The effect of catch weight on trawl behaviour

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Abstract

Measurements at sea during fishing trials on bottom trawl, have revealed that the geometry of the trawl is affected by the catch. A series of 27 hauls of around 3h have been carried out during the EFFICHALUT project. This project aimed to find out improvements on the fishing gear in order to reduce the energy consumption. For this project numerous sensors have been used, for bridles tension, doors spread, vertical opening, doors attitude. The measurements show quite clearly that the doors spread decreases and the bridles tension increases along most of the hauls. The doors spread decreases by 1.35m per hour, with a standard deviation of 1.98m/h when the top bridle tension increases of 47kg/h, with a standard deviation of 59kg/h. The mean catch per haul is around 1.48ton. The modelling of the trawl gear and the catch with a FEM allows to explain the variation of the doors spread and the bridle tension: The model explains a mean decrease of 0.77m/h for the door spread and a mean increase of 55Kg/h for the top bridle tension.

Keywords

Trawl, data, modelling, doors spread, bridle tension, catch weight.

Introduction

The Effichalut project (Priour, 2012), has been dedicated to energy efficiency of bottom trawl. During this project measurements at sea have been carried out. In the present paper we propose to described one of findings of this project which is about the effect of catch on gear geometry behaviour.

Trawl performance is generally speaking investigated by flume tank tests, full scale tests at sea, analytical modelling or numerical model (Priour 2013). These investigations take into account the design of the gear, the water speed, the bottom contact, but there are only few studies on catch effects (O'Neill et al., 2005, Priour 2013).

Methodology

The trawl has been provided by the fisherman (Priour, 2012). The doors, (Morgere company) are of 2.9m by 1.85m wide and weigh 1.4 t. The warp length is 150m for the first week at sea and 60m for the second. The fisherman drives the trawl at constant engine power (107l/h of fuel).

Tests at sea have been carried out during two weeks. The depth during the first week was around 50m and 20 m for the second. The trawl is equipped of 6 tension sensors: on each bottom bridle, top bridle and warp (Figure 1). The tension are recorded by NKE SF sensors (range 5 ton, accuracy 25kg and resolution 2.2kg). The doors depth are also recorded as well as doors spread. The sensors used are NKE S3AP for doors depth and SCANMAR sensor for the doors spread. The water speed on the head-rope and the gound speed are measured as well as the vertical opening of the mouth of the trawl. The water speed and the vertical opening of the mouth of the trawl. The water speed and the vertical opening of the mouth of the trawl.

The water speed and the vertical opening are measured with SCANMAR sensors fastened to the headline of the trawl. The ground speed is measured with a GPS on the boat.
Each sensor provides a time series. From the measurement of the depth of the doors (Figure 2), the beginning and the end of each haul are determined. The catch has not been measured for each haul, but the total catch per week has been assessed by the fisherman and was around 40tons.
The modelling of the gear is based on the Finite Element Method (FEM) model of the net based on a triangular element (Priour 2013). The FEM requires to know the volume inside the surface of netting affected by the catch. This volume is assessed using the model of Priour & Herrmann (2005).

Results

For few hauls it appears quite clearly that the doors spread (Figure 3) decreases with time since the beginning of the haul if the former and later minutes are neglected. The linear relation between doors spread and time since the beginning of the haul is calculated for each haul. On Figure 3 this relation is:
DS=69.1-1.28 HT
DS=doors spread (m),
HT=time since the beginning of the haul (h).
That means that the doors spread at the beginning of the haul is assessed to be 69.1m and the decrease of the spread is assessed to be 1.28m per hour.

For each haul the linear relation between door spread and time since the beginning of the haul is calculated. On Figure 4 there are all the hauls, the 5 first minutes and 2 last minutes of each haul have been removed from the Figure 4 and from the calculation. From the linear relations the doors spreads is calculated for each time by the way the mean spread and the standard deviation is calculated for each time by the way the mean spread and the standard deviation is calculated for each time. On Figure 4, the line is the mean value of the spread and two curves below and above the line are mean value more or less the standard deviation. The spread for all hauls follows the relation:
DS=58.5(±7.35) –1.35(±1.98) HT
DS=the mean doors spread (m)
HT=time since the beginning of the haul (h).
That means that the mean decrease is 1.35m/h.

The catch is around 40tons per week (landed catch and by catch) for the 27 hauls. That means that the mean catch per haul is 1.48ton. The model of Priour & Herrmann (2005) drives to a volume inside the cod-end of 2.6m^3 when the catch is 1.48ton. We define 3 durations since the beginning of the haul: 0h, 1.5h and 3h. 0h represents obviously the empty cod-end, at 1.5h the cod-end is suspected half full (1.3m^3) and finally at 3h the cod-end is suspected full (2.6m^3).
The simulation of these 3 catch (empty, 1.3m^3 and 2.6m^3) have been made considering the mean water speed measured at sea (1.59m/s). The shapes of trawl are displayed on Figure 5.
These simulations are displayed on Figure 4 for the doors spread, on Figure 6 for the bottom tension and on Figure 7 for the top tension.

Discussion and conclusion

The fitting of the simulations with the measurements is pretty good for the doors spread (Figure 4), the bottom tension (Figure 6) and the top tension (Figure 7). That means that the variation of shape along the haul duration is probably mostly due to the catch increase.

The modelling uses an uniform speed around the trawl, up to the catch. This hypothesis is problbly discussable: the hydrodynamic drag of the netting leads necessary to a decrease of the water speed.
In this study the catch has been assessed for all the hauls of the week, for future work on this subject is would be profitable to record the catch after each haul, in order to model for each haul the exact conditions.
In this study the modelling has been made for a trawl in a mean condition except for the catch, we could suspect an improvement when the modelling is carried out for each haul: for example in case of Figure 3 the modelling could model the exact condition of this haul. This exact condition includes the depth and the water speed which have been recorded during this haul.
The most discussable point is probably the relation between the catch mass and the volume inside the netting surface affected by the catch. This relation has been defined in Priour & Herrmann 2005. It is extracted from flume tank tests. It would be of interest to measure at sea such relation, by underwater video for example.

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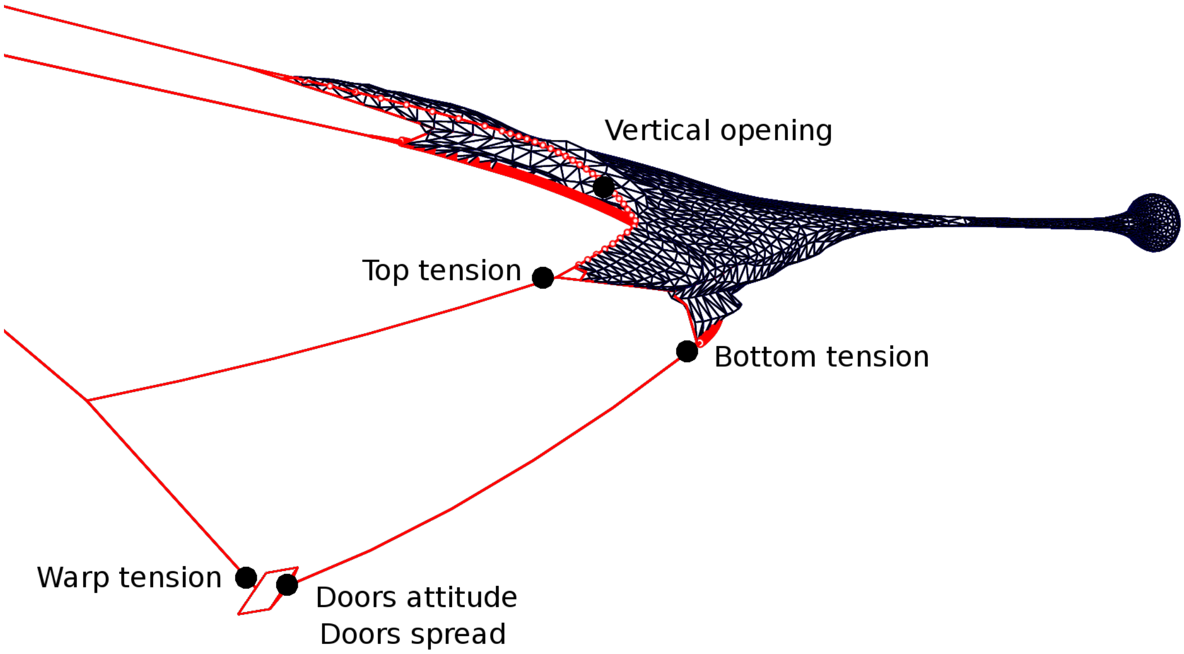

Figure 1

View of the simulated trawl. a) The net is split into contiguous triangles in the modelling. The door is between the warp and the bottom bridle. b) Position of the port sensors on the trawl. 6 Tension sensors are placed on the warp, bottom and top bridles, port and starboard. The doors attitude sensor measures the depth, port and starboard. The doors spread and the vertical opening of the trawl are measured.

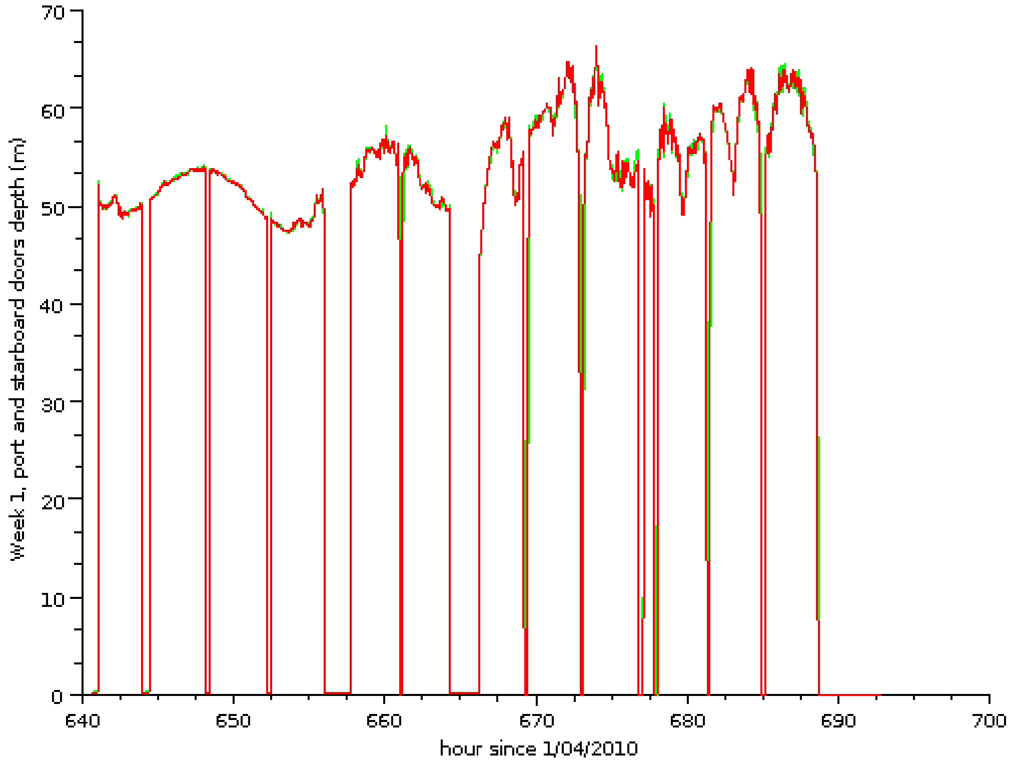

Figure 2

Depth of port and starboard doors during the first week of test. The beginning and the end of the 12 hauls are easily determined. Hauls with a duration less than 1.5h are not taking into account in the study (such the haul at 675h).

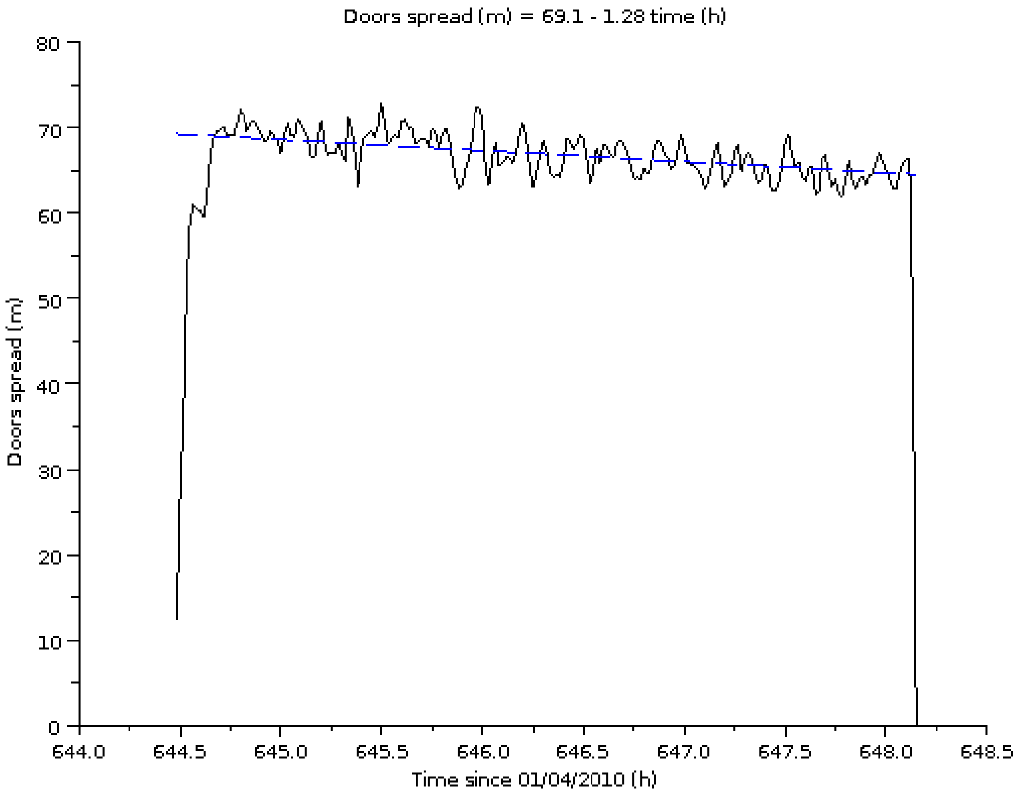

Figure 3

Doors spread for the first haul. Except for he first and last minutes, its appears a decrease of around 5m between the beginning and the end of the haul. The linear relation between doors spread and time since the beginning of the haul is calculated. This calculation shows that the spread decrease of 1.28m/h. The drag on catch is suspected in this decrease.

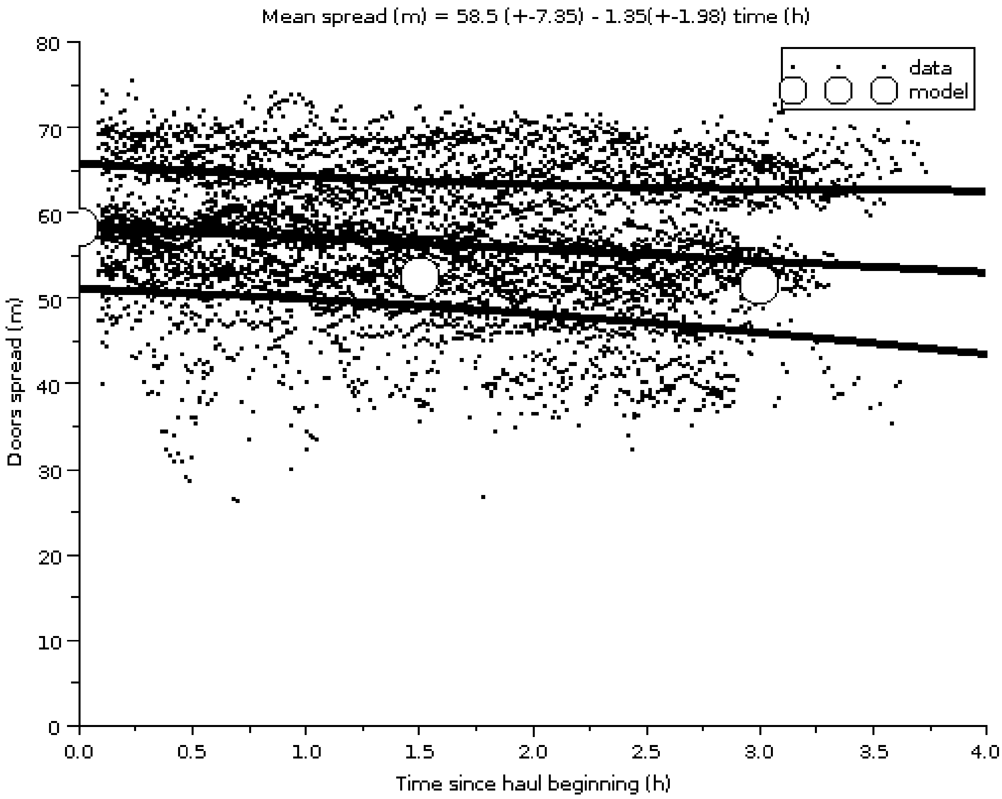

Figure 4

Doors spread versus time since the beginning of haul for all hauls. The line is the mean value of the spread and the two curves below and above the line are mean value more or less the standard deviation. The modelling of empty trawl (0h), half mean catch (1.5h) and full mean catch (3h) is noted. Measurement and simulation show a decrease of the spread due to the catch.

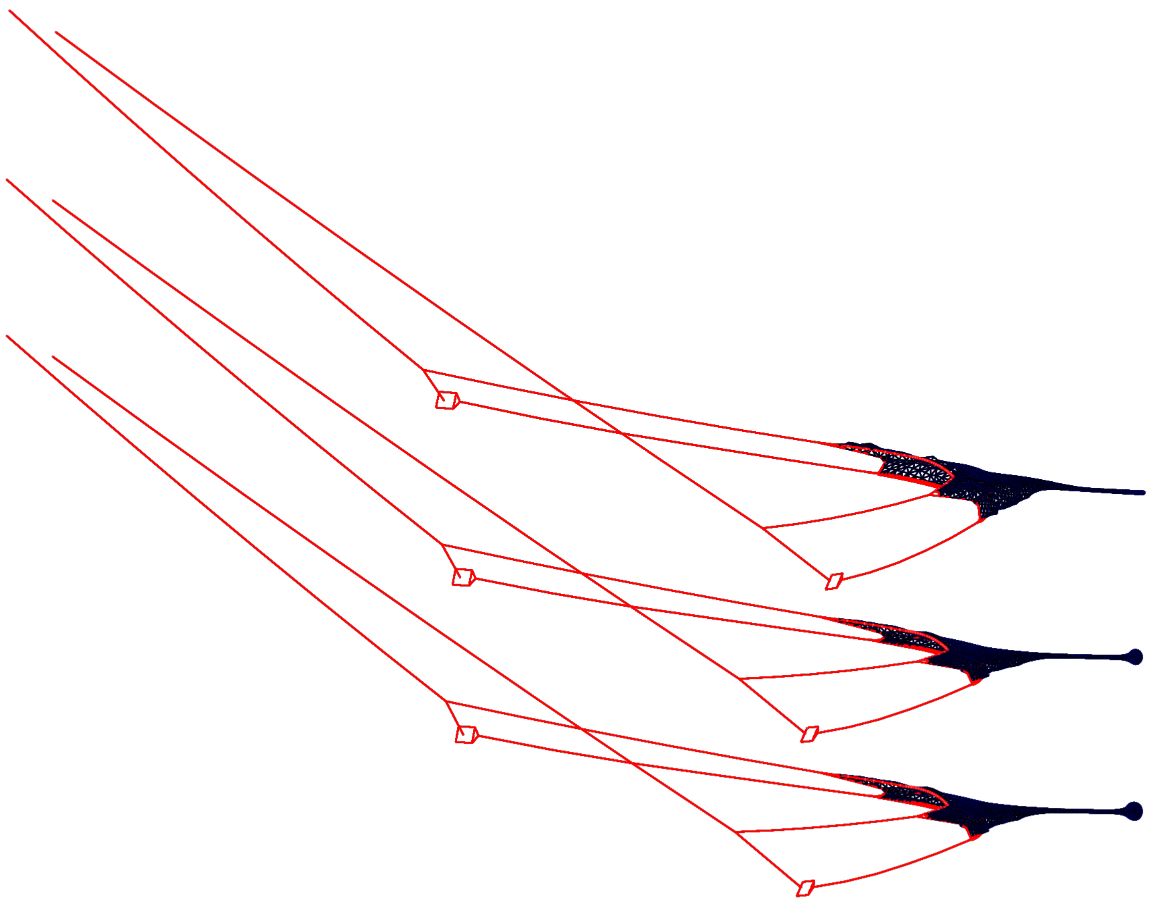

Figure 5

Simulation of empty trawl (top), half mean catch (middle) and full mean catch (bottom). It is noticeable that the catch increases.

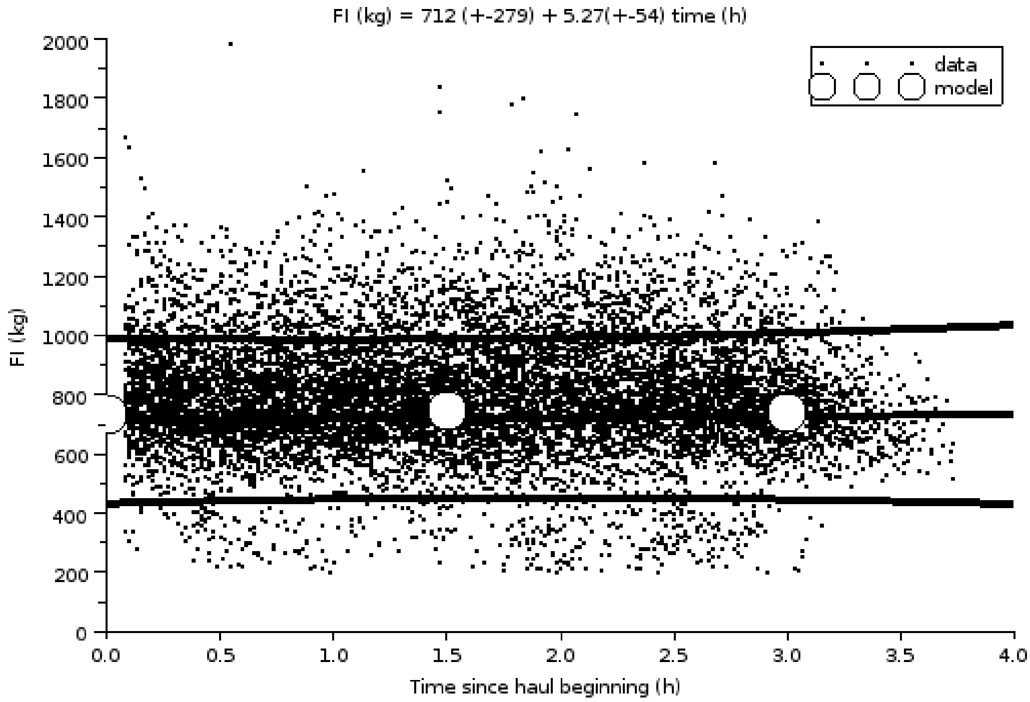

Figure 6

Bottom bridle tension versus time since the beginning of haul for all hauls. The line is the mean value of the tension and the two curves below and above the line are mean value more or less the standard deviation. The modelling of empty trawl (0h), half mean catch (1.5h) and full mean catch (3h) is noted. Measurement and simulation show more or less no variation of bottom tension due to the catch.

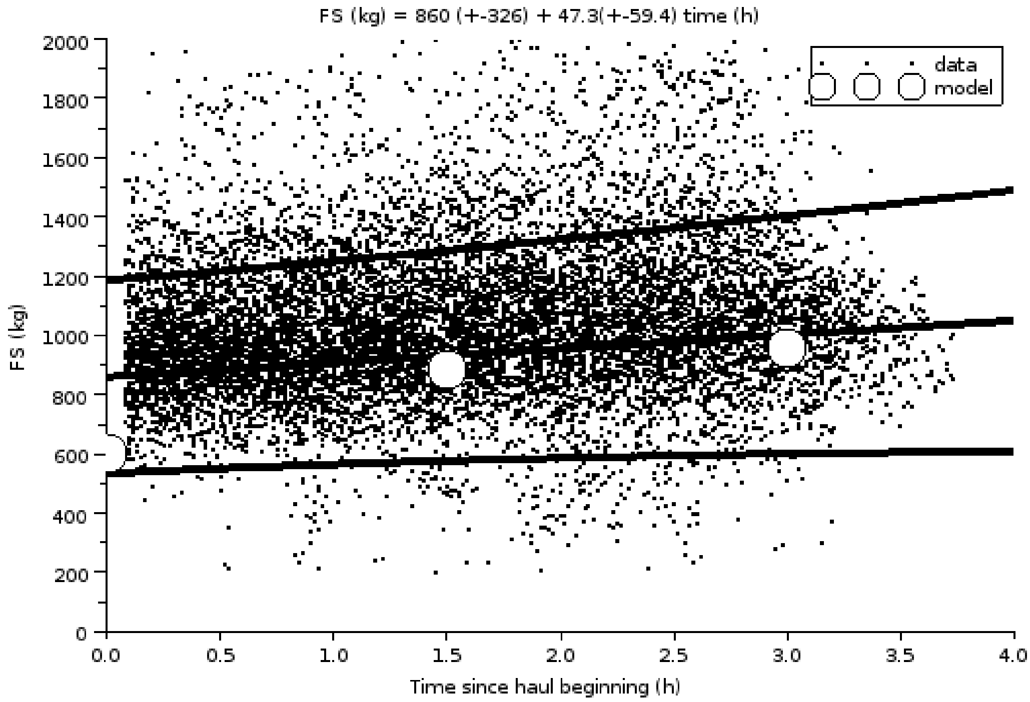

Figure 7

Top bridle tension versus time since the beginning of haul for all hauls. The line is the mean value of the tension and the two curves below and above the line are mean value more or less the standard deviation. The modelling of empty trawl (0h), half mean catch (1.5h) and full mean catch (3h) is noted. Measurement and simulation show a small increase of top tension due to the catch.