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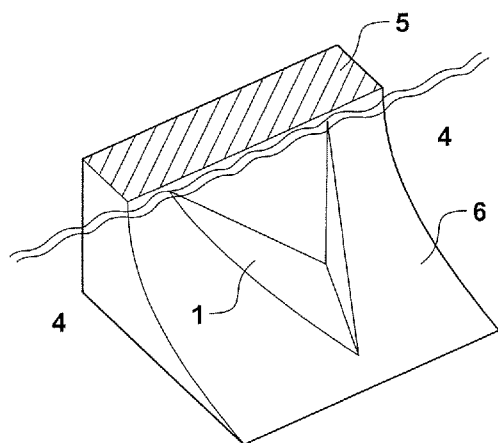
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(54) Title: ARTIFICIAL REEF AND METHOD OF ASSEMBLY

**Figure 3**

(57) **Abstract:** An artificial reef (1) comprises a body formed having a base layer (10) joined and sealed to a surface layer (11) forming at least one sealed compartment there between for receipt of air or a pourable material there between to form a volumetric shaped artificial reef (1) for location on a seabed or lakebed. The body provides an external surface to cause the waves to be altered in a way suitable for surfing and/or protection of a coastline. The artificial reef (1) also includes at least one inlet and outlet valve to allow air or any pourable material to be filled or discharged therefrom the sealed compartment. The artificial reef (1) is constructed to allow it to be built on a dry surface and be floated out to a precise position whereby when in position on the substrate such as a seabed, wherein the dimensions of the artificial reef (1) comprises a broad base with horizontal planar dimensions being at least 8 m to prevent toppling over by waves and sinkage into a sandy seabed or lakebed under wave and current action.





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ARTIFICIAL REEF and METHOD of ASSEMBLY

The present invention relates to a permanent and portable artificial reef for use by surfers or
5 to a reef to protect the coastline and to a method of assembly. The invention is directed particularly but not solely towards an artificial surfing reef comprising a volumetric sealed shape formed of sheets with a pourable material therein thereby allowing the sealed artificial reef to be built and floated out to a precise location.

10 **Background of Invention**

In this specification unless the contrary is expressly stated, where a document, act or item of knowledge is referred to or discussed, this reference or discussion is not an admission that the document, act or item of knowledge or any combination thereof was at the priority date, publicly available, known to the public, part of common general knowledge; or known to be
15 relevant to an attempt to solve any problem with which this specification is concerned.

Typically a reef can include the following juxtaposed structural elements. Firstly a coast line leads to a lagoon zone or reef flat zone, which then leads in turn to the reef. The reef in cross section includes from the reef flat zone leading to a back reef, a reef crest buttress zone and
20 finally a deep fore reef.

Various artificial surfing reefs have been created and designed by computer models and tested in the ocean. However, the problem of converting these computer designs into accurate structures on the seabed has not been solved. Many of these reefs have been made
25 from large and small geo-bags with sand inside or soft material containers because the “soft” material is considered safer for surfing than rocks or other hard materials. Large geo-bags are custom made from geotextile and filled in situ with sand to pump them up. A typical large geo-bag is 18-60 m long and some 4 m in diameter. As seen in figure 1 there shown a typical surfing reef which is 130m long and 135m at the base. The highest elevation is 4 m
30 above the seabed. On a natural seabed the reef shape is shown in figure 2. Figure 2 shows a typical surfing reef when placed on natural seabed contours. It creates an elongated shaped pointing out to sea in deep water ie blue ‘m’. The light green colour ‘l’ on the far left is the

beach. The key on the right of each figures 1 and 2 represent the depth or elevation in meters. For figure 1 the elevation starts from 3.5 in the top of the key for figure 1 down the page to 0 m. In figure 2 the key starts from the top at 1m and decreases down the page to -5m. In figure 1 the elevations are mostly shallow elevation about 0m surrounding a reef (max height of 3.5-4 m) located in the middle of the figure 1 with greater elevations recorded in graduation around the reef (ie 0-3.5m), while for figure 2 the elevations are around 1- -1 m on the left in a protruding portion pointing to the right and leading to -5 to the right of the protruding portion.

Small geo-bags are not suitable on the crest of the reef due to their instability under heavy wave attack. The waves actually break on the reef. Problems encountered include migration of the sand within the geo-bag, which leads to flapping of the front and sometimes destruction of the geo-bag. In addition, the geo-bags create steps in the surface of the reef which are not suitable for even wave breaking that is required and ideal for surfing.

Moreover, filling accuracy using dredge pipe equipment is difficult to achieve and so the crest elevation may undesirably vary along the reef, which leads to further errors in construction. If the reef crest is too high, the waves will surge. If the reef crest is too low, the waves may not break at all.

A typical reef may have a volume exceeding 10,000 m³, which means that numerous geo-bags must be filled. Filling numerous geo-bags in situ is difficult, as the reef is placed in a zone with waves that make the operational aspects difficult to achieve using divers who must handle large dredge pipes. The dredge pipe is inserted into a geotextile nozzle known as an elephant trunk. The manipulation of the equipment is time consuming, costly and geo-bags can be under-filled. At completion, the elephant trunks must be tied up and secured with a cover. Problems have been encountered whereby the covers of the elephant trunks are torn off the relatively flimsy geotextile under large waves and the geo-bag then empties under wave action. Large elongation factors for geotextile make geo-bag height accuracy hard to achieve. After time, the geo-bags are known to “pancake”, whereby the height reduces and the bags widens as the geotextile stretches which causes the required elevation of the reef to be lost. Finally, the geo-tech bag material has been known to break at the seams, or simply

fray. Furthermore the geo-bags may be punctured by boat anchors, fishing knives, boat propellers etc. and so the durability of the reef is not guaranteed.

Others have tried filling the geo-bags using a split-hull hopper barge vessel to overcome the need for divers and underwater operations. The geo-bags are filled on the vessel, which then drives over the selected reef site. The boat splits and the bags fall down to the seabed. This method has been successfully adopted for deep reefs in zones with large tidal ranges. However, shallow reefs cannot be built in this way because the draught of the barge is too deep.

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Rocks instead of sand, are not suitable because they are dangerous to handle and can present a hazard to surfers. Large diameter rocks are needed for stability which makes the reef surface very irregular, dangerous and unsuitable for surfing.

There is disclosed a means to attach the geo-bags to a large web of straps, sewn together to provide connection points for the geo-bags, known as the RAD (Rapid Accurate Deployment) method. The geo-bags were tied to a large web on an open space on land, craned onto a barge and deployed at sea onto a series of anchors. However, the geo-bags still needed to be filled in situ. If large waves arrived before the geo-bags were filled, they can easily tear away from the large web. And the same filling and sealing problems are still encountered.

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Another problem has been the unwanted settling of the geo-bags into a sandy seabed. A large geo-mat is often deployed under the geo-bags to reduce sinkage, but the geo-mat is difficult to deploy. In addition, any gaps between the geo-bags create wave-induced vortices that can remove sand and exacerbate the geo-bag sinkage. The sinkage means that an extra layer of geo-bags on top may be needed, which greatly increases the cost of construction. And with more geo-bags on top, the reef may sink further. The reef accuracy in terms of shape and position, is then difficult to forecast.

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However any such constructed reef must still be safe for surfing and so concrete structures are not favoured due to difficulties with the size and weight of the resulting reef structure, gaps between components and sharp edges. The costs of these types of reefs can also be very large. Inter-locking concrete blocks have been widely adopted for breakwaters (not

surfing reefs), but there has been relative movement with respect to each other with many blocks dislodged by waves, or moved sideways leaving large dangerous and sharp gaps between the blocks.

- 5 Another example of a constructed reef is whereby a series of posts are driven into the seabed and a platform is then attached to the top of the posts to form a suitable sloping surface for wave breaking. To our knowledge, this invention has not been built yet to full scale in reality because the costs are large and the structure stability, especially the platform, has not been proven.

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What is needed is a surfing reef that is easy to deploy, with an accurate surface elevation, with no steps in the surface, stable and sufficiently large with a broad base to reduce settling/sinkage. The reef should be easy to deploy and stable on the seabed. An improved reef will allow most of the manufacturing and construction to occur on land, thereby greatly
15 reducing the costly problems associated with using divers and vessels at sea in a surf zone. This also increases the accuracy of the reef shape and quality of the workmanship.

When built an improved reef can be towed to the site. A smaller reef may be built on the beach inshore of the reef site and then simply towed by a vessel or winches offshore to its
20 preferred position. Such a reef could be used for a short period, flushed of sand and brought back to shore (e.g. for surfing contests).

Thus, an improved reef will be removable and able to be re-deployed at another location, if required, or if the environmental impacts on the beach dynamics are found to be
25 unacceptable by the public.

By using easy connector systems already built into the reef surface, divers should be able to efficiently move the dredge pipe to other inlets so that the reef is evenly and fully filled with sand. These openings should be designed to be much stronger and more easily sealed than
30 those presently adopted in geo-bags.

Methods adopted so far have not simultaneously provided all of these features. A better reef design and a simpler construction method is needed. More accurate and durable materials,

other than the difficult materials like geo-bags, need to be used. The construction materials need to be strong, yet suitable for making complex shapes.

So far, no-one has tried to build a large reef using modern and durable flexible material, such as for example High Density Polyethelyne (HDPE). This invention provides the means to utilise these materials. The invention also eliminates the many hindrances that are currently preventing the successful construction of high quality surfing reefs. While the patent is focussed on surfing reefs, the same methods could be adopted for many coastal protection structures.

Object of the Invention

It is an object of the invention to provide artificial reef for surfing and/or coastal protection and a method of assembly that ameliorates some of the disadvantages and limitations of the known art or at least provide the public with a useful choice.

Summary of Invention

Accordingly in one aspect the invention consists of an artificial reef 1 comprising a base layer 10 and a surface layer 11 wherein the base layer 10 is joined and sealed to the surface layer 11 forming at least one sealed compartment there between for receipt of air or a pourable material there between to form a volumetric shaped reef for location on a substrate (eg seabed or lakebed) and providing an external surface to cause the waves to be altered or break in a way suitable for surfing and/or protection of a coastline, the artificial reef 1 also includes at least one inlet and outlet valve to allow air or any pourable material to be filled or discharged therefrom the sealed compartment wherein artificial reef 1 is constructed to allow it to be built on a dry surface or land and be floated out to a precise position whereby when in position on the seabed whereby the artificial reef 1 comprises a broad base with horizontal planar dimensions being at least 8 m to prevent toppling over by waves and sinkage into a sandy seabed or lakebed under wave and current action.

Preferably the dimensions of the artificial reef 1 will exceed 15 m in at least one horizontal planar dimension and a base surface area exceeding 100 m^2 and a ratio of (volume):(base surface area) not exceeding 3 to prevent toppling over by waves and sinkage into a sandy

seabed under wave and current action, wherein the volume to base area ratio not exceeding of 4.

Preferably the pourable material is a formed as a granular or powdery material such as sand,
5 rock and/or fluid such as a liquid.

Preferably the base layer 10 and surface layer 11 comprise a waterproof planar material.

Preferably, the base layer 10 and the surface layer 11 comprise a flexible and resilient
10 material such as plastics, material, rubber or cloth.

Alternatively the base layer 10 and surface layer 11 is formed of a stiff material such as metal like for example steel or aluminium.

15 Preferably, the plastics material is PVC, water proof cloth or fabric or High Density Polyethelyne (HDPE).

Preferably, the reef will be a single element but a large reef may be made in smaller segments which are towed to the site individually and placed adjacent to or joined to the
20 other segments at the seabed.

Preferably at least a portion of an external or top surface will have minimal sharp or dangerous protuberances or shape edges that may be a hazard for surfing or at least a portion of the top surface of the reef is rippled, corrugated or irregular in some way to induce more
25 frictional resistance and thereby minimise the intensity of wave-induced currents passing over the reef.

Preferably, at least one support member 12 is located between the base layer 10 and support layer 11 inside the sealed compartment and functions to temporarily support an initial shape
30 of the artificial reef 1 and open up an air filled interior void to allow access for the pourable material therein.

Preferably, at least one resilient elongate member 13 is connected by a resilient elongate member connection assembly, to the base layer 10 and to the surface layer 11, and functions to resist any upward forces from the sand on the surface layer 11 wherein the resilient elongate member is a strap member having looped ends.

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Preferably, the sand and strap members are shaped and designed to keep the reef shape.

Preferably, the reef (shape, volume) is designed using computer software to obtain a shape which provides quality surfing.

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Preferably, computer software is used determine the correct length of the posts and straps which give the reef the designed shape.

Preferably, the support member 12 is formed of a stiff or rigid material such as metal or plastics member having a length between ends wherein at least one end includes a looped end shaped to be connected with a connector support assembly to at least the base layer 10.

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Preferably, the resilient elongate member connection assembly is a strap connector assembly is for connecting an end of each strap member to the base layer 10 and surface layer 11, the strap connector assembly includes two circular plates 36 and bolts 37 wherein the two plates 36 clamp a portion of the surface layer 11.

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Alternatively, the resilient elongate member connection assembly is a strap connector assembly for connecting one strap member to the base layer 10 and surface layer 11 which includes one plate member 45 and a handle member 50 forming a gap 50a there between the handle member 50 and plate member 45 whereby the plate member is welded to an inner surface of the surface layer 11 and base layer 10 and one looped end of the strap member 13 is connected to the handle member 50.

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Preferably the support member 12 includes post members formed as a tripod frame 33 comprising three post members with one end together connecting all three member at one position to the surface layer and the other end of the tripod having the three members splayed apart.

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Alternatively the support member 12 is a lattice frame 33a.

Preferably a post connector assembly 35 connects one end of a post member to the base layer and surface layer, wherein each post connector assembly comprises two plate members 36 and bolts 37 whereby the plate members 36 are joined or connected to the upper portion of the tripod frame 33 which in use clamp a portion of the surface layer 11 whereby one plate member 36 is connected to an upper portion of the support member 12 and the other plate member 36 is a separate member adapted to abut the outer surface 23 of the surface layer 11 which are then clamped by at least one bolt 37 through the plate members 36 and the thickness 24 of surface layer 11 there between.

Preferably, the surface layer 11 and base layer 10 are each formed from several strip sheets which are joined/sealed using electronic means.

Preferably, the surface layer 11 and base layer 10 are joined at their edges with elongate strip members which clamp an edge portion of the HDPE by bolting through the HDPE and elongate strip member to form the sealed compartment which is able to allow air water or sand therein when filling without leakage.

Preferably the sealed compartment which creates a water-tight, air-filled cavity with sufficient buoyancy to allow the structure to float and be controlled by a series of valves which exchange air in the cavity with a pourable material to control the sinking of the object to a precise location on the seabed for deployment.

Preferably the artificial reef 1 includes an inlet and outlet connection assembly which comprises two plate members 51, seal cap and bolts, whereby the plate members 51 are bolted together, to sandwich a portion of the surface layer 11 there between the two plate members, and the plate members 51 have a central hole 54 with a threaded portion which is co-linear and fluidly connected with an aperture 25 in the surface layer 11, to allow the threading engagement of the dredge pipes and fluid travel there through, and the seal caps 53 can be used to seal the central hole 54.

Preferably, the surface layer 11 includes at least one inlet and outlet aperture 25 for a dredge pump having main dredge pipes fluidly connected to a splitter pipe member which is then fluidly connected to several flexible dredge pipes which are then connected to an inlet and outlet connection assembly which is fluidly connected to aperture 25 through the surface layer 11.

Preferably, the inlet and outlet connection assembly has a smooth rounded edges for surfing safety.

10 Preferably, the edges of the artificial reef 1 include means to stabilize the artificial reef 1 on the substrate, comprising sand bags, rocks or anchors.

Preferably, the base layer 10 of the artificial reef 1 is left incomplete leaving an opening in the base whereby air is still trapped under the upper surface for flotation, deployment and retrieval of the reef by adopting the methods and valve system described already.

Preferably in a first stage of construction of the artificial reef 1, a data collection programme is undertaken at a proposed reef site to determine the extreme wave heights and currents, whereby a steel reef would then be designed using standard practice by an expert of the engineering profession who would ensure that internal beams and steel plates for the base layer 10 and surface layer 11 have sufficient strength to withstand the forces of nature and waves breaking on the reef.

Preferably computer software and engineering tables are used which specify the strength and bending moments of steel beams so that the steel reef can have sufficient weight to be stable with only water inside the reef's internal cavity, but sand can be added and to reduce rusting, welding would be done within the reef cavity which is not receiving new oxygenated water once sealed.

30 Preferably the artificial reef 1 is shaped as a triangular shaped wedge box like member or as a curved slice box like member.

Accordingly in one aspect the invention consists in a method of assembly of an artificial reef 1 which comprises at least a base layer 10 and surface layer 11 wherein the method includes the steps of:

- a) A base layer 10 of HDPE sheet material is placed on a floor seabed lake bed or substrate
- 5 6;
- b) A surface layer 11 of HDPE is then added and joined to the base layer 10;
- c) The edges of the base layer 10 and surface layer 11 are then joined to make a space structure water-tight for receipt of sand **to form the volumetric shaped reef.**

10 Accordingly in one aspect the invention consists in a method of assembly of an artificial reef 1 which comprises at least a base layer 10 and surface layer 11 wherein the method includes the steps of:

- a) On a suitable dry work site close to a proposed location of an artificial reef 1, a base layer 10 is formed of a certain area;
- 15 b) Support members 12 are placed on top of the base layer 10 and are connected by post member connection assemblies to the base layer 10;
- c) A surface layer 11 is formed of a certain area and is then connected to the post member connection assemblies;
- d) The surface layer 11 is edge joined to the base layer 10 to form a water tight compartment
- 20 between the layers without the pourable material inside;
- e) Inlet and outlet connection assemblies are then formed whereby plate members 51 clamp a portion the surface layer 10 with holes 54 in the plate members fluidly connecting an aperture 25 in the surface layer 11 to allow filling or emptying;
- f) The watertight compartment is then placed on the water to float and then is towed into
- 25 position;
- g) A splitter pipe member 58 is fluidly connected by a flexible pipe 59 to the inlet outlet connection assembly and also fluidly to a main pipe 56 which is connected to a sand and water pump;
- h) the air in the artificial reef 1 is then discharged and replaced with water and then if
- 30 required, filled with water and enough sand to cause the artificial reef 1 to be stable and sink down to a location on the sea/lake bed;

i) if more weight is needed for stability, the artificial reef 1 is then filled with more granular material such as sand or rocks to displace any water, and/or to form the required volumetric artificial reef 1 shape.

5 Alternatively several post support members 12 are formed as a tripod frame.

Preferably the lattice frame is shaped to produce a correct shape of a full artificial reef 1 wherein the shaped lattice frame is placed on the base layer.

10 Preferably the post support members 12 or 33 are connected with post member connection assemblies to at least the surface layer 11.

Preferably after step a) resilient elongate members in the form of strap members 13 are connected with strap connection assemblies to the base layer and surface layer.

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Preferably the inlet and outlet connection assembly is formed in the surface layer 11 comprising circular plates 51 to clamp a portion of the surface with a removable cover cap 53.

20 To those skilled in the art to which the invention relates, many changes in construction and widely differing embodiments and application of the invention will suggest themselves without departing from the scope of the invention as defined in the appended claims. The disclosures and the descriptions herein are purely illustrative and are not intended to be limiting.

25 **Brief Description**

The invention will now be described, by way of example only, by reference to the accompanying drawings:

Figure 1 is a graph showing the sea currents around a typical reef next to a coast

30 **Figure 2** is a graph showing the sea currents around an artificial reef 1 when placed near the coast.

Figure 3 is a schematic perspective view of the artificial reef 1 of the present invention with an angled or wedge like volumetric shape.

Figure 4 is a schematic side view of the reef of figure 2 .

5 **Figure 5** is an upper perspective view of an artificial reef 1 for surfing which has a smooth and curved surface layer showing the artificial reef without side walls.

Figure 6 is a schematic side view of the artificial reef 1 having a simple lattice support.

Figure 7 is a schematic side view of the artificial reef 1 of figure 5.

Figure 8 is a schematic perspective view of the connection between the surface layer and base layer using the support as straps and tripod.

10 **Figure 9** is a perspective view of the circular plates used for joining the support members, strap members and inlet-outlet for a dredge pump.

Figure 10 is a schematic perspective view of the filling operation to the artificial reef 1.

Figure 11 is a perspective of a splitter pipe for the dredge pump to connect to the surface layer of the artificial reef 1.

15 **Figure 12** is a top plan view of an artificial reef as a triangular wedge shape either comprising multiple surface layers or with an indication of water currents surrounding the artificial reef 1.

Description of Drawings

20 The following description will describe the invention in relation to preferred embodiments of the invention, namely an artificial reef 1 for surfing 1 and/or beach or coastal protection and a method of assembly as shown in the examples of figures 1-12. The invention is in no way limited to these preferred embodiments as they are purely to exemplify the invention only and that possible variations and modifications would be readily apparent without departing

25 from the scope of the invention. The artificial reef 1 is designed comprising a planar material forming a certain volumetric shape with certain reef gradients, having at least one internal and sealed compartment or cavity 2 for the receipt of air or a pourable material 3 therein, designed to form an artificial reef 1 volume to be located on a substrate like for example in a sea or body of water 4 adjacent to any suitable coast of a land mass 5 and

30 anchoring or resting on a base 6 such as for example a sea bed, lake bed or pool floor. The artificial reef 1 of the present invention is designed to allow re-sealable filling or emptying/discharge when required and at least minimal leakage during use.

The artificial reef 1 creates a water-tight, air-filled cavity with sufficient buoyancy to allow the artificial reef structure to float and be controlled by inlet and outlet connection assemblies eg a series of or at least one inlet and outlet valve which exchange air in the cavity with a pourable material to control the sinking of the object to a precise location on the seabed for deployment. The inlet/outlet valves which can be used for different materials such as air, would be normally placed around a highest point of the artificial reef 1 or the highest point of any internal compartments. Other inlet/outlets for water would be located near or in the base of the reef. Yet other inlet/outlets for say sand would be spread across the surface of the reef. Sand evacuation would require outlets near the base of the reef.

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The reef may be retrieved by exhausting the pourable material and refilling the cavity with air and towing to another site. The reef when in position on the seabed will exceed 15 m in at least one horizontal dimension and a base surface area exceeding 100 m^2 and a ratio of (volume):(base surface area) not exceeding 3 to prevent toppling over by waves and sinkage into a sandy seabed under wave and current action.

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The reef will be constructed with a precise shape designed by computer to cause the waves to break in a fashion suitable for surfing and/or for protecting the coastline. A horizontal dimension can be defined as being coincident with a general horizontal plane when the artificial reef is resting on the substrate which in some options can be substantially horizontal though not necessarily exactly horizontal but in other options, the base layer 10 of the artificial reef 1 can be sloped or angled to match the shape of the seabed or lakebed.

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To enable the accurate shape and ease of construction, the reef will be constructed on land unlike the previous art whereby reefs have been built in the sea. At least a portion of an external or top surface of the sealed compartment, will have minimal sharp or dangerous protuberances or shape edges that may be a hazard for surfing. At least a portion of the external surface of the reef can also be rippled, corrugated or irregular in some way to induce more frictional resistance and thereby minimise the intensity of wave-induced currents passing over the reef. As shown in the figures the artificial reef 1 can be shaped for example as a triangular shaped wedge box like member (see figure 4) which might better suited to coastal protection or as a curved sliced box like member (figure 5) which might be better

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suited to surface. The curved sliced box like member provides a smooth contoured surface layer 11.

The reef can be constructed in one of the following ways:

- 5 • using steel plate welded or bolted to an internal frame designed to withstand the forces of the breaking waves;
- Using a more flexible material and the precise shape will be controlled by straps or internal lattice frames linking the base to the surface with known lengths and the force of the waves will be absorbed by filling the compartment with a pourable
- 10 material such as sand;
- Using a blend of both.

The more flexible material may be HDPE, PVC, heavy duty tarpaulin, rubber or a similar product. The pourable material may be water or sand. Additional buoyancy may be added

15 in the form of temporary floats when the artificial reef 1 is being moved.

The planar material can include a flexible resilient material (eg a plastics material) or can be a stiffer material like for example a metal such as for example steel or aluminium. In this example the pourable material can be air or a granular material such as sand or a fluid

20 including a liquid such as water.

The artificial reef 1 provides an external surface to cause the waves to be altered or break in a way suitable for surfing and/or protection of a coastline and also includes at least one inlet and outlet valve to allow air or any pourable material to be filled or discharged therefrom the sealed compartment. The artificial reef 1 is constructed to allow it to be built on a dry surface

25 or land and be floated out to a precise position whereby when in position on the seabed the dimensions of the artificial reef 1 will exceed 15 m in at least one horizontal planar dimension and a base surface area exceeding 100 m² and a ratio of (volume):(base surface area) not exceeding 3 to prevent toppling over by waves and sinkage into a sandy seabed

30 under wave and current action.

The artificial reef 1 is constructed to allow it to be built on a dry surface or land and be floated out to a precise position whereby when in position on the seabed the dimensions of

the artificial reef 1 the artificial reef 1 comprises a broad base with horizontal planar dimensions being at least 8 m to prevent toppling over by waves and sinkage into a sandy seabed or lakebed under wave and current action. The dimensions of the artificial reef 1 will exceed 15 m in at least one horizontal planar dimension and a base surface area exceeding 100 m² and a ratio of (volume):(base surface area) not exceeding 3 to prevent toppling over by waves and sinkage into a sandy seabed under wave and current action, wherein the volume to base area ratio not exceeding of 4.

In another description of the dimensions of the artificial reef 1, the artificial reef 1 comprises a broad base with horizontal planar dimensions being at least 8 m to prevent toppling over by waves and sinkage into a sandy seabed or lakebed under wave and current action. Furthermore or alternatively the volume to base area ratio not exceeding of 4. The volume is a surrogate for mass or weight and easier to describe.

The artificial reef 1 is formed from the following components:

- a base layer 10 of a planar water proof material joined in sheets
- a surface layer 11 of a planar water proof material joined in sheets
- at least one post support member 12
- at least one elongate resilient member 13

Base layer 10 and Surface Layer 11

The base layer 10 is formed of a planar material of any suitable shape having an outer or external surface 17 separated from an inner surface 18 by a thickness dimension 19.

Similarly the surface layer 11 is also formed of a planar material having an inner surface 22 separated from an outer surface 23 by a thickness dimension of 24. Surface layer 11 also includes at least one inlet or outlet aperture 25 and inlet outlet connection assembly, to enable filling or discharge there through using a dredge pump and water discharge.

The planar material of the base layer 10 and/or surface layer 11 in this example is formed of a plastics material which can be formed from any suitable material that is water resistant, resilient, sealingly joinable, UV resistant and stable in a whatever fluid environment such as for example salt water or chlorine treated body of water. For example, the plastics material can be a PVC, or waterproof cloth, a high density polyethylene (HDPE) type of sheet

material which is low moisture absorbent, chemical and corrosion resistant, excellent impact resistance and high tensile strength. Importantly material needs to be resistant to abrasion by sand and be strong enough to resist wave breaking thereon. Typically the HDPE sheet material can have a thickness of up to 30 mm but thicknesses of 5-10mm will also work in most situations.

In use, at least one or many separate base layers 10 and surface layers 11 can be edge joined or connected together in at least one layer, to form the desired sealed compartment or volumetric area 2 of the artificial reef 1 which can be shaped of any suitable shape like for example a tent or wedge shape with water and sand tight seams, as required.

Post Support Members 12

The post support members 12 are designed to at least temporarily support the surface layer 11 above the base layer 10 to allow access for construction, filling or discharge and when the artificial reef 1 is being towed on to a selected site. The post support members 12 can be formed from at least a one piece stiff or rigid material such as plastics or metal elongate member or from several members joined or connected together or alternatively can be an extendable or folding member eg (telescoping or hinged). The metal needs to have a certain structural strength to at least resist the temporary weight of the surface layer and corrosion resistance especially for use in the salt water environment.

For example, the post support member 12 can be galvanized steel, plastic or aluminium with a cross-section such as L, H or C or U. Aluminium or plastic can be useful for corrosion resistance. Each post member 12 has a length portion 30 between a first end 31 and a second end 32. In use the length portion 30 can be used to define a height dimension between the inner side 22 of the surface layer 11 and inner surface 18 of the base layer 10.

In this example post members 12 can be formed as a tripod frame 33 whereby three post support members are joined at an in use at first and second ends each at a custom made post connector assembly 35 whereby the three post support members fan out or splay at an in use lower portion at the first end. The first end includes three post connector assemblies 35 as seen in figure 8. At the second end at the upper portion of the tripod frame 33 it is designed

to minimally rest and abut with the inner surface 18 of the base layer 10 using a single post connector assembly 35.

5 The post connector assembly 35 comprises two plate members 36 (eg circular) and bolts 37 whereby the plate members 36 are joined or connected to the upper portion of the tripod frame 33 which in use clamp a portion of the surface layer 11 whereby one plate member 36 is connected to an upper portion of the post support member 12 and the other plate member 36 is a separate member adapted to abut the outer surface 23 of the surface layer 11 which are then clamped by at least one bolt 37 through the plate members 36 and the thickness 24
10 of surface layer 11 there between.

As mentioned the bottom of the tripod frame 33 can simply rest or locate or connect on an underside of the base layer 10 but in other variations, the lower portion of the tripod frame 33 ie each post support member 12 can be formed similar to the upper portion if necessary.
15 As seen in the figures the tripod frames 33 can be spaced apart from each other of varying height 30 to allow the surface layer 11 to form the desired outer upper shape of the artificial reef 1. The fitting of the tripod frames 33 to the base layer 10 can be designed to break when the forces (eg weight of water) exceed a pre-determined breaking force.

20 **Strap Members 13 see figure 8**

The resilient elongate members can be formed as strap members 13 which are each connected to the surface layer 11 and base layer 10 using purpose made resilient elongate member connection assembly which are in the form of strap connector assemblies made up of a circular plate 45, bolts 46, similar to the post connector assembly or can include pin and
25 cap (not shown). These strap connector assemblies include two circular plates 45 which have a portion of the HDPE sandwiched between them which are bolted together by bolts 46 (Figure 6). The looped end 44 of the strap member 13 is passed through the central hole 47 in the plates 45 and pin 47 is inserted into the loop 44 of the end 41, 42 of the strap member 13 to hold it in place. The cap 49 can be placed over the connector assembly to ensure that
30 the pin 47 is not lost.

In another example, a simpler strap connector assembly can include welding one circular plate 47 directly to an inner side of base layer 10 and inner surface layer 11 in the form of

5 sheets. The strap connector assemblies can be placed in the factory on the base layer or surface layer sheets before bringing the base and surface layer as sheets to the site. In this way, each sheet can be drawn individually using computer software and fitted with connectors in the factory, prior to joining all the sheets on site. The strap member connector assembly can be formed from a single plate member 45 with a handle member 50 forming a gap 50a between the handle member 50 and plate member 45 for receipt and connection of an end of the strap member 13

10 The strap members 13 can be manufactured off-site and transported to the work site to be connected or they can be fitted on site by fitting just the connectors to the surface layer.

Dredge pump for filling or emptying the artificial reef 1 – see figures 9 and 10

15 The inlets and outlet apertures 25 of the surface layer 11 are combined with an inlet and outlet connection assembly for removable receipt of the dredge pump and comprise two plate members 51 (eg can be circular in shape) with HDPE sandwiched between (Figure 7), bolts 52, and sealing caps 53. The two plate members 51 will be bolted together by bolts 52 with nuts to form an inlet or outlet nozzle. There will be a threaded hole 54 in the plate members 51 which are co-linear with the aperture in the surface layer 11 to be fluidly connected together, so that flexible dredge pipes 59 can be screwed in for filling or emptying of fluid (eg water and/or any pourable material like sand). Sealing caps 53 can be screwed into place, when the dredge pipe is removed after the artificial reef 1 is filled with sand.

25 Similarly, the dredge pump (not shown) can include a main dredge pipe 56 located at the surface, fluidly connected to a splitter pipe member 58 (see figures 10 and 11) which is then fluidly connected to a flexible dredge pipe 59 located in the water, which is in turn able to be fluidly connected to the hole 54 in the plates 36 (after threadingly removing the sealing cap 53) to then enable filling or emptying of the compartment 2 of the artificial reef 1. For filling the artificial reef 1, splitter pipe member 58 can include a main single inlet 58a leading to at least one outlet or as seen in figure 11 there can be four peripherally spaced outlets 58b. The terms ‘outlet’ and ‘inlet’ can be swapped around if not filling or emptying but are discharging or emptying the artificial reef 1.

- If the artificial reef 1 is to be used for surfing, the fittings of the inlet outlet connection assembly should have smooth rounded edges to reduce the chance of injuring the surfer or public. Bolt heads could be embedded into the fittings. It may be convenient to split the dredge pipe into four or more smaller pipes so that the artificial reef 1 can be more evenly
- 5 filled with sand (Figure 8).
- Once the full surface of the artificial reef 1 is completed with internal straps 13 and tripod frames 33 in place, it should have the required shape.

Surface layer and base layer assembly

- 10 During the assembly, the surface layer sheets 11 and base layer sheets 10 of HDPE are joined around their peripheral edges using an edge joining assembly. The assembly includes PVC or steel elongate strip members with the two HDPE layers sandwiched between. The joining strip members can be bolted together bolts through the two layers of HDPE.
- 15 The bolts and the strip members located around the edge may be removed later, opening up a section along the side of the artificial reef 1 for the removal of sand, if the artificial reef 1 needs to be emptied of sand and moved to another site. It may be necessary to pump water through the inlet apertures 25 to flush the sand. The artificial reef 1 can then be sealed, filled with air, and floated to the surface.

20

Other aspects

- The artificial reef 1 of the present invention will need to be able to withstand the forces of the sea. It will also experience pressure from within when the artificial reef 1 is being filled. The sand will fill the internal compartment 2 and act to push down on the base layer 10
- 25 which is resting on a seabed. The sand will also push up the surface layer 11 when the artificial reef 1 is completely filled. Accordingly, one of the large forces acts to lift the crest of the artificial reef 1 upwards. Thus, the purpose of the strap members 13 is to maintain the required shape of the artificial reef 1 by resisting the upward force caused by the sand.

- 30 In contrast to the strap members 13, the tripod frames 33 are not designed to keep the artificial reef 1 shape. The combination of strap members 13 and sand will achieve this. The tripod frames 33 are merely placed to form the initial shape of the artificial reef 1 and open up the air-filled interior void to allow access for construction workers or assistance with

buoyancy when the artificial reef 1 is floated to the site. Thus, the tripod frames 33 are temporary. The upward force is contained by the more closely-spaced strap members 13.

5 The other force felt by the artificial reef 1 relates to the impacts when waves are breaking thereon. These forces are absorbed by the internally contained sand. Thus, the tripod frames 33 can be made of light material as they are not designed to brace against the wave impact forces.

10 Internally, in use the sand will try to spread laterally i.e. pancake. However, the sand is held within the artificial reef 1 by the joins and edge joining assembly around the peripheral edges. Because the artificial reef 1 gradients are usually much less than the natural angle of repose of the sand grains, these forces are mostly contained within the sand itself, by grain-grain interactions. Most beach sands have a natural angle of repose exceeding 20 degrees and the artificial reef 1 gradients are much less (usually less than 10 degrees). This means that
15 the lateral forces within the artificial reef 1 are not sufficient to damage the structure.

The edges of the artificial reef 1 may be further stabilised by addition of heavy sand-filled geo-bags or rocks placed around the edges or on the adjacent sand.

20 While the method described above shows how to build the artificial reef 1 in one piece, it could also be built in sections which are placed side-by-side in the sea during construction. However, vertical walls will bulge and will be difficult to join together without gaps. For a smooth join, the sections would be designed to overlap, thereby placing the second piece partially on top of the first after it is filled with sand. This would continue until the full
25 artificial reef 1 is completed.

Assembly method 1

The artificial reef 1 of the present invention is assembled on land, next to a water body.

30 When assembled or built, the artificial reef 1 is then towed to a selected site. Dredge pipes may be fitted while still floating. The artificial reef 1 is filled with water and enough sand for it to be stable and sink to the seabed. The artificial reef 1 is then filled fully with sand by the dredge.

By using easy inlet and outlet connector assembly systems already built into the artificial reef surface layer 11, divers will be able to efficiently move the dredge pipe 59 to other inlets so that the artificial reef 1 is evenly and fully filled with sand. These inlets (hole 54) which are threaded can be easily sealed using a threaded cap 53.

5

The position could be found with GPS or a Total Station by a professional surveyor. Some seabed anchors may also be used to initially position the artificial reef 1 which may be winched to the seabed to the correct position.

10 **Assembly Method 2**

Yet another method of assembly of an artificial reef 1 which comprises at least a base layer and surface layer wherein the method includes the steps of:

- a) A base layer of HDPE sheet material is placed on a floor seabed lake bed or substrate;
- b) A surface layer of HDPE is then added and joined to the base layer;
- 15 c) The edges of the base layer 10 and surface layer 11 are then joined to make a space structure water-tight for receipt of sand.

Assembly Method 3

Another method of assembly of an artificial reef 1 which comprises at least a base layer 10 and surface layer 11 wherein the method includes the steps of:

- a) On a suitable dry work site close to a proposed location of an artificial reef 1, a base layer 10 is formed of a certain area;
- b) Support members 12 are placed on top of the base layer 10 and are connected by post member connection assemblies to the base layer 10;
- 25 c) A surface layer 11 is formed of a certain area and is then connected to the post member connection assemblies;
- d) The surface layer 11 is edge joined to the base layer 10 to form a water tight compartment between the layers without the pourable material inside;
- e) Inlet and outlet connection assemblies are then formed whereby plate members 51 clamp a portion the surface layer 10 with holes 54 in the plate members fluidly connecting an aperture 25 in the surface layer 11 to allow filling or emptying;
- 30 f) The watertight compartment is then placed on the water to float and then is towed into position;

g) A splitter pipe member 58 is fluidly connected by a flexible pipe 59 to the inlet outlet connection assembly and also fluidly to a main pipe 56 which is connected to a sand and water pump;

- h) the air in the artificial reef 1 is then discharged and replaced with water and then if required, filled with water and enough sand to cause the artificial reef 1 to be stable and sink down to a location on the sea/lake bed;
- 5 i) if more weight is needed for stability, the artificial reef 1 is then filled with more granular material such as sand or rocks to displace any water, and/or to form the required volumetric artificial reef 1 shape.

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Assembly Method 4

A base layer of HDPE sheet material is placed on an open area on land adjacent to a water body. A lattice frame is shaped to produce the correct shape of a full artificial reef 1.

The shaped lattice frame is placed on the base layer.

- 15 A surface layer of HDPE is then added and joined to the top of the lattice frame.

The edges of the base layer 10 and surface layer 11 are joined to make a full space structure water-tight. This could be achieved using PVC or steel strips that are above and below the edges and joined with bolts with the 2 sheets of HDPE sandwiched between. Other designs are also possible.

20

After placing the base layer, several post support members sized and shaped according to a correct shape of a full artificial reef 1 wherein the post support members are placed on the base layer.

Alternatively the several post members are formed as a tripod frame.

25

A lattice frame is shaped to produce a correct shape of a full artificial reef 1 wherein the shaped lattice frame is placed on the base layer. The post support members are then connected with post member connection assemblies to at least the surface layer.

- 30 After laying the base layer and surface layer, resilient elongate members in the form of strap members are connected with strap connection assemblies to the base layer and surface layer.

The inlet and outlet apertures 25 are then formed in the surface layer 11 and the inlet and outlet connection assembly which comprise circular plates with a central hole 54, to clamp a portion of the surface layer 11 with holes 54 being fluidly connected to the aperture 25, with a removable cover cap 53.

- 5 The edges of the base layer 10 are then jointed to the surface layer to form a sealed compartment there between.

The completed artificial reef 1 is then towed into the ocean by a vessel to the deployment site and sunk to the seabed.

- A dredge pump then fills the sealed compartment with sand to form the required volumetric
10 shaped artificial reef 1.

Assembly Method 5

- The base layer 10 is cut into suitable strips off site;
- the surface layer 11 is cut into suitable strips off site;
- 15 - cut base layer strips are joined to each other at a work site;
- the strap members 13 are manufactured off site with looped ends;
- apertures 25 are cut into the surface layer 11 for the inlet or outlet connection assembly to receive a dredging or pumping apparatus;
- looped ends 44 of the strap members are connected to the surface layer;
- 20 -tripod frames or post members are placed on an inner side of the base layer
- tripod frame 33 members are made upright according to a predetermined required artificial reef 1 shape
- arrange and place surface layer 11 on top of the tripod frame 33;
- connect the top of the tripod frame 33 members to the surface layer 11 by using the post
25 connector assemblies;
- connect the bottom of the strap members 13 to the base layer 10 by using the strap connector assemblies;
- connect the peripheral edges of the surface layer 11 to the base layer 10 using an edge joining assembly to form the internal compartment 2;
- 30 Tow the reef 1 to the site, sink it etc.
- connect pump to inlet or outlet apertures 25 of surface layer 11;
- pump in sand into the internal compartment 2 and the desired volumetric shaped artificial reef 1 is formed.

Assembly Method 6

A less expensive method and lighter alternative or can be used in combination with the tripod frame 33, lattice frame or simple post member, is to use (eg heavy duty) strap

members 13, like seat belt straps, rather than a heavy support frame 12. The strap members

- 5 13 join to both the base and top of the artificial reef 1 through apertures 25 in the surface layer 11 and are held in place by strap connector assemblies. The strap members 13 will prevent the distortion of the artificial reef 1 and resist the expansion pressure when being filled with sand. Their lengths are chosen to give the artificial reef 1 the required shape. They may be spaced every 2 m, but other spacing measurements are equally possible.

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To ensure the artificial reef 1 has a correct shape initially and to give workers access, a series of support posts 12 can be placed between the base layer 10 and surface layer 11 and connected with the same connectors (Figure xx). The support post 12 can include a tripod shape with adjustable height, although simpler single posts may be adopted.

- 15 Purpose-made joiners or connectors could consist of two circular plates sandwiching the HDPE between them (Figure xx). They will have components for attaching the strap members 13 and a cap 53 to make the artificial reef 1, waterproof and safe for surfers. Other designs are possible.

- 20 By using this assembly system of the present invention, the artificial reef 1 is lighter, less costly and can be more readily towed into position for filling. The strap members 13 can be more readily brought to the site in a container, than the steel components. The whole artificial reef 1 structure 1 ie base layer 10 and surface layer 11 can be made from HDPE, plastic, strap members 13 and PVC to prevent corrosion. Some users prefer aluminium,
25 stainless steel or other corrosion resistant materials.

A series of filling inlets will be placed in the top HDPE layer of the artificial reef 1. These are custom-designed to allow easy “click-on” or “screw on” connection of the dredge pipes.

A series of outlets in the top HDPE layer will allow the water from the dredge slurry to
30 escape, leaving the sand inside the structure.

The inlets and outlets holes 54 are threaded so that custom sealing caps or plugs 53 can be screwed into place once filling is complete. These are then tightened securely. The caps 53

can have a bolt-shaped hole in their centre, so that a tool can be inserted for rapid tightening. The assembly artificial reef 1 structure is floated to the site, dropped to the seabed and then filled with sand.

- 5 The reader should understand that the sand absorbs the stress of wave breaking and holds the structure shape, rather than relying on the strength of the frame or straps. The strap members 13 prevent the reef 1 distorting due to the internal pressure of the sand. The weight of the sand also guarantees artificial reef 1 stability under wave attack. The accurate placement of the artificial reef 1 can be achieved using differential GPS on the corners or with a total
10 station from land. Anchors in the seabed can be used to assist with accurate placement. The anchors can be retrieved once the artificial reef 1 is filled with sand.

- Rocks or other heavy objects may be placed around the edges of the reef 1 to reduce scour or movement. Durable HDPE could be used for the artificial reef 1, while fittings could be
15 machined from PVC or steel. However, other suitable materials can be adopted.

Advantages

- a) Stable
- b) Removable
- 20 c) Is portable
- d) Can be a kitset
- e) Unlikely to sink into the sand
- f) Broad base
- g) Waves can be broken
- 25 h) Any shape possible
- i) Easy to fill with sand **or any other suitable material**
- j) Can be anchored to any base
- k) Straight forward construction
- l) Smooth surface for surfing
- 30 m) Can include pressure sensors
- n) Can include re-closable **scalable** filling ports
- o) Robust and durable construction
- p) Has custom made re-openable joints

- q) Supported by an internal frame **or posts**
- r) Frame can be flexible to allow for distortion
- s) Less need to use divers
- t) Can use heavy duty straps instead of frame
- 5 u) Relatively lightweight when compared to other methods
- v) Can be shaped according to computer design
- w) Material of artificial reef 1 is sufficiently flexible to form any shape
- x) Able to be floated and towed into place for deployment
- y) Can be constructed on land and then towed into place in water
- 10 z) Can use support posts or lattice frames
- aa) Can include baffles or ribs internally to improve shape
- bb) Can be used to surf over
- cc) Can be used to protect beach or coastal areas
- dd) Can be used as a sand retention structure
- 15 ee) Minimises sea based construction time

Variations

Throughout the description of this specification, the word “comprise” and variations of that word such as “comprising” and “comprises”, are not intended to exclude other additives, components, integers or steps. Any number of layers of the base layer and surface layer can be used. The shape of the plate members 36 or 51 can be of any selected shape and number. Though bolting is shown other methods either singularly or in combination can be used such as for example, riveting, pins, welding, adhesive or heating. The shape of the splitter pipe member 58 can also be of any suitable shape depending on what material is being pumped or the amount required to be pumped. Variations in the splitter pipe member 58 include material type, number of outlet or inlets, material type, lengths, diameters and cross sectional shape.

Support posts 12 are shown in this example as being tripod frames but equally any other shapes or orientation of the support posts 12 is equally possible such as for truss or lattice frames which can be formed in a curve, number of pipes, branches and/or straight or angled orientations etc. Filtering can also be combined where necessary. Minimally the artificial reef 1 can includes a base layer 10 and surface layer 11 but equally other shapes are possible

such as ones having side walls or having the base layer 10 curved continuously with surface layer 11.

It will also be understood that where a product, method or process as herein described or claimed and that is sold incomplete, as individual components, or as a “kit of Parts”, that such exploitation will fall within the ambit of the invention. As seen in the figures, the artificial reef 1 can include no separate side walls, with the surface layer 11 extending downwardly to meet the base layer 10, though in other options, there can be separate angled side walls such as vertical side walls.

Alternatively for the fixing means, a hole can be formed at the end. In yet other examples, baffles and rib like members can be formed or attached within the sealed compartment which can be used to strength the artificial reef 1 or provide different wave patterns. In yet other alternatives the ribs can be placed on the outside surface of the reef 1 especially when being use as shore protection.

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In one embodiment, the base layer 10 of the artificial reef 1 can be incomplete leaving a large opening in the base. Air would be still trapped under the upper surface for flotation, deployment and retrieval of the artificial reef 1 by adopting the methods and valve system described already.

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In a first stage of construction of the artificial reef 1, a data collection programme can be undertaken at the proposed artificial reef 1 site to determine the extreme wave heights and currents. A steel artificial reef 1 would then be designed using standard practice by an expert of the engineering profession who would ensure that internal beams and steel plates as base layer 10 and surface layer 11 have sufficient strength to withstand the forces of nature and waves breaking on the artificial reef 1.

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An engineer can use computer software such as AutoCAD and engineering tables which specify the strength and bending moments of steel beams. The steel artificial reef 1 can have sufficient weight to be stable with only water inside the artificial reef 1's internal cavity, but sand can be added. To reduce rusting, if possible welding would be done within the artificial reef 1 cavity which is not receiving new oxygenated water once sealed. In yet other

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variations the base layer 10 and/ or surface layer 11 can include a structure providing pockets or cavities separate to the sealed compartment. The pocket or cavities can be shaped as separate pockets within say a double skin like arrangement or can be a continuous pocket forming a peripheral pocket completely or partly surrounding the sealed compartment.

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These and other features and characteristics of the present invention, as well as the method of operation and functions of the related elements of structures and the combination of parts and economics of manufacture, will become more apparent upon consideration of the following description with reference to the accompanying drawings, all of which form part of this specification, wherein like reference numerals designate corresponding parts in the various figures. The artificial reef 1 will be a single element but a large reef may be made in smaller segments which are towed to the site individually and placed adjacent to or joined to the other segments at the seabed.

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It is acknowledged that the term 'comprise' may, under varying jurisdictions, be attributed with either an exclusive or an inclusive meaning. For the purpose of this specification, and unless otherwise noted, the term 'comprise' shall have an inclusive meaning - i.e. that it will be taken to mean an inclusion of not only the listed components it directly references, but also other non-specified components or elements. This rationale will also be used when the term 'comprised' or 'comprising' is used in relation to one or more steps in a method or process.

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For purposes of the description hereinafter, the terms "upper", "lower", "right", "left", "vertical", "horizontal", "top", "bottom", "lateral", "longitudinal", "side", "front", "rear" and derivatives thereof shall relate to the invention as it is oriented in the drawing figures. However it is to be understood that the invention may assume various alternative variations, except where expressly specified to the contrary. It is also to be understood that the specific devices illustrated in the attached drawings, and described in the following specification are simply exemplary embodiments of the invention. Hence specific dimensions and other physical characteristics related to the embodiments disclosed herein are not to be considered as limiting.

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It will of course be realised that while the foregoing has been given by way of illustrative example of this invention, all such and other modifications and variations thereto as would be apparent to persons skilled in the art are deemed to fall within the broad scope and ambit of this invention as is hereinbefore described.

What we claim is:

1: An artificial reef 1 comprising a base layer 10 and a surface layer 11 wherein the base layer 10 is joined and sealed to the surface layer 11 forming at least one sealed compartment there between for receipt of air or pourable material there between to form a volumetric shaped artificial reef 1 for location on a seabed or lakebed and providing an external surface to cause the waves to be altered in a way suitable for surfing and/or protection of a coastline, the artificial reef 1 also includes at least one inlet and outlet valve to allow air or any pourable material to be filled or discharged therefrom the sealed compartment wherein artificial reef 1 is constructed to allow it to be built on a dry surface and be floated out to a precise position whereby when in position on the seabed or lakebed whereby the artificial reef 1 comprises a broad base with horizontal planar dimensions being at least 8 m to prevent toppling over by waves and sinkage into a sandy seabed or lakebed under wave and current action.

2. The artificial reef as claimed in claim 1 wherein the dimensions of the artificial reef 1 will exceed 15 m in at least one horizontal planar dimension and a base surface area exceeding 100 m^2 and a ratio of (volume):(base surface area) not exceeding 3 to prevent toppling over by waves and sinkage into a sandy seabed under wave and current action, wherein the volume to base area ratio not exceeding of 4.

3. The artificial reef 1 as claimed in claim 2 wherein the pourable material is a formed as a granular or powdery material such as sand and/or fluid such as a liquid and the base layer 10 and surface layer 11 comprise a waterproof planar material.

4. The artificial reef 2 as claimed in claim 3 wherein, the base layer 10 and the surface layer 11 comprise a flexible and resilient material such as plastics material, rubber or cloth or alternatively the base layer 10 and surface layer 11 is formed of a stiff material such as metal like for example steel or aluminium.

5. The artificial reef 1 as claimed in claim 4 wherein at least a portion of an external or top surface will have minimal sharp or dangerous protuberances or shape edges that may be a hazard for surfing or at least a portion of the top surface of the artificial reef 1 is rippled,

corrugated or irregular in some way to induce more frictional resistance and thereby minimise the intensity of wave-induced currents passing over the artificial reef 1.

6. The artificial reef 1 as claimed in claim 5 wherein, at least one support member 12 is located between the base layer 10 and support layer 11 inside the sealed compartment and functions to temporarily support an initial shape of the artificial reef 1 and open up an air filled interior void to allow access for the pourable material therein wherein the support member 12 is formed of a stiff or rigid material such as metal or plastics member having a length between ends wherein at least one end includes a looped end shaped to be connected with a connector support assembly to at least the base layer 10.
7. The artificial reef 1 as claimed in claim 6 wherein, at least one resilient elongate member 13 is connected by a resilient elongate member connection assembly, to the base layer 10 and to the surface layer 11, and functions to resist any upward forces from the sand on the surface layer 11 wherein the resilient elongate member is a strap member having looped ends wherein, the sand and strap members are shaped and designed to keep the artificial reef 1 shape.
8. The artificial reef 1 as claimed in claim 7 wherein, the artificial reef 1 (shape, volume) is designed using computer software to obtain a shape which provides quality surfing wherein the computer software is used determine the correct length of the posts and straps which give the artificial reef 1 the designed shape.
9. The artificial reef 1 as claimed in claim 8 wherein, the resilient elongate member connection assembly is a strap connector assembly is for connecting an end of each strap member to the base layer 10 and surface layer 11, the strap connector assembly includes two circular plates 36 and bolts 37 wherein the two plates 36 clamp a portion of the surface layer 11.
10. The artificial reef 1 as claimed in claim 8 wherein the resilient elongate member connection assembly is a strap connector assembly for connecting one strap member to the base layer 10 and surface layer 11 which includes one plate member 45 and a handle member 50 forming a gap 50a there between the handle member 50 and plate member 45 whereby the

plate member is welded to an inner surface of the surface layer 11 and base layer 10 and one looped end of the strap member 13 is connected to the handle member 50.

11. The artificial reef 1 as claimed in claim 8 wherein the support member 12 includes post members formed as a tripod frame 33 comprising three post members with one end together connecting all three member at one position to the surface layer and the other end of the tripod having the three members splayed apart or the support member 12 is a lattice frame 33a.

12. The artificial reef 1 as claimed in claim 11 wherein a post connector assembly 35 connects one end of a post member to the base layer and surface layer, wherein each post connector assembly comprises two plate members 36 and bolts 37 whereby the plate members 36 are joined or connected to the upper portion of the tripod frame 33 which in use clamp a portion of the surface layer 11 whereby one plate member 36 is connected to an upper portion of the support member 12 and the other plate member 36 is a separate member adapted to abut the outer surface 23 of the surface layer 11 which are then clamped by at least one bolt 37 through the plate members 36 and the thickness 24 of surface layer 11 there between.

13. The artificial reef 1 as claimed in claim 12 wherein the surface layer 11 and base layer 10 are joined at their edges with elongate strip members which clamp an edge portion of the HDPE by bolting through the HDPE and elongate strip member to form the sealed compartment which is able to allow air water or sand therein when filling without leakage.

14. The artificial reef 1 as claimed in claim 13 wherein the sealed compartment which creates a water-tight, air-filled cavity with sufficient buoyancy to allow the structure to float and be controlled by a series of valves which exchange air in the cavity with a pourable material to control the sinking of the object to a precise location on the seabed for deployment.

15. The artificial reef 1 as claimed in claim 14 wherein the artificial reef 1 includes an inlet and outlet connection assembly which comprises two plate members 51, seal cap and bolts, whereby the plate members 51 are bolted together, to sandwich a portion of the surface layer

11 there between the two plate members, and the plate members 51 have a central hole 54 with a threaded portion which is co-linear and fluidly connected with an aperture 25 in the surface layer 11, to allow the threading engagement of the dredge pipes and fluid travel there through, and the seal caps 53 can be used to seal the central hole 54.

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16. The artificial reef 1 as claimed in claim 15 wherein, the surface layer 11 includes at least one inlet and outlet aperture 25 for a dredge pump having main dredge pipes fluidly connected to a splitter pipe member which is then fluidly connected to several flexible dredge pipes which are then connected to an inlet and outlet connection assembly which is

10 fluidly connected to aperture 25 through the surface layer 11.

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17. The artificial reef 1 as claimed in claim 16 wherein, the inlet and outlet connection assembly has a smooth rounded edges for surfing safety and the edges of the artificial reef 1 include means to stabilize the artificial reef 1 on the substrate, comprising sand bags, rocks or anchors.

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18. The artificial reef 1 as claimed in claim 17 wherein, the base layer 10 of the artificial reef 1 is left incomplete leaving an opening in the base whereby air is still trapped under the upper surface for flotation, deployment and retrieval of the artificial reef 1 by adopting the methods and valve system described already.

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19. The artificial reef 1 as claimed in claim 18 wherein in a first stage of construction of the artificial reef 1, a data collection programme is undertaken at a proposed artificial reef 1 site to determine the extreme wave heights and currents, whereby a steel artificial reef 1 would then be designed using standard practice by an expert of the structural engineering profession who would ensure that internal beams and steel plates for the base layer 10 and surface layer 11 have sufficient strength to withstand the forces of nature and waves breaking on the artificial reef 1.

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20. The artificial reef 1 as claimed in claim 19 wherein computer software and engineering tables are used which specify the strength and bending moments of steel beams so that the steel artificial reef 1 can have sufficient weight to be stable with only water inside the artificial reef 1's internal cavity, but sand can be added and to reduce rusting, welding would

be done within the artificial reef 1 cavity which is not receiving new oxygenated water once sealed.

21. The artificial reef 1 as claimed in claim 20 wherein the artificial reef 1 is shaped as a triangular shaped wedge box like member or as a curved slice box like member.

22. A method of assembly of an artificial reef 1 which comprises comprising a base layer 10 and a surface layer 11 wherein the base layer 10 is joined and sealed to the surface layer 11 forming at least one sealed compartment there between for receipt of air or pourable material there between to form a volumetric shaped artificial reef 1 for location on a seabed or lakebed and providing an external surface to cause the waves to break in a way suitable for surfing and/or protection of a coastline, the artificial reef 1 also includes at least one valve to allow air or any pourable material to be filled or discharged therefrom the sealed compartment wherein artificial reef 1 is constructed to allow it to be built on land and be floated out to a precise position whereby when in position on the seabed or lakebed the dimensions of the artificial reef 1 will exceed 25 m in at least one horizontal planar dimension and a base surface area exceeding 200 m^2 and a ratio of (volume):(base surface area) not exceeding 2 to prevent toppling over by waves and sinkage into a sandy seabed or lakebed under wave and current action wherein the method includes the steps of:

a) On a suitable dry work site close to a proposed location of an artificial reef 1, a base layer 10 is formed of a certain area;

b) Support members 12 are placed on top of the base layer 10 and are connected by post member connection assemblies to the base layer 10;

c) A surface layer 11 is formed of a certain area and is then connected to the post member connection assemblies;

d) The surface layer 11 is edge joined to the base layer 10 to form a water tight compartment between the layers without the pourable material inside;

e) Inlet and outlet connection assemblies are then formed whereby plate members 51 clamp a portion the surface layer 10 with holes 54 in the plate members fluidly connecting an aperture 25 in the surface layer 11 to allow filling or emptying;

f) The watertight compartment is then placed on the water to float and then is towed into position;

- g) A splitter pipe member 58 is fluidly connected by a flexible pipe 59 to the inlet outlet connection assembly and also fluidly to a main pipe 56 which is connected to a sand and water pump;
- h) the air in the artificial reef 1 is then discharged and replaced with water and then if
- 5 required, filled with water and enough sand to cause the artificial reef 1 to be stable and sink down to a location on the sea/lake bed;
- i) if more weight is needed for stability, the artificial reef 1 is then filled with more granular material such as sand or rocks to displace any water, and/or to form the required volumetric artificial reef 1 shape.

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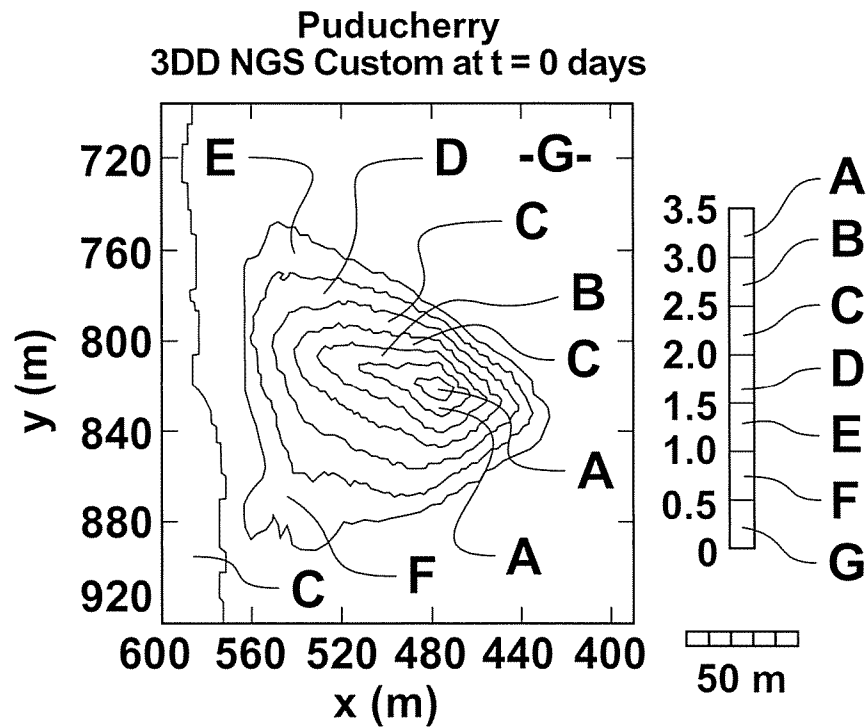


Figure 1

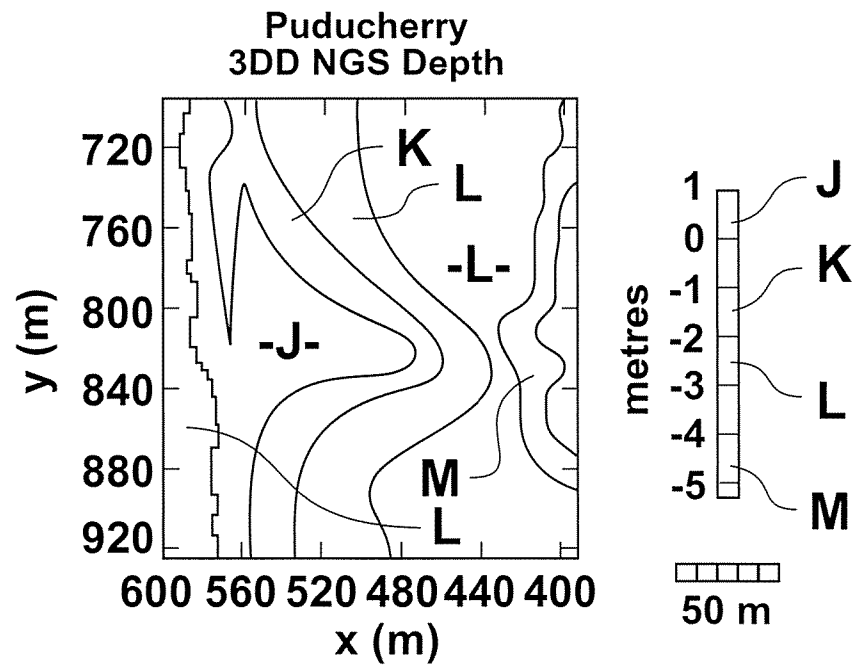


Figure 2

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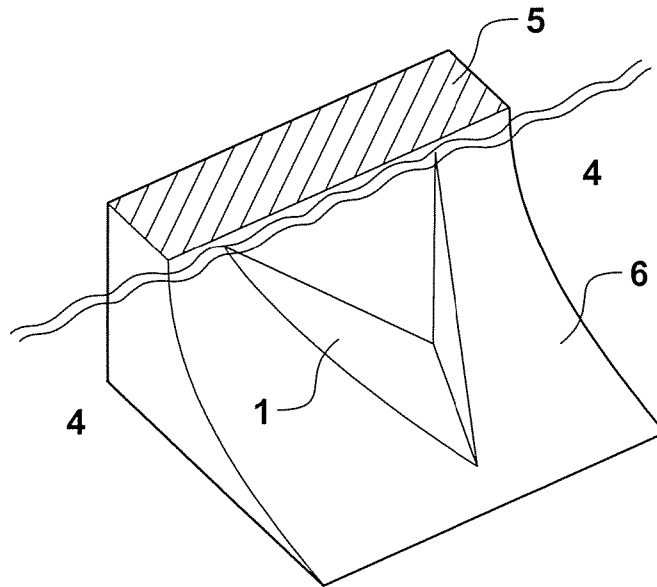


Figure 3

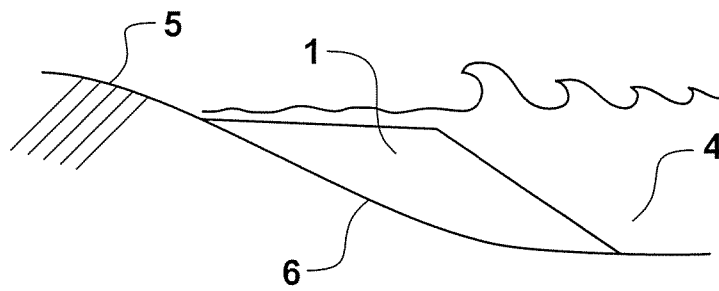
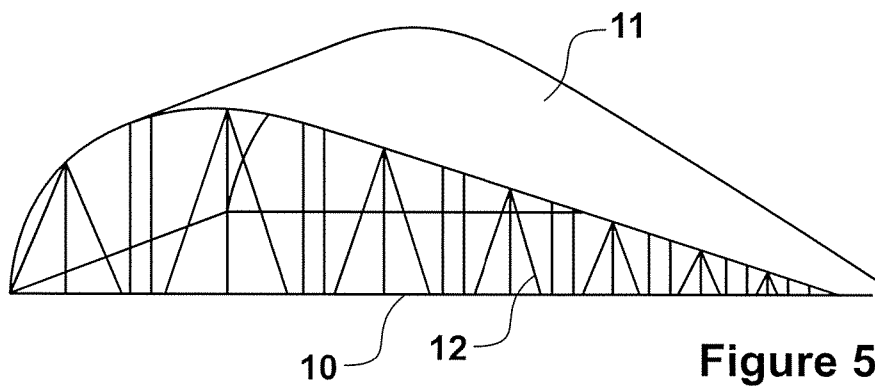


Figure 4

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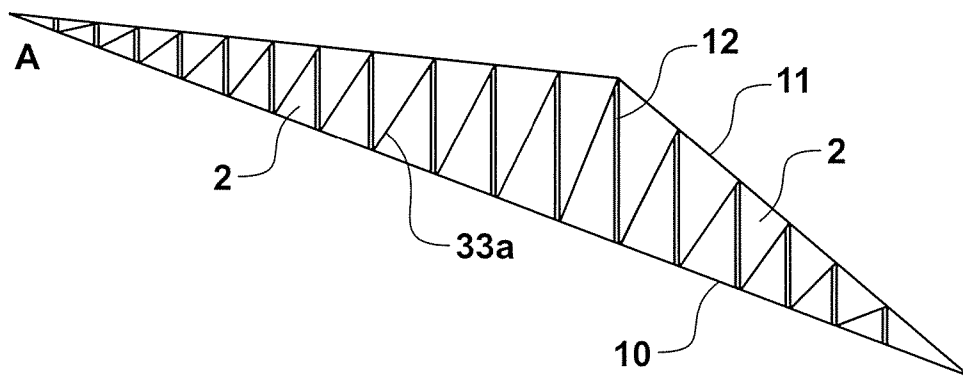


Figure 6

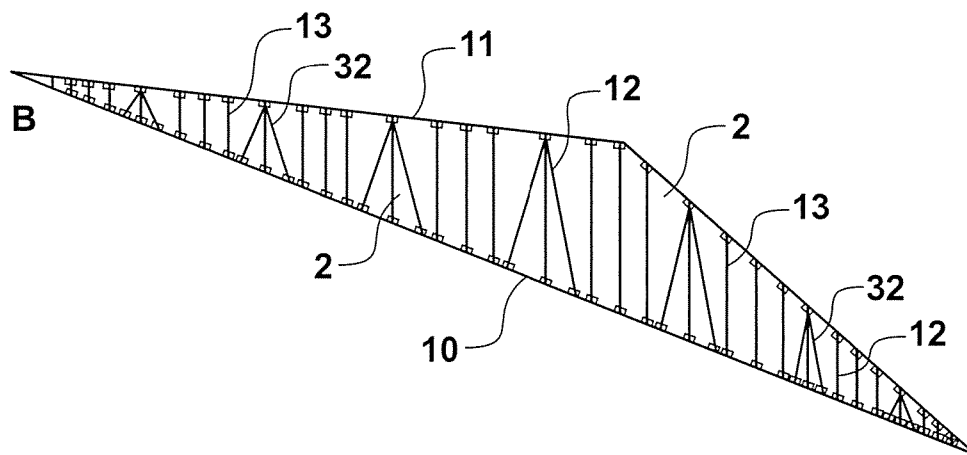


Figure 7

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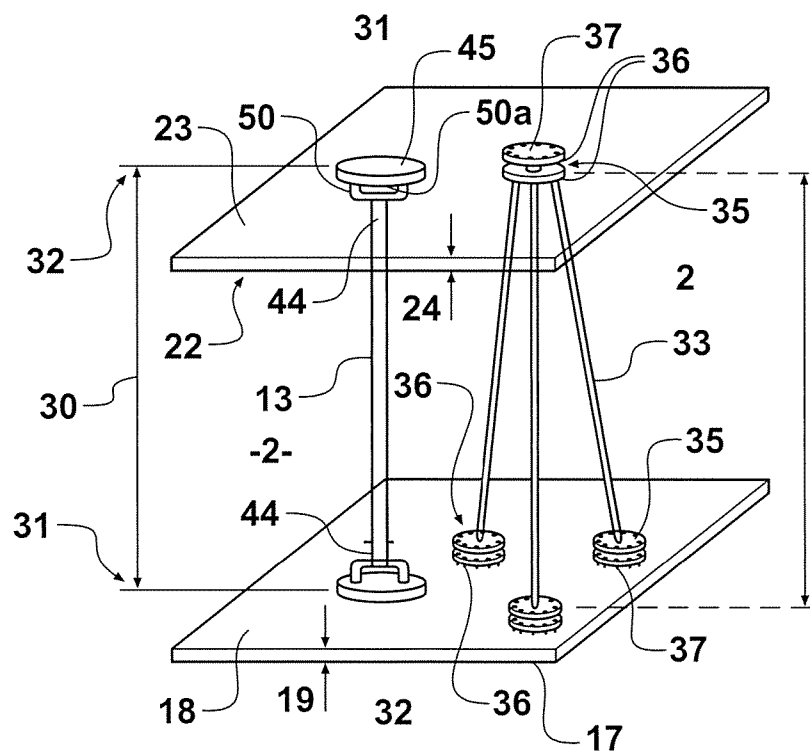


Figure 8

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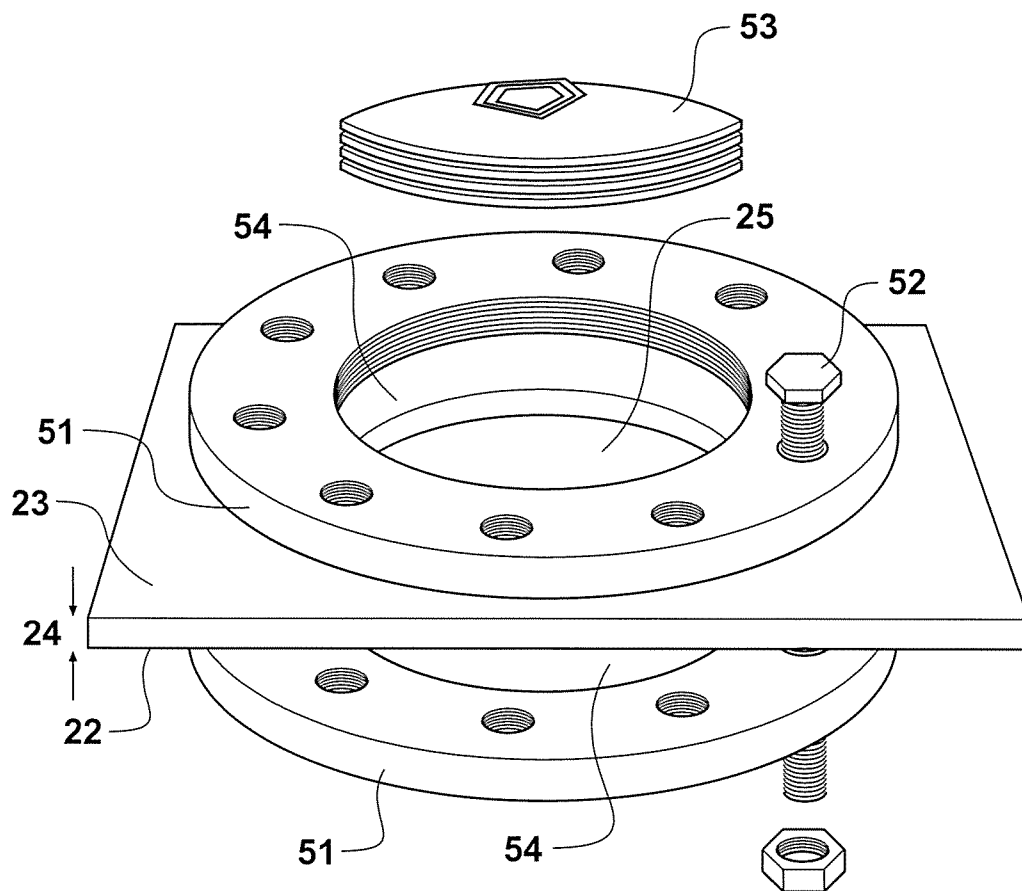
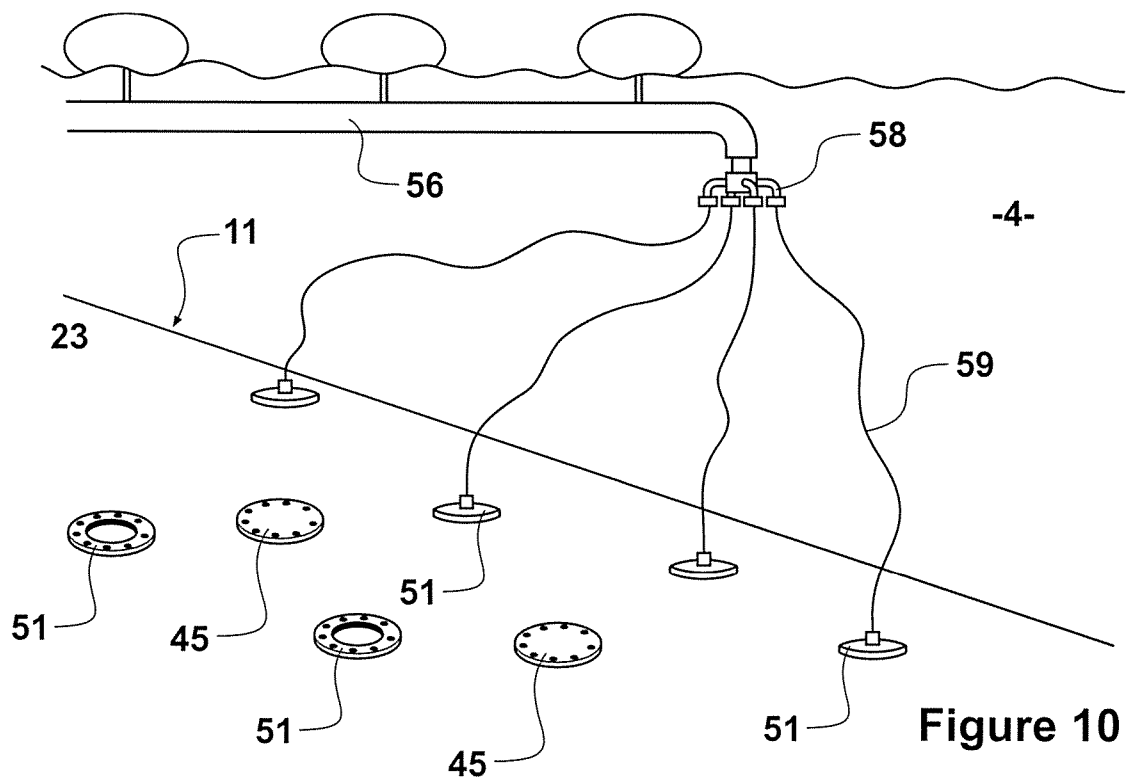


Figure 9



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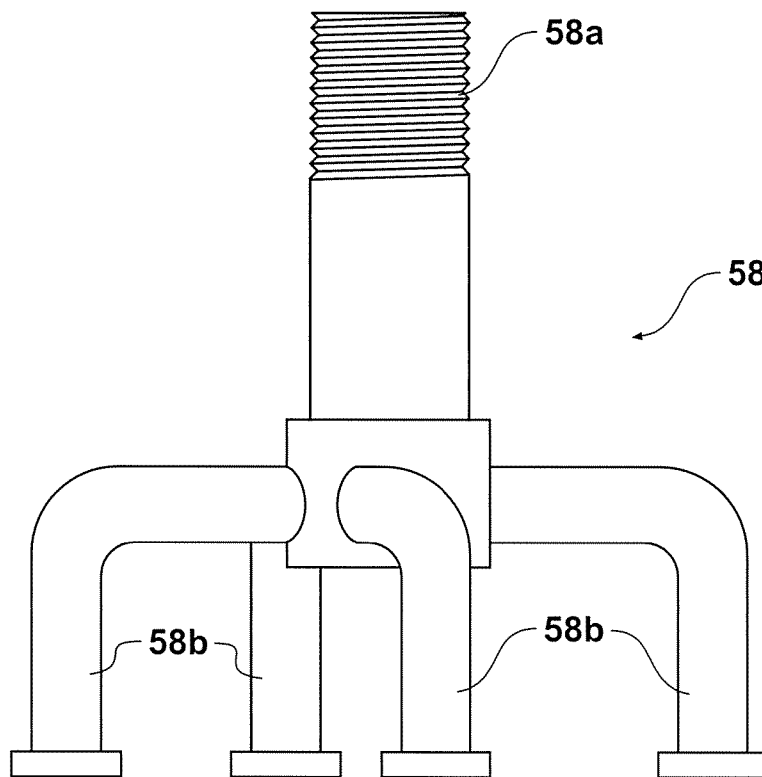


Figure 11

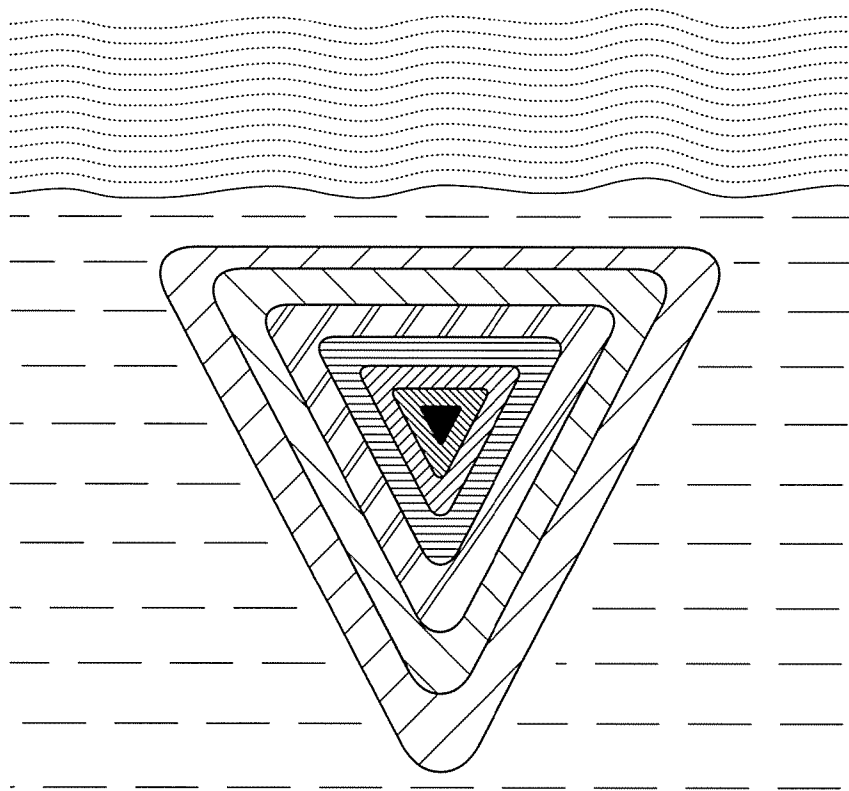


Figure 12

INTERNATIONAL SEARCH REPORT

 International application No.
PCT/NZ2017/050008

A. CLASSIFICATION OF SUBJECT MATTER

E02B 3/04 (2006.01)

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)

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 practicable, search terms used)

PATENW: /IC/CC OR E02B3/04/low, E02B3/046, A01K61/70/low & Keywords (compartment, valve, pour, frame, float) and similar terms and/or combinations

Google Patent & Keywords: (Artificial, reef, barrier, compartment, inlet, rib, float) and similar terms and/or combinations

Applicant/Inventor searched using both internal (provided by IP Australia) and external (Google Patent, Espacenet, AUSPAT) databases: Black, Kerry Peter; Artificial surf reefs limited

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
	Documents are listed in the continuation of Box C	



Further documents are listed in the continuation of Box C



See patent family annex

* "A"	Special categories of cited documents: document defining the general state of the art which is not considered to be of particular relevance	"T"	later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"E"	earlier application or patent but published on or after the international filing date	"X"	document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"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)	"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
"O"	document referring to an oral disclosure, use, exhibition or other means	"&"	document member of the same patent family
"P"	document published prior to the international filing date but later than the priority date claimed		

Date of the actual completion of the international search 31 May 2017	Date of mailing of the international search report 31 May 2017
Name and mailing address of the ISA/AU AUSTRALIAN PATENT OFFICE PO BOX 200, WODEN ACT 2606, AUSTRALIA Email address: pct@ipaustalia.gov.au	Authorised officer Aditya Angadi AUSTRALIAN PATENT OFFICE (ISO 9001 Quality Certified Service) Telephone No. 0399359624

INTERNATIONAL SEARCH REPORT		International application No.
C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		PCT/NZ2017/050008
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 2006/094552 A1 (DMS V.O.F.) 14 September 2006 figures 1-13, abstract, page 1 lines 1-7, page 4 lines 21-35, page 6 lines 1-10, page 7 lines 1-25, page 8 lines 27-29	1-22
X	US 5040919 A (HENRIX) 20 August 1991 figures 1-5, abstract, column 2 line 60 – column 3 line 21, column 3 lines 55-63, column 4 lines 10-17	1-22
X	AU 2012258446 A1 (KAYE RATCLIFFE) 20 June 2013 figures 1-6, abstract, page 3 lines 28-33, page 4 line 1 – page 5 line 38	1-22
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X	US 2007/0154264 A1 (BARUH) 05 July 2007 figures 1-9, abstract, paragraphs [0030], [0050]	1-5
X	US 2015/0110558 A1 (MCKENZIE) 23 April 2015 figures 1-33, abstract, paragraphs [0073], [0129]-[0130]	1-22

Form PCT/ISA/210 (fifth sheet) (July 2009)

INTERNATIONAL SEARCH REPORT		International application No.	
Information on patent family members		PCT/NZ2017/050008	
This Annex lists known patent family members relating to the patent documents cited in the above-mentioned international search report. The Australian Patent Office is in no way liable for these particulars which are merely given for the purpose of information.			
Patent Document/s Cited in Search Report		Patent Family Member/s	
Publication Number	Publication Date	Publication Number	Publication Date
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		CA 2872321 A1	07 Nov 2013
		WO 2013163763 A1	07 Nov 2013
End of Annex			