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DEVELOPMENT OF LONGTUBE MUSSEL SYSTEMS FOR CULTIVATION OF MUSSELS (*mytilis edulis..*

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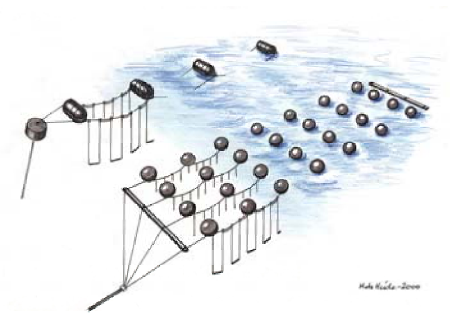
Introduction.

Traditional mussel farms uses so called longline systems for growing of mussels. These systems uses individual floats attached to a longline which carries the collector.
A competitive system using PEH tubes at replacement of both the floats and the longline have been introduced. The main reason for this was to introduce a more secure system with respect to sinking. There has always been a challenge to keep mussel farms afloat. This subject is discussed in a separate paper at this conference.
Farmers experience loss of mussels, especially during harsh conditions. Dynamics of mussel farms have not yet been theoretically studied.



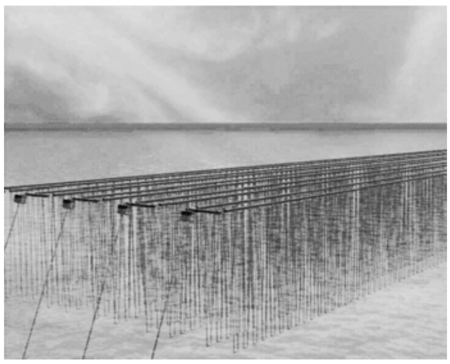


Figure 1. Illustration of traditional mussel farming systems, long-line, and the new developed long-tube

SINTEF Fishery and Aquaculture have performed dynamic analyses on both traditional longline systems as well as on these new longtube concepts for comparative studies, ref. 1.

Method.

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For the dynamic studies, we have used a finite element computer program, RIFLEX, ref. 2, originally designed for analysing riser dynamics on offshore oil installations.

Full-scale systems are normally very long. Typical length of a system is 2-300m with one collector for every 0.5m. In order to reduce the computation time to an acceptable level, the numerical model was simplified by reducing the overall length to 100 m as well as the number of collectors was limited.

The weight of mussels in water is approximately 20% of the dry weight.
Only two collectors were modelled completely, the rest where lumped into either the main line or the tube by correcting the mass and hydrodynamic coefficients.

Longtube system.

The modelled system consists of one 100 m long polyethylene tube. In order to reduce the element systems, only two collectors are attached to the tube.
One collector is positioned at the middle and one 5m from the end. Equally spaced collectors with 0.5m distance is lumped into the tube by adjusting the mass and hydrodynamic coefficients.

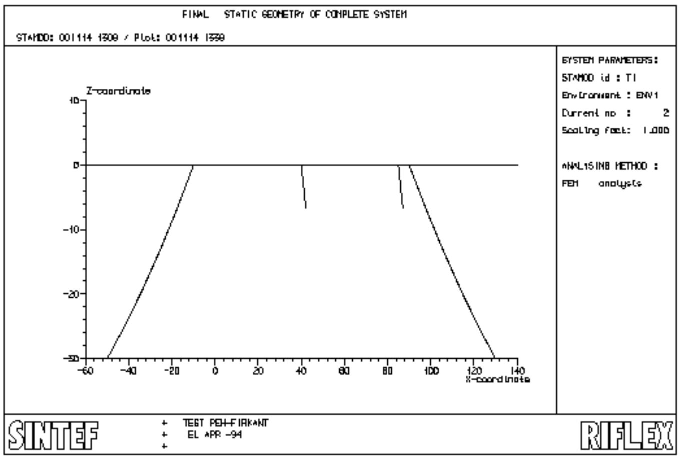

Figure 2 Modelling of the long-tube.

Longline.

The longline is modelled with 4 buoys and two collectors, fig. 3.

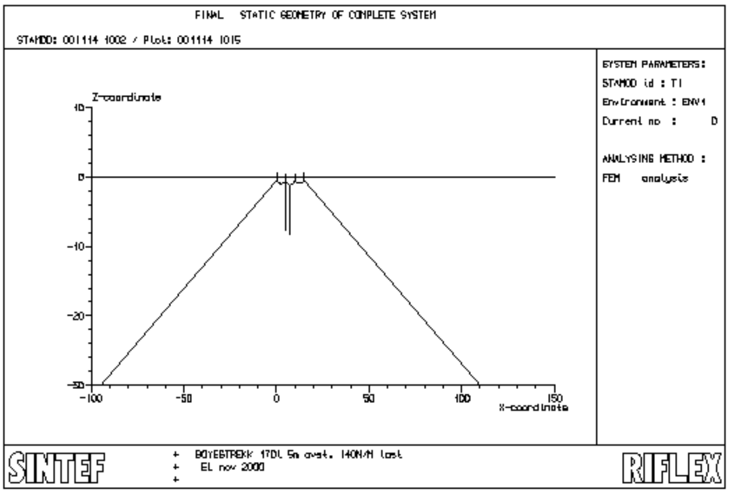

Figure 2 Modelling of the long-line.

Model data.

Collectors:

The collectors were identically modelled on both models..
Shell weight: 7kg*0.2~20N/m
Collector length: 7m
Distributed load on mainline (and tube) = 140 N/m
Drag coefficients : Cn, normal = 1.4; Ct, tangential=0.4

Setting the additional weight to 140 N/m for the whole tube includes normal weight of the mussels.

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Buoy:

Vertical cylinder. Diameter 500mm PEH tube PN4, length 1.0m, 27 kg.

Longtube:

100 m long, 250mm PEH tube, thickness=9.3 mm.
For the comparative analyses, the weight was adjusted to carry the collectors.

Strength analyses of longtube system:

An initial study was performed in order to evaluate the dynamic stresses on the polyethylene tube. Regular waves vary in height between 1 and 4m with different direction. The weight on the tube is varied by 6.7, 20 and 35 kg pr meter.
The tube has a buoyancy capacity of 42 litres/m. The lower weight, 6.7 kg/m represents a empty tube, recently installed, 20kg/m are for a high crop weight, while 35 kg/m is a tube with maximal growth and full capacity.

No	H [m]	T [s]	Alfa [deg]	W [kg/m]	$M_{y,max}$ [kNm]	M_{tot} [kNm]
1	1	3.58	45	6.7	1,6	1.8
2	1	3.58	45	20	2.0	3.0
3	1	3.38	45	35	2.5	4.5
4	2	5.06	45	20	2.2	2.3
5	1	2.12	0	20	1.0	1.0
6	1	2.12	45	20	1.0	1.8
7	4	4.24	45	20	6.0	7.0

Table 1. Moments in the tube for varying sea and mussel load.

Conditions no 1,2,3 og 4 represents ”normal” waves, while 5,6 and 7 is waves with it’s maximal steep, nearly breaking..

Tension in the wall in MPa from deflection is found by multiplying the moment (kNm) with a factor of 1.25 for this particular cross section..
Maximum stresses are all below 8.5 MPa, well below magnitudes causing fatigue problems. Lower pressure classes, i.e. less wall thickness may be used.

Evaluation criteria.

The behaviour of the collectors is the main evaluation criteria when comparing the two different methods. First of all, snap load in the collectors should be avoided in order to reduce the risk for loosing mussels. Snap loads occur when the tension in the collector is reduced to zero.

Evaluation criteria will be comparative studies of the tension in the collectors. Small tension variations indicates small accelerations and thereby less loss of mussels.

Dynamics of collectors.

Comparative study of the dynamic tension for the two above described systems

These collectors are equally modelled,
Collector type 1 is on a longline system under the buoy
Collector type 2 in on a longline system in the mid span
Collector type 3 is on a longtube in the middle
Collector type 4 is on a longtube 5m from the end

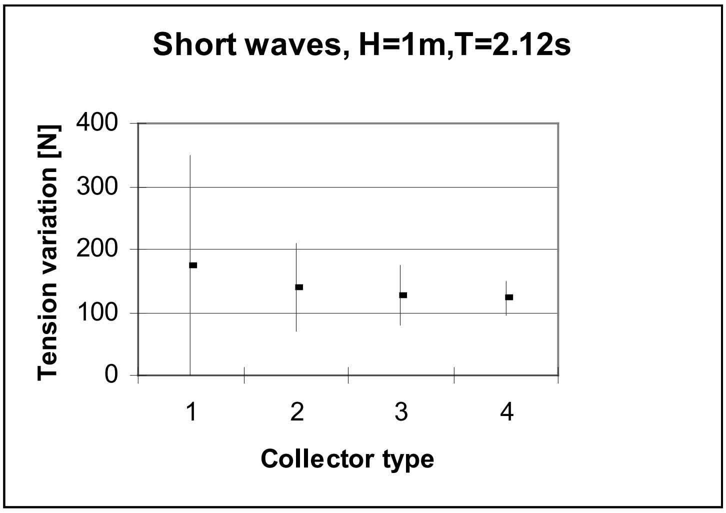

Figure 3. Tension variation in collectors for short, steep waves.

The motion of the longtube is very low compared with the longline system. The vertical motion of the tube is small. The dynamics of the longline is large under the buoy, collector type 1, causing snap loads for the collectors close to the buoy.

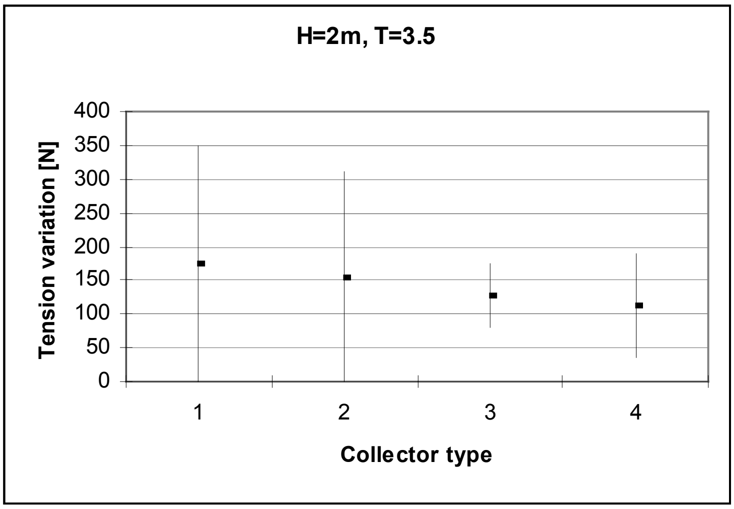

Figure 4. Larger waves causes snap loads for the longline system, while the longtube motions are still acceptable.

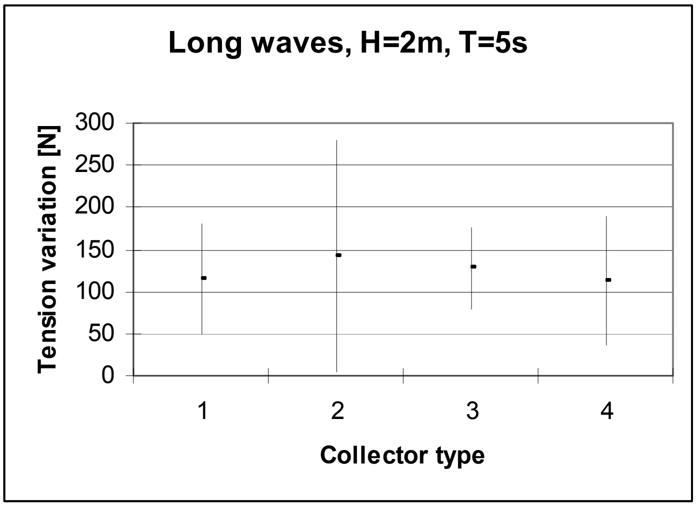

Figure 5. This wave condition represents long waves with a wave height/ wavelength ratio of 1/18

Acceptable tension variations for all collectors except at the mid span between the buoys.

The dynamic loads on the longtube system are significantly lower than for the longline system.

If we look at the longline results, collector type 1 and 2, we see a change in behaviour between type 1, under the buoy and no 2 at the mid span. The dynamics under the buoy dominates for smaller waves, fig 3 and 4., while the dynamics at the span increases with larger waves, fig 5.. This seems to verify the experiences of the farmers. On sheltered locations there is larger losses of mussels under the buoys while on exposed sites their looses are larger on the mid span.

Large waves transverse to the line directions causes large horizontal motion of the line which stretches the main-line giving large accelerations on the span, see fig. 6. On a rigid tube these effect is avoided, as there is no coupling between horizontal tension in the tube and vertical motion of the collector.

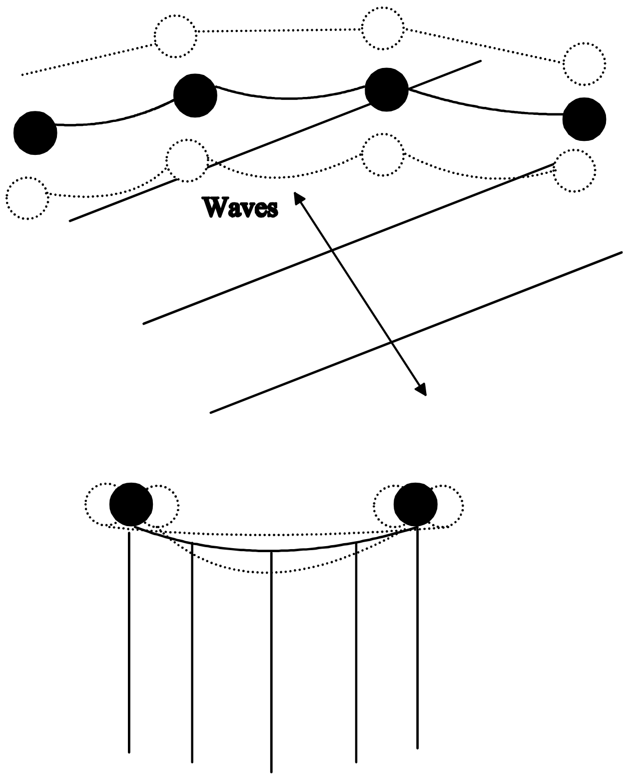

Figure 6. Illustrates how large horizontal deflection from long waves causes the hanging span between the buoys to stretch. This causes large accelerations on the collectors.

This effect is a large problem for the farmers, especially with light collectors. Sometimes the collectors become twisted around the main line. This effect is not modelled as the author thinks this is more a matter of mooring technique.

Discussion

Even if these studies are not complete with respect to varying the total number of parameters that influence the dynamic response of these types of mussel farms, the tendency from these analyses is obvious. Using a tube instead of the traditional longlines with individual floats gives a considerably reduction on the dynamic loads. These motion reductions will both cause less loss of mussels as well as a decrease in operational costs. With sufficient buoyancy on the tube, there will be no need for adding buoyancy as the mussels are growing. The main objective of introducing this technology is however the need of introducing a safer technology with respect to sinking. In contrary to most other areas with a mussel industry, large areas of the Norwegian coastline is deep fjords. Loosing a farm to a larger depth is catastrophic for a farmer.
There is no doubt that future technology both will be represented by old traditional longline systems with use of both commercially developed buoys and waste barrels as well as longtube systems. Hopefully one will account for the risk of sinking when evaluating the production technology.
Adaptable technology is an evaluation of local environmental condition, topography, investments and running costs.

References

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2 Ormberg, H. (1991). “Non-linear response analysis of floating fish farm systems”, Dr. ing. thesis, Division of Marine Structures, The Norwegian Institute of Technology (NTH), ISBN-82-7119-330 9, Trondheim 1991