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Innovation & Investment

Netherlands farms tune recirculation systems to production of varied species

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Systems can be adjusted for African catfish, European eel, turbot, others

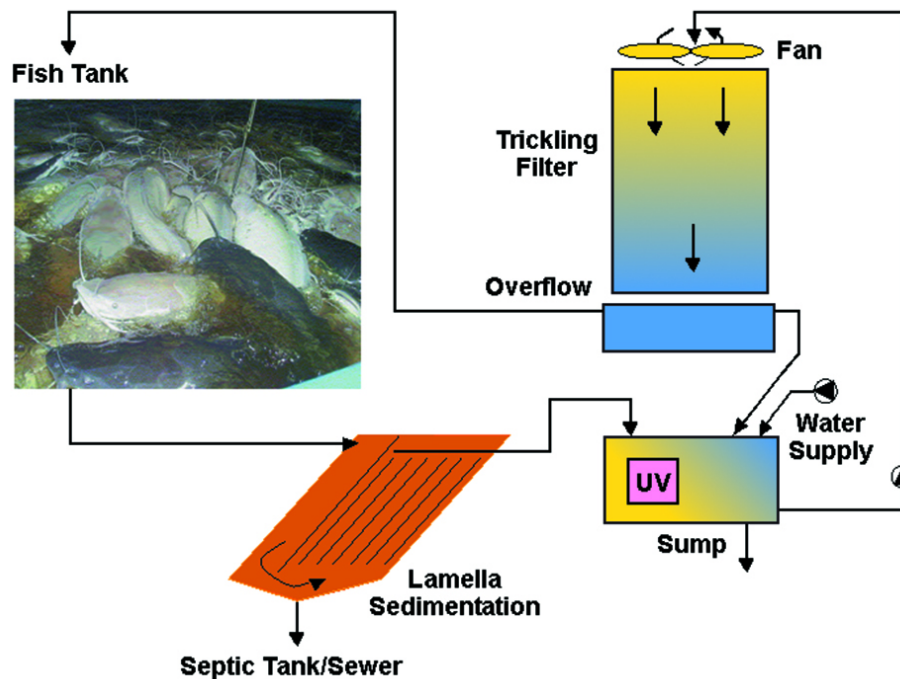


Fig. 1: Schematic of a recirculation system for the production of African catfish. Catfish photo by Oliver Schneider.

Because of its number and diversity of recirculation systems in production, the Netherlands offers an interesting opportunity to study differences in system design that pertain to the species farmed. In addition to established industries for eel and catfish production (with respective annual production of about 4,800 and 4,000 metric tons (MT)), new species like tilapia, turbot, sole, and pike perch are gaining ground in the country.

All production systems use the same basic technology with some specific adaptations for each species. The differences in systems for eels, catfish, and turbot are good examples of these adaptations. To understand the differences in design, however, it is important to compare the biological performance of the farmed animals (Table 1).

Table 1. Production data for African catfish, European eels, and turbot in recirculation systems.

Parameter	African Catfish	Eel	Turbot ¹
Culture temperature (° C)	25	25	17
Growth interval (g)	10-1,000	0.25-200	10-1,000
Productivity (kg/m ² /year)	1,000-1,500	200-300	55
Average standing stock (kg/m ² tank area)	170	114	35
Specific growth rate (%/day)	1.7	0.75	0.42
Feed conversion (kg feed/kg growth)	0.85	1.3	1.1
Oxygen (kg/kg feed)	0.3	1	0.6

¹ Personal communication, K. Kloet, Fishfarm Yerseke.

Productivity

Productivity depends on density and growth rates, among other variables, and these differ significantly between the three species. Catfish production is extremely high at 1,000 to 1,500 kilograms per square meter per year, while eels can produce 200 to 300 kilograms per square meter per year and turbot reach 55 kilograms per square meter per year.

Growth, FCR and waste

Growth rate and body composition affect feed conversion, which is important in determining the amount of waste produced. Waste production ultimately determines the capacity of water treatment systems. Fast growth is efficient growth, represented by the African catfish. Eels are a very fatty fish with a moderate growth rate that results in relatively high feed conversions.

Dissolved oxygen

Oxygen is one of the factors that first limit production, and its consumption is a determinant of the recirculating flow. Since African catfish can utilize atmospheric oxygen and live in water devoid of oxygen, the fish require only a small recirculating flow. This lower flow rate allows the use of lamella sedimentation (tube settlers) rather than more expensive microscreen filters (Fig. 1).

System characteristics

Table 2 shows the characteristics of recirculation systems designed in the Netherlands for the annual production of 100 tons of African catfish, European eel, or turbot. Given the different productivities of each, the area needed for tanks and a building are very different for each species. This has important consequences, for capital costs for land and buildings are considerable for those species with low productivity.

Table 2. Characteristics of recirculation systems designed for the annual production of 100 tons of African catfish, European eels, or turbot.

Parameter	African Catfish ¹	European eel ²	Turbot ³
Building surface area (m ²)	350	1,200-1,500	3,400
Culture tank area (m ²)	100	390	1,850
Tank volume (m ³)	100	312	1,850
Total system water volume (m ³)	135	450	2,500
Flow-rate fish tanks (m ³ /day)	3,000-4,000	16,000-18,000	48,000
Water exchange (times/hour)	1	2-4	1
Suspended solids removal	Tube settler	Hydrotech drum-/discfilter	Hydrotech drum-/discfilter
Biofilter	Trickling filter	Upflow- and trickling filter	Trickling filter
Biofilter volume (m ³)	110	172	280
Biofilter surface area (m ² /m ³)	150	200	150
Cross-sectional surface area (m ³ /m ² /day)	120	300-400	400-500
Upflow filter (m ³)	–	33	–
Biofilter surface area (m ² /m ³)	–	150	–
Denitrification (carbon source)	Faecal carbon	Faecal carbon + methanol	Faecal carbon + methanol
Installed power (kW)	7	75	125
Electricity use (kWh/kg fish)	0.7	7	10
System water cooling through:			
Ventilation	Yes	Yes	Yes
Ventilation over trickling filter	No	Yes	Yes
Groundwater cooling system			Yes
Water-exchange (l/kg feed)	100	85-100	800

¹ Pers. comm. P. Nooyen, Fleuren and Nooyen. ² Pers. comm. A. de Bondt, Hesy.

³ Pers. comm. K. Kloet, FishfarmYerseke.

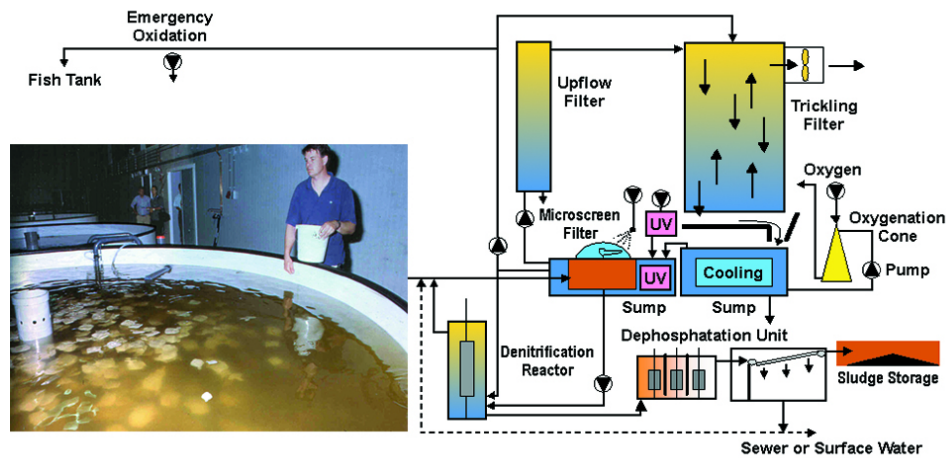


Fig. 2: Schematic of a recirculation system for the production of European eels and turbot. All water treatment works continuously to reduce fluctuations due to backflushing of filters.

Managing waste

Only microscreens are used to manage the large flows of water and waste in eel and turbot farms (Fig. 2). For nitrification and removal of soluble biological oxygen demand, all systems predominantly use trickling filters.

In general, the total recirculating flow is pumped over the biofilter in order to guarantee optimal removal of carbon dioxide. This results in a large difference in hydraulic surface loads between systems. The trickling filters can handle these differences, and also avoid clogging with high loading.

Biofilters

Catfish produce relatively little waste and have high tolerance for less than ideal water quality, so a relatively small biofilter is used. For turbot, which are cultured in seawater, the negative effect of chloride on nitrification has to be taken into account when sizing the biofilter. A submerged upflow filter is used in some eel farms to remove small particles. The need and design of this piece of equipment is still being debated.

Denitrification and water use

Fresh water is an expensive resource, and denitrification is becoming routine in farms for catfish and eels. Catfish farms use settling areas, with sludge management and settler sizing considered important management processes. Most eel farms now operate with denitrification using feces or methanol as a carbon source. Because of denitrification, water exchange ranges between 100 liters per kilogram feed for catfish and eels, to 800 liters per kilogram feed for turbot.

Energy-friendly systems

Once a recirculation system is planned for a fish species, the building or greenhouse has to be designed. Computer models like ANIPRO are now being used to design energy-friendly recirculation systems. Models can simulate climate and energy use in recirculation system buildings and design energy-efficient, cost-effective heating and cooling systems for fish farms in different geographical regions. Climate control through ventilation and/or groundwater cooling is has received attention, especially for species like turbot, which require moderate water temperatures.

Heat management

The ANIPRO model incorporates heat production in the fish farm through the conversion of feed from fish and bacterial biomass, pumps, lighting (including ultraviolet lighting for disinfection), and heat transmission into the building (especially solar radiation). Heat loss occurs by air ventilation; transmission of heat through the floors, walls, and roof; and water renewal.

Specific data has been collected for catfish, eels, and now turbot farms. Parameters in the model were obtained from literature and fine-tuned with on-farm measurements for African catfish and European eels. The model has been recently extended with a simulation for greenhouses.

Conclusion

Several fish species – including European eel, African catfish and turbot – are currently produced in the Netherlands using recirculation systems. Other fish species are also becoming important.

The production systems use the same basic technology with specific adaptations for each species. Efficient management of waste and physical systems designed to be energy-friendly are important considerations for further industry development.

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