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Report

Estimating the Physical Behaviour of Seine Ropes for Evaluating Demersal Seine Fishing

Reporting on experiments in the flume tank

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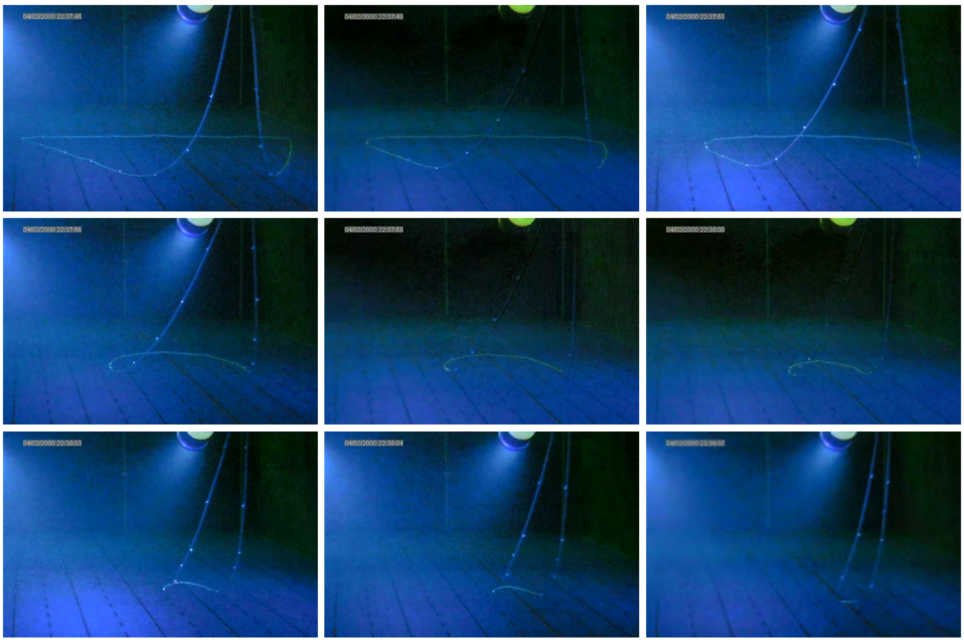

SINTEF Fisheries and Aquaculture

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28th November 2014

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Report

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ABSTRACT
Demersal Seining is an active fishing method which is based on seine ropes and a seine net. The seine ropes and net are laid out on the fishing ground in a way that they encircle an aggregation of fish. Because the area the seine ropes encircle is much larger than area swept by the seine net during the hauling process, the catching efficiency of a demersal seine depends to a large extent on the herding efficiency of the seine ropes. During the fishing operation, the fish is gradually herded by the seine ropes into the path of the net. Knowledge about how the size and shape of the area encircled by the seine ropes gradually change during the fishing process is important for an efficient fishery. The purpose of the project "Danish Seine: Computer based Development and Operation" (MAROFF-2 project no. 225193 / FHF 900861), funded by Research Council of Norway (RCN) and Norwegian Seafood Research Fund (FHF), is to develop software tools to investigate Danish Seine fishing. An important aspect of the research is to be able to simulate the physical behaviour of the seine ropes during the fishing process. This report describes flume tank experiments carried out with the purpose of later being able to validate a numerical simulation model for seine rope behaviour. The flume tank experiments were conducted by using two rope with varying physical properties and by varying the initial shape of ropes. The seine ropes were hauled back from the tank floor at different speeds. We applied a motion tracking system based on stereo vision with six underwater cameras to record the gradual change in the geometry of the area defined by the ropes. Information about the kinematic behaviour of the seine ropes and its dependency on its physical properties, initial layout pattern and hauling speed were acquired.

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Contents

1 Introduction

The purpose of the project ”Danish Seine: Computer based Development and Operation” (MAROFF-2 project no. 225193 / FHF project no. 900861), funded by Research Council of Norway (RCN) and Norwegian Seafood Research Fund (FHF), is to develop software tools to investigate Demersal Seine fishing. These tools include simulating the physical behaviour of the demersal seine gear during the fishing process. The project is led by Sintef Fisheries and Aquaculture (SFH), and is carried out in collaboration with the Norwegian College of Fishery Science at the University in Tromsø (UiT). About 20% of the Norwegian cod quota is caught by demersal seining (the Norwegian style fly dragging) and cod is the most important species in the Norwegian white fish fishery when measured in both tonnes landed and in value (http://www.råfisklaget.no). Thus, knowledge about the physical behaviour of this type of gear during fishing is very relevant. Most of the Norwegian demersal seine fishing targeting cod is conducted north of 64ºN. This fishing method has been increasingly favoured over the last decades at the expense of e.g. gillnetting and long lining. Many of the seine vessels operate in coastal areas, including fjords, while larger vessels also target fish in deeper waters. Especially within the last 15-20 years, vessel size, main engine power and gear size has increased (Digre et al. 2010). Demersal seining in Norwegian fishery targeting cod and other demersal fish is practiced by deploying two long seine ropes connected to the wing tips of the seine net in one end and the winches of the vessel on the other end. The length of the seine ropes is restricted to 2000 m each when fishing inside the four nautical mile limit. The seine net has a typical headline and fishing line length of 123 m and a maximum circumference of 156 m stretched in the mouth when used inside the four nautical mile limit. The seine ropes, made of up to Ø60 mm combination rope (polyethylene with a steel core) weighting more than 2 kg/m, are placed on the seabed in a quadrilateral pattern in order to encircle the targeted fish (Sainsbury 1996). Once the ropes and the net have reached the seabed the vessel starts moving forward at a speed of 1-1.5 knots. As a result of the vessel movement the seine ropes are moving towards each other and herd the fish into the centre of the encircled area; the collecting phase. At some instance the net will start moving along the seabed when pulled by the seine ropes. When the distance between the ropes has decreased to a certain level the rope drums are activated in order to close the wings fast and to force the last fraction of collected fish into the seine net; the closing phase. This fly dragging principle of demersal seining is shown in figure 1.

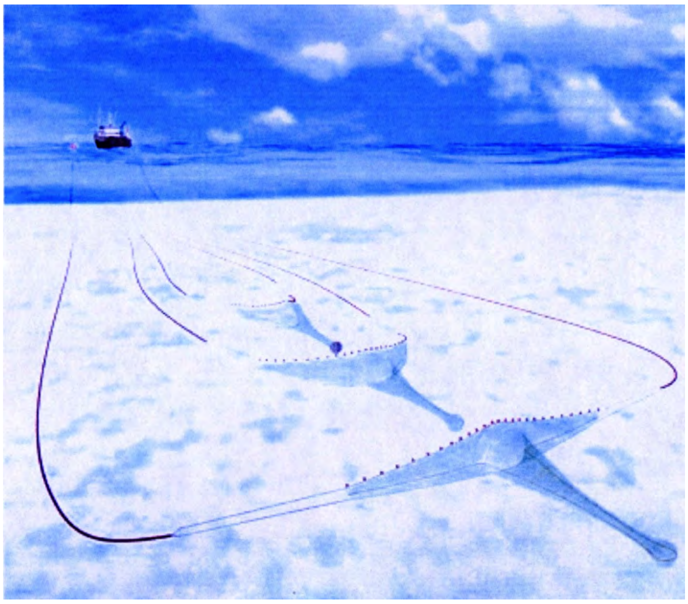

Figure 1: Principles of a demersal seine in a fly dragging operation (not scaled), showing the collecting and closing phases. © Crown copyright 2004.

Recent underwater observations have confirmed that fish starts entering the funnel of the net as soon as the seine net is sat in motion during the collecting phase. However, the majority of those fish herded by the ropes enter the belly and codend of the seine net in the latter stage of the closing phase. The actual fishing time, i.e. the collecting and closing phases, may be as short as 15 minutes. The good initial physical condition of seine net caught fish is often explained by the relatively low towing speed and short fishing time. This is the reason demersal seine is the gear commonly used to catch live cod for capture based aquaculture (Dreyer at al. 2008).

Since the area on the seabed encircled by the seine ropes is typical much larger than the swept area that will be covered by the seine net during the fishing process the catching efficiency of a demersal seine fishing operation depends to a large extent on the efficiency by which the seine ropes are able to herd the fish into and subsequently maintain them in the path of the net until they are overtaken by it in the late stages of the fishing process. Knowledge about how the size and shape of the area encircled by the seine ropes gradually change during the fishing process is therefore important for an efficient fishery. Thus, being able to simulate the physical behaviour of the seine ropes during the fishing process is an important aspect of simulating the demersal seine fishing process.

To be able to develop a reliable simulation model for the physical behaviour of seine ropes it is necessary with some experimental data to validate the model against. The flume tank experiments reported here were carried out to obtain such data. This report describes those flume tank experiments. The flume tank experiments were conducted by varying the physical properties of the ropes and the initial shape of the area encircled by them. The seine ropes were hauled back from the tank floor at different speeds. We applied a motion tracking system based on stereo vision with six underwater cameras to record the gradual change in the geometry of the area encircled by the ropes. Information about the kinematic behaviour of the seine ropes and its dependency on its physical properties, initial layout pattern and hauling speed were acquired. The current report outlines experimental cases conducted and methods applied. It also provides a detailed description of all results obtained with the purpose of easing its later use in connection with the development and validation of the simulation model, which is also being developed in the research project.

2 Material and Method

2.1 Flumetank

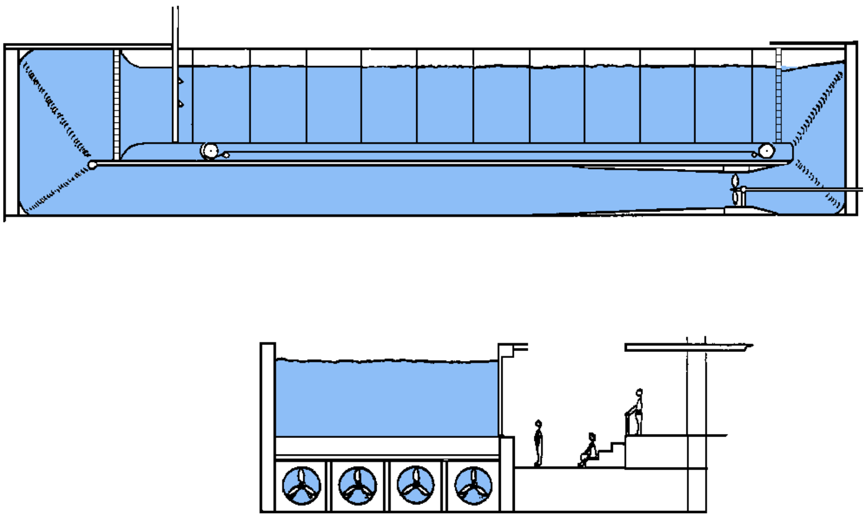

Figure 2: Sketch of the flume tank

The experiments were conducted in the SINTEF operated flume tank in Hirtshals, Denmark. The measuring section of the tank is 21.3 m long and 8 m wide, with an average water depth of 2.7 m. The volume of water is 1200 m3. The maximum water speed is 1 m/s. Four propellers and motors of 64 KW generate the water flow. The bottom consist of a conveyer belt made of nylon. Speed adjustable, it can be locked with water speed. The seine rope experiment were conducted with neither water current nor bottom movement. Figure 2 shows a sketch of the flume tank.

Figure 3: Foto from the flume tank

2.2 Motion Tracking

To measure the shape of the seine ropes in the flume tank continuously during the haul back procedure we applied the motion tracking system installed in the flume tank. This system is based on hardware and software from the Swedish company Qualisys AB. The measuring principle in the system is based on stereo vision techniques using six underwater cameras of the type ”Oqus Underwater”. Four of the cameras are mounted on a beam in the aft of the flume tank while the two other on a second beam further forward in the tank. The object under investigation is being equipped with a number of reflective markers in the current case, the seine ropes. Each camera emits a blue stroboscope light by LEDs build into each of the cameras in a circular arrangement. The emitted blue light is then reflected on the surface of the marker back to the camera to provide a 2D position in camera coordinates of the markers. The maximum sampling frequency of the system is more than 100 Hz and the system can follow more than 200 reflective markers. Extracting 3D coordinates for a marker requires that at least two of the six cameras simultaneously acquire the 2D position for the marker. Thus 3D motion tracking of the target object occurs only at the points where markers are located on the object. The markers we used for the experiment consist of a spherical body (diameter of 3.2 mm) covered in a retro-reflective tape designed to work underwater (figure 4).

Figure 4: The reflective marker sewn on to the seine rope.

For the motion tracking we mounted 23 reflective markers on the seine rope along its length. For the stretched rope the distance between neighbouring markers was approximately 1m except for between two pairs of the markers. For these the distance was only 0.5 m to obtain a better resolution on the motion of the seine rope near the corners of the initial layout patterns. Figure 5 shows a seine rope in the flume tank with reflective markers mounted along it.

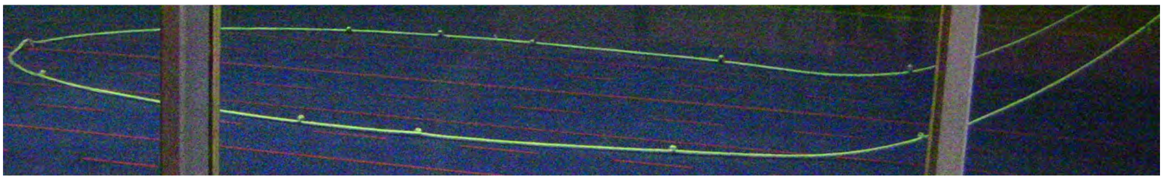

Figure 5: A seine rope in the flume tank. Showing the reflective markers attached to the rope along its length.

Figure 6 demonstrates the data acquisition principle applied for the motion tracking of the seine rope. The figure shows the camera emitting blue light to illuminate the reflective markers attached along the seine rope. The light is then reflected on the surface of the markers to generate a 2D light spots in the cameras' field of view.

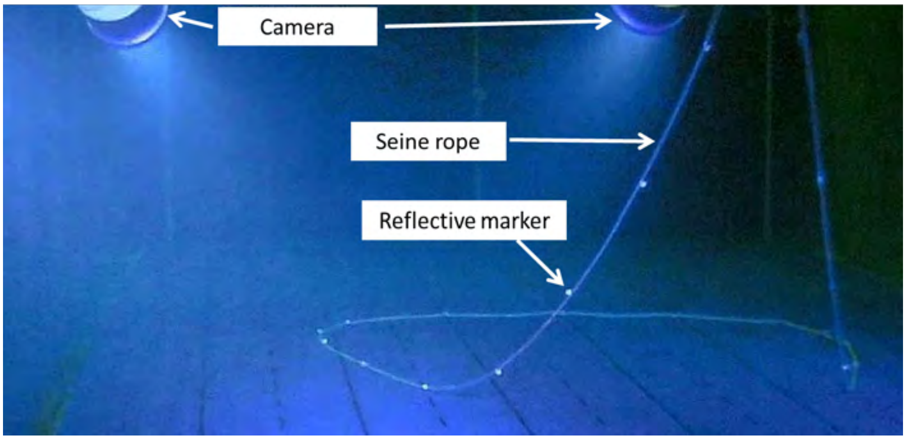

Figure 6: Photo from the flume tank of the data acquisition principle applied.

Using the data acquisition method illustrated in figure 6 simultaneous 2D camera positions for all of the reflective markers was obtained by using the total field of view obtained with the six underwater cameras applied. These was then processed in the Qualisys analysis software using the stereo vision principle to obtain the simultaneous 3D geometrical coordinates on the position of all the reflective markers mounted on the rope. Figure 7 shows an example of this with a screen dump form the Qualisys software.

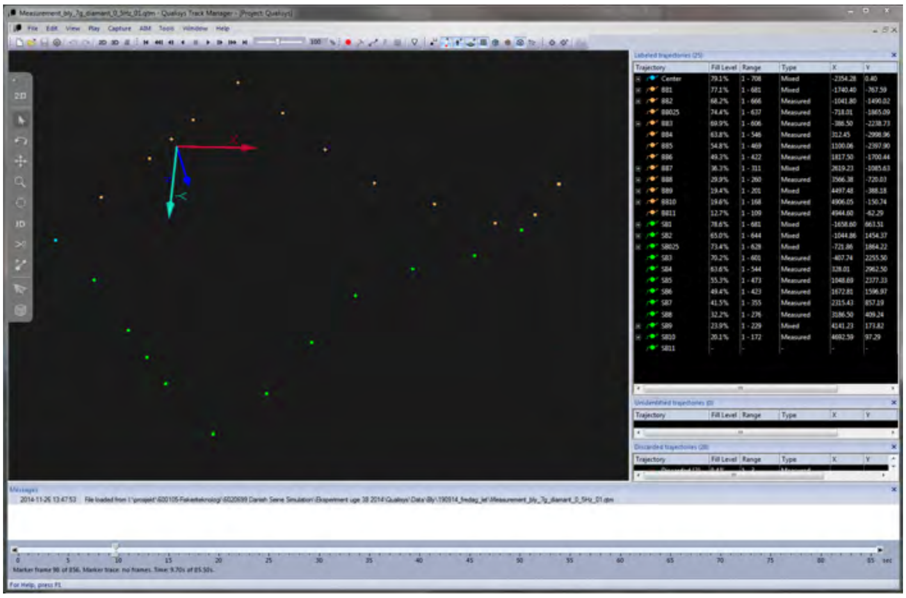

Figure 7: Screen shot of the Qualisys software, showing the result of a measurement of a diamond layout seine haul.

With a frequency of 10 Hz during the haul back procedure, we acquired the 3D position of the reflective markers on the seine rope. From this we obtained by means of the Qualisys analysis software a time trace of the position of each of the markers during the process. Figure 8 illustrates this by a screen dump from the Qualysis analysis software.

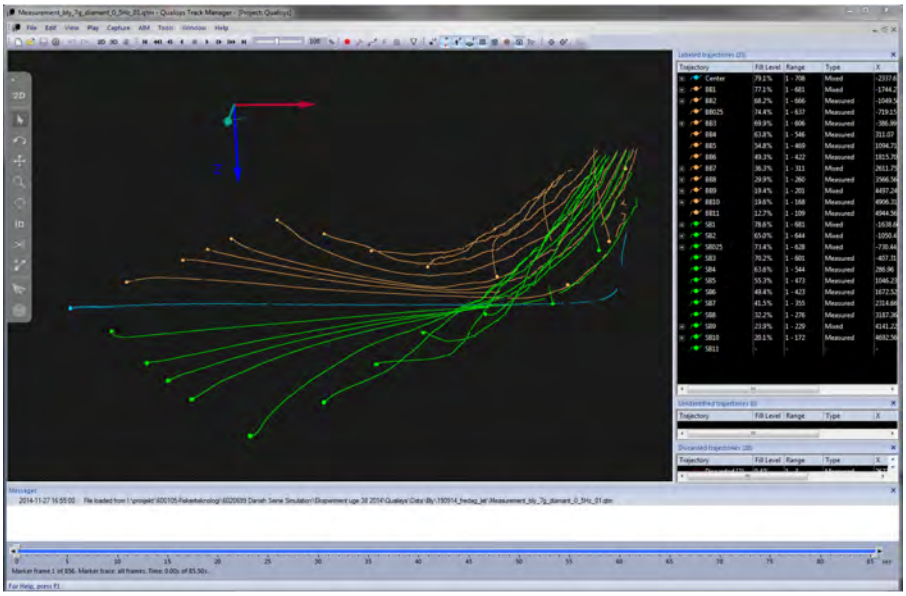

Figure 8: Screen shot of the Qualisys software, showing the traces of the movement of the individual markers during the haul back of the seine rope.

Based on the time traces of the reflective markers during the haul back of the seine rope (Fig. 8) we processed the data further to produce a sequence of 2D pictures of how the shape of the seine rope gradually change during the haul back process. We produced this sequence of the kinematic behaviour of the rope seen from above and from the side. Figure 9 shows an example on this. The type of information shown in this figure is later to be overlaid with similar plots obtained from simulations with the purpose to be able to validate the simulation model.

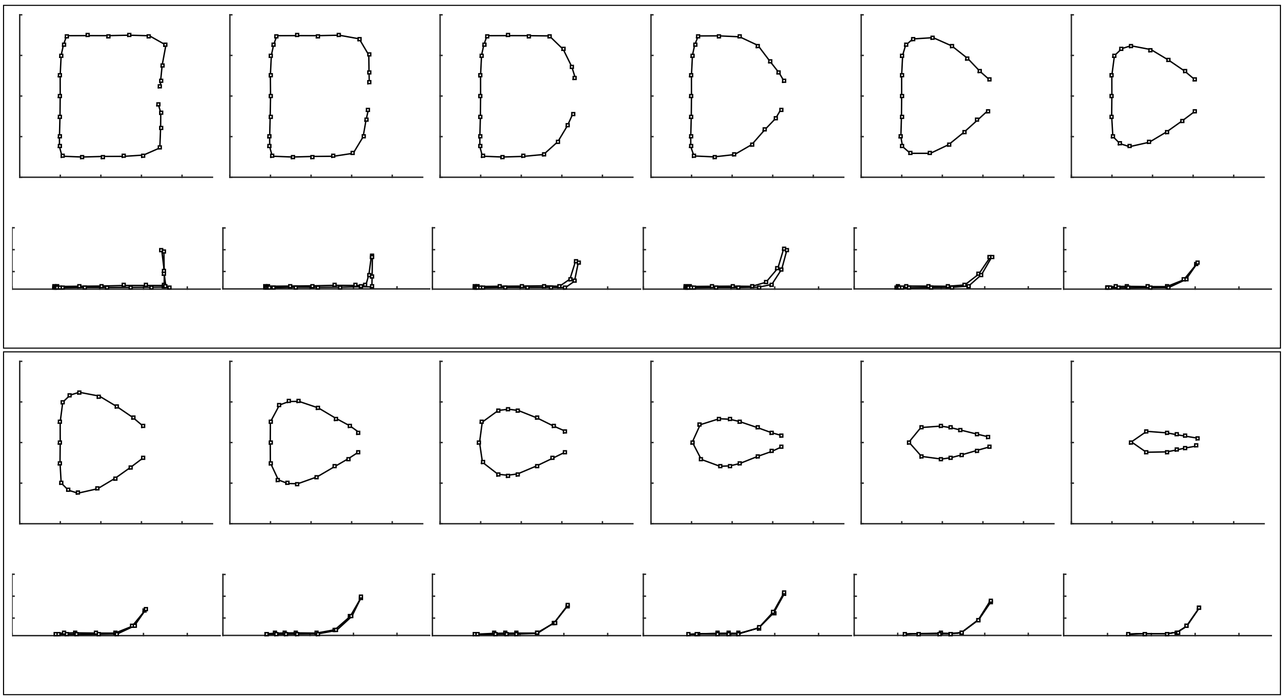

Figure 9: Showing the markers position from the top and side. The frames are 4 seconds apart.

2.3 Haul back procedure

To conduct the haul back (haul in) of the seine rope in the flume tank an electricity driven winch was mounted on the bridge of the flume tank and applied (Fig 10). A frequency convertor enable running different winch speeds between the different haul back procedures to investigate the potential effect on the seine rope behaviour by the winch speed.

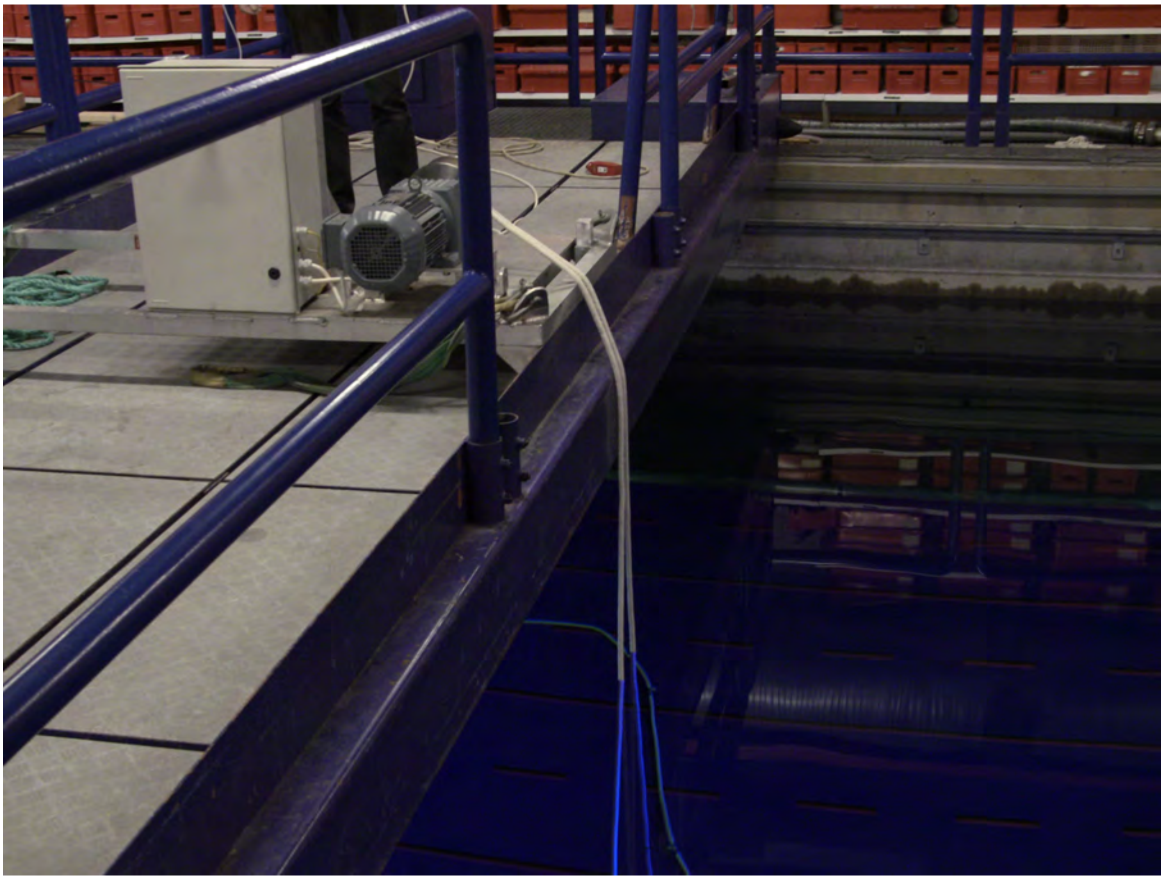

Figure 10: The winch with seine rope.

The winch drum had a diameter at 10 cm (Fig 11).

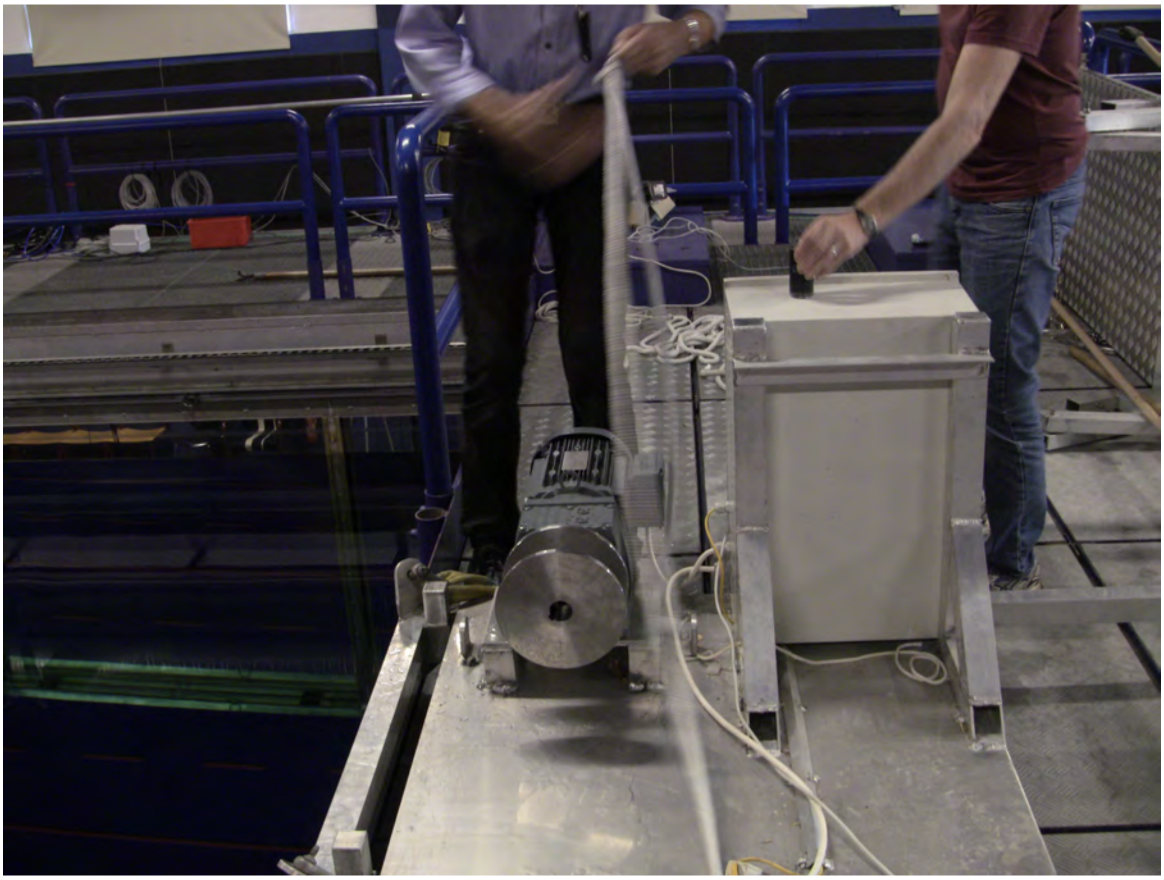

Figure 11: The 10cm winch

During the experiments we conducted the same haul back cases with two different winch speeds at respectively 0.5 hz (15.7 cm/s) and 1.0 hz (31.4 cm/s). Figure 12 shows an example of how the winch procedure gradually changed the seine rope geometry in the flume tank.

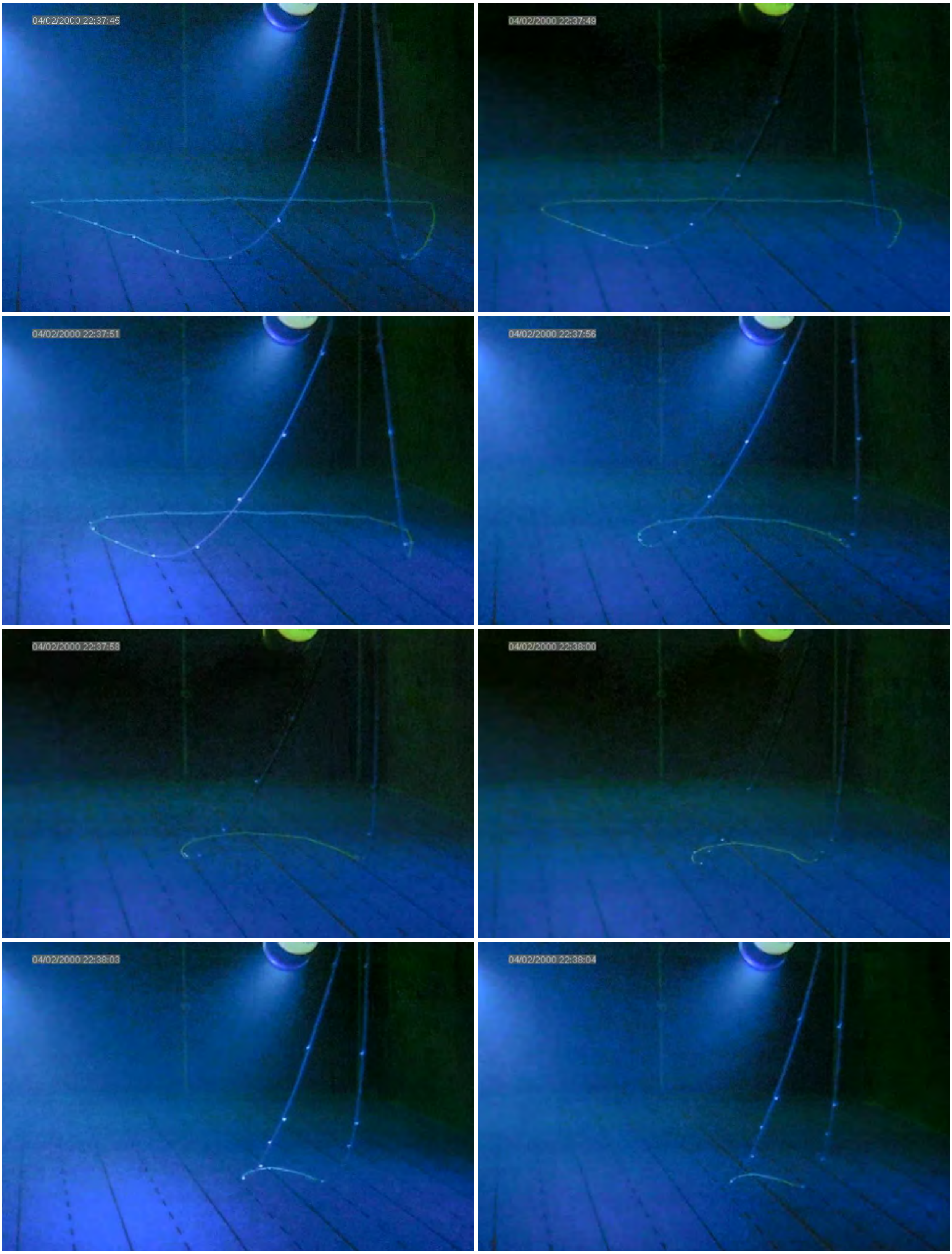

Figure 12: Winching in seine ropes from a triangle layout

2.4 Layout Patterns

The seine rope was laid out on the flume tank floor in a specific pattern before starting the haul back process. One of these patterns was ”diamond shaped”. Fig. 13 shows the seine rope laid out in this pattern.

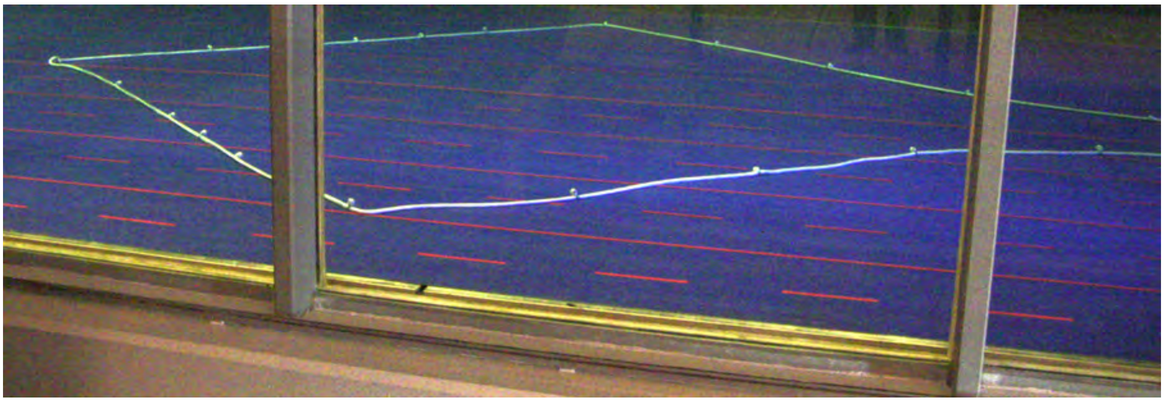

Figure 13: Diamond Layout

Since the seine rope behaviour might be different for different initial layout patterns we acquired motion tracking data for three different initial layout patterns: diamond, square and triangle. Fig. 14 shows photos for these initial layout patterns.

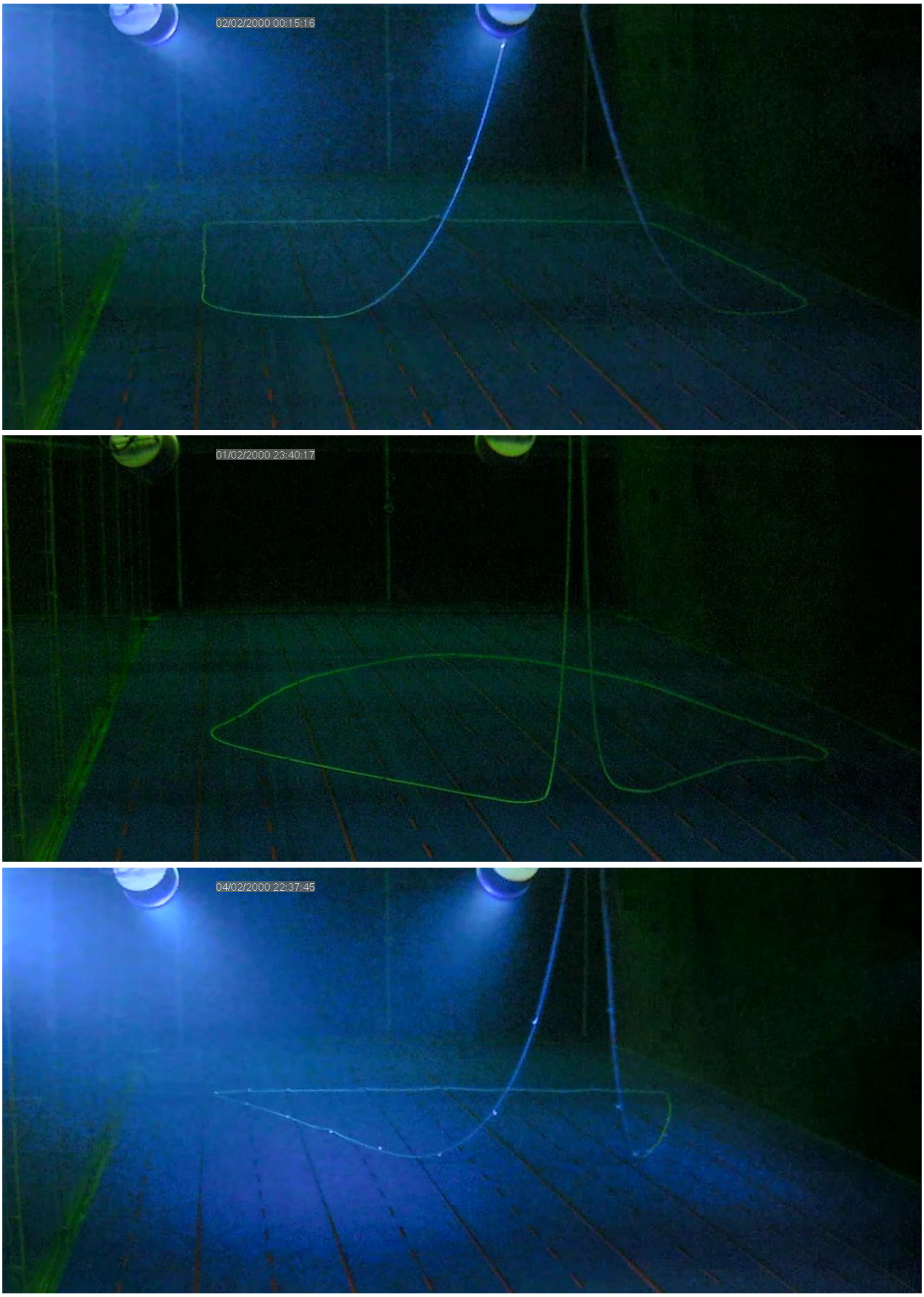

Figure 14: Photo of the three initial layout patterns envestigated. The square layout pattern on top, the diamond layout pattern in the middle, and the triangle layout pattern on the buttom.

2.5 Seine Rope Configurations

To be able to investigate the potential effect of seine ropes density on the shape encircled by the seine ropes, two ropes differing considerable regarding density was applied:

- Light weight polyester rope with diameter 14 mm and a weight og 0.18 Kg per meter rope.
- Heavy combinations rope with a lead core and a polyester cover. The diameter was 14 mm and a weight of 0.50 Kg per meter rope.

Both ropes had very small bending stiffness as is clear from Fig 15 which shows one of the ropes. On the contrary the elongation stiffness was large, resulting in negligible elongation of the ropes during the flume tank experiments. The ropes were 30 m long.

Figure 15: The combination rope laid out on the platform of the flume tank. Showing the very small bending stiffness

To emulate potential influence of seine net dragging resistance on seine rope behaviour during haul back two different situations were applied to both ropes during the flume tank experiment:

- Low resistance case. In this case was the middle point of the seine rope equipped with a mounting hinge weighting 7 g (Fig 16)
- High resistance case. In this case was the middle point of the seine rope was two clumps each weighting 800 g attached to the hinge (Fig 17)

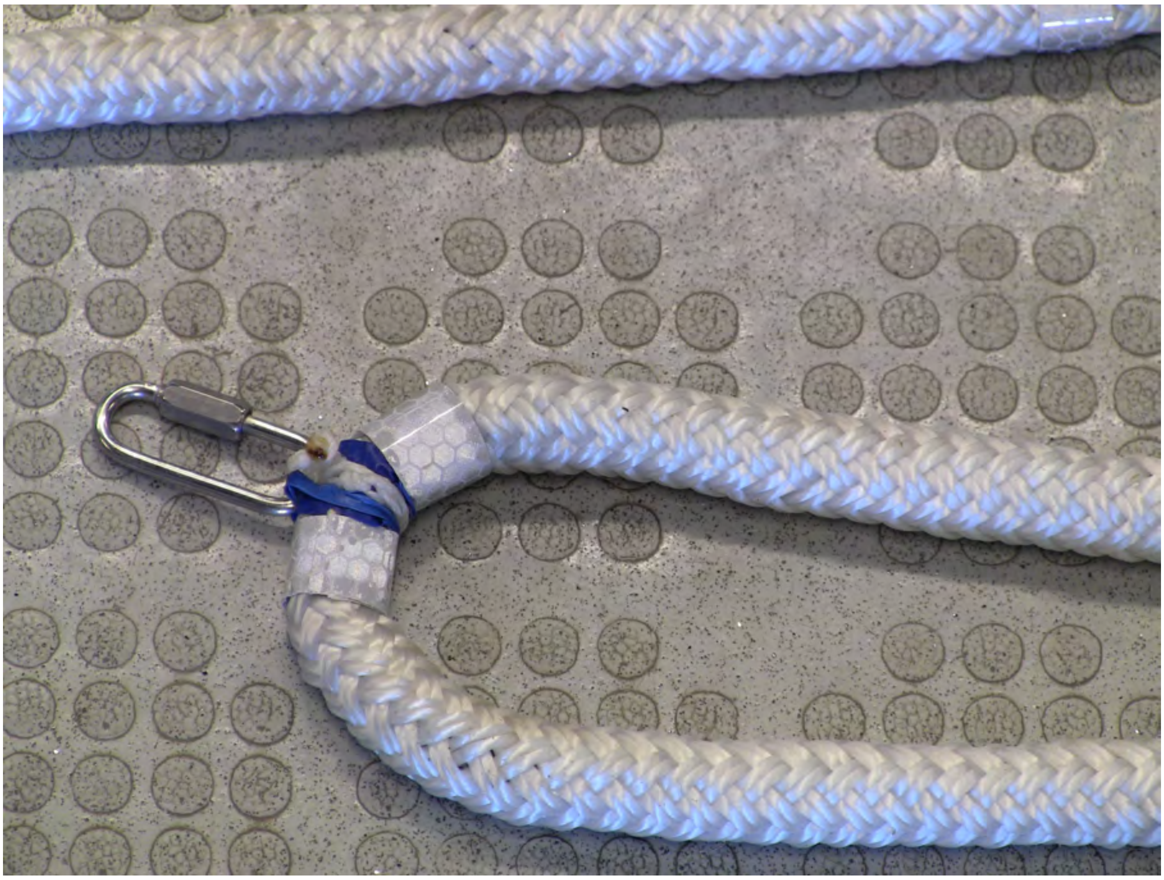

Figure 16: The hinge weighting 7 g. Used for the experiments with low resistance.

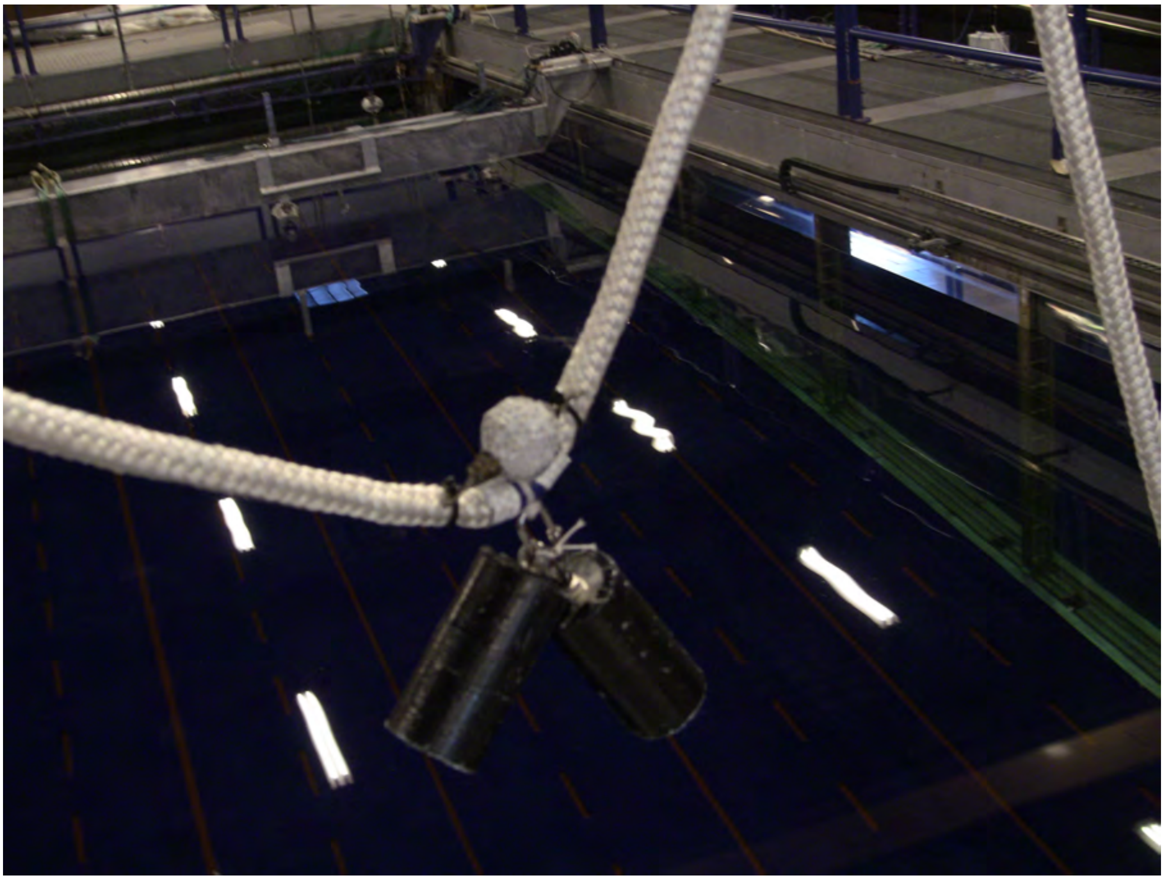

Figure 17: The clumps used for the high resistance case.

2.6 Experimental cases

Applying three different initial layout patterns, two different winch speeds, two different seine rope types and two different winch speeds makes 24 different experimental haul back cases (Table 1)

Layout	Rope	Net Weight	Winch Speed
Square	Combination Rope	7 g	0.157 m/s
Square	Combination Rope	1607 g	0.157 m/s
Square	Combination Rope	7 g	0.314 m/s
Square	Combination Rope	1607 g	0.314 m/s
Square	Polyester Rope	7 g	0.157 m/s
Square	Polyester Rope	1607 g	0.157 m/s
Square	Polyester Rope	7 g	0.314 m/s
Square	Polyester Rope	1607 g	0.314 m/s
Diamond	Combination Rope	7 g	0.157 m/s
Diamond	Combination Rope	1607 g	0.157 m/s
Diamond	Combination Rope	7 g	0.314 m/s
Diamond	Combination Rope	1607 g	0.314 m/s
Diamond	Polyester Rope	7 g	0.157 m/s
Diamond	Polyester Rope	1607 g	0.157 m/s
Diamond	Polyester Rope	7 g	0.314 m/s
Diamond	Polyester Rope	1607 g	0.314 m/s
Triangle	Combination Rope	7 g	0.157 m/s
Triangle	Combination Rope	1607 g	0.157 m/s
Triangle	Combination Rope	7 g	0.314 m/s
Triangle	Combination Rope	1607 g	0.314 m/s
Triangle	Polyester Rope	7 g	0.157 m/s
Triangle	Polyester Rope	1607 g	0.157 m/s
Triangle	Polyester Rope	7 g	0.314 m/s
Triangle	Polyester Rope	1607 g	0.314 m/s

Table 1: The scenarios

Motion tacking data for all these 24 cases were acquired during the flume tank experiments following the procedure described in section 2.2.

3 Results

3.1 Overview

Figure 18 shows the complete set of experiments performed. The data points are analysed by the motion tracking camera system. Each of the 24 plots shows the seine ropes as seen from above. Each plot consists of 6 superimposed paths corresponding to the time development. The time between the paths shown are 10 seconds for the first two columns, for the slow winch speeds. The last two columns are for the fast winch speed experiements. Here the time step is 5 seconds. Each plot area is 8 m wide and 9.5 m long.

The odd rows are from combination rope experiments, the even rows from polyester rope. The odd columns are for light net weight, even heavy weights. The layout pattern used in the experiment are organised top: square, middle: diamond, bottom: triangle.

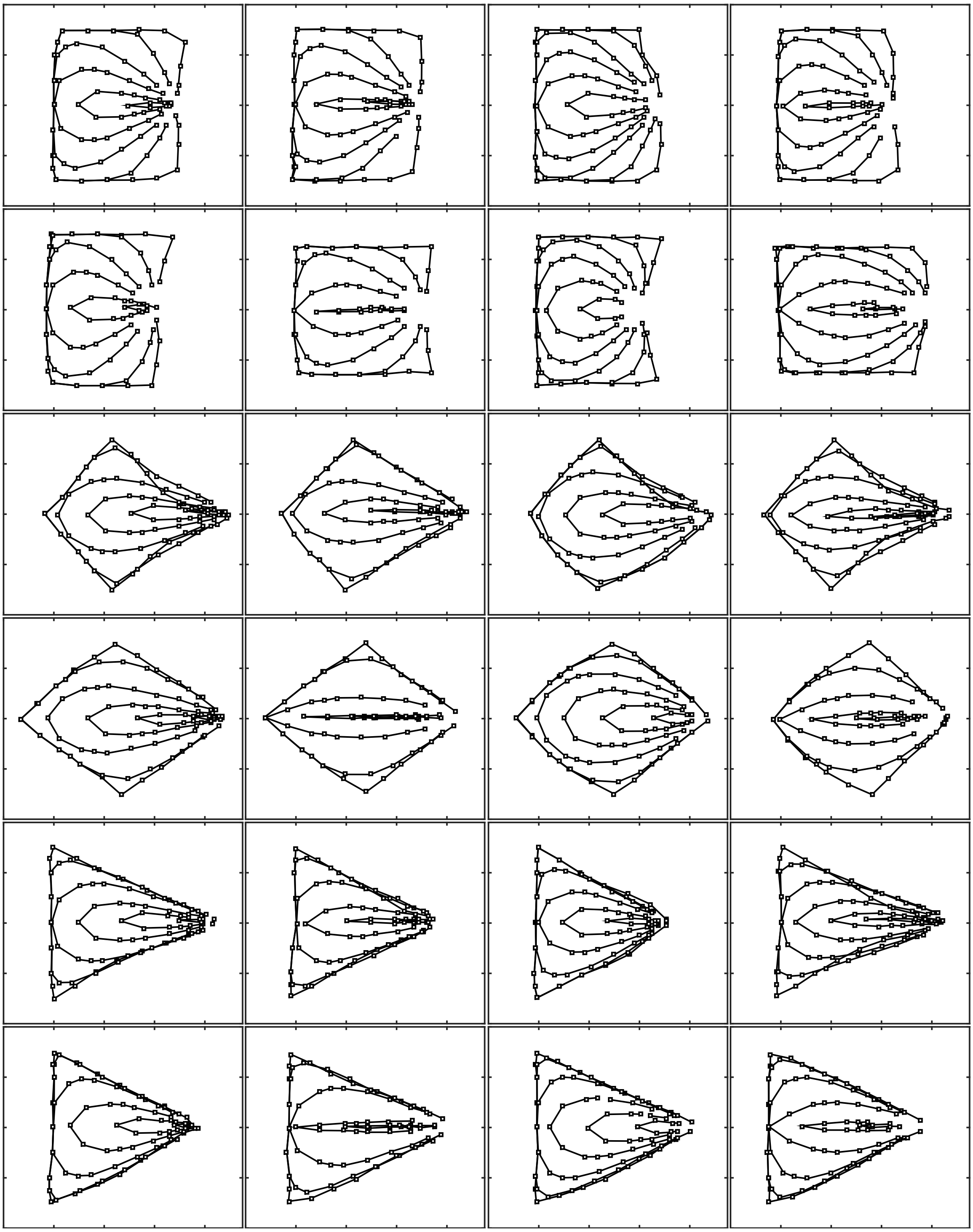

Figure 18: Odd rows: Combination rope, even rows: Polyester rope. Odd columns: light net weight, even columns: heavy net weight. First two columns slow winch speed, last two columns fast winch speed.

3.2 Square Layout

3.2.1 Combination Rope, Light, Slow

Here we present the results for the scenario with combination rope laid out in a square, using the light weight and the slow winch speed. Figure 19 shows the seine rope configuration seen from above. The area covered by this plot is 8 m by 9.5 m. The same size plots are used for all similar plots in this report. The pattern of the seine ropes during the haul back is uniform.

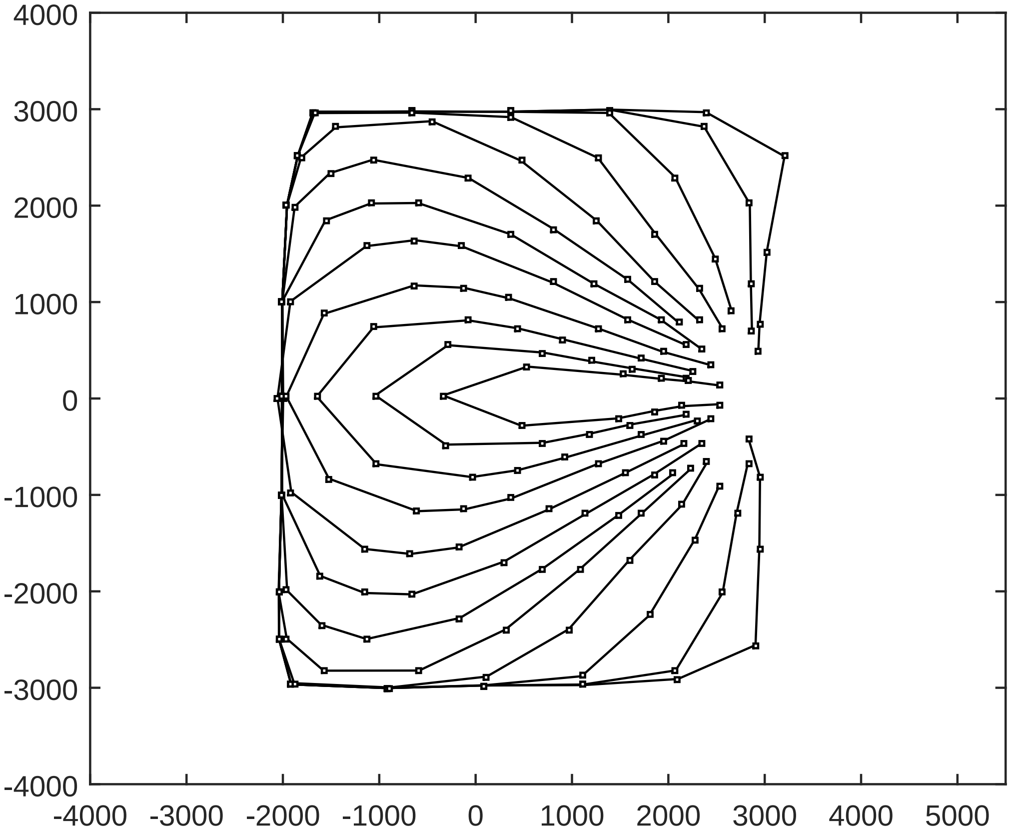

Figure 19: Combination Rope, Light, Slow, dt 4 sec

Figure 20 shows the area encircled by the part of the seine ropes which is resting on the bottom of the flume tank.

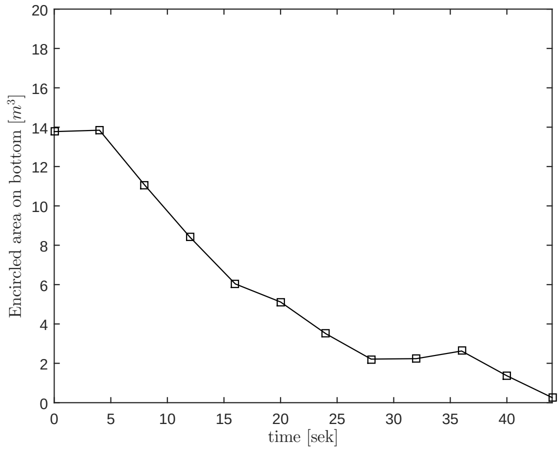

Figure 20: Combination Rope, Light, Slow, ButtomArea

Figure 21 shows the seine rope configuration seen from above and from the side. The interval is 4 seconds in figure 19 and 21. The seine ropes remain apart and on the bottom while the light weight is being pulled along the bottom.

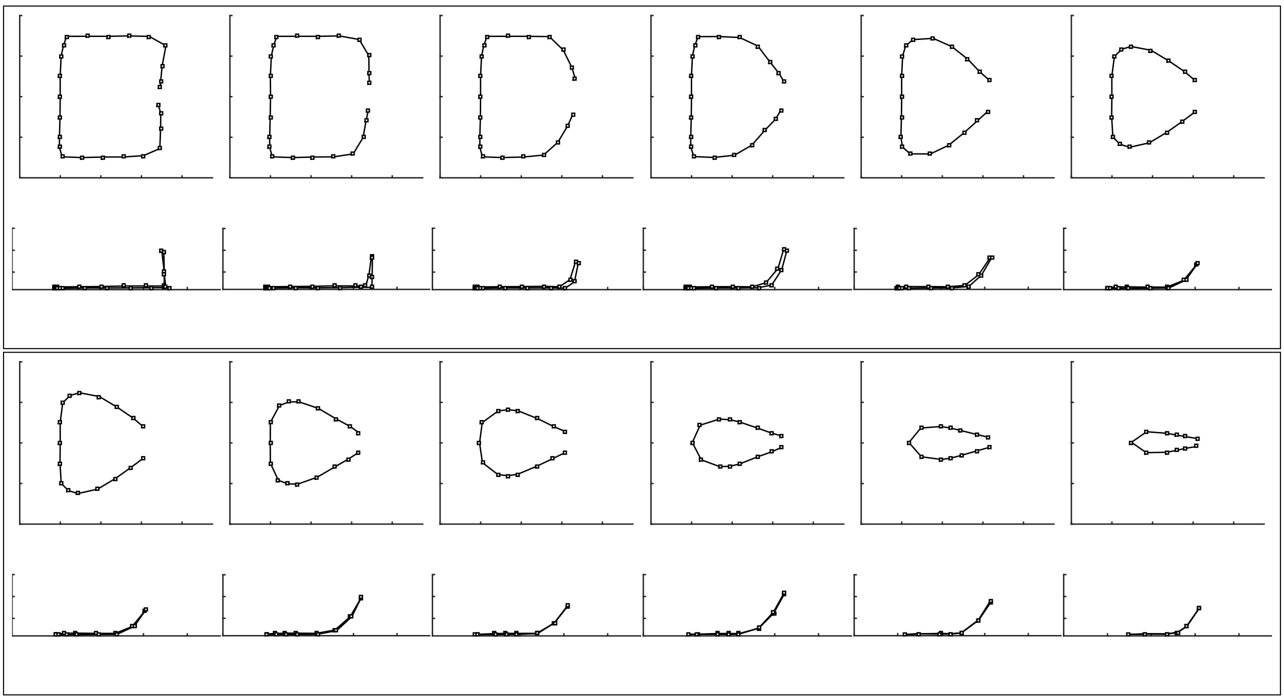

Figure 21: Combination Rope, Light, Slow, Frame dt 4 sec

3.2.2 Combination Rope, Heavy, Slow

Here we present the results for the scenario with combination rope laid out in a square, using the heavy weight and the slow winch speed. Figure 22 shows the seine rope configuration seen from above.

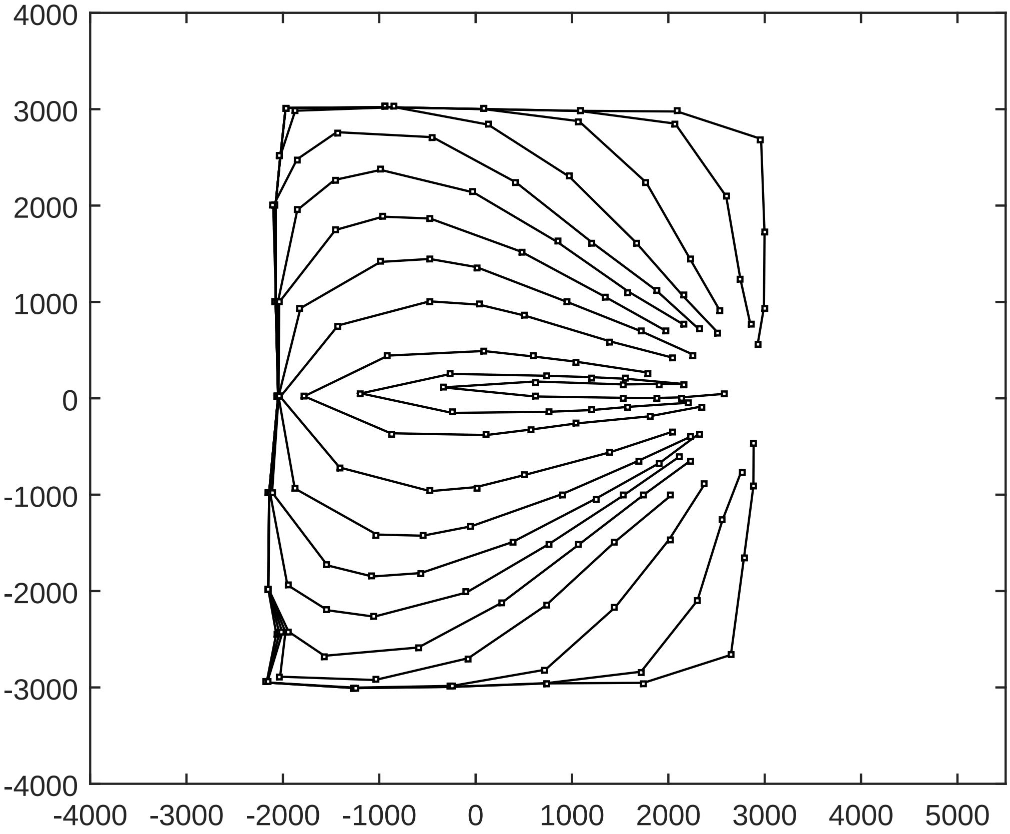

Figure 22: Combination Rope, Heavy, Slow, CombinedSeine

Figure 23 shows the area encircled by the part of the seine ropes which is resting on the bottom of the flume tank.

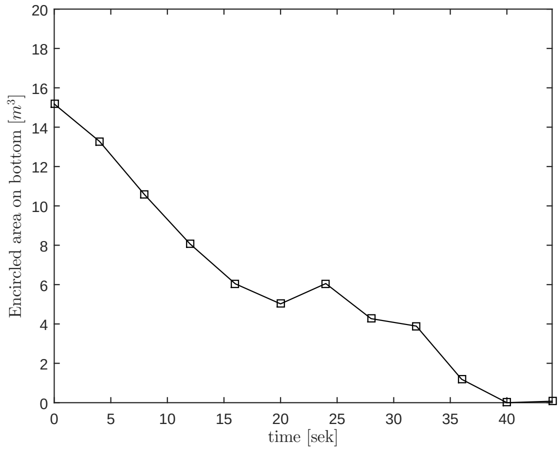

Figure 23: Combination Rope, Heavy, Slow ButtomArea

Figure 24 shows the seine rope configuration seen from above and from the side. The interval is 4 seconds in figure 22 and 24. The seine ropes nearly collapse towards the very end of the haul back procedure.

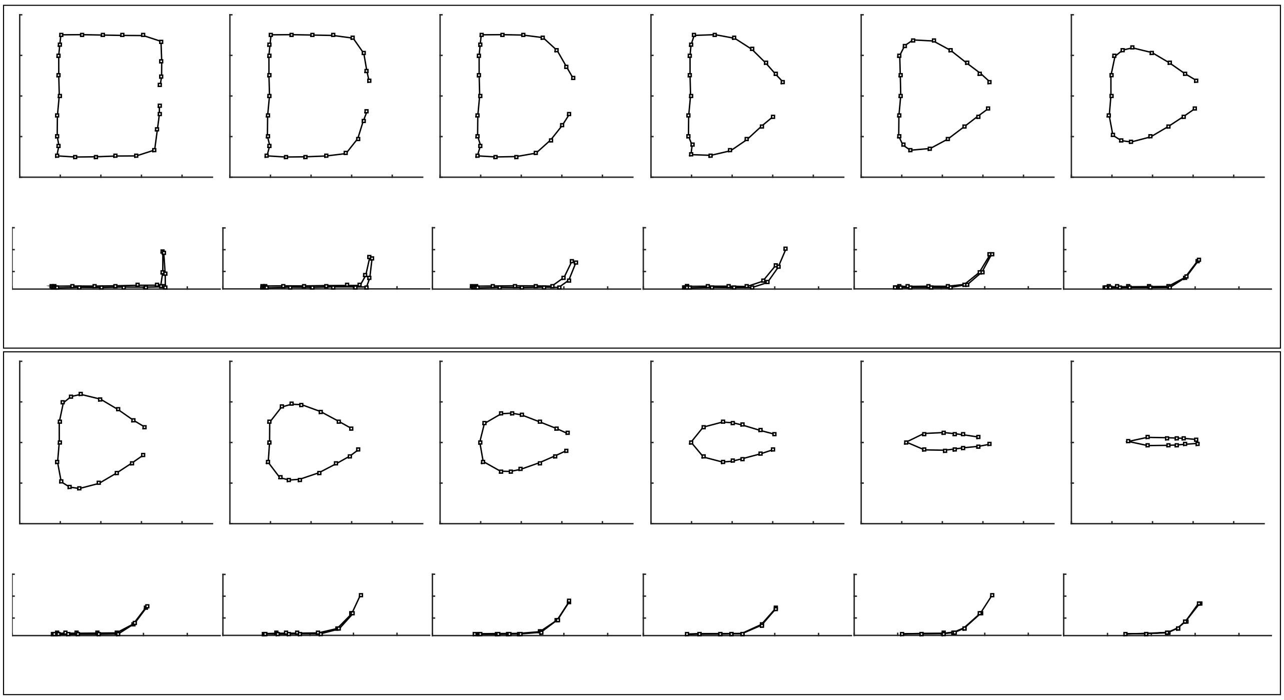

Figure 24: Combination Rope, Heavy, Slow, MovieClip frame 4 sec

3.2.3 Combination Rope, Light, Fast

Here we present the results for the scenario with combination rope laid out in a square, using the light weight and the fast winch speed. Figure 25 shows the seine rope configuration seen from above.

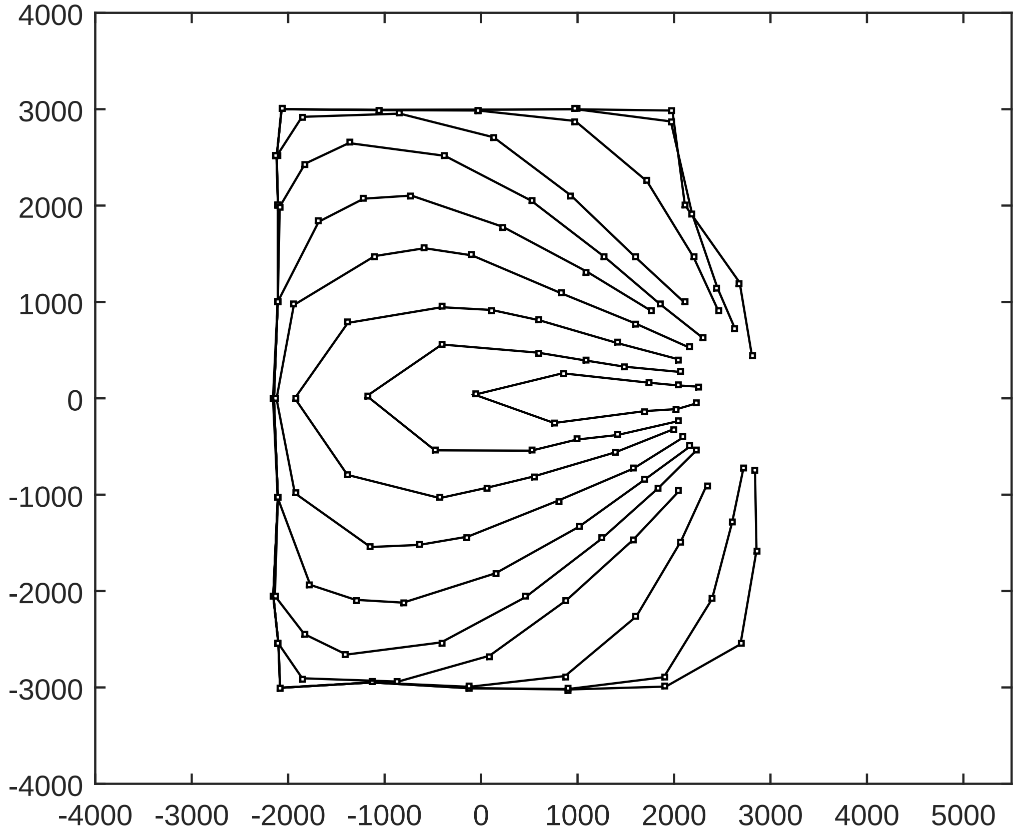

Figure 25: Combination Rope, Light, Fast CombinedSeine dt 3 sec

Figure 26 shows the area encircled by the part of the seine ropes which is resting on the bottom of the flume tank.

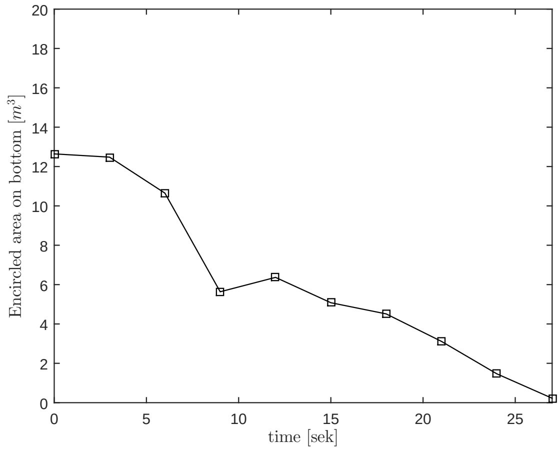

Figure 26: Combination Rope, Light, Fast ButtomArea

Figure 27 shows the seine rope configuration seen from above and from the side. The interval is 3 seconds in figure 25 and 27. The seine ropes stay apart and on the bottom for the haul back procedure.

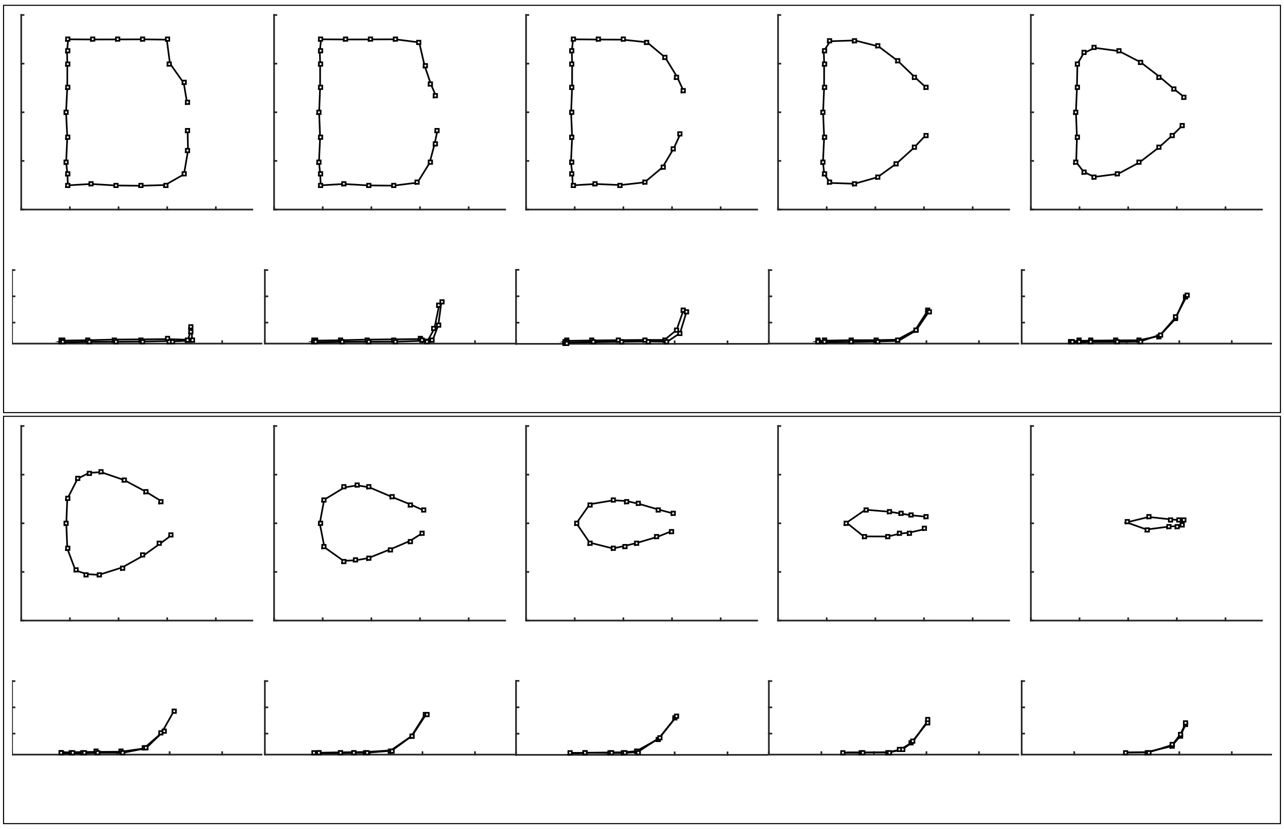

Figure 27: Combination Rope, Light, Fast MovieClip, frame 3 sec

3.2.4 Combination Rope, Heavy, Fast

Here we present the results for the scenario with combination rope laid out in a square, using the heavy weight and the fast winch speed. Figure 28 shows the seine rope configuration seen from above.

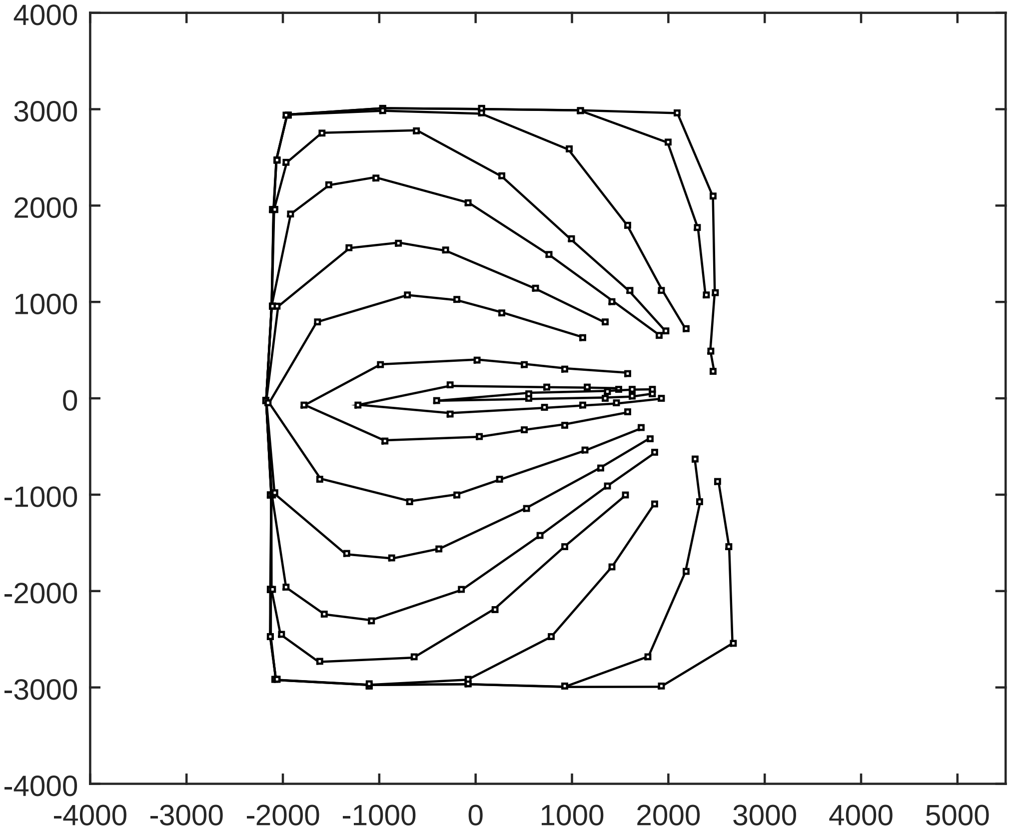

Figure 28: Combination Rope, Heavy, Fast CombinedSeine dt 3 sec

Figure 29 shows the area encircled by the part of the seine ropes which is resting on the bottom of the flume tank.

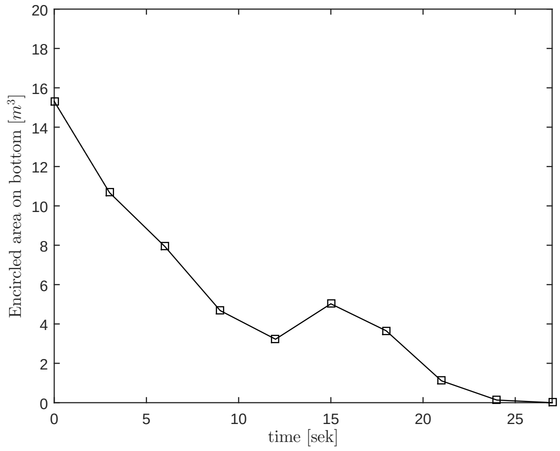

Figure 29: Combination Rope, Heavy, Fast ButtomArea

Figure 30 shows the seine rope configuration seen from above and from the side. The interval is 3 seconds in figure 28 and 30. Towards the end of the haul back procedure the seine ropes collapse.

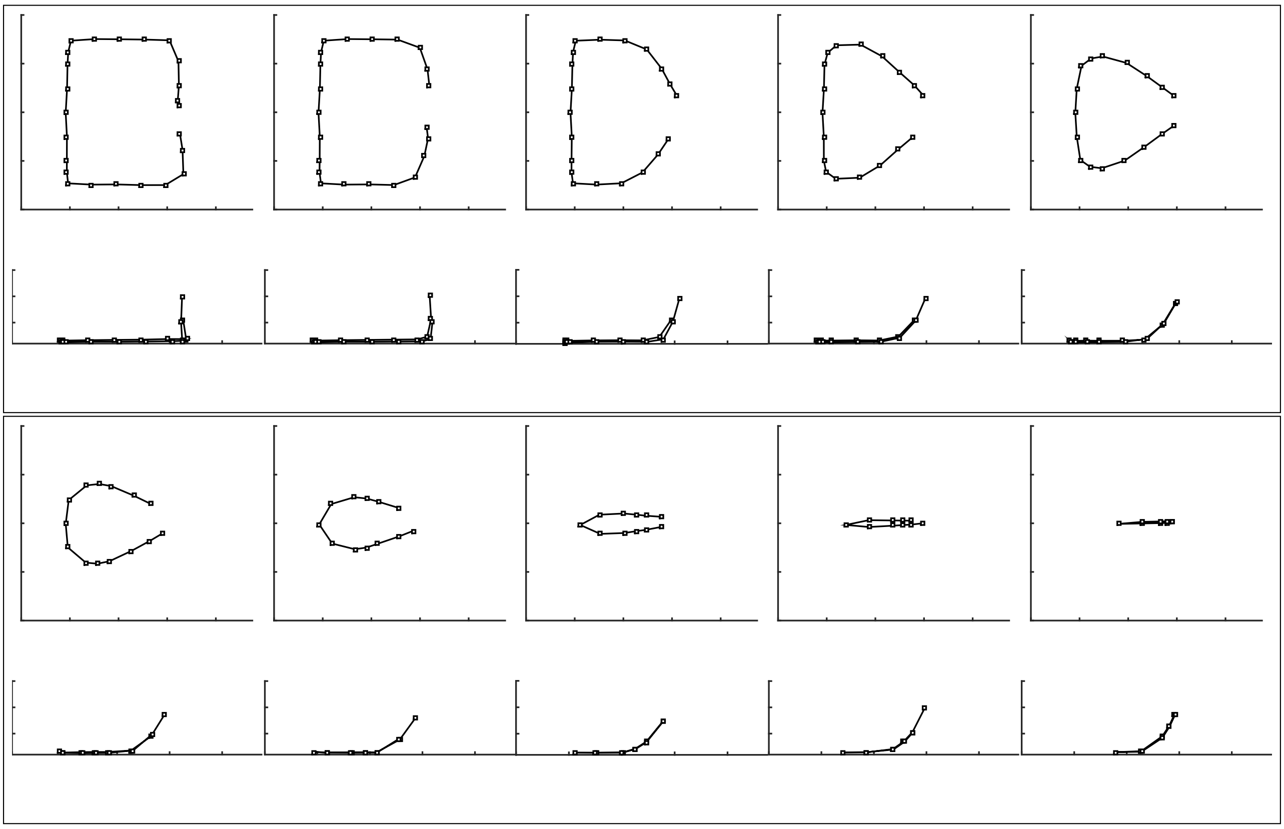

Figure 30: Combination Rope, Heavy, Fast MovieClip Frame dt 3sec

3.2.5 Polyester Rope, Light, Slow

Here we present the results for the scenario with polyester rope laid out in a square, using the light weight and the slow winch speed. Figure 31 shows the seine rope configuration seen from above.

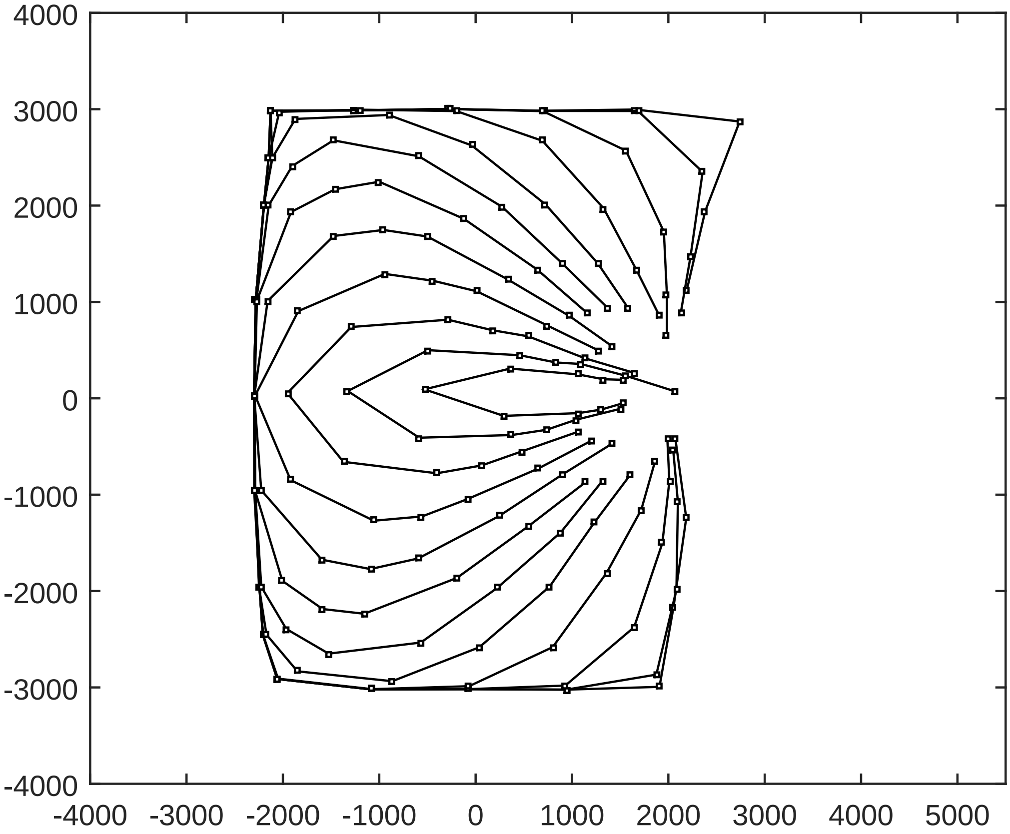

Figure 31: Polyester Rope, Light, Slow CombinedSeine dt 4 sec

Figure 32 shows the area encircled by the part of the seine ropes which is resting on the bottom of the flume tank.

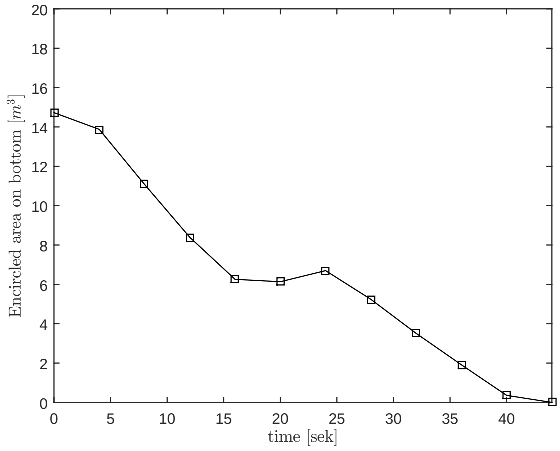

Figure 32: Polyester Rope, Light, Slow ButtomArea

Figure 33 shows the seine rope configuration seen from above and from the side. The interval is 4 seconds in figure 31 and 33. The seine ropes remain open for a long time during the haul back procedure, while dragging the net towards the winch.

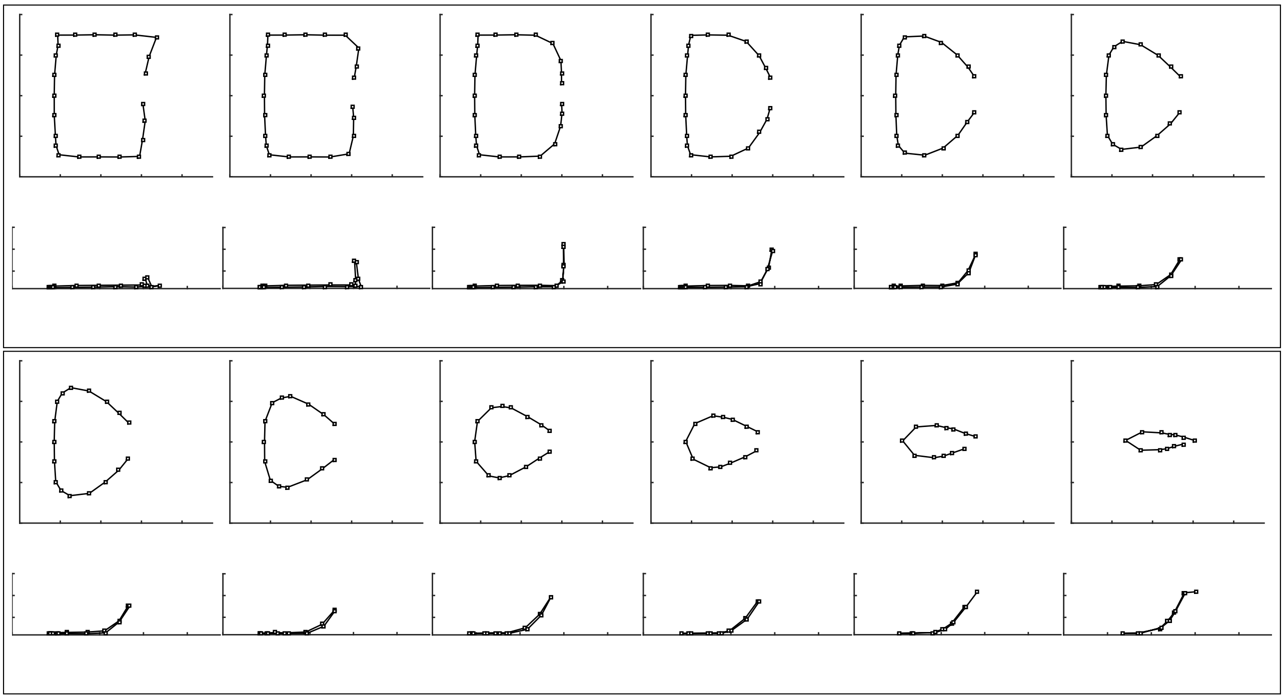

Figure 33: Polyester Rope, Light, Slow MovieClip Frame dt 4sec

3.2.6 Polyester Rope, Heavy, Slow

Here we present the results for the scenario with polyester rope laid out in a square, using the heavy weight and the slow winch speed. Figure 34 shows the seine rope configuration seen from above.

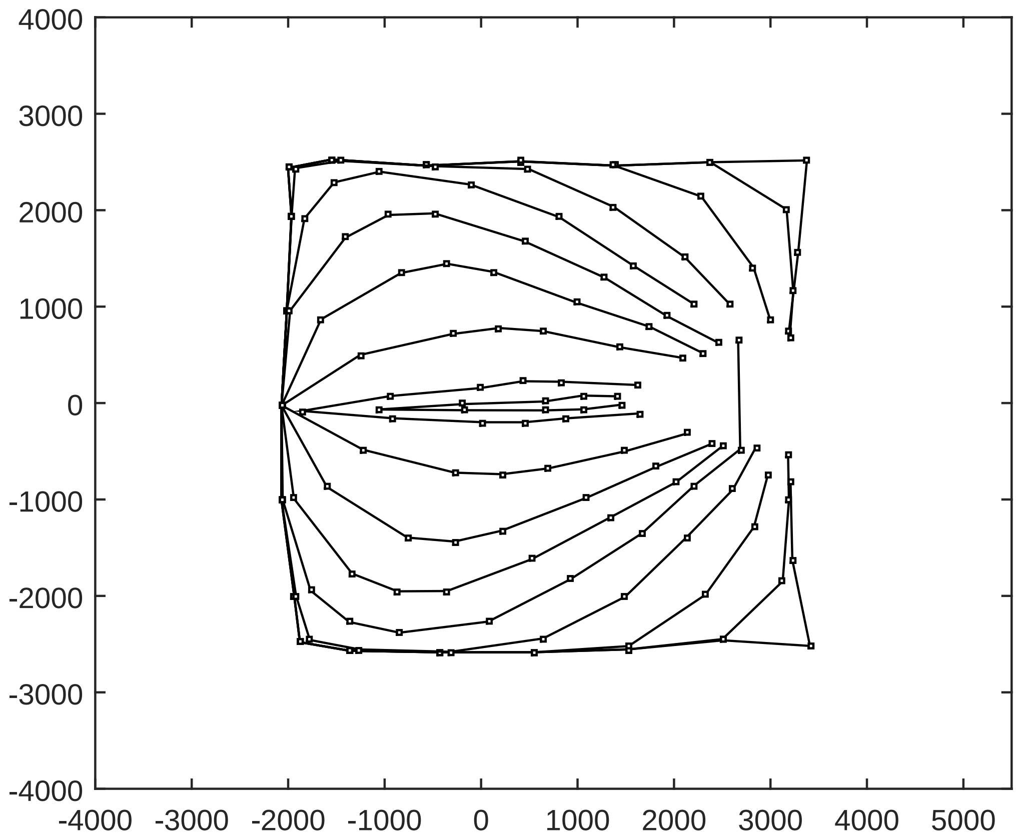

Figure 34: Polyester Rope, Heavy, Slow CombinedSeine dt 4.5 sec

Figure 35 shows the area encircled by the part of the seine ropes which is resting on the bottom of the flume tank.

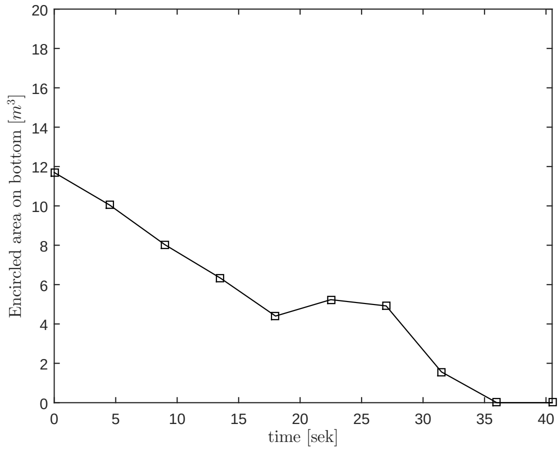

Figure 35: Polyester Rope, Heavy, Slow ButtomArea

Figure 36 shows the seine rope configuration seen from above and from the side. The interval is 4.5 seconds in figure 34 and 36. The polyester seine ropes clearly collapses and lifts of the bottom during the haul back. The seine ropes are lifted from the bottom before the heavy weight (the seine net) starts to move toward the winch.

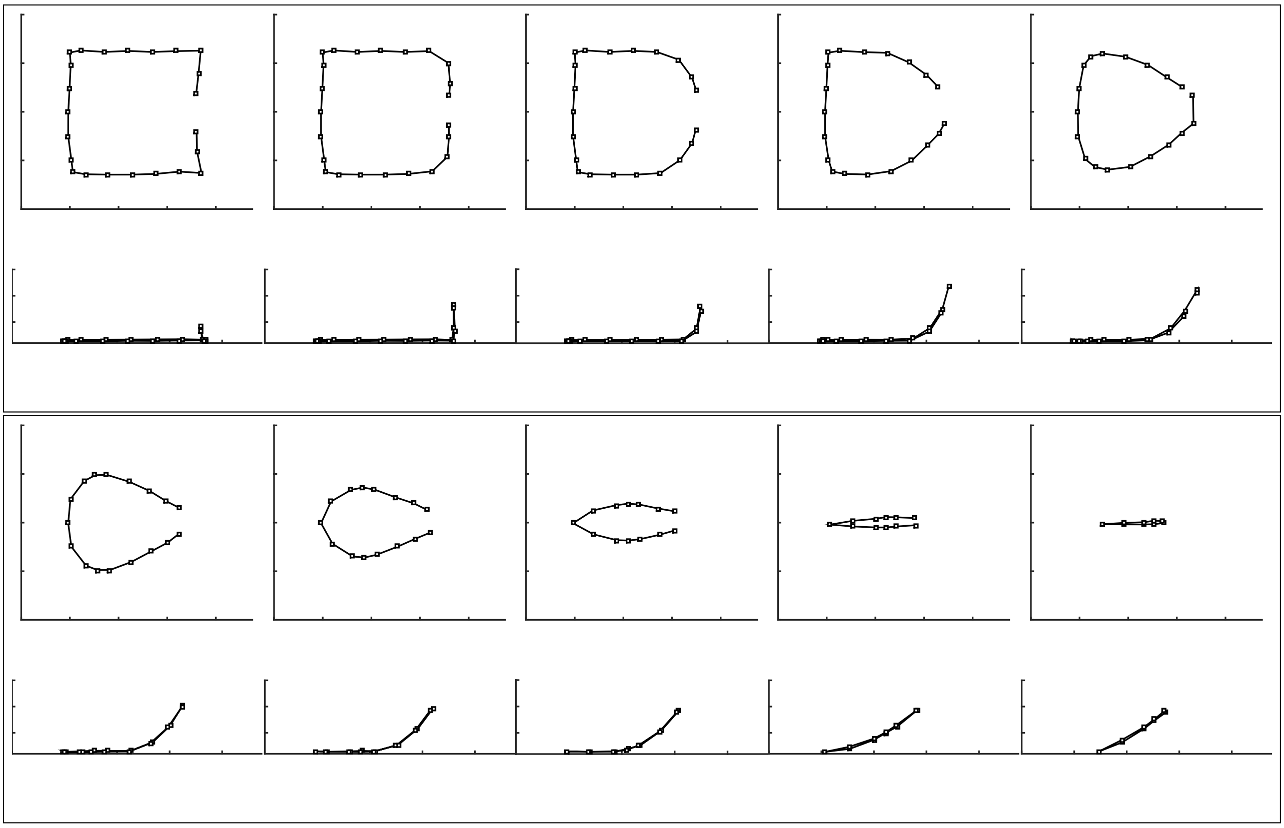

Figure 36: Polyester Rope, Heavy, Slow MovieClip Frame dt 4.5 sec

3.2.7 Polyester Rope, Light, Fast

Here we present the results for the scenario with polyester rope laid out in a square, using the light weight and the fast winch speed. Figure 37 shows the seine rope configuration seen from above.

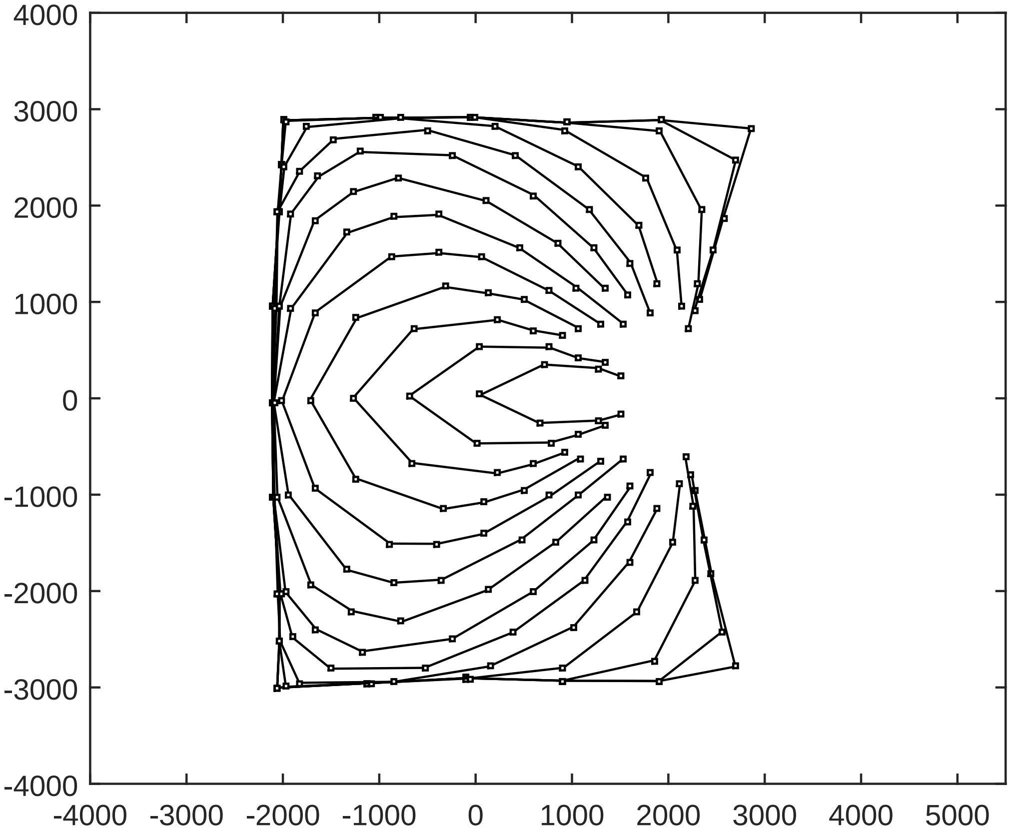

Figure 37: Polyester Rope, Light, Fast CombinedSeine dt 2 sec

Figure 38 shows the area encircled by the part of the seine ropes which is resting on the bottom of the flume tank.

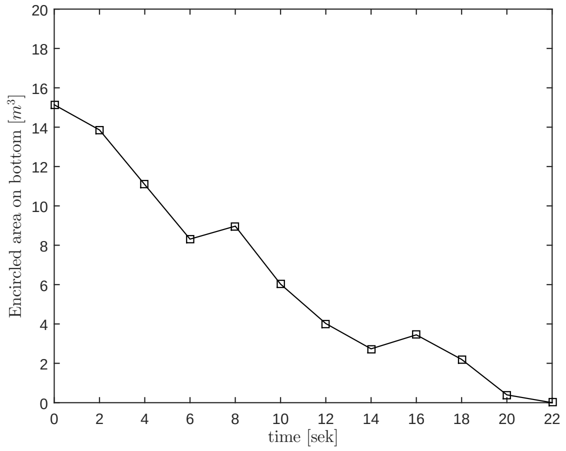

Figure 38: Polyester Rope, Light, Fast ButtomArea

Figure 39 shows the seine rope configuration seen from above and from the side. The interval is 2 seconds in figure 37 and 39. The seine ropes stay apart and on the bottom during the haul back procedure.

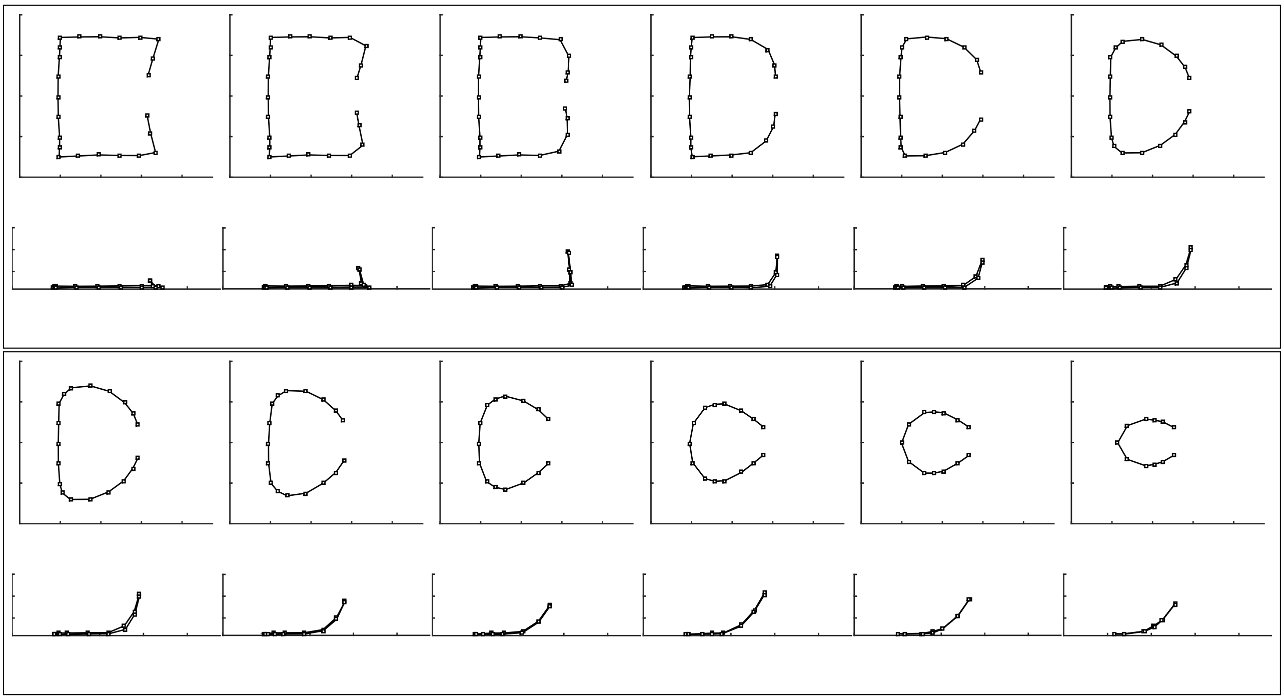

Figure 39: Polyester Rope, Light, Fast MovieClip Frame dt 2 sec

3.2.8 Polyester Rope, Heavy, Fast

Here we present the results for the scenario with polyester rope laid out in a square, using the heavy weight and the fast winch speed. Figure 40 shows the seine rope configuration seen from above.

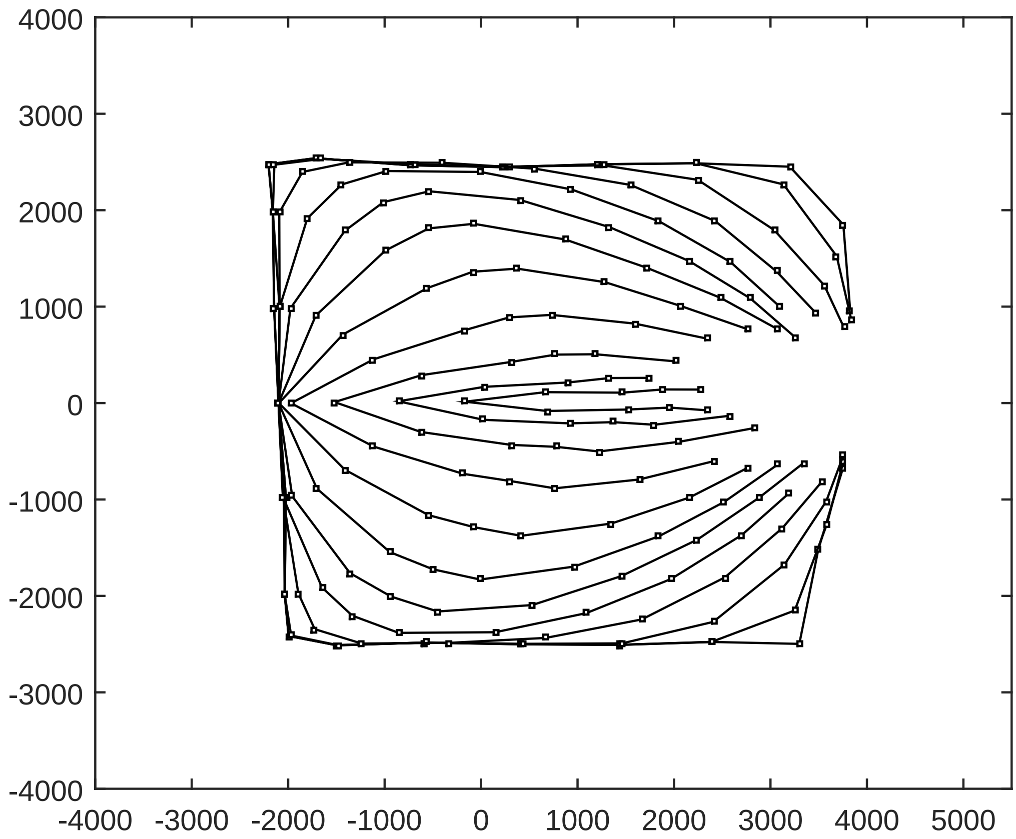

Figure 40: Polyester Rope, Heavy, Fast CombinedSeine dt 2 sec

Figure 41 shows the area encircled by the part of the seine ropes which is resting on the bottom of the flume tank.

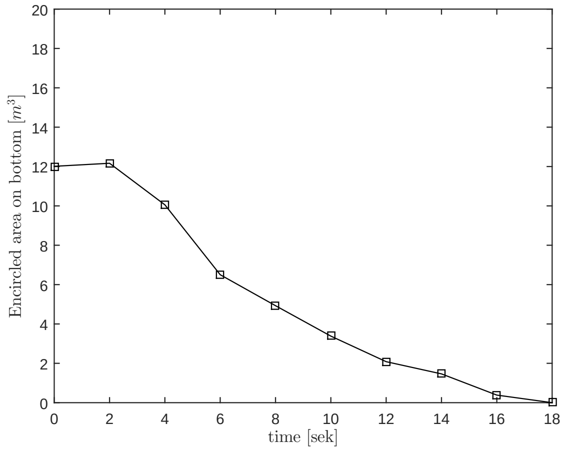

Figure 41: Polyester Rope, Heavy, Fast ButtomArea

Figure 42 shows the seine rope configuration seen from above and from the side. The interval is 2 seconds in figure 40 and 42. During the haul back procedure the seine ropes lifts from the bottom and nearly collapse.

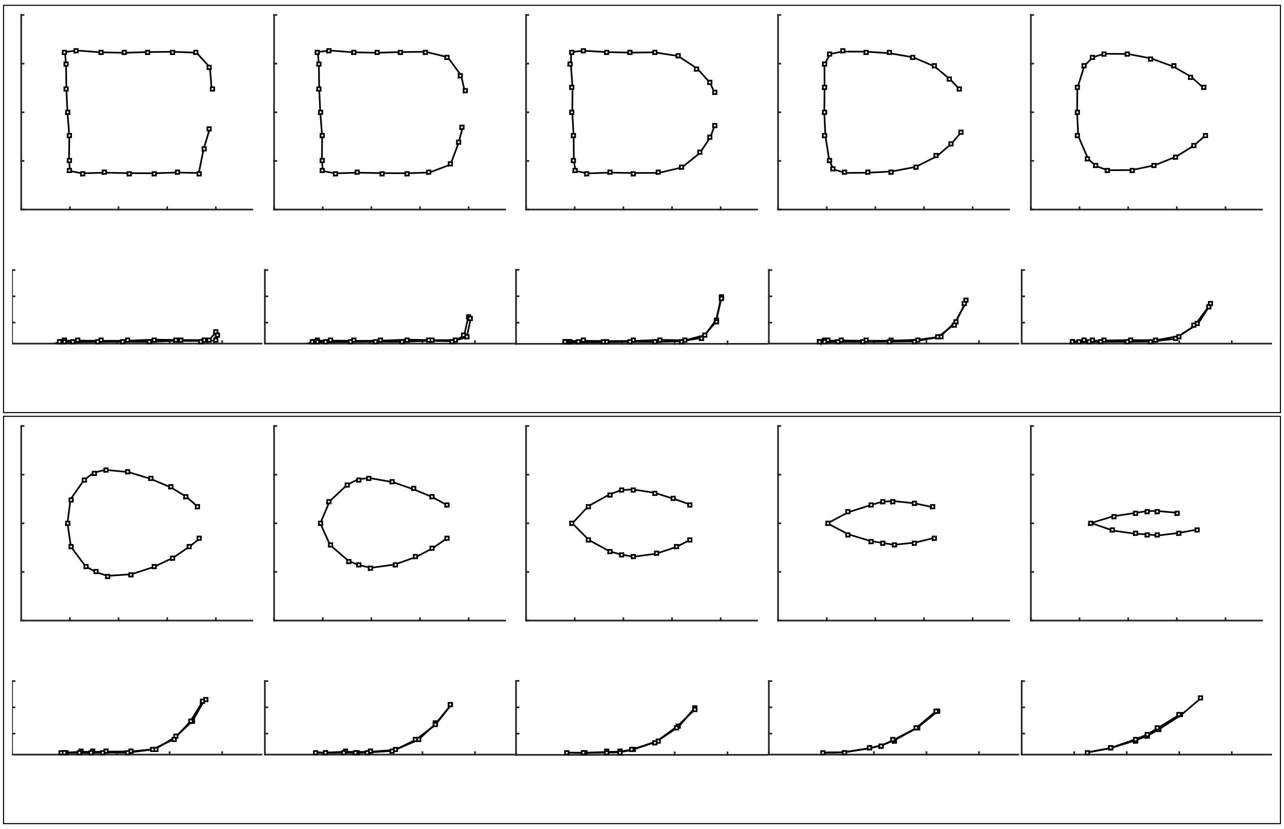

Figure 42: Polyester Rope, Heavy, Fast MovieClip Frame dt 2sec

3.3 Diamond Layout

3.3.1 Combination Rope, Light, Slow

Here we present the results for the scenario with combination rope laid out in a diamond, using the light weight and the slow winch speed. Figure 43 shows the seine rope configuration seen from above. Notice the initial layout pattern is being pulled outward from the sharp diamond form.

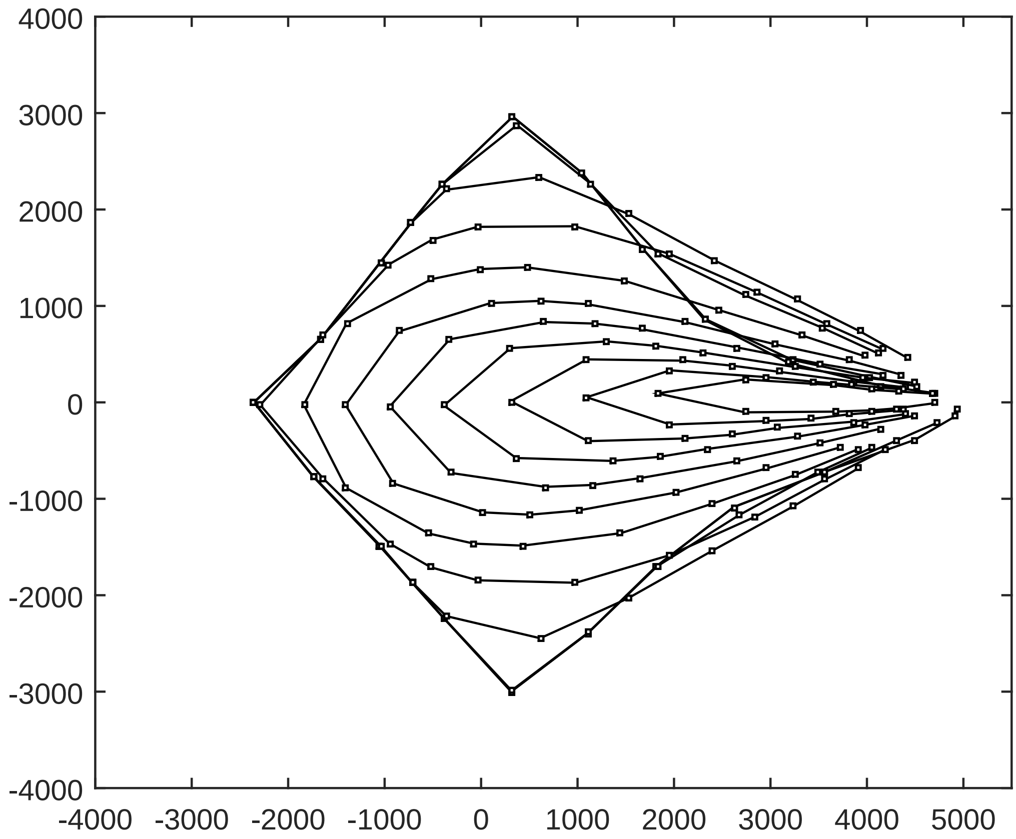

Figure 43: Combination Rope, Light, Slow, dt 4 sec

Figure 44 shows the area encircled by the part of the seine ropes which is resting on the bottom of the flume tank.

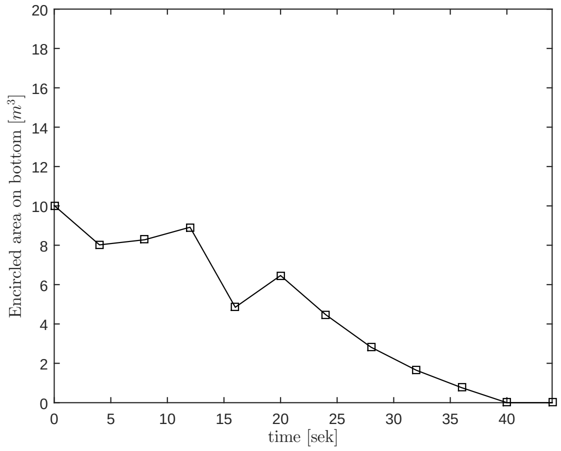

Figure 44: Combination Rope, Light, Slow, ButtomArea

Figure 45 shows the seine rope configuration seen from above and from the side. The interval is 4 seconds in figure 43 and 45. During the haul back procedure the seine ropes stay on the bottom and apart.

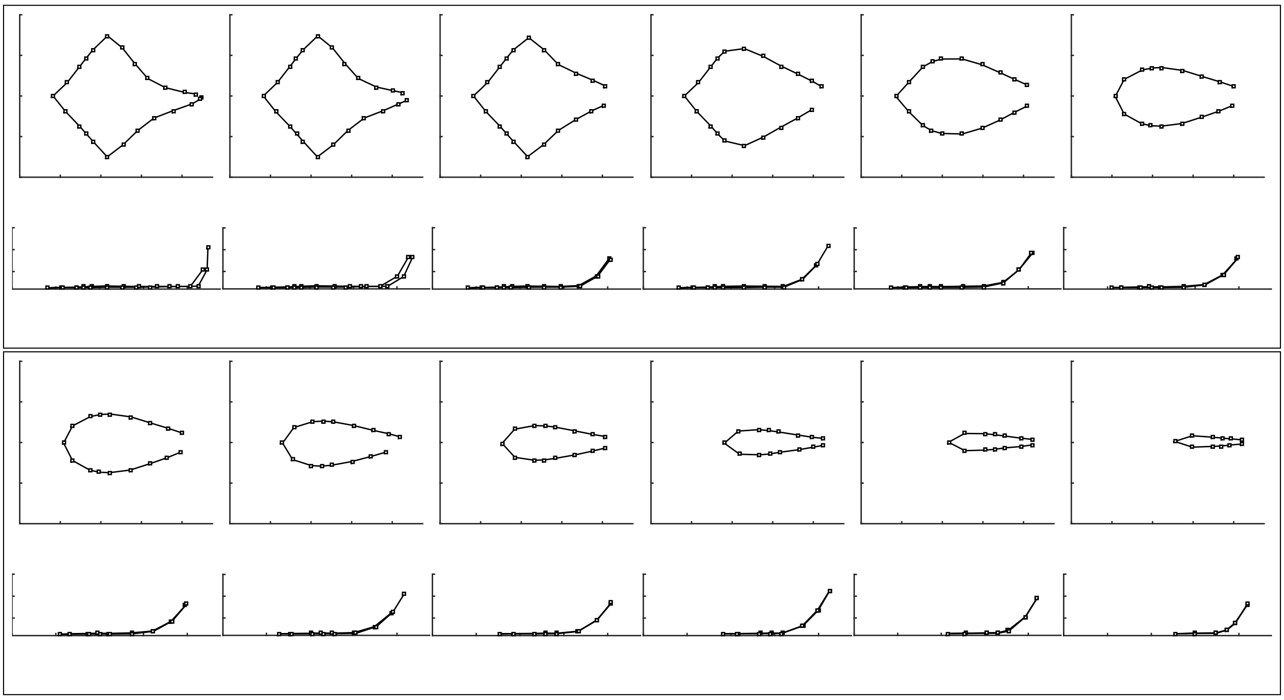

Figure 45: Combination Rope, Light, Slow, Frame dt 4 sec

3.3.2 Combination Rope, Heavy, Slow

Here we present the results for the scenario with combination rope laid out in a diamond, using the heavy weight and the slow winch speed. Figure 46 shows the seine rope configuration seen from above.

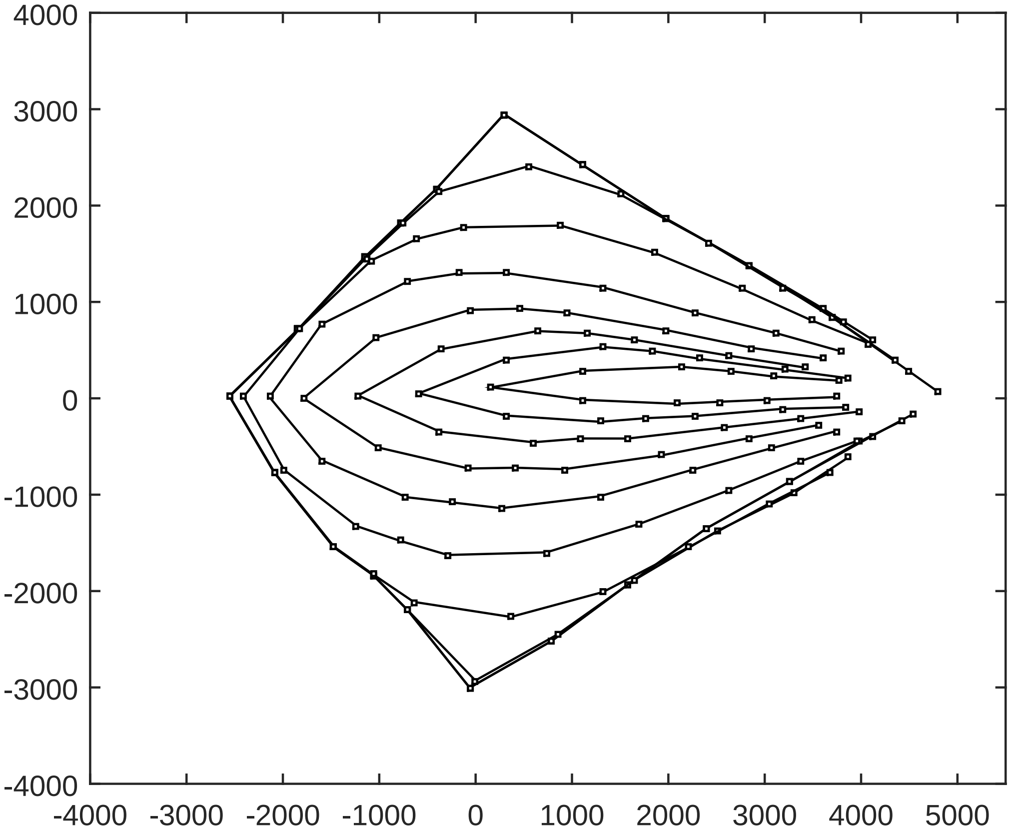

Figure 46: Combination Rope, Heavy, Slow, CombinedSeine

Figure 47 shows the area encircled by the part of the seine ropes which is resting on the bottom of the flume tank.

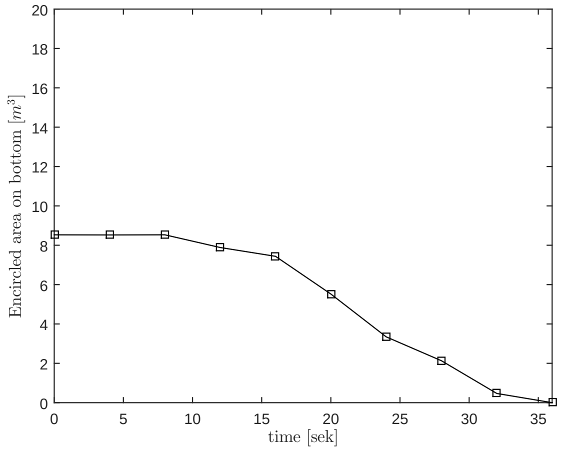

Figure 47: Combination Rope, Heavy, Slow ButtomArea

Figure 48 shows the seine rope configuration seen from above and from the side. The interval is 4 seconds in figure 46 and 48. During the haul back procedure the seine ropes stay on the bottom and apart.

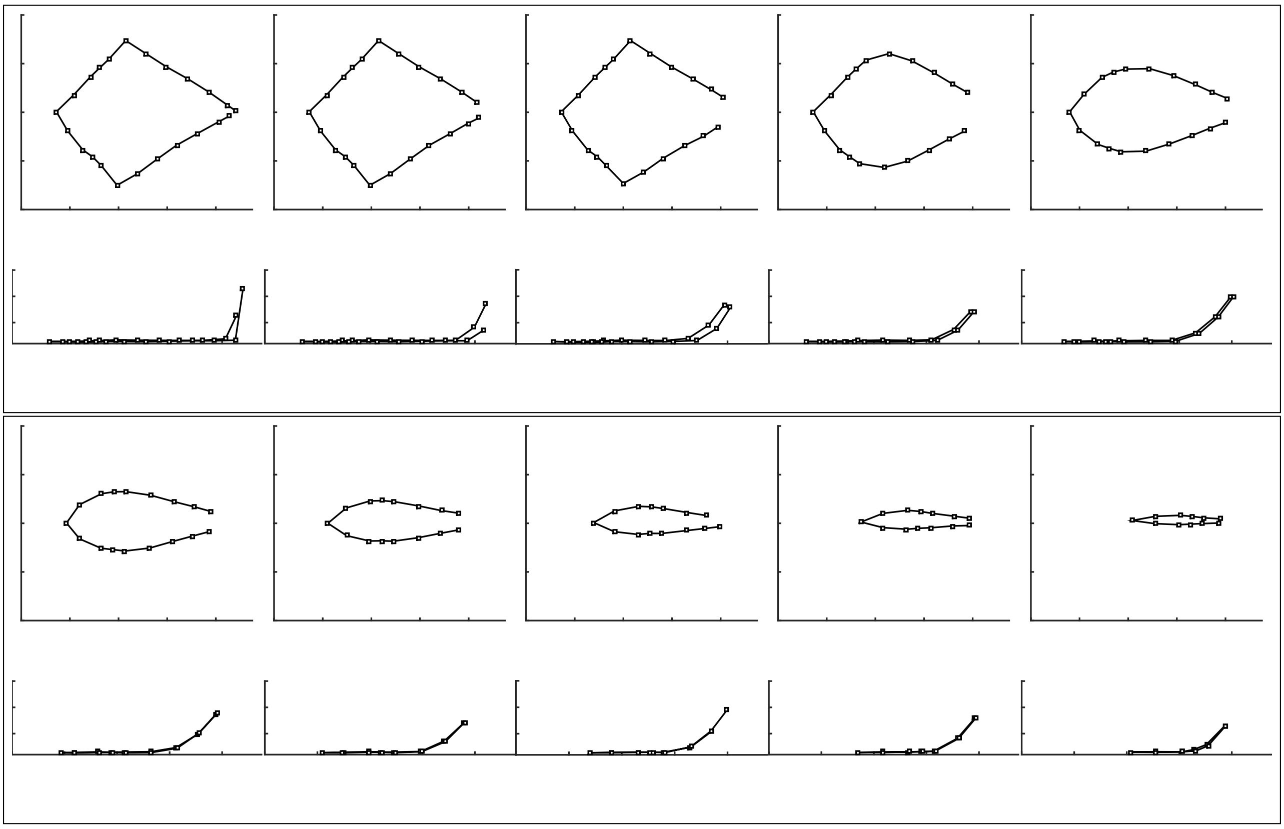

Figure 48: Combination Rope, Heavy, Slow, MovieClip frame 4 sec

3.3.3 Combination Rope, Light, Fast

Here we present the results for the scenario with combination rope laid out in a diamond, using the light weight and the fast winch speed. Figure 49 shows the seine rope configuration seen from above. Notice the initial layout pattern is being pulled outward from the sharp diamond form.

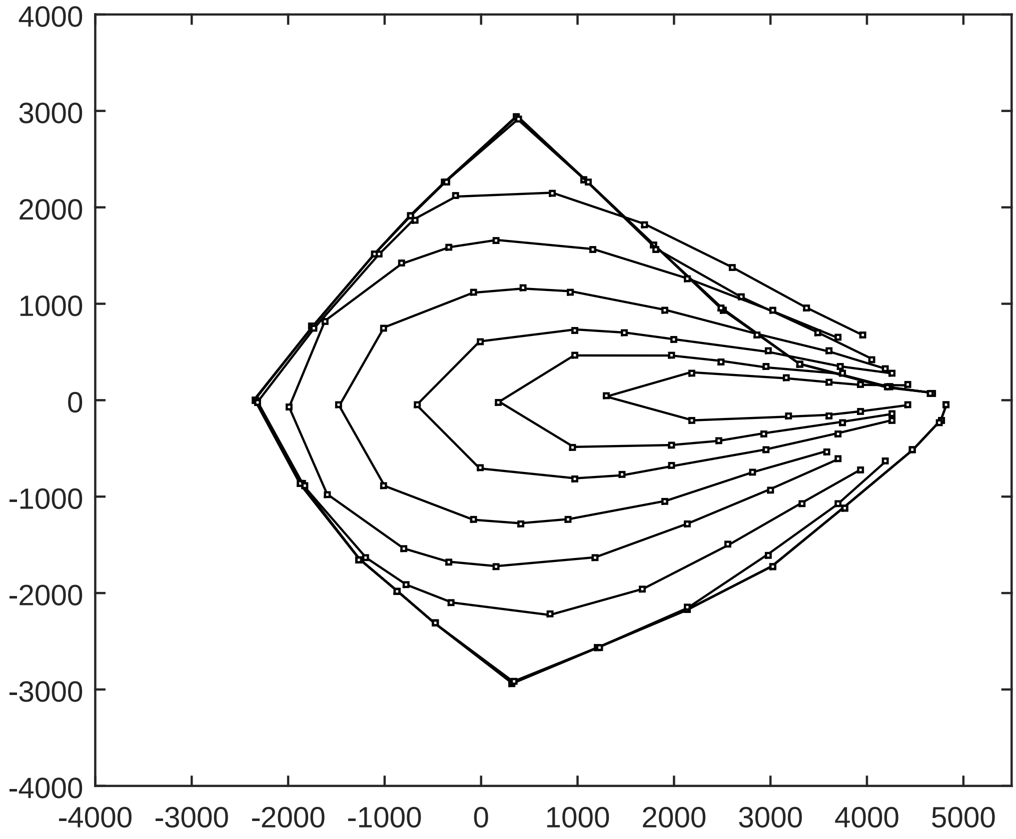

Figure 49: Combination Rope, Light, Fast CombinedSeine dt 3 sec

Figure 50 shows the area encircled by the part of the seine ropes which is resting on the bottom of the flume tank.

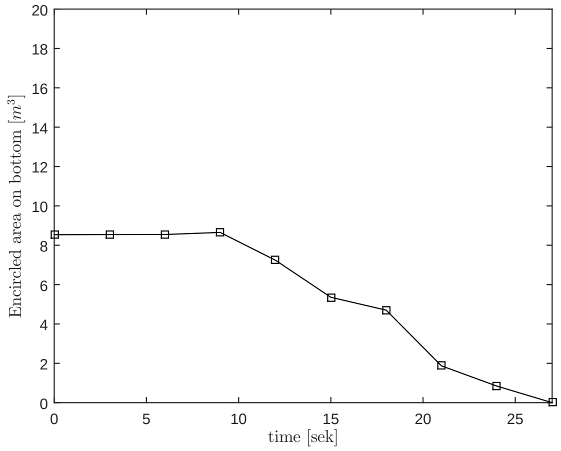

Figure 50: Combination Rope, Light, Fast ButtomArea

Figure 51 shows the seine rope configuration seen from above and from the side. The interval is 3 seconds in figure 49 and 51. During the haul back procedure the seine ropes stay on the bottom and apart.

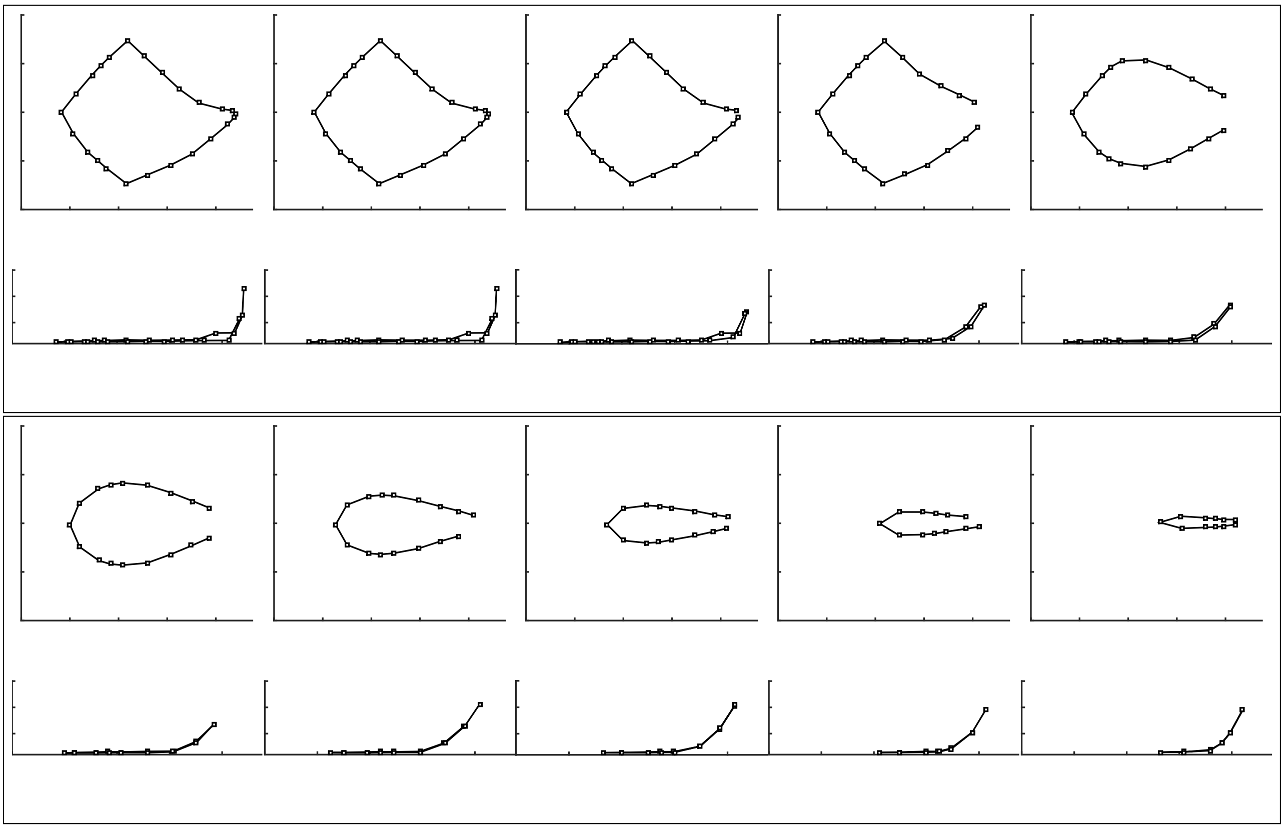

Figure 51: Combination Rope, Light, Fast MovieClip, frame 3 sec

3.3.4 Combination Rope, Heavy, Fast

Here we present the results for the scenario with combination rope laid out in a diamond, using the heavy weight and the fast winch speed. Figure 52 shows the seine rope configuration seen from above.

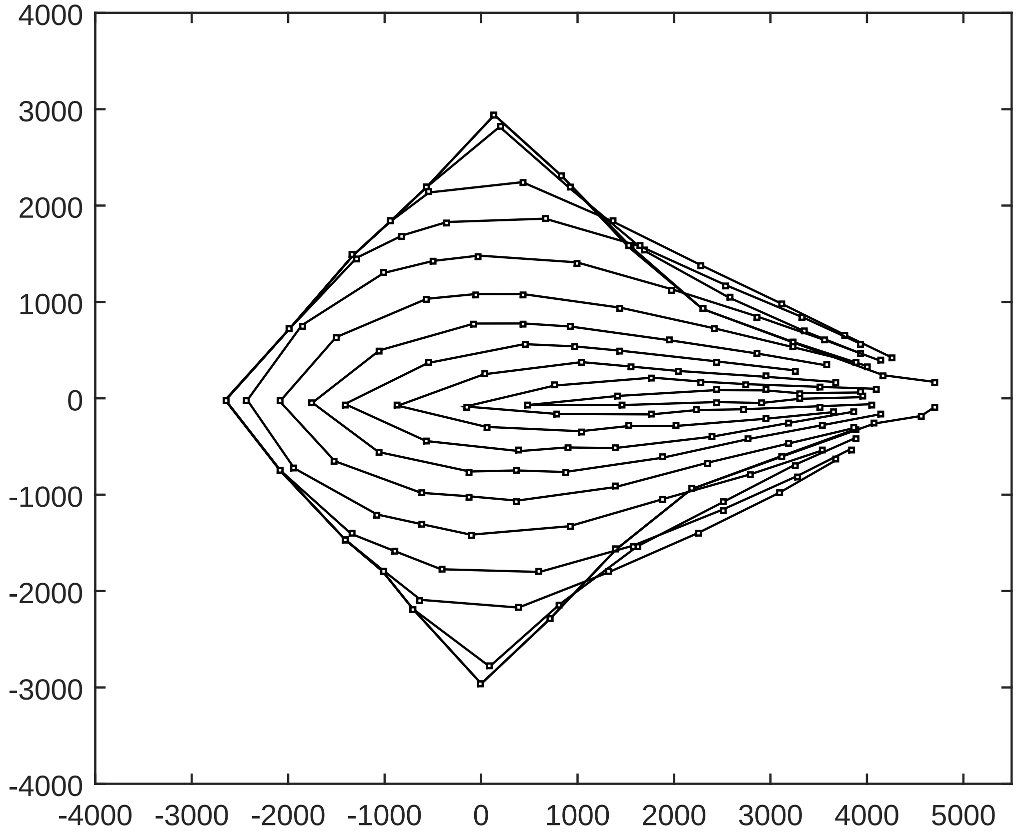

Figure 52: Combination Rope, Heavy, Fast CombinedSeine dt 2 sec

Figure 53 shows the area encircled by the part of the seine ropes which is resting on the bottom of the flume tank.

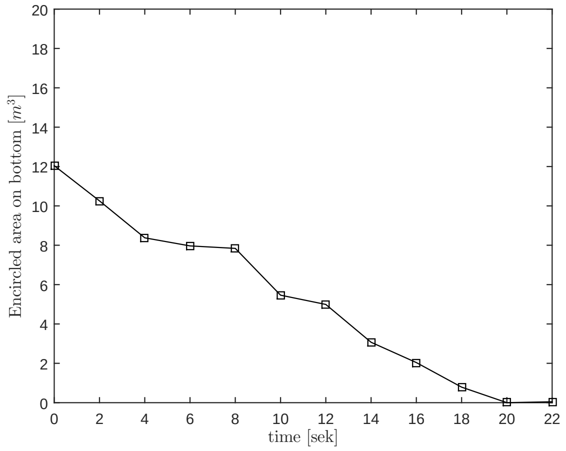

Figure 53: Combination Rope, Heavy, Fast ButtomArea

Figure 54 shows the seine rope configuration seen from above and from the side. The interval is 2 seconds in figure 52 and 54. During the haul back procedure the seine ropes stay on the bottom, but not appart, leaving a very small area towards the end.

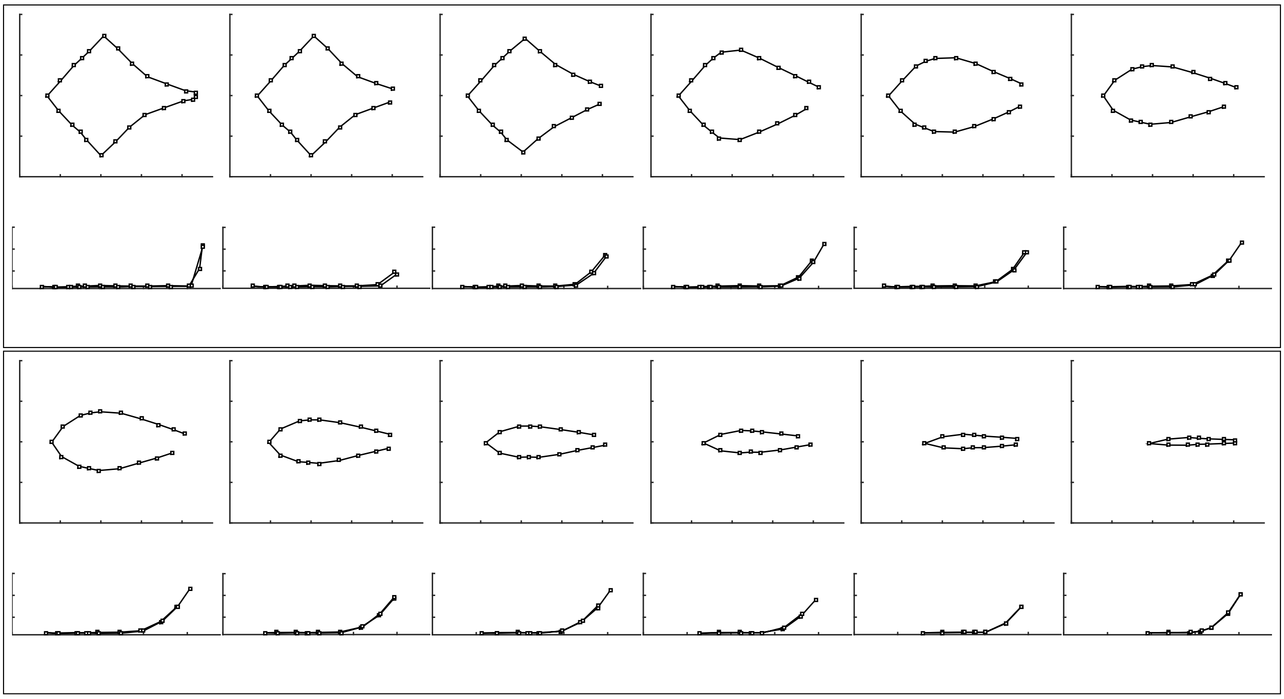

Figure 54: Combination Rope, Heavy, Fast MovieClip Frame dt 2 sec

3.3.5 Polyester Rope, Light, Slow

Here we present the results for the scenario with polyester rope laid out in a diamond, using the light weight and the slow winch speed. Figure 55 shows the seine rope configuration seen from above.

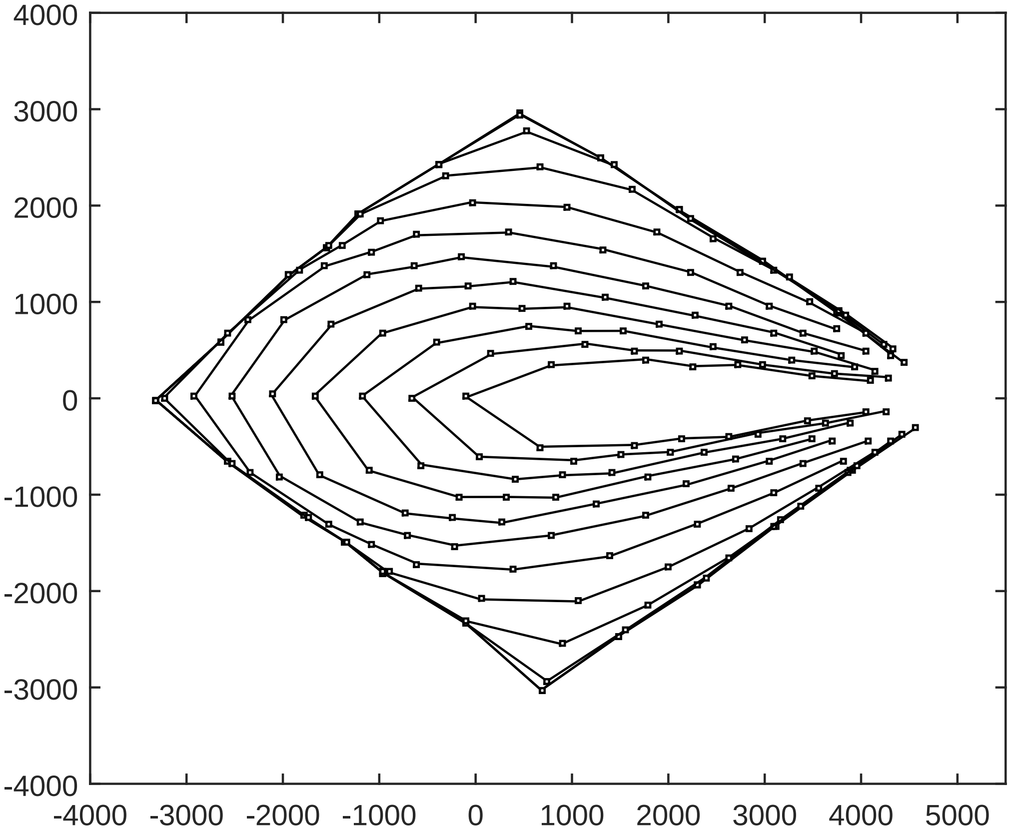

Figure 55: Polyester Rope, Light, Slow CombinedSeine dt 3 sec

Figure 56 shows the area encircled by the part of the seine ropes which is resting on the bottom of the flume tank.

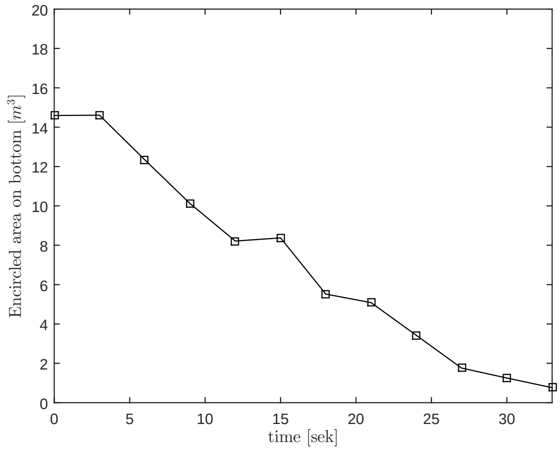

Figure 56: Polyester Rope, Light, Slow ButtomArea

Figure 57 shows the seine rope configuration seen from above and from the side. The interval is 3 seconds in figure 55 and 57. During the haul back procedure the seine ropes stay on the bottom and appart.

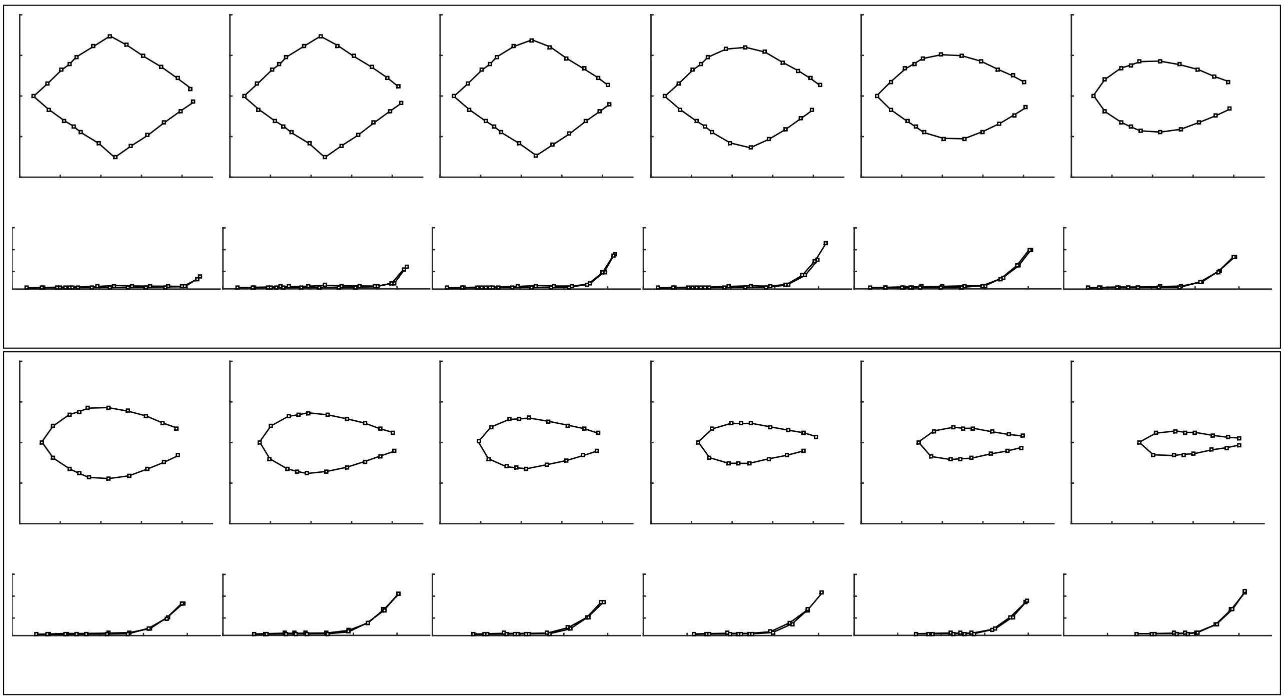

Figure 57: Polyester Rope, Light, Slow MovieClip Frame dt 3 sec

3.3.6 Polyester Rope, Heavy, Slow

Here we present the results for the scenario with polyester rope laid out in a diamond, using the heavy weight and the slow winch speed. Figure 58 shows the seine rope configuration seen from above.

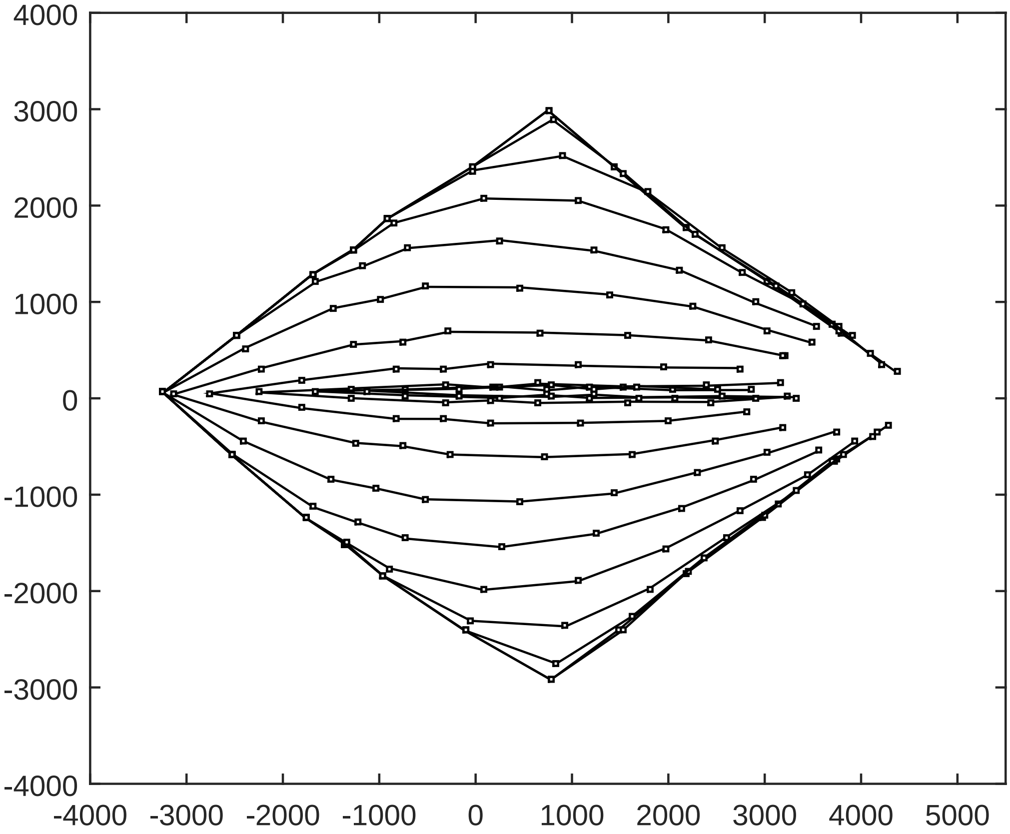

Figure 58: Polyester Rope, Heavy, Slow CombinedSeine dt 3 sec

Figure 59 shows the area encircled by the part of the seine ropes which is resting on the bottom of the flume tank.

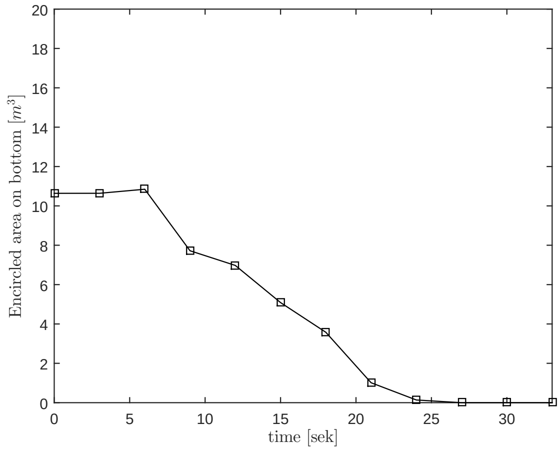

Figure 59: Polyester Rope, Heavy, Slow ButtomArea

Figure 60 shows the seine rope configuration seen from above and from the side. The interval is 3 seconds in figure 58 and 60. During the haul back procedure the seine ropes lifts of the bottom and collapse.

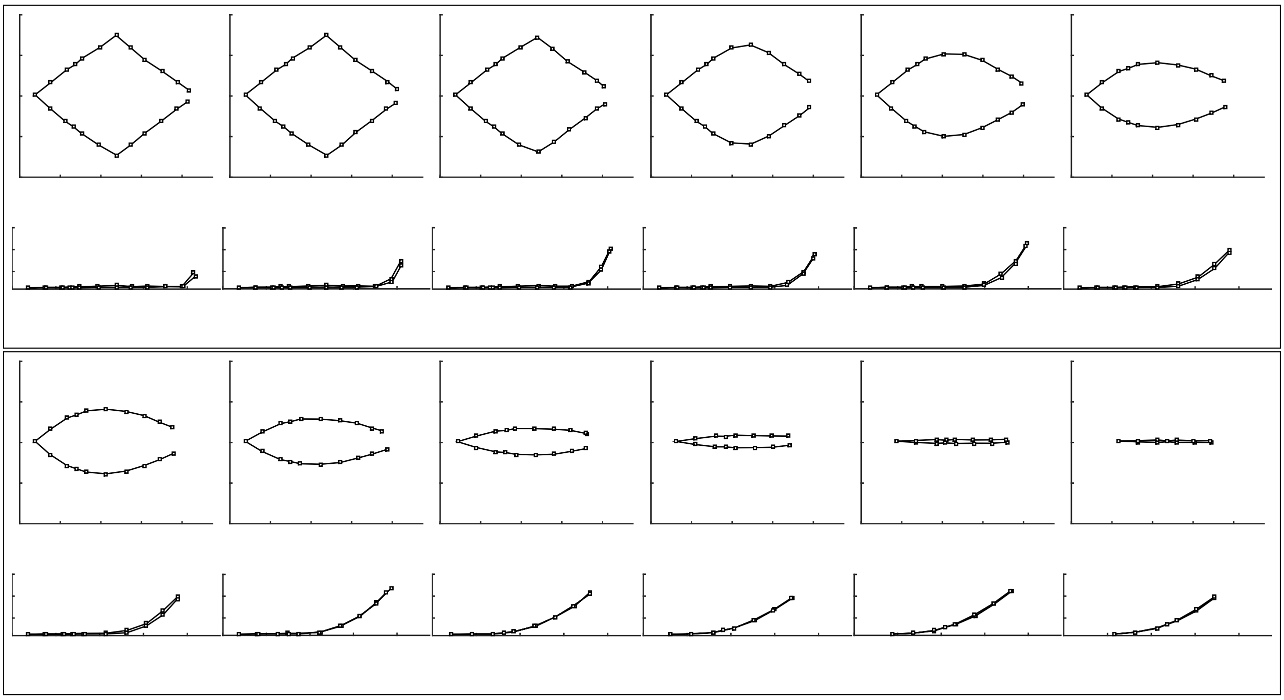

Figure 60: Polyester Rope, Heavy, Slow MovieClip Frame dt 3 sec

3.3.7 Polyester Rope, Light, Fast

Here we present the results for the scenario with polyester rope laid out in a diamond, using the light weight and the fast winch speed. Figure 61 shows the seine rope configuration seen from above.

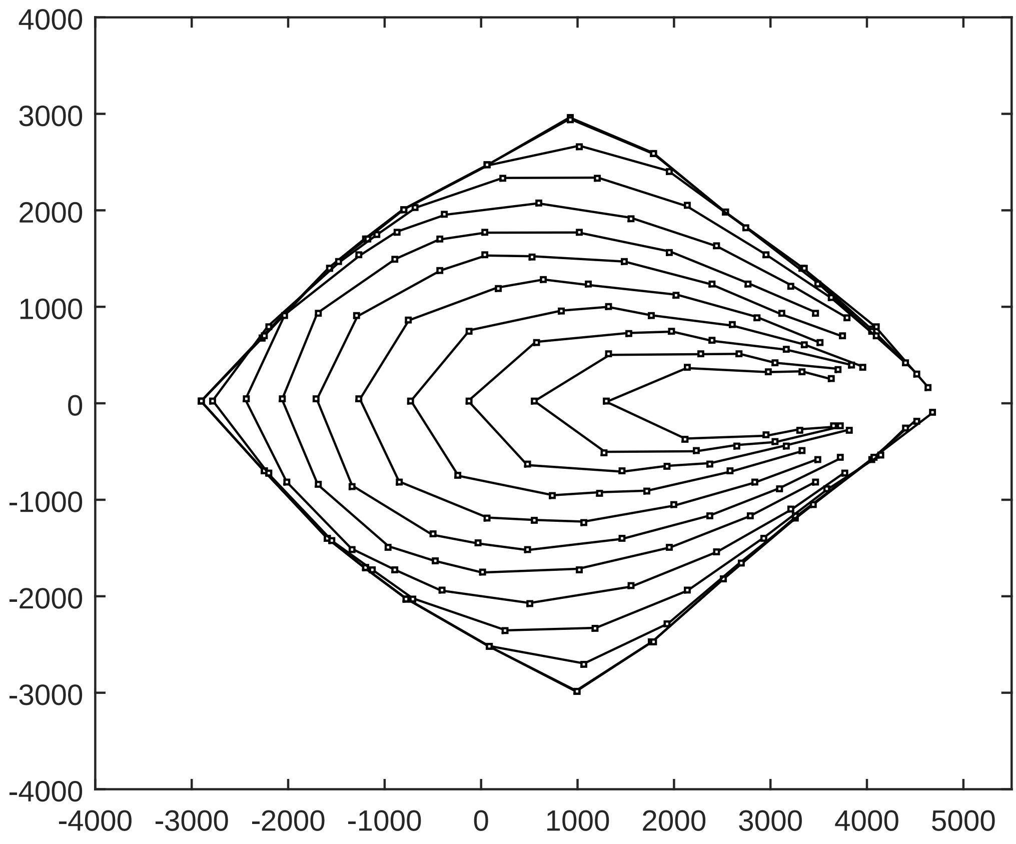

Figure 61: Polyester Rope, Light, Fast CombinedSeine dt 2 sec

Figure 62 shows the area encircled by the part of the seine ropes which is resting on the bottom of the flume tank.

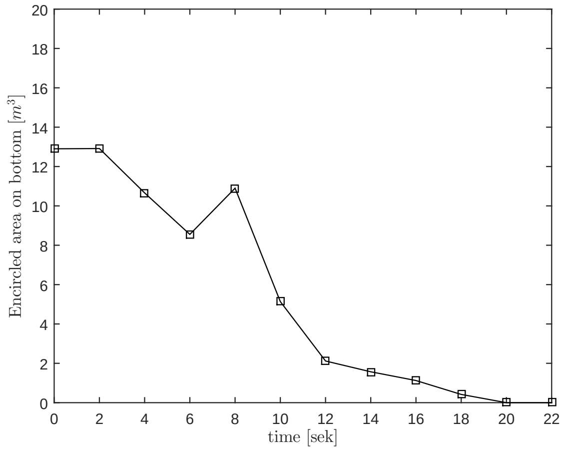

Figure 62: Polyester Rope, Light, Fast ButtomArea

Figure 63 shows the seine rope configuration seen from above and from the side. The interval is 2 seconds in figure 61 and 63. During the haul back procedure the seine ropes lifts of the bottom but does not collapse.

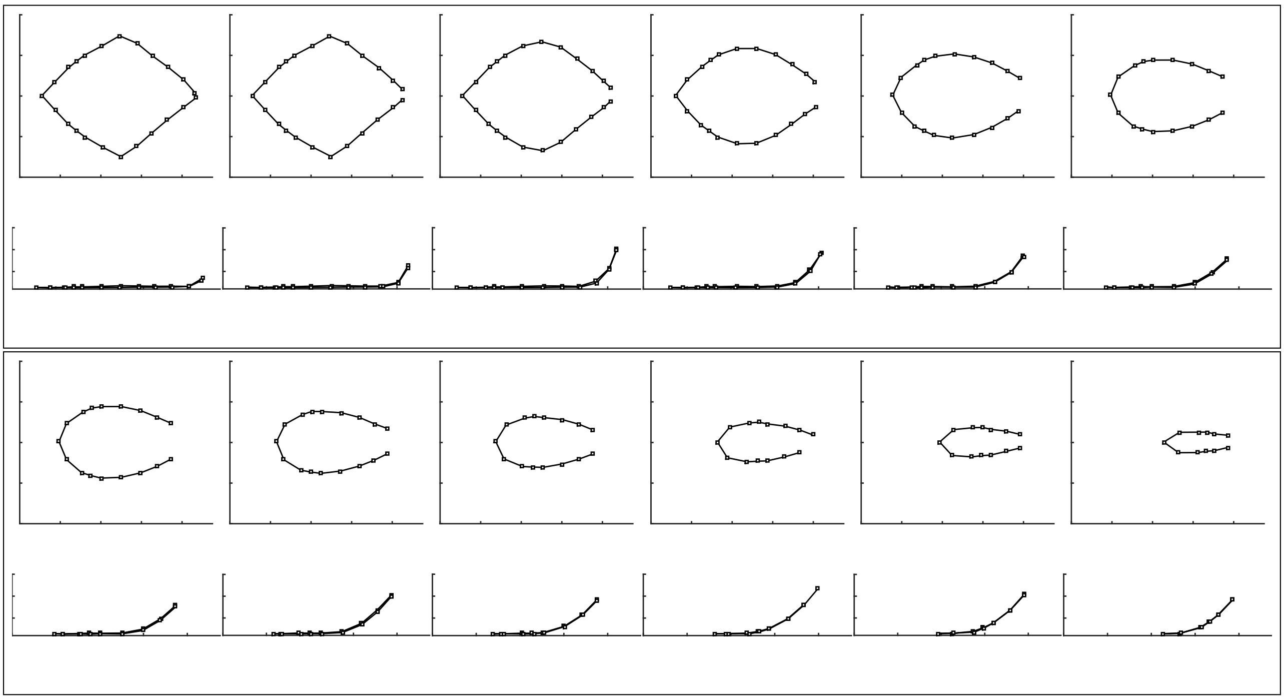

Figure 63: Polyester Rope, Light, Fast MovieClip Frame dt 2 sec

3.3.8 Polyester Rope, Heavy, Fast

Here we present the results for the scenario with polyester rope laid out in a diamond, using the heavy weight and the fast winch speed. Figure 64 shows the seine rope configuration seen from above.

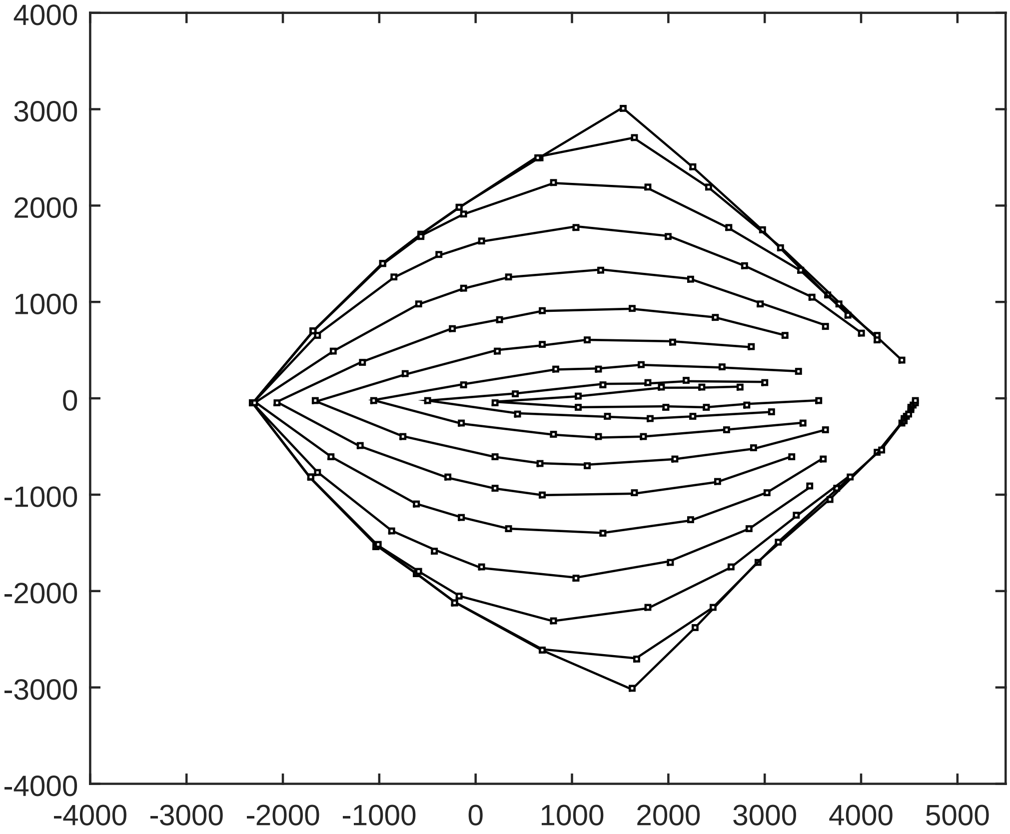

Figure 64: Polyester Rope, Heavy, Fast CombinedSeine dt 2 sec

Figure 65 shows the area encircled by the part of the seine ropes which is resting on the bottom of the flume tank.

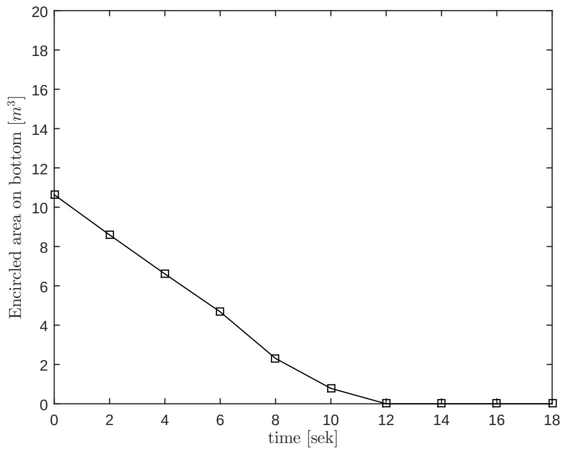

Figure 65: Polyester Rope, Heavy, Fast ButtomArea

Figure 66 shows the seine rope configuration seen from above and from the side. The interval is 2 seconds in figure 64 and 66. During the haul back procedure the seine ropes lifts of the bottom and collapses.

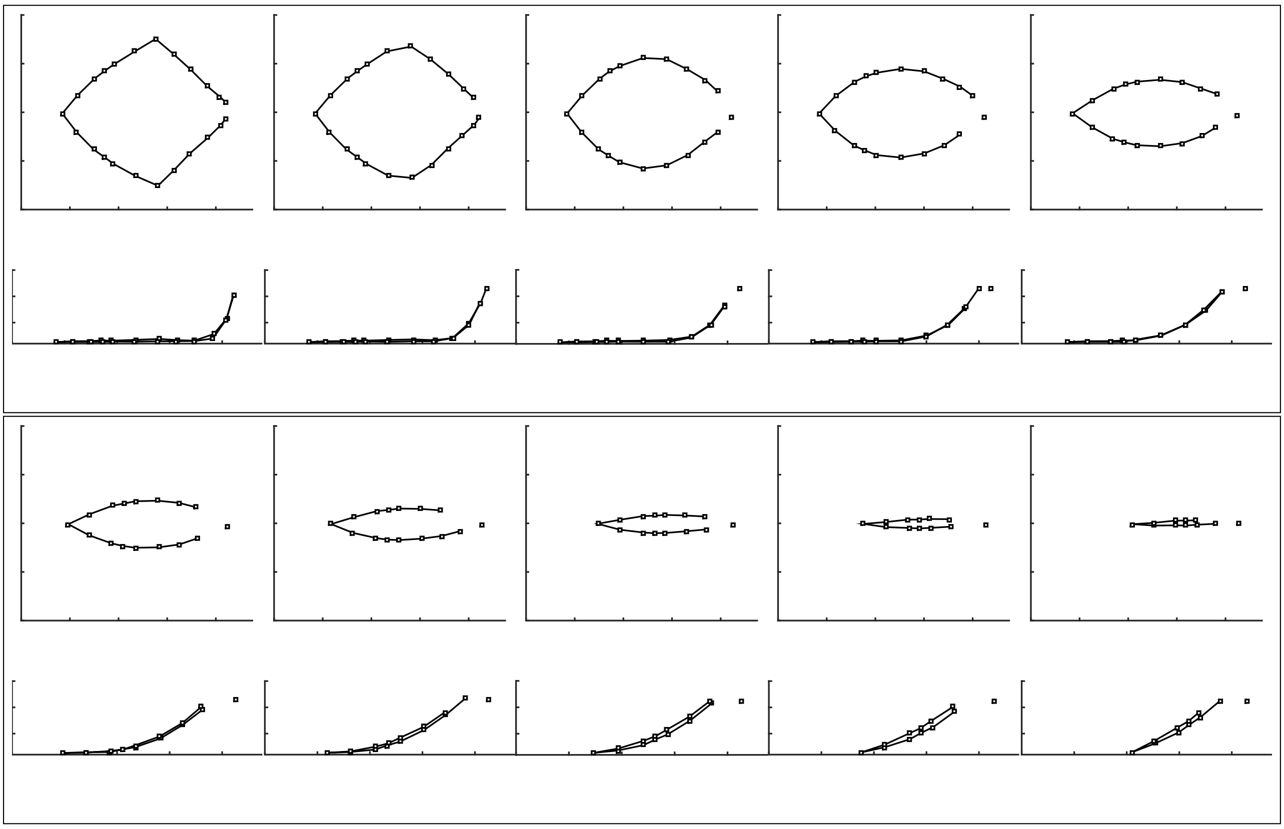

Figure 66: Polyester Rope, Heavy, Fast MovieClip Frame dt 2sec

3.4 Triangle Layout

3.4.1 Combination Rope, Light, Slow

Here we present the results for the scenario with combination rope laid out in a diamond, using the light weight and the slow winch speed. Figure 67 shows the seine rope configuration seen from above.

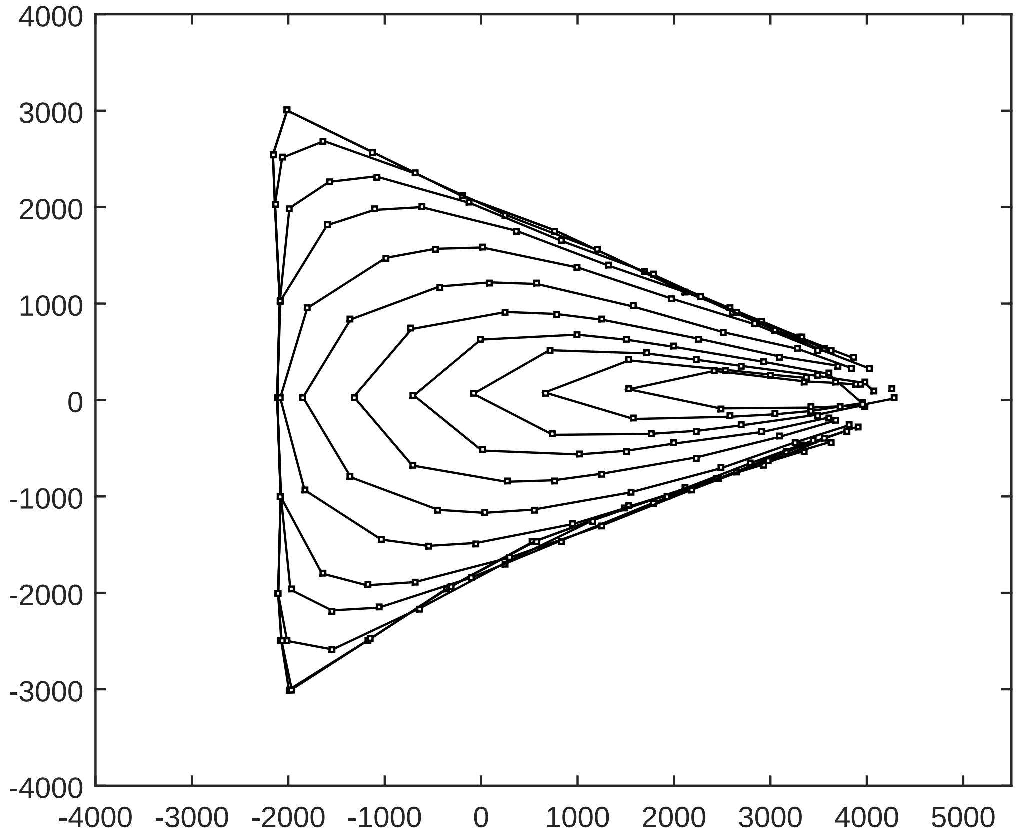

Figure 67: Combination Rope, Light, Slow, dt 4 sec

Figure 68 shows the area encircled by the part of the seine ropes which is resting on the bottom of the flume tank.

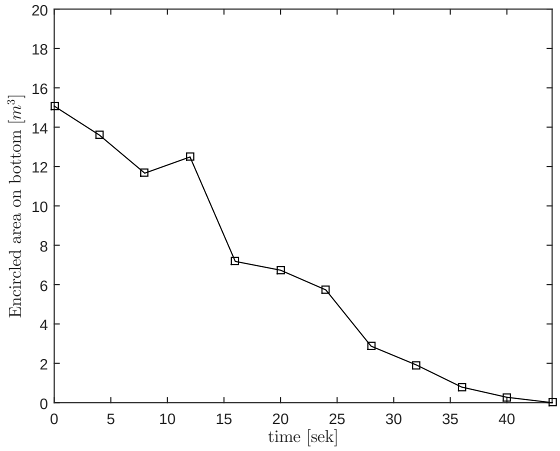

Figure 68: Combination Rope, Light, Slow, ButtomArea

Figure 69 shows the seine rope configuration seen from above and from the side. The interval is 4 seconds in figure 67 and 69. During the haul back procedure the seine ropes stays on the bottom and keeps an elongated shape.

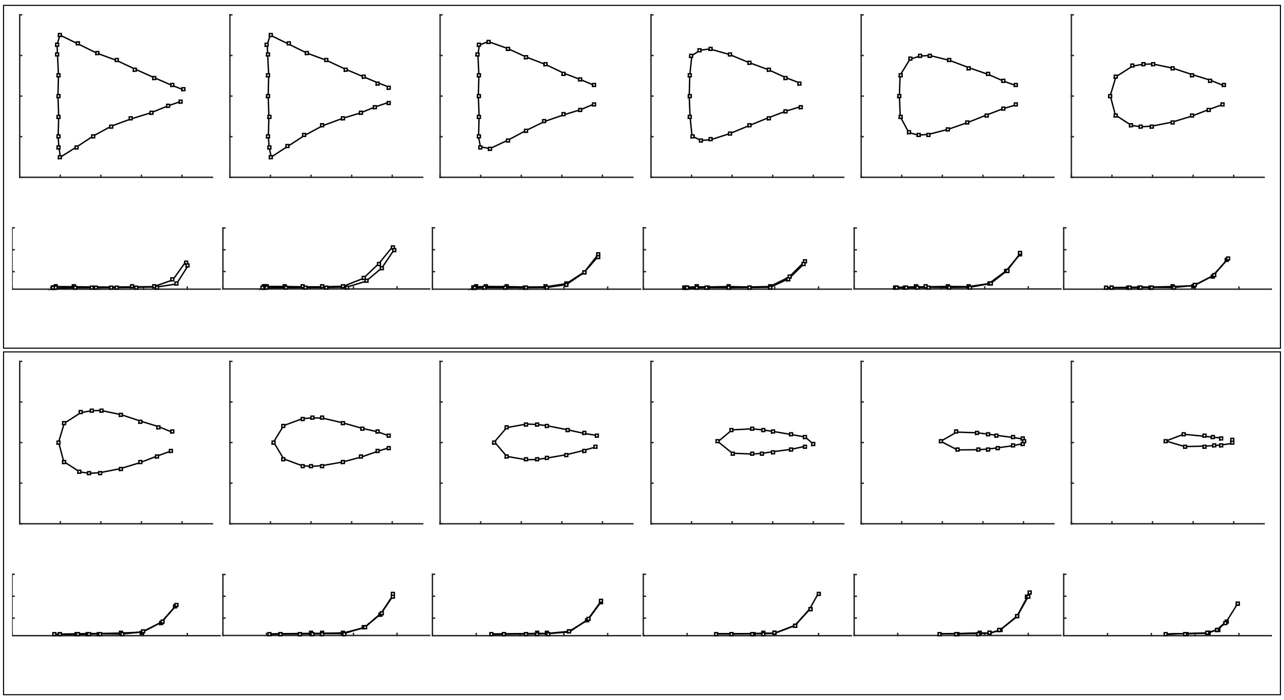

Figure 69: Combination Rope, Light, Slow, Frame dt 4 sec

3.4.2 Combination Rope, Heavy, Slow

Here we present the results for the scenario with combination rope laid out in a diamond, using the heavy weight and the slow winch speed. Figure 70 shows the seine rope configuration seen from above.

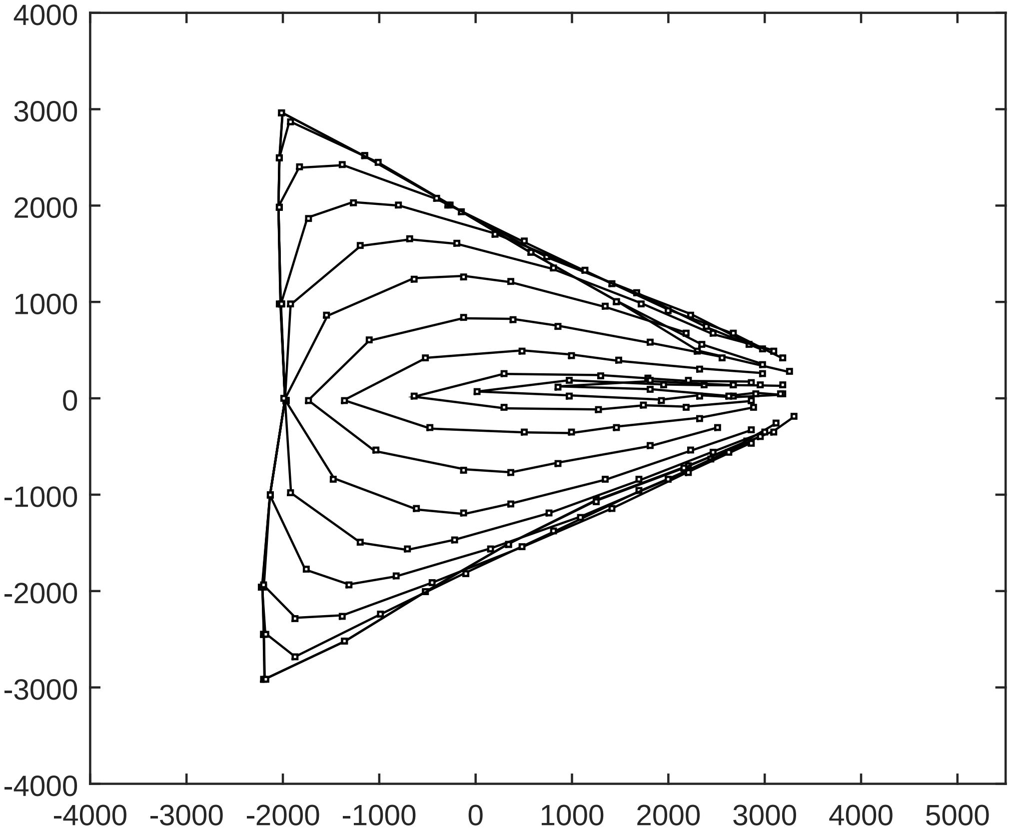

Figure 70: Combination Rope, Heavy, Slow, CombinedSeine, dt 4 sec

Figure 71 shows the area encircled by the part of the seine ropes which is resting on the bottom of the flume tank.

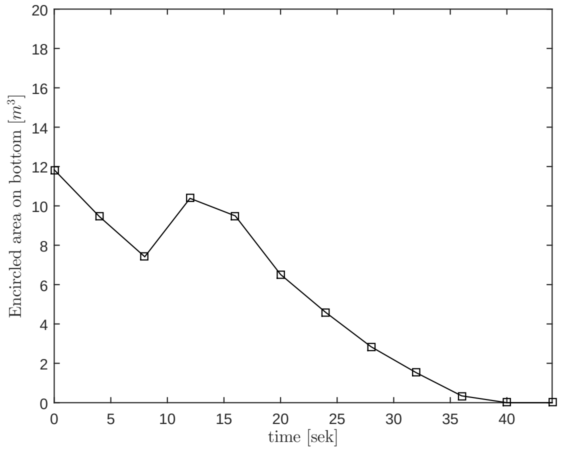

Figure 71: Combination Rope, Heavy, Slow ButtomArea

Figure 72 shows the seine rope configuration seen from above and from the side. The interval is 4 seconds in figure 70 and 72. During the haul back procedure the seine rope collapses and remains on the bottom.

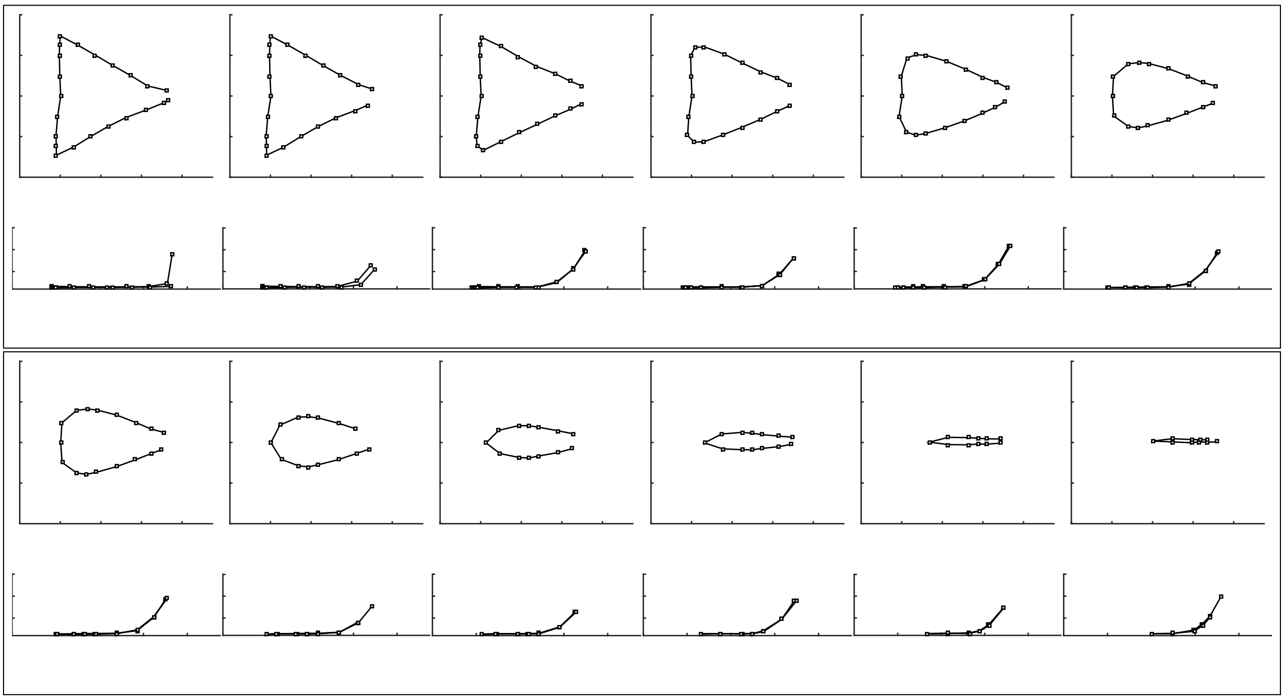

Figure 72: Combination Rope, Heavy, Slow, MovieClip frame 4 sec

3.4.3 Combination Rope, Light, Fast

Here we present the results for the scenario with combination rope laid out in a diamond, using the light weight and the fast winch speed. Figure 73 shows the seine rope configuration seen from above.

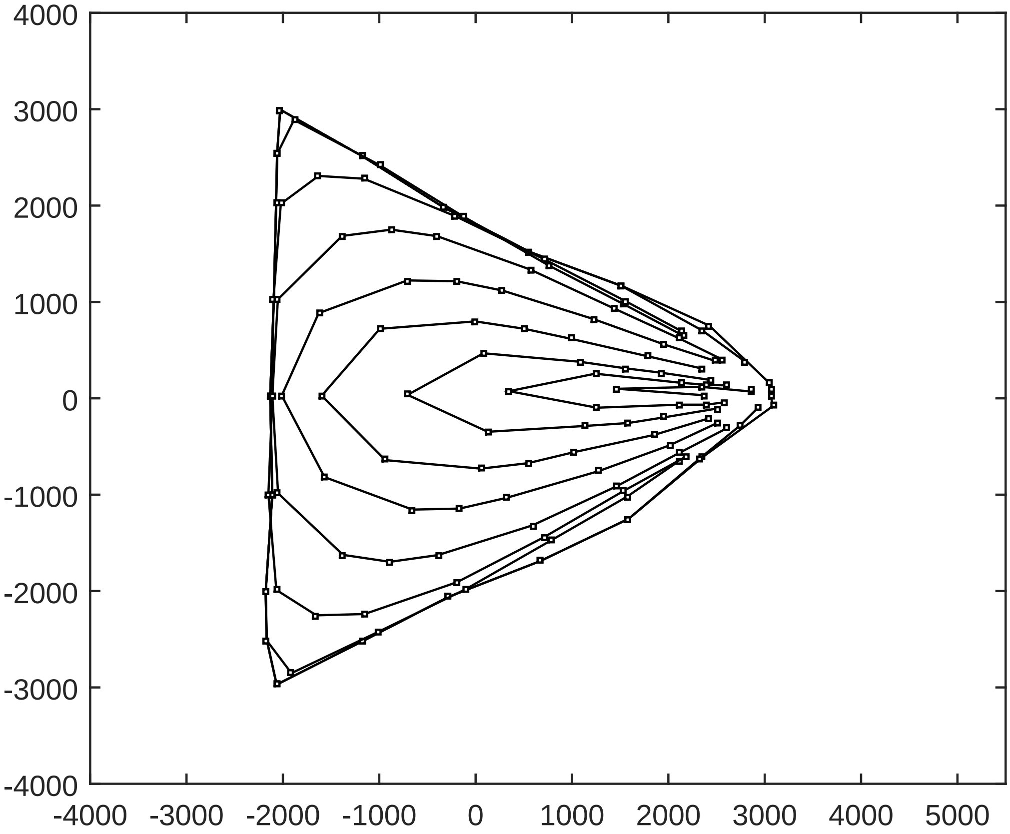

Figure 73: Combination Rope, Light, Fast CombinedSeine dt 3 sec

Figure 74 shows the area encircled by the part of the seine ropes which is resting on the bottom of the flume tank.

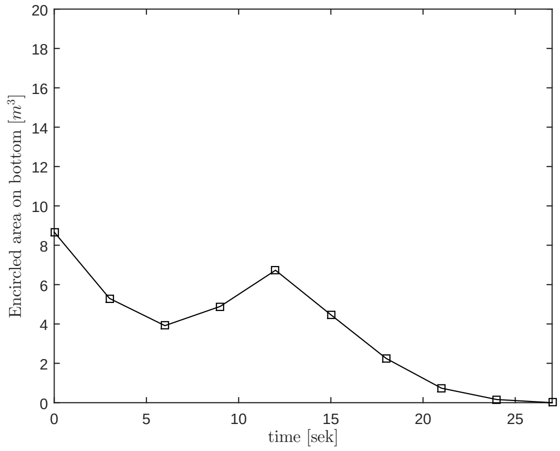

Figure 74: Combination Rope, Light, Fast ButtomArea

Figure 75 shows the seine rope configuration seen from above and from the side. The interval is 3 seconds in figure 73 and 75. During the haul back procedure the seine rope nearly collapses and remains on the bottom.

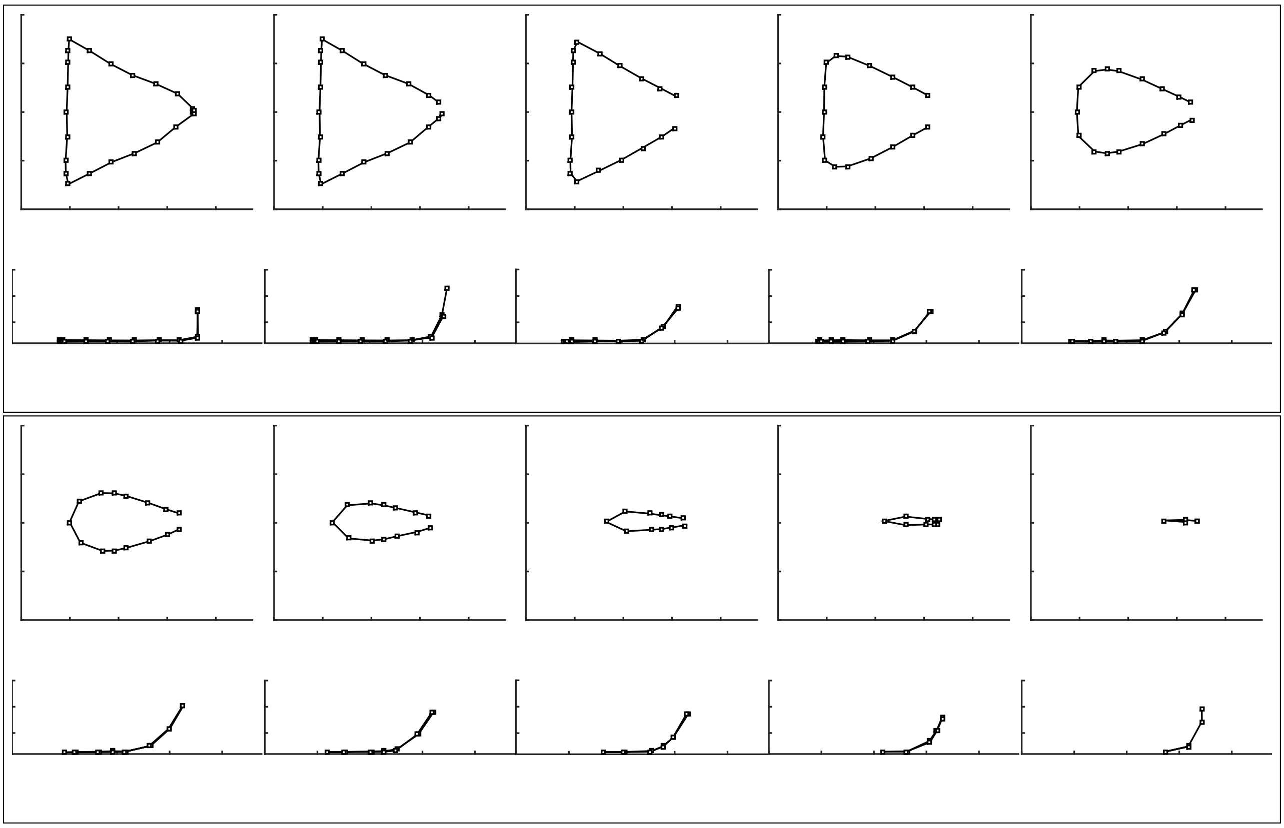

Figure 75: Combination Rope, Light, Fast MovieClip, frame 3 sec

3.4.4 Combination Rope, Heavy, Fast

Here we present the results for the scenario with combination rope laid out in a diamond, using the heavy weight and the fast winch speed. Figure 76 shows the seine rope configuration seen from above.

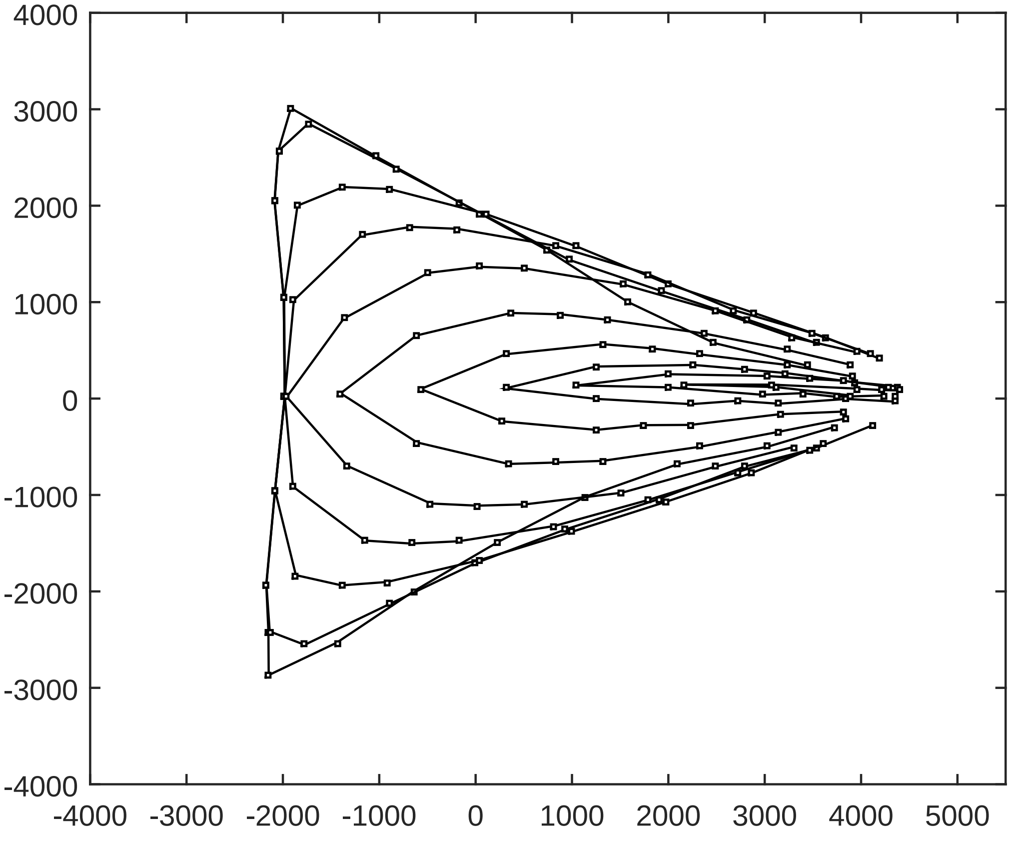

Figure 76: Combination Rope, Heavy, Fast CombinedSeine dt 3 sec

Figure 77 shows the area encircled by the part of the seine ropes which is resting on the bottom of the flume tank.

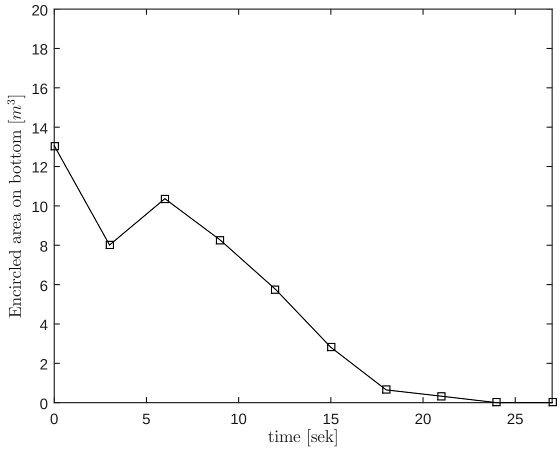

Figure 77: Combination Rope, Heavy, Fast ButtomArea

Figure 78 shows the seine rope configuration seen from above and from the side. The interval is 3 seconds in figure 76 and 78. During the haul back procedure the seine rope collapses but remains on the bottom.

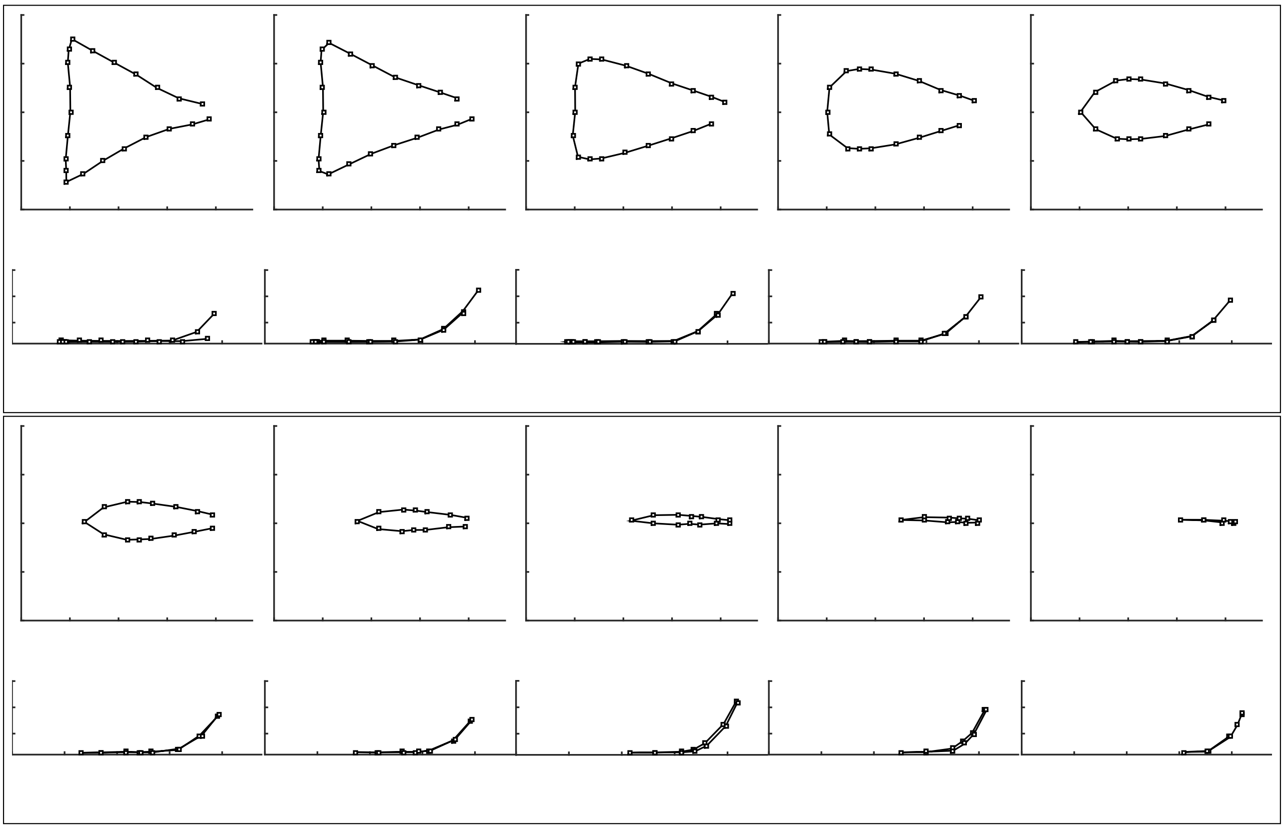

Figure 78: Combination Rope, Heavy, Fast MovieClip Frame dt 3 sec

3.4.5 Polyester Rope, Light, Slow

Here we present the results for the scenario with polyester rope laid out in a diamond, using the light weight and the slow winch speed. Figure 79 shows the seine rope configuration seen from above.

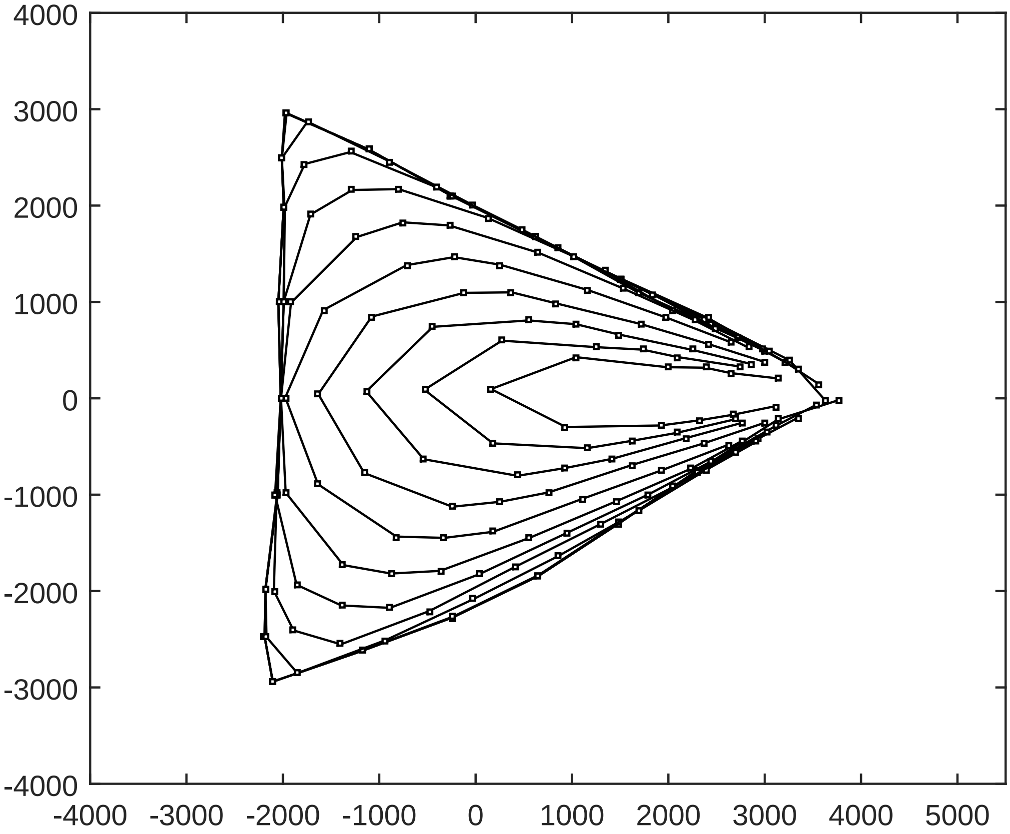

Figure 79: Polyester Rope, Light, Slow CombinedSeine dt 3.5 sec

Figure 80 shows the area encircled by the part of the seine ropes which is resting on the bottom of the flume tank.

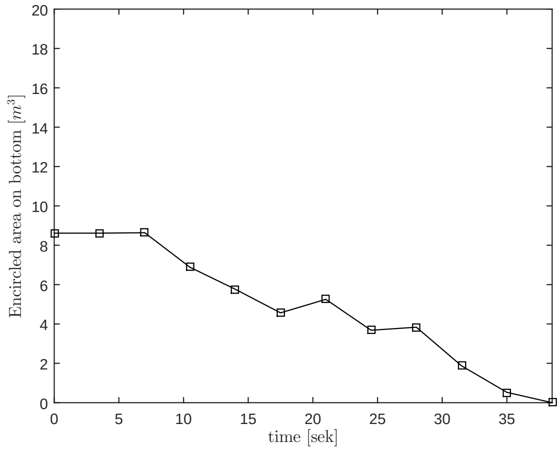

Figure 80: Polyester Rope, Light, Slow ButtomArea

Figure 81 shows the seine rope configuration seen from above and from the side. The interval is 3.5 seconds in figure 79 and 81. During the haul back procedure the seine rope remains open and on the bottom.

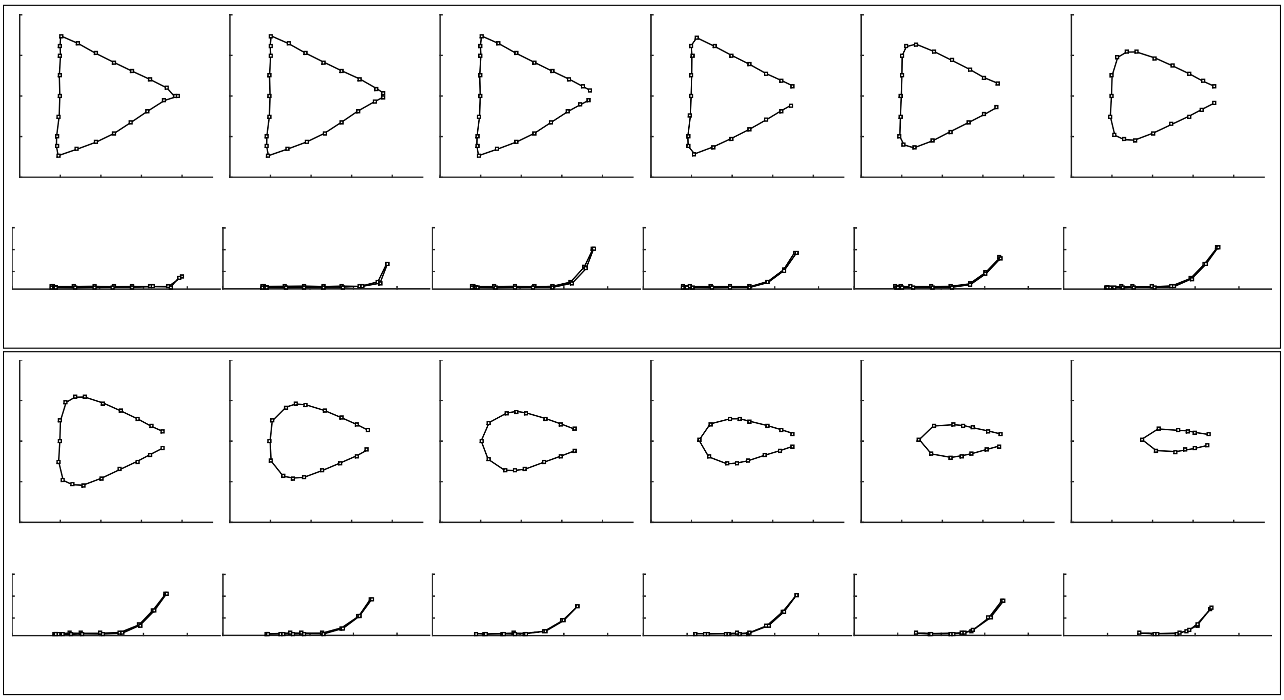

Figure 81: Polyester Rope, Light, Slow MovieClip Frame dt 3.5 sec

3.4.6 Polyester Rope, Heavy, Slow

Here we present the results for the scenario with polyester rope laid out in a diamond, using the heavy weight and the slow winch speed. Figure 82 shows the seine rope configuration seen from above.

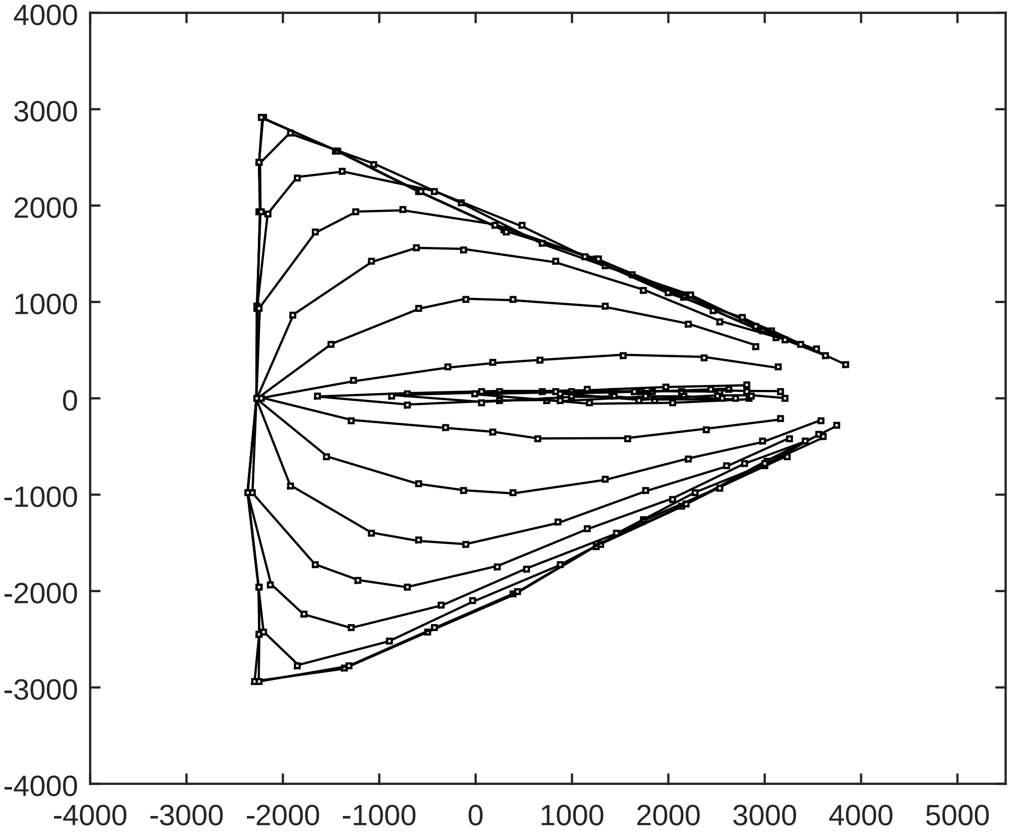

Figure 82: Polyester Rope, Heavy, Slow CombinedSeine dt 4 sec

Figure 83 shows the area encircled by the part of the seine ropes which is resting on the bottom of the flume tank.

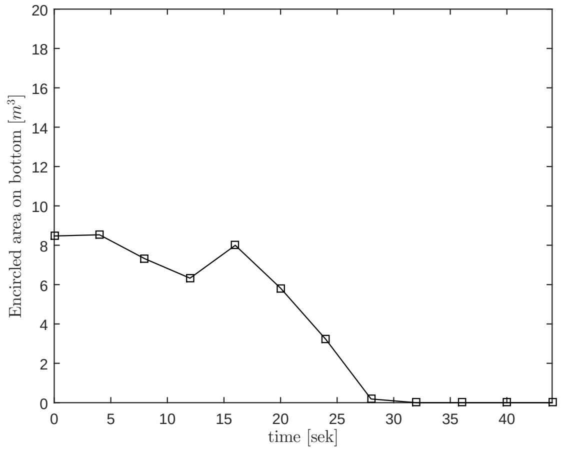

Figure 83: Polyester Rope, Heavy, Slow ButtomArea

Figure 84 shows the seine rope configuration seen from above and from the side. The interval is 4 seconds in figure 82 and 84. During the haul back procedure the seine rope collapses and lifts of the bottom.

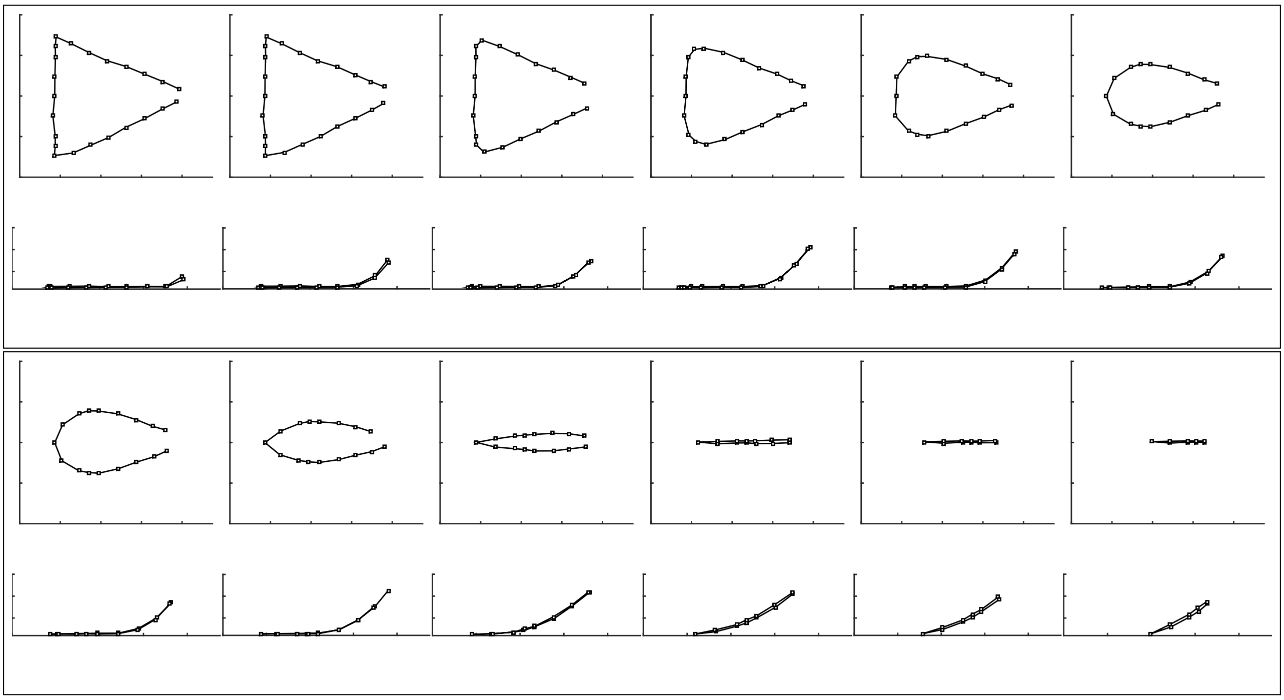

Figure 84: Polyester Rope, Heavy, Slow MovieClip Frame dt 4 sec

3.4.7 Polyester Rope, Light, Fast

Here we present the results for the scenario with polyester rope laid out in a diamond, using the light weight and the fast winch speed. Figure 85 shows the seine rope configuration seen from above.

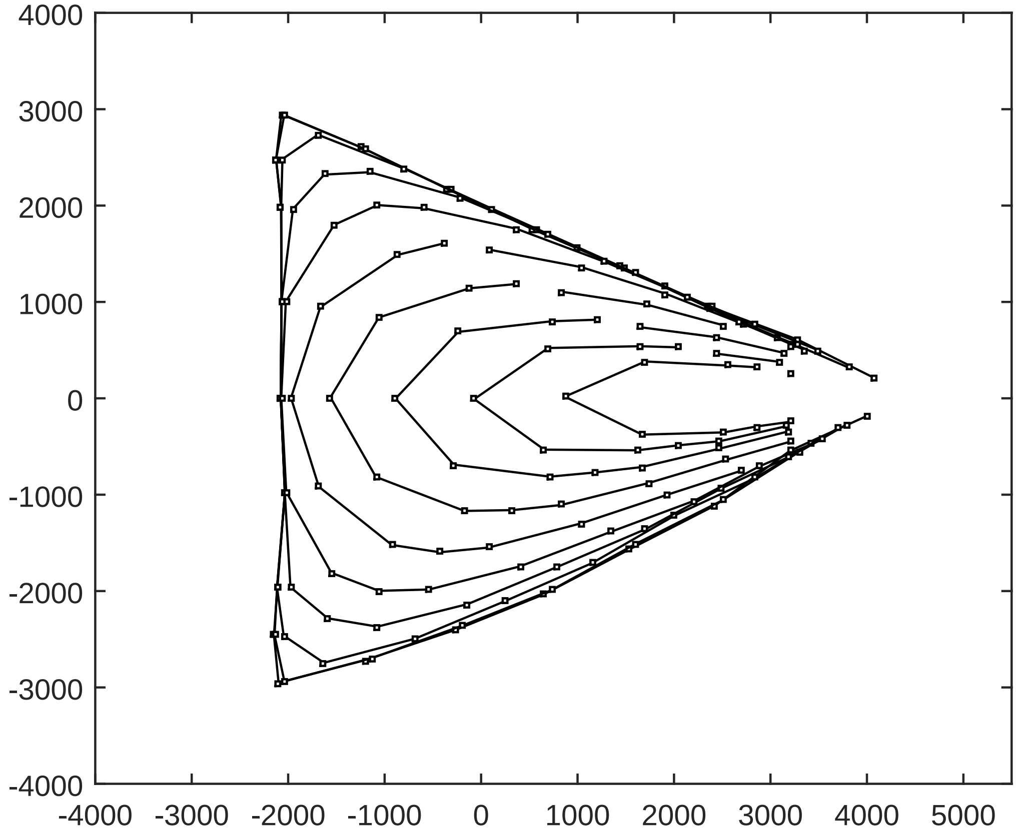

Figure 85: Polyester Rope, Light, Fast CombinedSeine dt 2.5 sec

Figure 86 shows the area encircled by the part of the seine ropes which is resting on the bottom of the flume tank.

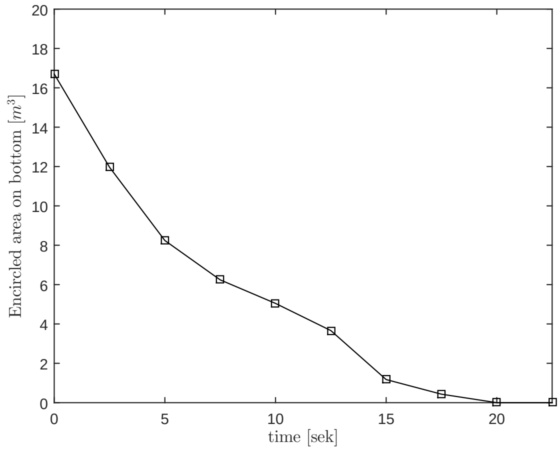

Figure 86: Polyester Rope, Light, Fast ButtomArea

Figure 87 shows the seine rope configuration seen from above and from the side. The interval is 2.5 seconds in figure 85 and 87. During the haul back procedure the seine rope remains open but lifts of the bottom.

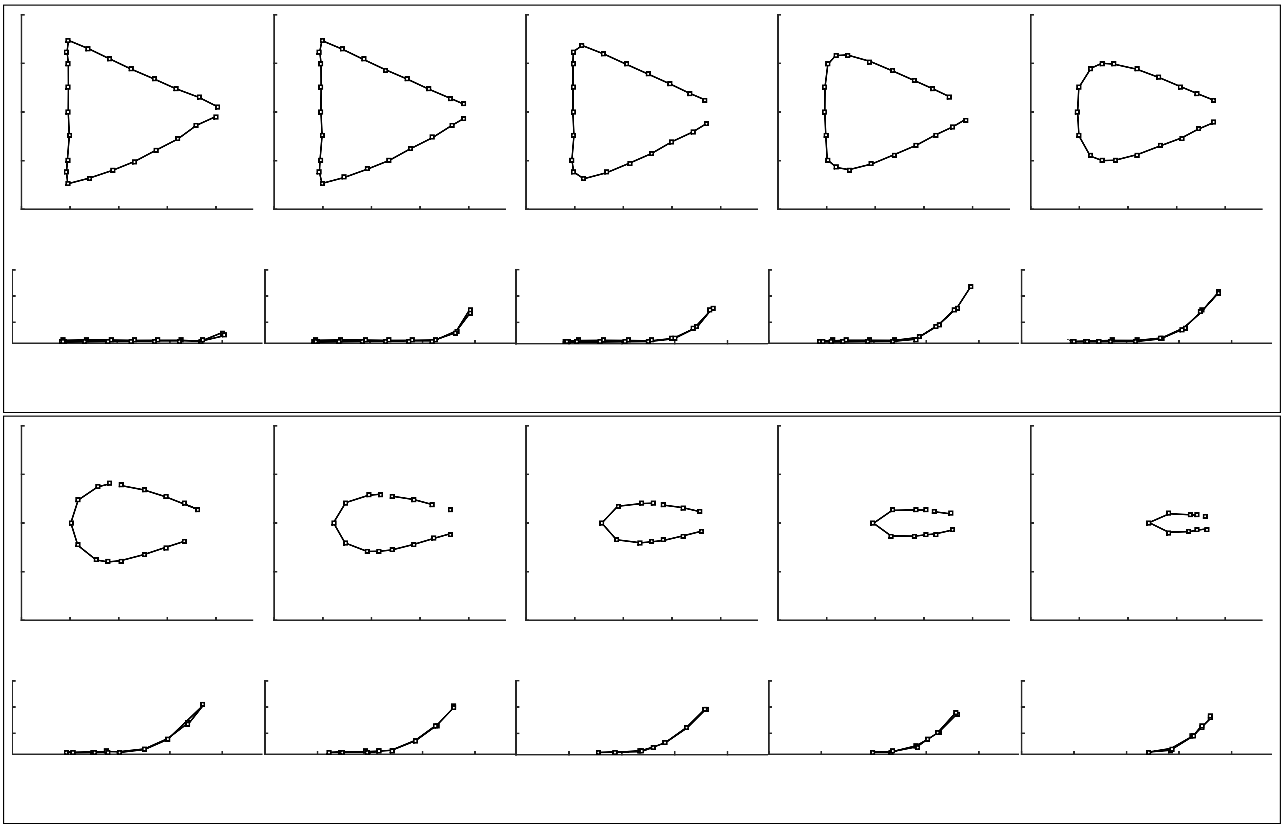

Figure 87: Polyester Rope, Light, Fast MovieClip Frame dt 2.5 sec

3.4.8 Polyester Rope, Heavy, Fast

Here we present the results for the scenario with polyester rope laid out in a diamond, using the heavy weight and the fast winch speed. Figure 88 shows the seine rope configuration seen from above.

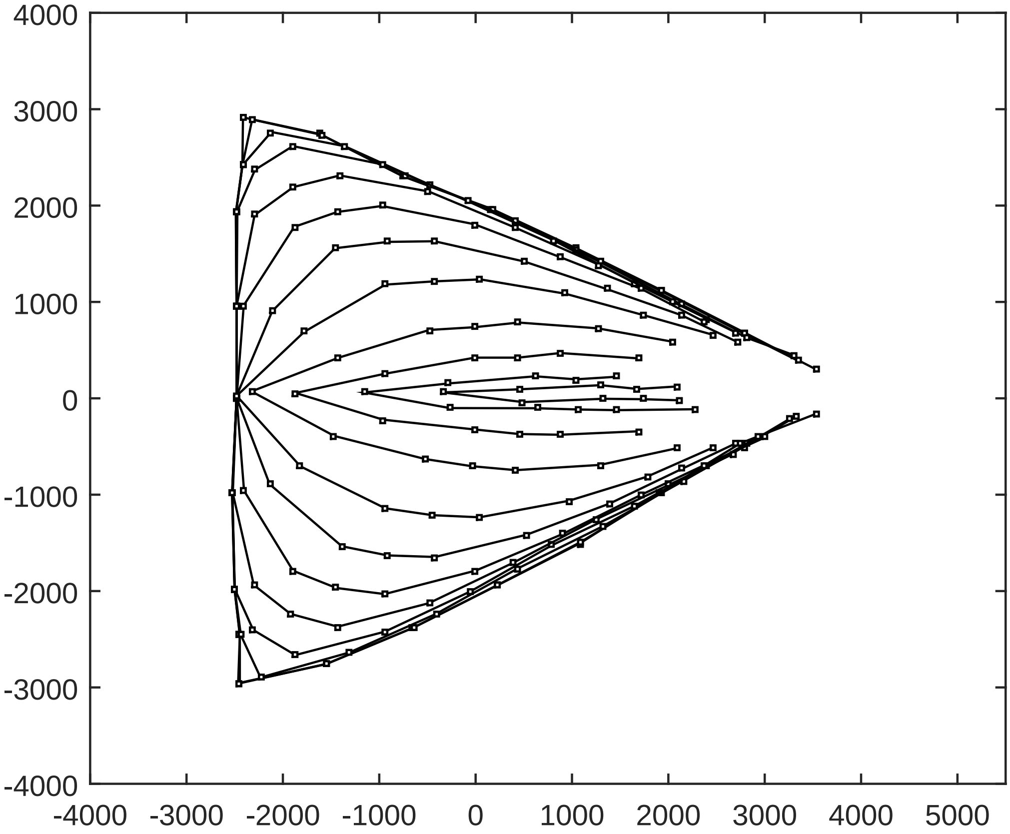

Figure 88: Polyester Rope, Heavy, Fast CombinedSeine dt 3 sec

Figure 89 shows the area encircled by the part of the seine ropes which is resting on the bottom of the flume tank.

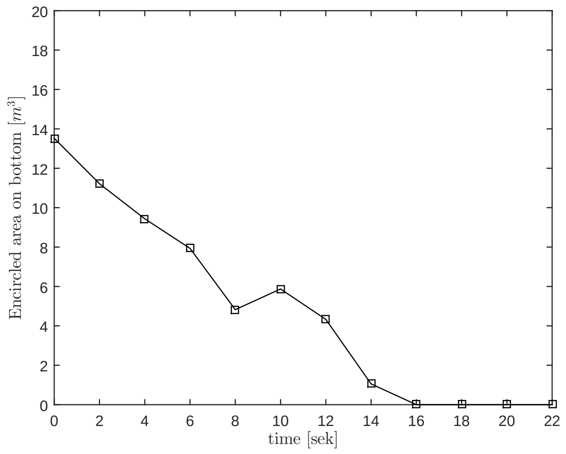

Figure 89: Polyester Rope, Heavy, Fast ButtomArea

Figure 90 shows the seine rope configuration seen from above and from the side. The interval is 3 seconds in figure 88 and 90. During the haul back procedure the seine rope remains open but lifts of the bottom.

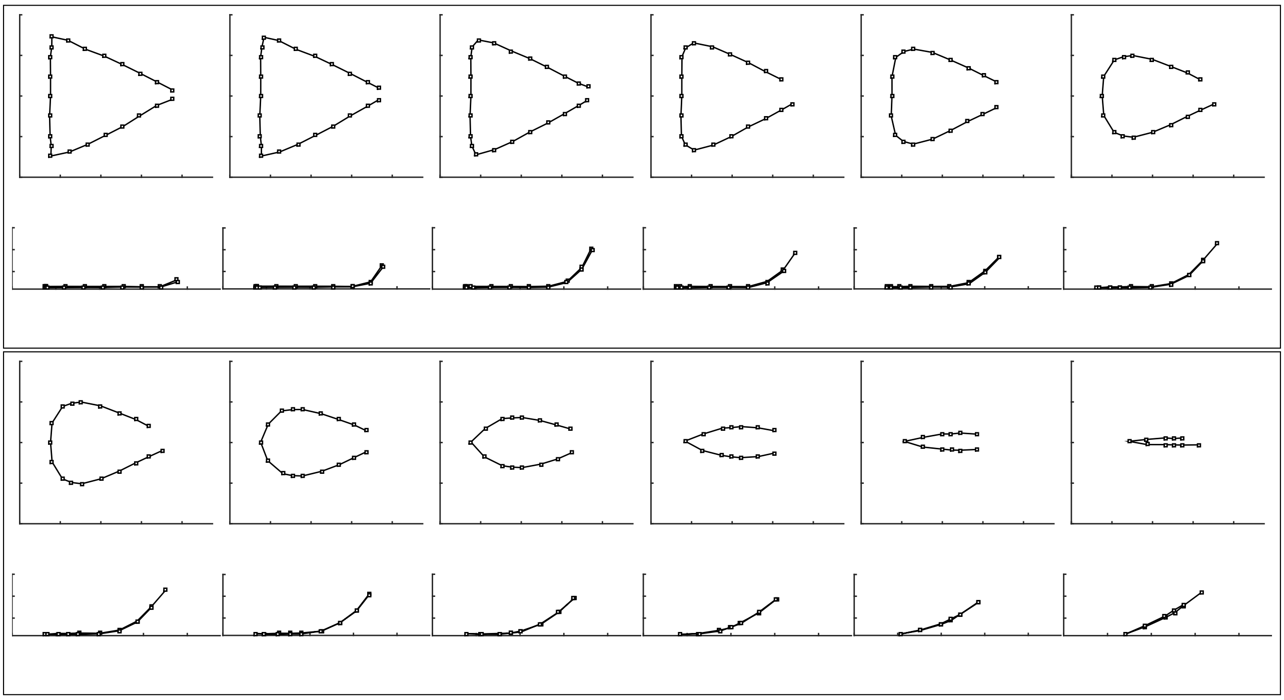

Figure 90: Polyester Rope, Heavy, Fast MovieClip Frame dt 3 sec

4 Acknowledgements

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