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Urban Seascaping: Seaweed as a catalyst for urban shoreline transformation in the age of the Anthropocene

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ABSTRACT

This article offers an introduction to a research project, "Urban Seascaping" (USS), which re-envisions the boundary between city and sea in response to the phenomenon of sea-level rise and frequent storm surge in the age of the Anthropocene. USS seeks to reconceptualise the current business-as-usual waterfront developments and coastal protection by investigating an unexplored solution space of embracing the agency of the sea and its coastal ecosystems as a key driver in the transformation of urban shorelines. With a focus on the coastal regions of Denmark, the research seeks to induce critical trans-disciplinary discussions on the limitations of a "hard approach" to coastal protection dominated by defence-driven mechanical handling of water. Moreover, the research highlights the current lack of marine nature-based "soft approach" in the waterfront area as part of coastal protection strategies. The project proposes a new form of urban commons in the waterfront, particularly exploring the full spectrum of coastal ecosystems using seaweed as a representative of a marine nature-based solution to enhance coastal resilience. The key is to depart from the current dualistic relationship between nature and culture to a more hybrid, interconnected and dynamic zone by incorporating coastal ecosystems as an active part of the socio-cultural cityscape and future resilience.

Keywords: blue urbanism, urban seascaping, nature-based solutions, blue infrastructure, coastal resilience, seaweed.

1. INTRODUCTION

There is a need to rethink the current status quo of urban waterfront developments. Contemporary coastal cities have developed into the sea in the form of land reclamation that is not designed to handle the increasing impacts of climate change nor sensitive to the loss of coastal ecosystems. This article offers an introduction to a research project, Urban Seascaping (USS)[1], which re-envisions the boundary between city and sea in response to the phenomenon of sea-level rise and frequent storm surge in the age of the Anthropocene[2]. USS seeks to reconceptualise the current business-as-usual waterfront developments and

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[1] Urban Seascaping is situated in the emerging approach of blue urbanism and within the interdisciplinary field of urban design, planning and landscape architecture. This article only discusses a small part of the PhD which discusses the ethical and theoretical proposition. The article serves as an introduction and a manifesto for students, practitioners and municipal members who wish to depart from the current business-as-usual urban developments at the coast.

[2] In this article, the term Anthropocene is used to refer to a geological age during which human activity has been the dominant influence on climate and the environment. The article mainly refers to the negative impacts of human activity in the Anthropocene which is causing rise in sea level, frequent storm surge, loss in biodiversity and increasing pollution. There are other appropriate terms such as the Capitalocene which focusses on the current global capitalistic economic

coastal protection by investigating an unexplored solution space of embracing the agency of the sea and its coastal ecosystems as a key driver in the transformation of urban shorelines. With a focus on the coastal regions of Denmark, the research asks: "How can coastal cities integrate the sea and its lifeforms in a way that contributes towards re-envisioning existing and new waterfront development in light of sea-level rise?" The research seeks to induce critical trans-disciplinary discussions on the limitations of a "hard approach" to coastal protection dominated by defence-driven mechanical handling of water. Moreover, the research highlights the current lack of marine nature-based "soft approach" in the waterfront area as part of coastal protection strategies. In exploring this knowledge gap, the project proposes a new form of urban commons in the waterfront, particularly exploring the full spectrum of coastal ecosystems using seaweed as a representative of a marine nature-based solution to enhance coastal resilience. Other added values of seaweed are explored, such as improving biodiversity, filtering pollutants, carbon sequestration, sustainable food production and beauty. The key is to depart from the current dualistic relationship between nature (the sea) and culture (the city) to a more hybrid, interconnected and dynamic zone by incorporating coastal ecosystems as an active part of the socio-cultural cityscape and future resilience.

2. THE WICKED PROBLEM OF LIVING ON THE EDGE

We live in an era of unprecedented ecological crisis. Impacts from global warming include frequent flooding, storm surges and rising sea levels, which are key issues to respond to in this century. Coastal cities will face the brunt of water-related issues. The severity of the impact of water in the future will depend on many complex factors, one of which is a significant need for global GHG reduction (National Center for Atmospheric Research/University Corporation for Atmospheric Research, 2018). The recent release of the sixth assessment report by the IPCC warns that radical, immediate and swift reductions in global GHG must happen within the next few decades as warming is accelerating (IPCC, 2021). It means halving global GHG emissions by 2030 and net-zero by 2050 from 2010 GHG levels to stay within the recommended limit of 1.5°C of global average temperature rise (IPCC, 2018). However, the current emissions rate indicates that global temperatures are expected to surpass 1.5°C of warming (IPCC, 2021). The predictions are now faring more towards the worst-case scenario and continued sea-level rise, contributing to the severity of more frequent and severe coastal storm surge events that previously happened once every 100 years to happen every year by the end of this century (IPCC, 2021). It is looking more likely that coastal cities would need to prepare for the inevitable.

This research focuses on low-lying coastal countries like Denmark[3] that are particularly vulnerable to the impact of water-related issues. Many Danish cities and towns are situated near the coast, river estuaries and fjords. They will face a higher risk[4] of frequent flooding from the sea, streams and rivers, along with stronger storm surge events and heavier rainfalls (Arnbjerg-Nielsen, 2011; Jebens et al., 2016). The challenges of addressing water-based issues in contemporary coastal cities in Denmark is exacerbated by the increase in urban densification that contributes to the rise in impermeable surfaces. These surfaces increase stormwater runoffs (along with urban pollution) that amplify the floods' impact. Worryingly, many existing urban

system as a key proponent in the Anthropocene (Moore, 2017), but due to the general familiarity of the term Anthropocene, it will be used throughout this article.

[3] The main reason behind why Denmark is chosen as a country for investigation as opposed to other countries, is due to the research context of the PhD. The researchers is at a Danish institution and it is part of the PhD to look into Danish coastal cities as a case study. Nevertheless, lessons learned could be applied to other similar contemporary coastal cities.

[4] Denmark's adaptation strategy expects a sea-level rise of 0.1-0.5m by 2050 and 0.2-1.4m by 2100 (DMI, 2018; Olesen et al., 2014). This figure is yet to be updated to the Danish context from the latest IPCC (the sixth assessment report that was released 9th of August 2021)

infrastructures are not sufficiently designed to handle the effects of climatic changes in the future (Zhang et al., 2018). Some examples are the old combined sewage and stormwater drainage pipes in many Danish cities that will overflood in the event of storm surge (contributed by sea-level rise) and heavier cloudbursts. Another example is that many existing buildings (both old and new developments) in risk areas are not equipped to handle inundation and are inflexible to retrofit to adapt to future climatic changes (see Figure 1).

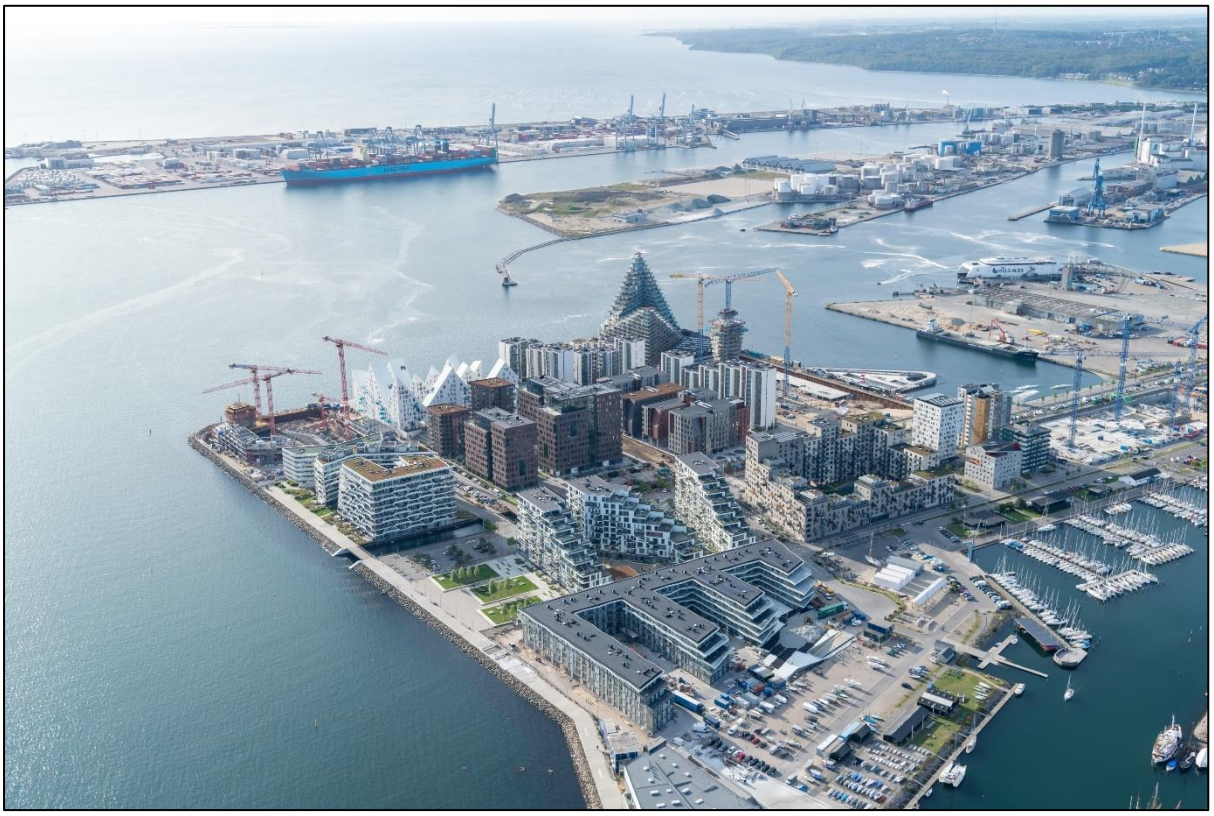


Figure 1: Photos of current waterfront residential development models in the coastal city of Aarhus in Denmark. The residential and commercial development on Aarhus Docklands (Aarhus Ø) started in 2007 on a former container terminal that was reclaimed land. It is 100,000 km^2 with plans to house over 10,000 residents. The Docklands is elevated 2.5m above the previous normal water level based on a future increase in sea level of 0.5m with stone reefs as coastal protection to dampen the waves. However, the Docklands is considered a storm surge risk area, and it seems to be under-estimated to deal with future predictions of SLR and storm surges by the end of the century (Aarhus Kommune, n.d.; Klimatilpasning, 2015). Aerial photo of Aarhus Docklands by Jesper Larsen and JFP.dk.

3. "OCEAN SPRAWL" – UNTAPPED LIQUID SPACE

The industrial revolution saw the onset of rapid urban development for coastal cities where space next to the water became a valuable economic commodity (Firth et al., 2016). It was achieved by land reclamation[5], which is done by dredging ports and harbours to expand industrial economic activity. Thus, the term "ocean sprawl" (Duarte et al., 2013) refers to the act of expanding human activity into the sea by reclaiming land for human use. More recently, the trend in coastal areas in Denmark is reclaiming land for commercial, recreational and residential use for highly sought-after waterfront real estate. This type of urban development pattern is prominent in most Danish coastal cities, as shown in Figures 1 and 2. Ocean sprawl

[5] *Before the industrial revolution, land reclamation was driven by intensifying agricultural activity that drained fertile land, both on land and at sea. Former wetlands, marshes, fjords and beach meadows were drained to make space for farming in Denmark peaking in the 19th century (Stenak, 2005).*

goes hand-in-hand with urban sprawl as the convenience of petroleum transport and the development of pump technology allowed the possibility of creating land out of the water. It resulted in a huge expansion of harbours near the city for trade and higher demand to live near the water, increasing waterfront property prices. As the global economic system became more dependent on unbridled capitalism of endless economic growth, the view of the sea increasingly became an economic commodity, an "untapped resource" to be exploited (Danmark and Ministeriet for Fødevarer, Landbrug og Fiskeri, 2010; Magnason, 2021).

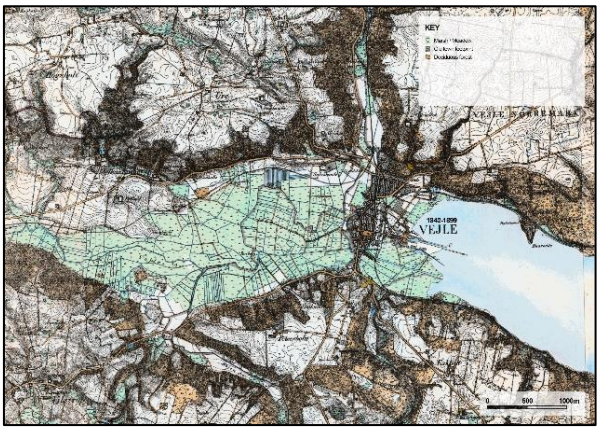
The act of expanding the city out into the sea has not only increased Danish coastal cities' vulnerability towards the impact of rising sea levels but also led to the destruction of former marine habitats and seabeds by removing large amounts of boulders, rocks and stones to use for construction on land (Mørk Jørgensen, 2020; Stubgaard, 2020; Svendsen, 2020). Reclaiming land from the sea creates marine dead zones on the ocean bed because it claims coastal areas ideal for the survival of many marine habitats dependent on specific depths below sea level with access to sufficient sunlight to thrive (Bishop et al., 2017; Palmgren, 2019). Furthermore, the removal of habitat-forming boulders, rock reefs, and small stones resulted in lifeless sea beds as marine habitats like seaweed could not attach their holdfast impacting the food chain[6] (Bishop et al., 2017).

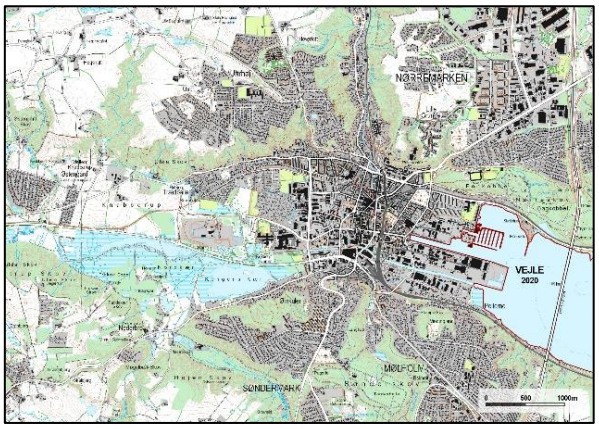
Despite the fact that marine lifeforms are adaptable entities, the destruction of marine habitats through land reclamation and the impact of human activity such as increasing urban water pollution, eutrophication[7], changes in sediment input and temperature rise jeopardises their chance of survival (Pilkey and Young, 2011). The irony is that these marine ecosystems face an unprecedented future that needs to be shielded from the impact of human activities while requiring active human management to survive (Orff, 2016). Therefore, coastal cities have a conundrum of ensuring that it safeguards from future water issues due to global warming without compromising the coastal ecosystems that inhabit the area.

Figure 2 (following page): History of urban transformation in the city of Vejle in East Jutland, Denmark - Vejle 1842-1889. (Top left), Vejle 2020 (top right) and Vejle 1842-1889 map superimposed with 2020 developments. (Second row) The land reclaimed (ocean sprawl) from the fjord is coloured in red, totalling 720,000 square meters/135 football fields worth of new land. The former beach meadows and marsh are in yellow, which is now commercial, industrial and residential developments, totalling 550,000 square meters/103 football fields that used to provide buffer zones in the event of storm surges. The former meadows totalling over 5km are now mainly non-permeable surfaces (in red). Only the green shades remain as green and blue spaces. Historical QGIS map from Miljøstyrelsen Denmark (Miljøstyrelsen, n.d.) and further illustrated by the author.
(Bottom row) Photo of Vejle waterfront area with residential, commercial, recreational and industrial developments. Photo credit: Vejle Municipality (Danske Landskabsarkitekter, 2020).

6 Furthermore, the intensive fishing industry (i.e. bottom trawling) also removed habitat forming substrates like stones, rocks and boulders.

7 Eutrophication defined by the European Environmental Agency: "A process of pollution that occurs when a lake or stream becomes over-rich in plant nutrients; as a consequence, it becomes overgrown in algae and other aquatic plants. The plants die and decompose. In decomposing the plants rob the water of oxygen... Nitrate fertilizers which drain from the fields, nutrients from animal wastes and human sewage are the primary causes of eutrophication" (European Environmental Agency, n.d.).


KEY
1842-1899
VEJLE


NØRREMARKEN
VEJLE
2020
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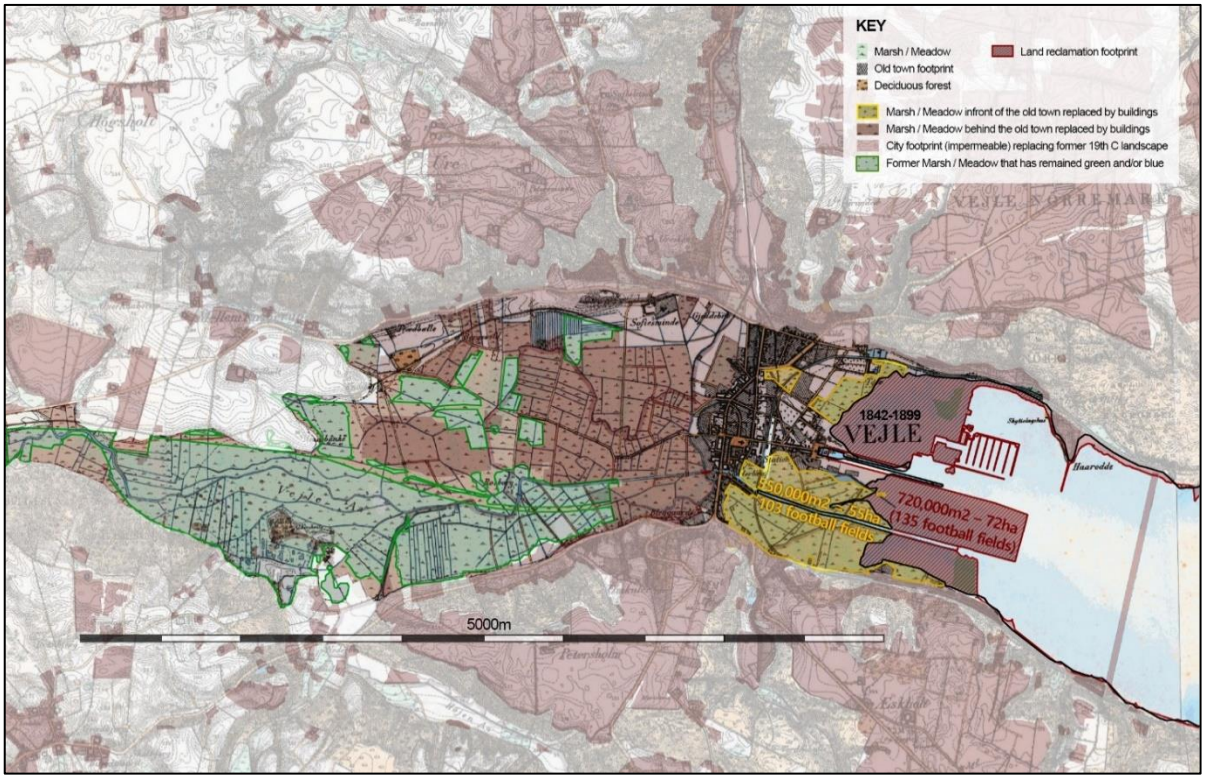
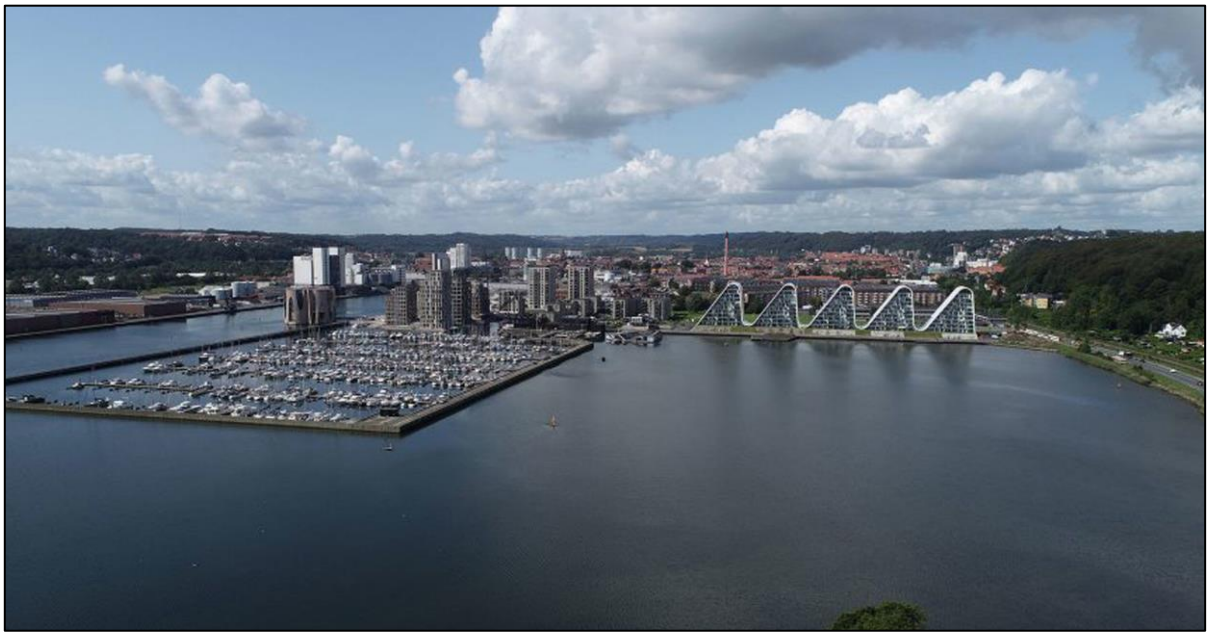

KEY
Marsh / Meadow
Old town footprint
Deciduous forest
Land reclamation footprint
Marsh / Meadow infront of the old town replaced by buildings
Marsh / Meadow behind the old town replaced by buildings
City footprint (impermeable) replacing former 19th C landscape
Former Marsh / Meadow that has remained green and/or blue
1842-1899
VEJLE
350,000m2 ~ 35ha
(103 football fields)
720,000m2 ~ 72ha
(135 football fields)
5000m



4. HIDING BEHIND A FALSE SENSE OF SECURITY

To mitigate the water reaching the coastal cities, the prevailing coastal protection model for many Danish coastal cities has a strong tendency to implement the "control and conquer" mentality where human-made structures attempt to control non-human forces at bay (Orff, 2016). This model is often referred to as the "hard approach" (Faragò et al., 2018). It consists of seawalls, dikes, locks and levees, which are engineered infrastructures working as defence systems to manage and contain the water. Moreover, (as shown in Figure 3), the edge conditions where the city meets the sea is riddled with hard concrete edges. These hard approaches contribute to severing the city's visual, tactile and ecological connection to the water.

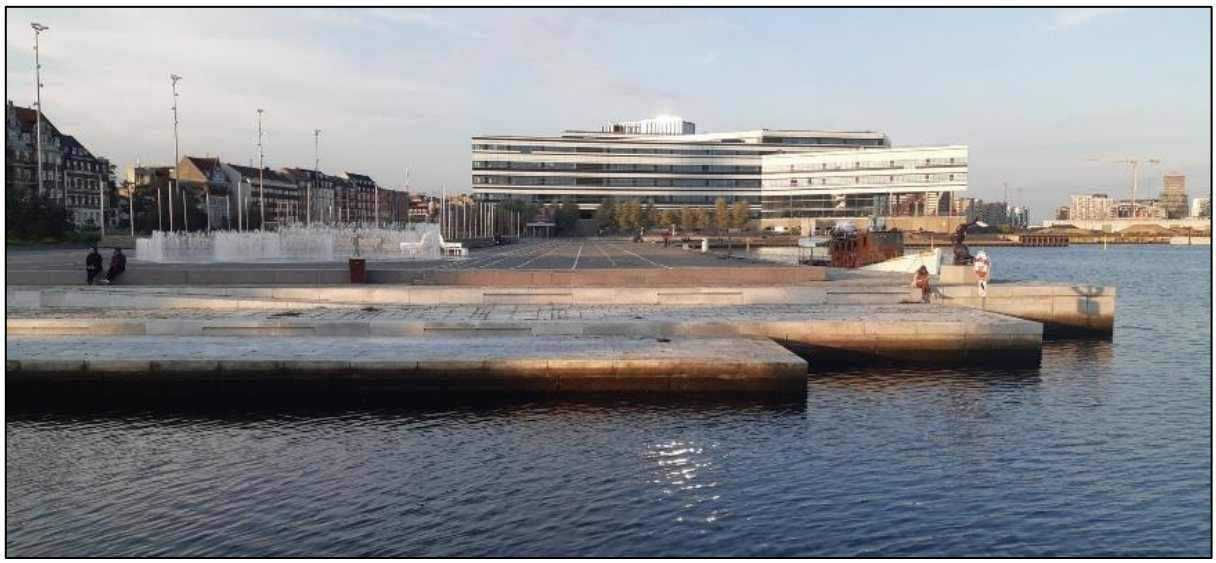


Figure 3: A typical form of urban coastal harbour edge condition with a defined, segregated, hard boundary between land and water that severs a closer and more tactile connection with the water and its life forms. The public space in the waterfront is mainly is made of concrete for humans. Very little consideration is given to terrestrial plants, and there is no designated space for interacting with the marine world. The photo was taken by the author in Aarhus, Denmark, in October 2021.

Furthermore, the heavy reliance on protection systems such as dikes and sea walls provides a false sense of security at the coast[8] that tends to continue business-as-usual harbourfront developments, which are not sufficiently designed to be adaptable for future changes in climate. This phenomenon is called the "levee paradox" to describe the irony of the presence of levees that leads to less awareness of the flooding risks and, in turn, increased development in the so-called "protected" risk area (Smith, 2002). Furthermore, these hard strategies are expensive and inflexible to refurbish, but more importantly, they are temporary solutions in the face of rising sea levels in an unpredictable future (Pilkey and Young, 2011). Nevertheless, hard defence strategies have an important role in protecting the low-lying coastal cities in the short term.

The main problem with these forms of defence strategies is not only that they cannot guarantee 100% protection, but it is also often without future intention to relocate people away from high-risk areas (ibid.). It is not surprising that managed retreat (also known as realignment or relocation) as a coastal adaptation strategy is the least discussed option when deciding how to respond to the water issues for coastal cities in

[8] This is because these seawalls (levees) are constructed at a certain height level based on a prediction of how high sea level rise and storm surges might be in the future. Past storm surge events around the world (e.g. Hurricane Katrina in New Orleans) have shown that these seawalls and levees can be overtopped due to unpredictability of storm levels thus run the risk of underestimation (UC Berkeley News, 2005).

Denmark. Simply put, retreat as a strategy is commonly considered the "elephant in the room." There is a reluctance to address the need to retreat the most vulnerable and problematic areas of coastal cities in the future. Many complex factors are involved in the difficulty of implementing retreat of a big area, such as inflexible existing infrastructure, housing that people's livelihoods depend on, cultural heritage, the associated costs, and the belief that one can always engineer oneself out of these issues. Regardless, there is currently an absence of officially designated "no-build zones" for the future in Danish coastal cities at risk[9]. Furthermore, prolonging the relocation of critical areas can make future responses to sea-level rise more difficult and expensive (Pilkey and Young, 2011).

Another issue regarding hard approaches is that installing impermeable concrete dikes or locks interferes with the sediment flows from rivers to the ocean. It deprives many existing coastal ecosystems such as coastal wetlands[10], salt marshes[11], eelgrass, seaweeds of needed nutrients by trapping them within the physical structures (Pilkey and Young, 2011). These physical defence structures interfere with the existing coastal ecosystem's ability to survive (see Table 1 for details), thus compromising its biodiversity.

Coastal zone	**Supratidal**				**Intertidal**												**Subtidal**			
Coastal defence/ modification	Beach meadows				Salt marshes				Soft-bottom				Biodiversity				Eelgrass			
Harbours	●		●	●	●		●	●	●		●	●	●		●	●	●		●	●
Dikes	●	●	●	●	●	●	●		●	●	●	●	●	●	●	●	●	●	●	●
Land reclamation	●	●			●	●		●	●	●		●	●	●	●	●		●		
Groyne	●				●				●		●		●	●	●			●	●	●
Breakwater									●	●		●	●	●						
Slope protection	●				●								●							
Beach nourishment									●		●	●	●			●	●		●	●
Seawalls		●				●				●			●	●				●		

Table 1. Examples of major direct and indirect impacts of coastal defences and modifications in selected coastal and marine habitats (i.e. impact on the biodiversity). Impacts represented by circles include habitat loss (red), changed soil/sediment biogeochemistry (blue), erosion and turbidity (yellow), and release of excess nutrients (green) (Quintana et al., 2021).

5. MARINE NATURE-BASED SOLUTION: "THE SOFT APPROACH."

Urbanites often forget that life on land and sea are closely connected by a network of coastal ecosystems which are strongly dependent on each other. For instance, estuaries supply nutrients to coastal areas, and the coastal ecosystems protect inner land from flooding via wave attenuation and help mitigate coastal erosion (Quintana et al., 2021). These coastal ecosystems are seen as alternatives to the engineered hard approach and are referred to as "nature-based solutions[12]" (NbS) or the "soft approach." Examples include

[9] *There are however, a coastal protection zone in nature areas which functions like a no-build zone where only coastal protection systems can be built with municipal permission (except in cities). The local government can allow new developments in flood prone (designate high risk area in the EU floods directive) areas according to the Danish Planning Act if developers are able to protect the new developments from flooding and the local municipalities are obliged to develop flood risk management plans (Miljø- og Fødevareministeriet, 2020).*

[10] *Coastal wetlands are in coastal (transition) zone between land and sea where it is regularly inundated in fresh, brackish, or saline water all or part of the year that contains a variety of vegetation and animals that are uniquely adapted to those conditions (Hatvany, 2009).*

[11] *A salt marsh is a coastal ecosystem in the upper coastal intertidal zone between land and open saltwater or brackish water that is regularly flooded by the tides. It is covered with dense salt-tolerant grasslike plants (Adam, 1993).*

[12] *The European Commission's official definition of NbS: "Solutions that are inspired and supported by nature, which are cost-effective, simultaneously provide environmental, social and economic benefits and help build resilience. Such*

salt marshes, beach meadows, swamps, coastal wetlands, dunes, rocks and reef-building species like seaweeds, oysters and mussel beds (see Figures 4 and 5 for an example of integrating this approach). A softer "division" between land and ocean is a key focus in these efforts. Additionally, these coastal ecosystems - the roots, leaves, fronds and shells form characteristic patch structures called seascapes (Boström et al., 2011) that provide a range of critical ecological and socio-economic services (otherwise known as ecosystem services[13]).

An example of a least explored coastal ecosystem as a potential nature-based solution is seaweed[14]. Seaweed has multiple values and properties that make it a good contender for NbS. However, more research is needed to assess the various potentials of seaweed as this area is understudied. Some of the key characteristics of seaweed as NbS are elaborated below:

i) Wave attenuation

As part of the coastal resilience strategy, kelp forests[15] can reduce the strength of waves from storms (Gundersen et al., 2017). It is dependent on various factors, such as the morphology, strength of the wave, season, size, age and density of the forest, to name a few. (Løvås and Tørum, 2001; Marine Scotland Directorate, 2016; Smale et al., 2013). Kelp is the only known species with wave attenuating properties (ibid.). Although, based on an old study in 1996, research from a natural kelp forest (i.e. Laminaria Hyperborea) in the coast of Norway extending 6-8km offshore has proven to significantly reduce the impact of waves from waves storm surges up to 60% in height. These kelp forests played an important role in protecting the coastal cities behind them by lessening the impact of the waves (ibid.).

ii) Water pollution control

Seaweed improves water quality by filtering pollutants such as retaining fine sediment particles and uptake nutrients (fertiliser runoffs) from the mainland (Bruhn et al., 2020; Seghetta et al., 2016). Thus, kelp forests help combat eutrophication that reduces the threats of algal blooms and hypoxia, improving ecosystem diversity and functionality (Gundersen et al., 2017). However, they have a threshold at which excessive pollutants in the water will prevent it from growing due to murkier waters from floating particles that inhibits sunlight (ibid.).

iii) Blue carbon

Seaweed is regarded as one of the most ecologically productive photosynthesising systems on earth. It has higher carbon sequestration properties than land-based plants and grows rapidly (Boyd, n.d.; Krause-Jensen and Duarte, 2016; Nellemann et al., 2009). Furthermore, seaweed forests do not need fertilisers, pesticides, or land space. It does not burn like forest fires on land,

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solutions bring more, and more diverse, nature and natural features and processes into cities, landscapes and seascapes, through locally adapted, resource-efficient and systemic interventions… Nature-based solutions must therefore benefit biodiversity and support the delivery of a range of ecosystem services." (European Commission, n.d.)

[13] According to Encyclopedia Britannica: "Ecosystem services, outputs, conditions, or processes of natural systems that directly or indirectly benefit humans or enhance social welfare. Ecosystem services can benefit people in many ways, either directly or as inputs into the production of other goods and services" (Johnston, 2018).

[14] The author hypothesize perhaps it might have something to do with the fact that it is less seen by humans (it is more submerged under water) compared to other coastal ecosystems such as marshes and wetlands that are partially submerged thus visible.

[15] Seaweed forest is also called a kelp forest which is a type of brown seaweed/macroalgae in the Laminariaceae family. Common names of the kelp species available in Denmark are: 'Sukkertang' (Suger Kelp), Fingertang (Oarweed) and Palmetang (tangle or cuvie).

and there are potentials for sinking the kelp to the bottom of the ocean bed at the end of its life, guaranteeing carbon capture (Krause-Jensen et al., 2018; Krause-Jensen and Duarte, 2016). However, the potential of dead kelp material storing carbon for the future is under-researched with no conclusive data yet (Gundersen et al., 2017).

iv) Improve biodiversity

The various forms of seaweeds are habitats, nursery ground and food for fish, marine invertebrates, mobile pelagic and benthic organisms, improving biodiversity and opportunities for recreation (i.e. marine nature reserves) (Orth et al., 2020). Moreover, kelp forests host one of the world's most diverse ecosystems responsible for providing habitat and food for marine animals and humans (Gundersen et al., 2017; Mouritsen, 2013).

Nature-based protection measures are gaining traction in research and practice because they can be more cost-effective than hard strategies. Additionally, ongoing and active management is unnecessary after a certain period, unlike the engineered approach (Pilkey and Young, 2011). However, there are also limitations with nature-based infrastructure. While it provides certain levels of protection from storm surges by dissipating the strength of the waves, it requires a large area (minimum several square kilometres) to reduce a significant amount of the strength of waves in storms (Orff, 2016). Furthermore, it is complex and difficult to calculate the relationship between storm surges and these nature-based solutions. Therefore, it is essential to predict better the ability of NbS to reduce storm surges and flooding impact with computer modelling and testing on-site (ibid.). This area of research requires more investigation to ensure the effective implementation of NbS from its wave attenuating properties (i.e. from storm surge). However, it is important to note that NbS are not the saving grace from sea level rise as it does not provide direct protection. Thus, one should be cautious when promoting restoring coastal ecosystems to avoid a false promise of guaranteeing full security from future water issues (Pilkey and Young, 2011). Furthermore, there are challenges in trying to establish soft approaches in challenging environments[16]. For instance, urban areas that suffer from severe water pollution (i.e. eutrophication), lack of sediment flow due to locks and gates at the mouth of the river, and increasing cloudburst affecting the salinity levels, to name a few. Careful analysis and inter-disciplinary collaboration are required to understand the various factors inhibiting coastal ecosystem restoration efforts.

More importantly, the main issue behind the coastal protection and adaptation is when there is a heavy reliance on one system (i.e. hard approach), making it vulnerable to responding to the complexity of numerous issues that may arise from climate change. Therefore, the presence of a range of different approaches becomes critical to ensure that the most flexible and holistic strategies can be implemented at the coast (Hill, 2015). It is critical that coastal cities move past short-term quick-fix strategies to prepare for future climatic changes and embrace other added-values of coastal protection systems such as one provided by coastal ecosystems to ensure diverse responses to unpredictable future scenarios (Hill, 2015; Pilkey and Young, 2011).

[16] For instance, in the fjord city of Vejle, eelgrass restoration efforts are hindered by the large amount of floating particles from excessive fertiliser use, turning the fjord water murky. The lack of nursery habitat for fish as the eelgrass struggled to grow under these conditions has impacted the food web. The predatory fish decreased in numbers, which exploded the crab population that feeds on the eelgrass. Therefore, unless the water pollution issues and the unbalanced food web is addressed, there will be limits to the eelgrass restoration efforts (Vejle Kommune, 2020).

6. HYBRID APPROACH

Hybrid approaches combine the strengths and limitations of both hard and soft approaches to go beyond the singular aim of defence during extreme weather events and sea-level rise by enhancing the city's coastline by increasing biodiversity (Hill, 2015; Orff, 2016; Wiberg, 2019). Combining hard and soft approaches to coastal resilience and adaptation becomes more of a dynamic system (Depietri and McPhearson, 2017; Sutton-Grier et al., 2015). Hybrid approaches aim to increase many ways to respond to sea-level rise and global warming (Hill, 2015; Lister, 2007). For instance, these hybrid strategies include increasing coastal edge elevations via beach nourishment, bulkheads, tide gates, armour stone (revetments) and drainage devices. Secondly, hybrid strategies can minimise upland wave zones via offshore breakwater, sand dunes, living shorelines, oysters, mussel or rock reefs, coastal wetlands, salt marshes and groins (see Figures 4 and 5). Finally, hybrid strategies protect against storm surge through the integrated flood protection system, such as floodwalls, levees and local storm surge barrier (Orff, 2016). Furthermore, it is important to incorporate a long-term retreat strategy plan in many highly risky coastal zones as part of the hybrid approach. These critical zones[17] need to be designated "no-build zones" in the future, which leads to the question of what these critical zones need to be transformed into in the future as the sea takes over these spaces.

Figure 4: Visualisation by SCAPE Studio – Oyster-tecture, developed for the Museum of Modern Art exhibit "Rising Currents" (2009) by SCAPE in collaboration with Bart Chezar, Hydroqual Engineering, MTWTF, the New York Harbour School, NY/NJ Baykeeper, Paul Mankiewicz and Phil Simmons. The project is a proposal for reviving the former oyster beds in New York, USA, as part of its coastal adaptation strategy. In combination with mussels and eelgrass, oysters reefs are used for wave attenuation and harbour water filtration (Orff, 2016).

7. "BLUE URBANISM" – BEYOND THE GREEN

The increasing influence of ecology in the field of landscape architecture and urban planning, such as ecological urbanism, addresses a shift in focus that integrates better the various environmental and contextual factors (e.g. hydrological, ecological, geological) (Orff, 2016). However, the influence of ecology has primarily been focused on green environmental movements within the territorial boundaries of the land. Nevertheless, this duty of care has been extended to include the "blue" issues, primarily due to the increasing threat of rising sea levels and growing awareness of the ecological footprint of coastal cities that impact

[17] *In this article a critical zone refers to an area where it is at risk of frequent or permanent inundation due to sea level rise or storm surge event due to global warming.*

beyond its immediate vicinity. Coastal cities are intricately connected to the oceans and are dependent on marine resources for food, raw materials, fuel and medicine, to name a few (Beatley, 2014). As the negative impact of human activities on the oceans is becoming more well known, there is a growing awareness of the vital role marine ecologies play in addressing global warming. As a response, an emerging ethical approach called "blue urbanism" by Timothy Beatley highlights the need to change the current overt instrumental relationship with the oceans, along with addressing the exclusion of marine environments in modern policy, planning and design of cities (ibid.). Beatley (2014) calls for coastal cities to exercise more proactive conservation and integration of marine ecosystems (as with land-based ecosystems) to tackle unprecedented risks to ocean health. Therefore, blue urbanism is an argument for heightened awareness and partnership among city governments, planners, designers, scientists and urbanites to become part of a more complementary, mutually sustainable relationship between the city and the ocean (ibid.).

Figure 5. Project by Rafi Segal (AU) and DLand Studios (Susannah Drake) – "Bight: Coastal Urbanism" in New York, USA. This project aims to replace the hard edge that segregates the city and sea with a new "landscape economic zone" — "a buffer that allows land and water commingle, creating new spaces for habitation, conservation, work, and play. This project is an example of long-term retreat as part of the coastal adaptation strategy" (DLand Studio, n.d.).

There is a narrowing window of opportunity for coastal cities to respond effectively to sea-level rise and other associated water issues. Understanding the complex entanglements and interdependency of human and coastal ecosystems is crucial and needs to be explored through various disciplines, contexts and mediums. Therefore, there is a need to include marine nature-based strategies as part of coastal protection and adaptation strategy along with planning regulations, community outreach and educational programs (Gendall et al., 2015).

8. RESEARCH GAP – THE ROLE OF CREATIVE FIELDS IN INTEGRATING MARINE LIFE FORMS INTO THE URBAN SHORELINES

Research in the field of urban design and landscape has the potential to develop a subfield that includes marine lifeforms such as seaweed in creative ways to adapt to the changing climatic conditions that will motivate more restorative relations between cities and the sea. Too often, the realm of coastal protection projects or marine restoration projects is primarily in the hands of engineers or marine biologists without the

inclusion of creative disciplines. Projects of this large magnitude and complexity could benefit from creative inputs from landscape architects, urban designers, planners and artists/designers who could exercise the skill of synthesising different interdisciplinary knowledge into a holistic and creative outcome that engages with the citizens as a form of public space. Fortunately, the benefits of inter-disciplinary collaboration are gaining traction in Denmark and worldwide in many coastal adaptation projects (Wiberg, 2019). The call for interdisciplinary collaboration is a response to acknowledging the various interconnected networks and dynamic processes that highlight the constant synergy between human and non-human, city and sea, short and long-time spans sea-level rise (5-100+ years). Nevertheless, despite recent efforts, there is still a clear lack of implemented (designed and built) holistic "blue projects" at the urban shoreline, and many relevant projects are still unrealised. The lack of implemented projects highlights the gap in research both in academia and in practice with only a limited number of state-of-the-art built projects. Moreover, the persistence of built projects that struggle to depart from the confines of the status quo of static hard approaches is an indication that moving past business-as-usual is still difficult.

9. WHY FOCUS ON SEAWEED? – THE FORGOTTEN ACTOR IN THE "SOFT APPROACH" TO URBAN SHORELINES

Research by Wiberg (2020), Hill (2015), Faragò et al. (2018) and Quintana et al. (2021) assess the various built coastal protection, adaptation and coastal ecosystem restoration projects in Denmark and around the world. The findings indicate a research gap in more dynamic landforms (unlike the static hard approaches) and the need to integrate more nature-based solutions that require further exploration. Furthermore, while there are research and projects on the benefits of integrating wetlands, marshes, meadows and eelgrass near the urban shorelines as part of coastal resilience strategy, very few exist for seaweed forests (see Table 2 – which only refers to seaweed farms for food production) (Quintana et al., 2021). It represents a gap in research of integrating seaweed as part of marine nature-based solutions and as urban landscaping (seascaping) feature that could be an integral part of the coastal city's urban shorelines as a key part of waterfront developments; and as a way to rethink the current boundary between land and water. As global warming pushes the sea to creep further into coastal cities, the question of how these inundated spaces could be transformed into a new urban common[18] inhabited by non-humans remains an unexplored field of possibility. In short, there is an unexplored solution space for seaweeds as a forgotten actor in marine nature-based solutions, as a potential residence of these new critical zones after risk areas are relocated further inland.

Nature-based solutions	Ecosystem services				
	Coastal protection	CO_2 sink (t $ha^{-1}yr^{-1}$)	Nutrient cycling	Biodiversity	Social engagement
Seaweed farms	n.a.	n.a.	●	●	●
Mussel farms/beds	n.a.	n.a.	●	n.a.	●
Concrete structures	●	n.a.	●	●	●
Stone reefs	●	n.a.	●	●	●
Salt marshes/meadows	●	7.6 (2.0)	●	●	●
Soft-sediments (MR)	●	0.4 (0.1)	●	●	●
Eelgrass	●	2.0 (0.5)	●	●	●

Table 2. "Main ecosystem services provided by coastal and marine habitats as nature-based solutions. The green circles represent the ecosystem services that are well documented by scientific research and (n.a.) not available or sufficiently scientifically tested. Coastal protection is referred to as both preventions of coastal erosion and waves attenuation" (Quintana et al., 2021).

[18] *The term urban commons represents shared material and immaterial resources (i.e. land) that belong to or impact the whole community in an urban environment (Hardt and Negri, 2009). It is founded on the guiding principle of equity that fundamentally reconceptualise how we view spaces and entities as something that affects all.*

Furthermore, there is a need to find different ways to spread awareness of the important role of coastal ecosystems in the environment as anthropogenic climate change[19] is profoundly altering the ocean, and continual uninhibited human activity puts these life forms under extra pressure[20]. In Denmark, for instance, most coastal water bodies are in poor ecological conditions due to environmental problems related to intense levels of eutrophication from excessive use of fertilisers for agriculture[21] (see Figure 6). Excessive levels of eutrophication hinder the restoration efforts of coastal ecosystems (MiljøGIS, n.d.). Thus, it becomes paramount that in order to restore the health of these water bodies, a greater emphasis should be directed to formulating more appropriate regulations to reduce pollution sources from agricultural activity and proactive recovery of these coastal ecosystems that have water filtering capacity.

This paper argues that seaweed, more commonly referred to as "the forests of the sea" (kelp forests), deserves more attention as it is an overlooked and underappreciated coastal ecosystem. The health of these marine ecosystems will play an important role in reducing the scale of sea-level rise in the future as they play a key role in climate change mitigation by taking up CO_2 from the atmosphere (Filbee-Dexter and Wernberg, 2018b). Moreover, despite the importance of these marine ecosystems, the protection of these vital ecological habitats are often disregarded at the expense of prioritising the urban environment and its future developments (Filbee-Dexter and Wernberg, 2018a; Galland et al., 2012). Perhaps the territorial bias[22] of human stakeholders, the lack of perceivable visibility, lack of awareness and exposure of the marine world with human actors are partly responsible for overlooking issues below sea level. Careful integration of coastal ecosystems such as seaweeds in the urban shorelines closer to human exposure and educational efforts could contribute to raising awareness about the plight of the forest of the sea.

Moreover, aside from the coastal protection and blue carbon role of seaweed, other values could be considered to support their integration into the urban realm as they have a history of influencing different cultural practices worldwide. For instance, seaweed can provide other ecosystem services[23] such as provisional (i.e. food) and cultural services (i.e. art), setting seaweeds apart from other vegetated coastal

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[19] According to the latest report by the IPCC (2021), the ocean is warming rapidly with more frequent marine heatwaves, accelerating ocean acidification[19] and deoxygenation[19] levels. IPCC (2021) issues a warning that "these changes affect both ocean ecosystems and the people that rely on them, and they will continue throughout at least the rest of this century." Moreover, the continual exploitation, negative impacts of global warming and water pollution are responsible for the global degradation of 66% of marine environments (IPBES, 2019).

[20] Seaweed forests (particularly kelp forests) are disappearing at an alarming rate due to global warming (Filbee-Dexter and Wernberg, 2018a; Harley et al., 2012). They are sensitive to changes in temperature and chemistry of the oceans; hence it has already resulted in a mass migration of these marine species putting pressure on them to adapt to its rapidly changing environment (ibid.).

[21] Land used for agriculture makes up over 60% of Denmark's total land area (as of 2017) and 80% of that land is used to grow fodders for animals (mainly pig feed) (Sådan ligger landet... – tal om landbruget 2017, 2018).

[22] Terrestrial bias is a situated perspective that responds to the fact that humans live on land, thus are bound by gravity and experience daily life as such (i.e. immersion in air rather than water). This parameter restricts human thinking and experiences to the ones on land, and thus lending to bias ways of thinking, perceiving and decision making to prefer the terrestrial realm as the norm. This can be problematic when dealings with the watery realm of the sea with differing parameters and conditions that requires human stakeholders to depart from anthropocentrically terrestrial way of doing things (Jue, 2020).

[23] There are four different categories of ecosystem services. 1. Provisioning services that are those that benefit people which can be extracted from nature such as plants as food, wood for fuel, etc. 2. Regulating services are those that make life possible for people such as plants that produce oxygen, bacteria that decomposes waste etc. 3. Cultural services are non-material benefit that contributes towards advancement of culture such as through art, music etc. 4. Supporting services are those that provide living habitat for humans and non-humans as the basis of all ecosystems and their services (Gundersen et al., 2017).

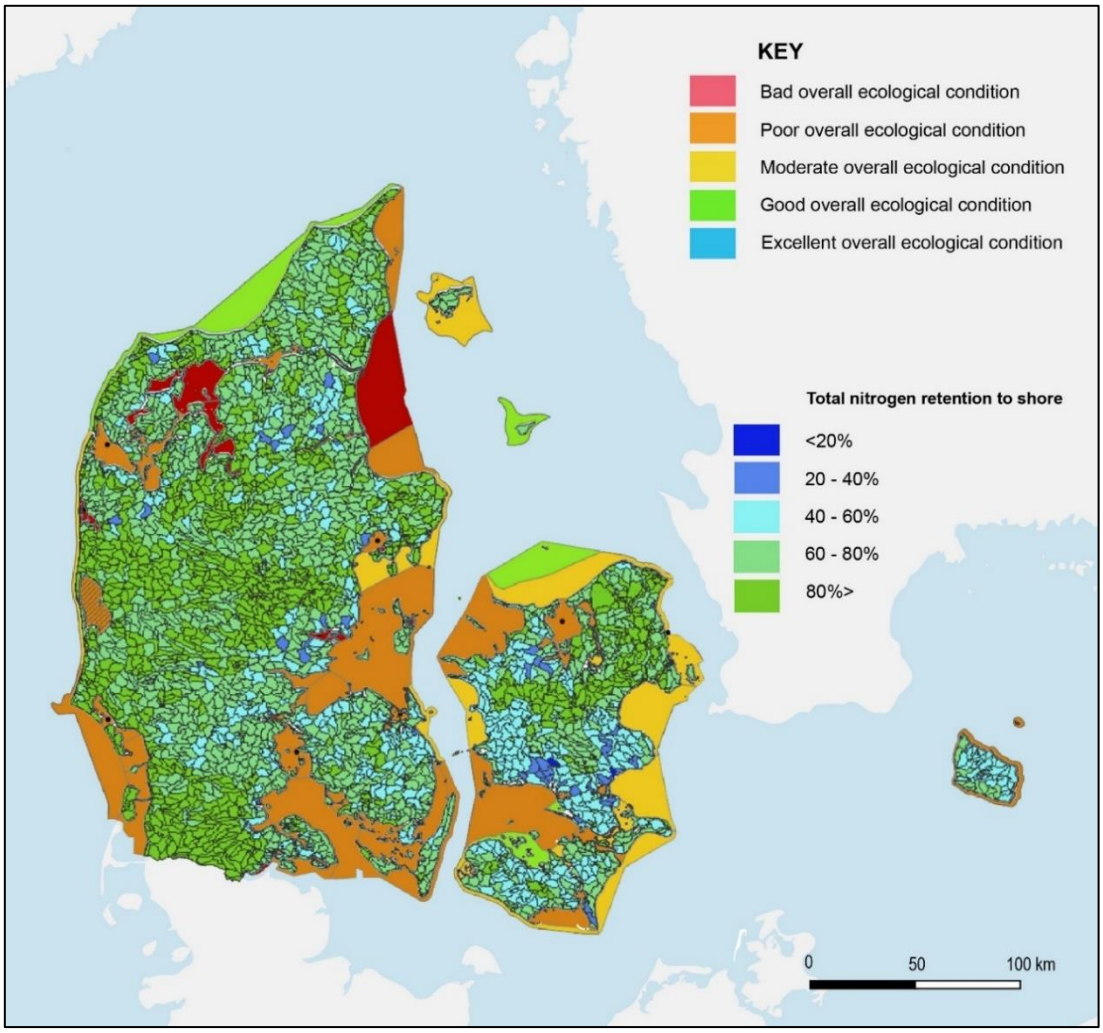


Figure 6. Overall ecological status of coastal waters in Denmark from as of July 2021. The map shows the overall ecological condition of coastal waters based on several quality measures[24] with the nitrogen load on land. The poor condition is mainly due to excessive phosphorus and nitrogen load from agricultural farming. Recent efforts to clean up the coastal waters have shown some levels of improvement in water quality over the years. However, none of the coastal water bodies is in excellent ecological condition.
GIS map from Miljøstyrelsen Denmark (Miljøstyrelsen, 2021) and further illustrated by the author.

ecosystems like salt marshes or wetlands. Some of the influences seaweed has had on human culture are elaborated below:

i) *Provisional Services[25]: Food production*
Seaweed can be eaten by humans, contributing to local, sustainable food production. It has impacted food culture in the Nordic region as early as the 10th century, where seaweed was in the diet of the Nordic people (and Greenland), with stories of Viking voyagers bringing dried seaweed as provisions for long expeditions (Mouritsen 2013). Seaweed was a common substitute during harsh winter months and was also given to farm animals as supplements (fodders) (ibid.). However,

[24] They are: ecological condition of phytoplankton, rooted plants, benthic invertebrates, environmentally hazardous pollutant(MFC) and chemical status of EU's list of substances. There is very little data on the oxygen and light levels of coastal waters which will also impact the ecological condition (Miljøstyrelsen, 2021).

[25] Seaweed (agar) has the added benefit that it can be converted into a wide arrange of uses such as for medicine, beauty products and biofuel, to name a few (AlgaeCenter Denmark, 2013; Hasselström et al., 2018)

with the onset of the agricultural revolution, seaweed was slowly forgotten from the Nordic diet and in the western world. By contrast, in East Asian cultures, seaweed continues to have a strong influence on traditional cuisine. To this day, in South Korea, seaweed soup is eaten as a form of celebration, i.e. on birthdays and when mothers give birth (Jeong, 2013; Korean Food Promotion Institute, 2018). Seaweed has a significant impact in Korea as a cultural symbol of celebrating life, and the different common names are known to the general public. It is not termed "weed", unlike the Anglo-sphere designating its purpose as a nuisance and a useless entity. Nevertheless, seaweed is making a resurgence in Nordic cuisine as a healthy superfood and a form of sustainable food that does not require any land, freshwater, or pesticide to grow and can mitigate food shortages in the future due to global warming (Efstathiou and Myskja, 2018; Krause-Jensen and Duarte, 2016; Krause-Jensen et al., 2018; Mouritsen, 2013). The ability of seaweed to influence the cultural sphere as sustainable food and its unexplored beauty makes seaweed a good contender and a representative of the vegetated marine realm that can fill the current research gap in integrating seaweed into coastal adaptation strategies.

ii) Cultural Services: Cultural and aesthetic value

Aside from seaweed making an impact on food culture, it has also had another cultural impact during the natural history boom of the Victorian period made popular by Darwin. British women who were excluded from the practice of scientific fieldwork engaged in more socially acceptable "fieldwork" to collect seaweed, called "seaweeding", to dry press seaweed showcasing its beauty (Mouritsen, 2013; Trethewey, 2020) (see Figure 7). As a source of beauty, seaweed is an under-explored avenue (unlike terrestrial plants) that could be better exemplified at the meeting place between the terrestrial and the marine world. Seaweeding and other educational initiatives involving seaweed play an important role in marine knowledge centres that teach children about the importance of the sea through the lens of seaweed (Havhøst, 2019; Hjerl, 2019; Palmgren, 2019). Thus, seaweed is a relevant actor that continues to play a role in telling the story of human customs and practices both past and present, and it will continue to do so in the future.

Figure 7. Various dry pressed seaweeds from the coast of East Jutland, Denmark by the author on July 2020. There are over 350-400 different types of seaweed in Denmark (Lundsteen and Nielsen, 2019a, 2019b).

Nevertheless, existing narratives and how seaweed is viewed have predominantly been for its instrumental use to humans (i.e. food, blue carbon and biofuel). There is an emerging field of considering non-human entities for their intrinsic values beyond their instrumental use to humans, i.e. for its own sake. This alternative view has especially been the case with studies of indigenous world views that are much more in line with an intrinsic view of the non-human world, which has been exemplified as a way to think differently about the environmental crisis (Mentink, 2018; Rodgers, 2017). The urban landscape realm (design and planning) could depart from overt anthropocentric worldviews to explore a radically different way to integrate non-human entities by recognising their right to exist and thrive by thinking from their perspective.

The article so far has explored the various complexities involved in dealing with how coastal cities need to move past the business-as-usual approach to respond better to the impending threat of global warming. It highlighted various marine nature-based solutions available to mitigate and adapt to the challenges posed by sea-level rise, storm surge, the biodiversity crisis, increasing urbanisation and pollution. The following sections focus on addressing the research gap of integrating seaweed as a representative of a marine nature-based solution in the field of urban design and landscape architecture. Moreover, the article seeks to explore the potential of seaweed as a representation of multispecies coexistence[26] at the meeting place between city and sea. It addresses the ethical and theoretical point of departure to catalyse urban waterfront transformation in the form of a new urban commons that include marine life (i.e. seaweed) as a key player. Departing from the current status quo in coastal cities is needed to explore what it could truly mean to live not just by the sea but *with* the sea.

10. URBAN SEASCAPING: RE-ENVISIONING THE BOUNDARY BETWEEN CITY AND SEA, HUMAN AND NON-HUMAN

The research proposes a conceptual, ethical and theoretical neologism called "Urban Seascaping" (USS). USS explores the potentials of contributing towards a new form of watery public space that enhances marine-based eco-aesthetics as part of coastal adaptation strategies for this century in light of sea-level rise. The area of concern is the boundary where the coastal city meets the water in Denmark. The importance lies in the fact that the research is focussed on the urban context where these distinctions between nature and culture are either more marked, segregated and destructive. The urban context is where the majority of humans live; thus, it is a place where awareness about the marine realm will be most impactful. Furthermore, it is a challenging site of intervention as terrestrial bias are most at play in the urban context. Moreover, it is precisely the area that will face the biggest challenges of future water issues from the sea.

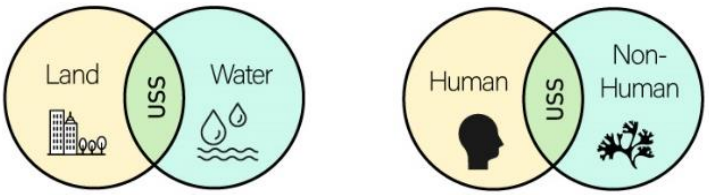
The neologism of Urban Seascaping is proposed as a linguistic tool to grasp and express the desired changes we want to see in the unforeseeable future (Fink, 2012) for coastal cities. The introductions to new conceptions can form discussions about values that we want to address and, through their frequent use, make the new conceptions more familiar and normative. USS seeks to contribute a framework for decision-making processes that holistically integrate the sea and the non-humans into the urban realm. The main aim of Urban Seascaping is to reflect a more unified concept of nature and culture[27], in this case, the forgotten

[26] Multispecies coexistence, multispecies future, multispecies cohabitation, multispecies response-ability are one of many terms that deal with the need for co-existing with other species in a more equitable and mutually beneficial manner in the age of the Anthropocene. There are many scholars and proponents of this theory, one of the prominent scholars who made this term well-known is Donna Haraway (Haraway, 2007, 2016).

[27] The discussion on the conceptions and relationship of nature and culture is an age old, on-going debate. Nature in traditional western notion is considered separate and independent from the human. There are many new materialist scholars (and other scholars) that argue for a much more interrelated conceptions of nature and culture. They critique the dualistic conceptions of nature and culture in being responsible for the current ecological crisis (Bennett, 2010;

marine world. It attempts to reimagine the traditional dualistic notions of urban city as "culture" and sea as "nature" to a more hybrid and dynamic zone that may include the often-ignored agency of the sea and its marine life in coastal urban development. The use of "scaping" unifies the two worlds by emphasising their inter-relationality and inter-dependency (see Figure 8).

***URBAN** (CULTURE) + **SEA** (NATURE) + **SCAPING** (INTEGRATION OF NATURE-CULTURE)*



Seascape ~~Landscape~~ architect noun

Definition: *A person who develops ~~land for human use and enjoyment~~ the zone between land and sea for the human and non-human benefit, ~~placement of structures, vehicular and pedestrian ways and plantings.~~ through structures that integrate marine life while strengthening coastal adaptation and resilience in light of sea-level rise (global warming).*

Figure 8: Urban Seascaping – Looking at the inter-relationship between human and non-human, land and water at the urban shorelines. Urban Seascaping seeks to establish a sub-field within urban design, urban planning and landscape architecture. The potential role of a seascape architect is redefined (in red) from the definition of a landscape architect (in black) from Merriam Webster Dictionary (Merriam-Webster, n.d.). Illustration by the author.

The main focus of this research is to explore ways of integrating the sea and its lifeforms, such as seaweed, into the urban coastal landscape by making it more tangible and visible. The development of the USS's theoretical principles provides a foundational basis to include marine restoration as a normative practice in urban design, planning, policymaking, waterfront developments and coastal adaptation strategies. USS seeks to develop further existing theories of blue urbanism and ecological urbanism and utilise the power of design and qualitative methods of inquiry to re-envision coastal cities for a new reality with the sea. Furthermore, it attempts to address the gap in research of reconfiguring the conundrum of ocean sprawl in current waterfront development via utilising the full spectrum of ecosystem services (and NbS) provided by coastal ecosystems such as the seaweed.

The proposed principle of Urban Seascaping is built from existing theories and state-of-the-art practices and establishes a sub-field within urban landscapes. Moreover, the research draws cross-disciplinary knowledge from marine biology, geology, literature and philosophy to add various perspectives to strengthen different affiliations between living things and infrastructure. The USS framework proposes four core principles that can help guide design decisions and form new narratives about coastal adaptation at urban shorelines, looking specifically at the Danish context. The first principle is an ethical proposition of how to live with sea-

Guattari, 2000; Haraway, 2016; Morton, 2012; Rosa, 2019). According to the scholars Scherer and Klingan (2013) "Nature, as we know it, is a concept that belongs to the past. No longer a force separate from and ambivalent to human activity, nature is not an obstacle nor a harmonious other. Humanity forms nature. Humanity and nature are one, embedded from within the recent geological record" (Prominski, 2014). Nevertheless, interconnected conceptions of nature and culture is nothing new, as it has been for many indigenous world views around the world.

level rise in coastal cities. The second and third principle is a spatial proposition of creating a meeting space for urbanites and the sea (and its marine life). The last principle is a design proposition of creating an accessible, safe, visible and beautiful marine nature-based infrastructure that addresses the previous three principles. The four main principles under the USS framework are elaborated in the proceeding sections.

10.1 Principle I: Multispecies coexistence with the marine world

The first core principle of USS discusses what it means to shift from the conventional view of the sea as a threat for coastal cities to a co-resident, forging deeper relations with the "more-than-humans[28]" of the sea. In short, there is a need for a paradigm shift in the current anthropocentric worldview of the water to acknowledge them as an integral part of the entangled network of beings. To respond to the challenges and devastating impacts of climate change that will affect every being on earth to varying degrees, one cannot ignore the notion of justice, equity and responsibility of those who have the power to change the course of action. Reorientating our understanding of the world as interrelated and interdependent will help us understand that the well-being of more-than-humans is congruent to the humans'. It challenges us to think from the perspective of more-than-humans and acknowledge their inherent right to exist besides their instrumental use to humans.

Thus, the first principle departs from Donna Haraway's (2007, 2016) coexisting with the more-than-human. Currently, the needs of humans and more-than-humans seem to be in direct conflict with each other in urban environments. Once we recognise that more-than-humans and humans are intimately linked (as humans also have aquatic origins) and are mutually interdependent, the duty of care[29] should extend to other species. Therefore, this research calls for better inter-relations with coastal habitats such as seaweed as the representative symbol of a marine lifeform in light of sea-level rise. The first principles seek to ask questions about how we can create coastal cities not just for human habitation but also for marine lifeforms and whether the structures we design for them will be received well by them. As the sea continues to rise in the future, one questions how the inundated infrastructures and buildings should be designed for habitation by marine lifeforms as a better meeting place for citizens and marine life (see Figure 9 for examples of this approach).

The first principle of multispecies coexistence is to recognise the need for better protection and restoration of these coastal ecosystems as marine habitats are often excluded in nature protection areas, unlike land-based ones[30]. Furthermore, the implication for better protection and restoration of coastal ecosystems means coastal cities need to address a range of anthropogenic pressures on these coastal ecosystems. These are dealing with the sources of water pollution, restoring the imbalanced food chain and reinstating the sea bed with stone and rock reefs for marine lifeforms, to name a few. Without addressing these barriers to coastal ecosystems, coastal ecosystems will have difficulty surviving the continual climatic changes of warming and acidification.

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28 More-than-human' is a term conceived by the feminist scholar Donna Haraway (Haraway, 2007, 2016) to refer to the entangled multispecies reality (termed Multispecies Response-ability) that goes beyond the human. It is also used to depart from the binary notion of thinking of the world as being human and non-human. The term is used to illuminate new ways of thinking about agency and power of the different living forces. In this article, the term will be used to refer to the marine world, in particular the coastal ecosystems such as seaweed as the main representative marine species.

29 This claim is rooted in the science of ecology and many ecological thinkers that focuses on intertwined interrelations and networks and that care should extend to other living species in order for a mutually beneficial future for all. See (Alaimo, 2016; Bennett, 2010; Guattari, 2000; Haraway, 2016; Latour, 2007; Morton, 2012).

30 Furthermore, European coastal cities need to fulfil the various biodiversity goals set out by the EU directive for coastal ecosystem restoration (European Commission, n.d.).

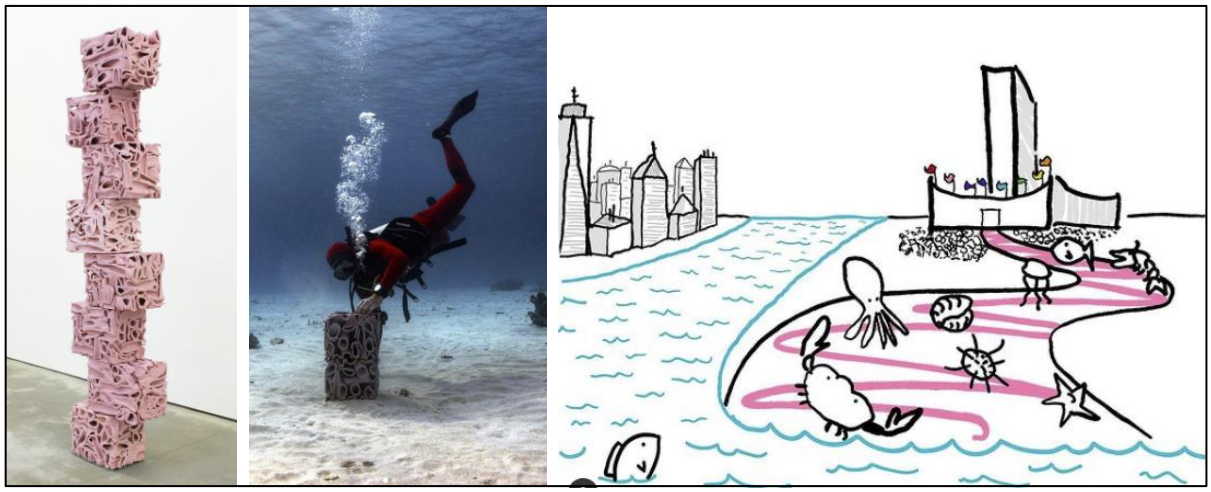

Figure 9. (Left): "Pink Elements" (no.6/Zig Zag Column) is part of the research project called "Deep Sea Minding" by Superflex. The pink sculpture is built with coral friendly bricks for fish. Installed at Galería OMR, Mexico City, 2019. Photo credit: Enrique Macías Martínez (Superflex 2019).
(Middle): A diver installing the pink element to test if the fish would inhabit and interact with the sculpture (Superflex n.d.).
Image credit (right): "Interspecies Assembly" - A drawing of what it means to mark the very first gathering of humans and other marine species on earth, to promote interspecies dialogue and cooperation (Superflex n.d.).

Therefore, the first principle emphasises the need for care of these coastal ecosystems and to ensure that we provide favourable space for them in our coastal cities, so we learn to coexist with them and not just by them.

Marine stewardship

It would be naïve to suggest that urban design and coastal landscape architecture alone would resolve the current nature-culture divide at the coast. Marine biologists, researchers, activists and people who work with ocean advocacy emphasise the critical role of creating a community around ocean literacy parallel to material initiatives (Hjerl, 2019; Mouritsen, 2019; Palmgren, 2019). These can include marine education centres, community outreach programs, marine restoration projects, sea gardens, cultural initiatives surrounding marine food. Local educational outreach programs for young students are essential as this generation will likely face the consequences of global warming and sea-level rise in this century. Therefore, the role of these initiatives is to help people develop "an ethical lens that extends beyond human self-interest" (Beatley, 2014), one that is mindful and respectful toward marine life and which inspires new ways to forge relations with the sea. Hence, USS's first principle of multispecies coexistence reflects the model of stewardship, which advocates integrating educational, restorative and cultural initiatives with coastal urban seascape design interventions to help nurture and sustain the design interventions. Harbouring this network that offers unique experiences to people living near the coast is a positive step towards multispecies coexistence.

Therefore, the first principle of USS is not just merely an ecological or an aesthetic approach dealing with sea-level rise but also an acknowledgement of the importance of education, community involvement, policymaking. They all play a vital role in aiding the material and mental transformation of coastal cities for the future.

10.2 Principle II: Invite the agency of the sea

Water as a connector, an actor, a living entity

Humans have conceived the sea in many different ways, and these conceptions influence how we shape our urban coastal environment. For more than a century of human history, the industrialised nations exercised a

superior proposition of ownership and management of the water by expanding coastal cities into the sea. The current typical physical design of the urban shorelines reflects this sentiment, as it demarcates a clear delineation between land and sea through land reclamation and hard edges. However, there are alternative ways of regarding this dualistic relationship manifested in physical form. For instance, alternative notions from societies such as the Caribbean islands have a concept called the "archipelagic thinking", which emphasises the dissolution of the boundary between the sea and land by conceiving the water as a connector, a bridge between islands, not as a divider (Pugh, 2013). The various island communities do not consider themselves separated by sea but integrally connected as a whole by the water (Pugh, 2013; Shields, 2020). By developing from this type of interconnected thinking, there may be scope for new urban shoreline infrastructures and coastal seascapes to use the agency of the water as a connector rather than a divider where human and more-than-human actors can enhance interaction that can develop over time.

Additionally, other unique and alternate worldviews acknowledge the agency of water bodies, such as the indigenous Māori people of New Zealand. New Zealand was one of the world's first to recognise a more intrinsic value of more-than-human entities in the legal system. The Whanganui River was recognised as a living entity by the New Zealand government (Roy, 2017; Warne, n.d.). They passed legislation declaring that the river and all of its physical and metaphysical elements - "is an indivisible, living whole, and henceforth possesses all the rights, powers, duties, and liabilities of a legal person" (ibid.). This law reflected the Māori relational worldview to see the water as an ancestor, living kin. There are contemporary urban planning applications of these paradigms, where the coastal waters of New York were legally recognised as the "sixth borough" with its human representation and legal frameworks just like the land boroughs (Ameel, 2019). It was a way to recognise that the city and the sea were integral to the urban environment.

Thus, the second USS principle questions the influence of current dominant worldviews of water and how it shapes the way we make decisions at the coast. The second principle is a call to embrace the agency of the sea and alternative views of the water to influence different decisions for the future of coastal cities.

Wet territory as the new commons (after retreat)

The second USS principle takes the proposition that the sea is a key actor and a spatial design driver to influence the meeting place between humans and more-than-humans, city and sea in an increasingly watery world. In the age of the Anthropocene and rising sea levels, water could be an integral part of place-making and identity for coastal cities.

Inevitably for many coastal cities, a long term strategy of retreat needs to be carefully considered by various stakeholders to plan a secure future of coastal cities at the end of this century. There will be areas that will increasingly be high-risk zones that need to be relocated to higher ground. This provides a unique opportunity to experiment with the vulnerable low lying shorelines and urban waterfront as areas of transformation - the new commons (see Figure 9 as an example of interspecies assembly). These new commons can potentially rethink and transform the coastal urban edge conditions to aid in overcoming the perceptual, physical and emotional barriers between sea and land while providing essential services at the coast. Since guaranteeing the full protection of coastal cities from the forces of the sea is not possible without resorting to more drastic measures of higher walls and pumps, USS suggests the radical act of opening up some of the shoreline edges to the sea to provide new connections and opportunities to create softer, more dynamic zones. These zones can better respond to tides, periodic flooding, and long-term rise in sea levels. Inviting the agency of the sea into the coastal cities can inspire the design process by understanding how the water weaves through the urban landscapes.

A relevant reference to an implemented project of reversing the colonisation of the sea[31] is in Gyldensteen Beach in Fyn, Denmark[32] (see Figure 10). Although this is not an urban setting nor a "designed" element, this blue infrastructural strategy led by marine biologists allowed a planned conversion of the hard coastline to an intertidal marine habitat. It did so by breaching the dikes and purposely flooding the farmland as a buffer zone to protect the neighbouring town from coastal flooding. This initiative was possible due to the increasing financial burden of maintaining the dikes that were frequently breached by storms. The former site was a wet marshland that required extensive human effort to convert to dry land. Therefore, understanding the former conditions before human intervention is critical in realising that in the future, it no longer makes sense to resist the forces of the sea to keep it dry. In order to move forward with addressing the challenges of tomorrow, a long-term sustainable solution is needed that considers various factors beyond mere coastal protection.

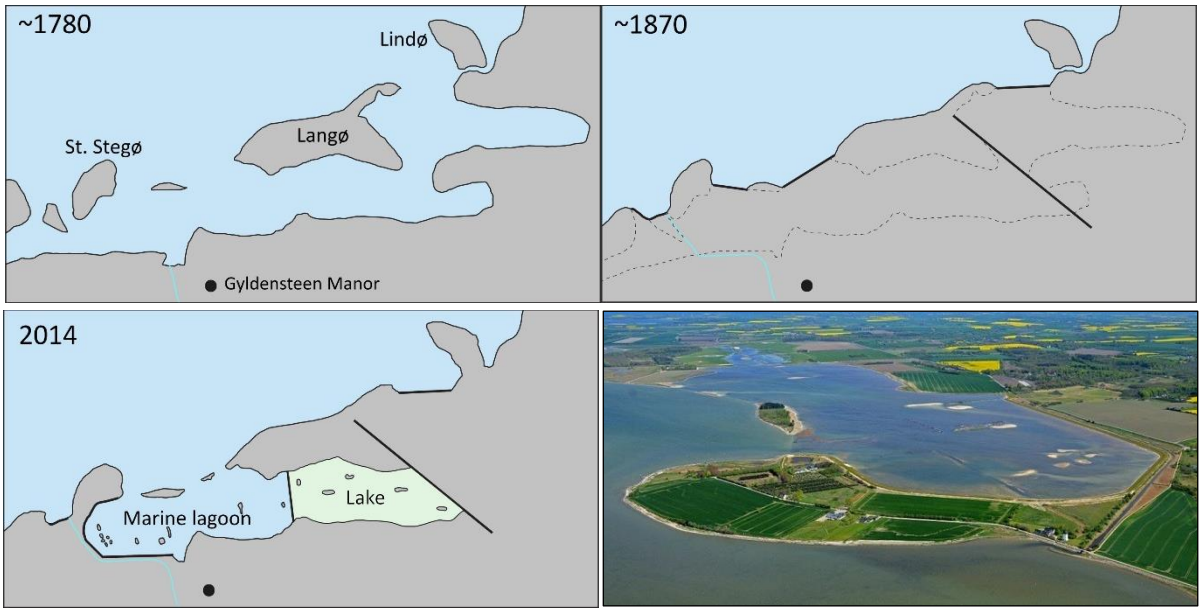

Figure 10. Three maps of the history of land reclamation in Gyldensteen Beach in Fyn, Denmark, from the 1780s to 1870. The land was given to researchers to be purposely flooded in 2014 to create a marine nature reserve. In 1870 dikes were used to block and drain out the sea. In 2014, coastal defences were breached to create intertidal habitat. Maps credit: Cintia O. Quitana and Klimatilpasning (Faragò et al., 2018; Klimatilpasning, n.d.). Aerial image credit: Viggo Lind

Furthermore, USS seeks to tell a story of returning some of the critical areas to the oceans to critically rethink the traditional ways cities occupy the waters' edge. The most appropriate strategy may depend on several complex factors, and it requires careful decision-making and management in what these new commons could be.

Living with wetness

As we expect a much wetter future for Denmark, we need to ask how much wetness we are willing to accept as the new reality of living in the Anthropocene. Water needs to be a key connective force that shapes the

[31] One of the earliest examples of an implemented project reversing the colonisation of the sea (due to land reclamation) was in the UK in the late 1970s, to the marshy northern coast of the County of Norfolk. Note, this is not an urban example, therefore, the idea of reversing land reclamation is noted, rather than the actual relevance of applicability in the urban context.

[32] One of the few examples of managed realignment projects in Denmark where it invites the sea into the former agricultural land to form saltwater lagoon and artificial freshwater lake as a buffer strategy to protect the town (Bogense) from coastal flooding. It also serves as a nature reserve for birds and marine life and a hot spot for recreation with an education centre (Aage V. Jensen Naturfond, n.d.; Klimatilpasning, n.d.; VisitNordfyn, n.d.).

city's relations with water as an integral part of everyday coastal urban life as forces of the sea is expected to have a stronger and unexpected presence in the future. Continuing the "control and conquer" approach of the water (as discussed in the previous sections) will have limitations in a changing climate with negative consequences on humans and more-than-humans. Thus, if the residents at the coastal cities wish to live with the water, they need to accept the new reality of living with a higher presence of water that requires higher levels of adaptation and resilience from the residents.

Finally, an integrated and closer exposure to the sea and its life forms would aid the current and future citizens to discover their encroaching watery neighbour to understand the ephemeral nature of coastlines and more fluid notions of boundaries beyond the concrete edge. Coastal cities have the unique opportunity to explore and experiment with a better relationship to the water by providing a safe, beautiful, educational and innovative meeting place between the citizens and the sea. The more-than-human world should not be subjected to the "out of sight, out of mind" mentality confined to nature reserves but also in the mesh of entanglements in coastal cities where new narratives and spaces can form as a key part of the city's identity.

10.3 Principle III: Beyond Walls

Seaweed as part of the nature-based solution

The third principle of Urban Seascaping seeks to address the unexplored solution space by going beyond the dominant hard approach to coastal protection to one of adaptation. USS argues that it is critical to consider long-term strategies by integrating a marine nature-based approach as part of the coastal adaptation strategy. This long-term thinking means ensuring that the aforementioned critical function of coastal ecosystems such as seaweed is protected, restored and integrated into urban shorelines for the benefit of humans and more-than-humans in light of changing climatic conditions.

From an edge to a zone

Furthermore, going beyond walls means thinking spatially from an edge to a zone. Nature-based solutions require a vast area to achieve a significant level of wave attenuation, carbon sequestration and water filtration. Therefore, coastal protection should no longer be limited to the narrow boundaries of the urban shoreline edge but to expand to a zone to address the interconnection between land and water (see Figure 11). It also means conceiving the site of intervention as a series of networks from a multi-scalar, systems approach to understanding the zone - everything from macro/global to micro/local level.

As the sea continues to rise in this century, the territories of water will no longer be confined within the neat concrete hard edges of current urban shorelines, transforming the current arbitrary boundaries to be more blurred and dynamic.

In the case of seaweed to perform wave attenuating properties, kelp forests (brown macroalgae) inhabit deeper, colder and saltier waters out of human sight (See Figure 11 and 12). Kelp forests can perform the first line of defence as it reduces the strength of waves in the event of storm surges. Thus, by the time the attenuated waves reach the coastal city, it reduces the need to implement harsher hard approaches of coastal protection, such as higher sea walls that severs the connection to the water. Kelp can be grown on buoys and lines (as shown in Figure 12) as a potential method to create a dense forest for coastal protection that will correspond to a rise in sea level in the future due to its buoyancy (Zhu et al., 2021). Moreover, other smaller and more beautiful seaweeds that grow near the coastal shorelines can be integrated as an urban design element, e.g. "sea gardens" to be the visual symbols of sea-level rise, a new resident of the critical coastal zone (the new urban commons). These sea gardens need to provide an opportunity for citizens to engage with the sea and its lifeforms to envision them as an active part of the physical, ecological and

aesthetic coastal cityscape (see Figure 13 as an example of an attempt to integrate marine life into an urban designed public structure).

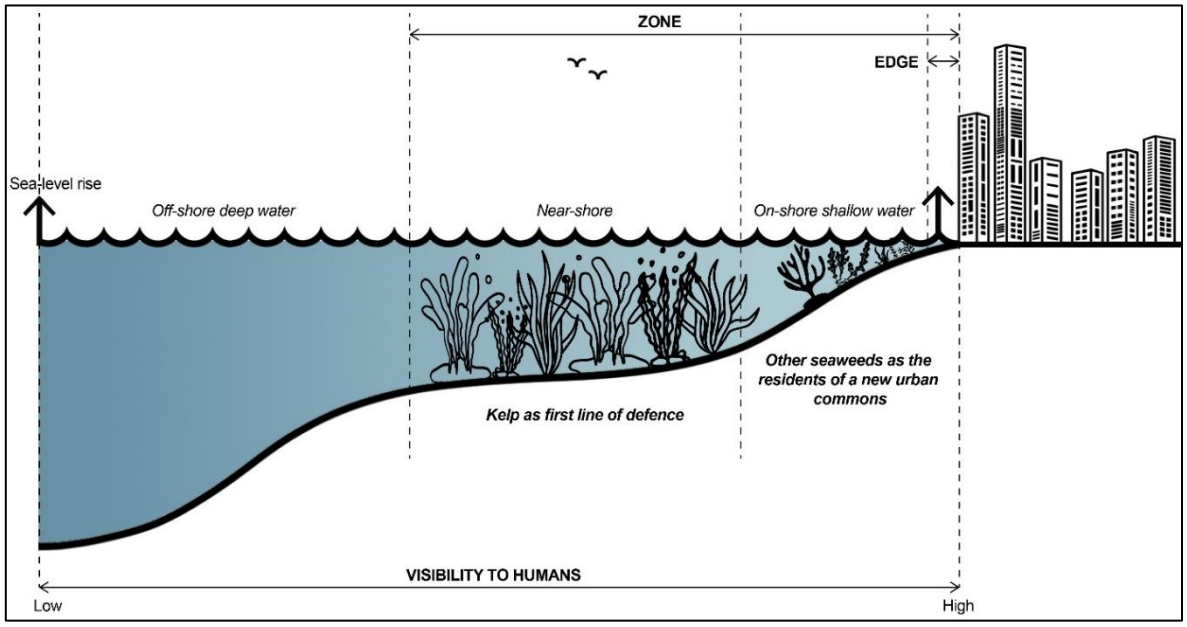

Figure 11. Thinking past edge conditions to a zone when considering water and marine lifeforms into coastal adaptation strategy. Kelp (brown macroalgae) as the "invisible" first line of defence against storm surge via wave attenuation and other seaweeds near the urban shorelines as a visual storytelling element of sea-level rise and as the residents of the new urban commons in the waterfront.

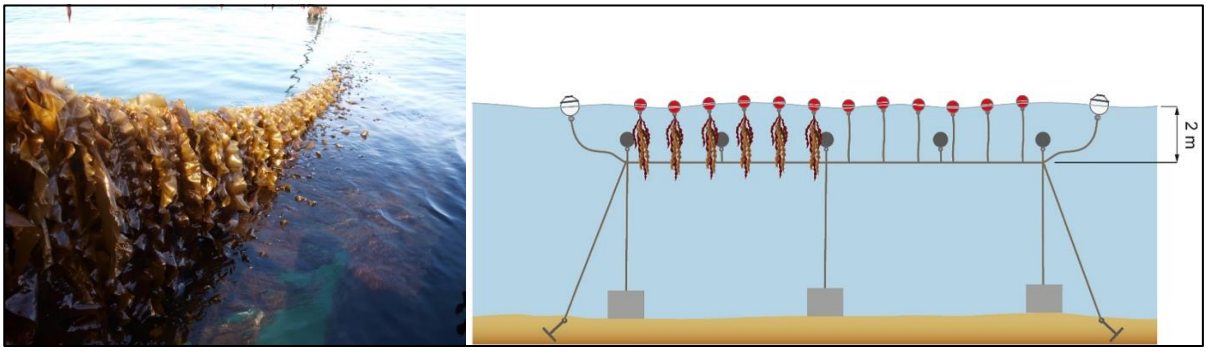

Figure 12. Sugar kelp (Laminaria saccharina) is grown on lines and buoys in Danish waters. There is scope to grow kelp forests in appropriate conditions to dissipate the strength of storm surges (Zhu et al., 2021). (Note that several kilometres of dense kelp forests are required to provide a significant amount of coastal protection. Local testing is required to understand various factors that influence the performance of the kelp). Image credit: Teis Boderskov (Boderskov, 2020; Boderskov et al., 2021).

Additionally, Urban Seascaping emphasises the need for these so-called "sea gardens" at the urban shorelines not only to be a place of observation and interaction but also as a place that challenges our everyday terrestrial experience of the sea. For example, an art installation in Germany called "On Water" (refer to Figure 14) is an example of a tactile and sensuous approach to urban installations using the water. Although it does not integrate marine life forms as part of the design, it encourages the urbanites to cross the water via a partially submerged bridge, enabling the citizens to get their feet wet[33] and providing a different sensory

[33] *Of course this is not always appropriate in every urban shorelines due to strong wave action, but in the calm waters of the Danish coast in East Jutland, Fyn and Zealand, this type of example is much more applicable.*

experience of the watery neighbour. This simple art installation highlights the paradigm shift of challenging the dry urban experience to include water in the design.

Figure 13. Oriental Bay Enhancement by Architecture Workshop in Wellington Harbour in New Zealand. People use this urban designed public space for contemplation and interaction with the sea. The design of the structure incorporated the transient nature of the tides through the use of steps, rock reefs and intertidal pools, allowing people to see and touch the marine lifeforms. Image credit: The photos were taken by the author in December 2019.

Figure 14: A temporary artistic installation called "On water" in Münster, Germany, by Ayşe Erkmen. A project in which people can experience and feel the various qualities of water (i.e. temperature and viscosity) by walking through the submerged bridge. A sensual way to connect the city separated by water by pedestrian access. Image Credit: Left image – Roman Mensing (Mensing, 2017), Right image – Gregory Volk (Volk, 2017)

10.4 Principle IV: Making the invisible visible

Seaweed as the visual, ecological symbol of coastal urban transformation

The fourth and final principle focuses on the importance of integrating seaweed (and other coastal ecosystems) in an accessible, tactile, sensuous and visually beautiful way. This approach means creatively exploring urban design solutions to integrate seaweed (and other coastal ecosystems) into the waterfront fabric to connect to the wider coastal city and its identity.

Thus, the fourth principle emphasises the importance of bringing the invisible and forgotten marine realm into the visible urban realm in light of sea-level rise. USS argues that seaweed can play a visual role as the representative symbol to highlight the importance of marine ecosystems in tackling global warming. Furthermore, "seascaping" (i.e. coastal landscape architecture) the urban shorelines with seaweed aims to celebrate its aesthetic and intrinsic value as an ecological symbol for positively rethinking urban

transformation. Therefore, to design a space that influences a future culture of becoming with the ecosystems of the sea means recognising and fostering the links and constant flux between environment, organisms, and land-use practices – both humans and more-than-human. Moreover, it means identifying and bringing forth the complex processes that tie together different species and systems. USS advocates going beyond human tendencies for territorial favouritism to extend solidarity towards the marine lifeforms by making them a key visible and integrated part of coastal cities. Thus, by turning our gaze not just on land but also below the water, we can start conceiving the invisible, visible (see Figure 15 of the typical seaweed growing in the Danish coastline).

Figure 15. Various seaweeds (macroalgae) are visible to the human eye from the coast in Elsehoved Beach, in Fyn, Denmark. The photo shows green seaweed called "Sea lettuce (Søsalat)" and brown seaweed called "Bladderwrack (blæretang)." The photo was taken by the author in July 2020.

11. CONCLUSION

We are edging closer and closer to the point of no return in our fight against anthropogenic climate change. The IPCC's latest report highlights the need for radical change and radical solutions to meet the necessary emissions reductions required to stay within a manageable temperature range. As the security of a sustainable global future is paramount, Urban Seascaping explores what it means to truly depart from business-as-usual practices, paradigms, and developments at the coast. What does it take to make significant changes needed without romanticising or reverting to the past? The future is one of creative possibilities to re-conceive, reorientate and re-design our relationship with the more-than-human agencies. Thus, Urban Seascaping seeks to contribute to a myriad of narratives currently at play in coastal adaptation.

Here are the key design principles, ethical propositions and coastal adaptation strategies that summarise what it means to Urban Seascape at our urban shorelines:

1) *Multispecies coexistence: Design our coastal cities not just for humans but also for cohabitation with the more-than-human.*

   - Proactive care, restoration and protection of coastal ecosystems are needed. For instance, reinstate the rock reefs back into the sea bed for marine lifeforms such as seaweed and deal with the sources of water pollution.
   - Plan for long term strategies that grow and adapt with time. For instance, design structures in the critical zone for inundation and adaptation at the coastal shorelines. These new structures need to be beneficial to marine life forms in material choice and design.
   - Initiatives must be coupled with local educational and socio-cultural practices that engage individuals and communities' lived experiences.

2) *Invite the agency of the rising sea into the coastal cities as the new meeting ground for multispecies coexistence.*

   - Identify high-risk areas in the future that can transform into new urban commons by inviting the agency of the rising sea and its marine life forms.
   - Acknowledge the agency of water as well as its intrinsic value – narratives and perspectives of water as a connector and a living entity. (for example, give water a legal representation – for better protection and restoration). Be wary of the dualistic view of nature-culture and be conscious of terrestrial bias to understand what it means to live with water in light of sea-level rise.

3) *Beyond walls: Shift our thinking of the coast from an edge to a zone.*

   - Depart from the current view of the water as a threat by going beyond the traditional defence-driven approach to coastal protection to include coastal ecosystems (nature-based solution). For instance, seaweed as a marine nature-based solution as the first line of defence against storm surges by dissipating the strength of the waves.
   - Assign a bigger area of focus (from an edge to a zone). Nature-based solutions require a much bigger area, and the marine world requires inter-relational systems thinking of space and boundaries.
   - The new commons need to understand the networks and processes from a holistic point of view that acknowledges the constant synergy between the urban and the sea.

4) Make the invisible visible: Explore the potentials of seaweed as the representative visual and ecological symbol for positively rethinking urban transformation.

   - There is a need for innovative coastal landscape architecture and coastal adaptation strategies that integrate marine lifeforms (seaweed) in a visible, tactile, accessible, restorative and beautiful manner. Therefore, integrate marine nature-based solutions in the new urban commons as a safe meeting place between urbanites and marine life, increasing their presence and awareness. Coastal ecosystems should be a key part of the future planning of coastal cities to ensure higher resilience to climate change and benefit from richer biodiversity.

These USS principles constitute an ethical call to the creative disciplines to derive new territories for action by giving more-than-human marine species a unified and equal foothold in the urban world. It is one way of envisioning alternative narratives and futures in the age of the Anthropocene; and a small contribution to an ongoing paradigm shift needed in urban shorelines to re-envision what it truly means to live not just by sea but *with* the sea.

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