Engineering: Building with Nature 101x MOOC

Some useful engineering concepts and information on fish

Case 3: Fish Manager

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Tidal variation in the Wadden Sea

The tide in the Wadden Sea varies approximately in the range from -1.20 m (to chart datum – NAP) to +1.20 m to NAP. The figure below is included to provide you with an indication of the tidal variation from high water to low water and back again within approximately 24 hours.

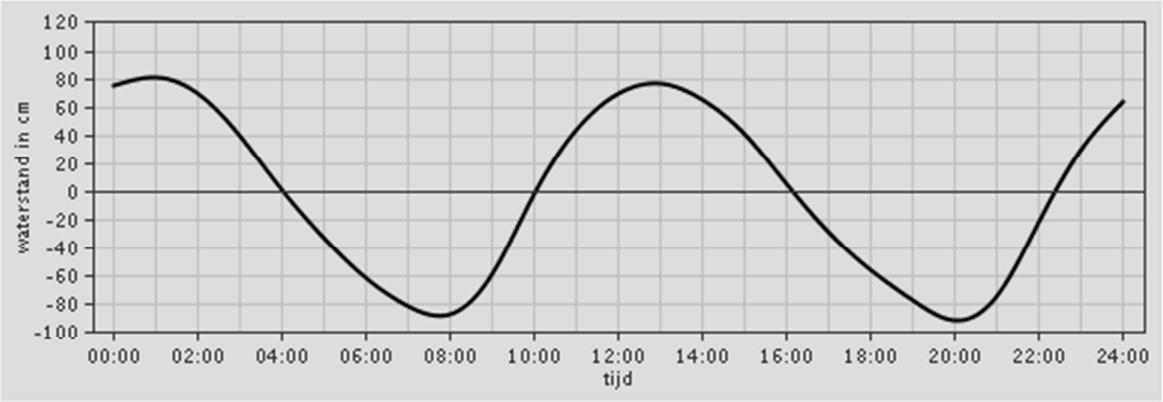

Figure 1: Indicative semi-diurnal tidal variation in the Wadden Sea at Kornwerderzand (predicted for 1-3-2016 (RWS 2016a))

Wind Set-up and Set-down

Differences in water level between the predicted tide and the actual tide can occur. The water level can differ by 0,5 m or more owing to wind set-up or set-down, depending on the direction of the wind. Under north westerly winds, set-up occurs at the barrier dike and water levels are elevated. Under south easterly winds set-down occurs at the barrier dike and water levels decrease.

Fresh water discharges into the Wadden Sea

The water levels in the Ijssel Lake are controlled by pumping the excess fresh water out into the Wadden Sea and by managing the river inflows as far as possible. In winter, the level in the Ijssel Lake is maintained at around NAP -0,25 m, while the level is allowed to vary more in summer between NAP -0.10 m and NAP -0.30 m. Throughout the year, the minimum water level should not be lower than NAP -0.40 m to maintain navigability and ensure the safety of the dikes. If dikes become too dry they can become more vulnerable to failure.

However, because it is important that the Ijssel Lake remains fresh, water can only be discharged to the Wadden Sea when the water level in the Lake is higher than the water level in the Wadden Sea. As can be seen in Figure 2, this occurs for about one third of the tidal cycle, when the water level in the sea is low, the so-called discharge window. Current practice is to close the sluice gates when water levels in the sea are above those of the lake so as to prevent the intrusion of salt water.

The capacity of the sluices and pumps is such that the current speeds near the discharge points are in excess of 0,5 m/s when the water is discharged. The pump capacity need not be considered as a limiting factor in your design – you may assume that the capacity will be adjusted to accommodate your nature friendly solution.

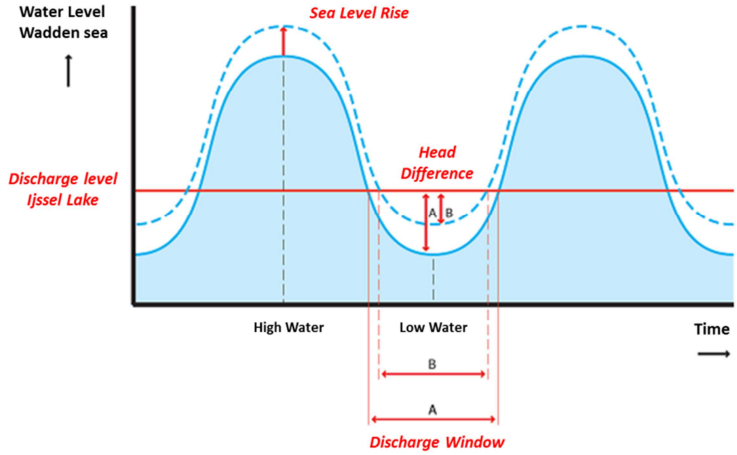

Figure 2: Window for freshwater discharge from the IJssel Lake to the Wadden Sea (adapted from RWS 2016b)

Fish species

There are a number of fish species that will benefit from river-sea connections and associated fresh-salt water gradients. Some of the fish species are threatened or endangered under European and international law. The fish species depicted in the Figure below are:

Sturgeon (Steur; *Acipenser sturio*). Originally occurred in all major European rivers. Now only a few populations in the countries of Georgia and France. As juveniles they live up to 4 years in freshwater, and then take some time to adjust to salt water, while living in brackish river mouths / estuaries. By five years of age they are living in the marine environment. They inhabit the shallow areas of coastal seas.

Sea Lamprey (Zeeprik; *Petromyzon marinus*) The Sea lamprey lives in both marine and freshwater environments and is common in large rivers. To reproduce, they return to freshwater where they make a nest, lay eggs and die.

Sea Trout (Zeeforel; *Salmo trutta trutta*). Migrates from the sea to the river to spawn at about 5 years of age. After one of two years the juveniles migrate to sea. Iconic migratory fish in the Rhine River.

Flounder (Bot; Platichthys flesus). Inhabits marine, brackish and freshwater environments, and is tolerant to wide ranges in salinity. Spawns between February and May in freshwater. Juveniles live in shallow areas of estuaries.

European smelt (Spiering; *Osmerus eperianus*). Live in both fresh and marine environments, but migrate upstream to spawn.

Houting (Houting; *Coregonus oxyrinchus*). Salt water fish that spawns in freshwater. Red listed species in Europe.

River lamprey (Rivierprik; *Lampetra fluviatilis*). Bottom dwelling larval phase for 4 years in which it requires flowing water. It then migrates as young adult to the sea, and lives in the marine environment for 2 to 3 years. When fertile the river lamprey migrates upstream to spawn.

Allis shad (Elft; *Alosa alosa*). Juvenile phase is spent in tidal freshwater areas. When they are about 12 cm in length, they migrate to the marine environment. Spawning occurs in quieter stretches of the gravel bed parts of rivers.

Three-spined stickleback (Driedoornig stekelbaarsje; *Gasterosteus aculeatus*). This species usually dies at two years of age, but may make four years. It migrates to freshwater to spawn.

Twait shad (Fint; *Alosa fallax*). Lives in the sea but spawns in river mouths; they deposit their eggs in shallow areas where there is tidal action.

Eel (Paling; *Anguilla anguilla*). Migratory fish that covers large distances from Europe across the Atlantic ocean. The life cycle has many stages and phenologies. Resides in muddy bottom sediments, and is a threatened species.

Atlantic salmon (Zalm; Salmo salar). Migratory fish species with larval freshwater and juvenile and adult marine life phases. They spawn upstream in rivers.

Figure 3: Fish that will benefit from restoration of fresh-salt interfaces (Source: RWS 2016b)

References

RWS (2016a). Retrieved from: http://getij.rws.nl/getij_resultaat.cfm?page=home&location=KORNWDZBTN&timezone=MET_DST&refplane=NAP&from=20160315

RWS (2016b) Retrieved from: http://www.deafsluitdijk.nl/projecten/pompen/waarom-is-het-er/