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(54) Method for protecting coasts and the like

(57) The invention relates to a method for protecting coasts and the like against the effects of a higher average low-water line. The method comprises of raising one or more existing sandbanks located off the coast. In a preferred embodiment at least one sandbank is raised periodically depending on the low-water line. The method provides at least equivalent protection as the known water barrier without existing infrastructure on land in some cases having to be modified or demolished.

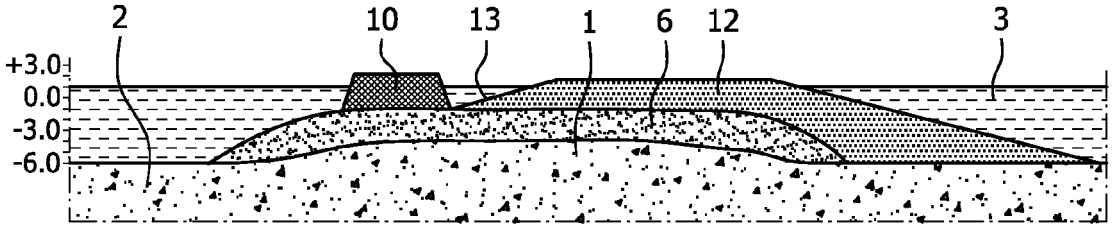

FIG. 1D

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Description

[0001] The invention relates to a method for protecting coasts and the like against the effects of a higher average low-water line.

[0002] It is generally assumed that the sea level in determined parts of the world, and in particular in the North Sea areas, will rise significantly over the coming decades due to melting of the ice caps and other environmental influences. For low-lying areas, such as for instance for parts of Belgium and the Netherlands, this means an increased risk of flooding.

[0003] The expected rise in sea level over the coming years will result in a higher average low-water line. Within the context of this application low-water line is understood to mean the water level associated with the lowest water line. The low-water line is also known to the skilled person as the LAT ("Lowest Astronomical Tide"). The LAT is determined per location on the basis of astronomical predictions.

[0004] A known method for limiting the risk of flooding and for protecting coasts and the like against the effects of a higher average low-water line comprises of building additional and optionally higher water barriers on land and/or along rivers.

[0005] Although the known method has advantages, it also has drawbacks. In some cases the existing infrastructure on land must for instance be modified, or even demolished, in order to provide space for a new water barrier.

[0006] An object of the present invention is to provide a method for protecting coasts and the like against the effects of a higher average low-water line, wherein a protection is provided which is at least equivalent to the known water barrier and the above stated drawback, among others, can be obviated.

[0007] This object is achieved according to the invention by a method which comprises of raising one or more existing sandbanks located off the coast. By raising the existing sandbanks a simple but effective protection of the coast is obtained, which can moreover be adjusted in flexible manner subject to for instance the low-water line. It has been found that raising sandbanks located off the coast not only decreases the wave transmission over the sandbanks, but also reduces the average wave height on the coast side of the sandbanks by some percent. The method according to the invention is further found to reduce the period of the waves which reach the coast. This reduces erosion of the coast. By raising offshore sandbanks periodically, for instance annually, by only a few centimetres the adverse effects of a rise in sea level off the coast can be reduced, or even prevented.

[0008] The raising can in principle be carried out by pouring any type of material, although use is preferably made for this purpose of bed material, in particular sand and/or gravel and/or a combination of the two. Another advantage of the method according to the invention is that the bed material necessary for raising purposes can be supplied in simple and rapid manner. Although supply of the bed material necessary for raising the sandbanks can for instance take place by supplying this bed material, generally sand, by road, it is recommended that the bed material is dredged in the vicinity, and more preferably in the immediate vicinity, of the sandbanks. Dredging is a per se known technique and can for instance be performed using a suction hopper dredger. This comprises a drag head which, together with a suction pipe, is lowered under water at the rear of the suction hopper dredger until it makes contact with the bottom under the influence of its own weight. Through the movement of the suction hopper dredger the drag head is dragged over the ground for dredging, wherein the soil is loosened and suctioned away with water via the suction pipe. If desired, the suctioned bed material can be immediately transported via a transport conduit to the desired location, more particularly to the sandbanks to be raised.

[0009] In a preferred embodiment of the method according to the invention the part of the underwater bed which does not form part of the sandbank(s) is raised at least less than the sandbank(s), or even substantially not raised. Not raising or hardly raising the water bed lying between the sandbanks saves a considerable quantity of raising material. It has moreover been found that the improved coast protection also already occurs simply by raising the sandbank(s). The present preferred embodiment moreover prevents disruption to shipping, and the ebb and flood currents are left substantially undisturbed. Silting is hereby counteracted.

[0010] A further advantage of the invented method is that the coast protection as it were adapts itself to future rises in sea level in highly flexible manner. In this respect a preferred embodiment of the method according to the invention is characterized in that at least one sandbank is raised depending on the low-water line, and more preferably in proportion to the low-water line. In this way it is for instance possible to ensure that the average water depth at the position of the sandbanks at least does not increase with the rise in sea level.

[0011] It is further advantageous if the flow conditions at the location of the coast for protecting are not changed too much, for instance for ecological reasons. In order to achieve this the method is preferably characterized in that the at least one sandbank is raised periodically, and more preferably annually. Such a method ensures, among other things, that the raised sandbanks remain substantially stable. It is advantageous in this respect to characterize the method according to the invention in that the average annual raising of the at least one sandbank amounts to between 0.1 and 20 cm, more preferably between 0.2 and 10 cm, and most preferably between 0.2 and 5 cm.

[0012] The method according to the invention is not limited to raising the sandbank(s) to a determined height. It is thus possible to raise the sandbank(s) or a part of the sandbanks to a crest level which exceeds the low-water line. In such a case the crest of the raised sandbank

will protrude above the water surface at low water. In a preferred embodiment the at least one sandbank is raised to a crest level which reaches as maximum to the low-water line. Although the transmission of waves over a thus raised sandbank is greater than for a sandbank which has been raised above the low-water line, the average wave height on the coast side of the raised sandbank is not found to be appreciably affected.

[0013] The invention is based on the raising of existing sandbanks off a coastline. The existing sandbanks can here be situated any random distance from the coast. They can also have any size, wherein typical dimensions can be many (tens of) kilometres. A preferred embodiment of the method according to the invention is characterized in that the at least one sandbank lies at a distance from the coast which amounts to a maximum of 20 km, more preferably a maximum of 10 km, and most preferably a maximum of 5 km.

[0014] In a particularly suitable method according to the invention the raised entity is obtained by arranging a quarry stone water barrier on the side of a sandbank remote from the coast, raising the relevant sandbank to the desired height on the coast side thereof by pouring sand, and allowing the thus obtained sand body to acquire a natural incline on the side of the water barrier. The natural incline on the side of the water barrier is obtained by transmission of waves through the quarry stone water barrier. Such a water barrier is sufficiently water-permeable to make this possible. It is possible to once again remove the water barrier after the sand body has acquired the natural incline. It is also possible to keep the water barrier. A raised entity according to the present embodiment is stable and results in relatively little silting. If the water barrier is kept, the water barrier preferably comprises a protective layer of stones, concrete blocks and/or fibrous open stone asphalt. Fibrous open stone asphalt is described in, among others, European patent EP 0 344 141 B1, the content of which is incorporated in its entirety into the present application.

[0015] In the case the depth of the existing sandbank is insufficient, in a preferred embodiment the sandbank is raised with sand or other bed material to a level below the low-water line prior to arranging of the water barrier.

[0016] A further preferred embodiment of the method according to the invention is characterized in that the raised sandbanks are compacted. Compacting of the raised sandbanks can for instance be carried out by vibration or by pile-driving with a drop weight. It is also possible and advantageous to provide the raised sandbanks with grout columns for further stabilizing thereof.

[0017] The raised underwater bed can in principle be compacted to any desired saturated density. The saturated density is understood to mean the density of a volume of material which is substantially wholly saturated with water. It has been found advantageous for the raised sandbank to be compacted to a saturated density lying between 1.6 ton/m^3 and 2.3 ton/m^3, more preferably between 1.7 ton/m^3 and 2.2 ton/m^3, and most preferably between 1.9 ton/m^3 and 2.1 ton/m^3.

[0018] The invention will now be further elucidated with reference to the accompanying figures, without otherwise being limited thereto. In the figures:

figures 1A-1D show schematically a number of steps of an embodiment of the method according to the invention; and

figure 2 shows a schematic top view of a number of raised sandbanks according to the invention.

[0019] Referring to figures 1A-1D, an embodiment of the method according to the invention is shown. The method comprises of raising one or more existing sandbanks 1 located off the coast. Figure 1A shows an existing sandbank 1. Sandbank 1 comprises a sand body which is on average higher than underwater bed 2. The level of water mass 3 shown in figure 1A corresponds to the high-water line (in the shown example this is 3 m). According to the invention sandbank 1 is raised by pouring material such as sand or gravel onto sandbank 1 by means of a pontoon or ship 4 provided with a chute 5. This preferably takes place at high water, wherein the raising takes place to just below the low-water level (in the shown example this is 1 m). A raised entity 6 thus results which in the shown variant extends substantially only over the surface of existing sandbank 1. The part of underwater bed 2 not forming part of sandbank 1 is therefore substantially not raised.

[0020] In a subsequent step of the method shown in figure 1B, a water barrier 10 from a mass of quarry stone 9 is arranged on the side of sandbank 1 remote from the coast. Water barrier 10 is preferably provided with a protective layer of stones, concrete blocks and/or open stone asphalt. For the purpose of arranging water barrier 10 two pontoons (7, 8) are moved into the vicinity of sandbank 1. Pontoon 8 carries a mass of quarry stone 9, while pontoon 7 is provided with a crane 11 which moves quarry stone 9 from pontoon 8 onto raised entity 6 at the location where water barrier 10 must be placed.

[0021] In a subsequent step shown in figure 1C sandbank 1, and more particularly raised entity 6, is raised further to the desired height on the coast side of water barrier 10 (in the figure this is the right-hand side of water barrier 10) by pouring sand and/or gravel. A sand body 12 is thus created. In the shown exemplary embodiment the desired height of sand body 12 corresponds to a height which extends just beyond the low-water level. It is however also possible to raise to a level below the low-water level or, conversely, to a level just below, at or beyond the high-water level.

[0022] According to the present embodiment of the invention, a subsequent step comprises of allowing the thus obtained sand body 12 to acquire a natural incline 13 on the side of water barrier 10. This natural incline 13 can be brought about in that water barrier 10 is constructed from a mass of quarry stone 9. This ensures that water barrier 10 is to a certain extent permeable to water.

[0023] A sand body 12 obtained according to the above described method ensures a decreased average wave height at the coast, even in the case of a higher average low-water level due to a rise in sea level. It has also been found that the average period of the waves at the coast also decreases. This decrease has a particularly favourable influence on preventing coastal erosion.

[0024] A further advantage of the method according to the invention is that the obtained sand body 12 can be raised further in simple manner in the case of a rise in the water level. This preferably takes place depending on the low-water line, and more preferably in proportion to the low-water line. Sandbank 1, or sand body 12, is preferably raised periodically, for instance annually.

[0025] Figure 2 shows a schematic top view of a number of raised sandbanks 13-17 according to the invention. The raised sandbanks 13-17 lie off the Belgian coast 20, have a typical maximum dimension of 5-10 km, and are at some distance from each other. According to the invention the intermediate distances preferably do not become smaller, or hardly so, through raising the existing sandbanks. This ensures a natural flow at the position of the coastline, wherein ebb and flood currents can for instance continue to occur. In the example of figure 2 the overall distance over which the sandbanks extend (the distance between points A and B) amounts to about 70 km. The average shortest intermediate distance between the sandbanks therefore amounts to about 5 km.

[0026] Not all existing sandbanks lying off the coast need in principle be raised. It is sometimes advantageous to raise only some of the sandbanks that are present. Preferably raised are those sandbanks 1 situated at a distance from the coast of a maximum of 20 km, more preferably a maximum of 10 km, and most preferably a maximum of 5 km.

[0027] The amount of sand and/or gravel which must be poured periodically, in particular annually, can amount to several million m^3 and more per sandbank. If desired, this quantity of material can be dredged in the vicinity of the sandbanks to be raised. This avoids large quantities of sand or other bed material having to be stored. By allowing sandbanks 1 to as it were grow together with the rise in sea level as according to the invention, it is possible to prevent the erosive effect of the waves on the coast increasing as the sea level rises. In the shown example a raising of the sandbanks by 1 cm per year can accommodate a rise in sea level of 50 cm by 2050, and of 100 cm by 2100. In the case of a so-called super storm, which occurs once every 10,000 years, the average wave height of the waves behind the raised sandbanks 13-17 is reduced by 35% at high water and by 70% at low water, at least if the sandbanks are raised to a level of 1.5 m below the low-water line.

[0028] The invention is by no means limited to the above described exemplary embodiments, and many variants are possible within the scope of protection of the appended claims.

Claims

1. Method for protecting coasts and the like against the effects of a higher average low-water line, the method comprising of raising one or more existing sandbanks located off the coast.

2. Method as claimed in claim 1, **characterized in that** the part of the underwater bed which does not form part of the sandbank(s) is substantially not raised.

3. Method as claimed in claim 1 or 2, **characterized in that** at least one sandbank is raised conditional on the low-water line, and more preferably in proportion to the low-water line.

4. Method as claimed in any of the foregoing claims, **characterized in that** the at least one sandbank is raised periodically.

5. Method as claimed in claim 4, **characterized in that** the at least one sandbank is raised annually.

6. Method as claimed in claim 5, **characterized in that** the average annual raising of the at least one sandbank amounts to between 0.2 and 5 cm.

7. Method as claimed in any of the foregoing claims, **characterized in that** at least one sandbank is raised to a crest level which reaches at least to the low-water line.

8. Method as claimed in any of the foregoing claims, **characterized in that** the at least one sandbank lies at a distance from the coast which amounts to a maximum of 20 km, more preferably a maximum of 10 km, and most preferably a maximum of 5 km.

9. Method as claimed in any of the foregoing claims, **characterized in that** the raised entity is obtained by arranging a quarry stone water barrier on the side of a sandbank remote from the coast, raising the relevant sandbank to the desired height on the coast side thereof by pouring sand, and allowing the thus obtained sand body to acquire a natural incline on the side of the water barrier.

10. Method as claimed in claim 9, **characterized in that** the water barrier comprises a protective layer of stones, concrete blocks and/or open stone asphalt.

11. Method as claimed in claim 9 or 10, **characterized in that** the sandbank is raised with sand or other bed material to a level below the low-water line prior to arranging of the water barrier.

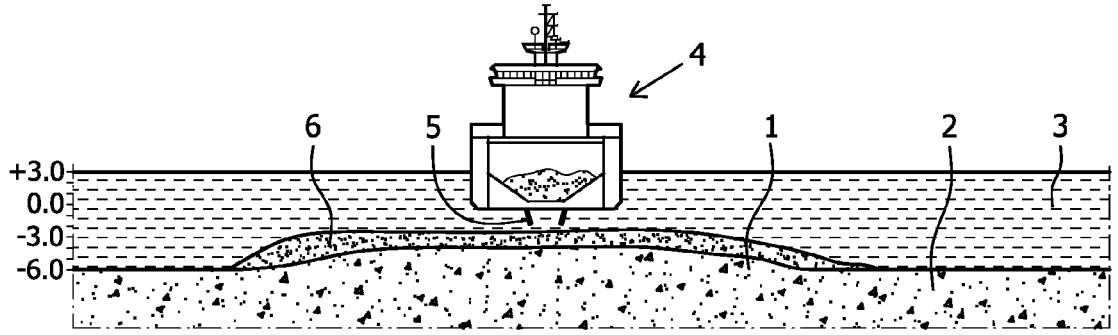

FIG. 1A

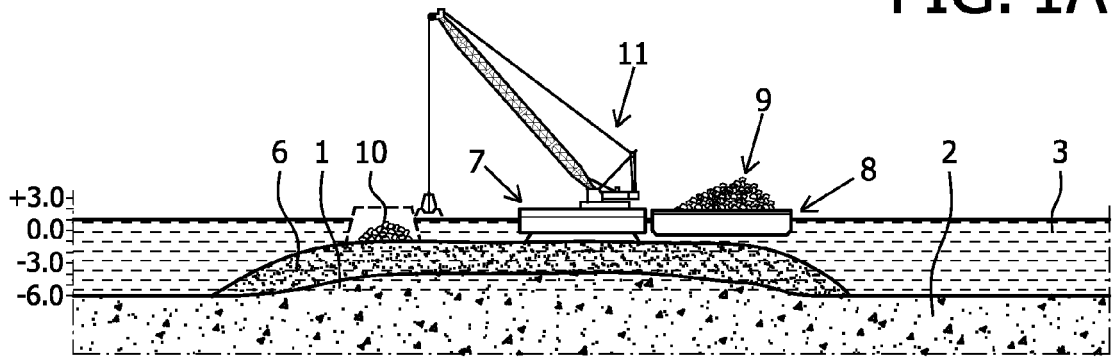

FIG. 1B

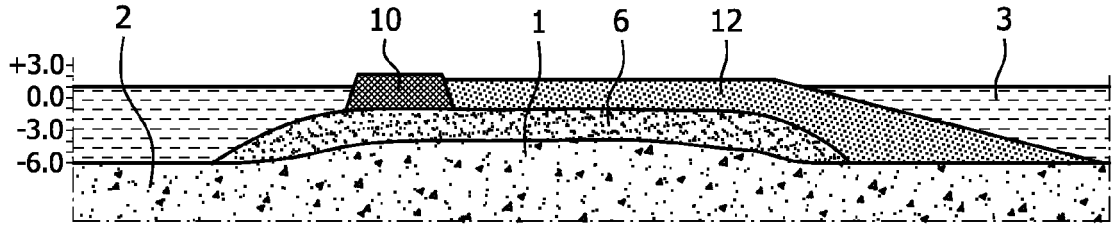

FIG. 1C

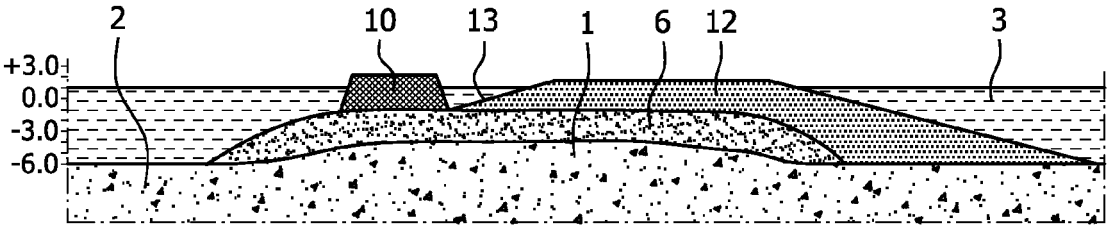

FIG. 1D

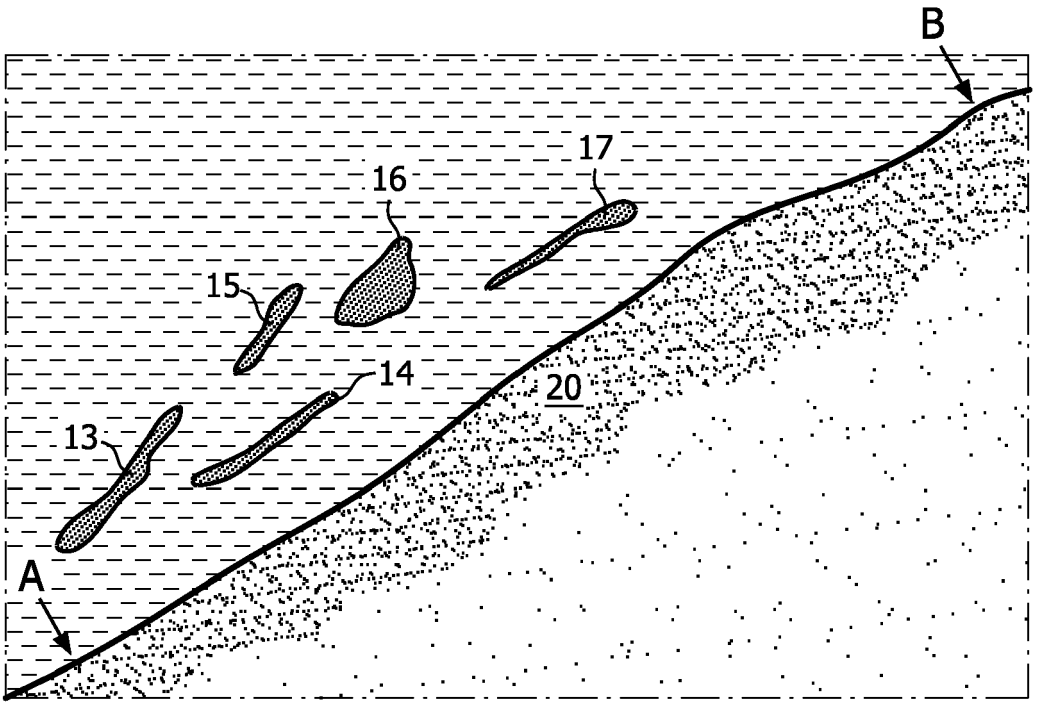

FIG. 2

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EUROPEAN SEARCH REPORT

Application Number
EP 09 17 2798

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X	US 3 564 853 A (CSISZAR ZOLTAN) 23 February 1971 (1971-02-23) * column 5, lines 29-38,47-52; figures 1,2 * -----	1,2,4	INV. E02B3/04
X	US 4 367 978 A (SCHAAF CECIL [US] ET AL) 11 January 1983 (1983-01-11) * column 5, lines 29-32; figure 1 * -----	1,2,10	
A	DE 35 03 031 A1 (HOYER ERICH [DE]) 31 July 1986 (1986-07-31) * page 8, paragraph 2 * -----	1	

TECHNICAL FIELDS SEARCHED (IPC)

E02B

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
Munich	22 February 2010	Leher, Valentina

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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EPO FORM 1503 03.82 (P04C01)

ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO. EP 09 17 2798

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report. The members are as contained in the European Patent Office EDP file on
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22-02-2010

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 3564853 A	23-02-1971	NONE	
US 4367978 A	11-01-1983	NONE	
DE 3503031 A1	31-07-1986	NONE	

EPO FORM P0459

For more details about this annex : see Official Journal of the European Patent Office, No. 12/82

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- EP 0344141 B1 **[0014]**