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A NEW DESIGN IN TRANSPORTATION AND NET CAGE TECHNOLOGY FOR LIVE SEAFOOD AND AQUACULTURAL PURPOSES

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ABSTRACT

The need to extend and diversify the Norwegian aquaculture industry and a growing demand to store live seafood has led to the development of several new technological solutions. This paper describes the construction, operation and performance of a new flat-bottom net cage and a specialised holding tank for the transport of live aquatic organisms at high stocking densities (e.g. 750 kg/m^3).
The net cage bottom is 180 m^2 and is supported by a taut DYNEEMA™ -net. About 10 tons (e.g. plaice or lemon sole) can be stored or raised in each cage. The rigid, but elastic construction enables the caretakers to inspect the fish by waders. The net cage serves several purposes:

- receiving newly-caught wild cod, where a flat bottom is required for proper restoration and acclimation prior to transfer to traditional net cages
- storage of wild caught species without a gas bladder (e.g. plaice, lemon sole, halibut, wolfish and turbot)
- rearing of halibut and spotted wolfish
- storage and feeding of crustaceans (e.g. king crab)

The coastal seine-net fleet can efficiently transport and store their catches by using the combination of the holding tank and the net cage systems.

The new technology has improved the first hand value of fish and motivates a better utilisation of the coastal resources. In addition it provides practical working conditions for the emerging sea-based halibut farming in Norway.

Theme session (L)

Keywords: net cage, flatfish, live seafood, transport.

INTRODUCTION

Storing of live seafood has a long history in Norway (Midling et al. 1996). Pelagic species (e.g. herring (*Clupea harengus*), sprat (*Sprattus sprattus*) and mackerel (*Scomber scombrus*)) have been stored periodically at least during the last two centuries, mainly caught by beach seines (Beltestad 1996, Beltestad and Misund 1993).

Demersal species (e.g. cod (*Gadus morhua*) and plaice (*Pleuronectes platessa*)) have been stored on industrial level from the 1880s when the Norwegian herring- and cod fisheries were developed off the Icelandic coast. During the last two weeks of each trip, live cod were kept in primitive wells perforated with one-inch holes to allow for water exchange. If the weather conditions were favourable, the catch were delivered in Grimsby, England, were the prices could be one hundred times higher compared to the traditional salted cod.

From being the most convenient storing method in times were freezing, chilling and logistic facilities were scarce (Sundness 1957), these methods were abandoned during the post-war rebuilding in the 1950s. With the breakdown of the Barents Sea cod stock in 1988, and the introduction of vessel quotas in 1990, the coastal fleet experienced a reduction of up to 85% of their previous annual catch. In order to increase the value of their limited catch, the practice of live storage and fattening got its renaissance. Caught by Danish seine and transported in newly developed transportation tanks (Isaksen and Midling 1995), a 70 feet vessel could deliver 10-15 tons of live cod a day. However, this industry experienced high mortality, up to 50% in the net cages during the first three days after transfer. This mortality was reduced to 5% by introducing the first flat-bottom net cages in 1994 (Midling and Isaksen 1995).

Plaice used to be a high-value species in Norway. In 1950, plaice caught by gillnet or seine and stored alive in wooden boxes, gave up to three times higher prices than that paid for cod. Today, plaice only has half the cod's value, first hand. The main reason for this development is that flatfish species in Norwegian fisheries mainly is a by-catch, and hence are delivered irregularly and in small quantities. In order to increase the value of plaice and other flatfish species (e.g. lemon sole, *Microstomus kitt*), a new net cage for live storage has been developed. Small catches can be collected from several vessels and the markets need of supply, volume and security of deliverance can be met. In addition, a new holding tank for high stocking densities were constructed and adjusted for live transportation of flatfish. The coastal seine-net fleet can now combine these technologies and thereby increase the value of their catches substantially.

The Norwegian aquaculture industry is today synonymous with the production of salmonids (340.000 tons in 1997). To diversify the industry, large effort has been put in to developing the culture of halibut (*Hippoglossus hippoglossus*) in Norway since 1982. The annual production of 200.000 to 400.000 halibut fingerlings together with a small number of spotted wolfish (*Anarhichas minor*) are today mainly farmed on land, but several attempts has been made to develop a sea-based technology (Lien 1993). Until now, none of these has proven to meet the technological specifications made by the industry.

MATERIALS AND METHODS

Holding tank

The holding tank consists of three sections, or drawers, with separate inlets (Fig.1). Each section has a net volume of 350 L. The sections can be lifted out of the outer tank by manual or hydraulic lift. The water is led through a double bottom and distributed upwards through a perforated bottom. The degree of perforation is less than 1%, hence allowing the water to be evenly distributed independent of species (e.g. cod or plaice) and during high-density transport. During testing of the holding tank, water supply were kept at minimum 200 $l^{*} min^{-1} {*} ton^{-1}$ fish. Oxygen-level was recorded continuously in the water outlet (Oxyguard, Handy MK III).

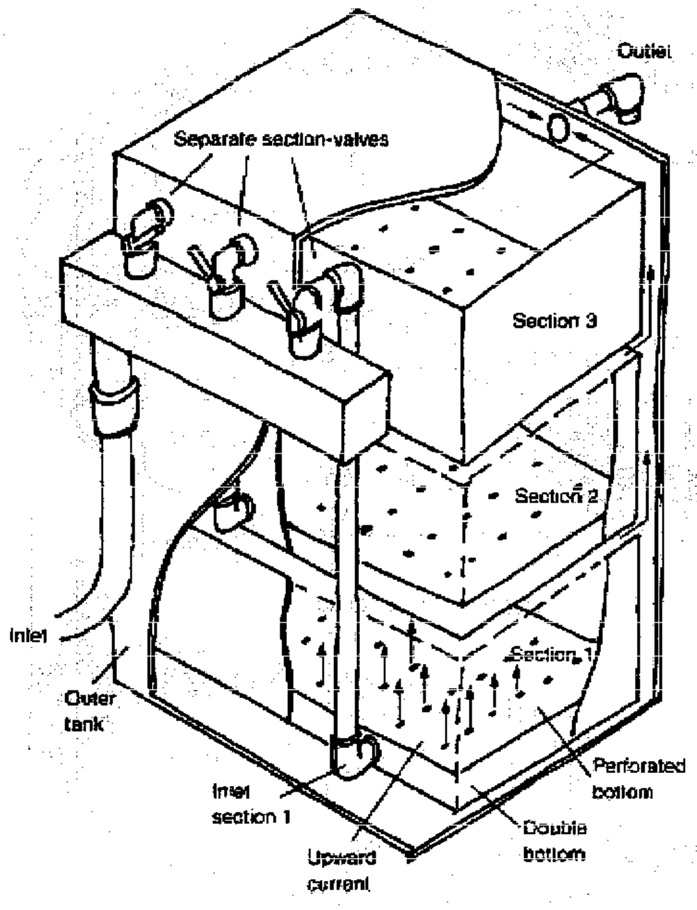

Figure 1. Principle of experimental high-density transportation tank.

Net cage

The new net cage basically consists of three major parts; floaters, net and supporting bottom (Fig.2). A traditional 50-meter circumference floater was chosen. It consists of two pipes (PEH), 25 cm. diameter, and has a total buoyancy of four tons.

The net is adjusted to fish size and in this experiment the side-panels had a mesh-size of 25 millimetres (half mesh) and the bottom 15 millimetres. All net is knot-less to minimise damages to the fish during storage and was treated with anti-fouling. 12 ropes connecting the floater and bottom frame alter depths for production or inspection. To avoid vertical movement induced by waves, the 12 ropes have elastics that allow the floater to move maximum one meter vertically independent of the bottom.

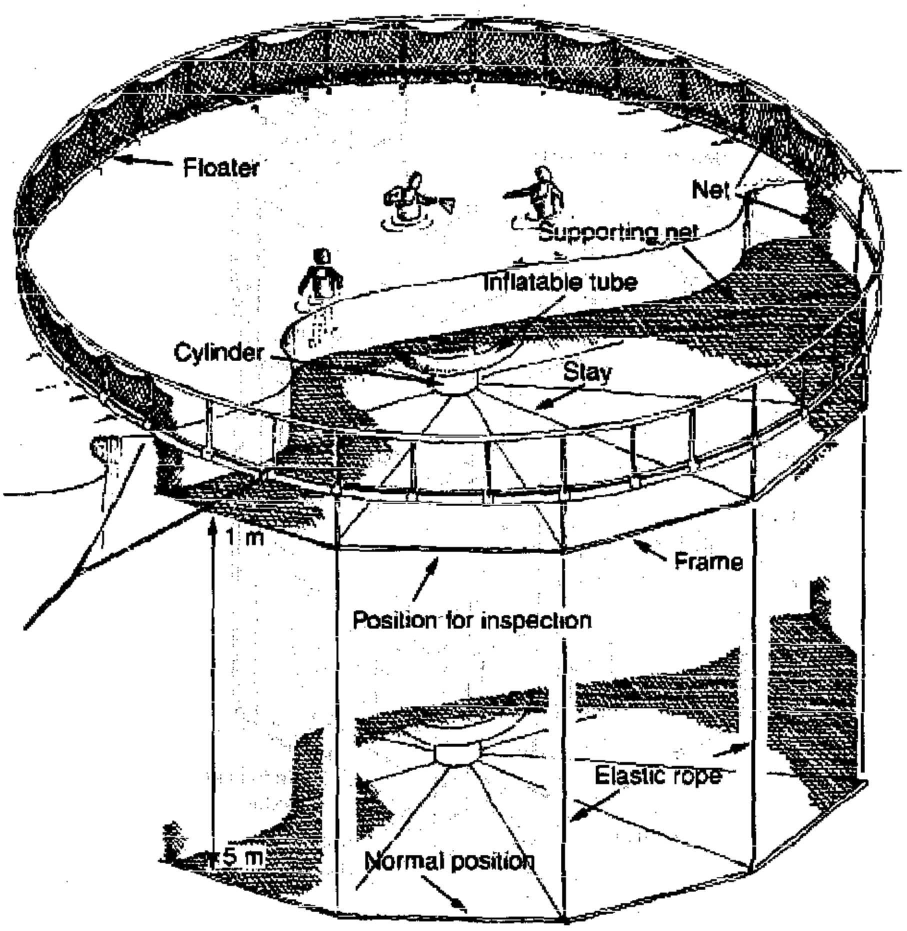

Figure 2. Principle of construction of the new flat-bottom net-cage

The bottom area is 180 m^2 and is firmly connected to the supporting frame.
The frame consists of 12 aluminium pipes (125*4 millimetres), each four meters long. The pipes are connected with 12 bends (30^0 angle) fitted inside the pipes and secured by bolts. Every second pipe is filled with Isopore, which leaves the bottom construction slightly positive buoyant (approximately 20 kg.). Figure 3 indicates the orientation of the supporting DYNEEMA ™-net mounted on the frame and tightened manually.

To further tighten the net, the centre is pulled through a cylinder with a force of 2500 N. The lower end of the cylinder (length 160 cm.) is connected to the frame by ropes and hence stabilising the bottom vertically (Fig.4). The depth of the bottom can be altered pneumatically from the surface by inflating a collapsible tube to a maximum volume of 1 m^3.

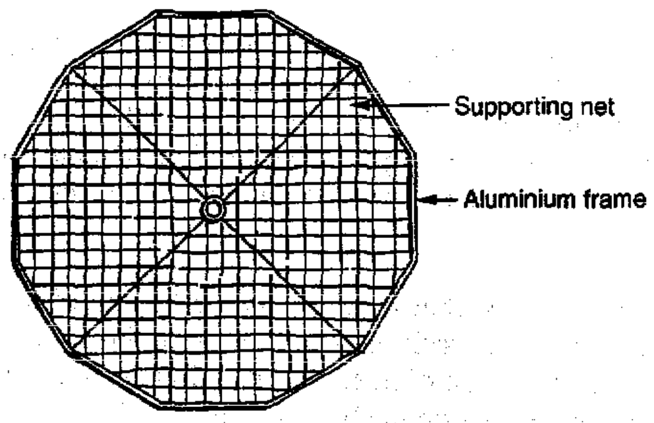

Figure 3. The mounting and orientation of the supporting net on the frame.

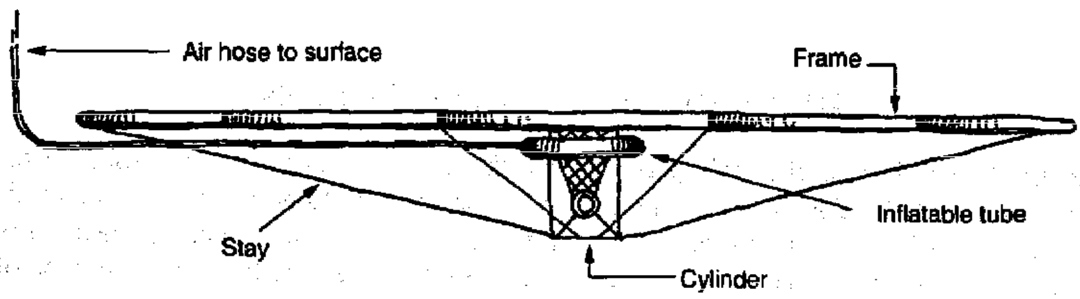

Figure 4. Positioning of the tightening cylinder, the inflatable tube and ropes to the supporting bottom frame.

RESULTS

Transportation tank

The new holding tanks are gentle to the fish and function well at very high densities, up to 750 kg/m^3 (260 kg in each section). The mortality was less than 1% on average after 72 hrs from the fishing grounds to the net-cages, provided no damage during catch or onboard handling. Small abrasions were observed on the head of the plaice after long high-density transports.

The oxygen-levels showed little variation and were kept above 70% saturation. The catch had to be graded with regard to species and to some extent to individual size. Large size variation resulted in increased mortality among the smaller size-groups due to pressure from large individuals when transported at maximum densities.

Flat bottom net-cage

Technological
The supporting net became a very taut springboard. On land the centre will sink one meter when 100 kg is put on. Once in the sea it enabled the caretakers to inspect the fish by waders (fig.4). After inflating the tube until the bottom was slightly positive buoyant, the bottom rose slowly to the surface (one meter per minute). The bottom area was constant during rising/lowering and through different natural conditions (e.g. current, waves etc.).

Biological
The plaice and lemon sole distributed evenly on the bottom of the cage after transfer. They were kept in the cage for three weeks on densities up to 55 kg/m^2. The specific weight of the plaice was measured to 1,067 g/cm^3 in seawater (34‰). With a stored volume of 10 tons the net weight of the flatfish resting on the bottom is hence 670 kg (3,7 kg/m^2). The fish seemed to behave normally and no damages induced by the net were registered.

The stored plaice and lemon sole were slaughtered and sold after three weeks of storage and received premium prices. This enabled us to increase the first hand value for plaice and lemon sole by NOK 3.50,- and 7.00,- , 50 and 100%, respectively.

DISCUSSION AND CONCLUSIONS

The technologies described in this paper enable the coastal fleet to increase their income by delivery of live fish. The transportation tank is far more volume-efficient than traditional storage on ice (750 kg/m^3 in contrast to 380 kg/m^3). In addition the tanks are easily adjusted to vessel size and can be achieved at reasonable prices. It is suitable for a number of fish species (gadiformes and pleuronectiformes) as well as large crustaceans (e.g. king crab).

The outer tank can be used for traditional handling of the catch (e.g. bleeding and cleaning). As long as freshness is considered the most important measurement for quality, live fish will always give opportunity to achieve better prices. By applying this technology the vessels can stay at the fishing grounds for longer periods and maintain superior quality at all time.

The new net-cage performed well in connection with live storage of flatfish and facilitated all normal working procedures such as inspection, cleaning and removal of dead fish compared to traditional flatfish-cages. The taut supporting net that permitted the workers to walk inside the cage enabled us to empty it prior to slaughtering within one hour. This indicates that operations like grading and vaccinating can take place in the cage, as well.

The technology should be easily implemented in farming of species like halibut and turbot in addition to storage and feeding of crustaceans and sea urchins.

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