Control of blue algae with ultrasound – the effects on fish

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1 Introduction

The waterboard Hoogheemraadschap van Rijnland, wants to control the growth of blue algae in the Westeinder lake. The tools used for controlling blue algae include flow and ultrasound. Currently, little is known about the effects of ultrasound (US) in surface waters. Rijnland, therefore wants to visualize the effects on the various biological quality elements (phytoplankton, zooplankton, macrofauna, vegetation and fish) before deciding on the application. Between May and September 2007, a pilot will be conducted, in which ultrasound installations will be placed in the field.
The pilot aims to:

- Test ultrasound (US) as a technique for controlling cyanobacteria;
- Evaluate the effects of ultrasound on the ecosystem, in this report specifically on fish.

Initially, a ditch called the Uiterwegsloot (Aalsmeer, near the Westeinderplas) was selected as the pilot area. This location is regularly affected by the growth of cyanobacteria and has therefore been selected by the Hoogheemraadschap for testing the US technique. The ditch is relatively long, which allows it to be subdivided into a number of duplicate sections. The US technology would then be applied in a number of sections, while other sections would serve as untreated controls.

After a test with the US equipment, it turned out the ditch was too shallow. This restricted the range of the equipment to such an extent, that further tests would not have been useful. A baseline measurement of the fish population was already done by VisAdvies (in appendix I, the results of the baseline measurement in the Uiterwegsloot are presented).

The Hoogheemraadschap van Rijnland went in search of a new location to research the effects of US equipment. The chosen location is a pair of basins on the site of a wastewater plant called, Afvalwaterzuiveringsinstallatie (AWZI) Zwaanshoek.

Chapter 2 describes the research location and the methodology used to answer the research questions. Chapter 3 describes the results of the research into the effects of US equipment on fish, including fish population samplings, fish mortality and visual observations. Lastly, in chapter 4, the discussion and conclusions are presented.

2 Description of the research location and methodology

This chapter describes the research location in section 2.1, followed by the applied methodology in section 2.2.

2.1 The basins at AWZI Zwaanshoek

The basins at AWZI Zwaanshoek are filled with effluent water from the purification process and are continuously flowed with a small amount of this water. The basins have not been dry for a number of years, which means an ecological balance has been able to develop in the water. The basins are located on the roof of two buildings, and both buildings are connected in the middle. Image 2.1 shows the side view of one of the basins. The red line in the image indicates the dimensions of the bottom of the basin. It's clear that the bottom of the basin is funnel-shaped. The water depth in the center is about 4 to 5 meters. Both basins are similarly dimensioned.

image 2.1 *Side view of one of the basins.*

The basins are connected via a rectangular tunnel, which makes it possible for fish to migrate from one basin to the other. Image 2.2 shows this tunnel. When image 2.2 was taken, the water level was approximately 70 centimeters lower than the normal water level. Image 2.3 shows a top view of the two basins. There's a structure on posts along the inside of the basins, which contains a substrate, in which different types of waterside plants grow. Furthermore, there's a large post in the middle of the basin, which was previously attached to a rotating arm.

A stack of stones is positioned on this post and water flows through the stones. Its function is to create flow in the basins.

image 2.2 *View of the tunnel and an image of one of the basins.*

This research focuses on the effects of US technology on fish. Therefore, the presence of a researchable fish population is a requirement. For this purpose, a number of fish were released in the basins. The exact quantity of fish present in the basins before the launch of this experiment is unknown, but Mr. Lamfers at the AWZI Zwaanshoek reported that the amount is minimal. However, there are grass carps present in the basins.

2.2 Methodology

Release of fish

On June 6th, around 50 kilograms of fish was released in each basin:

- 25 kilograms of bream (approx. 20-50 centimeters, about 50 fish);
- 20 kilograms of smaller fish (approx. 10-25 centimeters, about 200 fish) consisting of the species: bass, common roach, silver bream, ruffle and common rudd;
- 3 tenches (approx. 30-40 centimeters);
- 3 pikes (approx. 30-70 centimeters).

image 2.3 *Distribution of the marked fish across the two basins. (Source: Google Maps)*

To be able to determine in which basin a captured fish was released, the fish are marked through fin-clipping. The fish in basin 1 are marked at the top of the tail fin, in basin 2 the marking is at the bottom of the tail fin (see image 2.3).

Fish population sampling

To determine the effects of the US technique, three fish population samplings were conducted. The first sampling took place on June 28, 2007, before the US technology was activated (baseline measurement to inspect the distribution of fish across both basins and for the inspection of tunnel migration). The second and third fish population samplings (Measurement 1 and Measurement 2) were done to determine the effect of the US technology. These samplings were conducted on July 26, 2007 and October 5, 2007. The US was activated on July 4th.

The fishing process was carried out in collaboration with fishing company van Wijk (OVB certified) from Groot Ammers.

Due to the dimensions of the basins and the present obstacles, fishing in the basins proved to be a difficult task. The difficulty was, among other things, caused by the funnel-shaped bottom of the basin and the resulting depth in the middle (Image 2.1). The fish could flee and were almost impossible to catch in this depth. A dragnet could not be used to fish in the tip of the funnel shape. The constructions (planters) at the banks of the basins also made fishing with a dragnet impossible. As a result of the planters, a dragnet could not be closed at the bank and fish could escape by hiding under the construction.

The best sampling strategy turned out to be a combination of elecrofishing and the use of a gillnet (an entangled net). The fishing was carried out from a rowing boat, present at the AWZI. Using this boat, the gillnet could be placed in the basins.

To prevent fish from crossing over to another basin during the fish population sampling, the entries of the tunnels were blocked with netting.

There are two different mesh sizes (60 mm and 120 mm hollow mesh) used to catch fish of different sizes.

After placing the gillnet, fishing was done with an electro aggregate. Fishing with this device works best in shallow banks with water-growing plants. The banks of the basins, however, turned out to be quite deep and very steep, and the present vegetation grows above the waterline. These were therefore not ideal conditions for catching fish directly with the electro aggregate. However, by working with this device, the present fish population will be triggered to move, due to the shock reaction. As a result, the fish will swim into the gillnet faster and will thus get caught.

To be able to compare the fish population in both basins at different times, the same effort was applied for each fish population sampling and for each basin. For each sampling, the following procedure was repeated 3 times: 2 pieces of gillnet of different mesh sizes were placed in a circle within the basin and were removed after electrofishing.

image 2.4 *The left picture shows electrofishing, the right picture shows the gillnet.*

Fish mortality

Employees of the AWZI Zwaanshoek were asked to pay attention to any dead fish in the period of June 6th to July 26th. They were given a form, to document the fish mortality, and pictures of the released fish species to be able to determine the species.

3 Resuls

This chapter describes the results of the three fish population samplings that took place in the basins at the AWZI Zwaanshoek. Section 3.1 describes the baseline measurement, section 3.2 and 3.3 describe the first and second control samplings

3.1 Baseline measurement (First Sampling)

The first sampling took place on June 28 2007 about three weeks after the fish were released. The catch mainly consisted of bream (Table 3.1). In basin 1, 16 fish were caught, in basin 2, 17 fish were caught. Despite the efforts of using a gillnet with a small mesh size, mainly large fish were caught. In basin 1, an unmarked common roach was caught. This fish was not released by VisAdvies. Most fish were caught in the basin where they were released. Table 3.1 shows that an exchange of fish occurred between the two basins.

table 3.1 *Overview of the catch before US equipment was activated*

basin 1 without US			**basin 2 with US**		
Species	**lentgh (cm)**	**Fin marking**	**Species**	**length (cm)**	**Fin marking**
common roach	18	-	bream	43	top
bream	32	top	common roach	22	bottom
bream	42	top	bream	21	bottom
bream	42	top	bream	21	bottom
bream	43	top	bream	22	bottom
bream	45	top	bream	30	bottom
bream	47	top	bream	39	bottom
bream	49	top	bream	41	bottom
bream	50	top	bream	41	bottom
bream	50	top	bream	42	bottom
bream	53	top	bream	42	bottom
bream	45	bottom	bream	44	bottom
bream	47	bottom	bream	46	bottom
bream	48	bottom	bream	46	bottom
bream	50	bottom	bream	46	bottom
tench	45	bottom	bream	46	bottom
			bream	52	bottom
Average	44 cm			38 cm	
Total quantity	16			17	

3.2 Measurement 1 (second sampling)

The second sampling took place on July 26, 2007. As with the baseline measurement, the bream is the species that was mostly caught. In basin 1, 26 fish were caught, in basin 2, 19 fish were caught. Compared to the previous sampling, more small fish were caught. For this sampling, the captured fish were also generally caught in the basin where they were initially released, but exchange of fish between

the basins definitely occurred. In basin 2, a grass carp and a pike were caught that managed to escape from the tub were they were temporarily stored. As a result the length, and for the pike, the fin marking could not be determined. The grass carp was not released by VisAdvies.

table 3.2 *Overview of the catch after the ultrasound device had been activate for one month*

basin 1 without US			**basin 2 with US**		
Species	**lentgh (cm)**	**Fin marking**	**Species**	**length (cm)**	**Fin marking**
bream	21	top	grass carp	?	-
bream	24	top	pike	?	?
bream	24	top	bream	23	top
bream	25	top	bream	27	top
bream	26	top	bream	42	top
bream	28	top	bream	48	top
bream	31	top	bream	23	bottom
bream	34	top	bream	41	bottom
bream	36	top	bream	42	bottom
bream	45	top	bream	43	bottom
bream	45	top	bream	46	bottom
bream	45	top	bream	47	bottom
bream	46	top	bream	47	bottom
bream	47	top	bream	48	bottom
bream	49	top	bream	51	bottom
bream	50	top	bream	51	bottom
bream	51	top	bream	51	bottom
bream	51	top	common rud	24	bottom
bream	52	top	pike	37	bottom
bream	52	top			
bream	53	top			
pike	53	top			
bream	22	bottom			
bream	31	bottom			
bream	49	bottom			
bream	51	bottom			
Average	41 cm			40 cm	
Total quantity	26			19	

3.3 Measurement 2 (third sampling)

On October 5th, the third fish population sampling took place. In this sampling, the bream was once again the species that was mostly caught. A total of 43 fish were caught, of which 28 were caught in basin 1 and 15 in basin 2. In basin 1, besides the bream species, 1 pike, 1 common roach and 1 grass carp were caught. In basin 2, 3 pike and 1 grass carper were caught. The remaining catch consisted of bream.

table 3.3 *Overview of the catch after the ultrasound device had been active for four months*

basin 1 without US			basin 2 with US		
Species	**length (cm)**	**Fin marking**	**Species**	**length (cm)**	**Fin marking**
grass carp	85	-	grass carp	80	-
bream	25	?	bream	32	?
common roach	22	top	bream	37	top
bream	23	top	bream	52	top
bream	37	top	bream	36	bottom
bream	38	top	bream	40	bottom
bream	38	top	bream	45	bottom
bream	38	top	bream	45	bottom
bream	39	top	bream	50	bottom
bream	41	top	bream	51	bottom
bream	44	top	bream	51	bottom
bream	47	top	bream	68	bottom
bream	48	top	pike	52	bottom
bream	50	top	pike	58	bottom
bream	50	top	pike	67	bottom
bream	51	top			
bream	52	top			
bream	53	top			
bream	59	top			
snoek	52	top			
bream	18	bottom			
bream	37	bottom			
bream	40	bottom			
bream	41	bottom			
bream	41	bottom			
bream	45	bottom			
bream	47	bottom			
bream	53	bottom			
Average	44 cm			51 cm	
Total quantity	28			15	

3.4 Other results

Fish mortality, period from release to measurement 2

The mortality observed was mainly among the smaller fish that were released. Seven smaller fish were found dead, belonging to the bass and common roach species. In addition, a pike of 70 cm was found dead. The extent to which fish mortality occurred was evenly distributed across the two basins. Of the eight dead fish, seven had a top marking. Given the minor catches of smaller fish that were released, it is likely that the mortality numbers are higher. It is also very likely that fish remains were eaten by seagulls.

Visual observation

Before the first fish population sampling, professional fisherman van Wijk, observed a school of bream. These fish came out of the tunnel connecting the two basins.

4 Discussion and conclusions

This final chapter describes the discussion in section 4.1, followed by the conclusions in section 4.2.

4.1 Discussion

Catches
Despite the efforts, it was not easy to catch the released fish from the basins. The existing obstacles, i.e. the planters and the posts in the middle, as well as the dimensions of the basins, made it relatively easy for the fish to avoid being caught by the applied fishing methods. VisAdvies was not aware of these characteristics of the basins beforehand.

Migration

- From the results of the first round of fishing, it can be determined that exchange of fish between the basins occurred. Fish were found in both basins that were released in the other basin. Exchange has also been observed.
- In addition, professional fisherman van Wijk, observed a school of bream swimming out of the tunnel, connecting the basins. He made this observation right before the first fish population sampling took place.
- Determining migration between the two basins is of great importance to the question of whether fish will show flight behavior when US equipment is used. If migration between the basins was not possible, fish who wanted to escape from the environment with the US equipment would not be able to leave the basin. However, this was not the case. Migration between the basins was possible.

Effect US equipment
After the US equipment had been working for some time, the fish population was still evenly distributed across the two basins. In both basins, fish originally released in the other basin were found. This indicates voluntary migration between the basins as well as the fact that the equipment does not lead to disturbance. The difference in captured numbers is most likely not due to the possible effects of US equipment. If the ultrasound was noticed or considered unsafe by fish, all fish would have left basin 2. The difference in the number of captured fish per basin may be caused by factors other than the US equipment. The position of the two basins (sunlight) could be a factor.

In addition, a test was conducted to determine whether there are differences in the length distribution of fish in the 2 basins. For this purpose, a two-sided T-test was performed (two samples with uneven variations). This determines whether the fish in one basin are larger or smaller than the fish in the other basin. This was done for all 3 measurements. The results were as follows: Baseline measurement P (T <= t) two-sided = 0.067, Measurement 1 P (T <= t) two-sided = 0.857, Measurement 2 P (T <= t) two-sided = 0.114 (with α = 0,05). None of the test values is significant. Thus, the

length of the fish in both basins did not differ significantly.

4.2 Conclusions

1. Released small fish were not or barely caught;
2. Migration of fish between the basins was possible;
3. The fish population in both basins, during the baseline measurement, as well as the second and third sampling, had similar results, both in terms of species and to a lesser degree in terms of quantities;
4. Given that the fish in the basin with US equipment did not massively flee, it can be concluded that the ultrasound with the applied load, is not noticeable or considered unsafe by these species of fish. Furthermore, no excessive mortality of fish has been observed in the basin where the US equipment was used. The amount of dead fish found in basin 2 was equal to the amount found in basin 1.

Appendix I Sampling Uiterwegsloot

The baseline measurement at the research site in the Uiterwegsloot took place in May. The ditch is characterized by a thick layer of silt and by the corresponding shallow waters (+/- 20 centimeters). The water is relatively clear with a limited amount of water plants. An overview of the catch during the sampling in the Uiterwegsloot is shown in the table below.

table *Overview of the catch in the Uiterwegsloot.*

Location	Fish species	Min. (cm)	Max. (cm)	Total
1	Small loach	6	10	15
	Pike	5	63	3
2	Small loach	8	8	1
	Eel	19	30	2
	Pike	5	5	1
3	Eel	35	35	1
	Pike	5	6	2
4	Small loach	9	10	2
	Eel	40	40	1
	Pike	5	5	2
5	Bass	16	16	1
	Eel	35	40	2
	Pike	26	26	1
6	Small loach	8	10	2
	Pike	25	25	1
	Tench	4	4	1
Total fish species	**5**			
Total				**38**

The detected fish population and low fish biomass are typical for the environmental conditions in the Uiterwegsloot (shallow waters, relatively clear and silt-rich water). Most fish caught were relatively small fish, only a few larger fish were caught.

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