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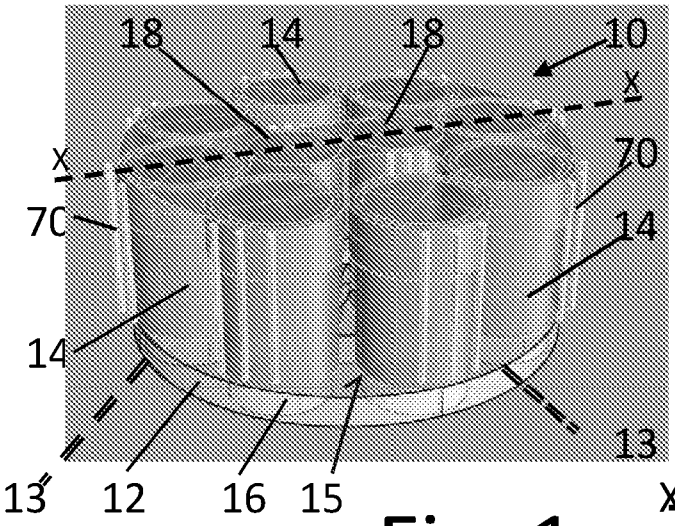

Fig. 1

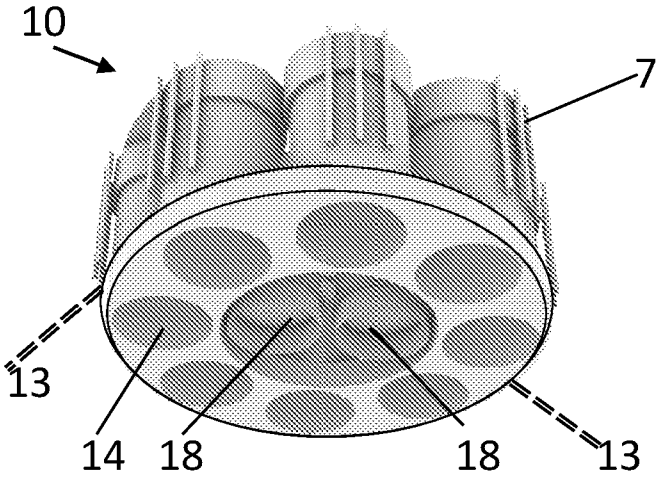

Fig. 2

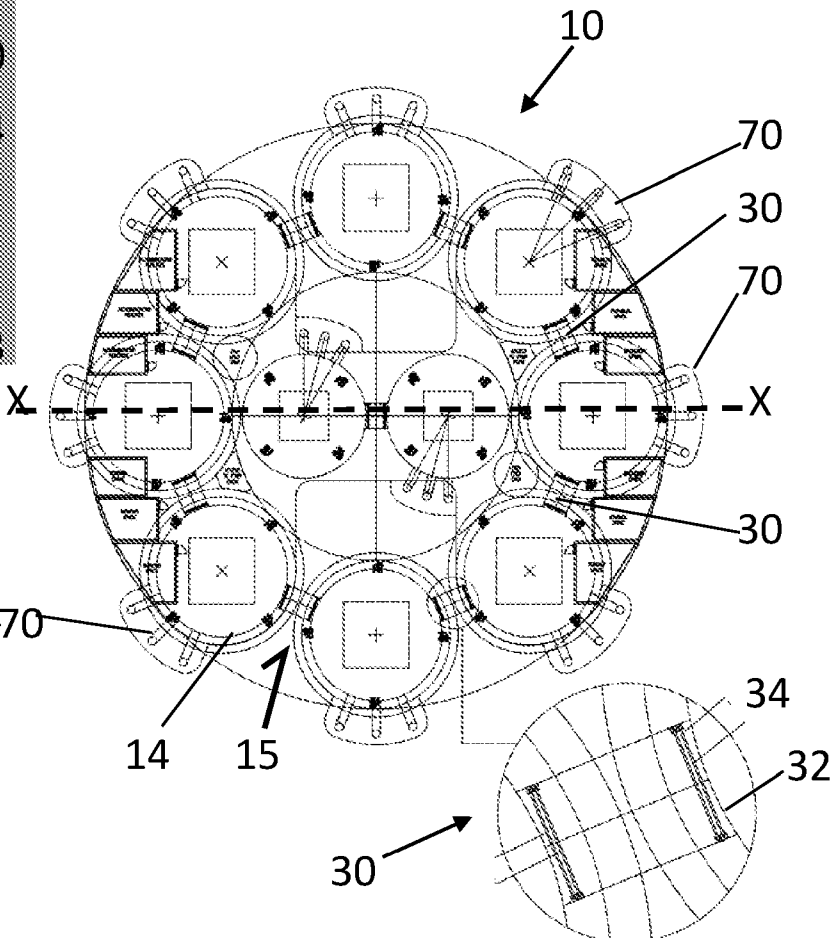

Fig. 3

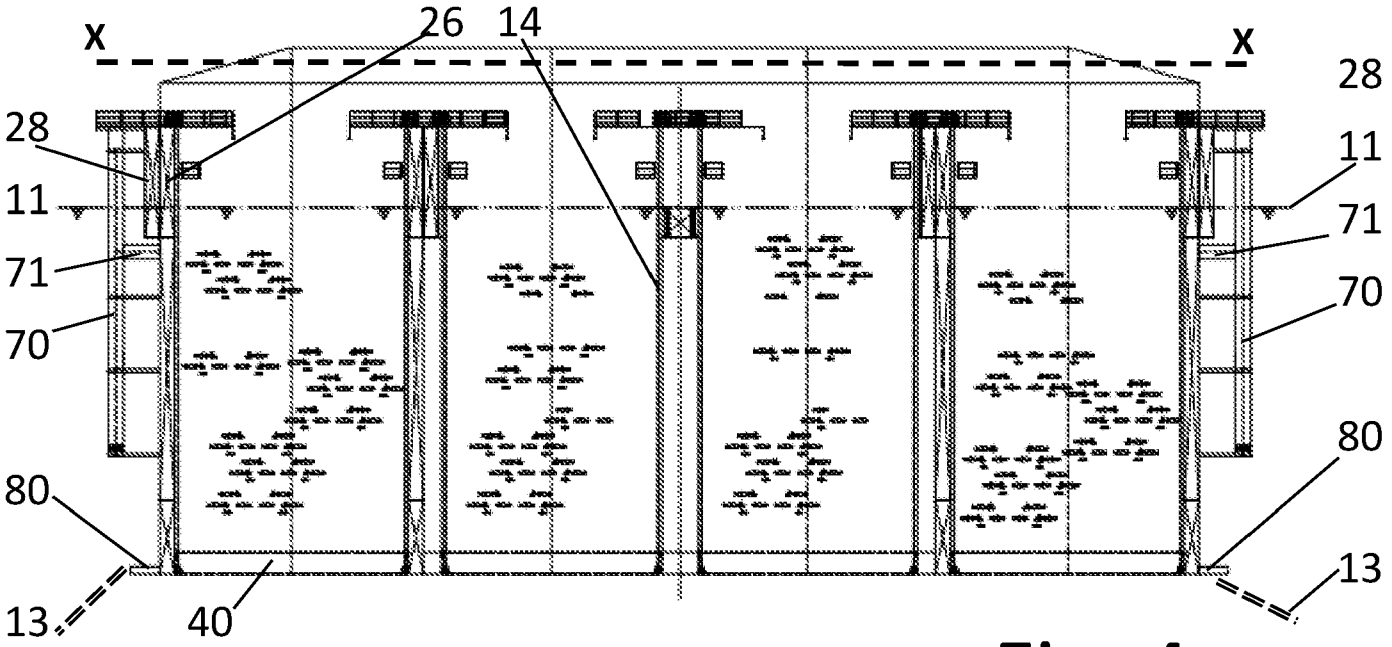

Fig. 4

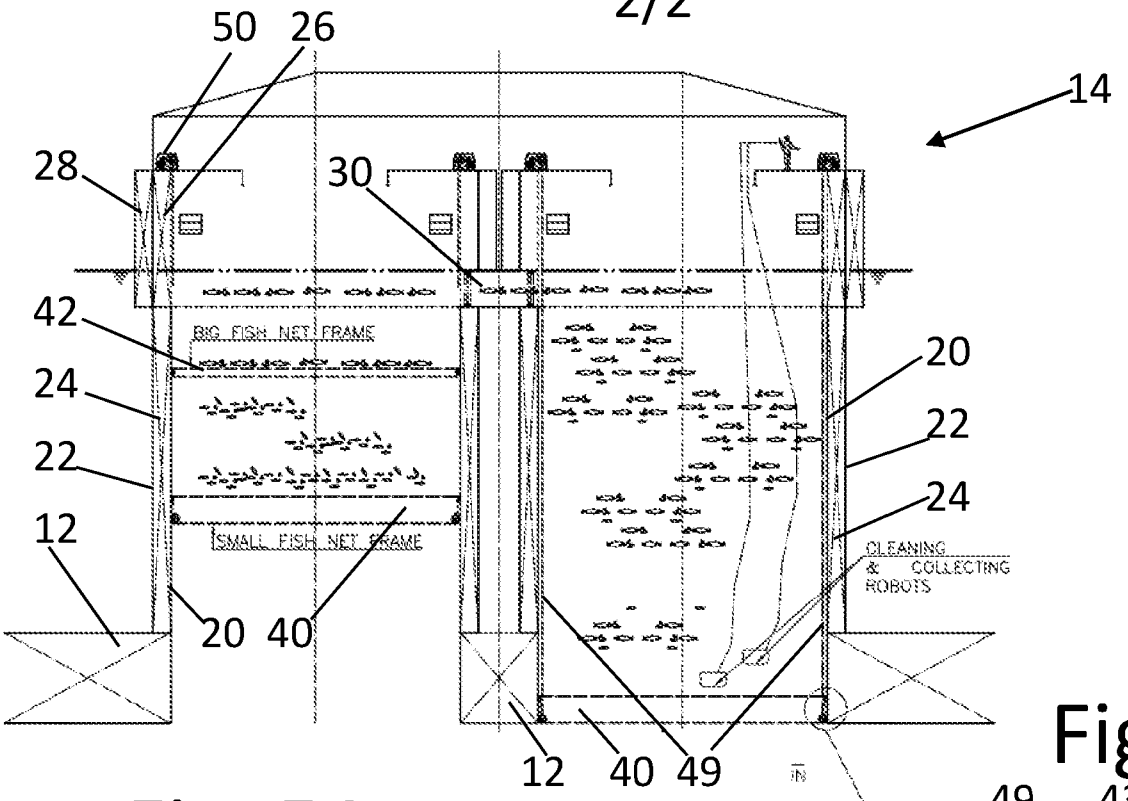

Fig. 5A

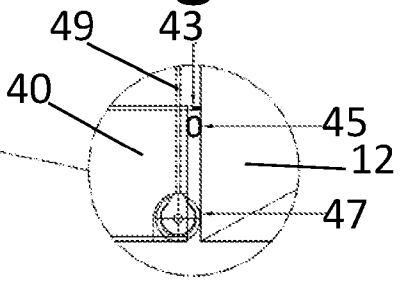

Fig. 5B

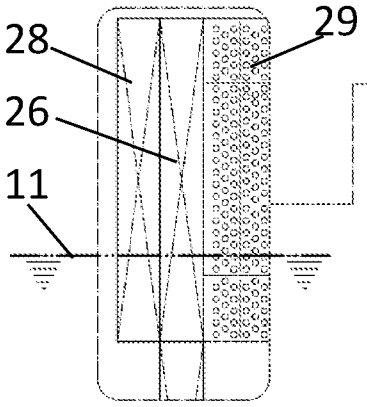

Fig. 6

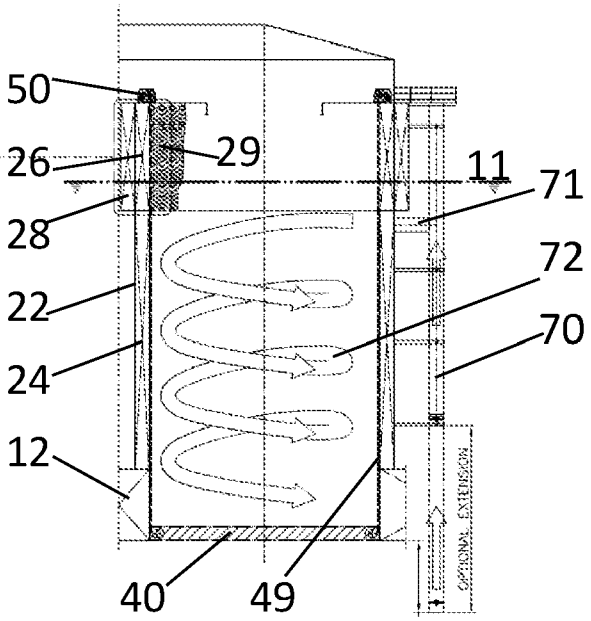

Fig. 7

STRUCTURE FOR FISH FARMING

Background

The present invention relates to a new designed structure for fish farming as given in the preamble of the following claim 1. Further the invention concerns preferable applications or methods and using of the structure as given in claims 10 and 11.

The state of the art

Fish-farming in Norway has traditionally been organized within protected fjords, to avoid impact of waves damaging the net cages containing the fish. The protection within fjords also facilitate more easy access to the cages for all kind of necessary service functions.
In addition, the open net cages permit a free flow of water through the cages, renewing the content of oxygen rich water to serve the breathing of the fish, as well as serving the purpose of removing the faeces and surplus of food by deploying it to the surroundings.

Further, the open net cages, see for example NO158201B and NO336739B, enable establishment of fish farms at low investment cost.

However, the net cage farm solution put, due to the protected and sheltered environment required, some limitations to where location of farming may be possible, with negative effect on finding new suitable areas where establishment of fish farms may be permitted.
Also, as the open net solution is favourable with respect to exchange of water within the cage, the free flow of surface water unfortunately also give access to parasites, particularly the sea lice, which has given the fish farming industry big challenges. On this background fish farm designers have been looking for new solutions, which in addition to dealing with the matters commented above, also may introduce new alternatives of operation, improve the efficiency of the farming, the environment of the service personnel and the pollution impact on the surrounding area of the farm.

Semi-submersible structures are well known for offshore oil and gas related vessels in deep waters. They have one or more pontoons, which in operation is submerged below the action of surface waves, and a plurality of vertical columns both being buoyancy and stability bodies and structural elements for a part of the vessel being over the surface. Due to the counter action of the mass forces acting on the submerged pontoons and the pressure forces acting under the vertical columns, and the deep draft, a semi-submersible platform, is substantially less influenced by waves at the surface than a surface vessel, at least at the conditions, i.e. wavelength, and wave height, for which they are constructed. A skilled person is able to construct a semi-submersible for a specific location based on statistics on weather and wave at the intended location. The structure may be elevated by reducing the volume of water introduced in the ring pontoon as ballast.

Further well known fish breeding structures

Patent NO 20170955 A1 describes a tank for fish farming where the tank (1) has a polygonal or circular ring pontoon (2) as the lower part of the tank. The vertical side walls (4) may be single or double and perforated as appropriate, and the cross section may be circular or polygonal.
Vertical columns (3) are supported on the ring pontoon and attached to the sidewalls to the top of the tank. The pontoon and the vertical columns are subdivided in watertight compartments, which may or may not be ballasted with water to secure buoyancy and stability of the tank. The net buoyancy of the ring pontoon is sufficient to enable deballasting of the tank structure above

to a water line above sea surface. The tank is equipped with a steel net at the bottom level with a set mask size to enable circulation of water in and out of the tank as well as blocking fish from escaping.

The present patent application differs from the above patent in that there is a number of circumferential tanks which are penetrating the pontoon through a recess all the way to the bottom of pontoon, enabling a favourable structural and hydrodynamic optimisation of the floater by calibration of the bottom nets of the tanks not only to hinder escape of fish but also, due to the calibration, to serve tuning of the hydrodynamics of the floating structure. Further, the number of tanks are interconnected with a gate at the top and equipped with vertical elevators enabling separation of fish of various sizes within each tank and between tanks.

Tank according to patent NO 20170955 A1 is a cylindric tank with it's main buoyancy element at the sea surface, extending to about 5-10 meter above. At the bottom level tank is open downwards and with side openings as well, and equipped with a cone net which hinder escape of fish and which can be manipulated to reduce the volume of the net and thereby force the fish together and upwards towards the water surface for more convenient collection. This procedure is common for many fish containment systems used by fish farms, but principally different from present patent application in that the boundary restrictions of containment system for present patent application, are mechanical elements with fixed steel borders (tank walls, elevators) enabling controlled volumetric displacement and separation of fish, within a tank (within containment boundary) and/or between neighbouring tanks through gate valves.

The floater arranged for fish farming according to patent NO 158201 B, has flexible sidewalls (2) and the cage is fixed to buoyancy elements (3) in upper part of sidewall (2a). The lower part of the cage (2b) is fixed to a frame (5) which may be elevated up or down. The flexible sidewalls of the cage are fixed to the bottom frame. Bottom frame and upper frame are interconnected by guide frames. In the bottom frame is arranged buoyancy element(s) enabling the cage to be elevated by use of compressed air (ref.page 3, line 1-23 and figures). The principle of this invention is that the whole cage containing fish is partly elevated above sea surface to reduce the cage volume below water and the space available for the fish to breathe, so that the collection of fish can be done more practically. But basically there are no means of separation (sorting of size) considered within a cage or sorting of size by escape to neighbor tank(s). Further, in present invention the whole container (tank) is at all times fully submerged, so the sorting of fish is done by volumetric manipulation of space within a tank by the elevation of the net frames, considered to secure proper welfare of the fish content during manipulation, as well as enabling assortment of various size fish .

The floating fish farm according to patent US 2019166808 A1, is having a cage supported by a surface floating element which may have a circular shape (paragraph 0012). The cage can be elevated to a position above the floating element. Figure 43 show also a sketch of a floater with multiple cages, with floating elements at the lower part of the floater, allowing cages and/or floating elements to elevate separate and/or together. This invention is different from present patent application as for patent NO 158201 B above, in that the cage(s) containing fish by elevation only reduce the available volume for the fish below sea surface to ease the collecting, but lack the consideration of means of separation of various sizes within a cage (tank) and/or lead different size fish through gate valve to a neighbor tank, as well as provide proper volumetric control of available volume within a submerged cage.

The object of developing the present tank farm, is to present solutions to a variety of new requirements related to an innovative way of farming fish. The inventor was previously one of the inventors of the invention as disclosed in NO343577B (application No.
NO 2017 0955 A1), which presented new solutions for suppressing the sea lice problem, protect the operating personnel as well as making operations in more exposed environments with heavy waves and strong currents possible.

According the mentioned patent a tank for fish farming is described, wherein the tank comprises: a polygonal or circular ring pontoon forming the lower part of the tank, sidewalls being substantially vertically arranged on the ring pontoon to form a substantially vertically arranged tubular member having a circular or polygonal cross section, and vertical columns being arranged perpendicular upwards on the ring pontoon and being connected to the sidewalls, and extends from the ring pontoon to the top of the sidewalls, where the ring pontoon and the vertical columns comprise closed buoyancy elements, and where the ring pontoon is adopted to be ballasted by means of water being pumped into the buoyancy element(s) therein.

Objects of the present invention.

An object of the present invention is to further develop the known fish farming structure described in said Norwegian patent, and offer alternative solutions in the design of the hull, improve hydrodynamics and stability in order to deal with even more heavy wave and weather environment, improve the handling and wellbeing of the fish during operation, and further rationalize the efficiency of the farm.

A further object is to provide a structure based on a bottom or lower polygonal or circular ring pontoon structure supporting plural number of stabilizing columns containing semi open concentric tanks for fish farming on top, with inside tanks penetrating the pontoon from top to bottom, and where the tanks are interconnected at the top.

A primary object of the invention is further to deal with the abovementioned disadvantages of other present fish farming structures.

Further preferred applications of the inventive structure is described.

The present invention.

The floating structure of the present invention is characterized by the features as given in the following claim 1.

The preferred embodiments of the floatable fish breeding structure appear in the following dependent claims 2-9, which discloses the preferred features of the invention as described below:

The floating fish breeding structure of the present invention is characterized in that a polygonal or circular ring pontoon is a lower part of the structure forming a basis for a plurality of columns/tanks for containing fish, each column/tank being arranged upwards in an annular pattern on the pontoon top surface with inside tank penetrating the ponton through recess structure, and where at least two adjacent tanks are interconnected by a closable lock structure in the upper part.

The breeding structure of the invention is a semi-submersible floater structure, where a plurality of columns/tanks are configured in ring on top of and integrated into said ring shaped pontoon structure.

The tanks are semi open with steel net in the bottom to prohibit escape of fish, allow circulation/escape of the water supplied on top of the tanks to refresh oxygen content, and removal of harmful waste and faeces.

The semi open bottom with a calibrated metal net also enables tuning of the waterflow in and out of the tanks and thereby the hydrodynamic behaviour of wave inside the tank, to improve inside environment and the hydrodynamic behaviour of the floater.

Together with tuning of column displacement and water plane area, and in combination with shape and displacement of ring pontoon, the motion characteristics of the present invention is expected to be very good and suitable for rougher sea and weather environment than is the case for most fish farms operating today.

The environment in the tanks are further improved by a sloshing suppression system (anti sloshing perforated cofferdams) circumferencing the top section of each tank.

The combination of good motion characteristics of the floater, and the protected environment inside the tanks, are expected to provide excellent conditions for farming of fish.
Another characteristic of the invention given in claim 1, is that the structure is configured to separate fish of different sizes in a tank by leading the smaller fish to escape through a gate or the net in the upper of two installed elevators, into the lower part of tank, by moving the second elevator in the tank upwards, so that the larger sized fish is carefully forced upwards to be collected, or moved into adjacent tank in neighbor column, and the smaller sized fish swim or escape into the lower part of the tanks.

For circulation of water to the fish tanks, is provided water supply by a pump system with the intake of water at depths located below the draft where sea lice is expected to occur.

To secure rigidity of columns, accurate concentric shape of tanks is important for free movements of elevator frames up and down, and columns are for that reason double hull cell structure with clean inside and outside skin. The clean skin do also contribute to favorable corrosion protection and maintenance of structure.

In the open area within pontoon ring and circumferential columns, is available space for an extra set of tanks similar to circumferential columns, but without buoyancy elements for less influence on hydrodynamics.

In the hull of the floater of the present invention is provided tanks and a pump system for ballasting/deballasting the hull, between service draft at operating water line, and the minimum maintenance/moving draft with the pontoon deck above sea surface.

At deck level of floater above operating water line, is a variety of service facilities, to accommodate people, to assist operation, to provide power, to store and provide food for the fish, receive supplies and service vessels etc.

The preferred applications of the fish breeding structure appear in claims 10 and 11.

Drawing figures.

The invention will be disclosed more detailed by reference to the drawings, wherein;
Figure 1 and 2 are perspective views, seen obliquely from above and below respectively, of a semi-submersible fish farm structure of the invention, of a eight tanks which are anchored on top of a submersible ring pontoon structure.

Generally, none of the figures deal with deck level outfitting facilities due to no significance for this patent application.

Figure 3 is a plan perspective view, partly in section, of the fish farm unit of figures 1 or 2.

Figure 4 is a vertical cross section view of the fish farm structure along line X-X as indicated on figures 1 and 3, i.e. with the structure arranged floating in the sea in its upright correct position.

Figure 5A shows a vertical cross section of two adjacent positioned tanks mounted on top of the bottom floater structure. The figure also shows the two internal hoistable elevator net frames inside each tank.

Figure 5B shows the sealing of the gap between the liftable net mesh elevator and the inner wall of tank.

Figures 6 and 7 show a coffer dam structure and the downward rotating water flow through the tank.

Specific embodiments of the invention.

The invention will be disclosed more in detail with reference to the drawing figures, in that the basic design is explained first.

The semi-submersible structure 10 shown in figures 1 -3 comprises a ring pontoon 12 onto which a plurality vertical hollow tanks (or columns) 14 are arranged. The ring pontoon 12 and the vertical columns/tanks 14 serve as structural support, buoyance and stabilizers for the fish farming unit. The ring pontoon 12 is a substantially circular ring shape but may be polygonal having four or more straight sections. The pontoon is arranged substantially horizontal or parallel to the sea surface 11 (figure 4) at the lowermost part of the unit. The circular inner wall of lower section of each tank, is designed to penetrate the pontoon 16, extending from the top surface of the pontoon 12 to the bottom, see figure 2. Each tank is firmly secured to the pontoon. The bottom section and each tank defines a water permeable net section creating liquid communication between the tank internal volume and the free water environment outside and below.

The pontoon structure 12 is preferably divided into two or more individual separated sub tank volumes all enabled to be individually ballasted.

According to the invention the volumes of the pontoon 12, the gap 24 between two tanks 22,24 and the hollow collar 28 are arranged to be ballasted by water/air to contribute to the draft position and balance/stability of the fish farming structure in the sea. In this manner, by filling or draining water in/off the pontoon/gap or in further arranged extra floats, high level in the sea of the structure may be regulated. While the fish containing tanks are open in bottom for free drainage of water through the bottom mesh-net elevator.

Each tank 14 is connected vertically upwards on the ring pontoon 12, and outer shell parts on to the pontoon 12 top surface 15,. The inner shell 20 of each tank with a reduced diameter form a plug like socket 16, arranged to fit into a circular recess extending from the top surface of the

pontoon 12 to the bottom, see figure 2. More precise as best shown in the enlarged figure 5A, the outer ring shaped shell wall 22 and the intermediate section 24 are terminated at the top of the pontoon, while the inner shell wall 20 penetrate the pontoon to it's very bottom facing the sea volume below the breeding structure.

The present fish farming structure is kept in position on location by a set of mooring lines 13 fixed to the unit's mooring system in one end and the seabed by anchors or piles in the other end as shown in figures 1 and 2.

In the preferred case, eight - 8 – column/tanks 14 are fixed to the pontoon 12 along the periphery around the circle.

Water is supplied into each tank at the top level, close to the water surface 11. Said tank bottom 15 is arranged with a grid of a calibrated mesh, to prevent escape of fish from the tank inside and further to allow water including faeces, various waste and surplus of food particles to flow out of the tank bottom and into the surrounding water. The floater provides for a forced circulation of necessary water to supply the fish comfortably with oxygen illustrated in figure 7.

In the open space internal of the circumferential pontoon and columns, extra tanks 18 (one or more, preferably two) is/are arranged as shown in figures 1-3. The height of the tanks are extending from the pontoon 12 bottom surface to the same level as the circumferential tanks. These tanks 18 are preferably of a single wall structure. The bottom of each of these tanks 18 is safely secured to the surrounding pontoon. The geometrical design of the tank set appears of the figure 3 plan view.

Each tank 14 is designed with a double hull, of concentric fashion, with an inner 20 and outer 22 shell wall (figure 5A) being separated by a gap or space 24 having honeycomb structure to ensure stiffness and circular concentric shape of tank, minimize the shell thicknesses and reduce weight, which is essential to secure the payload capacity and performance of the unit.

The space 24 is preferably intended to be ballasted by supplying water and/or air to balance and give buoyancy to the fish farming structure in the sea. The double hull volume between inner and outer shells of columns serve the purpose of stabilizing the structure hull, hydrostatically as well as hydrodynamically. The concentric solution is also particularly configured to make possible on design stage minor tuning of the structure without significant change of the structural design.

The tanks are designed to include open top of inner tank making sufficient access to the tank for all kind of service purposes. The inner cylinder of columns bordering the tank, is a uniform cylinder from bottom to top, to allow installation of a hoistable floor with metal grating, to be elevated up and down with the intention to vary the permissible fish volume of the tanks above the floor. A bilge keel 80 (figure 4) may be provided to brake pitch/roll and add mass to the dynamic system.

At the upper part of tanks, at the surface level, a cofferdam collar 26 circumferentially encloses the outside of tank. The collar inner wall comprises radially inward perforations 29 extending through the tank wall also. On figures 6 and 7 said perforations are also shown partly continuing around the tank wall.

The purpose of the cofferdam is to dampen the effect of sloshing water inside the tank and in order to meet the environmental conditions on the intended location where the unit will be installed. Preferably each cofferdam extends 2-5 meter below and 3-8 meter above waterline. A second hollow collar 28 is circumferentially enclosing the cofferdam 26, and provides buoyancy

to the structure at surface level and is also arranged to be fully or partly ballasted as/if necessary.

The external outside of each tank 20 is arranged with one or more vertical pipes 70 (figure 7) to conduct or rise water from greater water depths for example 18-20 meters and to flow the water into the top level of the tank by a mainly horizontal pipe 71 extending into tank through the tank wall. Thus the intake of water circulation units is located below the draft where sea lice is expected to occur. To secure circulation of water in the tanks, each tank unit is equipped with several circulation units, that take water from /- 18-20 meter depth and push the water at speed 1-3 meter pr second through pipes 71, to enter the tank at pre-set angles at the top. In some cases water may even be collected at greater depth.

Figure 7 indicates how the water is conducted at to flow from pipe 70 through the tank wall and continues in a slow whirl 72 from top to bottom of the tank where it escapes through the fixed or elevator floor 40 at the bottom, for example at depth /-25m (depending on actual farm size) helped by the outside current. This figure 7 shows the fixed or elevator floor 40 at the bottom outlet of the tank, while in figure 5A it is elevated 1/3 cut inside the tank volume. The capacity of the circulation system is at all times calibrated to feed the tank with the necessary amount of water to secure oxygen for the fish and remove harmful waste. Capacity of circulation units are computer controlled to ensure proper supply.

The structure will for each tank be equipped with a water circulation system feeding water by pumps in a dedicated piping system located on outside of the columns. To save energy the pumps to be low velocity in pipe flow type (propeller) with frequency control of the rotation speed to regulate the flow velocity.

The intake of the water circulation system (generally) to be just at or close to pontoon deck level, far enough away from sea surface to avoid sea lice entering the system, and above level of tank outlet under the columns from where the waste from the tanks are disposed.

In some instances, additional intakes may be located in deeper water to admit water of various temperature into the tanks and thereby have better seasonal control of the water temperature inside.

Flow connection of to adjacent tanks.

At an upper area of the water line 11, at least two adjacent tanks next to each other, and preferably all adjacent tanks, are interconnected by a closable lock structure 30. As shown in figures 3, 4 and 7, at an upper level, tank 14 is interconnected to a neighbouring tank via a channel section or lock 30 where the through flow opening 32 can be manipulated by inserted gate valves 34 with optional mesh openings. The interconnection channel shall serve the purpose of shifting fish from one tank to another tank when necessary to separate fish and/or treat fish individually. Preferably by means of the one or more liftable elevator floors which are disclosed further down in this specification.

The lock structure 30 between two tanks is situated in the area just below the sea level 11. The mesh size of a mesh net in lock passage, is regulated as to the size of fish one wishes to let through the lock port from one tank to the neighbouring tank.

Each tank bottom area, in the internal volume of the tank, comprises a net frame, allowing water to drain off the tank bottom and for preventing fish escaping. See the right hand tank 14 on figure 5A.

In the preferable embodiment, this net frame is, as shown in the left side tank of figure 5A, structured to operate as a liftable elevator. In the further preferred embodiment of figure 5A left, there are two individually liftable net frames, named a fixed or elevated floor 40 and an upper second net frame elevator 42, i.e. the one positioned above the other. Each elevator is suspending down into the tank volume by sufficient cable lines 49 up to a hoist unit 50 on top of the tank structure. The sealing structure to prevent fish from escaping, appears on the enlarged detail of figure 5B.

The purpose of elevators is to provide for separation of fish of different size, or to move fish from one tank 14 into another via the abovementioned port openings 30 as shown in figure 3. Preferably each elevator comprises a free flow metal net.

Elevating the floors (like a lift) up and down, enables a controlled variation of the part volume of the tank above the elevator floor containing the farmed fish, and by that several advantages are achieved. The fish may be carefully pushed towards the top of the tank enabling more convenient collection and transfer of the fish to transport ship, used to pick up the fish for processing.

For sorting fish in two sizes, use is made of the fixed or elevated floor 40 and the upper second net frame elevator 42 of different mesh size elevator nets. The upper second net frame elevator 42 includes a net of the right mesh size to allow fish of a certain size to escape down, while the net of the fixed or elevated floor 40 at all time is blocking escape of all sizes of fish intended for the tank.

The smaller net size accommodates the smaller size fish to be contained from the start of the fish farming or breeding. As the fish grow to bigger sizes, smaller and bigger sizes may be separated by elevating the upper floor upwards and letting smaller size fish escape to the lower section of tank through a calibrated mesh/escape section of the floor (mesh section to be opened occasionally). So when the upper tank volume containing fish of different sizes is reduced by lifting the upper second net frame elevator 42, the smaller fish may drop or swim downward into the tank compartment below the fixed or elevated floor 40 while the bigger fish is carefully forced upwards, to be collected for transfer to transport/treatment unit, or to escape

through the port and into a neighbouring tank. Thus smaller fish is contained between the fixed or elevated floor 40 and the upper second net frame elevator 42, while the larger fish is above the upper second net frame elevator 42.

Elevating of the floor may be used in cases where the fish need medical treatment to ease the catching for treatment by service vessel. The elevating floor in different tanks may be equipped with different (wire) mesh size for a particular tank to habit smaller size fish and another tank some bigger sizes.

As shown in figure 5B, each of the fixed or elevated floor 40 and the upper second net frame elevator 42 is guided on the cylinder wall 14 by rollers 47 to secure accurate and precise elevation and enable smallest possible slit between the fixed or elevated floor 40 and the cylinder wall 20. The slit to may be closed with suitable brushes 43 and/or by expandable rubber seal 45 or similar. In some cases the fixed or elevated floor 40 may even be fixed to the sidewall of the tank permanently.

Figures 5A (right side) and 7 show that the fixed or elevated floor 40 forms the bottom of the tank, and water including impurities is allowed for free flowing through the bottom of the tank since the fish farming structure is intended for operation at open seas. The tank bottom structure may though include robot systems to collect and discharge faeces, food remains and dead fish to be transported to the surface through hoses for adequate treatment.

To clean tanks, keep the elevator grating free of waste and remove dead fish from the elevator deck, cleaning robot and dead fish collecting robot will be installed. From a temporary storage at elevator deck level, dead fish will be pumped to deck for ensiling.

The elevating floor in different tanks may be equipped with different mesh size for a particular tank to habit smaller size fish and another tank some bigger size fish.

Above pair of tanks the accommodation and the machinery section will cover the tank top area and provide roof and enclosed working environment for those areas, while other freestanding tanks will each have protecting sides and a protecting roof. Access between the working areas on top of tanks will be on protected gangways. Enclosure of the tanks from outside light enables control of light environment inside tanks by making a controlled inside light environment.

The cleaning of tank-walls and floor as well as removing of dead fish will be performed by dedicated purpose-built robots. Most of the working areas will be indoor and/or environmentally protected to the extent possible to ensure safe and comfortable operation.

Typical size and capacity of structure.

A suitable size of the structure may have a ring pontoon diameter of about 70 meter, a draft of 25 meter and a height of the structure from keel to top of roof/shelter above tanks of about 36m. Volume of each fish tank may be about 5000m3 each, giving a total fish tank volume of 10 tanks of about 50.000m3.

Further advantages.

As described in the aforementioned, the present utilizes a floater, and like all floaters when operating in environment with heavy waves and current, the waves and the environmental forces will tend to amplify the motions. To reduce the impact of the waves and suppress the motions, in the oil industry long time ago introduced the design of the semi-submersible hull, which since

has been standard for oil drilling rigs. This principle as described above, is also utilized in this invention as was also the case for the solution appearing in NO343577.

But different from NO343577, in this invention utilizes a multicolumn hull configuration combining the function of the columns to have sufficient volume/waterplane to stabilize the floater hydrostatically and hydrodynamically, as well as containing the open tanks for fish inside, which are forming the centre part of the double hull columns.

By selecting this solution for the invention, it is possible to handle even more wave exposed environment than before achieved by other solutions, because a feasible diameter of the columns for stabilizing purposes can be combined with an inner tank having optimal diameter for suppressing of unacceptable sloshing, particularly if combined with the circumferent and partly open cofferdam at the surface level of the tank, and where the size of the bottom openings of the tank and net frame are tuned to suppress effect of critical environment surface waves.

At the same time, the open top makes access to the tank easy for all kind of service purposes, the semi open bottom with metal net prohibit escape of fish, and proportions makes it suitable for forced circulation of necessary water to supply the fish comfortably with oxygen.

In comparison with other concepts, where the open tank diameter is considerably larger, as for instance is the case for the structure of NO343577, the sloshing phenomena amplify more expressively with motions, and thereby limits the operational area more strictly for this kind of units than what is the case for the present new inventive structure named “AquaOcean”.

To get the necessary volume of tank capacity for a large farm unit according to the present invention, a number tanks/columns are needed. In this case the selected number of tanks/columns are spaced in a circle around, and penetrating a ring pontoon. The tanks/columns are concentric double hull configuration, to secure necessary displacement and stability, as well as provide space for free surface open tanks inside. More precise the upper section of the ring pontoon is designed with a plurality recesses around the circumference, each recess accommodating and securing the bottom of its belonging upright positioned double hull/walled tank/column. The ring pontoon may have a circular, oval or square other suitable ring shapes.

Advantages of the new inventive structure

The solution with double hull columns penetrating the hull of the ring pontoon also secures operational advantages; the tank walls located in concentric fashion inside the column, are like open wells, which can be made with same diameter and without obstructions all the way from bottom to top, enabling an elevated frame/floor with a free flow metal net, to be provided.

By elevating the floor(s), the fish may be carefully pushed towards the top of the tanks enabling separation of different sizes of fish by letting the smaller sizes escape to the neighbouring tank through calibrated openings in the piping system connecting the tanks at the top. The fish may be carefully pushed towards the top of the tank enabling more convenient collection and transfer of the fish to transport ship, used to pick up the fish for processing. Elevating of the floor may be used in cases where the fish need medical treatment to ease the catching for treatment by service vessel. The elevating the floor may also be lifted to the top for cleaning purposes and/or to equip the floor with some smaller mesh/restrictions to enable the tank to contain smaller size fish.

The elevating floor in different tanks may be equipped with different mesh size for a particular tank to habit smaller size fish and another tank some bigger sizes. So when the fish is grown to bigger size, the upper elevating floor is elevated to push the bigger fish to upper part of tank, while smaller fish escape through dedicated restrictions to lover part. Then escape restrictions are closed, and larger size fish are pushed through connecting pipe port/gate 30 to neighbouring tank with a more open mesh at the bottom, permitting more free circulation of water to satisfy oxygen requirement of bigger size fish, and ease deposit of faeces and food surplus.

The capability of the structure of the present invention, to stand environment with strong current is favorable, because strong current secure transport of waste deposits away from the farm unit, for less pollution of local environment and better dispersion of the waste in area of installation.

Inside the tank, the water preferably is conducted in a slow flow whirl 72 (figure 7) from top to bottom where it escapes through the mesh net at the bottom at depth +/-25m (depending on actual farm size) helped by the outside current. As shown in figure 7 the capacity of the system is at all times calibrated to feed the tank with the necessary amount of water to secure oxygen for the fish. Capacity of circulation units are computer controlled to ensure proper supply.

The placing of the intakes of the water circulation system deep down from the surface, are intended to avoid suction of sea lice puppets, mostly occurring at or close to sea surface, into the system, and thereby eliminate the problem of the sea lice parasite entering the tank. The size of the present inventive structure enables capacity of the unit to accommodate all necessary service functions to daily operate the unit independently, if necessary, also without supply of electric current from shore.

The structure will be equipped with accommodation for people to live and as necessary stay overnight. There will be service office, laboratory, and control room for people to operate all working functions of unit. An electric network to feed machinery and equipment utilizing shore current and/or installed current will be provided. There will also be storage and machinery for food supply, equipment and space for treatment of dead fish, and necessary equipment to serve the various farming operation etc.

The hull of the structure will be purpose designed for the actual environment where the unit will be installed. Of particular importance is the tuning of the hull configuration to secure proper hydrodynamic behaviour and protect the fish tank surface water from extensive sloshing. Depending on the chosen parameters, the capabilities of the fish farming structure to service a particular location can be optimized and meet requirements of many severe and demanding environments along the Norwegian coast.

To accommodate transport, installation and mooring of the structure, the draft of the unit can be varied by use of the installed ballast system, which is also used to keep the unit upright under all operating conditions. A variety of drafts are practically possible, by varying the water content of water in dedicated tanks, to elevate the unit from pontoon draft with the pontoon deck free above water, down to max operating draft by ballasting.

The capability of varying the draft, is also of practical use during maintenance and cleaning of the unit, giving access above water to major part of the hull and its equipment.

As mentioned before the fish farming structure will be kept in position on location by a set of mooring lines fixed to the unit's mooring system in one end and the seabed by anchors or piles in

the other end. Depending on local conditions related to environment, seabed, water depths etc, utilisation of buoyancy elements along the mooring lines, may be required.

Summary of the invention

The objects described above have been met by the invention of the inventive fish farming structure in the following way:

It is a multicolumn semi-submersible with the columns, (6, 8 or more), located close to each other in a (ring shape) circular fashion to maximize the permissible square area of the columns within the border of a circumferent circle. A ring pontoon which is penetrated by the columns, is provided to carry the weight of the columns, and locate the columns at the lower end. At the upper end, a ring deck structure is provided to locate and support the columns horizontally. The penetration of the pontoon at the lower end is essential to give water open access to the fish tank of each column.

A set of fixed or elevated floors 40 and an upper second net frame elevator 42 of suitable mesh sizes are guided on the tank 20 cylinder internal way by rollers to secure accurate and precise elevation and enable smallest possible slit between the fixed or elevated floor 40 and the cylinder wall. The slit to be closed with suitable brushes and/or by expandable rubber seal or similar. The fixed or elevated floor 40 may in some cases be firmly located at the bottom of one or more tanks.

The elevated floor may be equipped with grating of various mesh to fit various size fish which will be accommodated in the tanks. An alternative is to make the two elevated floors, one on top of the other. The one on top may be equipped with a different size mesh to allow smaller size fish escape to the lower part of the tank when the upper floor is elevated. Bigger size fish will ultimately be pushed upwards to be catched for further treatment.

The net frames which may or may not be elevated, contribute to the motion characteristics of the floater by tuning of the opening sizes in the net to the hydrodynamics of the unit.

The floater unit is equipped with adequate equipment to renew the water content in the tanks, supply the fish in the tanks with necessary food and treatment, removal of waste and faeces, control of light level, all kinds of practical service arrangements etc.

It is also intended to make possible tuning of the structure hull to various load capacity/load conditions and environments at design stage, by adjusting the volume and waterplane of the honeycomb as required. The concept can this way be adjusted, without major change of principal layout and design of unit.

The tanks are located narrowly in a with narrow space between them to maximize number/size within a given outer circumference (important measure defining the capacity of the unit and the physical size with respect to handling of current and waves), as restrictions to column diameter due to sloshing limit the diameter of column and thereby the fish tank volume within each column. The distance between columns is chosen to allow practical access during building, maintenance, and operation.

The ring pontoon of the fish farming structure will have sufficient buoyancy to elevate the complete unit from maximum operating draft, to a draft where the pontoon deck is elevated above sea surface. The transverse rectangular shape (aspect ratio beam/height) and volume of the ring pontoon has been selected to meet needed volume of displacement, mass and added

mass to carry loads and tune motion dynamics and particularly dampen the heave response of the fish farming structure in different waves environment.

The structure will be kept on location by a catenary mooring system, fixed in one end to unit by fairlead and chain stopper, and in the other end to seabed by anchors and/or piles. To soften the system and avoid dynamic response between unit motion and spring of mooring system, mooring lines may be equipped with floating elements (not shown).

Claims

1. A floating structure (10) for fish farming, wherein a polygonal or circular ring pontoon (12) is a lower part of the structure (10) forming a basis for a plurality of columns/tanks (14) for containing fish,

said column/tanks (14) being arranged upwards in an annular pattern on the pontoon (12) top surface (15) and the bottom of each tank (14) forms a bottom plug socket (16) extending downwards from the top surface (15) of the pontoon (12) to its bottom,

in that the plug socket (16) includes a water perforable frame unit that restricts escape of fish as well as brakes the inflow/outflow of water significantly at the bottom level to dampen the effect of pulsating water inside the tank,

the water perforable frame unit being fixed or elevatable inside the tank (14), and

at least two adjacent tanks (14) are interconnected by a pipe/channel passage in the tank upper parts which comprises a closable lock structure (30), and

each tank at the surface water level (11) comprises a radially perforated circumferential cofferdam collar (26) to dampen effect of sloshing and pulsating water inside the tank.

2. A floating structure (10) according to claim 1, characterized in that each column/tank (14) is a double hull structure having inner (20) and outer (22) shell walls being separated by a gap (24), said inner shell wall (20) defining said plug socket (16) of a reduced cross section to fit into a circular or polygonal shaped recess extending downwards from the top surface (15) of the pontoon (12) to the bottom.

3. A floating structure (10) according to any of claims 1 - 2, characterized in that the water perforable frame unit comprises a first bottom element that constitutes a fixed or elevated floor (40), and an upper second net frame elevator (42) arranged above the first bottom element, said fixed or elevator floor (40) and said upper second net frame elevator (42) being individually liftable inside the tank (14).

4. A floating structure (10) according to claim 3, wherein the upper second net frame elevator (42) includes a different mesh size than the fixed or elevated floor (40).

5. A floating structure (10) according to any of claims 1 - 4, characterized in that the close-able lock structure (30) includes a gate valve/lock port (30) with a mesh net (34) regulated to the fish size one wishes to let through the lock port.

6. A floating structure (10) according to any of the preceding claims, characterized in that the buoyancy gap volume between the double hull of the two inner (20) and outer (22) shells comprises ultimate hydrostatic and hydrodynamic stabilizing means of the structure, and the said gap comprises a honeycomb structure minimizing shell (20,22) thickness.

7. A floating structure (10) according to any of the preceding claims, characterized in that the volumes of the pontoon (12), the gap (24) and the hollow collar (28) are arranged to be individually filled/ballasted by water and/or air to contribute to the balance (stability) of the structure (10) at various drafts and sea state conditions.

8. A floating structure (10) according to any of the preceding claims, characterized in that the external side of the column (22) is arranged with one or more vertical pipes (70- figure 7) with pumps inside, to soak up water from greater depth and distribute the supply to the inside of the tanks at the top in a radial fashion, so that the water supply serves the purpose of renewing the content of oxygen rich water securing proper environment for the breathing of the fish as well as extinction of faeces and food reminiscences through the bottom mesh of the tank.

9. A floating structure (10) according to any of the preceding claims, characterized in that one or more free standing tanks/columns (18) are arranged inside the ring pontoon (2) and inside the circumferential columns, and the inside tank/column height is preferably ranging from bottom level of pontoon to the top level of the circumferential columns, and so that the inside tanks/columns should be equipped with bottom mesh elements and cofferdam collar (26) similar as for the

circumferential columns, and mesh elements and cofferdam should be calibrated to optimize the hydrodynamic behaviour of the structure (10) and suppression of waves inside the tanks/columns (18) as for the circumferential columns.

10. Use of the fish farming structure of any of claims 3-9 to separate fish of different sizes in a tank (14) by lifting the upper second net frame elevator (42) with a calibrated mesh net.

11. Use of the fish farming structure of claim 5-8 to separate fish of different sizes calibrated gate, so that the smaller fish may swim or drop downward into the tank compartment between the fixed or elevated floor (40) and the upper second net frame elevator (42), while the bigger fish is carefully forced to escape through the port (30) and into neighbouring tank or caught by proper equipment for transfer to external unit.