CTB3300WCx – Introduction to Water and Climate

IN2 – Water Intervention


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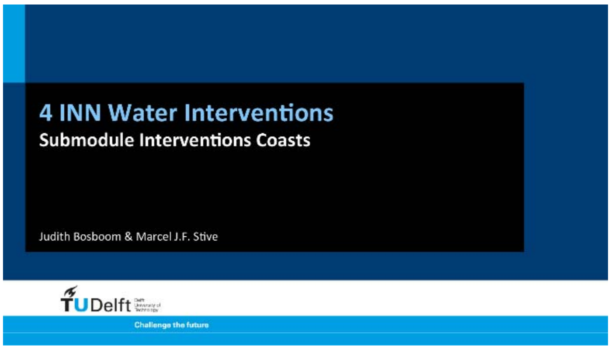
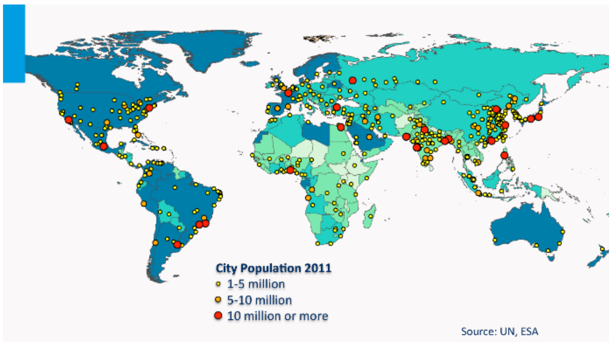
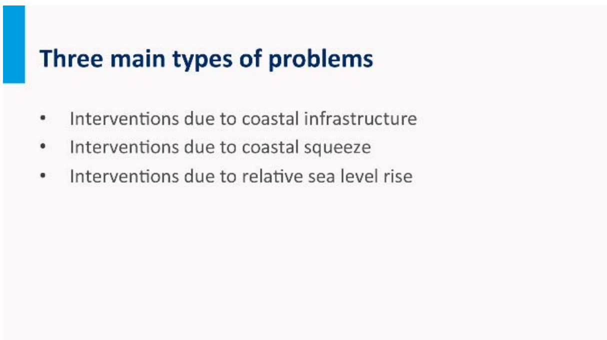


In this module, we will discuss the implications of human interventions along our coasts. Our coasts, estuaries and deltas offer many benefits, to our society and to our economy. And this holds especially for the trailing edge coasts that we discussed earlier. These coastal lowlands are generally fertile and gently sloping. This allows us the development of agriculture, industry, urbanization and recreation.

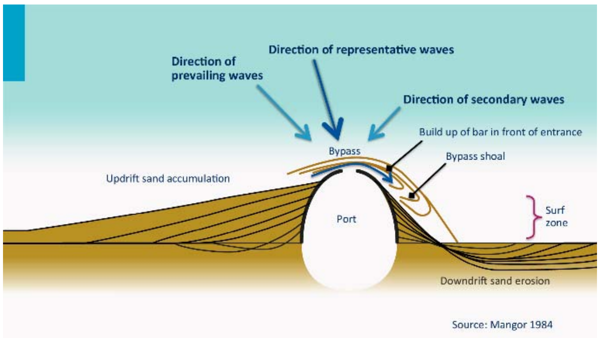


Note that nearly all our megacities worldwide are located at the coast. Also, we build infrastructure, like harbors, we reclaim land and take protection measures against erosion of those areas that we value. Now listen to Max reporting from the Dutch harbors of Rotterdam and Amsterdam.

Many harbors have been built along coastlines all over the world. The port of Rotterdam behind me even was extended into the sea with newly reclaimed areas of land. These harbors interact with the coastal system, and often lead to interruption of the along-shore sediment transport. The eroding coastline downdrift of the harbor needs to be maintained somehow, otherwise the sea would proceed and put the interland at risk.

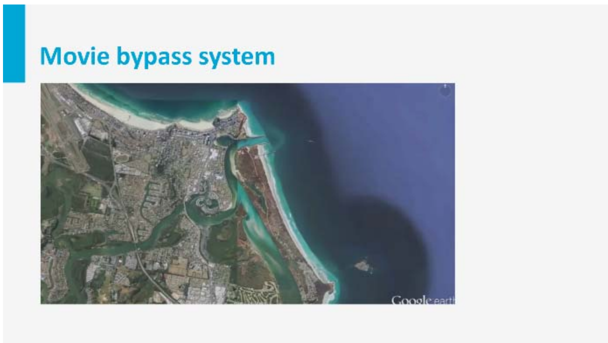


What then creates our most important problems? We face three main types of problems: Problem 1, Interventions due to coastal infrastructure, that structurally interrupt alongshore transport Problem 2, Interventions due to coastal squeeze, providing too little space to accommodate temporary erosion due to extreme events, And problem number 3, Interventions due to relative sea level rise, causing a sediment shortage leading to coastline retreat. As we have learnt from the module Water Systems Coast, there exists an alongshore river of sand. Coastal infrastructure that

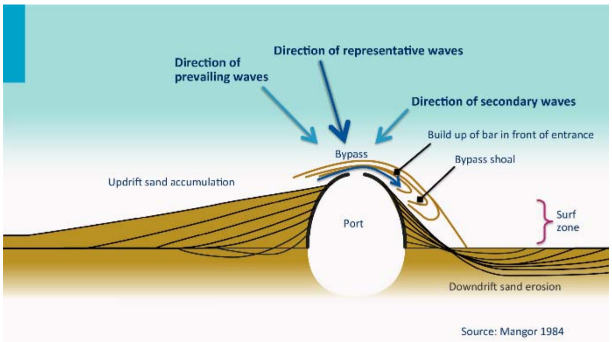


interrupts this river of sand can cause coastal problems. If, for instance,

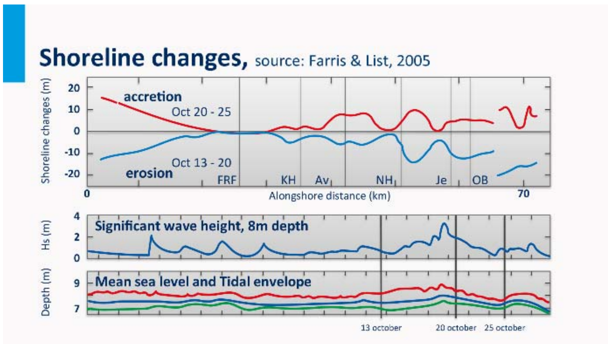
we construct a harbor we block the alongshore transport, resulting in accretion on the updrift side, but erosion on the down drift side. This is an important problem that occurs at many coasts. A large part of the engineering problems originates from this. One of the solutions that we have often adopted is to protect the down drift side by hard structures, like groins, in an attempt to counteract the erosion. This may work locally, but will only transfer this problem to the areas beyond, often this is counteracted by building more groins. It is like an everlasting problem, unless one reaches an area where the erosion is acceptable. Now what then, can we do to resolve this? In eastern Australia, at Tweed River and Nerang River, entrance bypass systems have been constructed.



As we zoom in on Tweed River entrance please note how the sand transport to the North is blocked by the harbor moles protecting the entrance. The bypass system consists of a jetty-like structure on poles from the beach to the end of the surf zone. You may observe the fluidizing jets, that help the pump system to suck up the sand. The sand is transferred to four downstream areas. A little further North at Nerang river entrance a similar system has been constructed, it is actually older than the Tweed River bypass system. These systems are effective and efficient because of the unidirectional and large transport, they act as a sediment engine. The net and gross alongshore transport there is about one million m3/year to the north.

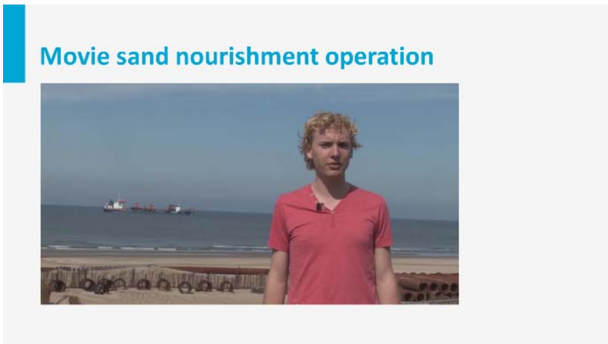


In other cases, like for instance the harbor moles of the Dutch harbors of Rotterdam and Amsterdam, the downstream side is nourished by extracting sediment from the offshore. This has a lot to do with the fact that the wave climate is not only from one direction, so that the transport is multidirectional and not that large, which makes artificial bypassing less effective and efficient. Our second problem to be discussed is Coastal Squeeze. Coastal systems need to be able to absorb the temporary impact of an extreme event. This holds for mangrove coasts, but also for beach and dune systems that need space for retreat of the beach and dunes as a result of a storm. After the storm impact, the coastline will recover again. An example is given for an 80km coastal stretch on the US East Coast.

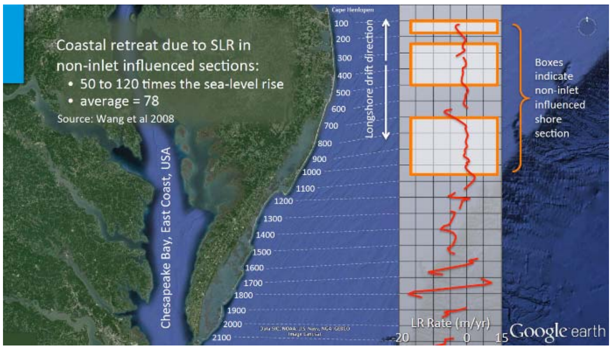


The middle panel shows the variation of the wave height in time. Around October 20, a storm occurred. The upper panel shows – in blue - the storm induced shoreline erosion along the entire coast. The recovery of the coastline, after the storm, is indicated in red.

Mid last century, many coastal systems looked pristine. But massive coastal urbanization created a quite different picture. This has been happening at many locations all over the globe. In our quest to create space for recreation, agriculture and urbanization, we build too close to the coastline. This squeezes the beach and dune system and one usually ends up with a hard defence structure. This however is often not a sustainable long term solution. For many Spanish recreational beaches, this problem has been resolved in the last decades by nourishing the beach, which is a very good remedy. The Spanish have also implemented a Coastal Act, which regulates the occupation of space in the beach and dune area to prevent coastal squeeze. This is a really good example and has been followed by the Netherlands. Regulation of the coastal zone is crucial to create a healthy ecosystem. Listen to Max who is present at a project site that that is being nourished.

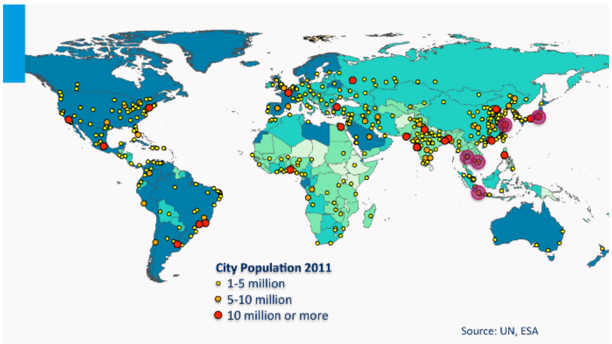


This is what a sand nourishment operation looks like. In this particular case, a weak link in the Dutch coastal defence is being strengthened, by placing 35 million cubic meters of sand in front of the existing dyke. This project is not only beneficial for coastal safety, but it also enhances recreational and ecological values of the coastline. This is a rather extreme example. A regular nourishment has less volume, and is restricted to the beach or the foreshore.



Now, let us finally discuss the impact of sea level rise. Sea level rise creates a sediment budget deficit along our coasts. Along large stretches of coasts, not interrupted by inlets or tidal basins, we can apply the so-named Bruun Rule. You will study this rule in your assignments. This rule, based on the observation that the beach profile responds relatively fast, implies that in response to sea level rise the coast will retreat with say 50 to 100 times the amount of sea level rise. Hence due to a sea level rise of 3mm/year a long stretch of coast will retreat with 15 to 30 centimeters per year. This is a very weak signal that may be obscured by our human interventions. When a stretch of coast is interrupted by inlets we may observe a stronger response due to sea level rise. This is because the accommodation space in the inlets is creating an additional sediment sink. Look at this slide.

Inside the boxes the Bruun Rule is valid, but not outside the boxes where the coast is interrupted by coastal inlets. This illustrates that along the East Coast of the US the coastal retreat near inlets is much stronger. All this, we have just discussed in the context of the eustatic or absolute sea level rise signal. But, in fact, we have to distinguish between absolute and relative sea level rise. Absolute sea level rise is the actual rising of the sea level. Relative sea level rise occurs when the land is sinking relative to the sea.



Earlier, we discussed that, presently, the impact of absolute sea level rise is rather modest. More important is relative sea level rise. And the importance of relative sea level rise increases, especially for urbanized coastal areas. Natural and human-induced subsidence, or sinking, leads to a relative sea level rise that far exceeds the absolute component. While the absolute sea level rise is in the order of mm's per year, subsidence reaches cm's per year. Large cities like Bangkok, Djakarta, Shanghai, Ho Chi Min and Tokyo suffer from subsidence. This is due to natural compaction of the sediments these cities are built on. But this compaction is strongly enhanced by drainage, and by extraction of groundwater or other resources. The adverse impacts of relative sea level rise need to be discussed urgently. Unfortunately, many governments prefer to blame absolute rather than local, relative sea level rise for problems of flooding and salt water intrusion. In summary, our use of the coastal systems brings along a number of problems, from structural erosion and coastal squeeze to relative sea level rise. Coastal engineers play an important role in the mitigation of these problems. In the past, we often used hard structures to solve our sediment budget problems. These days, we prefer to take soft measures, for instance bringing sediment to the coast. This makes our beach and dune systems stronger in a sustainable way. It is up to the younger generations, like you, to provide new answers to our coastal problems. This starts, of course, with a good understanding of the coastal system.