Title: A HYBRID STRUCTURE FOR CULTIVATING SALTWATER AND FRESHWATER HABITATS

Abstract: A hybrid structure for cultivating saltwater and freshwater habitats such as mussels having corrosion resistant and preferably fouling resistant elongated metal element(s) placed in a central strip portion and flanked on either sides in form of ribs are yarns to which the saltwater and freshwater habitats get attached to and mature before being harvested. The elongated metal element(s) may be copper based alloys which prevent the attachment of the saltwater and freshwater habitat to facilitate harvesting and increase life span of said hybrid structure.
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A hybrid structure for cultivating saltwater and freshwater habitats

Description

Technical Field
[0001] The present invention relates to a hybrid structure for cultivation of saltwater and freshwater habitats and more particularly to hybrid structures which can be suitable as seed capture installations and cultivation of shell fish such as mussels.

Background Art
[0002] Cultivation of shell fish such as mussels can be carried out on suspended ropes, a technique which aids in extending the cultivation offshore. This technique has an advantage of increasing the production of shell fish. The rope diameter ranges around 3-5 cm and is often made of synthetic material such as nylon or polyethylene. The rope has a length range of 6-10 m. The life span of these ropes is roughly 2 years which gets reduced if rope is exposed to a salt water environment. Furthermore the ropes can be suspended from rafts, or wooden frames, or buoys. Each raft can carry 50 to 1000 ropes. The average weight of ropes is roughly 50 kg. In addition, the ropes should also function as seed capture installations. Seed capture installations is a technique for growing and subsequently harvesting mussels from their seed. These installations make use of the lifecycle of the mussels. Mussels produce larvae in the spring. These larvae drift in the water for several weeks before latching onto a hard substrate. On the whole, the survival rate is much higher if the larvae can latch onto a substrate that hangs in the water rather than latching directly onto the seabed. After latching on, the mussel is known as brood and develops into seed, at a size that the mussel farming sector can use for bottom culture. Substrates such as ropes and nets are placed in the water in spring, at a time when large numbers of larvae are present in the water. Strength of these ropes is vital due to the risk of rough sea currents and fouling.
A problem often encountered is tendency of such rope installations to float away due to water currents and furthermore such installations pose a risk of being entangled and damaged due to the contact with an overhead vessel such as ship or boat. This leads to breakage and drifting away of part of installations leading to loss of the shellfish under cultivation. Yet another problem encountered is fouling, growth of such organic or inorganic matter forms a dense layer which creates problem during harvesting of the shell fish. Declumping of shell fish from the ropes becomes cumbersome due to fouling and lifespan of such ropes drastically decreases. Hence it is objective of present invention to address these drawbacks.

**Summary of Invention**

[0004] It is an object of at least certain embodiments of the present invention to devise a seed capture installation that is easier to install in a water environment such as sea, river or a lake and the hybrid structure is having a larger density (mass per volume) than the surrounding water body.

[0005] It is an object of at least certain embodiments of the present invention to devise a hybrid structure that is resistant to corrosion and fouling.

[0006] It is another object of at least certain embodiments of the present invention to devise a hybrid structure that is cut-resistant thus avoiding breakages in the seed installations and preventing cultivation losses by drifting away of the part of installation.

[0007] In one aspect, the present invention relates to a hybrid structure for cultivating saltwater and freshwater habitats comprising: (a) a longitudinal backbone member, wherein said longitudinal backbone member is extended over the length of the hybrid structure and wherein said longitudinal backbone member comprises corrosion resistant elongated metal element(s); and (b) a rib portion extended over at least a portion of the length of the longitudinal backbone member, the rib portion is comprising plurality of yarns, preferably filament yarns; and wherein said
rib portion is mechanically and/or chemically attached to the said longitudinal backbone member. In one preferred embodiment of the invention the mechanical attachment is achieved by weaving, knitting or braiding. Preferably, the corrosion resistant elongated metal element(s) are provided in the length direction of the backbone member. The yarns of the rib portion are extending outside the zone where the yarns of the rib portion are attached to the longitudinal backbone member.

[0008] In a specific embodiment, the plurality of yarns of the rib portion is comprising yarns with a linear density higher than 50 dtex, preferably between 50 dtex and 5500 dtex, more preferably between 500 and 3300 dtex. It is a benefit of such yarns that an optimum combination is obtained in productivity in producing the hybrid structure and the efficiency of growing mussels on it.

[0009] In one embodiment of the present invention the hybrid structure is a woven product selected from a group consisting of plain weave, twill weave or satin weave. In another embodiment of the present invention, the hybrid structure is a woven product having a leno weave. One of the benefits of use of a woven attachment of the rib portion to the backbone is that a firm attachment is achieved.

[0010] In another embodiment of the present invention, a warp knitting with weft inlay is provided. An additional set of warp yarns (e.g. multifilament yarns or monofilament yarns) are used to provide the attachment via the formation of stitches. In a specific embodiment, the elongated metal element(s) are provided in the warp knitting process as a standing warp and the plurality of yarns of the rib portion are provided as one or more weft inlays. An additional set of warp yarns (e.g. multifilament yarns or monofilament yarns) are used to provide the attachment via the formation of stitches in connecting (attaching) the elongated metal element(s) (standing warp) to the inlay weft. Preferably, the weft inlay is over part of the width of the backbone member and followed by an inlay in the other direction (in a next production cycle of the warp knitting machine); which is
beneficial as the bonding of the weft inlay into the backbone member is intensified thus creating a stronger bond and a higher resistance of the attachment of the rib portion to the backbone member against mechanical disturbances (e.g. against pull out of the yarn of the rib portion) compared to an inlay over the full width of the backbone member. A longer lifetime of the hybrid structure is thus obtained.

[0011] The advantage woven, knitted or braided product is that the central strip or longitudinal backbone member is kept intact and the monofilament members of this central strip do not get loosened from the yarns to which such the polymer monofilaments or elongated metal element(s) are engaged to. A firm attachment between the corrosion resistant elongated metal element(s) of the longitudinal backbone member and of the yarns of the rib portion is obtained, resulting in a good mechanical resistance of the hybrid structure. Such a grip is extremely useful in harsh weather conditions when water surface is severe and in addition the weight of shell fish attached to hybrid structure creates additional tension to the central strip member or longitudinal backbone member.

[0012] Another advantage of the central strip or longitudinal backbone member which represents to be a densely packaged structure as a result of when high stitch density (when warp knitting is used) or when high warp and weft density (when knitting is used) are used, is to hold the yarns intact so that during cultivation of the shell fish, increased weight stress resulting on the filament yarns does not lead to loosening of the filament yarns from the central strip or longitudinal backbone member.

[0013] In another aspect, the present invention relates to a seed capture installation comprising the hybrid structure of present invention attached to buoys spaced at regular intervals.

[0014] In one aspect, the present invention relates to a method of cultivating shell fish comprising the steps of: (i) suspending the hybrid structure of the present invention into installation area in a coiled form, wherein the hybrid
structure is in a circular coiled form; (ii) incubating the hybrid structure for seed capture process wherein seed of shell fish attach to the yarns of the rib portion to form a seed culture; (iii) opening and stretching the coiled hybrid structure in a linear manner and optionally suspending the hybrid structures from rafts, or frames or from long lines of floating buoys; (iv) rearing and harvesting the fully formed shell fish by separation from the hybrid structures. The advantage of such a process is that the farmers can avoid the thinning step wherein the half grown mussels are taken out of the water and rub off clusters of shell fish by hand and the mussels from original ropes are attached to new ropes. This thinning process is done to prevent mussels from falling off in rough weather. Such a labor-intensive process can be avoided by the method of the present invention.

**Brief description of Figures in the Drawings**

[0015] Fig. 1a and 1b illustrate one embodiment of the invention wherein the hybrid structure is a woven product.

[0016] Fig. 2a and 2b illustrate one embodiment of the invention wherein the hybrid structure is a knitted product.

**Definitions**

[0017] The term "elongated metal elements" are objects that have a high length to diameter (or equivalent diameter) ratio. Examples of elongated metal objects that can be used in the invention are elongated metal monofilaments, metal wires or cords (cords comprising metal monofilaments). In a preferred embodiment of the present invention, the shape of said elongated metal elements are selected from the group consisting of round, flat, square, rectangular, triangular, trapezoidal, oval, half-round and mixtures thereof.

[0018] The term "coated" or "coating" in the present invention refers to the context of covering on the elongated steel monofilaments and includes processes such as cladding, electroplating, painting, dipping and extrusion. The cladding process includes a process wherein the a strip of e.g. copper or
copper alloy is bent around said elongated metal monofilament and welded on said elongated metal monofilament.

[0019] The term "monofilaments" refer to filaments of elongated metal wires such as stainless steel alloys or any corrosion resistant metal wire such as copper, brass or stainless steel alloy wire further comprising a coating such as copper or copper based alloy. The term monofilaments may also refer to polymer monofilaments, usually of a denier higher than 14 and may be selected from a group consisting of polyester, polyvinyl chloride (PVC), polyethylene, polypropylene, poly(paraphenylene terephthalamide and nylon.

[0020] The term "woven" refers to a structure composed of two sets of yarns or filaments, warp and filling (or weft), that is formed by weaving, which is the interlacing of warp and weft. The term woven may also cover hybrid structures in which three or more sets of filaments are used to give a triaxial weave. The term woven also covers different types of weaves, plain, twill, satin and combinations thereof.

[0021] The term "knitted" refers to a structure made by interlocking series of loops of one or more yarns or filaments. The term knitted may include warp knitting and weft knitting. In one embodiment of the present invention, the structure is made of weft insertion warp knitting (WIWK) in which warp knitting stitches (loops) are made and in which a yarn or filament is inserted over at least part of the working width on the warp knitting machine. This inlay yarn is fastened between the over- and underlap of the loops (or stitches) formed in warp knitting.

[0022] The term "filament yarn" may refer to monofilament yarn or multifilament yarn for a continuous strand of polymer filaments in a form suitable for knitting, weaving or intertwining to form a textile fabric. Such a yarn may be characterized by dtex, denier or tex units. Multifilament yarn refers to a group of filaments being extruded through a spinneret to form a yarn, while monofilaments are spun individually. One example of multifilament yarn
could be polypropylene BCF (Bulk Continuous Filament) yarn. In one embodiment of the present invention, the rib portion of the hybrid structure comprises a plurality of multifilament yarns such as polymer multifilament yarns. Use of such a multifilament yarn in a hybrid structure of the present invention results in providing greater open surface area which will add efficiency during seed capture of saltwater or freshwater habitat such as a mussel seed.

[0023] When using knitting, the term "stitch density" refers to number of stitches per cm in the central strip or backbone member of the hybrid structure. In an embodiment of the present invention the stitch density ranges from 2 to 50 stitches/cm, preferably 5 to 25 stitches/cm, more preferably 5 to 15 stitches/cm.

**Detailed Description of the Invention**

[0024] Fig. 1a, 2a and 2b show a hybrid structure for cultivating saltwater and freshwater habitats comprising: (a) a longitudinal backbone member, wherein said longitudinal backbone member is extended over the length of the hybrid structure and wherein said longitudinal backbone member comprises corrosion resistant elongated metal element 10; and (b) a rib portion extended over at least a portion of the length of the of said backbone member comprising plurality of yarns; and wherein said rib portion is attached mechanically to the said longitudinal backbone member via weaving or knitted structure. Fig. 1a and 2a show the backbone member to include additional set of yarns in the longitudinal direction of backbone member such as polymer monofilaments which are similar in size to the elongated metal elements and are present in alternating manner.

[0025] In one embodiment of the present invention, the elongated metal element(s) is a copper alloy coated steel element and tensile strength of the steel is around 500-1 500 MPa. The tensile strength of a test specimen is the breaking load of the test specimen per unit of unstrained cross-
sectional area. The tensile strength is expressed in Newton per square millimeter (or MPa).

[0026] In yet a further embodiment the elongated metal monofilament is a steel wire of low carbon content below 0.20 wt%. In this embodiment the steel wire has preferably a carbon content ranging between 0.04 wt % and 0.20 wt %. The complete composition of the wire rod may be as follows: a carbon content of 0.06 wt %, a silicon content of 0.166 wt %, a chromium content of 0.042 wt %, a copper content of 0.173 wt %, a manganese content of 0.382 wt %, a molybdenum content of 0.013 wt %, a nitrogen content of 0.006 wt %, a nickel content of 0.077 wt %, a phosphorus content of 0.007 wt %, a sulfur content of 0.013 wt %.

[0027] In another embodiment the elongated metal monofilament is a steel wire of high carbon content above 0.25 wt% and lower than 1.0 wt%. The steel wire is highly mechanically deformed.

[0028] The polymer monofilaments are selected from a group consisting of polyester, polyvinyl chloride (PVC), polyethylene, polypropylene, polyparaphenylene terephthalamide and nylon.

[0029] In one embodiment of the present invention, the corrosion resistant metal monofilament is stainless steel alloy selected from a group consisting of 201, 202, 301, 302, 303, 303Se, 304; 304L, 309S, 310S, 306, 316L, 317, 317L, 321, 329, 330, 347, 409, 410, 416, 416Se, 420, 430, 440C, 442, 904L, 17-4 PH, 17-7PH, 2205, CA-6NM, CA-15, CA-40, CF-3, CF-3M, CF-8, CF-8M, CH-20, CK-20, HF, HH, HK. To enhance corrosion resistance, the metal wires may be coated with copper or copper alloys. The coating may involve dip, diffusion or cladding procedures. In one embodiment of the present invention, the cladding procedure involves a copper or copper alloy strip welded on or around said metal wires. The copper alloy may be copper nickel alloy comprising at least 80 percent by weight copper and between 5 percent by weight and 15 percent by weight nickel. A first benefit of copper is that it is resistant to corrosion and hence enhances the
lifetime of the elongated backbone member and hence of the hybrid structure. Another benefit of copper is that it is resistant to fouling. Hence less fouling will originate on the hybrid system, which means that harvesting the mussels is facilitated. In one embodiment of the present invention the metal wires may be coated with Zinc or Zinc alloys such as Zinc-Aluminum alloys.

[0030] In one preferred embodiment of the present invention the term filament yarn refers to multifilament yarn comprising at least 5, preferably at least 10, more preferably at least 25 filaments having a linear density of 900 dtex. Such multifilament yarn may be produced using air-jet technique.

[0031] In one preferred embodiment of the present invention the polymer multifilament yarns are of high tenacity, for instance a polyester of 1100 dtex.

[0032] In another preferred embodiment of the invention, the plurality of yarns of the rib portion is voluminous. It is meant that the yarns have a large surface area, e.g. because fiber loops or loose fiber ends are extending out of the surface of the yarn. Examples are spun yarns that intrinsically have hairiness and texturized multifilament yarns (e.g. BCF-yarns or air-jet textured yarns). The advantage of such yarns is that such products have a more voluminous surface texture which enhances seed capture of the salt and fresh water habitat and thus enhances anchorage and increases production.

Mode(s) for Carrying Out the Invention

[0033] Fig. 1a illustrates an embodiment of the present invention wherein elongated metal element(s) 10 (for instance a copper alloy cladded steel monofilament) and polymer monofilaments 12 are provided as warp yarns as part of the elongated backbone member. In a weaving process the warp yarns (the elongated metal element(s) 10 and the polymer monofilaments 12 are interlaced with weft yarns 14 which are filament yarns. The filament yarns 14 are forming the rib portion of the hybrid
structure. The weft yarns 14 extend outside the zone provided with warp yarns (and hence extend outside the zone where the interlacing is done). The weft yarns can e.g. be inserted on a shuttle or needle loom, resulting in loop ends at the outside of the rib portion. Via cutting the loops or via use of other weaving looms as are known in the art, cut ends can be obtained at the edges of the rib portion.

[0034] Fig. 1b show that 10 and 12 are positioned close to each other in an alternating manner to form the central strip or longitudinal backbone member which in turn are engaged with the filament yarns 14 in weaving to form a woven fabric.

[0035] Fig. 2a and 2b illustrates a different embodiment of the present invention. The hybrid structure comprises filament yarns 14, elongated metal elements 10 and optionally polymer monofilaments 12 which are connected via warp knitting stitches.

[0036] In Fig. 2b illustrates an embodiment of the present invention wherein elongated metal element(s) 10 for instance a copper alloy cladded steel monofilament. Fig. 2b represents warp knitting with weft inlay over part of the width length of the longitudinal backbone member and weft is filament yarn 14. In a first cycle of knitting process, the weft filament yarn 14 is inserted up to a certain position (for instance middle portion) of the longitudinal backbone member. In a next cycle of the process, the weft filament yarn 14 is laid in a direction opposite to the direction it was laid in the first cycle of process. As each of the inlays of the same filament yarns 14 are in different directions, and both said filament yarns are locked into the stitches formed by the one or more stitch forming warp elements, a very stable interlocking of the weft inlay is obtained which restricts movement of the filament yarns in transverse direction.
Claims

1. A hybrid structure for cultivating saltwater and freshwater habitats comprising:
   (a) a longitudinal backbone member, wherein said longitudinal backbone member is extended over the length of the hybrid structure and wherein said longitudinal backbone member comprises corrosion resistant elongated metal element(s); and
   (b) a rib portion extended over at least a portion of the length of the longitudinal backbone member, said rib portion comprises plurality of yarns; and wherein said rib portion is attached mechanically and/or chemically to the said longitudinal backbone member.

2. The hybrid structure of claim 1, wherein said rib portion is attached mechanically to said longitudinal backbone member and said mechanical attachment is achieved via weaving, knitting or braiding.

3. The hybrid structure of claims 1 or 2, wherein said metal element(s) comprise a stainless steel core coated with a metal or metal alloy coating.

4. The hybrid structure of claim 3, wherein said coating is in the form of a metal strip fixed around said steel core.

5. The hybrid structure of any one of the claims 3 or 4, wherein said coating is copper or copper based alloy.

6. The hybrid structure of claim 5, wherein said coating is copper based alloy and said copper based alloy is copper nickel alloy comprising at least 80 percent by weight copper and between 5 percent by weight and 15 percent by weight nickel.

7. The hybrid structure of any one of the claims 1 to 6, wherein elongated metal monofilament is having a round cross section and said round cross section is having a diameter between 0.2 mm and 2 mm, preferably between 0.5 mm and 1 mm.
8. The hybrid structure of any one of the claims 1 to 7, wherein said longitudinal backbone member further comprises an additional set of yarns in the longitudinal direction of said backbone member.

9. The hybrid structure of claim 8, wherein said additional set of yarns are polymer monofilaments and wherein said polymer monofilaments are selected from a group consisting of polyester, polyvinyl chloride (PVC), polyethylene, polypropylene, polyparaphenylene terephthalamide and nylon.

10. The hybrid structure of any one of the claims 1 to 8, wherein said plurality of yarns comprised in the rib portion are made from fibers selected from a group consisting of polyester, polyvinyl chloride (PVC), polyethylene, polypropylene, polyparaphenylene terephthalamide and nylon fibers.

11. The hybrid structure of any one of the claims 1 to 10, wherein said rib portion is attached to the said longitudinal backbone member in form of a woven product and said woven product comprises a warp and a weft structure wherein the said longitudinal backbone member is in form of a warp and wherein said plurality of yarns of the rib portion are in the form of weft.

12. The hybrid structure of any one of the claims 1 to 10, wherein said rib portion is attached to the said longitudinal backbone member in the form of a warp knitted product, wherein said longitudinal backbone member is in the form of a warp and wherein said plurality of yarns of the rib portion are inserted as weft inlay during warp knitting.

13. The hybrid structure of any one of the claims 1 to 12, wherein the shape of the cross section of said elongated metal element(s) are selected from the group consisting of round, flat, square, rectangular, triangular, trapezoidal, oval, half-round and mixtures thereof.

14. A seed capture installation comprising the hybrid structure of any one of the claims 1 to 13 attached to buoys spaced at regular intervals.
15. A method of cultivating shell fish comprising the steps of:

(i) suspending the hybrid structure according to any one claims 1 to 14 in to installation area in a coiled form, wherein the hybrid structure is in a circular coiled form;

(ii) incubating the hybrid structure for seed capture process wherein seed of shell fish attach to the plurality of yarn ends to form a seed culture;

(iii) opening and stretching the coiled hybrid structure in a linear manner and optionally suspending the hybrid structures from rafts, or frames or from long lines of floating buoys;

(iv) rearing and harvesting the fully formed shell fish by separation from the hybrid structure.
**INTERNATIONAL SEARCH REPORT**

**A. CLASSIFICATION OF SUBJECT MATTER**

**INV. A01K61/00**

According to International Patent Classification (IPC) or both national classification and IPC

**ADD.**

**B. FIELDS SEARCHED**

Minimum documentation searched (classification system followed by classification symbols)

A01K

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

**C. DOCUMENTS CONSIDERED TO BE RELEVANT**

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