The Blue Mussels Voice

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ABSTRACT

Globally, marine ecosystems are under pressure, losing species and ecosystem functions. On land – along the world's renewed waterfronts, humans have removed themselves from belonging to the sea. So far, the tendency in Norway is a development based on human interests. An alternative approach is to embrace the interests of other species, including the marine beings in multispecies cities.

Building multispecies cities demands a questioning of the relationships between nonhuman others and urbanscapes; Such as, what does it mean to include other-than-humans as participants in shared social worlds? Yet, is it worthwhile reaching out to organisms we cannot communicate with, and that most likely do not need our presence? How can we listen to critters other than us, and how can this make sense within urban development? In seeking answers to these questions, this essay is dedicated to one small and challenged creature – the blue mussel.

To reach an understanding of the urban tidalscapes, we must go beyond earth-bound senses. Possible interaction and care for blue mussels and other sea creatures, are explored through close one-on-one encounters with marine life, inspired by Rachel Carson's ethic of wonder. Moreover, in order to physically make space for life below water, a diversity-enhancing marine landscape architecture is proposed; a concept arising from artistic visions in exchange with marine biology, the tidal landscape and the sea creatures themselves.

KEYWORDS: multispecies urbanism, ethic of wonder, nature as mentor, a diversity-enhancing marine landscape architecture

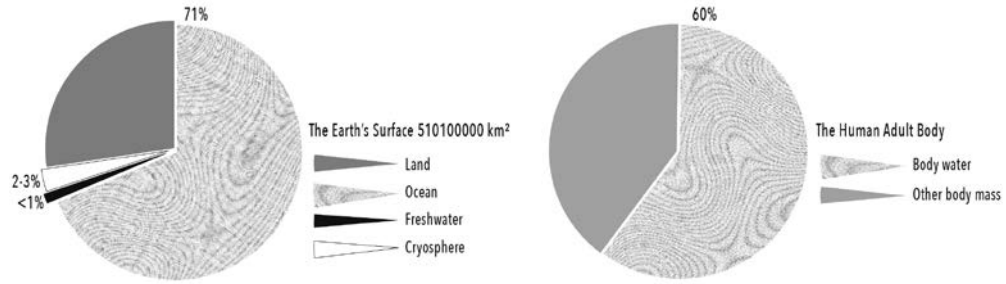
The sea washes the coasts – with the tides rising and falling from the gravitational interactions between the Sun, Moon, and Earth. Since the dawn of time, the tidal landscape has been a preferred place for human settlement and habitation – where the foundation for worldwide urban growth was laid. The World Ocean is an ecological zone of the greatest significance for all life on earth. Nothing less applies to the intertidal zone, where even fossil material shows us that the closer to the shore, the richer fossilized life[1].

The Ocean can also be fierce to humans and our built world. In the autumn of 2019, Hurricane Dorian led to severe coastal damage caused by strong winds, heavy rainfall and a storm surge. Thousands of homes in the Bahamas were demolished at an estimated cost of $7 billion.[2] As stated in the Washington Post: "Schools disappeared. Businesses floated away". On Abaco Island, journalists talked to a father who had

1 (Nystuen, professional dialogue, November 22, 2018)
2 (Fitz-Gibbon, 2019)

Blue mussels (*Mytilus edulis*) actively filtering seawater in Lysefjorden Norway, June 2007. Reprinted, by permission, from Tore Strohmeier, Institute of Marine Research in Norway.

sought refuge on a roof with his five-year-old son: "Then, the father said, came the unthinkable: a powerful gust of wind sent his son tumbling across the roof and into the murky water, where he watched him disappear amid floating debris".[3] This is one of many stories from deadly natural disasters. And for those of us who haven't had to endure such events it is incomprehensible. This image strongly contrasts with the soothing influence I long for and seek in the landscape I love most of all – the tidalscape. Still to me, the vast ocean space is obscure and mysterious, and the powers of nature are frightfully immense. The world's coasts are becoming increasingly urbanized, and in about a decade it is expected that 50 percent of the global population will live within 100 km of the coast, compared to today's 40 percent.[4]
Humans must find ways to resolve the global challenges in the populated urban blue.



Water is an inorganic, transparent, tasteless, odourless, and nearly colourless chemical substance. The brain and heart contain 73 percent of water, and the lungs about 83 percent. The skin contains only 64 percent, whilst muscles and kidneys 79 percent. Even the bones are watery, with 31 percent of their weight being water. The liquid surrounding human cells has about the same salt content as seawater (0.9%). Outside us, the World Ocean covers 71 percent of the Earth's surface, and contains 97 percent of the Earth's water and 99 percent of the living space on the planet. This space is fundamental to life on Earth in a multitude of ways, for example as a source of oxygen and food, and as a driver of our climate. Yet, to most of us, this watery world is as unknown as an alien planet. Diagram by Elin T. Sørensen © BONO 2020, based on information from the Hawaii Pacific University Oceanic Institute; the U.S. Geological Survey's (USGS) Water Science School; Store Medisinske Leksikon.

The Urban Blue

Along today's developed waterfronts, humans have removed themselves from belonging to the sea. *Shoreline hardening* is a term expressing the division between the marine environment and a human-centred urbanisation. When we create our functional and rational harbour and housing areas, the effect is that the natural shore is hardened and straightened. Hence, the qualities and ecological functions of the natural rocky shore are erased.
The latest Global Assessment on Biodiversity and Ecosystem Services tells us that we are rapidly losing species and ecosystem functions. Sixty-six percent of the marine environment is "severely altered", and seventy-five percent of the land. By human actions the very foundations of our economies, livelihoods, food security, health and

3 (Horton & Ward, 2019)
4 (Small & Nicholls, 2003)

quality of life is being eroded. Some of the threatened marine habitats are formed by kelp, rockweed and seagrasses, which create underwater forests and meadows; ecosystems of the same importance as the Amazon rainforest. Due to an overload of nutrients which causes ocean darkening, and ocean warming and overfishing, these are increasingly being overgrown and replaced by non-native species. Global warming and the artificial substrates that we put into the sea are some of the factors that increase the risk of invasions by alien species. As a result, native marine species become climate refugees.[5]

Like many of the world's harbours, the former industrial Port of Oslo has been transformed into residential neighbourhoods and recreational facilities. With the first redevelopment having started in the 1980s, the project entitled Fjord City is the biggest urban development in Norwegian history and one of the largest waterfront renewals in Europe. Nevertheless, within the Fjord City improvement-actions the urban blue has been forgotten. Divers and marine biologists tend to liken the hardened shore and altered seafloor to a desert – describing the urbanised marine environment as a harsh and stressed habitat; a condition classified in European natural resource management terms as a highly modified and disturbed water body.[6] By entering this hidden and neglected landscape, I myself have experienced the marine landscape as a void – as if there is nothing underneath. Nothing but a dim no-man's land. The condition raises several questions. Can this landscape possibly be amended – can anything at all be done? Do we have a responsibility to return the disturbed seafloor and shore land to a habitable place? If so, how to battle climate change driven by human activities, the overload of nutrients and invasive species choking the local undersea creatures? How can we build up a willingness to invest in an invisible world? In seeking answers and awareness concerning the urban blue, I dedicate this text to one small, common, yet challenged creature – the blue mussel.

Why should we care for and listen to a mussel? Of the sea dwellers, neither the blue mussel, toothed wrack or bladder wrack for that sake, is included in the official reports of *threatened species* in *Norway*. Like their human co-habitants, they are commoners along the coast. Nonetheless, the blue mussel is a key species in coastal ecosystems, contributing several important functions to the sea, and during the last few years, there has been concern about the decreasing abundance of the blue mussel in the coastal waters of southern Norway and western Sweden. The Institute of Marine Research is frequently contacted by concerned people who no longer find mussels in places where they used to. Furthermore, the Norwegian Institute for Water Research has problems gathering blue mussels in southern Norway for the purpose of monitoring contaminants in Norwegian waters. The declining stocks of mussels have raised concerns amongst the marine science community in Sweden too. Indeed, all over Europe, researchers observe that mussels have changed their life and settlement habits, and this is a process that has probably been going on for decades. One of the factors responsible for these changes could be warmer summer sea surface temperatures. Another, and often related factor, is that other organisms take

5 (Horton & Ward, 2019)
6 (Small & Nicholls, 2003)

over areas where the mussels were formerly settled. Yet, there are no clear answers.[7] Therefore, researchers have started to secure the future of the blue mussel and their efforts to re-create and restore mussel reefs show that it is possible to strengthen the stocks by technical solutions and human intervention.[8]

Mussels forming a mussel bed, tied together with strong silky threads.
maybe digital collage by Elin T. Sørensen © BONO 2019.

A Transformative Change

"In the Earth's wheel of life, the oceans provide the balance".[9] The Ocean is a common; waters connect the earth's populations, and humans depend on the ocean space as much as the kaleidoscope of life with which it churns.

Changes in the proportion of hard versus soft coastal habitats – as the natural, often sedimentary and more complex landscape features are replaced – has substantially altered the living conditions for marine species attached to coastal headlands. The biotic homogenization in the ocean space is comparable to the conspicuous deterioration of biological diversity because of urbanization on land. Regarding this, the term *ocean sprawl* addresses the proliferation of artificial structures in the sea: for example, offshore oil-rigs, wind power parks, harbours and coastal defences, aquaculture, artificial reefs, down to small buoys.[10] *Shoreline hardening* together with *ocean sprawl* are key concepts in understanding how human actions influence the blue commons. The message is that when we build something in the ocean or cover its surface, we change the environment and we take the place of somebody else.

Oslo's inner harbour has been subjected to gradual changes since people started settling the area. The extensive alterations of the shore and seafloor mainly result from the industrial development at the beginning of the 19th century and afterwards.[11] Today, the trend is to renew the industrial environments built into the sea.

7 (Mortensen, 2018)
8 (Liljenström, 2019)
9 (World Commission on Environment and Development, 1987)\
10 (Firth et al., 2016, p. 189)
11 (Oslo Havn, 2011, p. 36)

However, in most masterplans the sea is visualized as an opaque and concealing cover. Likewise, in the subsequent residential adverts, the sea appears as a glimmering surface accompanied by seductive wordings, as shown in the image below.
Field surveys along the urban sea areas of Fjord City and Oslo leave me with the impression that we have forgotten to re-scale the environment to fit human proportions and have disregarded marine creatures even more so. Often the seafloor has been excavated to make space for large cargo ships and become a landscape too deep to support photosynthesis dependent blue forests and seagrass meadows. Despite the longing and desire to live close to water, there is a knowledge gap and lack of awareness of the area between the land and sea.

The main attractions or hooks in the residential adverts tempting people to buy a property in the Fjord City are: "Do you love life by the fjord? Where the *smell* of the sea contributes to peace of mind in a busy, *everyday-life*". Photo by Elin T. Sørensen © BONO 2017.

The production of knowledge within this liminal realm clearly takes place in two separate worlds, where architects, landscape architects, gardeners and the building industry seem to be ocean illiterates. Compared to the long history of architecture and urban design examples of integrated practices where marine interests stand in the forefront are few. Even marine scientists show a lack of interest in the urban blue. As the urban ecosystem is so profoundly disturbed, this environment represents a lost cause. The tendency is not to account for the marine organisms, and the need for restoration of these habitats has so far been overlooked. Hence, the awakening of urban nature has not yet reached the sea.
As a hopeful 'bright-spot', the Global Assessment expert panel shares the optimistic view that nature can still be restored and used sustainably by means of *a transformative change* – that is also a key to meeting most other global goals. By this they suggest

a "fundamental, system-wide reorganization across technological, economic and social factors".[12] This is a wake-up call for the need to cross professional borders and join forces for a sustainable transformation of the urban blue. Urban planners, designers and marine scientists share the responsibility of restoring the marine landscape to a liveable place. Together we should take a fresh look upon this transitional space; envisioning a regaining of some of its richness.[13]
The above considerations are central to my doctoral study addressing Oslo's urban sea areas. Coastalscapes are evidently under pressure on a local and global scale, with biodiversity and human well-being at stake. Through the lens of landscape architecture, current practices for developing and treating the urban shore are explored. With the Inner Oslofjord as a fieldwork area, the study's overarching ambition is to re-establish the relationships between the land and the sea.

Multispecies Urbanism

Thom van Dooren and Deborah Bird Rose's consideration of the *multispecies city* supports the above reflections. Exploring the relationship between nonhuman others and urbanscapes, the two draw on the case of a small colony of little penguins (*Eudyptula minor*). These are small flightless seabirds inhabiting the headland of one of Sydney's busiest harbours – between the calm waters of the port and the waves of the Pacific Ocean. As part of the story we are told that these penguins connect to their hatching-spot with a high degree of "site fidelity". Another word for this is *philopatric*, literarily meaning "love of one's home". In biological terms, the phenomenon relates to how little penguins always return to their birthplace to lay eggs. The seabirds are inherently attached to a space which has been gradually altered by urbanization. Subsequently, some of the obstacles they must face in a fast-changing world are habitat loss due to development, disturbance by people such as noise, light and littering, as well as wild and domestic predators such as foxes and cats. This case is one example of the many species that must fit into human plans and spaces: Having to live in cities "on our terms, or not at all".[14] Through this, the authors present a critical view of the notion of inclusiveness, a debate that in their eyes mainly accounts for human diversity. Thus, Van Dooren & Rose call for a genuinely inclusive city – emerging from "the flourishing of as many different forms of life as possible"[15].
The concepts of the multispecies city and site fidelity changed the way I perceive a site. Suddenly, I became aware of other user groups – like the birds frequenting one of the places – again opening up new landscaping-approaches. We generally learn and know so little of nonhuman others. So, what is required to let as many different forms of life as possible flourish in the city? Looking at coexistence from a practical angle, the question I seek to find an answer to is what it really means to share space with other living beings – and how can we possibly treat them as active participants in shared social worlds?

12 (Díaz et al., 2019)
13 (Rinde & Sørensen, 2019)
14 (Van Dooren & Rose, 2012, pp. 5–10, 16)
15 (Van Dooren & Rose, 2012, p. 17)

The Community of Learners

The urbanised coastal ecosystem can probably not be restored completely to a natural state. Questions remain about how to change the current conditions to arrive at marine life friendly urbanscapes that allow the fullest potential for marine life. Changes that would benefit humans too. To break the ocean's glimmering surface, and go beyond idealising architectural narratives, the urban tidalscape is investigated by means of *explorative action research*. This is a method explained as cyclic by nature, revolving around planning, doing, seeking, and gathering. By reflection in action throughout the different phases, the researcher eventually develops a personal theory; arriving at instances of developing new knowledge as well as an emerging *community of learners*.[16]

To familiarise myself with marine life, the act of discovery started with knocking on the doors of marine biologists at the Norwegian Institute for Water Research. In order to find out how ideas such as caring for the Fjord and the possible reach for a multispecies city would be received by the planning community, I had to knock on the doors of property developers, contractors and municipality caseworkers as well. I even had to challenge my earth-bound senses by immersing myself below the surface of the sea. Over time a core learning-community has developed, consisting of me as the landscape researcher working ever more closely with a marine researcher, a project director for art and urban development, and a creative technologist. Moreover, in one of our sub-projects nearly twenty free divers took part a crowdsourced, observation and registration of the marine life in Oslo's inner harbour. Subsequently, new knowledge emerged from the responses and interactions with the landscape and people along two main trajectories.

The first trajectory is making space for the blue common by raising awareness. This is a seeding activity, aimed at opening people's minds on perspectives towards the unseen urban blue. This invisibility influences the way urban marine landscapes are treated. Henceforth, we need to go beneath the surface and include this world of the waters in our considerations. The linking of the marine and the planning communities is motivated from the desire to develop productive ways of co-creation and coexistence between urban forms and natural systems. This demands a shift from traditional human-centred urbanisation, and towards learning-by-doing across professional boundaries. To succeed, it is essential to establish a platform for shared understanding as well as a common language.

The second is to physically make space for life below the surface by articulating a marine landscape architecture; a concept arising from artistic visions in exchange with marine biology, the tidalscape and the sea creatures themselves. In seeking understanding of the architectural features of the tidalscape and for marine life, the research builds on 1:1 observation, microscope photography, and digital fabrication such as photogrammetry, 3D-visualisation and printing. The anticipated outcome is a way of building into the sea that is fundamentally different to the vertical sea walls and

16 (Øgrim & Johannesen, 2014)

the monotonous environments that typically form the urban edge; aimed at making shared housing with liveable structures connecting land dwellers with marine life.

To Sense the World of Waters

Obviously, this realm can only be fully grasped by going beyond earth-bound senses. One-on-one encounters with the tidalscape, at different times and seasons, has been essential to the understanding of this forgotten place. Through snorkelling, I have come to know a new world of life forms and colours. Like the yellows, greens and brown hues of sea wrack and the floating motion of the clear green leaves of the eelgrass. Beside miniature rock pools on the shore, I can linger for a long time to study their wonders: Housing the tiniest of crabs less than 5 millimetres in body size yet perfectly developed – moving sideways along the rocky walls encountering transparent shrimps along the way. Even more fascinating are the miniscule barnacles using their super thin fan-like feet, sweeping plankton and detritus from the water into their mouths. All together performing a mesmerising spectacle.

My desire to see the fjord from a nonhuman perspective arose after reading Rachel Carson's (1907–1964) *Undersea essay* from 1937. Her writings took my breath away, as I was literary submerged: "To sense this world of waters known to the creatures of the sea we must shed our human perceptions of length and breadth and time and place and enter vicariously into a universe of all-pervading water".[17] This quote exemplifies Carson's excellence in bridging poetic speech with biological facts. Not surprisingly, *Undersea* is acknowledged as a pioneer-work in how, in this case, a marine biologist invites the reader to explore the World Ocean from the position of the many creatures with which we share this environment. Much in the same way *Silent Spring* (1962) voiced a roaring silence: An observed silence in nature, resulting from the use of modern pesticides – not only affected the targeted species, but biodiversity at large. Carson made people see nature from new viewpoints, and, thus, is one of the originators of ecological concerns in the 20th century.[18] In honouring her communicative skills, Margaret Atwood highlights her ability to explain science to ordinary readers in a straightforward way. Carson's love of the natural world "shines through everything she wrote", and "if you don't love a thing you won't save it" Atwood continues, pointing to empathy as an agent in developing a desire to safeguard and protect.[19] This is right in line with Carson's *ethic of wonder* that formed the basis of her ecological philosophy that she began articulating a couple of years after writing *Undersea*; an ethic which pushes our awareness towards what lies beyond ourselves, and encourages us to become receptive to the idea that we all are "linked to a vast ecological community inherently worth preserving and protecting from depletion".[20]

Undoubtedly, it is hard to grasp how, for instance, a blue mussel may be included in our world. Would it be worthwhile reaching out to an organism that we cannot

17 (Carson, 1937, p. 322)
18 (McKie, 2012)
19 (Atwood, 2012)
20 (Stitt, 2019)

talk to – and that most likely does not need our presence. With *wonder* and engaged interest we may learn to share the environment despite our differences. And to get a bit closer, it is time to familiarise ourselves with the blue mussel.

A Common Blue Mussel Spurring Imagination

One key source of inspiration for my artistic and landscape practices is delving into the realm of biology. There each specimen or phenomenon has its own astonishing story. From a myriad of possibilities, I have chosen one important inhabitant of the urban blue – the blue mussel. Blue mussels are locals in the Oslofjord, amongst others, cleaning the water to the benefit of humans and other marine neighbours. So, I will start sharing my fascination by revealing some mussel facts. *Mytilus edulis*, from Linnaeus 1758, is the common blue mussel's binomial name. In Latin *mytilus* means a sea mussel, and *edulis* commonly refers to edible plants and animals.

The Blue Mussel's Life

Blue mussels usually permanently attach themselves on rocky shores, where they can live for 18–24 years in depths varying from one to twenty meters. The animal is extraordinarily adaptable, and may withstand wide environmental fluctuations in salinity, thermal conditions, dry conditions and more.

Blue mussels have their most mobile phase during the drifting larval stage, and this time between becoming a free-swimmer and an adult lasts nearly two months. From the moment the fertilized egg metamorphoses to a free-swimming larva, it develops fan-like protrusions lining its skin – and with these the mussel filter-feeds.[21] We can only imagine the beauty of these minute hair-like organs beating rhythmically to the waves. Yet, living freely in the water column implies a risky journey, and they suffer the highest mortality rates in this period.

As a youngster, less than two centimetres in length, the mussel starts spinning its elastic silky filaments or byssus threads, shown in the illustration. These threads help the shell to stay on the floor, thus affording an effective mooring which also yields to wave energy. For example, in a situation of wave-stress, mussels may orient and re-arrange the position of their byssus in compliance to tension and load to where the most pull is experienced. These strands may stretch to 160 percent of the shell length yet retain five times the strength of the human Achilles' tendon. It is even more fascinating to learn that when the youngsters get an impulse to move, they use their byssus' as climbing ropes – extending, attaching and pulling forward across a surface.[22]

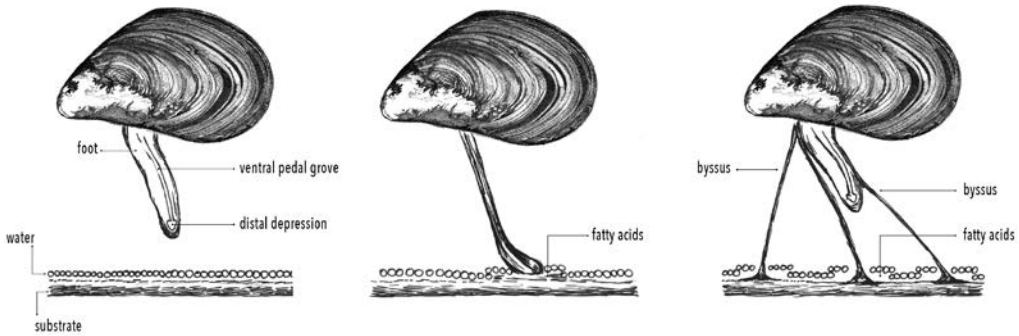
A blue mussel 'teenage-crib' is often found in small rock cavities, within threadlike, filamentous nets or among other aquatic invertebrate animals such as the Bryozoans. Presumably, due to competition, the young tend to place themselves away from

21 (Zagata et al., 2008)
22 (Brentner, 2002; Havforskningsinstituttet, 2019; Zagata et al., 2008)

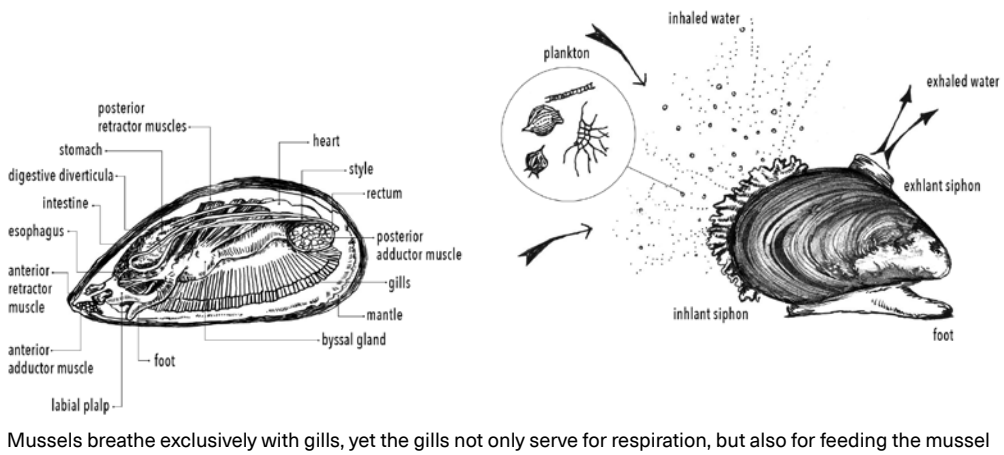
adults. The juveniles stay in one place for three weeks, and double in size, before setting themselves adrift to seek a permanent home. From the moment of settling, the mussel grows to full body-size, ranging from two to twenty centimetres, with an average of about seven. If there is a lack of firm ground, the mussels join together to form mussel beds. If knocked out of position, they can always regenerate new mooring-threads and reattach themselves. Besides, the threads function as a defence-mechanism to capture attacking molluscs. Other enemies to the mussels are starfish, crabs and snails, which limit their inhabitation of the low intertidal zone. Likewise, they are popular amongst larger marine species and seabirds – not forgetting humans. As ecological function areas, mussel-colonies bear a likeness to inclusive neighbourhoods as they are attractive to other organisms; Their shells are the building ground for encrusting algae, and the gap between the valves gives shelter to many other miniscule creatures. Mussel beds function as natural erosion control by trapping sediments and accelerating sedimentation. What is more, their irregular, flexible structure acts as a natural wave attenuator and slows down water flow. In some areas, a colony may house several thousand mussels per square meter. Blue mussel reefs are comparable to rainforests on land, and kelp forests and eelgrass meadows in the sea with respect to production rate, and all are recognized amongst the most productive natural systems on the planet.[23]

Mussels are grazers, like cows and sheep on land, and feed on the greenery of the ocean, living on a diet composed of phytoplankton, dinoflagellates, small diatoms, zoospores, various unicellular algae, bacteria and dead organic matter. When feeding, the mussel opens its protective shells to let its gills collect nutrients from the water column with small, moving hairs passing particles to its mouth. The greater the angle a shell gapes, the larger amount of water flows through the mussel, and a higher quantity of matter is extracted. On average, an adult mussel filters over a hundred litres of water a day, with up to five litres of water going through every hour before filtered water is pumped out through the exhalation opening. The blue mussels are ocean cleaners. Researchers have discovered that the mussels along the Norwegian coast are the fastest of filter-feeders. During a single day, they may clean a quantity of water corresponding to a well-filled bathtub.[24] The purifying-capacity is recognized to the extent that there exist off-the-shelf mussel-systems for water treatment and monitoring. Due to their cleaning abilities and subsequent storing of environmental toxins, the Norwegian Institute for Water Research, regularly collect mussels as part of monitoring-programs along the coast and on oil platforms. Encrusters and reef-builders such as mussels, cannot escape and must endure the environment in which they settle. This is a practical trait to the researchers: As the communities change if exposed to toxins or disruptions, their fixed position turns them into reliable monitoring-units. Eventually, the most sensitive species are lost, whilst the more robust remain.[25]

23 (Brentner, 2002; Christie et al., 2005; Havforskningsinstituttet, 2019)
24 (Havforskningsinstituttet, 2019; Robson et al., 2010; Zagata et al., 2008)
25 (Rinde, professional dialogue, April 2019)



Schematic drawings of the process of the mussel's thread formation on a hard surface



Mussels breathe exclusively with gills, yet the gills not only serve for respiration, but also for feeding the mussel (below, left). Gross anatomy of a blue mussel (below, right). Drawings/collage by Elin T. Sørensen © BONO 2020, based on Yunhong et al. 2018, p. 7152; http://respirationcbb.weebly.com/blue-mussels.html

The Blue Pastures

Mussel-farming represents highly sustainable food production. No manufactured animal feed or medication is required, as the shells feed on algae at the base of the food chain – and after one to two years, the mussels reach a marketable size. Mussel harvesting has a long history. Shell debris has been discovered in kitchen middens 10,000 years back in time, at the dawn of agriculture in the "New Stone Age". From then on, the mussel was picked from wild beds along the European coasts, utilized as food, fish bait and soil-fertilizer. Later, mussel-aquaculture was established for the sake of storage and to deliver reliable fishery products. Despite this, aqua-farming development often resulted in overfishing the natural beds, creating a need to overcome crashed populations. One innovation, dating back to the 13th century, was the French intertidal wooden-pole culture named "bouchots". During the 19th century this design-intervention spread along the entire French-Atlantic coastline, whilst in Northern Europe, a subtidal culture with bottom culture plots emerged. At the turn of the 1970s, new technological developments with a suspended longline rope culture streamlined the mussel-industry, with the keeping of wild beds for the supply of juveniles.

The blue mussel is a real cosmopolitan, thriving in most of the world's biogeographic regions. This has led to the introduction of blue mussels outside its native habitat, that together with technology transfer has expanded its cultivation. Today, China has become the world's largest producer. In Europe, Spain is in the lead, even though the potential of Norwegian waters is the greatest in Europe in terms of production. Still, some significant challenges need to be considered before Norwegian mussel-cultivation becomes economically sustainable.[26]

The Blue Mussle – a "technical" Genius

"My dream is to create – with the help of what we learn from byssus threads – self-healing materials in an environmentally friendly process that have similar physical properties..." Dr. Matt Harrington, Max Planck Institute of Colloids and Interfaces[27]
Byssal threads have caused excitement among material scientists. The mussel's silky filaments are produced in the mollusc's foot, from which the attachment fibres are spun within a fine groove. At the end of each thread is a small adhesive disc that allows the mussel to cling to hard surfaces, considered an unparalleled ability to adhere to structures undersea. Now, researchers at the Max Planck Institute, have found that these attachment-fibres stick to a surface better than any synthetic underwater glue. The study shows that many steps in the spinning-process are autonomous, without any active involvement from the mussel. This may reveal new insights on the technicalities of the assembly of polymers into more complex structures: "The biopolymer that forms the core of the thread is extremely tough and also heals itself when damaged. The cuticle of the thread is as hard as the epoxide resin used to manufacture printed circuit boards but is still highly extensible."[28] Their study promotes the blue mussel as a potential guide for developing advanced materials of biomedical and industrial relevance, for example, an environmentally friendly production of bioplastics based on biogenic high-performance polymers.

A Mussel Choir

Could art help us to come closer to mussel-ness? This is the intention behind the MUSSELxCHOIR, where other species' expressions are investigated artistically for the sake of co-creating a better future. In short, this artwork merges biological life and sound technology to convey new meaning. A choral society of mussels has performed at the Venice Architectural Biennale, in galleries and outdoors in Melbourne and New York, orchestrated by Natalie Jeremijenko, whose background includes studies in fine arts, biochemistry, physics, neuroscience and precision engineering.
As mentioned above, the blue mussels clean water and their physical responses indicate water quality, as they literally "shut-up" if exposed to a certain degree of pollution. To capture this, Jeremijenko instrumented the shells with sensors to collect data on the gap angles as the creatures open and close their valves. This

26 (Goulletquer, 2004; Havforskningsinstituttet, 2019)
27 (Max Planck Society, 2017, p. 3)
28 (Max Planck Society, 2017, p. 1)

data was converted into sound signals before eventually being refined into the mussel-recordings. The composition was further elaborated by making the pitch correspond to the depths in the water column where the mussels had settled. Finally, the tonalities were programmed to play a version of the tune "Daisy Bell (Bicycle Built for Two)".

To offer a bit of context, the 1892 pop-song "Daisy Bell" is an early example of a song that was recreated by speech synthesis or the artificial production of human speech. As a fun fact, this song was performed by HAL 9000, who is the spacecraft computer with machine intelligence in the seminal Stanley Kubrick sci-fi film "2001: A Space Odyssey" from 1968.[29] In my interpretation, Jeremijenko's artistic thinking adds new layers of context and understanding to scientific data-collection methods. Moreover, she enables us to listen to creatures normally unheard. The artist plays with technology, such as scientific instrumental precision analysis and the notion of artificial intelligence. However, concepts such as *intelligence* and *precision* are carried over to the natural world. In this way, the artist builds awareness of the capacity of mussels, and their potential role as active participants in our world. According to her, statistics shown in a graphical data representation provide insufficient readings of dynamic, complex, unpredictable urban ecosystems. In comparison, mussels perform with a legibility and honesty that embody far broader ranges than instrumental readings – by example a pH-sample. In general, the artist argues, the responses of nonhumans can help us understand the environment in ways unknown to us, and even more exactly than scientific recordings. As Jeremijenko puts it, "mussels have a higher standard of evidence, a higher literacy, and they're integrating over many more parameters".[30]

The artwork inspires critical thinking towards our relationship with nature by pointing at the wisdom, if we may say so, inherent in ecosystems – understood as the "complex of living organisms, their physical environment, and all their interrelationships in a particular unit of space".[31] Unarguable, Humankind is part of this complex but, regrettably, this perspective is neither particularly debated nor visible within the field of urban planning and design, and in the way the urban edge meets the sea.

Jeremijenko's choral society of mussels is part of an overarching art project called *Unshoreline*. The title resounds with the aforementioned concept of *shoreline hardening* – expressing the division between marine environments and urbanisation and, thus, the removal from the rocky shore of qualities and its inherent ecological functions.

I read the *Unshoreline* artwork to critically comment upon natural systems versus human-made environments. By reflecting upon the work-context, Jeremijenko states that all the cities' inhabitants bear the risk of how the public infrastructure is created. As large-scale infrastructure systems run on correspondingly large budgets, the design directly affects the public purse. Thus, urban renewal is a hugely public

29 (Hannah, 2017)
30 (Hannah, 2017, pp. 207–209, 211–212)
31 (Encyclopædia Britannica, 2019)

issue, and at the same time represents a socialized risk. On the other hand, large-scale constructions, such as sea walls, are built to protect the citizens from natural forces. Unlike hard-edge sea walls, the multifunctional mussel beds absorb energy in the water masses. Hence, Jeremijenko posed the rhetorical question of whether man-built seawalls improve water quality or add any other environmental benefits. In her imagination, these neighbourhoods of the blue form adaptable "mega-metropolises". Metropolis being a precise analogy, as mussel reefs may house thousands of individuals, sometimes representing dozens of species all living in one place.

Jeremijenko suggests that designing with natural systems is neither part of the traditional engineering companies' mind-set nor competence portfolio. To be explicit about who benefits from the environments we design, and to make sure there actually is a shared benefit is as a huge political responsibility. The artist claims there is a lack of recognition towards the paradigm shift that acknowledges that we cannot design with force and mass. As she put it, "we have to design with buoyancy and tension, with living systems".[32] This corresponds to findings presented in the *Sinking Cities* TV-documentary, which shared insights on how five global cities are coming to grips with the effects of extreme weather and rising seas. To mitigate these challenges, there is unanimous agreement upon infrastructure and engineering that are adaptive, encouraging the development of flexible building structures that yield rather than resist nature forces.[33]

To share existence with the mussel, or any organism that is very different from us, one must invest in understanding the creature's responses to the environment. Regarding the participation of nonhuman others in urban planning, we can ask to what degree Jeremijenko's artwork brings us further. She clearly builds on knowledge that is recognized within the marine research community, where mussels already participate in monitoring-programs to reveal environmental pollution. Nonetheless, Jeremijenko's choral society of mussels exemplifies how artistic actions may offer new ways of gathering and disseminating knowledge. The artist invites people to get to know the mussels as responsive organisms which we stand with in a mutual relationship, thus opening the minds of the larger audience to what it could mean to invite mussels into our lives, and inspiring a *multi-voiced literacy*.

The philosopher Mikhail Bakhtin (1895–1975) writes about a *dialogic imagination* coming to life as a "many-voiced" expression. During the *event of exchange*, the different voices combine, resulting in a dialogic sense of truth. The word "event" was important to Bakhtin. In Russian the root of this word relates to "existence" or "being". In a more literal form, it can be interpreted as "shared existence or being with another".[34] By this perspective, any understanding occurs through responses, and through listening and speaking. In this way, various points of view, conceptual horizons, and different social "languages" come to interact with one another within a living context of exchange.[35] A dialogic imagination might be a tool we can use to

32 (Hannah, 2017, pp. 202, 207, 213–214, 216)
33 (Cineflix (Cities) Inc. in association with THIRTEEN Productions, 2018)
34 (Bakhtin, 1963/1984, p. 6)
35 (Bakhtin, 1982; Bakhtin, 1986; Irvine, 2004)

include different life forms in our world, and thus a strategy relevant to place-making between the land and sea. In campaigning for the creation of better housing standards for others, the recognition of, for instance, the mussel's far-reaching abilities is an obvious asset. For example, to help us come closer to nature, Jeremijenko suggests setting up situations from which we can read the signs of (wild)life in the urbanscape; a proposal directly related to the inclusion of nonhumans as participants in designing our environmental commons.[36]

Additional perspectives on dialogic imaginings across mental, cultural and physical borders are offered in the anthology *Tidalectics – imagining an oceanic worldview through art and science*. Here, the tidal landscape is brought forth as a contact-zone analogous to "social spaces where cultures meet, clash, and grapple with each other."[37] As coastal landscapes enable exchanges between ecosystems, as well as mentalities and fields of knowledge – they are places from which new knowledge grows. Against this fluid backdrop, artistic practices are thought to produce a much-needed porosity, wherein different views can inform one another and co-exist.[38] In contrast to the interchanging coastal ecotones, disciplinary divisions are compared to the artificial lines of i.e. national boundaries. The traditional divisions between professions often block the exchange of information and the development of common understanding between people. To go beyond this, art is proposed as an arena where people can form new ties. Stefanie Hessler, the anthology editor, suggests that the artistic drive towards entering the unknown and testing boundaries can inspire an "*undisciplined*" mindset much needed for real interaction to take place.[39]

Undisciplined Co-creation

Whilst Jeremijenko's *unshoreline* refers to removal from nature, I understand *undisciplined*, to stand for letting go of disciplinary assumptions, know-it-all, and siloed mentalities – all standing in the way for productive co-creation. A deep professional collaboration requires the ability to set oneself aside and to be receptive to the other – that is making space for otherness. Hence, these *un*-words encircle the work I stand amidst, seeking to bridge architecture and biology for enhancing urban hardscapes for the pleasure of people as well as marine creatures.

Stepping into the realms of others can be accomplished by changing from the position of operating as an expert to becoming a beginner with respect to the question at hand. This in turn, requires patience and trust – and ultimately, the acceptance of results that none of the participants may have predicted. Thus, all parties must give up their preconceived notions along the way. During my action research process, it has become clear to me that deeper professional understandings come from producing knowledge together – over time. By sharing experiences while thinking and doing together, the co-creators become familiar with each other's ways of

36 (Hannah, 2017, p. 217)
37 (Pratt, 1991, p. 33)
38 (Von Habsburg, 2018, p. 8)
39 (Hessler, 2018, p. 32)

working and thus develop experiential ties that may eventually become a professional friendship. Here, the nuance added by 'friendship' opens up responsiveness and interdependencies.

Designing together is essentially different to what is still a common practice within the planning community, wherein each field delivers separate contributions in accordance with urban planning checklists. Within *undisciplined co-creation* the parts need to *un-learn* in order to build new *collaborative* knowledge. Yet, in the hasty world of urban development, to dissolve divisions and wait for people to loosen up to undisciplined co-work may be a utopian dream; even more so to include mussels as equal participants in the planning processes. Nevertheless, from undisciplined co-creation new conceptual horizons may arise, which at best can lead to innovation.

Being with Nonhuman Others

The activation of nature in urban development **is** clearly linked to making space for nonhuman others. Yet, how likely is it for us to include nonhuman others on the participant-list in decision-making processes, and to take the trouble to see the world from, for example, a blue mussel's perspective? There is a fair chance that such propositions would be perceived as naïve, and even silly. In the words of botanist Martin Spray, "If some or all of this seems silly, that is partly because we have placed *H. sapiens* at the head of Life's procession".[40] Only with an ethical paradigm shift in favour of all other living creatures will humans step down from this pedestal. As an option, Van Dooren & Rose suggest an *ethics of conviviality* (friendliness), putting the "burden back on humans".[41] To me this would imply being generous towards nonhuman others in planning and transforming our built environment. Technical inventions have enabled humans to perform the work of giants. Our footprints from making our way in landscapes through actions such as tunnel-blasting works, oil drilling and resources extraction are highly visible, and have fundamentally changed landscapes globally, even touching upon the Earth's atmospheric and climate system. Should we not turn our superpowers in the opposite direction, towards reclaiming and cultivating the ecological functions and qualities that are run-down or lost?

A keen communicator arguing nature's case was philosopher Arne Næss (1912–2009). In one of his last books, he suggested *ecosophy* as a comprehensive way of looking at the ecological crisis. Næss had already introduced these ideas in the autumn of 1972, in a lecture given at the 3rd World Future Research Conference in Bucharest. Regarding a multi-voiced *literacy*, Næss argues that ecologists are irreplaceable informants for policymaking and thus change. However, to him ecology is a "*limited* science which make *use* of scientific methods". He questions the belief in science as a value-free zone by proposing a wider perspective: With *ecosophy*, ecology is united with a kind of *sofia – wisdom*[42] containing both norms, rules, value priorities and

40 (Spray, 2019)
41 (Van Dooren & Rose, 2012, p. 19)
42 *Sofia* is the Greek word for wisdom, whilst the prefix eco- refers to the Greek *oikos*, that may translate to household in the sense of being the basis for life on earth.

hypotheses on the state of affairs in the broader universe: "Wisdom is policy wisdom, prescription, not only scientific description and prediction".[43] Næss suggests that such *ecological teams*, composed of scientists from varied disciplines, students and policymakers, would act as caretakers of this worldview. These ecophilosophical practitioners would supposedly act wisely with respect to life on Earth – beyond a strict reliance on scientific facts or truths.

In 1984, Næss and Georg Sessions defined eight principles which express the characteristics of the *deep ecology movement*. Regarding the above reflections, the third principle is of relevance; it states that "Except to satisfy basic needs, mankind does not have the right to reduce this diversity and this richness". By accepting that nature has intrinsic value the last principle points to a responsibility "for trying to contribute directly or indirectly to the realization of the necessary changes".[44] Stating that the deep ecology movement consist of as many "ecosophies as there are supporters"[45], they emphasise the importance of including a variety of views and voices. Actions as a companion to nature must grow from a value base that is adapted to individual capacity – but these together will form a multitude of responsible acts. By this, an ethical foundation for being with nonhuman others will be expressed.

It remains to be seen if we ever can escape from the human standpoint. This debate is seemingly on a gradient from human centeredness to a willingness to see and include nonhuman interests. Næss contributed to positioning nature as "a mentor, measure, and a partner rather than servant".[46] His approach corresponds to Carson's *ethic of wonder* and Van Dooren & Rose' *ethics of friendliness*. All see nature as a partner rather than a provider of useful services. Nevertheless, over the last decade, the concept of *nature services* has become widely accepted within urban planning and management. As an example, the Economics of Ecosystems and Biodiversity (TEEB) was initiated in 2007, as a global initiative focused on drawing attention to the economic benefits of biodiversity and ecosystems as well as the costs of biodiversity loss and ecosystem degradation. From this outlook, urban nature is promoted as being helpful and beneficial to humans. For example, a mature tree has many affordances: Within its root, interactions with soil enhancing microorganisms goes on, and additionally, the roots behave as a natural erosion control. Its trunk and canopy houses song birds and pollinating insects. The foliage gives shade, and trees may have a spiritual standing. As posted by the Norwegian Institute for Nature Research, "The concept of Ecosystem Services provides us with a new tool to communicate the value of nature, putting nature into a perspective based on human needs".[47] Biodiversity is made visible because to ignore it is inefficient, or because there is even the danger that the natural capital might be ruined. From my professional experience, I acknowledge *ecosystem services* as an argumentation-tool which has paved the way for a willingness to invest in *nature-based solutions*. Yet, services are the work of servants. Is it not time to move beyond this perception of nature?

43 (Næss, 1972, p. 99)
44 (Næss, 2002, pp. 108–109)
45 (Næss, 2002, p. 101)
46 (Glasser, 2002, p. xxvi)
47 (Norwegian Institute for Nature Research, 2019)

Tidalscape Actions

The Fjord has several important nature values[48], and as we have seen, marine plants and organisms play important roles in adding to this. To answer the question of whether we have the *responsibility* to return the disturbed seafloor and urban shoreline to a habitable place for all, it is productive to view nature as a mentor and a partner.

A longing amongst people for new courses is seemingly rising. Yet, longing for new directions is not enough. Change requires action. Arne Næss present a good personal example of this as he was an environmental activist and was the first chairperson of Greenpeace Norway when it was founded in 1988.[49] Both Carson and Næss stand out as guides leading us towards a knowledge-based dissemination where compassion for the environment emerges from close identification with, and feeling for, all life forms. Carson's marine fieldwork observations lay the basis for her emphatic and vivid wildlife accounts. Similarly, in Næss' lecture from 1972, the importance of engaging in close encounters with the environment is highlighted: "The ecological field-worker acquires a deep-seated respect, or even veneration, for ways and forms of life. […] To the ecological field-worker, *the equal right to live and blossom* is an intuitively clear and obvious value axiom".[50] A statement reinforced by Næss being an advanced mountaineer, exposing himself to a high degree of interaction with landscapes. Climbing, in a sense, happens as a teamwork between the senses, the vertical rocky walls and gravitational forces – requiring great awareness. Thus, the climber literary participates in a two-way communication with nature.

In my own participation with the marine landscape, my research is spurred by an urge to possibly influence people's mindset as well as the physical appearance of the urban foreshore. Stepping out of my comfort zone and indulging in *wonder as a state of mind*, snorkelling allowed me to be within this fluid world; discovering hitherto unfamiliar shapes, colours and ways of being. Further, by placing various building materials in the sea, I have been able to study how sea wrack develop from tiny spores, to more complex sea plants. I have seen minuscule crabs, barnacles and shells as small as sand grains grow and develop. Thus, I have cultivated a deeper understanding of the blue realm through multisensory observations – which have fundamentally changed my perception and fostered a desire to care for marine environments and creatures.

To achieve acceptance for *nature as an equal partner* and to change the urban development-culture, requires persuasive campaigners. But, before becoming a trustworthy advocate, one must start with becoming aware of and receptive to the often-overlooked wonders and rhythms of the natural world. What kind of neighbourhood and landscape do they need? Through my explorative action research, I have been able to examine these aspects in cross-disciplinary engagements. The first one concerned recommendations for the establishment of new marine landscapes in Bærum,

48 (Chen et al., 2019)
49 (Greenpeace Norway, 2009)
50 (Næss, 1972, pp. 95–96)

a municipality neighbouring Oslo. The second discussed possible restoration actions to strengthen the biological diversity of Oslo's urban sea areas and the Fjord City.[51] The third realized an *undisciplined* co-creation between marine biologist Eli Rinde and myself, through several workshops at a local porcelain factory. In this work we upscaled industrial wreckage products to new marine housing.

Multispecies Housing

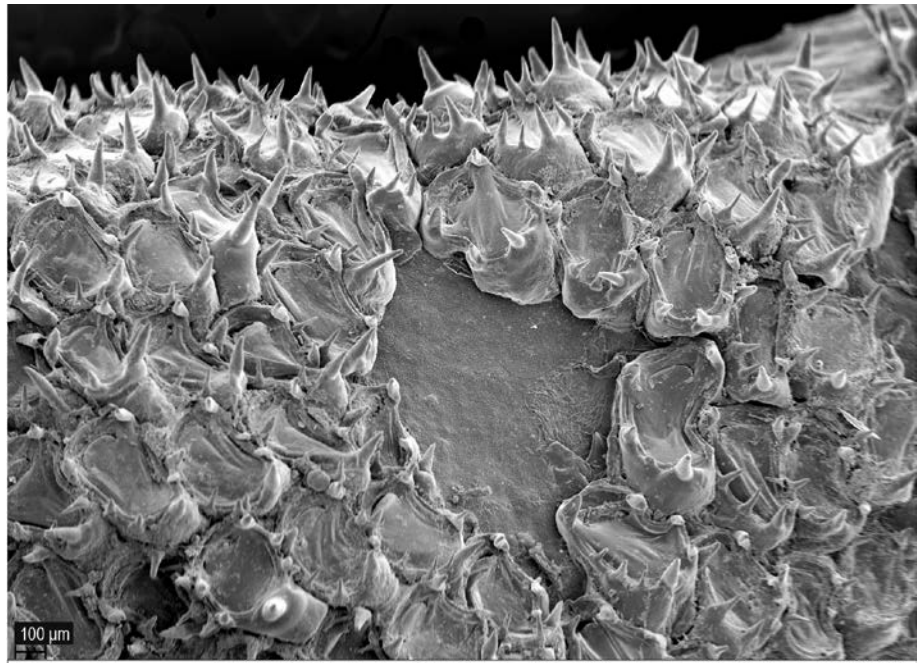
Through the aforementioned co-creation-processes, we have articulated a common language for restoring the urban tidalscape, such as a *diversity-enhancing reparation of developed shoreline* and a *diversity-enhancing marine landscape architecture*.
The current extent of using smooth surfaces, straight walls and floor, providing few opportunities for plants and animals to settle, is striking. Additionally, it is highly likely that the light levels reaching the floor will be too low for any algae to grow and thrive. This is illustrated in the figure below, where the co-workers stand on the artificial concrete seafloor of a new building complex in the Fjord City.
As a landscape architect pursuing a *diversity-enhancing marine landscape architecture*, I fall short due to a lack of knowledge regarding all the user groups. In the case of submerged structures, they would be marine plants and animals together with the

The team of marine biologists, the property developer, and the landscape architect at the building-site of the new urban quarter in Bispevika Oslo. Photo by Elin T. Sørensen © BONO 2018

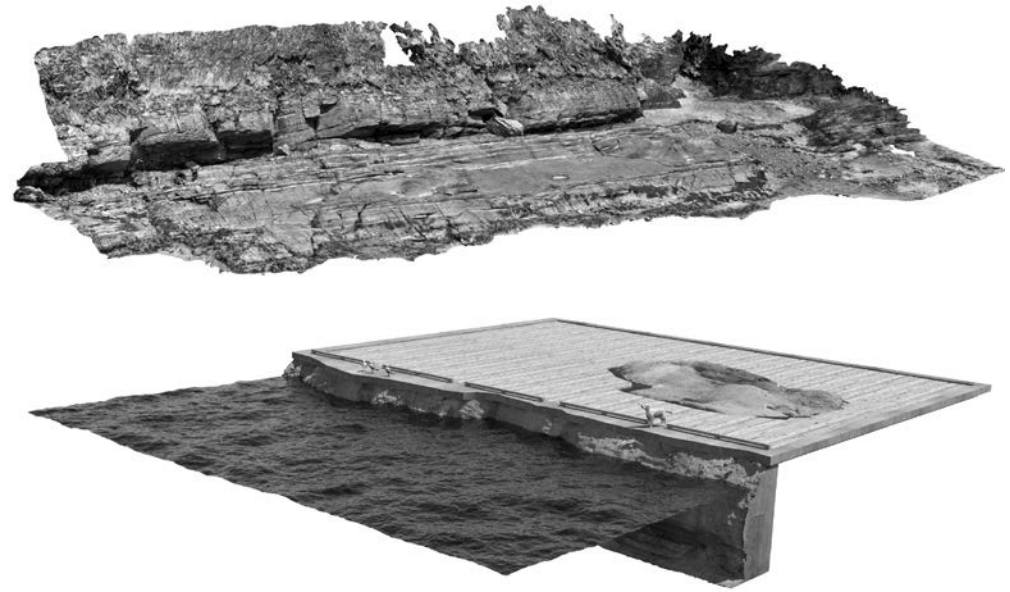
51 (Rinde, Sørensen & Haraldsen 2019; Rinde et al., 2019)

tidalscape features. Here we find a boundless diversity, from small sheltered niches to open spaces exposed to wind and waves. These are qualities and ecological functions spanning from micrometres to kilometres in scale. Marine organisms need folds, cracks and crevices to establish their communities. They opt for irregular surfaces and complex structures. In a review of worldwide ecological engineering measures applied to urban infrastructure, the researchers found that species responding most positively were those whose "body size most closely matched the dimensions of the resulting intervention".[52] Why not create such miniature worlds for marine life onto our built environment? Here the natural rocky shore can teach us a lot about spatial wellbeing factors that are important both to humans and marine organisms. For new designs between land and sea the natural rocky shore is our best mentor and that is why I see the landscape as the true architect.[53]
Humans and marine organisms are non-comparable, yet we share some common needs. Daylight is a key issue within architecture, and light is similarly essential to most marine life. Hence, we all need the benefits arising from forming good neighbourhoods and community living. Also, we have different needs through our life cycle. Along the natural rocky shore, each sea creature seems to have its own specialized way to withstand natural forces, such as seeking appropriate shelters for warding off predators from above and below, and in finding places that keep the creature moist and protect it from drying out, and in breathing within air pockets found in the cracks and crevices of the rocky shore. Hence, the natural shoreline provides creatures with a spatial layout and functionality with similarities to human shelters. Moreover, plants and some animals act as habitat forming species, creating and modifying their own environment. In my imagination, the layered world of kelp forests and seagrass communities resemble productive *residential neighbourhoods*. In the marine world, you find hosts facilitating a great diversity of inhabitants. Here, the plants' stems and leaves, as well as the blue mussel colonies, form three dimensional structures: An "Architecture" influencing currents, creating shelters and functioning as the local food supplier. In this sense, these habitat-forming species afford an undersea lifetime home standard with shelters, nurseries, and a graveyard kept clean by bottom dwelling scavengers. As living-complexes they comprise an interplay between form, function and diversity. Thus, I see them functioning as an all-in-one system from which to draw constructive inspiration.
The creation of a *diversity-enhancing marine landscape architecture* builds upon digital fabrication. For example, photogrammetry is the technique of taking multiple overlapping photographs and from them creating 3D models of objects or scenes. The 3D-models enable large-scale manufacturing, such as large-scale additive manufacturing of three-dimensional objects by means of, for example, extruded cement-based mortar. In this case, close-range photogrammetry is used to record local geological features, and thus enable the transfer of physical features of the natural rocky shore. An example of structural adaption are artefacts with features based upon local geotopes and marine nature types such as *rock pools*. Textural examples may be the

52 (Firth et al., 2016, p. 225; Strain et al., 2018, p. 426)
53 (Rinde & Sørensen, 2019)



Above: In the wild, the individual Bryozoans are minuscule. They join in colonies on rocks, seaweeds and on other sea creatures. Within each colony they live in numerous tiny houses, made from self-produced calcium carbonate. The individual Bryozoan's dwellings are only a few millimetres high, yet they can spread out in metropolises of a whole metre. In the colony they have different tasks. The chefs cook, the doctors are responsible for the children's health and upbringing. They even have their own army guarding the colony. Like mussels and other filter feeders, bryozoans gradually cleanse the water as they feed. Scanning electron microscope (SEM) image shot at the Imaging Centre NMBU, by Lene Cecilie Hermansen & Elin T. Sørensen © BONO 2020
Below: An example of diversity-enhancing marine landscape architecture for the Bispevika quarter, with a light-penetrating surface inspired by Bryozoa-colonies. The model also has a habitat-enhancement landscape element on the artificial seafloor, however this is not visible in this rendering. Concept Elin T. Sørensen, marine guidance Eli Rinde, and 3D-visualisation by Ivar Kjellmo. Kjellmo/Sørensen © BONO 2020



Above: A photogrammetry model with 1911 of 1930 aligned images of a Cambric-Silurian tidalscape at Hovedøya, an isle off the Inner Oslofjord. Photogrammetry by Ivar Kjellmo, assisted by Elin T. Sørensen. Kjellmo/Sørensen © BONO 2020
Below: Diversity-enhancing marine landscape architecture in the form of a Cambro-Silurian waterfront. Concept Elin T. Sørensen. 3D-visualisation by Ivar Kjellmo. Kjellmo/Sørensen © BONO 2020

transfer of geological surfaces from the local Cambric-Silurian coastal formations, as shown in the 3D-renderings below. The marine landscape-architectural elements are inspired by marine nature types which are fitting for the conditions of the Inner Oslofjord. Hence, the refined 3D-models suggest new ways of connecting the gap between the urban foreshore and the marine environment.

Another viable option for designing good marine neighbourhoods is to re-create and restore mussel beds, as has been done along the Swedish coast. Filter-feeders like the mussels may help us to clean the waters much in the same manner as certain plants work to remediate contaminated soil. In plant-based remediation processes, the plants are removed after a while and treated as hazardous waste. For the blue mussels, this would imply sacrificing some generations for the sake of better water quality. A more nature-friendly solution would be to let mussels assist in monitoring water quality, keeping us informed on a real-time basis. Inspired by the artist Natalie Jeremijenko, one could imagine that mussel-monitoring units, for instance in the form of sound art pieces, were set up along the urban foreshore – an intervention that would bring life below water to the surface and contribute to public education and awareness raising. Yet another option is to seek inspiration from the blue mussels' time-tested functionalities, such as, for example, the research on byssus threads. In my imagination, I picture building structures that attach to the shore with comparable strength and flexibility as byssus threads, giving us a marine landscape architecture which yields and adapts to the waves and the forces of nature.

One could imagine coastal defence structures put together like mussel beds as a permeable quilt of mussel-patches and empty spaces, retaining and slowing down the wave energy. And what if all plastic ropes used in the sea were replaced by marine-friendly manufactured byssus-like threads. One could just imagine the benefits of a bio-based product which could replace the eight million tons of plastic ending up in the World Ocean (equivalent to ten full grocery bags for every half meter of coastline in the world).[54]

To conclude, Van Dooren & Rose's consideration of the city as a place for a variety of housing potentials, shelters, and habitats that complement each other is uplifting. As they point out: "Humans do not live in burrows or tree tops; there is room for everyone".[55] We have the option to adjust and rethink our built environment, both on land and undersea. Our artificial structures can be made complementary in ways to which *only imagination sets the limits*.

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The formatting of this article has been left different from other texts in the book to comply with the author's dissertation.

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54 (Le Guern, 2019)
55 (Van Dooren & Rose, 2012, p. 18)

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