

Offshore fish farming system

The present invention is related to an offshore fish farming system, according to the preamble of claim 1.

The present invention is especially related to gentle handling of fish, such as salmon, cobia, seabass,
5 trout, cod and similar, in an offshore fish farming system.

Background

Global population growth and global warming are drivers behind the search for new and more climate friendly ways of producing food for humans. Marine protein (including fish) is generally
10 considered relatively climate friendly food, and growth in various forms of fish farming is generally considered desirable.

Lately it has been an increasing focus on offshore fish farming systems to be used in remote locations offshore for fish farming, due to the advantages in the context of biological production, among other better water quality and more stable and optimal water temperatures compared to areas closer to
15 shore.

Arrangement of an offshore fish farming system in a remote location offshore requires that it is arranged to withstand and handle the harsh and rough environment, hereunder waves. Such an offshore fish farming system must also be self-sustained (for periods), and it must be designed in such a way that it meets the various requirements for biological production of fish.

20 In NO 342556 B1 it is described a floating arrangement for breeding fish and shellfish. The arrangement comprises an elongated cylinder element, and a framework attached to the cylinder element and configured to define a cage for the fish and shellfish around the cylinder element. The cylinder element is configured with a buoyancy that constitutes a main portion of the buoyancy of the floating arrangement. It is further described volumes interior in the elongated cylinder element
25 for fish distribution, fish grading, dead fish treatment and fish treatment.

The main drawback of NO 342556 B1 is that the cage structure and elongated cylinder element are fixed together, resulting in that the cage structure cannot be moved below the affection from current and waves and/or below affection from lice and similar organisms.

A solution solving this drawback is described in WO2020/091605 A1. In WO2020/091605 A1 is disclosed an offshore fish farming system comprising an elongated vertical support column floating vertically in water with a larger extension below sea surface than above the sea surface, and a rigid cage structure enclosing the elongated vertical support column in circumferential direction and
5 arranged movable in longitudinal direction of the elongated vertical support column to a submerged position below the affection of current and waves and/or affection from lice and similar organisms.

A drawback of the solution of WO2020/091605 A1 is the lack of availability to move fish to and from the offshore fish farming system, as well as interior in the offshore fish farming system, especially in submerged position of the cage structure.

10 There is accordingly a need for an offshore fish farming system enabling gentle movement of fish to or from the offshore fish farming system, as well as interior in the offshore fish farming system.

Another problem fish farmers are facing is the introduction of smolt into the offshore fish farm. The farmers are facing issues like fish health, regulations and legality in relation to the introduction of smolt into the sea. They also face capacity problems with breeding large smolt in fish farms close to
15 shore or on shore, as well as the risk of the transport of the large smolt to the offshore fish farm bringing along diseases.

There is accordingly a need for an offshore fish farming system wherein at least one separate volume is available for receiving smolt, and where the smolt can be bred in a protected environment until they are ready to enter a sub-cage of the cage structure. Without the possibility to breed smolt on
20 site offshore, one will have to breed smolt to a fish size ready for farming offshore on shore or close to shore and then move the pre-bred fish to the offshore fish farming system ready for the sea exposure.

There is further a need for an offshore fish farming system wherein at least one separate volume is available for grading.

25 It is further a need for an offshore fish farming system wherein at least one separate volume is available for performing treatment of fish (for example treatment for lice).

Object

The main object of the present invention is to provide an offshore fish farming system partly or entirely solving the mentioned drawbacks and lacks of the prior art solutions.

It is further an object of the present invention to provide an offshore fish farming system enabling
5 gentle movement of fish to or from the offshore fish farming system.

An object of the present invention is to provide an offshore fish farming system enabling gentle movement of fish interior in the offshore fish farming system.

An object of the present invention is to provide an offshore fish farming system enabling movement of fish interior in the offshore fish farming system with the cage structure thereof both at the surface
10 and in submerged position.

It is an object of the present invention to provide an offshore fish farming system enabling movement of fish via at least one volume separate from the cage structure of the offshore fish farming system.

It is an object of the present invention to provide an offshore fish farming system providing at least
15 one volume separate from the cage structure of the offshore fish farming system where smolt can be bred until they are ready to enter a sub-cage of the cage structure, ensuring high fish welfare.

An object of the present invention is to provide an offshore fish farming system providing at least one volume separate from the cage structure of the offshore fish farming system available for grading.

20 An object of the present invention is to provide an offshore fish farming system providing at least one volume separate from the cage structure of the offshore fish farming system for performing treatment of fish, hereunder, but not limited to, delousing, medicating/treating and disease treatment.

It is an object of the present invention to provide an offshore fish farming system enabling
25 movement of fish without the fish being stressed, resulting in higher quality of slaughtered fish.

An object of the present invention is to provide an offshore fish farming system providing at least one volume separate from the cage structure of the offshore fish farming system moving with the cage structure in longitudinal direction of the elongated vertical support column.

An object of the present invention is to provide an offshore fish farming system providing at least one volume separate from the cage structure of the offshore fish farming system enabling a waiting chamber before slaughtering, resulting in flexibility in the retrieval of fish for slaughtering, as well as will contribute to lower stress for the fish and thus improved quality.

- 5 An object of the present invention is to provide an offshore fish farming system providing at least one volume separate from the cage structure of the offshore fish farming system enabling movement of fish in connection with repairs and maintenance of the fish cage.

Further objects of the present invention will appear from the following description, claims and attached drawings.

10

The invention

An offshore fish farming system according to the present invention is disclosed in claim 1. Preferable features of the offshore fish farming system are disclosed in the dependent claims.

- The present invention is related to an offshore fish farming system as described in WO2020/091605
15 A1, the disclosure of which is included herein by reference.

The offshore fish farming system according to the present invention is formed by an elongated vertical support column having an extension both above and below the sea surface, wherein the extension below the sea surface is longer than the extension above the sea surface.

- The elongated vertical support column is further arranged to float upright in the sea with a center
20 of gravity down in the water such that the elongated vertical support column as little as possible is affected by currents and waves.

The offshore fish farming system further comprises a rigid cage structure with at least two sub-cages.

- According to the present invention, the rigid cage structure is enclosing the elongated vertical
25 support column in circumferential direction and is arranged movable in longitudinal direction of the elongated vertical support column via an attachment assembly.

The attachment assembly according to the present invention is formed by a sealed elongated tubular structure arranging the rigid cage structure movably and stable to the elongated vertical support column.

5 The sealed elongated tubular structure according to one embodiment of the present invention is formed by double walls, both for increased structural stiffness and for accommodating means for controlling water flow into and out of the sealed elongated tubular structure, as well as providing dry space for pipelines, lines or cables for sensors, data, power, controlling, etc.

The sealed elongated tubular structure is arranged in fluid communication with the respective sub-cage via respective controllable openings arranged therein.

10 The (double-walled) sealed elongated tubular structure thus provides at least one volume separate from the rigid cage structure, enabling gentle movement of fish to and from the rigid cage structure, as well as movement of fish interior in the cage structure both at the surface and in submerged position.

15 The sealed elongated tubular structure will be water filled prior to any fish moving operations, such that the fish will only experience different water flows, at the same time as the fish moving operations by this will be energy effective.

In addition to moving fish to and from the cage structure, and interior in the cage structure, the mentioned at least one volume separate from the rigid cage structure further enables grading of fish, treatment of fish, as well as breeding of smolt to a fish bred ready for sea exposure and
20 movement into a sub-cage of the cage structure.

According to the present invention framework elements/rings of the rigid cage structure are configured or designed for providing long term/permanent ballast and/or controllable ballast or buoyancy that can be used in connection with elevating and lowering (submersion) of the rigid cage structure in longitudinal direction of the elongated vertical support column.

25 In accordance with one embodiment of the present invention, the sealed elongated tubular structure is configured or designed for providing controllable ballast or buoyancy that can be used to assist the ballast or buoyancy of the framework elements/rings in connection with elevating or lowering the rigid cage structure rigid cage structure in longitudinal direction of the elongated vertical support column.

The cage structure is further provided with rigid or semi-rigid cage sides for limiting the sides thereof, and dividing the interior of the cage structure into at least two sub-cages. The use of sub-cages (individual cages) will be essential for moving fish between sub-cages as fish grow bigger in size and weight, and also for providing continuous production of fish for slaughtering. By having
5 several sub-cages this provides for optimal feeding procedures and easy access for grading of fish between different sub-cages via the sealed elongated tubular structure.

In accordance with the present invention each sub-cage is provided with a double bottom in the form of a fixed lower bottom and a movable upper bottom, wherein the upper movable bottom is movable in vertical direction of the sub-cage. The movable bottom may e.g. be implemented as a
10 sliding bulkhead.

According to a further embodiment of the present invention, the mentioned movable bottom is tilted an angle in relation to the horizontal plane, inclined towards the mentioned respective at least one controllable opening in the sealed elongated tubular structure.

In accordance with one embodiment of the present invention, the mentioned controllable openings
15 are provided with one or more of: controllable or fixed closing member, such as a valve, hatch or similar, and/or controllable or fixed grid, grating, netting, net, screen or similar, or a combination of the mentioned.

The mentioned sealed elongated tubular structure may be configured with a number of separate interior volumes forming sub-volumes in the sealed elongated tubular structure, wherein the sub-
20 volumes are separate by interior partition walls, wherein each sub-volume is in fluid communication via controllable openings with at least two adjoining sub-cages of the cage structure.

According to a further embodiment of the present invention, the interior partition walls are provided with controllable openings for fluid communication between adjoining sub-volumes in the sealed elongated tubular structure, enabling movement of fish between adjoining sub-volumes.

25 In connection with grading (sorting) of fish, the mentioned controllable openings in the mentioned interior partition walls and/or the controllable openings in the sealed elongated tubular structure against the sub-cages are provided with grids or gratings enabling grading of fish of desired size into the desired sub-volume and/or sub-cage.

In accordance with one embodiment according to the present invention, the sealed elongated
30 tubular structure is provided with at least one horizontally extending sliding bulkhead, arranged

movable in the vertical direction of the sealed elongated tubular structure, at least one movable horizontally extending sliding bulkhead for each sub-volume.

According to one embodiment of the present invention, the sealed elongated tubular structure is provided with at least one vertically extending sliding bulkhead, movable in the horizontal plane in
5 the sealed elongated tubular structure, at least one movable vertically extending sliding bulkhead for each sub-volume.

In accordance with one embodiment of the present invention, the sealed elongated tubular structure is provided with flow control means, such as one or more pumps, in fluid communication with the interior volume or sub-volumes of the sealed elongated tubular structure and with the
10 exterior of the sealed elongated tubular structure enabling a controllable water flow into and out of the elongated tubular structure or sub-volumes thereof.

According to a further embodiment of the present invention, the mentioned partition walls dividing the interior volume of the sealed elongated tubular structure to sub-volumes, may be fixed or movable. By using movable partition walls, the respective sub-volume may be change according to
15 desired preferences for different purposes.

According to the present invention, the sealed elongated tubular structure is provided with at least one opening at upper end thereof to allow access to the interior thereof, such as the respective separate sub-volume.

The offshore fish farming system is further preferably provided with feed lines from a feed storage
20 to the respective sub-cage and/or respective sub-volume in the sealed elongated tubular structure for feeding of fish or smolt farmed therein enabling feeding also when the cage structure is submerged. As discussed above, these feed lines may further be arranged in the double walls of the sealed elongated tubular structure.

The offshore fish farming system is further preferably provided with means for providing one or
25 more of: electric power to the respective sub-cages and sub-volumes, for operation, maintenance, lighting or other purposes, also when the cage structure with the sealed elongated tubular structure is submerged.

Illumination may be used for simulating day and night.

The offshore fish farming system is further preferably provided with means for providing
30 compressed air and/or oxygen to the respective sub-volume, also when the cage structure with the

sealed elongated tubular structure is submerged, in case of problems with seawater flow or that the oxygen concentration becomes too low.

The mentioned flow control means is according to one embodiment of the present invention arranged to a water inlet extending to an area of the surrounding seawater which is below the area
5 that is considered to hold lice and parasites, as well as away from the cage structure to avoid sediments and feed is coming into the supplied seawater, such that one ensures that the supplied seawater is fresh and healthy without contaminants.

Repair and maintenance of the sealed elongated tubular structure is performed when the sealed elongated tubular structure/sub-volume is empty for fish. All the controllable openings may then be
10 closed and the sealed elongated tubular structure/sub-volume be emptied for water by a movable pump.

According to the present invention, the mentioned controllable ballast and/or buoyancy means of the cage structure are used for controlled elevating and lowering of the cage structure with the sealed elongated tubular structure along the elongated vertical support, assisted by the controllable
15 ballast and/or buoyancy means of the sealed elongated tubular structure, if required. Due to the different sections of the cage structure and/or elongated tubular structure are arranged for providing controllable ballast or buoyancy, this according to the present invention be used for balancing, by using different ballast/buoyancy in different positions, the rigid cage structure and elongated tubular structure to prevent jamming when the rigid cage structure with the elongated
20 tubular structure is elevated or lowered along the elongated vertical support column. By this a controlled movement of the cage structure with the sealed elongated tubular structure along the elongated vertical support column is achieved.

According to a further embodiment of the present invention the offshore fish farming system further is provided with controllable moving means, such as at least one winch, for elevating and
25 lowering of the cage structure with the sealed elongated tubular structure in combination with using controllable ballast or buoyancy means of the cage structure assisted by the controllable ballast or buoyancy means of the sealed elongated tubular structure if required.

By that the cage structure with the sealed elongated tubular structure is movably arranged to the elongated vertical support column, the cage structure with the sealed elongated tubular structure
30 may be submerged below the affection of the waves preventing fish therein from being seasick, as well as protecting the offshore fish farming system from the affection from waves and current, and is storm safe.

By that the offshore fish farming system is provided with means for feeding also in submerged position of the cage structure with the sealed elongated tubular structure, continuous feeding and operation is achieved.

5 The present invention also provides continuous production by that the cage structure is provided with at least two sub-cages, enabling insertion of fish multiple times during a production cycle, effective grading in the entire production cycle, and frequent slaughtering.

According to a further embodiment of the present invention, there are arranged optical means in connection with the mentioned openings in the sealed elongated tubular structure to collect information of each fish being moved.

10 The design and features of the elongated vertical support column ensure stability for the entire farming system by providing wave dampening, heave dampening and reduced natural frequency, as described in WO2020/091605 A1.

By the present invention is provided a solution enabling the use of at least one volume separate from the sub-cages to gently move fish from and to the offshore fish farming system, as well as
15 interior in the offshore fish farming system.

The present invention further provides at least one volume separate from the cage structure available for treatment of fish, hereunder, but not limited to, delousing, medicating/treating and disease treatment.

In addition to the mentioned, the present invention further provides at least one volume separate
20 from the cage structure available for grading of fish.

By the present invention is further provided at least one volume separate from the cage structure available for breeding of smolt to fish of a size ready for being introduced into a sub-cage.

The present invention further provides at least one volume separate from the cage structure that may be used for relocating fish if maintenance of the cage structure/sub-cage is required or in case
25 of any other emergency.

Further preferable features and advantageous details of the present invention will appear from the following example description, claims and attached drawings.

Example

The present invention will below be described in further details with references to the attached drawings where:

Fig. 1 is a principle drawing of an offshore fish farming system according to prior art
5 WO2020/091605 A1,

Fig. 2 and 3a-b are cross-sectional views of an elongated vertical support column according to prior art WO2020/091605 A1,

Fig. 4a-c are principle drawings of a cage structure according to prior art WO2020/091605 A1,

Fig. 5a-g are principle drawings of an offshore fish farming system according to the present
10 invention with a rigid cage structure with a sealed elongated tubular structure,

Fig. 6a-h are principle drawings of the sealed elongated tubular structure and interaction with a sub-cage of the rigid cage structure,

Fig. 7 is a principle drawing of details of interaction between the cage structure and elongated vertical support column, and

15 Fig. 8a-b are principle drawings of moving means for elevating and lowering the cage structure with the sealed elongated tubular structure along the elongated vertical support column.

Reference is now made to Figure 1 which is a principle drawing of an offshore fish farming system
100 according to prior art WO2020/091605 A1. The disclosure of WO2020/091605 A1 is
20 incorporated herein by reference. The offshore fish farming system 100 comprises an elongated vertical support column 200 and a rigid cage structure 300. The rigid cage structure 300 is arranged enclosing the elongated vertical support column 200 in circumferential direction thereof and arranged movable in longitudinal direction of the elongated vertical support column 200 via an attachment assembly 310.

25 The elongated vertical support column 200 is an elongated structure floating mainly vertically in the water and is initially designed with a neutral buoyancy when arranged in the sea. The elongated vertical support column 200 has a larger extension below the sea surface 10 than above the sea surface 10.

The elongated vertical support column 200 is designed to have a buoyancy under the level for wave affection. The elongated vertical support column 200 will at lower end thereof be provided with a permanent ballast element 210 ensuring stable vertical position of the elongated vertical support column 200 even at current and wave affection.

- 5 Reference is also med to Figure 2 showing a cross-sectional view of an elongated vertical support column 200 according to the offshore fish farming system 100 presented in WO2020/091605 A1, showing interior features thereof. According to the shown embodiment, the elongated vertical support column 200, at one or more locations along the elongated vertical support column 200, is provided with at least one ballast tank 220 in fluid communication with the exterior allowing
10 seawater to be added and removed for controllable ballasting of the elongated vertical support column 200.

- As shown in Figure 2, the elongated vertical support column 200 is further provided with at least one feed storage tank 230, preferably arranged at lower part of the elongated vertical support column 200. The offshore fish farming system 100 is further provided with a feed distribution system
15 400, such as at least one container 410 arranged to an elevation system 420 allowing containers 410 to travel inside the elongated vertical support column 200, down to the at least one feed storage tank 230 for retrieving feed when this is required.

- As shown in Figure 2, ballast tanks 220 can be arranged both above and below the at least one feed storage tank 230, enabling adjustment of the ballast according to feed amount in the at least one
20 feed storage tank. Accordingly, as feed is taken out and the weight of the feed in the at least one feed storage tank 230 is reduced, seawater can be added to maintain the ballast of the elongated vertical support column 200. Similarly, when feed is added to the at least one feed storage tank 230, the ballast water is removed from the at least one ballast tank 220 maintaining the ballast of the elongated vertical support column 200.

- 25 According to a further embodiment of the elongated vertical support column 200 according to WO2020/091605 A1, the elongated vertical support column 200 can further be provided with additional ballast tanks 240, as shown in Figures 3a-b, arranged for providing long term/permanent controllable ballast in addition to the above mentioned at least one ballast tank 220 which is being controlled in relation to filling degree/weight of the feed in the at least one storage tank 230.

- 30 The elongated vertical support column 200 in WO2020/091605 A1 is in a further embodiment provided with dampening means 250 for dampening as shown in Figures 2, 3a-b, preferably arranged in an upper part of the elongated vertical support column 200, i.e. in a wave affected area

thereof. For details of the dampening means 250, reference is made to the disclosure of WO2020/091605 A1.

By the elongated vertical support column 200 of WO2020/091605 A1 is provided a structure with dampening, low natural frequency, as well as a gravity center below the buoyancy center providing
5 safety and continuous operation, which not only provides welfare for fish, but also for personnel.

The elongated vertical support column 200 further, by its design, provides lower natural frequency and improved dampening in relation to all existing solutions.

According to a further embodiment of WO2020/091605 A1 there is arranged at least one tank 260 between the upper ballast tank 220 and the dampening means 250, which can be filled with air for
10 controlled buoyancy or used as additional storage, e.g. for feed.

Reference is now made to Figures 4a-c which are principle drawings of a rigid cage structure 300 according to WO2020/091605 A1. The rigid cage structure 300 comprises an attachment assembly 310 formed by an upper inner cage ring 311 and a lower inner cage ring 312, spaced apart in vertical direction and attached to each other by means of vertical beams or rods 313 extending between
15 and attached to the upper 311 and lower 312 inner cage rings, at the circumference thereof. The upper 311 and lower 312 inner cage rings enclose the elongated vertical support column 200 and is provided with sliding surfaces (covered with low resistance material) for traveling in longitudinal direction of the elongated vertical support column 200. Accordingly, the upper 311 and lower 312 inner cage rings and the vertical beams or rods 313 form the inner frame of the rigid cage structure
20 300.

Reference is now made to Figures 5a-c, 6a-e and 7 for description of the offshore fish farming system according to the present invention. The present invention is based on and comprises the above described elongated vertical support column 200 and a modified rigid cage structure 300, that will be described in further detail below. As shown in Figures 5a-c, the attachment assembly 310
25 according to the present invention is formed by a sealed elongated tubular structure 370, such as an elongated tubular tank, replacing the mentioned upper 311 and lower 312 inner cage rings, as well as the vertical beams or rods 313 extending therebetween. The sealed elongated tubular structure 370 is preferably double walled and wherein the space/spacing/volume 371a-b between the walls is used for arranging reinforcing structure elements. The mentioned volume 371a at upper
30 part of the sealed elongated tubular structure 370 is designed to provide a sealed space for arrangement of means 375, such as at least one pump, for controlling water flow into and out of the sealed elongated structure 370 or sub-volumes 390 thereof, further described below. The upper

dry volume 371a is thus providing a sealed dry space for pumps, motors, lines or cables for sensors, data, power, controlling, etc.

The mentioned volume 371b at lower part and longitudinal parts of the sealed elongated tubular structure 370 may further be used for providing adjustable ballast/buoyancy, as well as providing
5 space for arrangement of pipelines, etc.

The sealed elongated tubular structure 370 according to the present invention has an extension in longitudinal direction that is at least the height of the rigid cage structure 300. According to the present invention, the sealed elongated tubular structure 370 has an interior circumference adapted the exterior circumference of the elongated vertical support column 200 and is arranged enclosing
10 the elongated vertical support column 200. The sealed elongated tubular structure 370 is provided with sliding surfaces (covered with low resistance material) for traveling in longitudinal direction of the elongated vertical support column 200.

As shown in Figure 6d, the interior volume of the sealed elongated tubular structure 370 may be divided into two or more sealed or separate sub-volumes 390 by fixed or movable partition walls
15 391. In the embodiment shown in Figure 6d, the sub-volumes 390 of the sealed elongated tubular structure 370 is arranged to serve two adjoining sub-cages 300a of the cage structure 300. In the embodiment in Figure 6d, the sealed elongated tubular structure comprises four sub-volumes 390 serving eight sub-cages 300a of the cage structure.

The rigid cage structure 300 is according to the present invention further provided with upper 320
20 and lower 321 exterior cage rings. According to one embodiment of the present invention, the upper exterior cage ring 320, having a larger diameter than the exterior circumference of the sealed elongated tubular structure 370, is arranged in the same horizontal plane as the upper end of the sealed elongated tubular structure 370 and the lower exterior cage ring 321, having a larger diameter than the exterior circumference of the sealed elongated tubular structure 370, is arranged
25 in a parallel horizontal plane above the lower end of the sealed elongated tubular structure 370. The upper 320 and lower 321 exterior cage rings according to one embodiment are of similar diameter.

The upper 320 and lower 321 exterior rings are attached to each other by vertically extending cage structure members 322, such as vertical beams or rods. The upper exterior cage ring 320 is further
30 arranged to the upper end/part of the sealed elongated tubular structure 370 by means of horizontally extending cage structure members 323, such as beams or rods, and the lower exterior cage ring 321 is arranged to the lower end/part of the sealed elongated tubular structure 370 by

cage structure members 324, such as beams or rods, extending between the lower part/end of the sealed elongated tubular structure 370 and the lower exterior cage ring 321.

In addition, there are preferably arranged mainly horizontally extending cage structure members 325, such as beams or rods, extending between the lower outer cage ring 321 and the attachment
5 assembly 310, i.e. sealed elongated tubular structure 370, preferably at intermediate positions between upper and lower end of the sealed elongated tubular structure 370.

In addition, there are preferably arranged cage structure members 326, such as cross beams or rods, at appropriate angles between the respective rings 320, 321, cage structure members 323-325 and the sealed elongated tubular structure 370 to form a rigid framework cage structure 300 with at
10 least two sub-cages 300a. The more cage structure members, such as beams or rods, forming triangles, the more rigid and solid the cage structure 300 becomes.

The rings 320-321 and cage structure members 323-326, such as beams or rods, exhibit an inner volume that can be utilized for long term/permanent or controllable ballast or buoyancy for the cage structure 300, associated with control devices (not shown) for controlling the ballast or
15 buoyancy. According to a further embodiment of the present invention the cage structure members 324, such as beams or rods, extending between the lower part/end of the sealed elongated tubular structure 370 and lower exterior cage ring 321, are arranged for providing controllable ballast or buoyancy that can be used for balancing the rigid cage structure 300 and prevent jamming when the rigid cage structure 300 is elevated or lowered along the elongated vertical support column 200.

The sealed elongated tubular structure 370 according to a further embodiment of the present invention may also comprise one or more controllable volumes 371b for controlled ballast or buoyancy, as shown in Fig. 5a and 6e, associated with control devices (not shown) for controlling the ballast or buoyancy. By having the possibility to control the ballast or buoyancy at the different
20 sections of the sealed elongated tubular structure 370 this will prevent jamming when the rigid cage structure is elevated or lowered along the vertical support column 200 as the sections may be independently controlled.
25

The fact that the sealed elongated tubular structure 370 is filled with seawater, the sealed elongated tubular structure 370 *per se* is provided with long term ballast, and the mentioned controllable ballast or buoyancy will be usable in connection movement of the cage structure 300 with the sealed
30 elongated tubular structure 370. In connection with maintenance or repairs, the sealed elongated tubular structure 370 or volumes 371b may be provided with buoyancy to help maintaining the upper part of the cage structure 300 with the sealed elongated tubular structure 370 above the sea.

The sealed elongated tubular structure 370 is according to one embodiment of the present invention, configured to provide controllable ballast by being arranged for taking in and removing water from the one or more volumes 371b at lower part and longitudinal sides thereof. By providing the sealed elongated tubular structure 370 with controllable ballast means, such as holes provided
5 with a controllable valve and at least one air pressure means, the sealed elongated tubular structure 370 will be able to provide ballast to assist, if required, the controllable ballast in the rigid cage structure 300, i.e. in the exterior cage rings 321-322 and/or cage structure members 324, 325, when the rigid cage structure 300 is to be lowered/submerged in the water and by removal of this ballast the buoyancy of the rigid cage structure 300 will be sufficient for elevating the rigid cage structure
10 300 in the water. In a further embodiment further assisted by moving means as disclosed in WO2020/091605 A1.

The mentioned controllable ballast or buoyancy of the cage structure members 324 and/or the sealed elongated tubular structure 370 can be controlled e.g. based on information from pressure sensors along sliding surfaces between the rigid cage structure 300, i.e. the sealed elongated tubular
15 structure 370, and the elongated vertical support column 200.

The above described rigid cage structure 300 will further be provided with rigid or semi-rigid cage sides 330, as shown in Figures 5c, hereunder walls, roof and bottom, formed by wire screens, grid, fabric or net, similar to the one used in prior art WO2020/091605 A1, as shown in Fig. 4b-c. In the present invention there is no need for a rigid or semi-rigid cage side 330 at the side facing the sealed
20 elongated tubular structure 370, as the sealed elongated tubular structure 370 itself form a cage side towards the elongated vertical support column 200.

For reducing the amount of fouling the cage sides 330 can be formed of brass or another copper alloy. By using cage sides 330 of metal steel or copper alloy the cage sides 330 will also contribute in the strength of the rigid cage structure 300. By using wire screens, grid, fabric or nets this will
25 reduce the drag the cage structure 300 is subjected to by the waves and currents due to the multiple openings therein. The mentioned rigid or semi-rigid cage sides 330 may also be used for forming partition walls in the cage structure 300 to form the sub-cages 300a in the rigid cage structure 300, similar to the embodiment shown in Fig. 4b-c of WO2020/091605 A1.

In accordance with the present invention, the rigid or semirigid cages sides 330 may further be
30 hybrid net solutions, formed by a combination of materials, inclusive different alloys, carbon fiber, polymer and other materials.

A problem with present net solutions is that they are not sufficiently solid for offshore use, something that result in high risk of escape of fish, breakdown, rapid exchange of the net and extensive maintenance.

In addition, present used solutions will “occupy” a part of the production volume available due to
5 present solutions must avoid steel constructions due to wear and tear on the net resulting in unavailable volume between the respective cages.

The use of a rigid or semirigid cage side 330 according to the present invention will have many advantages over the present used nets. A rigid or semirigid cage side 330 according to the present invention will be configured/designed to have sufficient strength for the harsh offshore conditions.

10 A rigid or semirigid cage side 330 according to the present invention further provides a barrier against larger fish/animals (shark, tuna fish, seal, sea lion, etc.) and foreign objects in the sea (e.g. containers, driftwood, etc.)

By using a rigid or semirigid cage side 330 according to the present invention, this enables the use of a single barrier, as shown in Fig. 5c, compared to the present used net solution that require at
15 least a double barrier.

A rigid or semirigid cage side 330 (e.g. of steel or other alloy) provides a simpler arrangement to the cage structure 300 and will reduce the wear and tear of between the fabric, screen or net and the cage construction.

As mentioned above, by using cage sides 330 according to the present invention it will be sufficient
20 with only such cage side 330 between the respective cages, opposite to the prior art requiring at least two barriers of nets.

Due to one only need one cage side 330 between the respective cages of the cage structure 300, this will also result in that there is no unnecessary occupation of the volume therein, resulting in that the production volume per cage will be increased, compared to the prior art solutions.

25 In accordance with one embodiment of the present invention the cage sides 330 are divided in sections or panels 330a-b, as shown in Fig. 5d, provided with appropriated mutual connection means 331 for connection to adjoining panels 330a-b at facing sides and with fastening means 332 for attachment to the cage structure 300 at sides facing the cage structure 300. The cage structure 300 will of course be provided with similar corresponding fastening means 333 for attachment of
30 the cage sides 330 or panels 330a-b thereto. In the shown embodiment the cages sides 330 are

divided in two panels 330a-b, but the number of panels can be different from this be higher than two.

An advantage with using cage side panels 330a-b is that this will simplify the mounting and maintenance.

- 5 As described in WO2020/091605 A1, in addition or instead of using the mentioned rigid or semi-rigid cage sides 330 as roof of the rigid cage structure 300, the rigid cage structure 300 may be covered by one rigid or semi-rigid cage side covering the entire upper side of the rigid cage structure 300, also working as a roof. The mentioned rigid or semi-rigid cage sides 330 acting as a roof is according to one embodiment of the present invention provided with at least one hatch (not shown)
- 10 enabling access to the interior of the sub-cages 300a.

The sealed elongated tubular structure 370 thus forms at least one volume separate from the sub-cages 300a formed in the cage structure 300, which at least one separate volume according to the present invention may be used for different purposes, further described below.

- As shown in Figures 5b-c and 6a-e, the mentioned sealed elongated tubular structure 370 are
- 15 provided with at least one controllable opening 372, such as a controllable valve or other closing member that can be moved between a closed and open position, wherein the at least one opening 372 is enabling fluid communication between the sealed elongated tubular structure 370/sub-volume 390 and the respective sub-cage 300a of the cage structure 300. The mentioned at least one controllable opening 372 will thus allow movement of fish between the respective sub-cage 300a
- 20 and the sealed elongated tubular structure 370 by means of the mentioned flow control means 375 and inlets/outlets 392-395, further described below. The at least one controllable opening 372 is arranged at upper part of the sealed elongated tubular structure 370 and thus the respective sub-cage 300a. Accordingly, there is associated at least one controllable opening per sub-cage 300a.

- As shown in Figures 6b-e, each of the respective sub-cages 300a is provided with a double bottom
- 25 in the form of a fixed lower part and a movable upper part. The fixed lower part is formed by the mentioned cage side 330 as discussed above, and wherein the movable part is formed by a horizontally extending sliding bulkhead 380 arranged movable in the vertical direction of the respective sub-cage 300a. The mentioned horizontally extending sliding bulkhead 380 is arranged movable by arrangement to suitable moving means (not shown), such as a drive unit, such as one
- 30 or more winches, moving guide wire(s)/support wire(s) attached to the mentioned horizontally extending sliding bulkhead 380 to elevate and/or lower the horizontally extending sliding bulkhead 380 in the vertical direction in the sub-cage 300a. Other alternative manners to install the

horizontally extending sliding bulkhead 380 movable will be within the knowledge of a skilled person.

Accordingly, by means of elevation of the horizontally extending sliding bulkhead 380, as shown in Figures 6b-c, fish in the sub-cage 300a will be crowded at upper part and in vicinity of the mentioned opening(s) 372 of the sealed elongated tubular structure 370, and will gently move from the sub-cage 300a and into respective sub-volume 390 of the sealed elongated tubular structure 370 via the associated at least one opening 372 assisted by the flow control means 375 and inlets/outlets 393, 395, further described below.

The mentioned horizontally extending sliding bulkhead 380 is according to one embodiment arranged such that the horizontally extending sliding bulkhead 380 is tilted or tiltable towards the sealed elongated tubular structure 370, such as, but not limited to 5-15 degrees in relation to the horizontal plane.

In accordance with a further embodiment of the present invention, as shown in Figure 6c, the sealed elongated tubular structure 370 comprises a double bottom in the form of a fixed lower bottom and a movable upper bottom 373. The movable upper bottom is e.g. formed by at least one horizontally extending sliding bulkhead 373 arranged movable in the vertical direction interior in the sealed elongated tubular structure 370 to enable crowding of fish therein. In an embodiment where the sealed elongated tubular structure 370 comprises more than one interior volume, i.e. two or more sub-volumes 390, there is arranged a movable horizontally extending sliding bulkhead 373 in each sub-volume 390 for crowding in the vertical direction in the respective sub-volume 390.

According to a further embodiment of the present invention, as shown in Figure 6c, the sealed elongated tubular structure 370 comprises at least one vertically extending sliding bulkhead 374 arranged movable in the horizontal plane interior in the sealed elongated tubular structure 370 to enable crowding of fish therein. In an embodiment where the sealed elongated tubular structure 370 comprises more than one interior volume, i.e. two or more sub-volumes 390, there is arranged a movable vertically extending sliding bulkhead 374 in each sub-volume 390 for crowding in the horizontal direction in the respective sub-volume 390.

According to the present invention the sealed elongated tubular structure 370 is further provided with flow control means 375, such as at least one controllable pump, configured to control the water flow into or out of the sealed elongated tubular structure 370 or respective sub-volume 390.

According to one embodiment of the present invention there are arranged separate flow control means 375 for each of the respective sub-volumes 390.

According to the present invention, the flow control means 375 are preferably arranged in the upper dry volume 371a of the sealed elongated tubular structure 370.

- 5 The mentioned flow control means 375 are arranged in fluid communication with surrounding seawater via at least one water supply pipeline 392 extending from the flow control means and into the surrounding seawater. The at least one water supply pipeline 392 preferably extends to an area of the surrounding seawater which is below the area that is considered to hold lice and parasites, as well as away from the cage structure 300 to avoid sediments and feed is coming into the supplied
10 seawater, such that one ensures that the supplied seawater is fresh and healthy without contaminants.

- The mentioned flow control means 375 is further arranged in fluid communication with the interior of the sealed elongated tubular structure 370/sub-volume 390 via at least one pipeline 393-394 for inlet and/or outlet of water from the sealed elongated tubular structure 370/sub-volume 390. In
15 the embodiment shown in Figure 6e, there is a combined inlet and outlet 393 at upper part, while an optional water inlet 394 for supplying fresh seawater is shown at lower part of the sealed elongated tubular structure 370/sub-volume 390.

- The mentioned flow control means 375 is further arranged in fluid communication with the exterior of the sealed elongated tubular structure 370 via at least one water discharge pipeline 395 for
20 discharge of water from the sealed elongated tubular structure 370/sub-volume 390.

- The mentioned pipelines 392-395 may further be provided with controllable members (not shown), such as controllable valves, hatches or other closing mechanisms, etc. to close or open for fluid flow therein, hereunder for selecting direction of flow. In open position the outlet/inlet 393 and inlet 394 are provided with a net, netting, screen, grid or grating to prevent fish in the respective sub-volume
25 390 from entering into the flow control means 375, and pipeline 392 is preferably also equipped with a net, netting, screen, grid or grating to prevent foreign objects entering the flow control means 375. Pipeline 395 is preferably also provided with a net, netting, screen, grid or grating to prevent foreign objects entering the flow control means 375.

- According to a further embodiment of the present invention, there is arranged at least one
30 controllable opening 396a in the partition walls 391 or controllable bypass flow means 396b, such as at least one pipeline enabling controlled flow from one sub-volume 390 to an adjoining sub-

volume 390. The mentioned controllable opening 396a or controllable bypass flow means 396b in a further embodiment is provided with a controllable or fixed grid or grating (not shown) enabling grading of fish moving therethrough by allowing only fish under a desired size to pass.

5 In accordance with one embodiment of the present invention, the sealed elongated tubular structure 370 is further provided with one or more access pipelines or tubes 376 at upper end thereof, extending from the exterior and into the sealed elongated tubular structure 370. When the sealed elongated tubular structure 370 comprises more than one sub-volume 390, there is preferably arranged at least one controllable access pipeline or tube 376 for each sub-volume 390, enabling insertion of fish or smolt to the respective sub-volume 390 or extraction of fish for
10 slaughtering from the respective volume to vessel. The mentioned at least one controllable access pipeline or tube 376 is preferably provided with a controllable closing member.

There is preferably further arranged at least one manhole 377 for easy access to the sealed volume 371a at upper part for access to the equipment and gear installed therein.

By the mentioned flow control means 375, controllable pipelines 392-395, 396b and the controllable
15 openings 372, 396a the sealed elongated tubular structure 370, as well as the mentioned controllable access pipeline (s) or tube(s) 376 the sealed elongated tubular structure 370 enables gentle movement/transfer of:

- I. fish from a vessel and into the offshore fish farming system in the sealed elongated tubular structure 370/sub-volume 390, and from the sealed elongated tubular structure 370/sub-
20 volume 390 and into a sub-cage 300a;
- II. small smolt from a vessel and into the offshore farming system in a sub-volume 390 of the sealed elongated tubular structure 370 for breeding to large smolt/small fish ready to be transferred to a sub-cage 300 and exposed to the sea environment;
- III. fish from a sub-cage 300a to the sealed elongated tubular structure 370/sub-volume 390 to
25 another sub-cage 300a or sub-volume via grading;
- IV. fish from a sub-cage 300a and to the sealed elongated tubular structure 370/sub-volume 390 for treatment or grading and back into the sub-cage 300a after treatment;
- V. fish ready for slaughtering from sub-cage 300a and to the sealed elongated tubular structure 370/sub-volume 390 and further to a slaughtering vessel or fish carrier.

30 Prior to any movement of fish or smolt into the sealed elongated tubular structure 370/sub-volume 390 it will be filled with seawater. With the sealed elongated tubular structure 370/sub-volume 390 filled with seawater, the controlling of the flow control means 375 and the mentioned controllable

openings 372, 396a or bypass flow means 396b, as well as water supply and discharge lines 392-395, the desired flow between sub-cage 300a and the sealed elongated tubular structure 370/sub-volume 390, between sub-volumes 390 or to and from the sealed elongated tubular structure 370/sub-volume 390 is achieved.

- 5 By that the sealed elongated tubular structure 370/sub-volume 390 always will be filled with seawater prior to performing fish movement operations, the energy required for configuring the desired water flows in the fish farming system 100 will be low and further result in gentle affections to the fish, as this will only be experienced as water flows in different directions.

10 By the present invention is provided an offshore fish farming system 100 where fish may be gently moved from and to the offshore fish farming system 100, as well as interior in the offshore fish farming system 100.

By further using the mentioned movable sliding bulkheads in the respective sub-cage 300a and the sealed elongated tubular structure 370/sub-volume 390, the desired water flow direction in addition to crowding provides a gentle movement of fish or smolt from one location to another interior in the fish farming system 100 and from the fish farming system to a slaughtering vessel or carrier vessel.

15 In connection with alternative I) and II) above, small smolt or fish is received in the sealed elongated tubular structure 370/sub-volume 390, and as the inserted smolt grow, sufficient flowrate is provided by the flow control means 375 (pump), pumping fresh seawater from pipeline 392 via inlet 20 393 or 394 into the sealed elongated tubular structure 370/sub-volume 390, and discharge via outlet 393 to discharge pipeline 395. The other controllable openings/bypass are in a closed position.

Further, for alternative II), smolt of approximately 100 grams is according to the present invention introduced into a sub-volume 390 of the sealed elongated tubular structure 370 and breed to a desired size, such as approximately 500-800 grams, whereafter the fish can be moved to the sub-cage 300a. In addition to supply of feed also oxygen is preferably supplied. In addition, the sub-cage 25 390 may be provided with means for illumination.

Further, for alternative I) and II), for moving fish or large smolt from the sealed elongated tubular structure 370/sub-volume 390 and into a desired sub-cage 300a one opens the associated at least one controllable opening 372 and controls the flow control means 375 to retrieve seawater via the 30 water supply line 392 and supplies seawater to the sealed elongated tubular structure 370/sub-volume 390 via at last one of the water inlets 393, 394 resulting in a water flow from sealed

elongated tubular structure 370/sub-volume 390 and into the desired sub-cage 300a at upper part of the sealed elongated tubular structure 370/sub-volume 390. To further facilitate the movement of the fish or smolt, the horizontally extending sliding bulkhead 373 is further moved vertically in the sealed elongated tubular structure 370/sub-volume 390 crowding fish/smolt in upper part of the sealed elongated tubular structure 370/sub-volume, and further facilitating the movement of fish by moving the vertically extending bulkhead 374 horizontally towards the opening 372 and into the water flow out of the sealed elongated tubular structure 370/sub-volume 390.

Alternatives III-IV involves the movement of fish from a sub-cage 300a and into the sealed elongated tubular structure 370/sub-volume 390, either for slaughtering, treatment or grading. Movement of from a sub-cage 300a to the sealed elongated tubular structure 370/sub-cage 390 is performed by opening the at least one controllable opening 372 and further controlling the flow control means 375 to arrange a water flow from the sealed elongated tubular structure 370/sub-volume 390 and to the exterior thereof by pumping water from the sealed elongated tubular structure 370/sub-volume 390 via the pipeline 393 and out via the outlet pipeline 395. In this manner there is enable a water flow in upper part of the sealed elongated tubular structure 370/sub-volume 390 from the sub-cage 300a to the exterior of the sealed elongated tubular structure 370/sub-volume 390, moving fish from the sub-cage and into the sealed elongated tubular structure 370/sub-volume 390. To facilitate the movement of the fish from the sub-cage 30a, the horizontally extending sliding bulkhead 380 (moving part of the bottom of the sub-cage) of the sub-cage 300a is elevated to crowd fish in upper part of the sub-cage 300a and into the water flow for movement into the sealed elongated tubular structure 370/sub-volume 390. The mentioned pipeline 393 will here be provided with a netting or similar preventing fish from entering the pipeline 393, while allowing water to pass.

The elevation of the horizontally extending sliding bulkhead 380, e.g. tilted approximately 6 degrees towards the at least one controllable opening 372 will result in that the fish is crowded into the water flow moving it into the sealed elongated tubular structure 370 without the fish being exposed to stress.

The tilting of the horizontally extending sliding bulkhead 380 together with rising the fish cage to a sufficient level, ensures that all fish is moved into the water flow and into the sealed elongated tubular structure 370/sub-volume 390.

By use of a tilted horizontally extending sliding bulkhead 380 movable in vertical direction of the sub-cage 300a together with the controllable water flow results in that it is possible to move all the

fish from the sub-cage 300a to the sealed elongated tubular structure 370/sub-cage 390 by using only one sliding bulkhead 380.

A problem fish farmers face is that the volume of the cages (production volume) becomes very large in relation to the biomass of the fish present in the respective cage when the fish is small (recently introduced). This results in that monitoring, tending and effective feeding becomes difficult.

By the present invention, utilizing movable parts (bottom) in the sub-cages 300a, such as a sliding bulkhead 380, it is possible to achieve a dynamic volume control that adapts to current biomass in the respective sub-cage 300a. Accordingly, by utilizing a dynamic control of the volume, the volume of the respective sub-cage 300a can be increased as the fish grows.

Effective movement of fish and fish logistics at high biomass are demanding tasks, as well these processes are stressful for the fish. The present invention provides a system that is effective and stress-free moving/transfer of fish by means of slow and gentle crowding.

As discussed above and will be further described below, crowding is required in connection with movement of fish from the respective sub-cage 300a and to the sealed elongated tubular structure 370 for handling, such as disease treatment, sorting or slaughtering.

By providing the respective sub-cage 300a with dynamic controlling of the farming volume thereof, one enables the use of a smaller farming volume for smaller fish resulting in improved control in connection with tending and feeding. In practice one can start with the sliding bulkhead 380 in an elevated position and lower the sliding bulkhead 380 dynamically as the need for larger farming volume occurs due to the fish growing and requiring larger farming volume.

In accordance with a further embodiment of the present invention, the sliding bulkhead 380 is provided with upwards extending sidewalls 381, as shown in Fig. 6f. A sliding bulkhead 380 with sidewalls 381 thus forms a funnel, collector or box sealing against the cage sides 330 and in this manner contains the fish in the restricted volume when the sliding bulkhead 380 is elevated.

As described above, the use of a tilted sliding bulkhead 380, with or without sidewalls 381, will further facilitate the movement of fish from the sub-cage 300a to the sealed elongated tubular structure 370.

In accordance with one embodiment of the present invention, the sliding bulkhead 380 is provided with sealing means or devices 382, as shown in Fig. 6g, arranged at sides thereof or sides of the sidewalls 381 facing the cage sides 330, preventing fish from entering between the sliding bulkhead

380 and cage sides 330 and below the sliding bulkhead 330. In the shown embodiment the sealing means or device 382 is only illustrated at one longitudinal side. The mentioned sealing means or device 382 is according to one embodiment of the present invention flexible. A non-limiting example of such flexible sealing means or devices are rubber members, fingers or similar. In accordance with
5 a further embodiment of the present invention, the sealing means or device 382 is further arranged for dynamically adjustable sealing, which enables adjustment of the properties thereof to provide satisfying sealing also at relatively large variation in distance that is required sealed, such as when the sliding bulkhead 380 passes structure members 321-326 of the cage structure 300. A non-limiting example of how to enable such dynamically adjustable sealing is to provide the sealing
10 means or device 382 with an inflatable member (not shown), such as a bellow or balloon, that may be adjusted by the degree of inflation. In an alternative embodiment, the sealing means or device 382 has integrated inflatable properties enabling inflation and deflation thereof.

By arranging sealing means or device 382 to the sliding bulkhead 380 this will prevent fish from escaping below the sliding bulkhead 380 and further enable effective crowding of fish.

15 A further advantage with such sealing means or device 382 is that this enables the use of sliding bulkheads 380 also when single barriers (cage sides 330) are used. The use of single barriers (cage sides 330) between adjoining sub-cages 300a results in that constructions members 321-326 of the cage structure 300 is exposed and must be passed by the sliding bulkhead 380 resulting in sealing challenges between the sliding bulkhead 380 and cage sides 330. The present invention solves these
20 problems by the mentioned sealing means or device 382.

In accordance with a further embodiment of the present invention, the cage sides 330 of the respective sub-cage 300a is configured/designed with different mesh width in upper and lower parts of the sub-cage 300a. In accordance with one embodiment of the present invention, the cage sides 330 is provided/designed with smaller mesh width in upper parts thereof than the lower part of the
25 sub-cage 300a. By utilizing increasing mesh width in relation to depth of the sub-cage 300a, the sub-cage 300a provides increased water flow therethrough, something that can be utilized when the fish becomes larger (and the need is highest) by lowering the sliding bulkhead 380 towards the bottom of the sub-cage 300a.

In this manner one may utilize a smaller volume in the sub-cage 300a when the fish is smaller by
30 holding them in upper part with the smaller mesh width. By reducing the volume when introducing smaller fish in the sub-cage 300a, one gain better control with the feeding and tending.

Similarly, when the fish grows and the biomass and volume increase there is a need for increased water flow therethrough to improve the fish environment that is easily adjusted/compensated for by lowering the sliding bulkhead 380.

5 In accordance with one embodiment according to the present invention, the sliding bulkhead 380 consists of a frame 383 being movable arranged to a track or guide 384, as illustrated in Fig. 6h, on the exterior wall of the sealed elongated tubular structure 370. In addition, there are a number of guide tracks or holes 385 arranged around the frame of the sub-cage 300a connected to vertically extending rods and/or wires 386 for guiding the sliding bulkhead 380 up and down in the respective sub-cage 300a.

10 In this manner a simple control of the sliding bulkhead 380 in the vertical direction of the sub-cage 300a is achieved. The sliding bulkhead 380 is by these means further maintained in position in the horizontal direction. A further advantage with the described embodiment is that relative movement between the sliding bulkhead 380 and the cage sides 330 are reduced, something that will simplify the sealing between the sliding bulkhead 380 and cage sides 330, as discussed above.

15 In embodiments where the mentioned cage sides 330 comprises fabric or net, measures must be taken to arrange the net to the cage structure 300. The mentioned net or fabric must be arranged to the cage structure 300 so that it is sufficiently tensioned. This can be achieved in in different ways and is partly depending on the materials used.

20 In accordance with one embodiment of the present invention, as shown in Fig. 5e, the fabric or net cage side 330 is arranged to the cage structure 300 and tensioned by means of support bars, wires, ropes or similar 334 arranged extending through the fabric or net at upper, lower and side edges thereof, wherein the support bars, wires, ropes or similar 334 in addition are arranged by means of tensioning means 335, enabling tensioning of the fabric or net, to the fastening devices 333, as shown in Fig. 5e, at appropriate positions on the cage structure 300.

25 In an alternative embodiment, the mentioned fastening devices 330 are configured to be provide tensioning features by having the tension means integrated therein for tensioning the fabric or net cage side 330.

30 In accordance with a further embodiment of the present invention, there are further arranged one or more horizontally extending support (stiffening) members 336, such as bars, beams, wires, ropes or similar, to the fabric or net cage sides 330, as show in Fig. 5f-g. Especially, the need for such

support members increases with increasing depth to maintain the shape and tensioning of the fabric or net cage sides 330. As above, these can be arranged to tensioning means.

According to a further embodiment of the present invention, as shown in Fig. 5g, there are further arranged one or more vertically extending support (stiffening) members 337, such as bars, beams,
5 wires, ropes or similar, wherein the mentioned support members 337 have flexible arrangement to the fabric or net cage side 330 and provided with/arranged to tensioning means, enabling tensioning as described above.

The fish can then be held in volume of the sealed elongated tubular structure 370 a desired time before transferred further for slaughtering. When the fish is ready for slaughtering, the fish is
10 transferred to a vessel by traditional means via one or more access openings 376 at upper end of the sealed elongated tubular structure 370. In connection with fish being pumped out of the sealed elongated tubular structure 370/sub-volume 390, the flow control means 375 supplies seawater to the sealed elongated tubular structure 370/sub-volume 390 from the water supply line 392 via the inlet 393 and/or 394 to the controllable pipeline or tube 376.

15 The possibility to move fish into and out of the sealed elongated tubular structure 370/sub-volume 390 may be used for treatment of fish, such as for louse and other parasites. The fish may receive treatment in the respective sub-volume 390 or moved via a surface unit/vessel and back into the same or another sub-volume 390 by the above described methods of moving the fish. The fish may after, being treated, be moved back into a sub-cage 300a, as described above.

20 Similarly, the possibility to move fish into and out of the sealed elongated tubular structure 370/sub-volume 390 may be used for grading. There are several methods for performing grading. As above, fish in a sub-cage 300a is moved into the sealed elongated tubular structure 370/sub-volume 390 by using the above described method. Depending on the destination of graded fish, a grid or grating with desired properties as regards size of fish that is allowed to pass, is arranged to the controllable
25 opening(s) 372, controllable opening 396a or bypass flow means 396b, depending on whether the graded/sorted fish is to be moved to the sub-cage 300a or a sub-volume 390.

When the fish have been moved to the sealed elongated tubular structure 370/sub-volume 390, the grating or grid with desired properties are arranged to the mentioned respective controllable
30 opening(s) 372 or 396a or bypass flow means 396b, depending on if the desired destination for the graded/sorted fish is a sub-cage 300a (same or different as the fish came from) or a sub-volume 390.

In the case where the destination is a sub-cage 300a, fish is moved from the sealed elongated tubular structure 370/sub-volume 390 to the sub-cage 300a as described above, and wherein the fish with a size below the properties of the grating or grid is allowed to pass, while larger fish is retained in the sealed elongated tubular structure 370/sub-volume 390.

- 5 In the other case where the destination is a sub-volume 390, the sub-volume 390 with the fish to be grated/sorted is set to transfer fish as described above, while the sub-cage 390 to receive the grated/sorted fish is set to receive fish, as described above, i.e. there is arranged a water flow from the first sub-cage 390 to the second sub-cage 390. As above, the fish with a size below the properties of the grating or grid is allowed to pass and into the other sub-cage 390, while larger fish is retained
10 in the sub-volume 390.

If desirable, there may also be performing grading (sorting) during the movement of fish between the sub-cage 300a and the sealed elongated tubular structure 370/sub-volume 390, by using a grid or grating with desired properties in the controllable opening(s) 372 when moving fish from the sub-cage 300a and into the sealed elongated tubular structure 370/sub-volume 390. Such an approach
15 would result in that the larger sized fish will remain in the sub-cage 300a.

Accordingly, the sealed elongated tubular structure 370 enables a wide area of use applications that will be needed on an offshore fish farming system 100.

Due to the sealed elongated tubular structure 370 at all times will be moved with the cage structure 300, the sub-volume(s) 390 thereof will at all times be available for use, at surface, in semi-
20 submerged and fully submerged position, which is a considerable improvement of the prior art solution WO2020/091605 A1.

As mentioned above, the cage structure 300 is arranged to move in the longitudinal direction of the elongated vertical support column 200. Reference is here made to Fig. 7. To ensure that the cage structure 300 is moved in fixed position in relation to the elongated vertical support column 200,
25 the elongated vertical support column 200 is provided with at least one longitudinal track 340 and the cage structure 300, i.e. the sealed elongated tubular structure 370 is, at interior circumference, provided with at least one guiding recess 341 adapted for engagement with the mentioned at least one longitudinal track 340 and for movement along the longitudinal track 340. In the example, the longitudinal track 340 is formed by a vertical steel (sliding) bearing covered with low friction material
30 protruding from the circumference of the elongated vertical support column 200. The at least one guiding recess 341 will be arranged at interior circumference of the sealed elongated tubular structure 370, e.g. arranged in connection with a projection 342 at the exterior circumference of the

sealed elongated tubular structure 370 facing the elongated vertical support column 200. By the at least one longitudinal track 340 and guiding recess 341 it is ensured that the cage structure 300 will not rotate/pivot about the elongated vertical support column 200 and effective elevation and lowering of the cage structure 300 in longitudinal direction of the elongated vertical support column 200. There will preferably be arranged a number of such longitudinal tracks 340 distributed along the circumference of the elongated vertical support column 200 and a number of corresponding guiding recesses 341 distributed along the sealed elongated tubular structure 370 at the circumference facing the elongated vertical support column 200.

According to an alternative embodiment, the guiding recesses 341 are arranged in the elongated vertical support column 200 and the longitudinal track 340 are arranged the exterior circumference of the sealed elongated tubular structure 370.

One alternative of the described sliding bearing can be a roller bearing. Other obvious alternatives will be within the knowledge of a skilled person.

The cage structure 300 will accordingly provide further dampening of the system as hole, and provide added mass to the system that will result in even lower natural frequency.

As shown in Figure 5a the offshore fish farming system 100 according to the present invention may be fixed to the seabed 20 in the same manner as the offshore fish farming system 100 in WO2020/091605 A1, by means of at least one anchoring means 900, such as one or more chains, wires or similar. When anchored to the seabed 20 by means of anchoring means 900, it will be preferable that the anchoring means 900 are fixed to the elongated vertical support column 200 a distance above the lower end of the elongated vertical support column 200, such that the ballast 210, 240 at lower end of this, and the moment it provides, ensures stable, vertical position of the elongated vertical support column 200 even at affection of current and waves. As shown in Figure 5a it can further be arranged a buoyancy means 910 to the anchoring means 900 for tensioning the anchoring means 900.

In an alternative embodiment the anchoring means 900 may be arranged to a winch or similar (not shown) that is arranged for tensioning the anchoring means 900.

As for the solution of WO2020/091605 A1, it may further be desired to rotate the offshore fish farming system 100 of the present invention according to current and/or wind direction. This may be achieved by moving the anchoring point at the seabed 20 to another location or by using several anchoring points positioned at different locations at the seabed 20 and attached to the elongated

vertical support column 200 by separate chains, wires or similar that may be separately controlled (tensioning and slackening) to rotate the offshore fish farming system 100. Another alternative is that the elongated vertical support column 200 is provided with a movable attachment point (not shown) (e.g. by means of slider, toothed wheel or similar) for the anchoring means 900 for
5 rotating/pivoting the offshore fish farming system to a desired position.

In a further alternative embodiment, the elongated vertical support column 200 is provided with propulsion means (not shown), such as thrusters or similar, and a control system controlling the propulsion means, such that the offshore fish farming system 100 may be floating free in the sea and held in desired position by the propulsion means.

10 The elongated vertical support column 200 will extend a distance above the sea surface 10, preferably a distance above the wave heights, wherein a work deck 500 is arranged, as shown in Figures 5a.

As for the solution of WO2020/091605 A1, the elongated vertical support column 200 extends with a smaller diameter above the work deck 500 than the part of the elongated vertical support column
15 200 below the work deck 500, but this part of the elongated vertical support column 200 may also be a separate part attached to the elongated vertical support column 200.

As for the solution of WO2020/091605 A1, the offshore fish farming system 100 further may comprise a housing 600 for operational equipment, machines, workshop, feed tanks, control central, etc. at lower part of this. At upper part of this housing 600 there may be arranged residential
20 area, living room, office, laboratory, etc.

It may further be arranged communication means for communication with onshore recipients, lifeboats, etc.

At top of the elongated vertical support column 200 there may further be arranged a helipad as shown in WO2020/091605 A1.

25 The parts of the offshore fish farming system above the sea surface preferably exhibits a smaller diameter than the parts below the sea surface to limit the affection from wind forces.

According to the present invention, the movement of the cage structure 300 with the sealed elongated tubular structure 370 along the elongated vertical support column 200 is achieved by using the controllable ballast and/or buoyancy means of the cage structure 300, assisted by the the
30 controllable ballast and/or buoyancy of the sealed elongated tubular structure 370.

As for the solution of WO2020/091605 A1, the offshore fish farming system 100, in accordance with a further embodiment of the present invention also comprises controllable moving means 800, as shown in Figures 8a-b, for assisting in elevation or lowering of the cage structure 300 with the sealed elongated tubular structure 370.

- 5 The movement of the cage structure 300 with the sealed elongated tubular structure 370 in longitudinal direction of the elongated vertical support column 200 can thus both be achieved by using the ballast or buoyancy means of the cage structure 300 and/or the elongated tubular structure 370 alone or by a combination of using the ballast or buoyancy means of the cage structure 300, assisted by the ballast or buoyancy means of the elongated tubular structure 370, if required,
10 and the controllable moving means 800, as shown in Fig. 8a-b.

According to one embodiment of the present invention the controllable moving means 800 is formed by at least one winch 810, in the example is shown two winches 810, arranged in the elongated vertical support column 200, at upper part thereof, below the work deck 500. The controllable moving means 800 further comprises at least one winch wire 820 extending from the
15 winch 810 at one end and is attached to the cage structure 300 at the other end, i.e. upper part/end of the sealed elongated tubular structure 370, via one or more pulleys 830 arranged in connection with the work deck 500. The winches 810 are preferably winches 810 provided with brakes. It will be preferably to use several winches 810 pulling or braking the movement of the cage structure 300 from different sides of the cage structure 300 to avoid jamming.

- 20 By using the properties of the controllable ballast and/or buoyancy provided in the cage structure 300 and/or the sealed elongated tubular structure 370, the cage structure 300 may be lowered and elevated in the longitudinal direction of the elongated vertical support column 200 in a controlled manner. By providing increased ballast in the cage structure 300 and/or sealed elongated tubular structure 370, the cage structure 300 can be lowered along the elongated vertical support column
25 200, assisted by e.g. the brake of the winch 810 for precise controlling/movement, if present. By removing ballast from or adding buoyancy to the cage structure 300 and/or sealed elongated tubular structure 370 and such that there still is more ballast than buoyancy, the winch 810 can hoist the cage structure 300 while the remaining ballast will retain the cage structure 300 to ensure that it will not elevate too fast to the sea surface 10, the cage structure 300 will be elevated in a safe and
30 controlled manner to the sea surface 10.

Other moving means can also be used, such as pinion racks, belt drives or similar arranged in the above-mentioned at least one longitudinal track 340 of the elongated vertical support column 200.

Other solutions that may be considered by a skilled person will be to use driving wheels that engage with the elongated vertical support column 200 exterior surface or longitudinal tracks 340 and capable of providing the necessary braking force when the cage structure 300 with the sealed elongated tubular structure 370 is lowered and the necessary hosting force when the cage structure
5 300 is elevated.

Yet another possible solution is to use wires extending over one or more pulleys at lower end of the elongated vertical support column 200 enabling the above-mentioned braking force and hoisting force.

As described in WO2020/091605 A1, there may further be arranged a locking mechanism for locking
10 the position of the cage structure 300 with the sealed elongated tubular structure 370 in relation to the elongated vertical support column 200 in longitudinal direction thereof. The details such a locking mechanism is described in WO2020/091605 A1.

Also shock absorbing means as described in WO2020/091605 A1 may be used in the present invention, absorbing contact forces between the cage structure 300 with the sealed elongated
15 tubular structure 370 and the elongated vertical support column 200/work deck 500.

Accordingly, as in WO2020/091605 A1, also the cage structure 300 with the sealed elongated tubular structure 370 according to the present invention is movable between an elevated position enabling access to the cage structure 300 from the work deck 500 and a submerged position below
affection from the waves.

Accordingly, by the present invention is achieved an offshore fish farming system 100 that enable
20 large-scale farming in remote areas with enhanced operational features compared to prior art solutions.

By the use of the elongated vertical support column 200 minimal movement of the cage structure 300 with the sealed elongated tubular structure 370 in the sea is achieved.

By that the cage structure 300 with the sealed elongated tubular structure 370 is arranged movable
25 in longitudinal direction of the elongated vertical support column 200 this enables the cage structure 300 with the sealed elongated tubular structure 370 to be lowered/submerged into the sea to ensure that the cage structure 300 with the sealed elongated tubular structure 370 is not affected by the waves, which will be essential to ensure that the cage structure 300 with the sealed elongated
30 tubular structure 370 will not be damaged by the harsh weather conditions. Further, by being able

to lower/submerge the cage structure 300 with the sealed elongated tubular structure 370 below the affection from the waves, one ensures that farmed fish, both in the sub-cages 300a and the sealed elongated tubular structure 370 will not be seasick. When fish are exposed to the waves it will become seasick and that result in that the fish will not grow as desired due to it will not eat properly.

By that the cage structure 300 with the sealed elongated tubular structure 370 is arranged movable in longitudinal direction of the elongated vertical support column 200 this also enable the cage structure 300 with the sealed elongated tubular structure 370 to be positioned lower than the area where lice and similar organisms live. Accordingly, by lowering the cage structure 300 with the sealed elongated tubular structure 370 below this area fish will not become affected by lice and similar organisms. It is also a fact that lice and similar organism are far less at remote locations offshore than close to the coastline.

To be able to feed the fish when the cage structure 300 with the sealed elongated tubular structure 370 is lowered into the sea, the offshore fish farming system comprises feed tubes as described in WO2020/091605 A1, arranged both to each sub-cage 300a in the cage structure 300 and the sealed elongated tubular structure 370/sub-volume 390, connected to a flexible hose that is arranged to means (not shown) for coiling in or rolling out in connection with elevation and lowering, respectively, of the cage structure 300 with the sealed elongated tubular structure 370. The flexible hose is further arranged to a feed central in the mentioned housing, as described in WO2020/091605 A1.

The offshore fish farming system, as in WO2020/091605 A1, further comprises supply of power and air to the cage structure 300 and the sealed elongated tubular structure 370 for enabling the control of ballast and buoyancy of the components of the cage structure 300 with the sealed elongated tubular structure 370. This may be achieved similar to the mentioned flexible hoses, by flexible power supply cables and flexible air supply tubes, as described in WO2020/091605 A1, that is arranged to means (not shown) for coiling in or rolling out in connection with elevation and lowering, respectively, of the cage structure 300 with the sealed elongated tubular structure 370. Air supply will be necessary for controlling the ballast or buoyancy of the cage structure 300 and the sealed elongated tubular structure 370 as described above. The power supply will be necessary for instrumentation, measurement and control of valves, actuators, sensors, etc. performing the control of the ballast or buoyancy of the cage structure 300 and the sealed elongated tubular structure 370, as well as for controlling the sliding bulkheads 380, 373-374, opening(s) 372, 396a, bypass flow means 396b and flow control means 375, as well as the pipelines 392-395.

According to a further embodiment of the present invention the cage structure 300 with the sealed elongated tubular structure 370 is further provided with artificial illumination means (not shown) for providing illumination of the cage structure 300 and the sealed elongated tubular structure 370/sub-volumes 390, powered by the mentioned power supply cables. When the cage structure
5 300 with the sealed elongated tubular structure 370 is lowered into the sea this results in that a lower amount of natural light reaches the cage structure 300, as well as the sealed elongated tubular structure 370/sub-volumes 390. It will thus be important to provide sufficient light for the welfare of fish in the cage structure 300 and the sealed elongated tubular structure 370/sub-volumes 390, ensuring both sufficient feed usage as well as desired growth of the fish.

10 The mentioned hoses, cables or tubes may be arranged as one unit, e.g. an umbilical, arranged to means (not shown) for coiling in or rolling out in connection with elevation and lowering, respectively, of the cage structure 300 with the sealed elongated tubular structure 370.

By this is achieved a solution where the cage structure 300 with the sealed elongated tubular structure 370 can be held in a submerged position over a longer period.

15 A problem that occurs in connection with large structures in the sea is wake zone mitigation. In the sub-cages 300a positioned downstream the elongated vertical support column 200, seen in the flow direction of the water current, there will be unfavorable conditions due to poor water current conditions, due to the blocking (shadow) effect of the elongated vertical support column 200. This may result in low oxygen level in the water, poor water quality and thus poor fish environment.

20 Further, in locations with low water current, there may also be a challenge to maintain good water quality in cases of high biomass.

In some locations there may further be challenges in periods to maintain desired temperature for the fish.

In accordance with the present invention, the offshore farming system 100 according to the present
25 invention is further configured/designed to establish a water current supplying fresh water into the “wake zone” downstream the elongated vertical support column 200, seen in the water current direction at the location.

In accordance with the present invention, the sealed elongated tubular structure 370 is utilized for achieving the mentioned water current. According to one embodiment of the present invention, the
30 sealed elongated tubular structure 370 is provided with at least one (dedicated) water current inlet

in upper part thereof, arranged upstream the elongated vertical support column 200, seen in the water current direction at the location. The sealed elongated tubular structure 370 is further provided with at least one (dedicated) water current outlet arranged in fluid communication with the mentioned wake zone downstream the elongated vertical support column 200, seen in the
5 water current direction at the location.

In accordance with a further embodiment of the present invention, there is arranged water distribution means (not shown), such as additional outlets, pipes or tubes, guide members or screens, etc. to distribute the water current to or in the mentioned wake zone or where needed. In addition, the mentioned water distribution means may be dynamically controllable enabling
10 direction and magnitude control of the water current as required.

In accordance with one embodiment of the present invention, the water current manipulation is mainly passive and utilize the sea water current at the location for enabling the water flow through the sealed elongated tubular structure 370.

In accordance with a further embodiment of the present invention, the sealed elongated tubular
15 structure 370 is provided with at least one (dedicated) pump (not shown) for increasing the mentioned water current.

According to a further embodiment of the present invention, the offshore farming system 100 further includes means for introducing (dosing) oxygen gas (not shown) into the water current if desirable or required.

20 In an alternative embodiment of the offshore farming system 100 according to the present invention the above described means for enabling water current flow can also be used in cases of generally poor water current in the sub-cages 300a. Accordingly, water is pumped from a lower part of the sub-cage 300a via at least one (dedicated) inlet (not shown) in lower part of the sealed elongated tubular structure 370 or via the mentioned flow control means 375, 392-395 as described above, to
25 create a water flow from lower part of the sub-cage 300a to upper part of one or more sub-cages 300a to increase the water current in one or more of the sub-cages 300a if needed.

In a further alternative embodiment, one in addition can supplement the water current supplied with water from deeper water to increase the water quality and more optimal water temperature.

By providing the offshore farming system 100 with water current manipulation means as described above one achieves improved water quality and fish environment downstream the elongated vertical support column 200, as discussed above.

As mentioned in the alternative embodiments, the water current manipulation means can also be
5 used for improving the water quality and fish environment in any of the sub-cages 300a if the water current generally is too low.

The mentioned water current manipulation means according to the present invention can be used for increasing the oxygen concentration in the water in the respective sub-cage 300a, providing a closer to optimal temperature, improving the current conditions and/or supplementing the sub-
10 cages 300a with deep sea water.

As shown in Figures 5b-c the upper end of the cage structure 300 may be provided with walkways 360, which may extend in transversal or circumferential direction of the upper end of the cage structure 300 enabling personnel to move on top of the cage structure 300 when in elevated position.

15 The offshore fish farming system 100 according to the present invention may be formed by sections that are assembled at the remote location offshore. E.g. the elongated vertical support column 200 may be formed by several sections that are assembled to form the final elongated vertical support column 200. Similarly, the cage structure 300, as well as the sealed elongated tubular structure 370 may be formed by several sections that are assembled at the remote location offshore to form the
20 final cage structure 300 and/or sealed elongated tubular structure 370. By that the offshore fish farming system components are formed by smaller sections that are assembled at the offshore location, it will be easier to transport the offshore fish farming system to the remote location offshore.

The offshore fish farming system may further be provided with solar cells, one or more windmills
25 for additional generation of energy for storage in an energy storage, as described in WO2020/091605 A1.

It should further be mentioned that the rigid cage structure 300 will further provide a safe quay for vessel to approach and lie alongside.

In cases where there is a need for cleaning or service of the sealed elongated structure 370, the
30 respective sub-volume 390 or the entire sealed elongated structure 370 is emptied from water by

closing all the openings/bypass flow means, and pipelines, and using a pump to empty the respective sub-volume 390 or the entire sealed elongated structure 370, preferably via a treatment plant.

The above described embodiments may be combined to form modified embodiments within the scope of the attached claims.

5

Modifications

The system according to the present invention can be adapted to make use of semi-submersible elongated vertical support columns for e.g. offshore windmills. This may be performed by either adapting the system to the existing elongated vertical support columns more similar to the farming
10 systems used today, or by adapting the elongated vertical support column of the windmill, such that it is adapted the system according to the present invention.

The use of renewable energy is a requirement today and the integration of energy generating means utilizing renewable source (wind, waves, solar) for generation of energy will in the future be a demand for farming systems.

15 The anchor attachment at the elongated vertical support column may be mobile around the circumference of the column (360 degrees).

The elongated vertical support column may be augmented by thrusters, preferably at the lower part of it but above the anchor attachment.

In connection with the offshore fish farming system according to the present invention integrated
20 with windmill or arranged in an area with offshore windmills, service vessels for the windmills may also be used for transport to and from the offshore fish farming system.

The cage structure 300 with the sealed elongated tubular structure 370 according to the present invention is scalable, both as regards size and number of sub-cages or sub-volumes 390 in the sealed elongated tubular structure 370, for adaption to existing or future elongated vertical support
25 columns or other floating or seabed attached constructions used as a fundament, as discussed above. E.g. windmills arranged offshore may be provided with a cage structure with the sealed elongated tubular structure 370 according to the present invention, being submergible or not (for protected areas). In this context, one may also choose to provide some of the supporting functions or services from a mobile vessel.

The mentioned sub-cage can further be provided with a separate support structure, making them detachably arranged to the cage structure. By this is enabled that an entire sub-cage can be removed from the cage structure and replaced with another sub-cage. The cage structure and sub-cages will then be provided with mutually corresponding attachment means for secure attachment of the sub-

5 cages in the cage structure. This solution makes it possible for vessels to approach and remove one sub-cage and replace it with another if desired.

Claims

1. Offshore fish farming system (100) comprising an elongated vertical support column (200) floating vertically in water with a larger extension below sea surface (10) than above the sea surface (10), and a rigid cage structure (300) enclosing the elongated vertical support column (200) in circumferential direction, which rigid cage structure (300) is arranged movable in longitudinal direction of the elongated vertical support column (200) via an attachment assembly (310), wherein the rigid cage structure (300) comprises at least two sub-cages (300a), **characterized in** that the attachment assembly (310) is formed by a sealed elongated tubular structure (370) in fluid communication with the respective sub-cages (300a) via respective controllable openings (372) at upper part thereof, wherein the sealed elongated tubular structure (370) enables at least one volume separate from the rigid cage structure (300).
2. Offshore fish farming system (100) according to claim 1, **characterized in** that the sealed elongated tubular structure (370) is provided with one or more fixed or movable partition walls (391) dividing the interior volume of the sealed elongated tubular structure (370) into at least two sub-volumes (390).
3. Offshore fish farming system (100) according to claim 2, **characterized in** that at least one controllable opening (396a) is arranged in the partition walls (391) or that controllable bypass flow means (396b) is arranged in connection with the partition walls (391) providing a fluid communication between the sub-volumes (390) enabling movement of fish therebetween.
4. Offshore fish farming system (100) according to claim 1 or 3, **characterized in** that the controllable openings (372 or 396a) or controllable bypass flow means (396b) are provided with controllable or detachable nets, netting, screen grids or gratings for grading of fish.
5. Offshore fish farming system (100) according to any preceding claim, **characterized in** that the sealed elongated tubular structure (370) is provided with at least one horizontally extending sliding bulkhead (373) arranged movable in the vertical direction of the sealed elongated tubular structure (370), one for each volume or sub-volume (390) in the sealed elongated tubular structure (370).
6. Offshore fish farming system (100) according to any preceding claim, **characterized in** that the sealed elongated tubular structure (370) is provided with at least one vertically extending sliding bulkhead (374) arranged movable in the horizontal plane in the sealed elongated tubular structure (370), one for each volume or sub-volume (390) in the sealed elongated tubular structure (370).

7. Offshore fish farming system (100) according to claim 1, **characterized in** that the cage structure (300) is provided with means for permanent and/or controllable ballast.
8. Offshore fish farming system (100) according to claim 7, **characterized in** that the sealed elongated tubular structure (370) is provided with means for controllable ballast or buoyancy.
- 5 9. Offshore fish farming system (100) according to any preceding claim, **characterized in** that the sealed elongated tubular structure (370) is provided with flow control means (375) in fluid communication with the interior volume or sub-volumes (390) of the sealed elongated tubular structure (370) and with the exterior of the sealed elongated tubular structure (370) enabling a controllable water flow into and out of the elongated tubular structure (370) or sub-volumes (390) thereof.
- 10 10. Offshore fish farming system (100) according to claim 1, **characterized in** that the cage structure (300) is provided with rigid or semi-rigid cage sides (330) limiting the sides thereof and dividing the interior of the cage structure (300) into the at least two sub-cages (300a).
11. Offshore fish farming system (100) according to any preceding claim, **characterized in** that each sub-cage (300a) is provided with a horizontally extending sliding bulkhead (380) arranged movable in the vertical direction of the sub-cage (300a).
- 15 12. Offshore fish farming system (100) according to claim 11, **characterized in** that the horizontally extending sliding bulkhead (380) is tilted or tiltable an angle in relation to the horizontal plane, inclined towards the at least one controllable opening (372) in the sealed elongated tubular structure (370).
- 20 13. Offshore fish farming system (100) according to any preceding claim, **characterized in** that the sealed elongated tubular structure (370) is provided with at least one controllable access pipeline or tube (376) at upper end thereof to allow access to the interior and/or sub-volumes (390) thereof for supply of smolt or fish or retrieval of fish ready for slaughtering.
- 25 14. Offshore fish farming system (100) according to claim 1, **characterized in** that the sealed elongated tubular structure (370) is formed by double walls.
15. Offshore fish farming system (100) according to any preceding claim, **characterized in** that the offshore fish farming system (100) is provided with means for feeding in the respective sub-cage (300a) and the sealed elongated tubular structure (370), also in submerged position in the water.

16. Offshore fish farming system (100) according to any preceding claim, **characterized in** that the sealed elongated tubular structure (370) is filled with seawater.