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(54) **Title:** NET FOR AQUACULTURE

(57) **Abstract:** A net for the purpose of aquaculture, said net comprising yarns joined at intervals to form net meshes, the yarns comprising at least one type of synthetic fiber, twisted around a core containing one or more glass fibers. The net shows improved bite resistance against predators and biting fish that are farmed in the net.

## NET FOR AQUACULTURE

The present invention relates to a net for aquaculture, said net comprising yarns joined at intervals to form net meshes.

5                   Aquaculture may be generally defined as the demand for favorable conditions for the growth of aquatic animals. The industry of aquaculture is also known as fish farming. Typical aquaculture systems utilizes nets suspended in water by flotation devices, such nets being used to prevent attacks on the farmed aquatic animals by aquatic predators and also to keep the farmed aquatic animals from  
10                   escaping. Serious losses are caused in such aquaculture systems by aquatic predators that easily penetrate the nets and feed upon the farmed aquatic animals. A further serious problem is that farmed fish escape from the nets in large quantities, if the nets are damaged by predators or by the farmed fish itself. Especially in case of genetically modified salmon this constitutes a serious problem.

15                   To alleviate the above – mentioned problems, many aquaculture systems utilize an auxiliary net that surrounds and is spaced from the fish retaining primary net. Heavy duty metallic meshes and shark meshes are usually employed in building the auxiliary nets. However, the metallic meshes are heavy and difficult to handle and tend to corrode in the sea water when the mesh is submerged for a long  
20                   period of time. A further drawback is that such metallic meshes encourage the growth of weed and the adhesion of marine organisms and must be regularly cleaned and maintained by a trained diver.

                    In an attempt to overcome such problems, WO 00/74476 discloses a marine netting comprising a network of grid elements, the network comprising an array  
25                   of core elements being coated with polyurethane, the core elements being polyester strands that may further comprise Vectran or Kevlar fibers. However, the polyester strands present a low breaking strength and furthermore fish may pull out strands from the polyester netting, making such net less suitable for fish farming.

                    In "*Fish Farming International*" – November 2005, pg.34 is described  
30                   a netting made of a very strong ultra high molecular weight polyethylene (UHMWPE) fiber – Dyneema® (manufactured by DSM Dyneema, Heerlen, the Netherlands. Such a netting prevents fish from biting holes in the net, and therefore prevents big losses for the farms. However, the "bite resistance" of such nets can still be improved especially to prevent attacks of large aquatic predators such as sharks and the like.

35                   A further drawback of the currently used nets constructed exclusively

from synthetic fibers is that the current nets are easily deformable by the water currents reducing therefore the water volume available for the farmed aquatic animals.

It is therefore an object of the present invention to provide a net for the purpose of aquaculture, said net having an improved resistance to deformability as well as an increased "bite resistance".

Surprisingly, the aim is achieved according to the invention in that a net is provided the net comprising yarns joined at intervals to form net meshes, the yarns comprising at least one type of synthetic fiber, twisted around a core containing one or more glass fibers.

Surprisingly, it has been found that the net according to the invention has improved strength and rigidity combined with an excellent resistance to nibbling, gnawing or biting by the aquatic animals, even though the glass fiber is in the core and is covered by the less resistant synthetic yarn with lower hardness.

Due to the improved strength and the presence of inorganic fibers, the net according to the invention presents less damage when subjected to nibbling by the farmed aquatic animals, or when subjected to nibbling, gnawing or biting by the aquatic predators. As a result, said net virtually eliminates losses, no farmed aquatic animal being able to escape from the confined water body, hence providing important financial benefits.

Due to the improved rigidity, especially due to the improved bending rigidity, the net according to the invention prevents external aquatic predators to harm the farmed aquatic animals by biting them through the net. The net also shows an improved planar rigidity resisting to horizontal deformation in response to aquatic predator impact and strong water currents. The improved planar rigidity prevents severe net deformations and crowding of the farmed aquatic animals, reducing the stress to which the aquatic animals are subjected and consequently promoting feeding and growth.

Furthermore the weight of the nets is maintained at a relatively low level.

A smooth production process of the net is possible, and also a net with excellent handling properties is obtained.

Yet a further important advantage is that fish is less damaged by the net if it comes in contact with the net, compared to known nets having special measures to improve the bite resistance of the net.

In the Gebrauchsmusterschrift DE 20 2005 003 291 U1 2006.08.17 a

net is disclosed containing a cord or rope having a core of synthetic fibers or natural fibers, surrounded by a cover of basalt or glass fibers, having a SiO<sub>2</sub> content of at least 50 wt. %. Because of the presence of the basalt or glass fibers in the cover of the net cords or ropes, the net has favorable anti-fouling properties.

5                   The net disclosed in DE 20 2005 003 291 U1 does not contain a yarn, having at least one glass fiber in the core, the core being wrapped with at least one type of synthetic yarn. Furthermore there is no indication that the net with the improved bite-resistance and yet favourable further properties is obtained.

                  The synthetic fibers used in the net according to the invention may be  
10 made from a wide variety of polymers used in the formation the synthetic fibers which may be spun by using conventional spinning techniques as for example those described in U.S. Patent Nos. 2,967,085; 2,716,586; 2,558,730; 3,147,355; 3,047,356; 3,536,219; 3,048,465; British Patent Nos. 985,729 and 1,100,497; and in the article by M. E. Epstein and A.J. Rosenthal, Textile res. J. 36, 813 (1966). Examples of polymers  
15 used for the production of synthetic fibers that may be used in the net of the present invention include nylon, polyester, polypropylene, ultrahigh molecular weight polyethylene (UHMwPE), poyvinylalcohol, polyacrylonitril and the like.

                  In a preferred embodiment, the synthetic fibers used to construct the net according to the invention are polyolefin fibers. In the most preferred embodiment,  
20 the fibers are UHMwPE fibers. In that case a strong net, also showing excellent bite resistance is obtained. Furthermore, said net is lightweight and therefore easy to install and handle no bigger lifting equipment or larger workboats being needed, even while the yarn of the net contains at least one glass fiber. Because of its improved mechanical properties said net needs much lees maintenance, and most important said  
25 net eliminates the use of the double – net system in cages.

                  The UHMWPE fibers are preferably manufactured according to a gel spinning process as described in numerous publications, including EP 0205960 A, EP 0213208 A1, US 4413110, GB 2042414 A, EP 0200547 B1, EP 0472114 B1, WO 01/73173 A1, and Advanced Fiber Spinning Technology, Ed. T. Nakajima, Woodhead  
30 Publ. Ltd (1994), ISBN 1-855-73182-7, and references cited therein.

                  Preferably the UHMWPE has an intrinsic viscosity (IV) of at least 5 dl/g. IV was determined according to method PTC-179 (Hercules Inc. Rev. Apr. 29, 1982) at a temperature of 135°C and using decalin as a solvent for UHMWPE, with a dissolution time of 16 hours, with an anti-oxidant DBPC in an amount of 2 g/l solution,  
35 and extrapolating the viscosities at different concentrations to zero concentration.

Particularly suitable, is UHMWPE with an IV of preferably between 8 and 40 dl/g, more preferably between 10 and 30 dl/g, even more preferably between 12 and 28 dl/g.

The UHMWPE can be a single polymer grade, but also a mixture of at least two different UHMWPE grades. By UHMWPE grade is understood UHMWPE with  
5 a specific IV or molar weight distribution, and a specific number of side chains, said side chains having a specific configuration.

Preferably, the tensile strength of UHMWPE fiber is at least 1.5 GPa, more preferably at least 2.5 GPa. Tensile strength, is determined on multi-fiber UHMWPE yarns as specified in ASTM D885M, using a nominal gauge length of the  
10 fibre of 500 mm, a crosshead speed of 50%/min and Instron 2714 clamps, type Fiber Grip D5618C.

Preferably the stiffness of UHMWPE fiber is at least 35 GPa, more preferably at least 50 GPa. Preferably the weight per unit length of the UHMwPE fiber is between 800 and 2400 denier, more preferably between 1200 and 1800 denier.

15 The glass fiber may consist of one or more glass filaments. Preferably the glass fiber is a multi-filament glass fiber. Preferably the weight per unit length of the glass fiber is between 800 and 1500 denier, more preferably between 900 and 1200 denier.

The yarn used in the net according to the invention may have a  
20 weight per unit length of up to 8000 denier, preferably up to 6000 denier, more preferably up to 4000 denier.

The yarn may contain more than 50 weight % of the synthetic fiber, preferably more than 50 weight % of the UHMwPE fiber. In that case a further improved net showing a very high strength and yet very good bite resistance is  
25 obtained.

Most preferably the yarn contains more than 75 weight % of the UHMwPE fiber.

The yarn may produced by winding one or more synthetic fibers around a core of one or more glass fibers by using conventional equipment well-known  
30 by the skilled person.

The net according to the invention is preferably a knotless net. Such knotless net has many advantages over traditional knotted net such as a decreased weight for the same area and therefore easiness to handling and lower production costs because of saving of material. Surprisingly it was also found that said knotless  
35 net when used in fish farming presents a higher breaking strength than the usual

commercial net. However, the most important advantage is the improved abrasion resistance because of the net's smoother surface, hence the eventual injuries that may be inflicted by the net to the fish due to abrasion are strongly reduced.

The mesh type of the net according to the invention may be square, 5 hexagonal, diamond and the like. Preferably, the mesh type is square, such a mesh construction giving the maximum water flow through the net and furthermore because of its continuous straight line of meshes the square mesh has extra strength.

The mesh size of the net according to the invention is preferably 10 chosen such to maximize the water movement past the fish in order to provide a good oxygenation, which is essential to growth and survival.

Optionally, the yarns comprising the net may coated with lubricant 15 coatings applied thereon, to further reduce abrasion and inner friction, to increase the life time of the net, to prevent bio-fouling growth on the net, which can reduce the water flow to the fish and increase drag on the net.

Equipment and processes for producing nets are well-known to the 15 person skilled in the art.

#### Example I

A yarn was produced by winding with standard equipment two 20 multifilament fiber of UHMwPE of each 1600 denier around a multifilament glass fiber having a weight per unit of length of 900 denier. As the UHMwPE fiber Dyneema™ SK 75 of DSM Dyneema in the Netherlands was used.

A knotless net was produced from the yarn in a 4-ply, ultra-cross 25 construction, having a width of 4 meters and a length of 10 meters.

The mesh width of the net was 42 mm. The mesh strength as 30 determined according to ISO 1806 was 180 kg.

The production of the yarn as well the production of the net was 35 carried out under normal production conditions for full UHMwPE yarns. A smooth production process was obtained.

#### Comparative example A

A yarn was produced by twisting two Dyneema™ SK 75 fibers of 1600 denier. A knotless net was produced from the yarn in an 8-ply ultra-cross 35 construction, having a mesh width of 50 mm.

The mesh strength as determined according to ISO 1806 was 172 kg.

Comparative example B

A yarn was produced by twisting two Dyneema™ SK 75 fibers of 1600 denier and a multifilament glass fiber of 900 denier.

5 It was not possible to produce a net from the yarn under the same conditions as in example I, since the yarn was damaged during the production process.

CLAIMS

1. A net for the purpose of aquaculture, said net comprising yarns joined at intervals to form net meshes, the yarns comprising at least one type of synthetic fiber, twisted around a core containing one or more glass fibers.
- 5 2. A net according to claim 1 wherein the synthetic fiber is ultrahigh molecular weight polyethylene (UHMWPE) fibers.
3. A net according to claim 2, wherein the stiffness of UHMWPE fiber is at least 35 GPa.
- 10 4. A net according to claim 2 or 3, wherein the yarns have a weight per unit of length of at most 8000 deniers.
5. A net according to any one of claims 2 – 4, wherein the weight per unit length of the UHMwPE fiber is between 800 and 2400 denier.
6. A net according to any-one of claims 2 – 5, wherein the glass fiber is a multi-
- 15 filament glass fiber.
7. A net according to any one of claims 2 – 6, wherein the glass fiber has a weight per unit of length of between 800 and 1500 denier.
8. A net according to any one of claims 1 – 7, wherein the yarn contains more than 50 weight % of UHMwPE fibers.
- 20 9. A net according to claim 8, wherein the yarn contains more than 75 weight % of UHMwPE fibers.
10. A net according to any one of claims 1-9, wherein the net is a knotless net.



**INTERNATIONAL SEARCH REPORT**

International application No  
**PCT/EP2010/053552**

**A. CLASSIFICATION OF SUBJECT MATTER**  
INV. D02G3/18 A01K75/00  
ADD.

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

**B. FIELDS SEARCHED**

Minimum documentation searched (classification system followed by classification symbols)  
**A01K D02G D01F**

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

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

**EPO-Internal, WPI Data**

**C. DOCUMENTS CONSIDERED TO BE RELEVANT**

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	JP 2004 308047 A (YOTSUAMI KK) 4 November 2004 (2004-11-04)	1,2,6
Y	paragraphs [0006] - [0013], [0044] - [0046] * abstract	3-5,8
X	JP 2003 064541 A (TOYO BOSEKI) 5 March 2003 (2003-03-05) paragraphs [0006] - [0009], [0012], [0013] * abstract	1,6
X	US 2 949 807 A (GUNTHER HERZOG AUGUST ET AL) 23 August 1960 (1960-08-23) column 2, line 21 - column 3, line 27 figures 1-3	1,6
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Further documents are listed in the continuation of Box C.

See patent family annex.

\* Special categories of cited documents :

- "A" document defining the general state of the art which is not considered to be of particular relevance
- "E" earlier document but published on or after the international filing date
- "L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
- "O" document referring to an oral disclosure, use, exhibition or other means
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- "Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.
- "&" document member of the same patent family

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INTERNATIONAL SEARCH REPORT

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C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 2002/127398 A1 (ANDREWS MARK A [US] ET AL) 12 September 2002 (2002-09-12) page 2, paragraph 19-21 page 3, paragraph 35-40 page 4, paragraph 45-47	3-5,8

# INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

PCT/EP2010/053552

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US 2949807	A	23-08-1960	NONE	
US 2002127398	A1	12-09-2002	NONE	