increasing in size and number. It uses the development, like Palisade Bay of soft infrastructure. It has identified the benefit of a combined system that incorporates the local environment into the urban fabric.

Firstly, the proposed houses are of three types. One is of permanent housing much like any land based development. The next stage of housing is semi-attached and like the housing of Tonle Sap Lake it is anchored to the ground, but through the use of floating foundations can rise with the water level in an occurring flood without being swept away. This type of housing has been labeled as amphibious. The last stage is housing that is completely free from land foundations and is located on the water using the concrete and polystyrene floating foundations. The project aims to demonstrate how floating and amphibious housing can be connected to existing urban fabric on land.

Similar to New York the project enhances the community by providing sustainable infrastructure that acts as both an absorbing barrier and recreational area. It incorporates water recreation, river ecology and vegetation zones to achieve a flood defense system as well as creating diverse environment for both wild life and people living in the area.

Figure 24, 25: Urban layout of the Nijmegen Peninsula development.

Proposed housing with floating foundations to cope with flooding.

Both images from Bacablog 2009, Retrieved 19/05/11, from http://www.baca.uk.com/blog/ projects/12



Precedent Review Summary

These case studies range from isolated traditional fishing villages with limited infrastructure and amenities to modern suburbs beginning to become incorporated with the surrounding urban fabric, utilising the latest design technologies. These case studies can be understood to present a pathway of adaptive solutions to living on water in response to fluctuating water levels to urban congestion.

The response from the case studies derived three main ideas to help inform the design. Firstly the idea of a floating community over fixed bases, such as stilts or moveable foundations responds better to the coastal city environment. The flexibility of a floating house offers many more possibilities than houses with fixed bases. This means the community is free to rearrange itself over time to adapt with changing conditions. Secondly these floating houses must develop a sense of character and identity that is apparent in each case study. This character will help contribute to the identity of the coastal city. Lastly the idea of using the environment to act with the community through the concept of soft infrastructure is an element that will be including within the design. This concept can help improve the coastal city and the communities within it through sea level rise protection, inner city green zones and help clean that water around the cities.

The environment is essential to coastal cities. The beautiful views traditional water living, like Cua Van in the pristine scenery of Halong Bay are only sustained through small developments. Aspects from these communities such as sewage disposal and power, will not function in a larger developments within coastal cities. The need for efficient services such as power, water and sewage are essential for developing a way of life on water. The design must solve the conflict between, water housing, which moves, and the services identified which are fixed.

An urban system of living that is developed to help mitigate the affects of climate change must itself not contribute to climate change. The proposed urban system for living on water must address these issues through the design case study to help create a way of life to both contribute to both the needs of the city and that environment.



In this chapter the elements of water living identified in the previous chapter, combined with research from the literature review are developed to explore the role architecture can play in address and improving the issues within the coastal city. This exploration is shown through a series of diagrams and images with accompanying discussion and explanation of important features incorporated within the design. This design chapter is presented in 4 sections. Firstly there will be a description of the chosen site leading onto highlighting existing design proposals in the area and how the presented design is affected and benefits from these developments. The design section is split into three scales, the urban planning and development, the modular elements and finally, detail.

The design outcome investigates how living on water can contribute to and help protect the coastal city. The design focuses on developing a community that fosters a social atmosphere and that through design creates a sense of identity, character and place. For this design community is defined as both the built forms, as well as the natural environment they exist within. Critical to design development is the notion of a lifestyle that is constantly changing through movement, both of the environment and the flexible changing lives of its inhabitants. The building block of the community is a variety of small apartments suited to inner city living.

Note: All images in this chapter are the authors own work unless otherwise stated.

Site

Site Outline

For this design the floating community must be located on the ocean, within the coastal city. The coastal city is centralized around the ocean, and it is within this inner city area that the community is to be created.

For a floating community to work successfully there must be a number of other met requirements. Easily accessible routes to the community are essential. Ease of accessibility means that the community integrates smoothly with the city as well as providing residents with a strong connection to the central city. Access routes are successful when a variety of different types are present, such as public transport, private car and pedestrian pathways.

Figure 26, 27, 28, 29, 30, 31: East facing view of CBD.

South East facing view.

South West facing view.

West facing view of Saint Marys Bay.

Important locations surrounding the Saint Marys Bay site.

Existing access routes to and through the chosen site.



Choosing a New Zealand Site

New Zealand has in many places a rough and rugged coastline. It was identified early in choosing a site that the community must be located next to some form of flat land. Auckland had the best choice of sites because of this. The chosen site in Auckland is Saint Mary's Bay, selected for the following reasons:

- Saint Mary's Bay is located directly next to the city CBD.
- It provides a sheltered bay with a large enough ocean area to accommodate a community of 300-400
- people.

There are areas of flat land surrounding the bay.

- It will not hide prime ocean views once the community is built.
- It is located next to popular pedestrian walkways and has existing road access.
- It is within walking distance of the central city and many transport routes.

Figure 32, 33, 34:

Aerial view of Auckland centre with Saint Marys Bay in the centre.

Retrieved 14/11/11, http://www.waterfrontauckland.co.nz/Areas/Westhaven---Harbour-Park/ Images/Westhaven-Photography.aspx

Rhythm study of Auckland city centre skyline, highlighting the change in rhythm scale from the edges of the study on the left through to the waterfront on the right. The design works to continue this scale rhythm within the city.

Building use of Auckland city centre.





Existing Proposals

The Auckland City council has identified the Wynyard Quarter (also known as the Tank Farm or Western Reclamation) as one of the largest undeveloped areas of Auckland's waterfront. With the Wynyard Quarter forming part of the Saint Marys Bay site, developments within this area will interact with the water community design. The Auckland waterfront is to be extended into the Wynyard Quarter linking the complete waterfront through a series of public spaces. Auckland City Council's proposed concepts identify the idea of 'turangawaewae' or 'sense of place' as an important element of the development. This idea is shared between the design and waterfront development which means they will work together to both create a successful and diverse waterfront, but also help contribute to Auckland City's identity as a coastal city.

There are three main concepts. Each of which focus on a pathway axis, drawing people towards the Wynyard Quarter, while also helping the water community design through this connection to the city. The concepts are, the Waterfront Axis, the Park Axis and the Wharf Axis.

The Waterfront Axis works to create a pathway from Quay Street in the CBD through the North Wharf and Jellicoe Street to end in Saint Marys Bay. The concept encourages on pedestrian walkways continuing through the axis to the Auckland Harbour Bridge.



1. The Waterfront Axis



3. The Wharf Axis 35

Figure 35, 36, 37: Plan diagrams highlighting the three concepts proposed for Auckland's waterfront.

The Waterfront Axis concept.

The Park Axis concept.

Both images from: Auckland Council. (2007). Wynyard Quarter: Urban Design Framework Sea+City. Auckland.



The Park Axis develops a connection between Victoria Park and a proposed recreational area at the end of the North Wharf in the Wynyard Quarter. The concept focuses increasing outside activity within the central city through the parks.

The Wharf Axis creates a connection between land a sea through the development of the Wynyard Wharf. This concept also includes a park similar to the Park Axis, although the focus is on the city side of the Wynyard Quarter.



Figure 38: The Wharf Axis concept.

Image from: Auckland Council. (2007). Wynyard Quarter: Urban Design Framework Sea+City. Auckland.

Urban Planning

People "want to be able to identify the part of the city where they live as distinct from all others" (Alexander, Ishikawa, & Silverstein, 1977).

Urban Layout

Water communities can expand, move and change form with ease. This change and movement of the community reflects the modern lifestyle of inner city living. The idea of a plug in community needs to have a set of rules to govern how it grows and expands. This idea of the intimate street or block is the essence of a community. The flexibility of space on water allows for a redefinition of how the street is formed. In a community the most communication between inhabitants on a standard street occurs between adjacent neighbours and those directly across the street (Alexander, et al., 1977). Between these houses a cluster is formed. This connection between residents is essential to establish the social atmosphere of the community.

Standard streets have limited connection with the behind house. The behind house does not improve the social atmosphere. However eliminating the behind house does not immediately create a more social community. It needs to be replaced by an element that will improve on its removal.

This space becomes a shared backyard between these clusters of houses. It eliminates the unsocial backhouse and replaces it with a shared space that provides the opportunity for activity and connection between the houses that surround it, improving on the sense of community. Shared areas encourage interaction between residents creating the sense of neighbourhood.

A community on water is a very public space. Land is associated with ideas such as ownership and privatization. Water on the other hand is regarded as a very public space. This is an element that the design encourages. Dense building side-by-side closes off views to shared public spaces such as the new water backyard. To help foster the public interaction a certain density must be maintain and not exceeded.

Figure 39, 40 (left to right): Street layout diagram.

Social cluster diagram.

Social interaction between residents occurs between fronts of houses. The back house lacks connections to its behind neighbour.



Main social connections within a standard street layout



Although the back house is eliminated, the roads that take its place create an even more unsocial community.



Back house is removed to create a repetition of the social cluster in its place to attempt to improve the social connection within the community.



a shared backyard sace.

Figure 41, 42, 43, 44 (left to right): Street layout variation.

Shared backyard diagram.

Backyard on water.

Housing density diagram.



The shared backyard space acts in the same way on water as on land.



Any central city living needs to maintain a certain density level, this is the same on water.





Housing built too densely closes off the shared backyard space, resulting in a much more private community, which is in conflict with the public lifestyle of water living.

Establishing a level of density that maintains the character and identity of place while supporting the welcoming nature of the public community.

The Community Block

The urban layout guidelines established identify how houses are organised together and on a street. This section describes how these streets are developed and formed into a community block.

For a house to move to a site and connect to form a street or block in an existing community in any way it wishes can create problems:

- A sense of pedestrian flow within the community can be lost.
- Pathways can be difficult to navigate within a randomly formed space.
- Waterways can be locked in by too many connections.
- Public spaces that are not planned often can result in limited use.

Circles and curve forms develop some sense of direction but do not enable easy connection and placement of houses with square edges. A form that is easily understood in terms of direction and location is the square. Houses can be easily organized in a square pattern to create neighbours and connection across the street, as well as the shared backyard space.

The square street poses a problem with the development of corners. A house on the corner loses its sense of belonging to a particular area as it is split between two streets or pathways. Also the organization of how houses meet on a corner can be awkward. As the square works so well in placement of houses in a line, erasing corners will present only straight lines. These defined straight streets create a strong sense of belonging to a particular street, fostering a sense of place within the community.

These new spaces created can form recreation or green zones within a community. They create variety in the community by breaking the monotony of continuous housing as well as providing areas to gather and connect on land, in addition to the shared backyard waterways.

Figure 45, 46 (left to right): High density diagram.

Permeable density diagram.

However, as a community grows in this form the sense of discovery and variety is lost in the ridged plain

square form. Cua Van precedent review highlights that the cluster formation of vernacular Vietnam villages has a strong sense of this discovery and variety. However these villages have an organization hierarchy centered around a chief, and in this inner city community there is no chief. A new hierarchy must be established to form these clusters within the water community.

As the water community must be connected to land, the shape of the land becomes the chief, at the top of the hierarchy. Pathways form the network of public space from the land and so form a secondary organization point in the hierarchy. Community hubs such a cafes and recreation areas are also important developments that develop a cluster affect around them.

Although this hierarchy can create some diversity through displacement, it does not fully develop the sense of variety and discovery. Breaking down the square shape into parts has the potential for numerous more forms.

This L shape base still maintains the core essence and rules of the square cluster, such as neighbour interaction and the shared backyard space. Through the increased opportunities for different organisations a variety of forms are created, breaking the repetition of the square. In this way the attractive clusters of the case studies are incorporated and developed as well as enabling the hierarchy organisation established within this new community.

Once the community grows to a certain size it can start to weave a more diverse urban fabric, through elements such as bridges, landscapes, lighting and community hubs.

Figure 47, 48 (left to right): Awkward corner meeting.

Green zone corner.



Introducing green zones at the meeting of streets creates a communal meeting point while solving the corner problem.





Figure 49, 50, 51, 52 (left to right): Street layout in module form.

The square 'block' formation.

Square block community layout.

Cluster hierarchy diagram.









Figure 53, 54, 55, 56 (left to right): Square block displacement.

The L shape street.

L shape community layout.

Community within Saint Marys Bay.



Pathways

Any community must have some form of linkage between people and buildings. A water community has an advantage in that it offers a different form of transport than that on land, the boat. Although this would be a unique way of daily transport in the city it is not functional in the same way as a car in terms of parking, maintenance and weather conditions.



Figure 57, 58 (left to right): Floating pathway; railing.

Floating pathway; services.
This community plugs into the city centre so should take advantage of public services such as buses, ferries and walkways. As the community is on the water cars cannot be used, so this leaves the pedestrian pathway as the most suitable for this community. These pathways form the building blocks of the community. As they connect the houses, streets and blocks together they must house the essential services a community requires. These are fresh water, power and waste disposal.



Bridges

Movement should be continued, not just through pathways, but through the water as well. Small-scale recreational boats can be used throughout the community, even being able to berth against houses. Single entry spaces through the community stops movement and the social atmosphere can be lost. Creating gaps in the community to allow multiple entries and exits to a particular house results in a disconnecting sections of the community.

Bridges need to be incorporated to allow water vehicles through these spaces. Bridges must be high enough to allow boats to pass underneath. However, due to the modular nature of the community there is little room to build large bridges. Compact bridges are needed, such as pathways that can be rolled up or disengaged when a boat needs to pass through.

An issue with these bridges is that they can still disconnect part of the community. The bridge must allow a boat to pass through while still maintaining the structure of the pathways and housing foundations. A bridge, and a floating bridge at that, is a unique feature of this community and should be celebrated, contributing to the identity of the place. In this way the bridge should act both as structure and as a marker of place.





Figure 60, 61 (left to right): Bridge concept; rotating bridge.

Bridge final design.



Orientation Markers

A solution was needed to overcome the problem orientation within the community. As water is flat it can be hard to get a sense of direction as there are no high points to navigate to and from. To deal with this a vantage point is offered at the entry to and through the use and lighting markers to give a sense of direction.

Orientation markers already exist, such as the bridges, but a more developed method is needed. As people need to pass through the community, markers at the ends of each pathway can help people to this destination.

As pathways are not straight this form of orientation is only relativity successful. Orientation should relate to the pathways. Through understanding the pathways layout a sense of the community can be created. Identifying changes in pathway direction will help contribute to this understanding. At every change is a corner. These corners provide an indication the pathway is changing. By placing markers on each of these a sense of direction and orientation is formed within the community, much like connecting the dots.

These markers are powered through sustainable electricity produced within the community. The wetlands incorporate sculptural wind turbines that aesthetically contribute to the wetland recreational area as well as powering many public services in the water community. These will be highlighted further in the chapter.

Figure 62, 63, 64 (clockwise from left): Orientation posts on floating pathway.

Orientation indicator placement one.

Orientation indicator placement final.



Endpoints

The community is a public space so the public when passing through should feel welcome. However a community on water offers no pass through point as every end is met with water. These end points must offer some form of activity to encourage and welcome the public to explore and pass through the community.

These end points act like a waterfront. Recreation activities like fishing and swimming occur around these spaces, as well as pick up and drop off points for boats. Incorporating these activities around the fringe of the community encourages movement through the community.







Figure 65, 66, 67 (left to right): End point perspective.

End point fold out module.

Community elements diagram.

Layers within the community

Connection To City: Wetlands

The community now performs well on it's own but its connection to the city must be addressed. The connection is very abrupt when the community is plugged directly into the city. It needs to have a more gradual change between the city and community.

The community should include not just buildings but its natural environment as well and the public belt can help contribute not just to the community but to its surroundings as well.

The community benefits the city in terms of creating diversity and density in the central city without overcrowding, and so too should this common land connector. The water community floats so is protected from problems such as sea level rise, however the city is not. The common land between them both should help protect the city from this problem and associated effects such as storm surges on the cities waterfront.

Barricading against the sea is outdated. From the case studies a trend emerged in types of sea level rise defense. These were defenses that embraced the change and act to reduce its affects. A majority of these case studies used the idea of soft infrastructure. Soft infrastructure involves using the natural environment, such as vegetation, to act in way that helps the city. In terms of waterfront protect vegetation such as reeds and rushes that form wetlands naturally protect the waterfront. All plants used are native to New Zealand and all found within the Auckland region.

To bring these protective wetlands into the belt of common-land with help benefit the community and city by:

- Naturally protecting the shoreline from erosion.
- Absorb high water levels and wave damage from storm surges.
- Filter pollutants from the water, which is highly useful in the city with high boat and usage.
- Provide an aesthetically attractive green belt within the city.
- ° Gives the community and greater sense of identity and sense of place.

These wetlands not only act and a medium form between the city and community but also act as a boundary of the community. This helps reduce the sprawl of the community and maintains its centralized identity that people can associate themselves with.

Community Power

Heat from the sun only affects the surface of the land which quickly cools at night due to the limited amount of heat absorption. Water however, has a lower surface temperature than land, and light and heat can penetrate deeper into water than it can on land. This means water has a greater thermal mass than land.

Because of the differing heating times between land and the ocean, sea breezes are caused during the day and land breezes at night (University of Illinois, 2010). The design integrates this environmental change into part of the community. Taking advantage of wind conditions, wind turbines are placed within the wetlands along the waters edge.

These wind sculptures power the sewage pumps, water works and lighting within the community. This contributes to the sustainable nature of this community which is supported by minimal site impact and water filtration systems through the wetlands.

Figure 68, 69 (follow page left to right): Wetlands plan within site.

Wetlands section.

Wetland Plant Types

1: Schoenoplectus Tabernaemontani

- 2: Baumea Juncea
- 3: Finicia Nodosa
- 4: Phormium Fluviatillis
- 5: Typha Orientalis 6: Typha Orientalis
- 7: Aviecennia Marin





Module

To help with ease of transportation and assembly, the housing modules are separated into two parts; the foundation module and housing module. Separation of functions allows more flexibility of use.

Conforming to the sizes of the existing shipping container industry allows for easy transportation of modules, continuing the adaptive qualities to the flexible freedom lifestyle of modern living.

To be able to be transported by sea, air, rail or road, these requirements must also be meet.

- Strong in compression
- Have female twistlocks in each corner
- ° All elements of construction must fit within the defined size of the transportable container.

Figure 70 (opposite): Model of 20" housing module part and 20" foundation module.



Housing

Inner city apartments are compact, they offer good location, price and are easy to maintain. Apartments on water offer these same elements in the same area however with the benefits of a public shared community environment and lifestyle that inner city apartment buildings struggle to achieve. The plans of these apartments highlights how this is achieved by living on water. All apartments are 56m squared. This is made up from two different types of modules.

There are many different combinations of how these two modules can be put together. This variation contributes to individual identity within the community as well as identity of the community itself and association with place.

To demonstrate this variety within the planning, three different types have been identified. Each one of these variations addresses a different combination and use of different sized modules:

- Plans centralize around the kitchen, or original hearth of the house.
- Apartments are designed for 2 people.
- All plans have 2 entries, encouraging movement through the house while also commenting on the restricting one entry apartment building typology.
- Water services are located as close together to enable single connection with services in the floating foundations.
- To take advantage of the community organization and movement through the house, living room walls open to extend this kiwi lifestyle of outdoor living through the house into the shared backyard space.

Planning also accounts for disassembling the modules. This means that solid walls or permanent items cannot be located across the boundary of two modules in the plan, unless these items can have construction joints that can be taken apart. As these houses are designed to be semi permanent it is acceptable to not be readily taken apart in all aspects of the plans.

The use of steel square hollow section frames provides solid compression strength in the design. This enables

lightweight construction throughout the rest of the module. This means that conventional timber construction can occur for the rest of the construction.

Conditions on the water, such as large light reflection, salt spray and rough seas require a more durable material on the exterior of the module. Danpalon cladding panels offer watertight connections, and 99% UV light resistance. These panels also offer different sizes and aesthetics. This contributes to both construction requirements and unique aesthetics. The appeal of different planning options to create a sense of personal identity must also be continued through to the facades of the buildings.

Figure 71, 72, 73, 74 (following page, left to

right): Example of two container sizes used and elements used to construct apartments, small 20 foot container and larger 40 foot container.

Container size example of an apartment using two 40".

Container size example of apartment using one 40", two 20".

Container size example of apartment using four 20".







Scale 1:100





Scale 1:100



Figure 75, 76 (previous page left to right): Two 40" apartment plan.

One 40", two 20" apartment plan.

Figure 77 (Opposite) 78, 79, 80 (current page left to right): Four 20" apartment plan.

. .

House deck closed, for transport of security.

House deck down, lets in light, provides docking area.

House with deck down and wall up, opeing house to outside and community.









Figure 82: Facade case study one.





Figure 85: Facade case study two.



Figure 86: Four 20" apartment front entrance elevation.

Figure 87: Four 20" apartment side elevation.





Figure 88, 89 (previous page left to right): Interior perspective of open living room.

Interior perspective front entrance and bedroom.

Figure 90 (opposite): Four 20" apartment perspective in Saint Marys Bay, looking towards Auckland CBD.



Foundations

The foundations are constructed from reinforced concrete with a polystyrene core. The concrete provides the compression strength for the house module to connect to while the polystyrene core provides a solid buoyancy. Other buoyancy materials like air have not being used as they are a much more fluid material and as concrete is permeable air can escape. Although polystyrene is heavier than air it is solid which means it will stay intact within the concrete shell.



The foundations maintain the same size modules as the housing modules. However this basic square module shape (figure 91) is not most stable in the water, it needs to be improved (figure 94).

Services are cast into the middle of the foundation with connection points at each end. The foundations are joined together through twistlocks and services are joined at the same time. The foundations are individual to each house as each different plan requires a different location for services.





Every part of the house and foundation must be kept within the module size. This means that they can be transported easily as well as being the exact same shape and size in every place they go to enable them to plug into existing communities with ease. These details successfully help each module to achieve this.

Twistlock

The twistlock is the detail that allows the community to exist. It is used in many ways to connect all the elements of the community together making it a whole. By incorporating this detail into the module it also conforms to shipping container standards allowing the module to connect to all existing services.

Figure 95, 96 (top to bottom):

Exploded detail of male twistlock part with elevations.

Diagram of connecting male twistlock into female part, highlighting simple effective locking mechanism.







FA76-R-C Fixed base twistlock









Twistlock connection

Roofing

The roof is a material membrane. As the roof needs to exist within the steel frame it needs to be as flat as possible. A metal deck roof can work on a slope of 2 degrees but is quite heavy. A membrane roof is more successful as it is lighter is much simpler to construct. This detail uses a ethylene propylene diene Monomer (EPDM) rubber membrane that is glued to a treated plywood roof. To create a watertight connection the EPDM membrane is heat welded to metal roof fixings that are then welded to the steel frame.

Figure 97 (opposite):

Roof membrane detail, highliting connection to roof and SHS frame.

Figure 98, 99 (following page): Water flow guttering diagram.

Roof guttering detail.





Gutter

The gutter, usually an exterior element is built within the steel frame of the housing module. The gutter is an essential detail as it contributes to the success of the low slope roof, enabling the roof to exist within the defined size.


1: EPDM Membrane

- 2: 18mm (WBP) Plywood
- 3: Ventilation Gap

4: Joist

- 5: M10 Bolt with 50mm Washer
- 6: Timber beam bolted to SHS
- 7: Batten firrings fixed to joists
- 8: 229*127 SHS
- 9: Hot air weld on membrane
- 10: Sarnametal roof trim piece
- 11: Firring joined to SHS
- 12: Timber beam
- 13: M10 Bolt with 50mm Washer
- 14: Danpalon Cladding
- 15: Vapour Barrier





Schoenoplectus Tabernaemontani A rush like plant that

is the most commonly used plant in constructed wetlands.

Grows in shallow water, suitable for surface to subsurface wetlands. Grows 1-2m high.



Phormium Tenax New Zealand flax. Inhabits lowlands, swaps and coastal areas. Hardy plant.

Grows in moist soils around the edges of wetlands and in riparian zones. Grows to a height of 2m.



Baumea Juncea Rush like perennial. Grows in mostly brackish or saline swamps. Suitable for sandy soils in coastal areas.

Suitable for surface to subsurface wetlands. Grows to a height of 1m.



Finicia Nodosa

A rush like plant common throughout New Zealand. Grows in coastal banks, sand dunes and wet zones in coastal areas.

Grows to a height of 0.7m.

Figure 100, 101, 102, 103: Schoenoplectus Tabernaemontani.

Photo courtesy of Martin Sommerfeld.

Phormium Tenax.

Image retrieved 05/11/2011, from: http:// en.wikipedia.org/wiki/File:NZflaxPiha02.jpg

Baumea Juncea.

Photo courtesy of Lee Littlechild.

Finicia Nodosa.

Image retrieved 05/11/2011, from: http:// en.wikipedia.org/wiki/File:Ficinia_nodosa.jpg



Avicennia Marin

A species of Mangrove tree. Tolerates high salinity by excreting salts through its leaves. Resists extreme weather conditions.

Grows very well in muddy soil conditions.

Grows as a shrub or tree to a height of 3-10m.



Typha Orientalis

An erect clump forming bulrush. Defined by large furry brown cylindrical flower heads.

Will grow in standing water up to 1m. Grows up to 2.5m high and 5m wide.



Bolbuschoenus Fluviatilis

Native rhizomatous perennial. Inhabits shallow fresh and brackish water in estuaries and shallow swamps.

Grows in depths of 250mm to 2.5m tall.

Figure 104, 105, 106: Avicennia Marin.

Photo courtesy of M. Rahimzadeh.

Typha Orientalis.

Image retrieved 05/11/2011, from: http:// en.wikipedia.org/wiki/File:Typha_latifolia_02_ bgiu.jpg

Bolbuschoenus Fluviatilis

Photo courtesy of Takato Natsui.

Conclusion

Coastal cities are some of the most important cities in the world. Historically, coastal cities were important because of their location for trade and transport. Today coastal cities offer a unique way of life that creates and molds the identity of each coastal city. This identity could be the wind in Wellington or the gondolas of Venice. Each coastal city has its own character that shapes its inhabitants connecting them to their city. The common link between all coastal cities is water.

Water is an element of life that has been celebrated throughout human civilisation. The ocean itself is an attraction that people travel all over the world to see and experience. It has inherent qualities that attract and draw people towards it. For this reason it is not surprising that coastal cities are predominantly the world's largest and greatest cities.

Within these coastal cities the growing problems of over crowding and urban congestion are met with the increasing threat from sea level rise. A new form of living within these cities is needed to provide a solution to

these issues. Water can be both the problem and the solution. By changing the cities perception of buildable space, moving the urban fabric onto the water to form a community helps to offer a solution to these problems through living on water.

In order to propose a suitable form of water living case studies were analysed. These case studies were split into two categories, traditional and modern responses to living on water. Understanding both past and present responses helped develop a broad knowledge of the successful elements of water communities.

The traditional water communities explored were Cua Van village Halong Bay in Vietnam, Chong Khenas in Tonle Sap Lake, Semporna in Malaysia and Kampong Ayer in Brunei. Cua Van village was selected for its independence as an isolated community. The social and physical heirachy was also an influence to consider. Chong Khenas and Semporna case studies were chosen for their variety of homes on the water, both free floating, and structurally fixed to the ground. It was important to explore the different methods of construction on water. Chong Khenas was selected particularly as a community that was resilient to both dry and wet seasons with a range of water levels affecting the buildings. Kampong Ayer was chosen for its integration within the urban fabric of a coastal city. As the oldest of the case studies it demonstrates the successful co existence of land and water communities within the coastal city context.

All the traditional case studies demonstrate the reality of living on water. These communities have existed for many decades and some for centuries, establishing that living on water is a viable and successful alternative form of living. From these case studies the lessons learned were that living on water is most successful when combined with support from land based communities. Also, that the identity of these water communities was essential to their success and must be maintained with their integration with coastal cities.

The chosen modern projects were Victoria Harbour in Hong Kong, Palisade Bay project New York and Nijmegen Peninsula in Holland. Victoria Harbour identified a particular solution for coastal city expansion by land reclamation in the harbour. Palisade Bay highlighted responses to sea level rise protection for the city, introducing the concept of soft infrastructure, which proved to be both successful and multifunctional for the inner city. Nijmegen Peninsula was selected as a modern equivalent to Chon Khenas. This was achieved

through the development of adaptive housing for both land and water.

Important concepts gathered from the modern case studies were that pure building is not a complete answer to the problems of the coastal city. Integration of both building and environment creates a diversity that is very successful, benefiting and protecting the coastal city. Another lesson learned is that land reclamation is not an answer for city expansion: while it provides a short-term solution it can sacrifice portions of the coastal environment that gives character to the city.

The case studies have addressed the issues outlined in the literature in the following way.



Through research gathered from the literature review and the case studies, it is clear that living on water can be successful and is becoming an increasingly examined solution to urban congestion and as a response to the effects of climate change. It is also apparent that projects that address living on water currently only exist as independent solutions and have no connection with one other. This is in part due to local conditions in each project but mostly because there is a lack a developed solution that can be implemented into a variety of situations. This chosen design for a community on water offers a solution that can be put into place in many coastal cities around the world. The guidelines which help form the community also create a level of tolerance so that each different project can develop the community in a way that is unique and relative to its location and environment conditions.

Building within the central city while maintaining but not increasing density contributes to reducing urban

congestion. Central development reduces urban sprawl and keeps the 'magic' of the inner city alive. To avoid the monotony of development within the central city there is a distinction between living on water and living on land. Land is perceived in terms of ownership and privacy, while water is a very public space that is shared. The water community creates a very social atmosphere through developing on the idea of water as public space, contributing to its inhabitants connection to the community and their own sense of place.

In keeping with the freedom of modern living, a level of flexibility is offered through living within the water community. Floating structures can move and this aspect is developed so that relocation of housing modules is possible both on the water and between any coastal city in the world. Conforming the design of the housing into modules allows them to be transported within the inter-modal container industry meant that the design was kept consistent through the communities while creating the very identifiable character of each house. It also meant separation of the house into living modules and foundation modules. This distinction between functions creates an awareness of the environment in which the community exists again informing the character of community.

While living on water solves issues of flooding and sea level rise, the connection to the city through soft infrastructure helps protect the waterfront. Soft infrastructure in the form of wetlands both contributes to the existing city by offering a recreational green belt within the central city as well as recycling harbour water through vegetation local to the area. The community is responding to climate change and by so doing can be perceived as a sustainable community. The wetlands greatly contribute to this sustainability within the community.

An identified flaw with living on water is that its success can be largely attributed to climate conditions. The traditional case studies reviewed are located around the equator so have warm climate conditions that are favourable when living in a wet environment. Scotland's coastal environment however may not be so suitable, due to rough seas, high winds and much cooler temperatures. However a point to note is that as climate change occurs, altering the conditions of many places around the globe, more locations may become suitable for this type of living. The design allows for this adaptability and freedom of movement.

For this community I have focused on apartment size residential living. In undertaking further research it would

be relevant to develop a greater variety of structures within the community, such as town halls, schools and large recreational zones like sports fields. The development of large and more varied structures would test the ability of my foundation type and could create a much more enriched community. The integration of services essential to the city could merge the community more successfully with the city. It would also be interesting to explore whether the water community could exist entirely independent of the city and what this would mean in relation to the communities sense identity and belonging.

Living on water is a type of living that looks to the future. The water community moves past purely offering walls and a roof overhead to live in. It provides identity, it creates awareness of its environment and solves growing issues within the coastal city. We came from water, and so we must return to it.

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The following is a calculation table used to determine the bouncy of the foundations.

Constants						
Gravity =	9.81 m/s^2					
Sea water density =	1020 kg/m^3					
External load =	50 KN					

Concrete blo	ck Dimei	nsions		Polystyrene Core		
Length =	6	m		Length =	5.8 m	
Width =	2.6	m		Width =	2.4 m	
Height =	3	m		Height =	2.6 m	
Density =	2400	kg/m^3		Denisty =	15 kg/m^3	
Weight force =	249.8	KN	-	Weight force =	5.3 KN	
Total Weight						
force =	305.1					
Depth of block in water =			1.95	-		
The pontoon will =			Float			
Height of block above water =			1.05			