

A SYSTEM FOR ENHANCING HARD COASTAL STRUCTURE USING BIOLOGICAL COMPONENTS

The present application relates to a shoreline or coastal
5 structure. In particular, the patent application relates to a shoreline protection structure that provides a habitat for marine organisms.

The shoreline structure may be a seawall or revetment. The
10 seawall is often a vertical shoreline structure at a transition between the sea and a mainland. The revetment is often a shoreline structure, which slopes down from a mainland to the sea. Seawalls and revetments are commonly used as foreshore protection structures in estuaries, ports, and coastal areas
15 for bank protection and earth retention to prevent inundation of low-lying areas. Seawalls and revetments are often constructed using, for examples, dry block stones, cast-in-situ concrete, and/or precast concrete blocks to form hard coastal structures.

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Presently, some hard coastal structures are fixed with marine tiles to allow intertidal organisms to colonize. Other hard coastal structures include reef balls which sit on a seabed. The reef balls form a solid structure to allow corals and
25 other marine organisms to attach to and to allow reef fish to hide within.

CN106120651A discloses a revetment. The revetment includes a plurality of revetment blocks. Each revetment block includes
30 grooves that are conditioned for growing plants. The revetment block is connected to a pile, which is embedded into the revetment.

It is an object of this application to provide an improved hard coastal structure for protection of a shoreline and for providing habitats for marine life.

- 5 The application provides a shoreline structure assembly. The shoreline structure assembly comprises a shoreline concrete structure and a marine eco-friendly structure assembly, which is connected to the shoreline concrete structure. The shoreline concrete structure often refers to foreshore concrete
- 10 structures that are constructed for shoreline protection and earth retention. The marine eco-friendly structure assembly has environmentally friendly features that are suitable to conserve marine life or organisms. The environmentally friendly features provide one or more habitats that are conducive for settlement and growth of marine organisms. The marine
- 15 eco-friendly structure assembly is also called marine eco-friendly shoreline protection device.

- The marine eco-friendly structure assembly comprises a holding
- 20 device for providing a habitat for marine organisms. It also includes a holding device supporting structure for positioning the holding device at a predetermined position. The holding device supporting structure and the holding device are adapted in that they are suitable for being submerged in water. The
- 25 design and/or the material of the holding device supporting structure and of the holding device allows them to withstand water. This means that they can last a long period in water without disintegrating.

- 30 The holding device comprises one or more carrier for holding sediment or substrate that is suitable for settlement and growth of marine organisms. Examples of sediment are sands, mud, gravel, cobbles, granules, pebbles. The sediment is often

purposefully selected to attract targeted marine organisms to settle and grow.

5 The holding device supporting structure comprises a horizontal supporting member for holding the carrier. The horizontal supporting member is connected to the shoreline concrete structure. The holding device supporting structure further comprises an inclined supporting member that is integrally connected to the horizontal supporting member. The inclined supporting member is connected to the shoreline concrete structure.
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The shoreline structure assembly improves biodiversity around the shoreline concrete structure by providing varying habitats for different marine organisms. This allows capturing of carbon by the marine organisms. The shoreline structure assembly also reduces water wave overtopping at the shoreline, thereby preventing coastal flooding and enhancing stability of the shoreline against erosion.
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20 In one implementation, the sediment carrier includes a container, which often has a shape of a box. In another implementation, the sediment carrier comprises a platform, which has a substantially flat surface.

25 The holding device supporting structure can be made of precast concrete. This allows the holding device supporting structure to be prefabricated in factory and connected to the shoreline concrete structure on site. This improves the efficiency of the construction of the shoreline structure assembly.
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In one implementation, the marine eco-friendly structure assembly comprises a water wave blocking device for connecting to the holding device supporting structure. The water wave

blocking device acts to reduce water wave run-up, thereby preventing the shoreline from erosion. The water wave blocking device is also called water wave blocking ledge. The water wave blocking ledge is also a security barrier to disallow any
5 intrusion or berthing of small vessels.

The horizontal supporting member can be connected to the shoreline concrete structure with one or more anchor bolts. The inclined supporting member can be connected to the shoreline concrete structure with one or more piles. The anchor
10 bolts and piles are driven into and embedded into the shoreline concrete structure. This fixedly secures the marine eco-friendly structure assembly to the shoreline concrete structure at a predetermined position.

15 The holding device can further comprise a biodegradable mesh. The mesh acts to stabilize or hold the sediment together, thereby preventing the sediment from being dispersed.

20 The horizontal supporting member can comprise a connector for connecting to a steel cable. The steel cable is often connected to a bollard. The connector acts to prevent the marine eco-friendly structure assembly from moving away from the predetermined position on the shoreline concrete structure.

25 In one implementation, the shoreline concrete structure comprises an inclined revetment. In another implementation, the shoreline concrete structure comprises a substantially vertical seawall.

30 The application also provides a marine eco-friendly structure assembly for being attached to a shoreline concrete structure.

The marine eco-friendly structure assembly comprises a holding device for providing a habitat for marine organisms. It also includes a holding device supporting structure for positioning the holding device at a predetermined position.

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The holding device comprises one or more carriers for holding sediment that is suitable for settlement and growth of marine organisms. The sediment is often purposefully selected to attract targeted marine organisms to settle and grow.

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The holding device supporting structure comprises a horizontal supporting member for holding the sediment carrier and for connecting to the shoreline concrete structure. The holding device supporting structure further comprises an inclined supporting member that is integrally connected to the horizontal supporting member for connecting to the shoreline concrete structure.

The marine eco-friendly structure assembly is simple and can be efficiently constructed and assembled. It improves biodiversity around the shoreline concrete structure and allows capturing of carbon.

In one implementation, the sediment carrier includes a container. In another implementation, the sediment carrier comprises a platform.

The holding device supporting structure can be made of precast concrete.

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In one implementation, the marine eco-friendly structure assembly comprises a water wave blocking device.

The horizontal supporting member can be provided to connect the shoreline concrete structure with one or more anchor bolts. The inclined supporting member can be provided to connect the shoreline concrete structure with one or more piles.

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The holding device can further comprise a biodegradable mesh for stabilizing the sediment.

The horizontal supporting member can comprise a connector for
10 connecting to a steel cable.

Fig. 1 illustrates a coastal structure with a marine eco-friendly shoreline protection device,

Fig. 2 illustrates a variant of the shoreline protection
15 device of the coastal structure of Fig. 1,

Fig. 3 illustrates another coastal structure with a marine eco-friendly shoreline protection device, which is a variant of the shoreline protection device of Fig. 1, and

20 Fig. 4 illustrates a variant of the shoreline protection device of the coastal structure of Fig. 3.

In the following description, details are provided to describe embodiments of the application. It shall be apparent to
25 one skilled in the art, however, that the embodiments may be practiced without such details.

Some parts of the embodiment have similar parts. The similar parts may have the same names or similar part numbers. The description of one similar part also applies by reference to another similar parts, where appropriate, thereby reducing repetition of text without limiting the disclosure.
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Fig. 1 shows a first coastal or shoreline structure. The first coastal structure 1 includes an inclined or sloping revetment 5 and a marine eco-friendly shoreline protection device 8, which is connected to the revetment 5. The shoreline protection device 8 is essentially submerged below a water surface 10 near a beach.

The sloping revetment 5 is made of block stones and concrete. It slopes down from a mainland to a beach.

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The marine eco-friendly shoreline protection device 8 includes a container supporting structure 12, a container 15 or platform, and a water wave blocking or returning ledge 18. The container 15 is placed on or connected to the container supporting structure 12 while the wave blocking ledge 18 is connected to the container supporting structure 12.

The supporting structure 12 is constructed using precast concrete. The precast concrete includes steel wire mesh and steel reinforcement bar. The precast concrete can withstand high physical forces arising from extreme waves and high-speed ocean currents. It includes a horizontal support member 22, a substantially vertical support member 25, and a connector 28. The horizontal support member 22 is integrally connected to the substantially vertical support member 25 such that the horizontal support member 22 is substantially perpendicular to the vertical support member 25. The horizontal support member 22 and the vertical support member 25 are respectively connected to the revetment 5. In detail, a first end portion of the horizontal support member 22 is connected to a major surface of the revetment 5 with, for example, one or more anchor bolts 32 or wall anchors 32. A second end portion of the horizontal support member 22 is integrally connected to a first end portion of the vertical support member 25. A second end

portion of the vertical support member 25 is connected to the major surface of the revetment 5 with one or more piles 35.

5 The connector 28 is mounted on the second end portion of the horizontal support member 22. The connector 28 is connected to a steel cable 38 or rope that is connected to a bollard 42 that is located on the mainland near the revetment 5. In another implementation, the connector 28 is mounted on the vertical support member 25.

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The container 15 is made of plastic, such as biodegradable starch-based plastic. It is dimensioned such that the container 15 is stably placed on the horizontal support member 22. In addition, a first edge portion of the container 15 is also supported or is attached to the major surface of the re-
15 vetment 5. A second edge portion of the container 15, which is opposite the first edge portion, is supported or attached to a part of the horizontal support member 22. Put differently, the revetment 5 and the horizontal support member 22 jointly bear
20 the weight of the container 15.

The container 15 is filled with sediment or substrate. The sediment includes soft and/or hard sediment. A biodegradable starch-based plastic mesh is placed on top of the substrate.
25 For simplicity, the mesh is not shown in Fig. 1. The substrate is selected such that it is suitable for growing selected marine organisms, which include seagrass, mangroves, corals, filter feeders, and associated fish communities. The container 15 is positioned at a predetermined water depth and it is positioned to allow marine organisms to be naturally introduced
30 into the container 15 from the sea. This also allows the marine organisms to receive substantial sunlight for growth.

The water wave blocking ledge 18 is connected to the second end portion of the horizontal support member 22.

5 In use, the revetment 5 acts to dissipate energy of incoming water from the sea, thereby preserving existing shoreline and its slope.

10 The container 15 is used to hold the sediment. The mesh in the container 15 serves to hold the sediment together, thereby stabilizing the sediment. The stabilized sediment is not easily dispersed, and it provides a stable habitat for marine organisms. The stabilized sediment acts to reduce the risk of strong currents or waves detaching the planted seagrass or mangroves from the sediment. This can enhance natural settle-
15 ment and growth of seagrass seeds and fragments as well as mangrove propagules to the shore.

20 The container supporting structure 12 is intended for providing structural support for the container 15 and for positioning the container 15 at the predetermined water depth. The container supporting structure 12 also acts to absorb and dissipate energy of incoming sea waves to maintain a stable support for the container 15. This provides safe habitats for the marine organisms to grow.

25 The pile 35 is used for supporting a weight of the supporting structure, and for securing the supporting structure to the revetment 5 at a predetermined position. This prevents the supporting structure from moving on the revetment 5.

30 The connector 28 is used for securing the container supporting structure 12 to a predetermined position.

The water wave blocking ledge 18 serves to reduce water wave run-up, which is the maximum vertical extent of wave uprush above the still water level of the sea. This can protect soft substrate of the shoreline from erosion. The water wave blocking ledge 18 acts as a security barrier to disallow any intrusion or berthing of small vessels.

The marine eco-friendly shoreline protection device 8 provides several benefits.

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The marine eco-friendly shoreline protection device 8 reduces loss of coastal habitats due to coastal development comprising construction of hard coastal structures. The hard coastal structures are often constructed in areas that are previously provided with inter-tidal and sub-tidal habitats for a wide range of marine life. The marine life includes various species of seagrass, mangroves, corals, filter feeders, as well as associated fish and invertebrate communities, such as crabs, shrimp, clams, and oysters. These habitats are permanently lost due to the construction of the hard coastal structures. The water depth is generally too deep to allow the marine organisms to grow again along the seaward side of the hard coastal structures. The marine eco-friendly shoreline protection device provides new habitats to replace the habitats that have been lost. The new habitats are provided at water depths that are optimal to recruit or attract targeted marine life to settle and grow. In short, the habitat that is lost can be recreated along the seaward side of the hard coastal structure. This will restore at least part of the ecological function and ecosystem services provided by the lost habitat.

The marine eco-friendly shoreline protection device 8 also improves biodiversity around a hard coastal structure. The hard coastal structure may provide some new habitats for marine

life such as corals and filter feeders, which need a hard substrate to settle on. However, the hard coastal structure often uses grouting to create a smooth major surface on the hard coastal structure. This reduces complexity of the substrate, and limits available space for corals and filter feeders. The marine eco-friendly shoreline protection device 8 provides structures that form a more diverse habitat. The habitat includes platforms and containers with soft sediment that is suitable for seagrass, mangroves and other associated flora and fauna, which cannot grow on the hard coastal structure.

The marine eco-friendly shoreline protection device 8 further widens areas with optimal light regime for growth of marine organisms on the hard coastal structure. The hard coastal structure is often built with either a vertical wall, or a slope. The amount of sunlight available for the growth of marine life decreases quickly as the water depth increases. Only a small area of the hard coastal structure is within a water depth that is optimal for growth. The marine eco-friendly shoreline protection device 8 provides structures with platforms and containers. The platforms and containers are positioned within an optimal growth zone for targeted marine life. This greatly increases spatial extent of newly provided soft and hard substrates for the targeted marine life.

The marine eco-friendly shoreline protection device 8 also reduces coastal flooding and erosion due to wave overtopping at the hard coastal structure. The hard coastal structure, particularly a sloped revetment or a vertical seawall, provides a runoff or ramp for incoming waves. This leads to waves overtopping the coastal structure, causing coastal flooding and erosion. The flooding and erosion may affect stability of the shoreline. The marine eco-friendly shoreline protection device 8 provides habitats for marine life, which can reduce energy

of incoming waves. This also prevents wave runup and overtopping at hinterland.

The marine eco-friendly shoreline protection device 8 also increases capturing of blue carbon. The blue carbon refers to marine vegetation such as seagrass and mangroves, which capture and store atmospheric carbon that causes climate change. The shoreline protection device 8 can provide habitats for the marine vegetation and achieve net zero greenhouse gas emissions from constructing the hard coastal structure. This is better than buying emission or carbon credits to offset the greenhouse gas emissions in the construction of the hard coastal structure.

In summary, the marine eco-friendly shoreline protection device 8 improves biodiversity in areas around the hard coastal structure. The shoreline protection device 8 allows forming of new habitats, which are designed and constructed at predetermined water depths that are suitable to allow natural recruitment and growth of selected marine organisms.

The marine eco-friendly shoreline protection device 8 also increases capturing of carbon to achieve substantially net zero greenhouse gas emissions for construction of the hard coastal structure.

Furthermore, the marine eco-friendly shoreline protection device 8 reduces water wave overtopping at the hard coastal structure, thereby avoiding or minimizing coastal flooding and enhancing stability of the shoreline against erosion.

The marine eco-friendly shoreline protection device 8 also improves conservation, aesthetics, and ecosystem around the hard coastal structure.

Different implementations of the marine eco-friendly shoreline protection device 8 are possible.

5 Fig. 2 shows a second coastal structure 1a with a marine eco-friendly shoreline protection device 8a, which is a variant of the shoreline protection device 8. The shoreline protection device 8a includes a container supporting structure 12a, which includes a corbel 52. The corbel 52 has a shape of a triangular prism. The corbel 52 includes a first triangular surface 10 55, a second triangular surface 56, a first rectangular surface 58, a second rectangular surface 62, and a third rectangular surface 65. First short edges of the rectangular surfaces 58, 62, 65 are respectively connected to corresponding edges of the first triangular surface 55. Second short edges 15 of the rectangular surfaces 58, 62, 65, which are opposite the first short edges of the rectangular surfaces 58, 62, 65, are respectively connected to corresponding edges of the second triangular surface 56. The first rectangular surface 58 is 20 connected to the major surface of a revetment 5.

The shoreline protection device 8a further includes a container 15a. The container 15a is placed against the revetment 5 and against the corbel 52. A first edge portion of the container 15a is supported by the major surface of the inclined 25 revetment 5. A second edge portion of the container 15a is supported by the second rectangular surface 62 of the corbel 52.

30 Fig. 3 shows a third coastal structure 1b, which is a variant of the first coastal structure 1. The coastal structure 1b includes an essentially vertical seawall 68 and a marine eco-friendly shoreline protection device 8b, which is connected to the seawall 68.

The marine eco-friendly shoreline protection device 8b includes a container supporting structure 12b and a container 15b, which is placed on the container supporting structure 12b. The container supporting structure 12b includes a horizontal support member 22b and an inclined support member 72. A first end portion of the horizontal support member 22b is integrally connected to a first end portion of the inclined support member 72 such that the inclined support member 72 is inclined with respect to the horizontal support member 22b with a predetermined angle. A second end portion of the horizontal support member 22b and a second end portion of the inclined support member 72 are respectively connected to the seawall 68 with anchor bolts. The container 15b is located on the horizontal support member 22b.

The shoreline protection device 8b further includes parts that are similar to the parts of the shoreline protection device 8 of the first coastal structure 1 mentioned above.

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Fig. 4 shows a third coastal structure 1c with a shoreline protection device 8c, which is a variant of the shoreline protection device 8b. The shoreline protection device 8c includes a container 15c. The container 15c is filled with sediment to form a habitat with a slope. This habitat is suitable for growing seagrass and mangroves together. The slope provides different levels of inundation during high tides for different mangrove species to grow.

30 In one embodiment, the shoreline protection device 8 includes a plurality of containers 15. The containers 15 are filled with a variety of sediment or substrate to provide different habitats for varying marine organisms, such as seagrass, mangroves and/or corals. This allows increased biodiversity.

- In a special embodiment, the coastal structure 1 further includes surface units, which are made from concrete, metal, or plastics. The surface units increase complexity of hard substrate of the coastal structure 1, which is suitable for settlement and growth of coral and invertebrate larvae. In particular, the surface units include gaps or pores of various sizes to provide microhabitats for larvae.
- 10 In another embodiment, the horizontal support member 22 is connected to the vertical support member 25 or to the inclined support member 72 with a fastening means, such as bolt and nut mechanism.
- 15 In a further embodiment, the supporting structure 12 is made of steel. The horizontal support member 22 is connected to the vertical support member 25 or to the inclined support member 72 using welding.
- 20 Although the above description contains much specificity, this should not be construed as limiting the scope of the embodiments but merely providing illustration of the foreseeable embodiments. The above-stated advantages of the embodiments should not be construed especially as limiting the scope of
- 25 the embodiments but merely to explain possible achievements if the described embodiments are put into practice. Thus, the scope of the embodiments should be determined by the claims and their equivalents, rather than by the examples given.

REFERENCE NUMBERS

	1	coastal structure
	1a	coastal structure
5	1b	coastal structure
	1c	coastal structure
	5	revetment
	8	marine eco-friendly shoreline protection device
	8a	marine eco-friendly shoreline protection device
10	8b	marine eco-friendly shoreline protection device
	8c	marine eco-friendly shoreline protection device
	10	wafer surface
	12	container supporting structure
	12a	container supporting structure
15	12b	container supporting structure
	12c	container supporting structure
	15	container
	15a	container
	15b	container
20	15c	container
	18	water wave blocking ledge
	22	horizontal support member
	22a	horizontal support member
	22b	horizontal support member
25	22c	horizontal support member
	25	vertical support member
	28	connector
	32	anchor bolt
	35	pile
30	38	cable
	42	bollard
	52	corbel
	55	first triangular face
	56	second triangular face

	58	first rectangular face
	62	second rectangular face
	65	third rectangular face
	68	seawall
5	72	inclined support member

CLAIMS

1. A shoreline structure assembly comprising
 - a shoreline concrete structure and
 - 5 - a marine eco-friendly structure assembly being connected to the shoreline concrete structure, wherein the marine eco-friendly structure assembly comprises
 - a holding device for providing a habitat for ma-
 - 10 rine organisms, and
 - a holding device supporting structure for positioning the holding device at a predetermined position,wherein the holding device comprises
 - 15 - at least one carrier for holding sediment,wherein the holding device supporting structure comprises
 - a horizontal supporting member for holding the carrier, the horizontal supporting member being connected to the shoreline concrete structure, and
 - 20 - an inclined supporting member that is integrally connected to the horizontal supporting member, the inclined supporting member being connected to the shoreline concrete structure.
- 25 2. The shoreline structure assembly according to claim 1, wherein the carrier comprises a container.
- 30 3. The shoreline structure assembly according to claim 1, wherein the carrier comprises a platform.
4. The shoreline structure assembly according to one of the above-mentioned claims, wherein

the holding device supporting structure is made of pre-cast concrete.

5. The shoreline structure assembly according to one of the
5 above-mentioned claims further comprising
a water wave blocking device.
6. The shoreline structure assembly according to one of the
above-mentioned claims, wherein
10 the horizontal supporting member is connected to the
shoreline concrete structure with at least one anchor
bolt.
7. The shoreline structure assembly according to one of the
15 above-mentioned claims, wherein
the inclined supporting member is connected to the shoreline
concrete structure with at least one pile.
8. The shoreline structure assembly according to one of the
20 above-mentioned claims, wherein
the holding device further comprises a biodegradable mesh
for stabilizing the sediment.
9. The shoreline structure assembly according to one of the
25 above-mentioned claims, wherein
the horizontal supporting member comprises a connector
for connecting to a cable.
10. The shoreline structure assembly according to one of the
30 above-mentioned claims, wherein
the shoreline concrete structure comprises an inclined
revetment.

11. The shoreline structure assembly according to one of claims 1 to 9, wherein the shoreline concrete structure comprises a substantially vertical seawall.
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12. A marine eco-friendly structure assembly for being attached to a shoreline concrete structure, the marine eco-friendly structure assembly comprising
- a holding device for providing a habitat for marine organisms, and
 - a holding device supporting structure for positioning the holding device at a predetermined position,
- 10
- wherein the holding device comprises
- at least one carrier for holding sediment,
- 15
- wherein the holding device supporting structure comprises
- a horizontal supporting member for holding the carrier and for connecting to the shoreline concrete structure, and
 - an inclined supporting member that is integrally connected to the horizontal supporting member for connecting to the shoreline concrete structure.
- 20
13. The marine eco-friendly structure assembly according to claim 12, wherein the carrier comprises a container.
- 25
14. The marine eco-friendly structure assembly according to claim 12, wherein the carrier comprises a platform.
- 30
15. The marine eco-friendly structure assembly according to one of claims 12 to 14, wherein

the holding device supporting structure is made of pre-cast concrete.

16. The marine eco-friendly structure assembly according to
5 one of claims 12 to 15 further comprising
a water wave blocking device.
17. The marine eco-friendly structure assembly according to
one of claims 12 to 16, wherein
10 the horizontal supporting member is provided to connect
the shoreline concrete structure with at least one anchor
bolt.
18. The marine eco-friendly structure assembly according to
15 one of claims 12 to 17, wherein
the inclined supporting member is provided to connect to
the shoreline concrete structure with at least one pile.
19. The marine eco-friendly structure assembly according to
20 one of claims 12 to 18, wherein
the holding device further comprises a biodegradable mesh
for stabilizing the sediment.
20. The marine eco-friendly structure assembly according to
25 one of claims 12 to 19, wherein
the horizontal supporting member comprises a connector
for connecting to a cable.