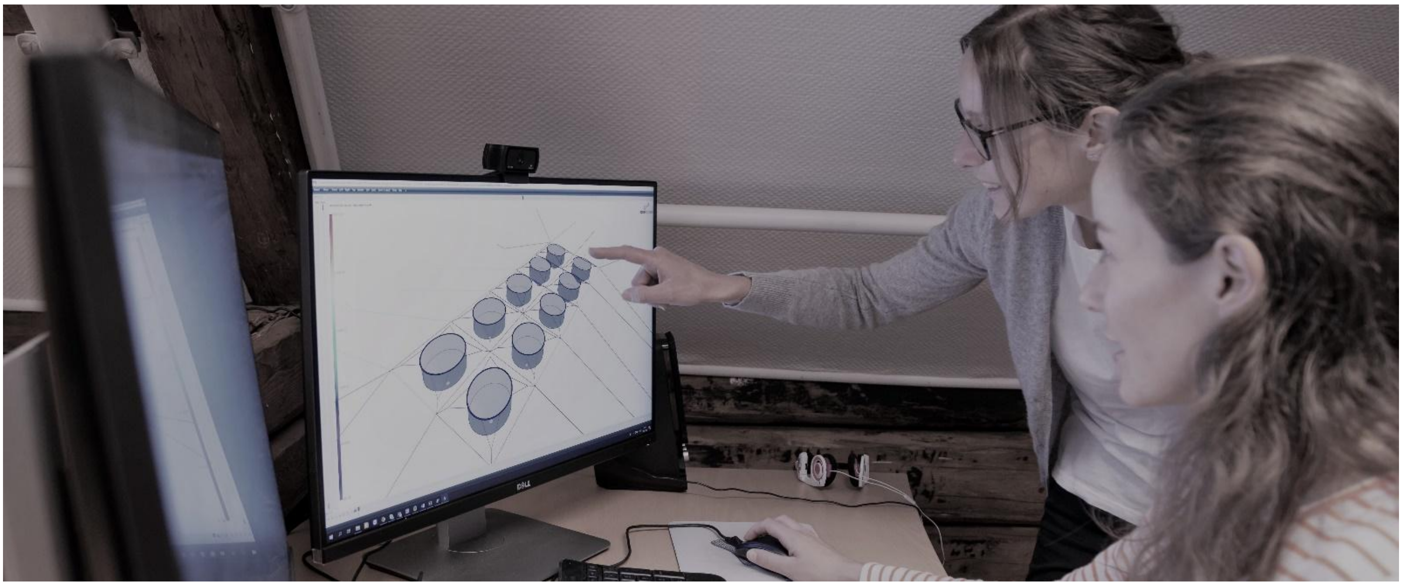
AquaSim training courses

- **Analysis of Marine Predator Attacking Fish Net**



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Aquastructures AS
Kjøpmannsgata 21, 7013 Trondheim
Norway

Content

1 Prerequisites

This tutorial presents a simple case study with the purpose of demonstrating functionality in AquaSim. It is assumed that the user is familiar with the basic principles of modelling and specifying material parameters in AquaEdit, as well as conducting analyses. If you are looking for an introduction to AquaSim we advise you to start with the Basic program tutorials. Familiarity with the *Component contact: Falling box* (Aquastructures, 2026a) tutorial is recommended, as the present tutorial builds on the same contact principles.

2 Introduction

2.1 Learning objectives

Upon completion of this case study, you will be able to:

- Model a predator net surrounding an aquaculture fish cage
- Establish a *Component contact*-table between the predator net and the fish cage net
- Understand how contact forces are transferred between two flexible net structures
- Define appropriate contact parameters including stiffness, damping, and contact distance
- Execute a dynamic analysis involving component contact
- Evaluate contact forces and structural response in AquaView

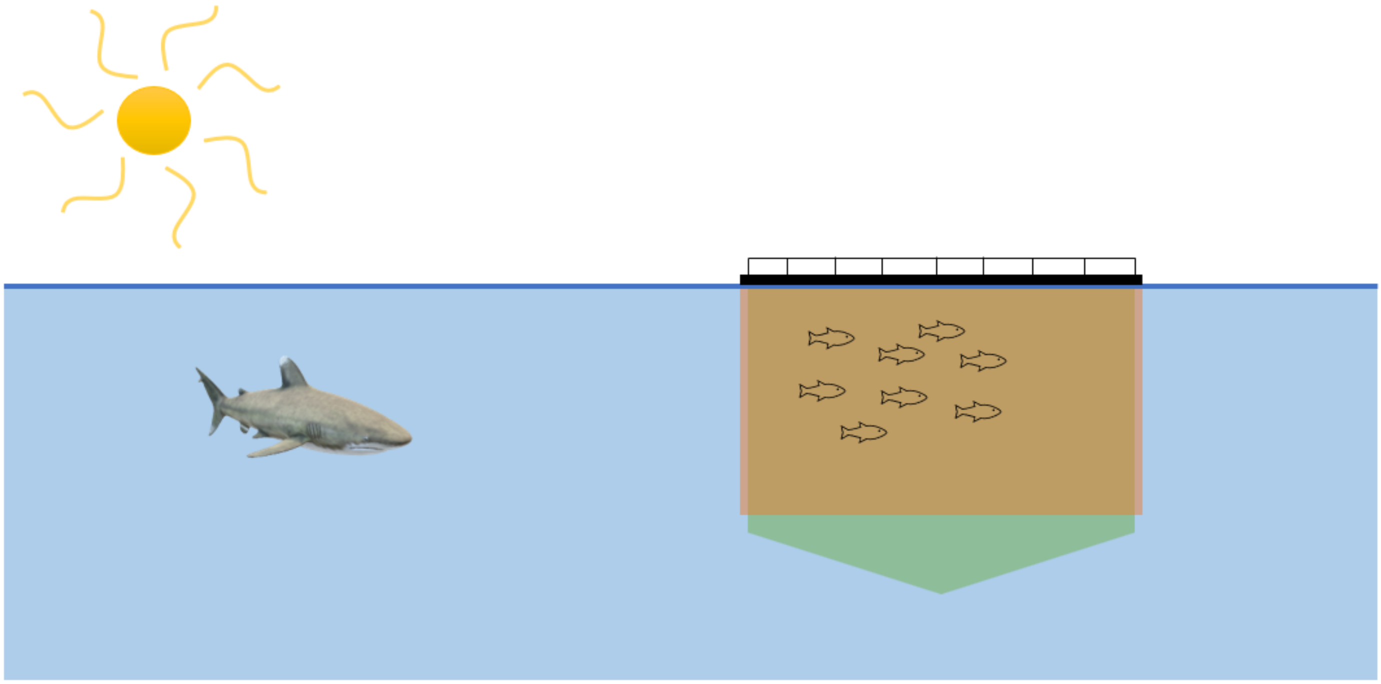

Figure 1

The marine predator may be any marine mammal, but can of course also be any objects such as lumber, boats, drones, ROVs, or torpedoes / missiles. This case study considers a net in water but also nets in air may be considered as the case shown in Figure 2.

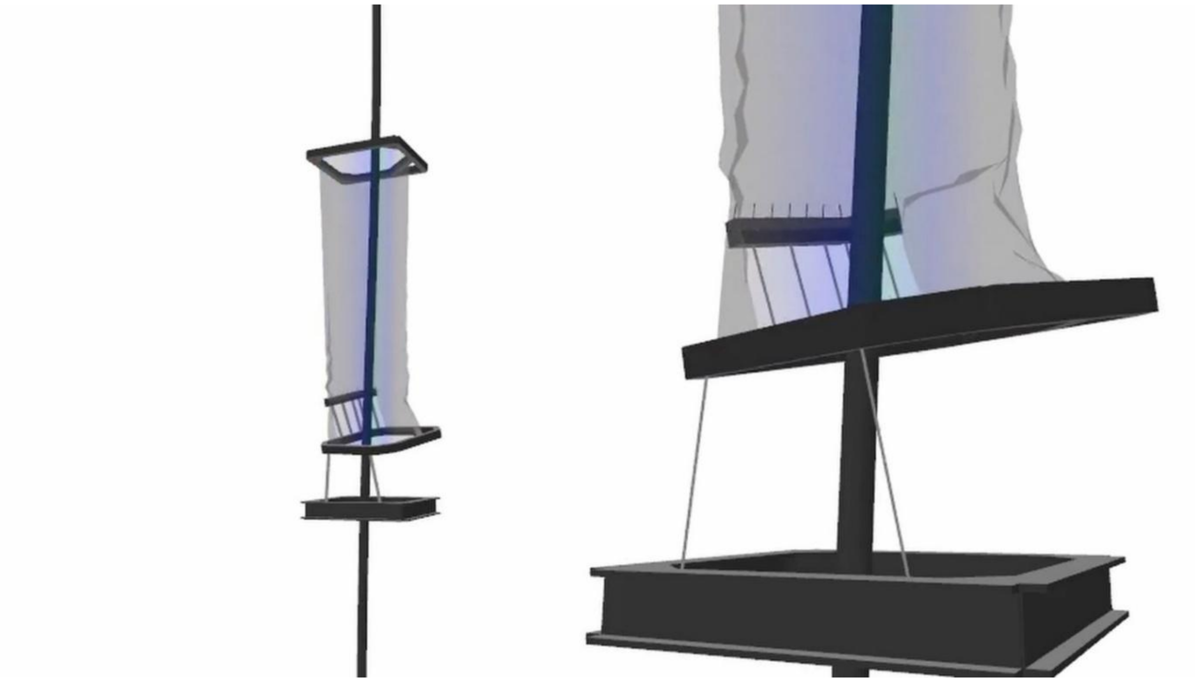

Figure 2 Safety net simulation (Aquastructures, 2026b)

2.2 Introduction

Predator nets are commonly used in aquaculture to protect fish cages from marine predators such as seals and sea lions. The predator net is typically a coarse, stiff outer net structure installed at a distance surrounding the main fish cage net. Under environmental loading from currents and waves, both the fish cage net and the predator net will deflect. In severe conditions, the two net structures may come into contact with one another — a situation that must be accounted for in the structural analysis to ensure neither net is overloaded.

This tutorial describes how contact between the predator and the fish cage net can be modelled and analyzed in AquaSim using the *Component contact* functionality. The basic principle is to define contact between two component groups (in this case the predator and the cage net) and specify the parameters governing the contact response. AquaSim tracks the relative position between the two component groups at every time step throughout the analysis. When elements from one component group approach elements from the other to within the specified contact distance, a repulsive contact force is activated.

The contact-force F is related to the contact spring stiffness k and the relative displacement r between the elements by:

$$F = k \cdot r^5$$

This nonlinear relationship means that the contact force increases rapidly as the two nets are pressed together, which is physically consistent with the behavior of flexible net structures in contact.

3 Modelling.

This section describes how to establish the numerical model in AquaSim. Before proceeding this tutorial, it is recommended that the user is familiar with the tutorial *Component contact: Falling box* (Aquastructures, 2026a), as the present case study builds on the same principles and methods. The overall model is illustrated in Figure 3. It should be noted that this model does not represent a complete fish farming facility with all its associated structural components. The model is intentionally simplified to include only the relevant components to demonstrate the situation on a principled level.

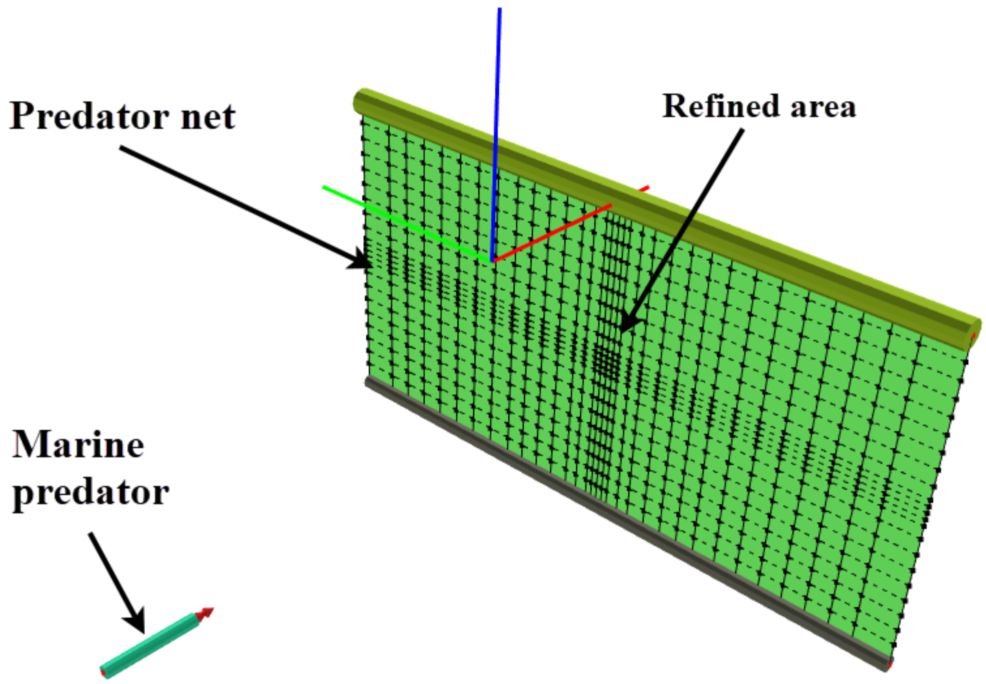

Figure 3 Net and predator approaching

3.1 Predator net model

The predator net is modelled with the use of MembraneX in AquaEdit. It is a flexible net structure suspended with a floating tube on the upper part and a sinker tube in the lower part. A local refinement of the net is introduced in the area where contact between the predator and net is expected. This is recommended when using contact elements, since the contact forces are transferred locally between the structural elements. Refinement will then improve the accuracy of the contact forces and stress distribution in the net.

3.2 Predator model

The predator is simplified to a *Beam* component in AquaEdit. It is a rigid element, considered sufficient to demonstrate the basic principle of structural response during impact. In practical applications, predator geometry may be represented using more advanced structural model depending on the required level of details. The structural input for the predator is illustrated in Figure 4.

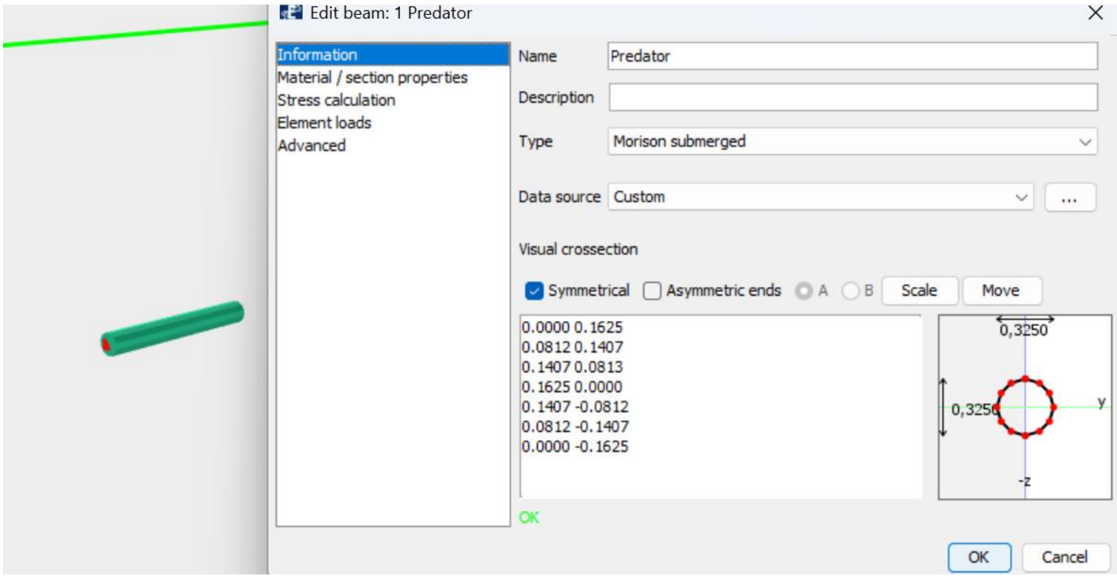

Figure 4 Structural input for the predator

The predator is assumed to be approximately self-buoyant in water. Therefore, the beam is assigned mass and buoyancy properties that reflect the effective submerged mass of the animal. The material- and hydrostatic properties of the predator are shown in Figure 5.

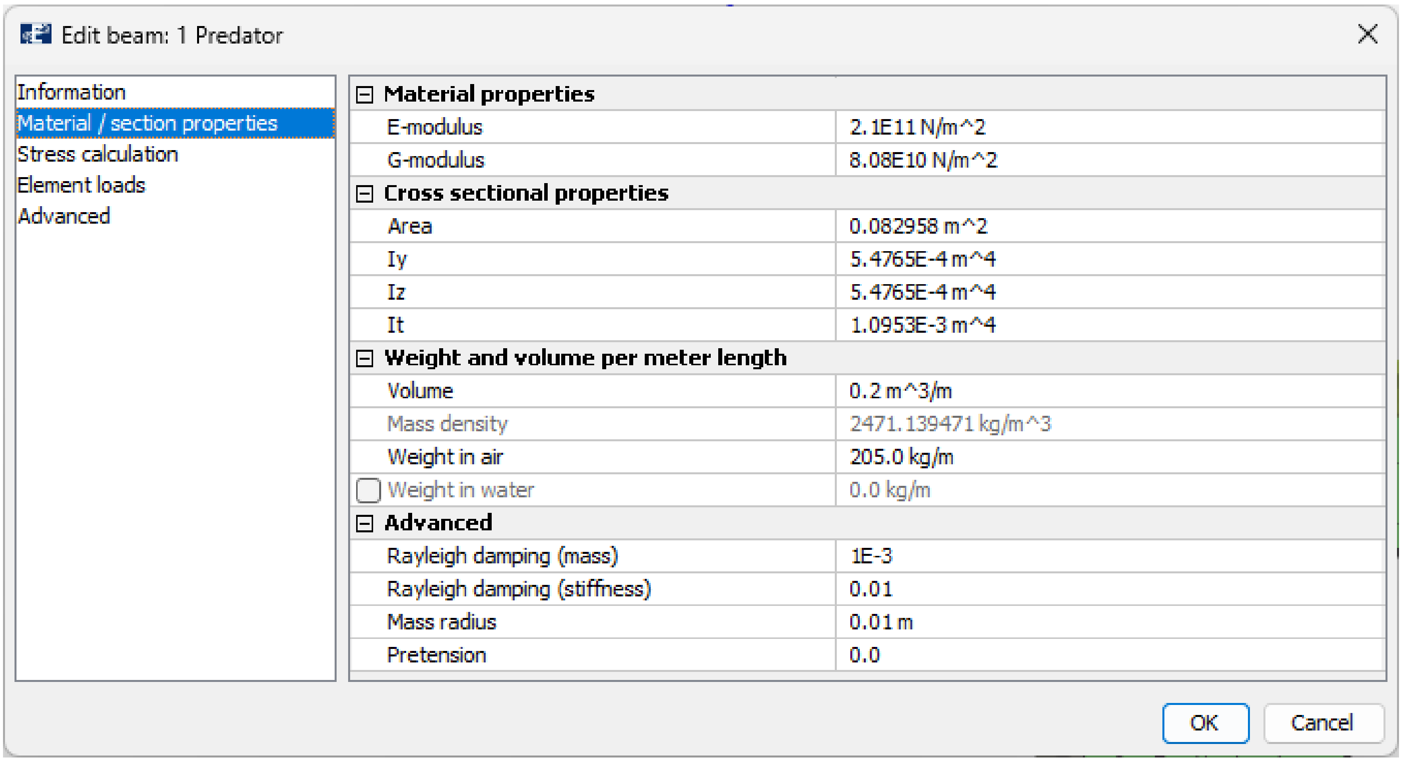

Figure 5 Properties of the predator

3.3 Predator acceleration

To generate impact velocity of the predator, a prescribed acceleration system is introduced to the predator beam. This is solved by applying:

- A time RAO function
- Offloaded springs connected to the predator nodes

This approach allows the predator to gradually accelerate to a target velocity before the impact occurs. The acceleration setup is illustrated in Figure 6.

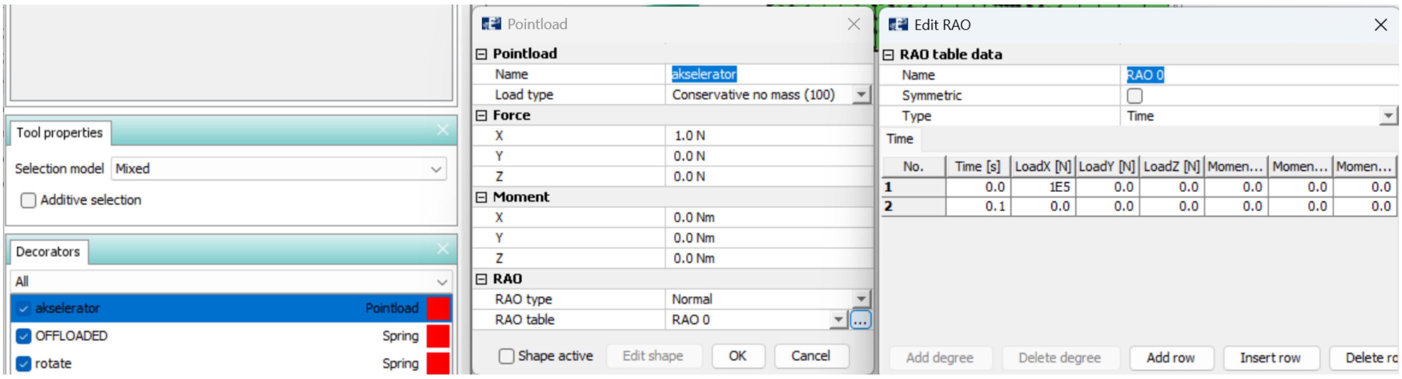

Figure 6 Introduction of accelerator and offloaded spring.

The accelerator and offloaded spring are attached to each node of the predator beam, as shown in Figure 7. Applying this velocity distribution on all nodes of the beam will provide a smoother and stable acceleration response during the initial phase of the simulation.

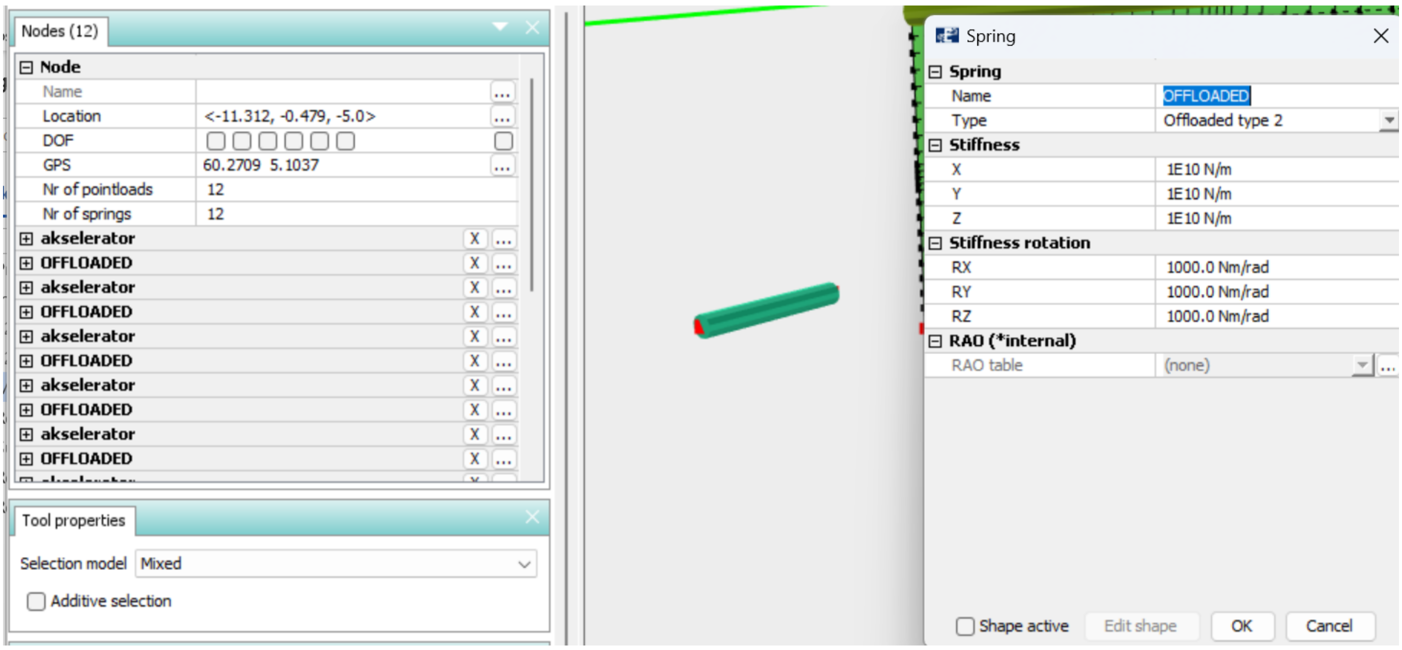

Figure 7 Accelerators and offloaded spring introduced to each node on the predator

3.4 Defining component contact

The properties of interaction between the predator and net are defined by applying the Component contact functionality found in the *Tools* > *Tables* section in AquaEdit. This is demonstrated in Figure 8.

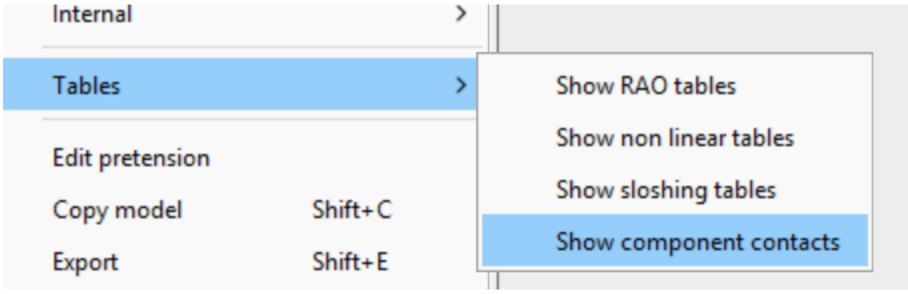

Figure 8 Component contact tables

The corresponding *Component contact* dialogue is shown in Figure 9.

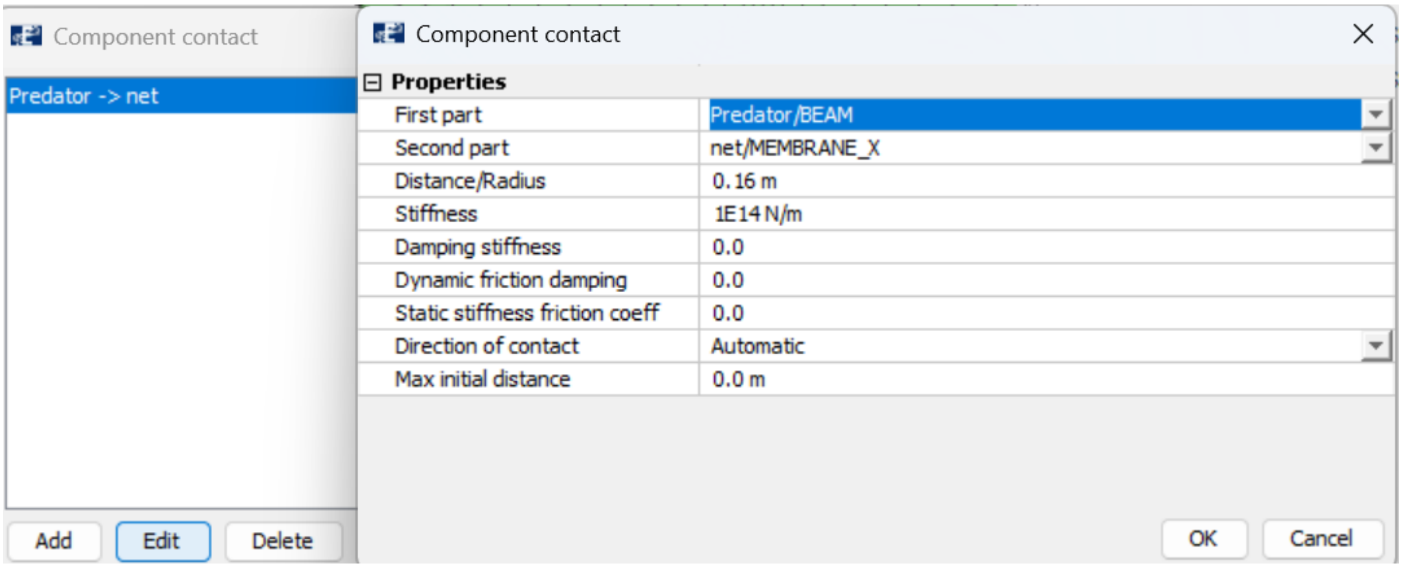

Figure 9 Component contact dialogue box.

The following parameters are important when defining the contact:

- Contact stiffness: defines the stiffness of the virtual contact springs that are activated at a specific distance between the components. Higher stiffness will reduce penetration but may also lead to numerical instability or convergence issues.
- Contact damping: introduce numerical damping during the contact and may help stabilize the analysis. This is a coefficient.
- Distance/ radius: defines when the virtual contact spring should be activated. When the distance between the First part and Second part is lower than this value, the spring is activated. In the present case study, this parameter may be interpreted as the radius of a sphere surrounding the front node of the predator beam.

When the contact sphere on the front node intersects the net elements, contact forces are activated. The selected radius should therefore be representative for the dimensions of the impacting body and evaluate this with the mesh density on the net. Having this in mind, the user might have to test and calibrate the contact input to achieve both a realistic impact and numerical stable simulation.

4 Analysis

The analysis parameters used for the simulation are presented in Figure 10.

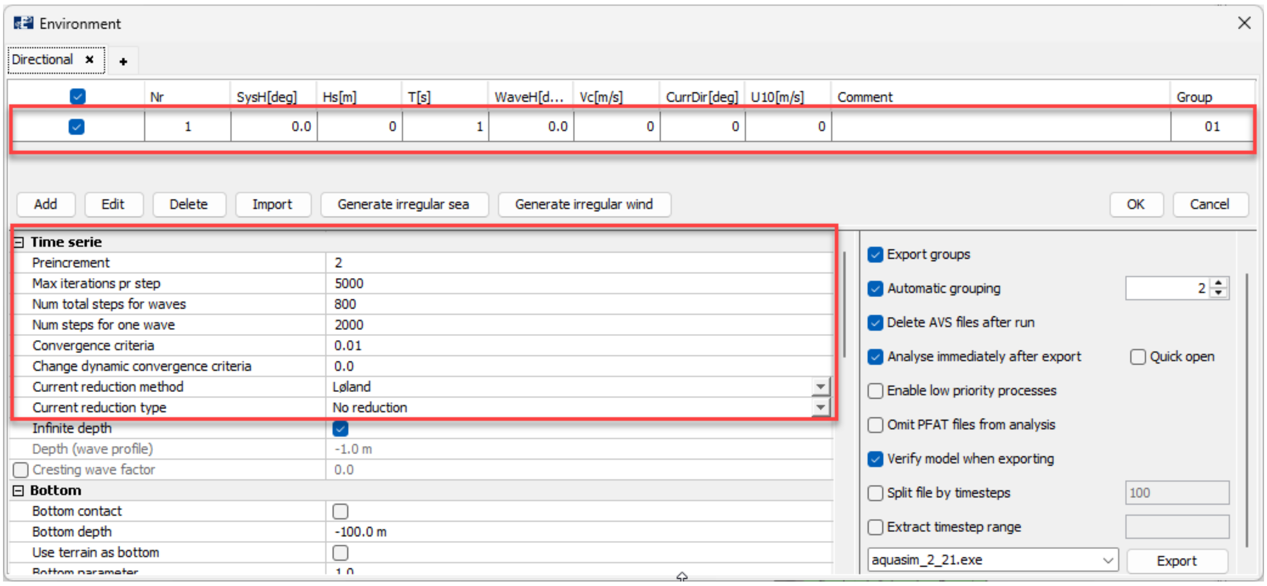

Figure 10 Analysis parameters

Since contact simulations are highly non-linear, the choice of analysis parameters might need several initial tests for achieving stable and physically realistic results. It is generally recommended to start out with simplified test analyses, such as this case study, before proceeding with the final simulation.

5 Results

This section presents results from the impact analysis and demonstrates how results can be evaluated in the post processor AquaView. When post processing, the main purpose is to verify that the contact simulation behaves as expected, evaluate the predator motion before and after impact, how the contact forces propagate through the net structure, and assess stresses and response in the area where impact occurs.

Figure 11 illustrates the vertical position of the predator and the net at the initial position.

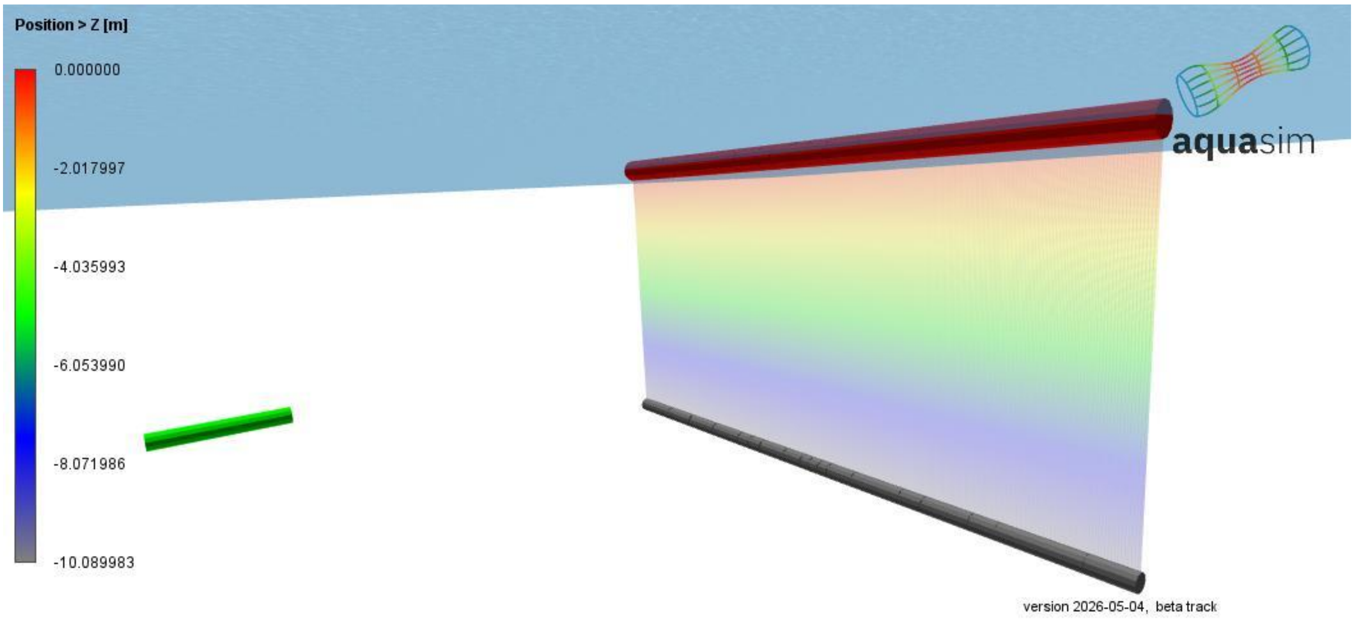

Figure 11 Vertical position of net system.

Figure 12 shows the velocity of the predator during impact. Initially, the predator beam is accelerated using the prescribed time RAO, and the offloaded spring system as described in previous sections. The velocity increases until the target in the RAO is reached. Then the RAO is no longer active. This is seen in the first part of the time-domain simulation in Figure 12. In the moment of impact, the velocity drops significantly due to transfer of kinetic energy from the predator beam to the net.

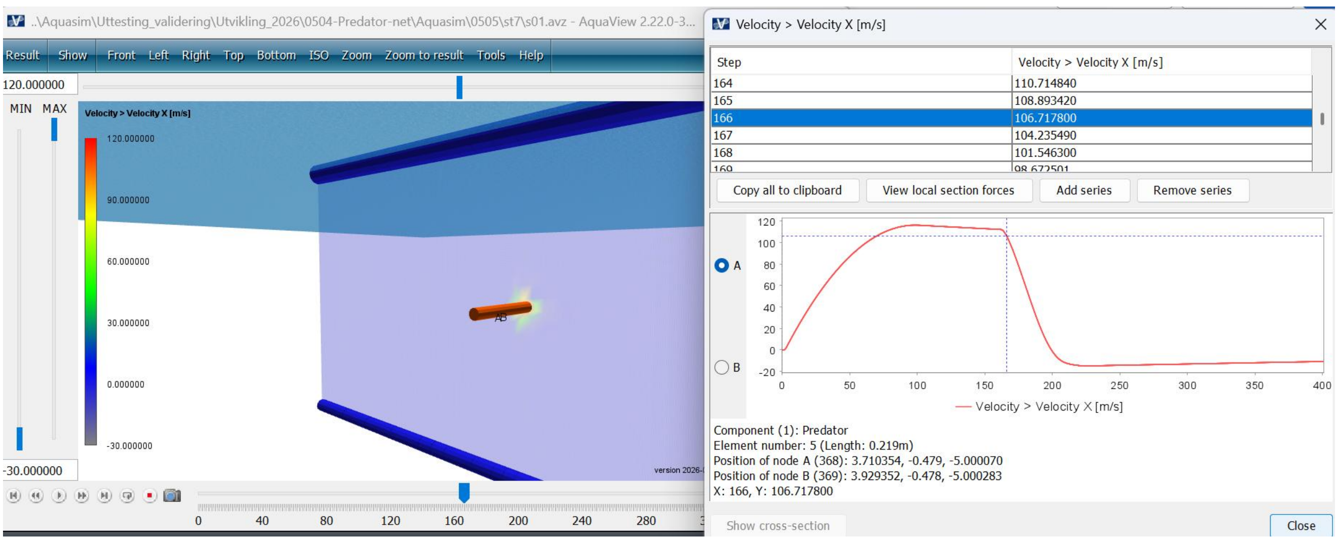

Figure 12 Predator velocity

Figure 13 - Figure 15 illustrates the stress distribution in the net during impact. Due to the flexibility of the net, the deformation and stress propagate through the surrounding mesh. Initially, the stresses are concentrated to a small region in the impact zone. This is seen in Figure 13. As time progresses, the contact forces are distributed through a larger part of the mesh.

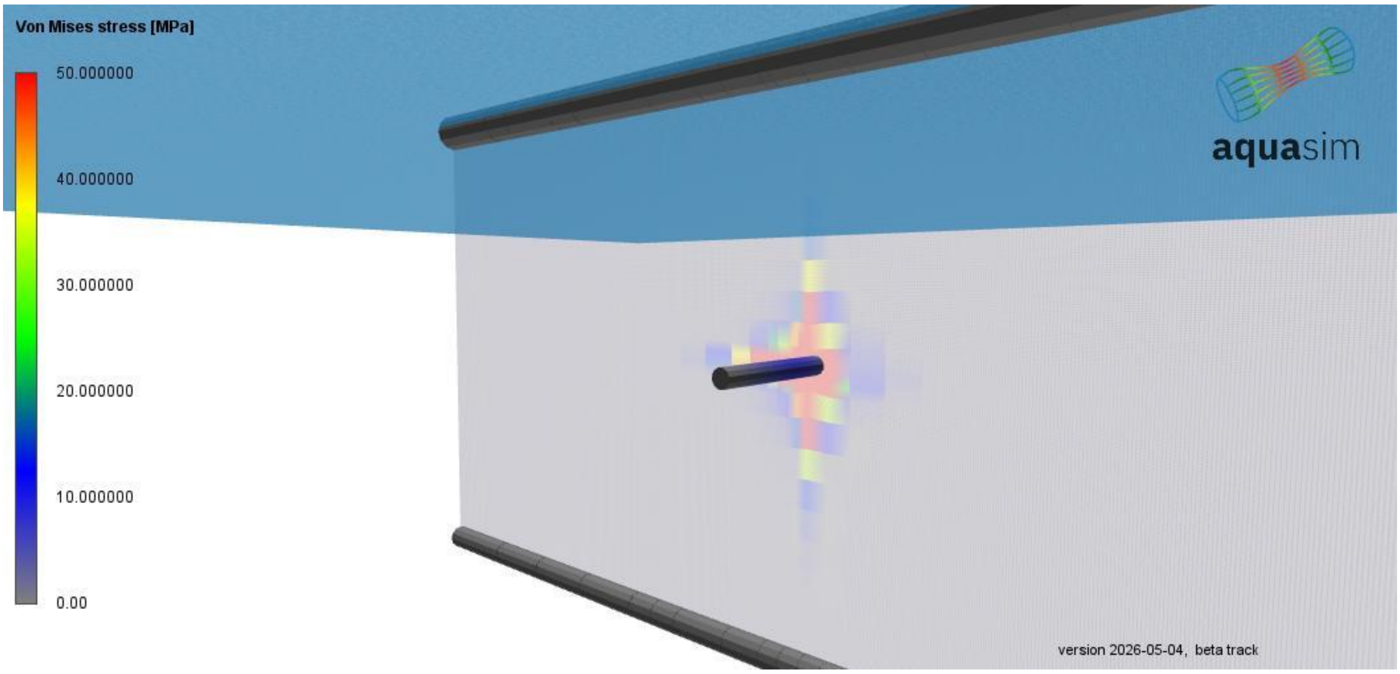

Figure 13 Right after impact

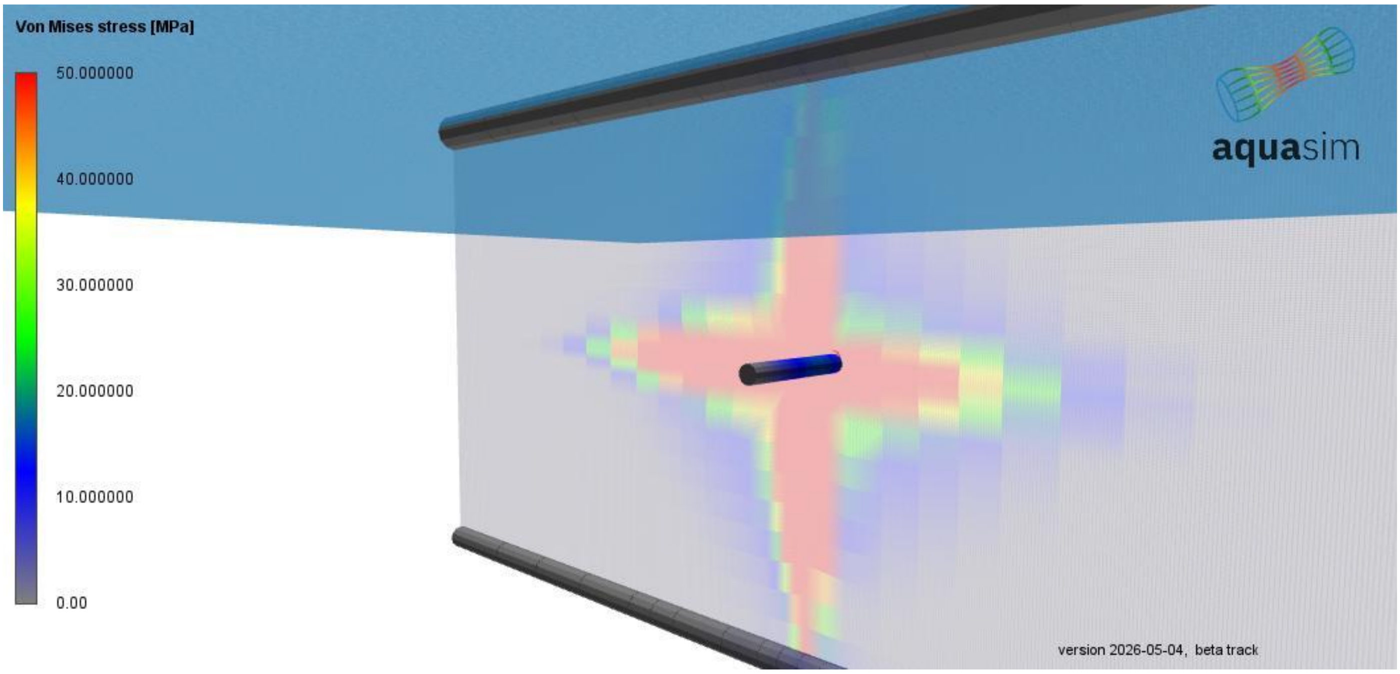

Figure 14 More milliseconds after impact

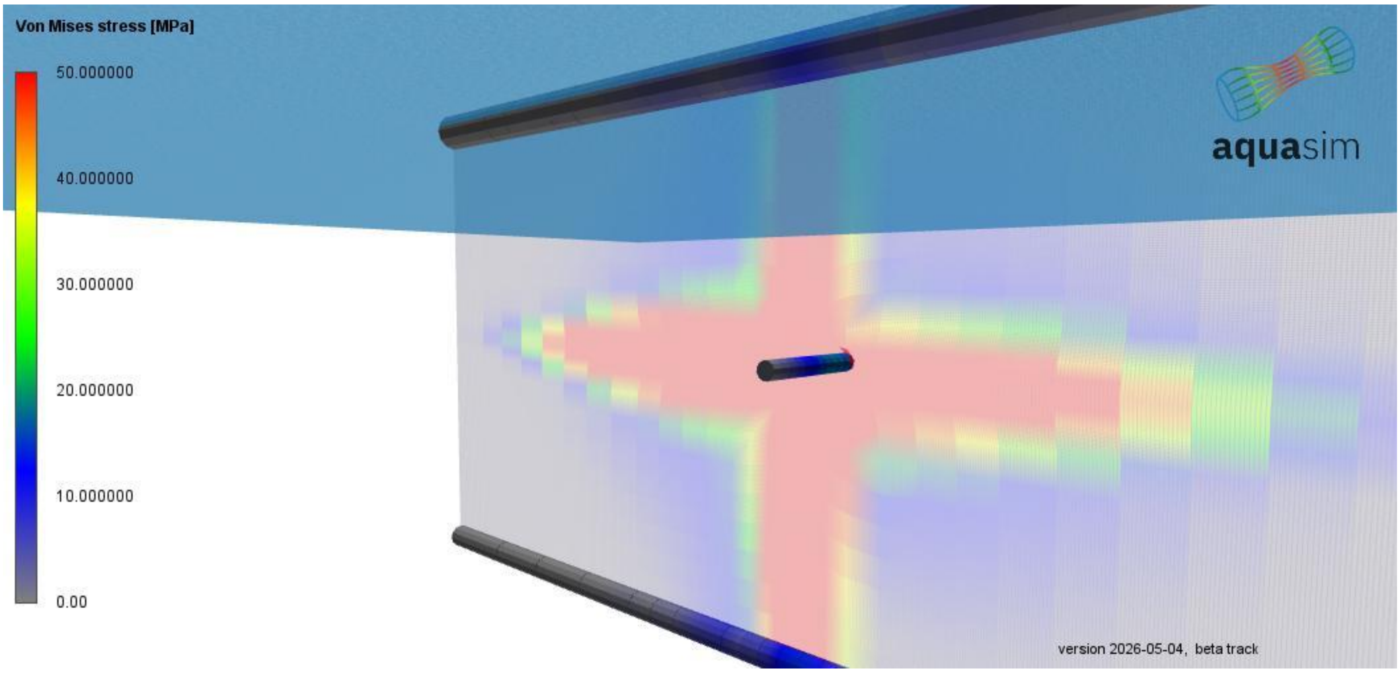

Figure 15 More milliseconds after impact

By reviewing the animation in AquaView, one can investigate when contact is initiated and how the contact forces are distributed over time. This is useful when it is necessary to identify regions with local high stresses, possible requirements for local reinforcements and general load transfer between construction parts.

6 Summary

This tutorial has demonstrated how to model and analyze marine predator attacks on fish net structures using the *Component contact* functionality in AquaSim.

The key steps covered include:

- Modelling the fish cage net with local mesh refinement in the expected impact zone
- Modelling the predator as a self-buoyant beam element with realistic mass properties
- Applying a time RAO and offloaded springs to accelerate the predator to a target velocity prior to impact
- Defining Component contact parameters — including contact spring stiffness, damping, and contact distance/radius — in the Tools–Tables section
- Running a dynamic time-domain analysis and evaluating results in AquaView

The contact force follows a nonlinear relationship with the relative displacement between the two components, meaning forces build rapidly as contact deepens. This will require calibration of the contact spring stiffness and the Distance/Radius parameter to achieve numerical convergence.

Post-processing in AquaView allows to track predator velocity, monitor the progression of stresses and forces in the net elements during and after impact, and follow how contact forces propagate through the structure over time.

Although this tutorial uses a simplified beam to represent the predator, the same modelling approach applies to any impacting body; including marine mammals, drifting objects, vessels, ROVs, or similar.

7 References

Aquastructures. (2026a, 05 07). *Component contact: Falling box*. Hentet fra aquasim.no: https://aquasim.no/documentation/componentcontact.html

Aquastructures. (2026b, 05 07). *Safety net*. Hentet fra aquasim.no: https://aquasim.no/fields/safetynet.html

8 Revision comments

Revision no.	Comment
1.0	First publication

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