Current reduction in AquaSim

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Summary:

This document describes how AquaSim deals with current reduction behind succeeding nets.

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Content

1 Introduction

AquaSim has a function to account for current reduction behind succeeding nets. Which means that a net panel, situated downstream of another net panel, will be exposed to a lower current velocity relative to the original current velocity. This is shown in Figure 1, where five net panels are spread out in the z-y plane, and the current travels along the positive y-axis. As seen from this figure, the axial force in the mooring lines belonging to the net panel downstream decrease further down the y-axis.

In this case, the axial force in mooring lines belonging to the first net panel is approximately 9000 N, while the axial force belonging to net panel number five is approximately 5000 N.

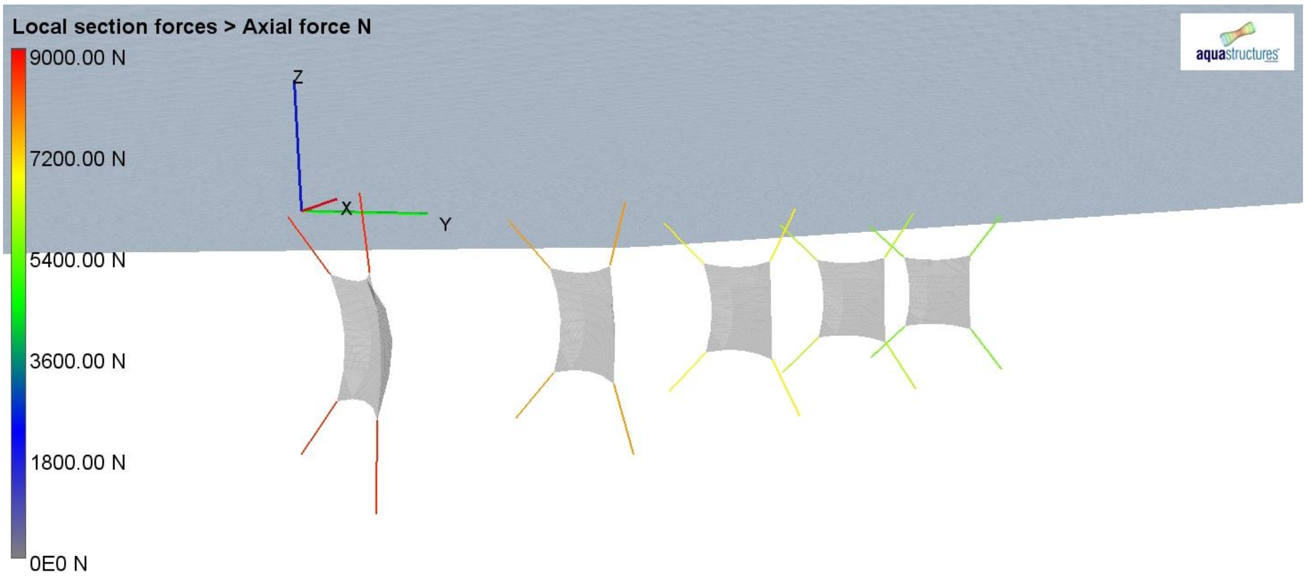

Figure 1 5 succeeding nets, colors shows axial force in lines

2 Theoretical formulation

The theoretical formulation for the current reduction According to Løland (1991) Eq. 211.

$$r = 1.0 - 0.46C_D$$

Equation 1

In order for a consistent formulation, C_D is found from Løland (1991) Eq. 199.

$$C_D = 0.04 + (-0.04 + 0.33Sn + 6.54Sn^2 - 4.88Sn^3) * Cos\alpha$$

Equation 2

Sn is the solidity. To be consistent with Løland (1991), Sn is found from Løland (1991) Eq. 198:

$$Sn = \frac{2d}{L} + \frac{d^2}{2L^2}$$

Equation 3

This can be compared to the simplified formulation of the 2D solidity, given as:

$$Sn_{2d} = \frac{2d}{L}$$

Equation 4

which is simply adding the diameters horizontally and vertically.

Where d is the diameter of the twine and L is the length both in y- and z- direction in the coordinate system where the net panel is located in the yz- plane.

Define a net panel shaded by several nets in front of it. Then Equation 1 is applied recursively.

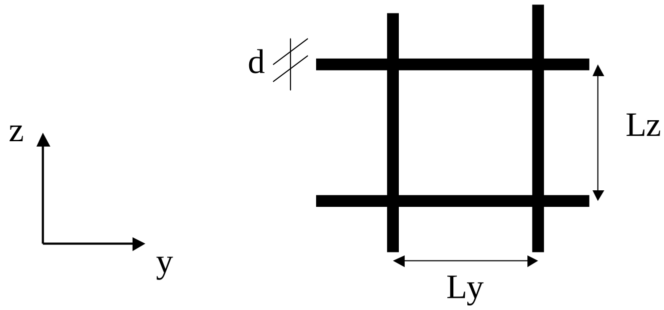

Figure 2 Basic definition of net parameters.

3 AquaSim implementation

In AquaSim one may choose four options regarding the current reduction behind succeeding nets. These are explained in Table 1.

Table 1 Options for current reduction in AquaSim.

Parameter in txt-file	Parameter in Aquabase	Description
0	No reduction	No current reduction behind net panels is accounted for.
1	From initial shape	The current reduction is found from the initial configuration.
2	Deformed by current	The reduction factor is found from the initial configuration, and updated for the deformed configuration as the current is put on.
3	Deformed by current and waves	This is the same as number 2 "Deformed by current", but the current reduction do additionally get updated at each wave step.

3.1 Example: 2. Deformed by current

Figure 3 shows the net reduction factor for succeeding nets. This is for a case with diameter of twine is 2 mm and the knot to knot distance, L is 25 mm. This gives ad 2D net solidity of 16 %.

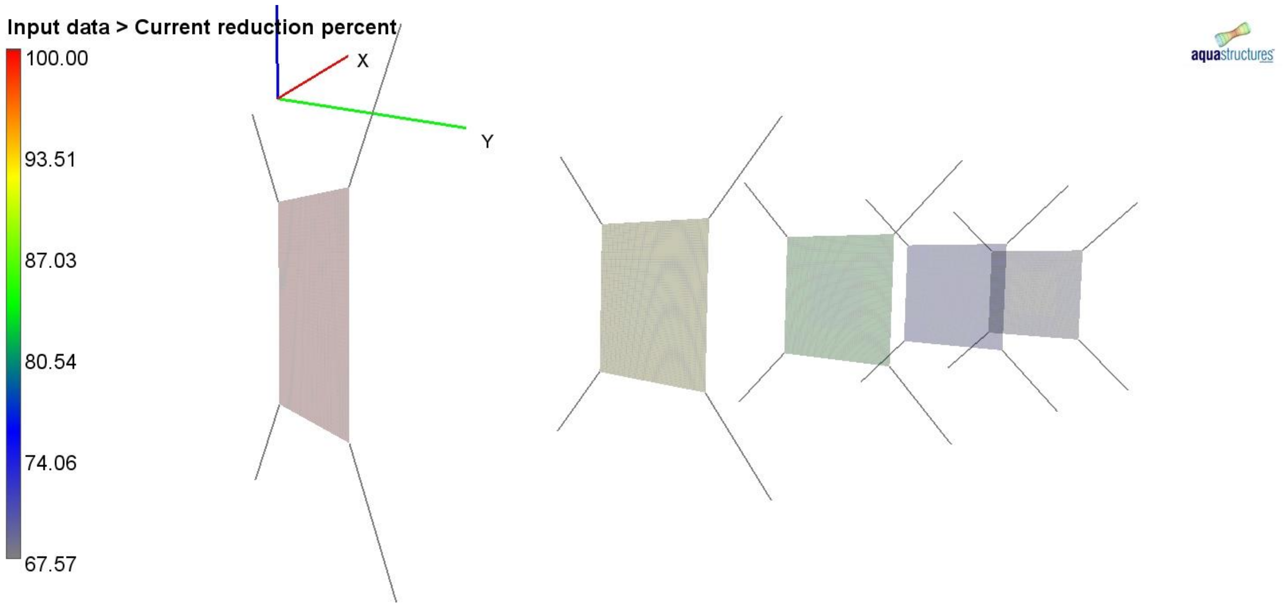

Figure 3 Current reduction for the different net panels. 100 % means no current reduction is accounted for. 67 % means the current velocity to the net is 67 % of the original current velocity. Solidity ratio of the net panels is 16 %.

Figure 4 shows how many nets shading upstream to the net. The number “4” means that the rearmost net panel has four net panels in front upstream.

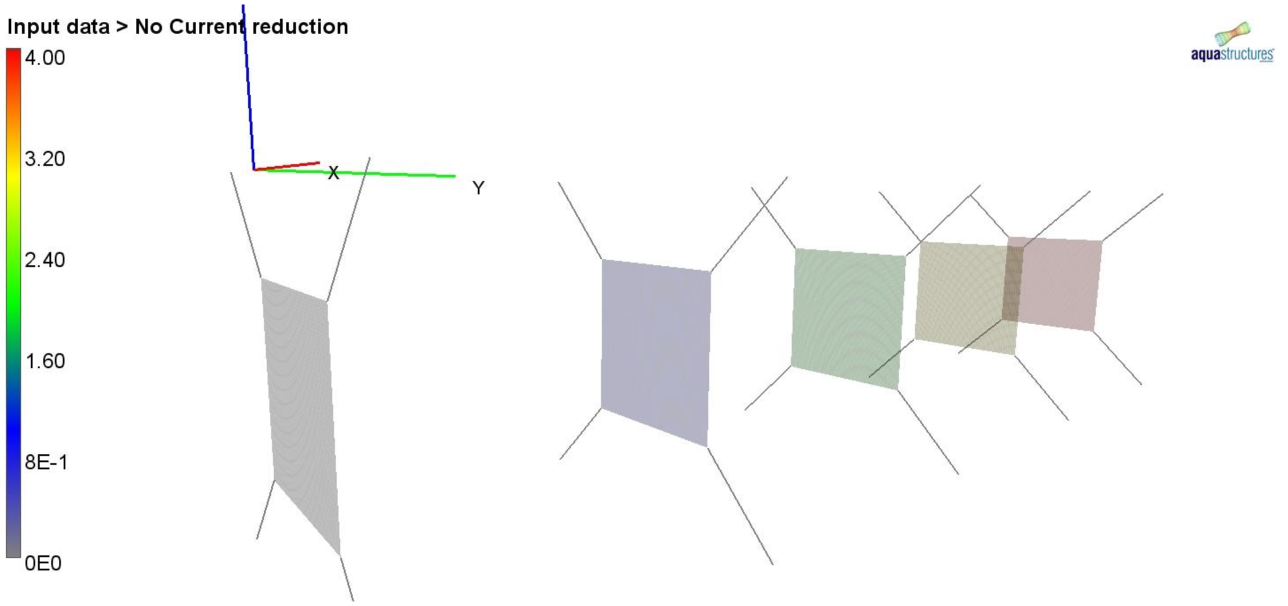

Figure 4 How many net panels in front that cast shadow to the current membrane.

Figure 5 shows the same case as in Figure 3, but with double solidity on the nets. As seen from this figure, the current reduction through nets is higher for this case. I.e. 67 % (from Figure 3), and 48.24 % (in Figure 5).

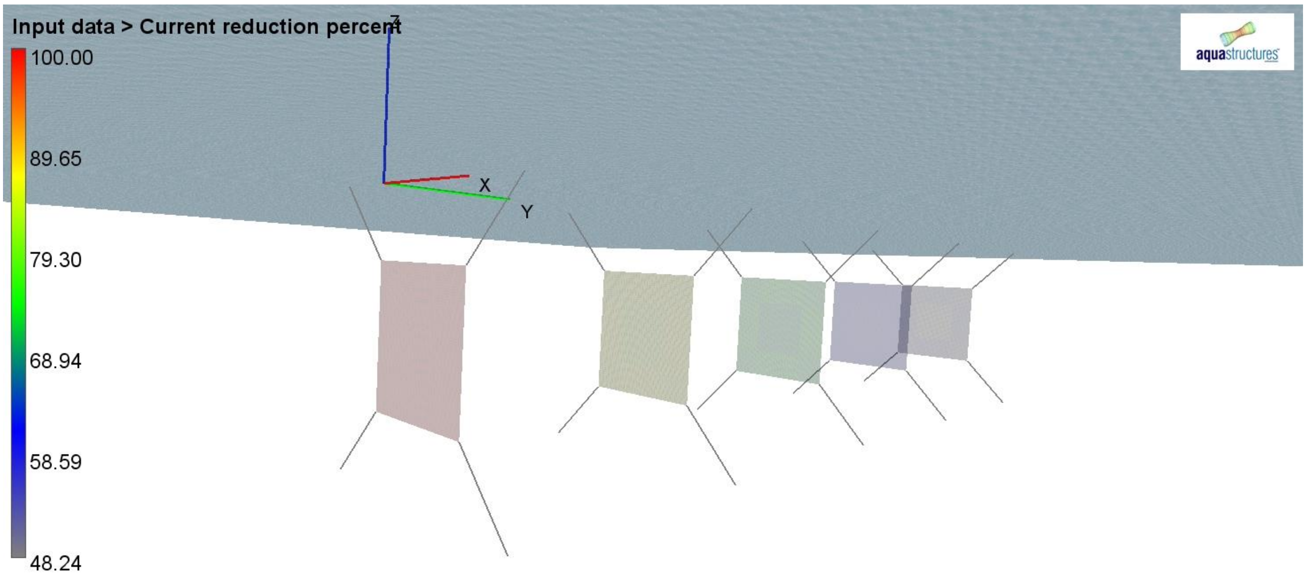

Figure 5 Current reduction with a solidity ratio of 32 %.

In Figure 6 the current has an angle relative to the y-axis, such that some parts of the net panels, situated downstream, does not experience any current reduction.

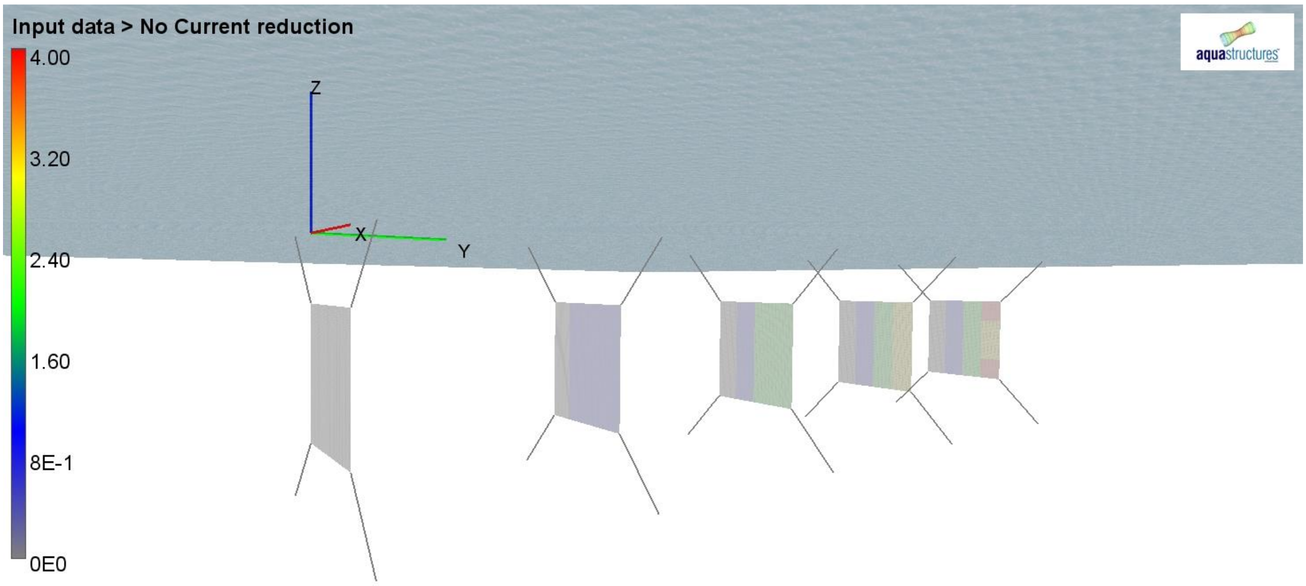

Figure 6 Number of nets accounting for current reduction for a case with skew current

3.2 Example: 1. From initial shape

Figure 7 shows the same as Figure 6 but in this case the current reduction factor is derived in the initial configuration, as seen from comparing the two, there is some difference

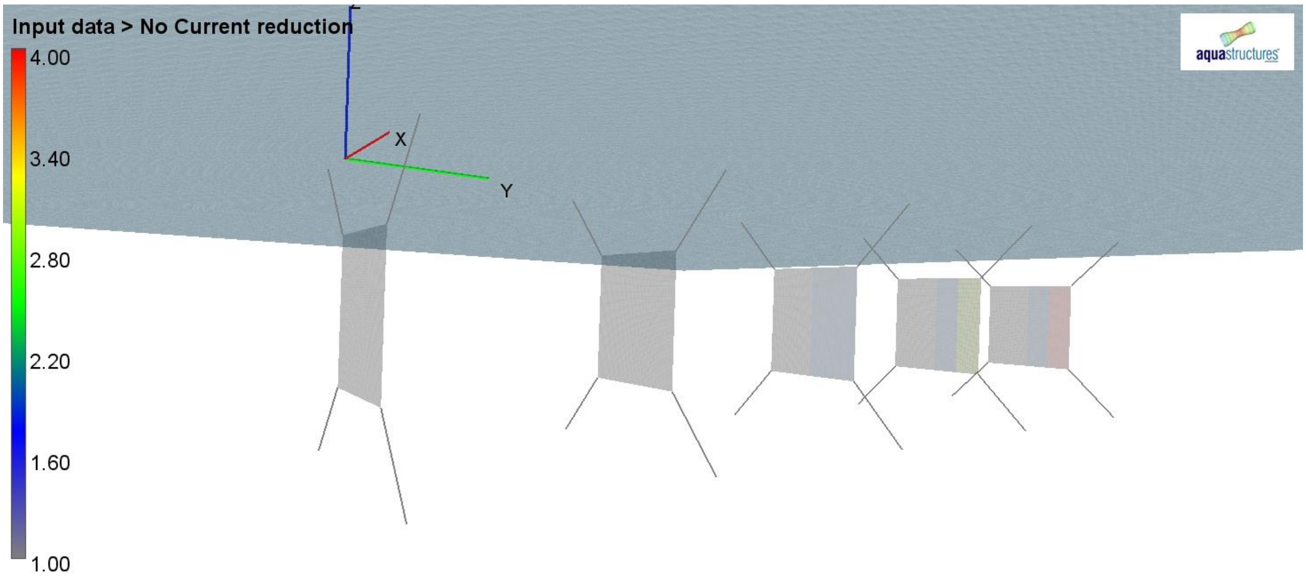

Figure 7 Same case as Figure 6, but in this case current reduction factor is derived from the initial configuration.

4 AquaSim case study – Fish cages with lice-skirts

In some cases, the implementation of current reduction can be of large importance for results. Chapter 4.1 and 4.2 presents two case studies regarding this.

4.1 Current reduction type: 1. From initial configuration

Consider the case shown in Figure 8, where conical fish cages are equipped with lice-skirts, and one uses the current reduction type: 1. From initial configuration (see Table 1).

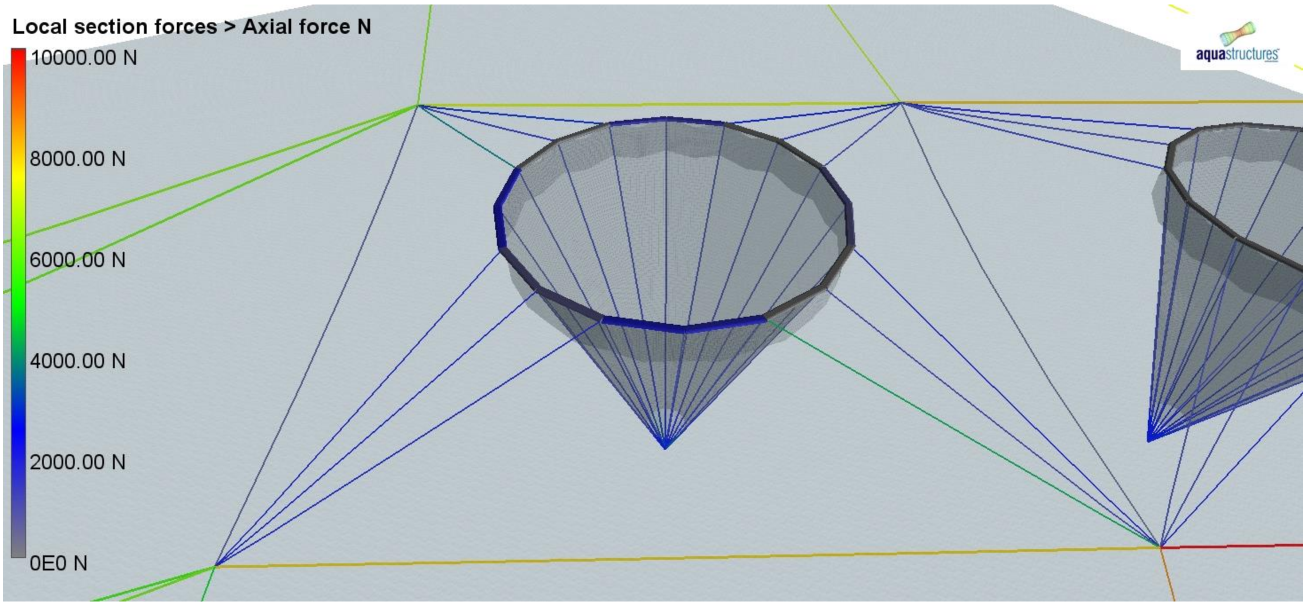

Figure 8 Cage system with lice-skirt.

The lice-nets have usually a rather high solidity. That means there will be a large current reduction in the nets situated downstream from the lice-net. As seen in Figure 9 the applied current velocity is approximately 60 % of the original velocity in the main net behind the first lice-skirt.

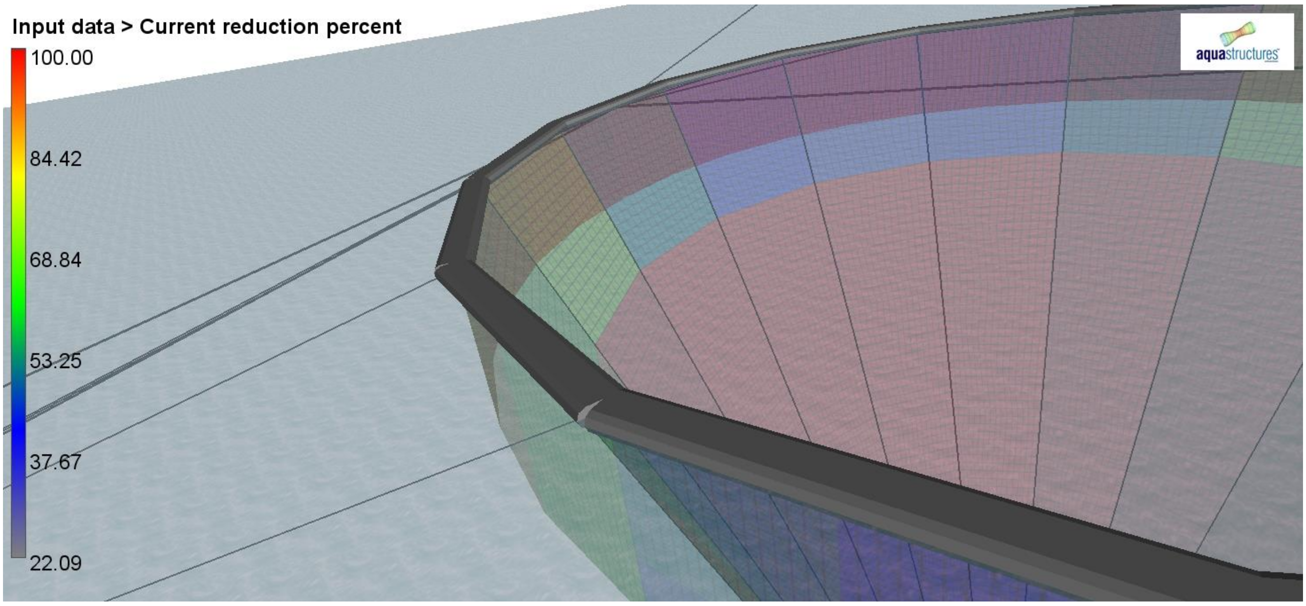

Figure 9 Conical net with vertical lice skirt on the upper part.

When current is applied, the net deforms as shown in Figure 10. As seen in this figure the deformation of the lice-skirt causes the lice-skirt to pass though the main net. When the current reduction factor, Type: 1. From initial shape, now is applied to the main net, the drag forces that the main net experiences is lower. In addition, the drag forces that the lice-skirt is exposed to is minimal since the lice-skirt has deformed to a position tangential to the incoming current. This combination, reduced current velocity from initial shape and the deformation of the lice-skirt, will lead to lower forces in a model with lice-skirt than in a model without lice-skirt.

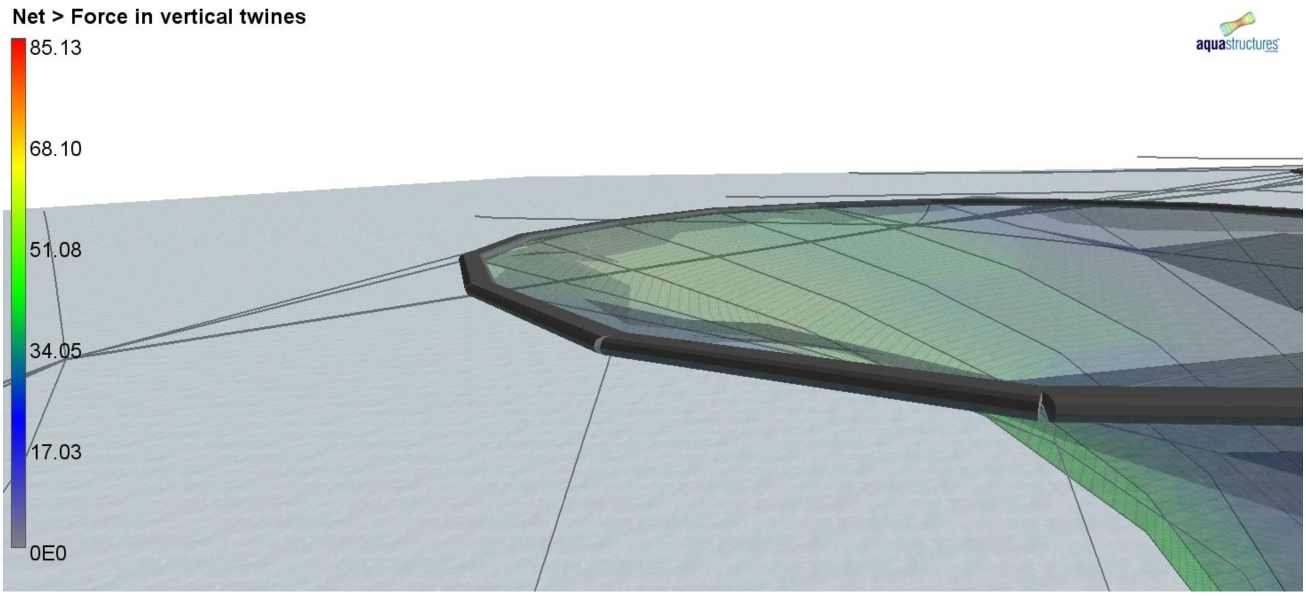

Figure 10 Deformed lice-skirt and main net.

4.2 Current reduction type: 2. Deformed by current

Figure 11 shows the same case as Figure 9, but in this case the current reduction factor has been calculated in the deformed condition. As seen from the figure, there is now none or little current reduction in the main net upstream and results shows higher forces with lice-skirt than without as it should be.

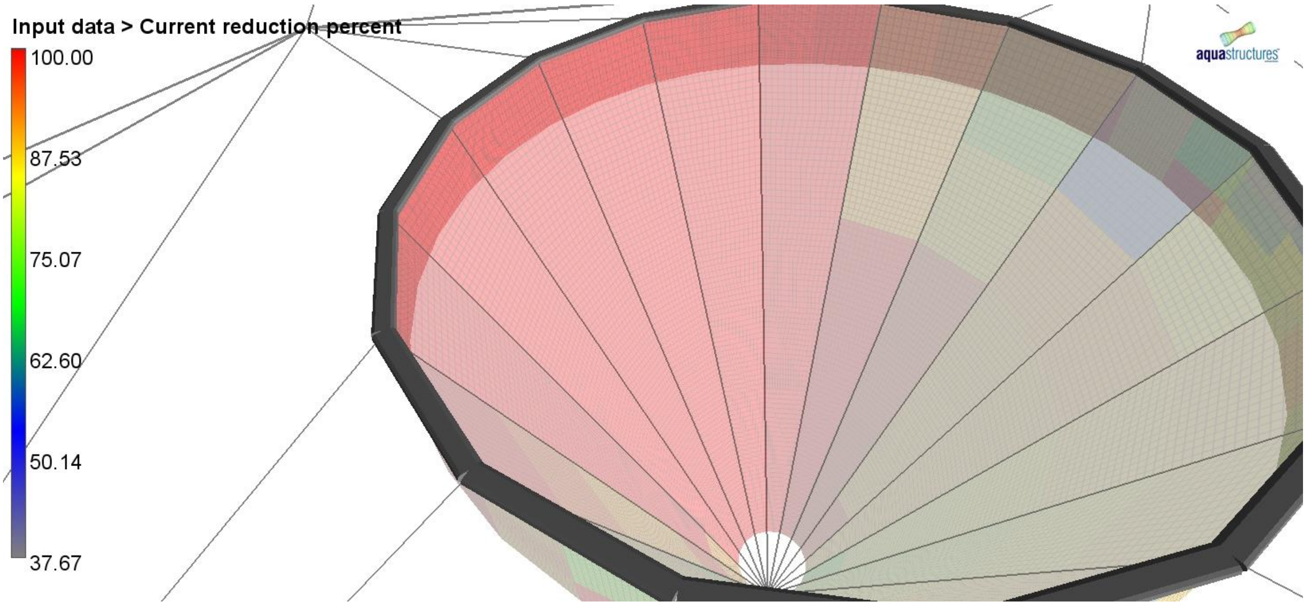

Figure 11 Current reduction factor calcu

5 Conclusions

This document shows how current reduction behind nets are accounted for in AquaSim in accordance with Løland (1991). It is shown that current reduction as such should be used with care, and one must be certain that the way current reduction is applied is relevant for the analysis.

6 References

1. Løland (1991) «Current forces on and flow through fish farms». Dr. Ing publication 1991:16. MTA report 1991:78. NTH, Institute for Marine Hydrodynamics.