International Expert Meeting Fish Migration River Afsluitdijk

- conclusions and recommendations -

Date:
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Location:
DLG - Government Service for Land and Water Management
Zuidersingel 3, 8911 AV Leeuwarden, The Netherlands

Participants Expert Meeting:

Piet Riemersma	Grontmij /FMR contractor
Tim Vriese	ATKB / FMR contractor
Jakob Asjes	IMARES / FMR contractor
Ben Griffioen	IMARES / FMR contractor
Jaap Quak	Dutch Angling Association
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Peter Gough	Environment Agency Wales
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Claudio Comoglio	Politecnico di Torino, Italy
Bauke de Witte	Rijkswaterstaat
Eddy Lammens	Rijkswaterstaat
Andre Breukelaar	Rijkswaterstaat
George Wintermans	Wintermans Ecologen Bureau
Guus Kruitwagen	Witteveen en Bos
Roef Mulder	FMR-project team
Erik Bruin-Slot	FMR-project team
Herman Wanningen	FMR-project team
Jeroen van Herk	FMR-project team

Program on headlines:

- Field visit to Afsluitdijk – Kornwerderzand
- Opening (Herman Wanningen)
- Introduction Fish Migration River Project (Roef Mulder)
- Literature Overview (Jakob Asjes / Imares)
- Design aspects FMR (Erik Bruins Slot - Piet Riemersma / Grontmij)
- Hydraulic Modelling FMR (Corné de Leeuw – Tim Vriese / ATKB)
- Additional Field Research and Monitoring (Ben Griffioen)
- Work Session: discussion on fish migration salt to fresh, strategy and FMR design optimisations.

Summary work sessions; discussion, conclusions and recommendations:

In the overview below the main components of the Fish Migration Project will be summarized and discussed.

The FMR is seen as an innovative and unique concept to allow fish passage for upstream passage at tidal barriers, especially for species that use the tide (tidal migrants) to move upstream in closed estuaries. The FMR should be operational 24/7. Hydraulic modelling of the FMR, preferably with fish tests, is seen as an absolute necessity to optimize design and management options, including location of fish entrances. Continued monitoring of fish behaviour at Kornwerderzand is advised to detail the design in the next year. Flexibility in the design and adaptive management of the FMR is advised because of the innovative character of the FMR and the fish species involved. New design aspects concluded from the expert meeting are:

- **The need for multiple entrances for the FMR on the west-side the discharge basin;**
- **Entrance(s) for technical passage on the east-side of the discharge basin;**
- **An open culvert instead of a closed culvert trough the Afsluitdijk to optimize light conditions and limit risks on turbulence and pressure differences.**

1 Fish-migration from salt to fresh – general;
For a fish passage facility in a tidal area the incoming tide is most important for tidal migrants (small/weak swimmers and larvae). Tidal migrants track the incoming tide as long as possible before switching to an active swimming strategy. There is a direct relationship between the volume of inflowing (salt/brackish) water and the number of tidal migrants facilitated. Almost all current fish passage facilities are designed for active migrants, the FMR is rather unique in it's design which aims to primarily facilitate tidal migrants. This objective should be the primary focus of the design (entrances/attraction flows). Strong swimmers show more active searching behaviour, which enhances their chances of finding the entrance (s) of the FMR.

Recommendations; allow maximum volume of the incoming tide into the FMR to facilitate tidal migrants in an optimal way.

2 Location Kornwerderzand;
The Afsluitdijk has 2 sluice-complexes; Den Oever and Kornwerderzand. Large numbers of fish gather at both locations and therefore both locations deserve a (large-scale) fish passage facility. In 2012 Kornwerderzand was the favoured location because of its connection through deeper troughs to the Wadden Sea. In earlier Dutch expert-meetings it was expected that more migrating fish will arrive at Kornwerderzand because most are expected to follow these deeper troughs. It was also agreed that both locations need a large-scale solution like the FMR. Kornwerderzand was also favoured from a practical point of view.

Recommendations; evaluate the historical fish monitoring data from Den Oever and Kornwerderzand

Most experts agree that the presence of a large attraction flow is the key factor, and thus focus on the (existing) sluices. This is confirmed by monitoring data which shows the presence of huge numbers of diadromous fish in the discharge basin. Monitoring also shows

that fresh-water fish from Lake IJsselmeer are flushed out in large numbers. These fish can also benefit from a FMR. Additional monitoring along the Afsluitdijk is advised and test the possibilities with the simulation of an attraction flow.

Recommendations; connect the entrance of the FMR to the discharge basin at Kornwerderzand.

3 East vs West entrance of the FMR;
Monitoring data shows that most weak swimmers prefer the Western side of the discharge basin. Strong swimmers are more evenly distributed, probably as a result of their more active searching-behaviour; they will travel larger distances to find the entrance/attraction. The western option is the preferred location because most fish gather there, there is space for a nature-like passage to be created and it will be easier to attract fish into the FMR. The Eastern option includes the technical challenge of crossing the navigation-channel which will always be sub-optimal because a new barrier (siphon) is introduced. The complicated connections required are unfavourable.

Monitoring shows that there are also fish present at the eastern side of the discharge basin. It is uncertain if these fish can cross the discharge basin to find an entrance on the western side. To optimize passage an additional opening or vertical slot fishway should be located on the Eastern side in the discharge basin, close to the discharge-sluices.

Recommendations; Locate FMR on the West of Kornwerderzand and connect to the West side of the discharge basin. Try also to facilitate fish in the Eastern part of the discharge basin.

4 Entrance & attraction flow;
The entrance should optimally be located as close as possible to the discharge sluices. Multiple entrances are preferred but each opening needs to have sufficient and concentrated attraction flow. Furthermore these openings should have their own channel to avoid complicated hydraulics. It is strongly advised to have additional openings in the discharge basin for flexibility and adaptive management for both short term (actual discharge) and long term (climate, after monitoring results). An extra pump could be used to add attraction flow directly into the entrance of the FMR. In the case of multiple entrances each entrance should have it's own channel.

The initial "artist design" included an entrance north, straight into the Wadden Sea. This entrance could provide attraction flow directly to the Wadden Sea during periods when discharge sluices are closed. The experts agree that this is not necessary because fish will find the discharge basin anyway. Additionally, the continuous discharge of the FMR will create a brackish zone in the discharge basin which provides an additional area for transition/adaptation.

Attraction Flow: the designed volume of 10-20 m3/s is large but is needed to compete with discharge volumes (and will be approx. 5% of the sluice discharge). A larger volume of 20-40 m3/s may increase efficiency. These large volumes will be needed in the discharge basin to attract fish to the FMR. It is paramount that entrance locations and attraction flow options, including the discharge basin be tested with hydrodynamic modelling.

Recommendations; locate entrance close to discharge sluice (on Western side in discharge basin). Create multiple entrances for optimal flexibility and with separate channels. Create additional attraction flow optionally (with pump). No need for an extra entrance outside the discharge basin. Maintain the attraction flow with large volume. Include discharge basin in hydrodynamic modelling.

5 The culvert in the Afsluitdijk;
More insight is needed in the passable timeframe. The experts advise that a graph of flow speed against time in tide is required. The incoming tide is important for tidal migrants; focus on prolonged opening of the small openings in the doors or closing the door gradually. Ideally the culvert should be open 24/7; this may affect the design of the culvert interior and add a gate at the IJsselmeer-exit which can shut to avoid salt intrusion.

Add a vertical slot to increase the migration-window at low tide, and separate the opening from the culverts (otherwise the entrance of the vertical slot cannot be reached because of high flow velocities).

An air layer above the water in the culvert is needed, an open construction is even more favourable. Culverts can be a challenge for some species, important factors are a gradual transition from light to dark as well as reducing turbulence and differences in pressure. Try to limit the culvert length and slope. Design at least a gradual transition with lighting at the entrance offering a mitigating effect. In the past, open systems at bridges have shown a higher passage-rate than culverts, even when considering the possible higher acoustic levels.

Multiple culverts facilitate maintenance; one can be in operation while the other is serviced. An open structure is easier to maintain/clean. The size of the culverts should be as large as possible to avoid a bottleneck (to avoid turbulence/high flow speeds, and to increase volume of incoming tide). The colour of the inside of the culvert is not very significant, it will be soon covered with moss etc. If the design allows multiple culverts it is advisable to have one smooth and one with friction on the bottom. The culvert is the bottleneck of the system and has priority in optimization.

Recommendations; design an open culvert or at least gradual transition from light to dark, multiple culverts for maintenance and variety. Maximise dimension of culverts to avoid "bottleneck" in water flow.

6 Inside FMR / transition zone;
Habitat diversity offers a comfort zone for the variety of species. Nature-like fishways may have higher passage-efficiency than a technical design. Fish abilities and behaviour, flow velocity and hydrodynamics are most important, and there should be sufficient and suitable shelter/hiding places (for all species and ages). Deeper water is needed to avoid predation, or think of other ways to mitigate. Design with soft material (sand) is a challenge due to erosion and makes it impossible to build steep banks. The shape is of less importance, but a spiralling design may disorientate migrating fish.

Recommendations; A nature-like fishway including habitat and shelter options is more favourable than a technical fishway

Little is known about the importance and (long-term) effects of a gradual transition from salt to fresh water, and this may also depend on the fish life-cycle period. There are indications that glass eel and stickleback have no problem at all. Some species may already start adapting their approach towards fresh water. The salt water inflow is more important for the tidal migrants. The brackish zone is more a result of this. Guus Kruitwagen will ask opinion from his prof. dr. S.E. Wendelaar Bonga from the Nijmegen University.

Including a transitional zone is the natural approach and is a no-regret measure. Currently there is no substantial gradient from salt to fresh water but fish have access to some brackish water; there is a deep sink close to the discharge sluices and in the shipway.

Recommendations; maintain the large volume of salt water inflow and therefore the brackish area; start monitoring the deep sink and troughs *in Lake IJsselmeer for better understanding of the current distribution and numbers of fish. Additional research on physiologic capabilities/limitations is needed. Large congregation of fish in a transitional zone may induce predation; try to mitigate in design.*

7 Lake IJsselmeer – exit;
An exit which can be shut enhances the ability to manage the FMR, i.e. to optimize fish passage, adapt to changes in water level in Lake IJsselmeer and Wadden Sea, and for maintenance reasons. The passage efficiency can be optimized because it will be possible to manage the volume of the inward and outward flow and velocity. This will have a positive effect on facilitating tidal migrants and optimizing attraction flows. Furthermore a more enclosed FMR allows for a higher water level inside, which will generate attraction flows earlier in time. A fresh or brackish FMR will allow vegetation to grow. An exit which can be shut allows prolonged salt conditions in the FMR to decrease vegetation growth.

Connect to deeper trough in Lake IJsselmeer and stay away from the discharge sluices. The FMR may divert flow in lake, so hydrodynamic modelling is needed. The existing trough can be deepened to maintain discharge capacity; the sediment can be used for building the FMR. Multiple gates are preferred for maintenance reasons. Variation in depth is needed to avoid predation. The location is essential for monitoring (passage efficiency), so take this into account when designing; not too big and no hydraulic constrictions.

Recommendations; design an exit which can be shut, include a monitoring facility, and connect the exit to deeper troughs in Lake IJsselmeer to avoid predation. The exit has to be located outside the area of influence of the main discharge sluices to prevent fish from being flushed out again to the Wadden Sea.

8 Monitoring fish behaviour and abundance;
The number of individual tracked fish is limited by the low catch of larger species. Current number may be insufficient for significant results. Advice; try to increase sample size to 100 or more.

HTI could give more detailed results than the currently used VEMCO system, but there is too much turbulence in the discharge basin to apply HTI. Monitoring is essential for optimisation. More detailed knowledge about the current situation is advised. What is happening now and how are fish behaving at Kornwerderzand? Monitoring locations needed at entrance (attraction flow) and exit IJsselmeer. An experimental spill could be used to test

the design/optimisation of attraction flow (*this option has been rejected earlier because of the costs*). An alternative could be to use the spillways and monitor the attraction flow and hydrodynamics. Turbulence and air bubbles are problematic for monitoring with tags, and radio telemetry is not operational in saline environment. Most important monitoring parameters are attraction efficiency, passage efficiency, delay and predation rate. Paul Kemp will provide paper about modelling flow/volume. RWS and FMR are both interested in monitoring data and will both contribute.

Recommendations; increase monitoring efforts for better understanding of current situation and for future optimisation. Karlstad University, IMARES, The Wadden Sea Academy and the FMR team are currently working on a monitoring plan.

Jeroen van Herk, Roef Mulder & Herman Wanningen