of the body portion or the plough share may be rotatable relative to body portion (otherwise termed the plough beam). However, the additional functionality provided by such solutions increase the cost, weight and complexity of the plough. Furthermore, the additional complexity may introduce potential failure points within the underwater plough.

Despite the additional complexity, an articulating bell mouth is beneficial in a number of ways. For example the product cable can be followed, for example by lowering the bell mouth, to reduce the chance of loop formation under the underwater plough in operation. In addition, the bell mouth can be raised during deployment and recovery to ensure the cable wrap angle through the plough is minimised to avoid difficulties with slack and residual cable tension in the ground and increased product contact loading.

It is an aim of the present invention to provide an improved underwater plough that addresses the above problems without foregoing the advantages provided by known systems.

Summary

According to a first aspect of the present disclosure there is provided an underwater plough for providing an elongated element into a submerged surface, the underwater plough comprising:

a body portion for receiving and guiding an elongated element therethrough, the body portion having:

a first end positioned at or towards the front of the underwater plough;

a second end positioned at or towards the rear of the underwater plough; and

a longitudinal axis along which the first end and second end are spaced;

a plough share extending from an underside of the body portion, the plough share comprising a cutting edge for cutting a bottom of a trench in which the elongated element is to be deposited;

support means for supporting the underwater plough with respect to a submerged surface, the support means comprising:

a first set of at least one support member extending from an underside of the body portion, the at least one support member of the first set having a contact portion for contacting the submerged surface; and

a second set of at least one support member extending from an underside of the body portion, the at least one support member of the second set having a contact portion for contacting the submerged surface, wherein the contact portion of the at least one support member of the first set and the contact portion of the at least one support member of the second set define a contact plane;

wherein the at least one support member of the first set is rotatable with respect to the body portion and the at least one support member of the second set is rotatable with respect to the body portion,

actuating means configured to rotate the at least one support member of the first set with respect to the body portion and/or to rotate the at least one support member of the second set with respect to the body portion.

wherein the underwater plough has an operational configuration for a ploughing operation in which:

the at least one support member of the first set extends from the body portion in a first direction;

the at least one support member of the second set extends from the body portion in a second direction, at an angle to the first direction;

the longitudinal axis of the body portion is angled with respect to the contact plane, with the longitudinal axis being closer to the contact plane at the first end of the underwater plough than at the second end of the underwater plough; and

the cutting edge is positioned so as to contact with the submerged surface or the bottom of the trench during the ploughing operation;

wherein the underwater plough is configured such that actuation of the actuating means within the operational configuration varies the first direction and the second direction changing the orientation of the longitudinal axis of the body portion with respect to the contact plane and/or the distance between the body portion and the contact plane while the underwater plough is supported by the support means.

That is, during use the weight of the underwater plough and any soil surcharge load can be supported by the support member(s) of the first set - i.e. the skids - and the support member(s) of the second set – i.e. the stabilisers. This allows the underwater plough to be operated in a stable pitched forward orientation. This stable orientation is achieved without complex articulating components. For example, there is no necessity for an articulated bell mouth or an articulated plough share.

In certain examples the underwater plough is configured such that, in the operational configuration, the at least one support member of the first set and the at least one support member of the second set contact the submerged surface such that the weight of the underwater plough on the submerged surface is supported by the at least one support member of the first set and the at least one support member of the second set so that the plough orientation and the depth of the resultant trench can be controlled by varying the first direction and second direction.

In certain examples the plough share comprises a heel portion extending rearwardly from the cutting edge, wherein in the operational configuration the heel portion is angled with respect to the contact plane so that the heel portion can remain elevated from the submerged surface or a bottom of the trench during the ploughing operation. In this manner the

underwater plough is not reliant on a heel reaction when changing the plough orientation and depth of the resultant trench.

In certain examples the first direction is such that the at least one support member of the first set extends towards, or past, the front of the underwater plough.

In certain examples the second direction is such that the least one support member of the second set extends towards, or past, the plough share at the rear of the underwater plough. The at least one support member of the second set are rearwardly extending stabilisers.

In certain examples in the operational configuration the angle between the first direction and the second direction is from about 80 degrees to about 180 degrees. In this manner, the range of the first and second directions allows the cutting edge to be lowered from the submerged surface to the required trench depth, while the weight of the underwater plough is supported by the skids and stabilisers.

In certain examples:

a connection point between the at least one support member of the first set and the body portion is located towards, or proximal to, the first end of the body portion; and

a connection point between the at least one support member of the second set and the body portion is located towards, or proximal to, the first end of the body portion.

By connecting both sets of support members towards the front of the underwater plough, the centre of mass of the plough is shifted forwardly in comparison to known systems. This helps balance the underwater plough during deployment. In addition this helps moves the connection points further from the soil rupture surface.

In certain examples a connection point between the plough share and the body portion is located towards, or proximal to, the second end of the body portion.

In certain examples the at least one support member of the second set is sized so as to be able to extend from the connection point between the at least one support member of the second set and the body portion to the cutting edge of the plough share. That is, the rearwardly extending support members are able to extend from the forwardly positioned connection point to the rear of the plough. As such, the rearwardly extending support members can support the rear of the underwater plough.

In certain examples in the operational configuration the at least one support member of the second set extends from the connection point between the at least one support member of the second set and the body portion up to, or past, the cutting edge of the plough share.

In certain examples the actuating means comprises:

first actuating means coupled to the body portion and the at least one support member of the first set, the first actuating means being configured to rotate the at least one support member of the first set with respect to the body portion; and

second actuating means coupled to the body portion and the at least one support member of the second set, the second actuating means configured to rotate the at least one support member of the second set with respect to the body portion.

In certain examples in the operational configuration, the orientation of the plough share with respect to the body portion is fixed. With the present disclosure it is not required that the plough share articulates with respect to the body portion. As such, the underwater plough is less complex but can still achieve a stable pitched forward configuration.

In certain examples the plough share includes:

a main body from which the cutting edge extends; and

a rear surface along which, in use, the elongated element traverses as it passes from the body portion into the trench cut by the cutting edge.

In certain examples the underwater plough further comprises a depressor extending from the second end of the body portion, the depressor being configured to guide the elongated element into the trench cut by the cutting edge.

In certain examples a lower portion of the rear surface is convex. In this manner the elongated element follows a curved path as it traverses the rear surface of the plough share and is deployed. This helps maintain the curvature of the elongated element above the MBR as it is deployed from the underwater plough with the plough pitched forward during deployment

In certain examples the underwater plough includes a drawbar coupled to the body portion, the drawbar being for connection to a towing line.

In certain examples the drawbar is rotatable between a towing position and a deployment position.

According to a first example of the present disclosure there is provided an assembly for providing an elongated element into a submerged surface, comprising:

an underwater plough according to the first aspect of the disclosure;

a vessel comprising a towing line, wherein said towing line is connected to the drawbar of said underwater plough.

According to a second aspect of the present disclosure there is provided a method of operating an underwater plough for providing an elongated element into a submerged surface, the method comprising:

providing a underwater plough comprising:

a body portion for receiving and guiding an elongated element therethrough, the body portion having:

a first end positioned at or towards the front of the underwater plough;

a second end positioned at or towards the rear of the underwater plough; and

a longitudinal axis along which the first end and second end are spaced;

between the body portion and the submerged surface while the underwater plough is supported by the support means.

In certain examples the underwater plough of the second aspect of the disclosure is that of the first aspect of the disclosure.

In certain examples in the operational configuration, the at least one support member of the first set and the at least one support member of the second set contact the submerged surface such that the weight of the underwater plough on the submerged surface is supported by the at least one support member of the first set and the at least one support member of the second set so that the plough orientation and the depth of the resultant trench can be controlled by varying the first direction and second direction.

In certain examples the first direction is such that the at least one support member of the first set extends towards, or past, the front of the underwater plough.

In certain examples the second direction is such that the least one support member of the second set extends towards, or past, the plough share at the rear of the underwater plough.

In certain examples in the operational configuration the angle between the first direction and the second direction is from about 80 degrees to about 180 degrees.

In certain examples:

a connection point between the at least one support member of the first set and the body portion is located towards, or proximal to, the first end of the body portion; and

a connection point between the at least one support member of the second set and the body portion is located towards, or proximal to, the first end of the body portion.

In certain examples a connection point between the plough share and the body portion is located towards, or proximal to, the second end of the body portion.

In certain examples the at least one support member of the second set is sized so as to be able to extend from the connection point between the at least one support member of the second set and the body portion to the cutting edge of the plough share.

In certain examples in the operational configuration the at least one support member of the second set extends from the connection point between the at least one support member of the second set and the body portion up to, or past, the cutting edge of the plough share.

According to a second example of the present disclosure there is provided a method of deploying an underwater plough for providing an elongated element into a submerged surface, the method comprising:

providing a underwater plough comprising:

a body portion for receiving and guiding an elongated element therethrough, the body portion having:

a first end positioned at or towards the front of the underwater plough;

a second end positioned at or towards the rear of the underwater plough; and

pitched forward the elongated element is subject to less severe bending as it passes through the underwater plough.

In certain examples the underwater plough of the second example of the disclosure is that of the first aspect of the disclosure.

In certain examples the step of deploying the underwater plough from the deployment vessel to a submerged surface in a body of water comprises:

over-boarding the underwater plough from the deployment vessel with the underwater plough in the deployment configuration.

In certain examples the step of deploying the underwater plough from the deployment vessel to a submerged surface in a body of water further comprises:

touching the underwater plough is down to the submerged surface with the underwater plough in the deployment configuration.

The deployment configuration reduces the risk of damage to the elongated element as the underwater plough reaches the submerged surface. That is, the deployment configuration allows the plough share to be angled in such a way that the elongated element cannot be trapped underneath the plough share as the underwater plough touches down on the submerged surface.

In certain examples the step of deploying the underwater plough from the deployment vessel to a submerged surface in a body of water further comprises:

configuring the underwater plough in a second deployment configuration by:

reducing the angle between the first direction and the second direction; and

rotating the drawbar forwardly to a second deployment position; and

lowering the underwater plough through the body of water in the second deployment configuration.

In the second deployment configuration the weight of the underwater plough is shifted. This helps ensure the underwater plough can be deployed through the body of water in an orientation that allows for the elongated element to pass through the underwater plough with a low wrap angle.

According to a third example of the present disclosure there is provided a method of deploying and operating an undersea plough combining the second aspect and second example of the present disclosure.

According to a fourth example of the present disclosure there is provided an underwater plough for providing an elongated element into a submerged surface, the underwater plough comprising:

a body portion for receiving and guiding an elongated element therethrough, the body portion having:

a first end positioned at or towards the front of the underwater plough;

In certain examples the underwater plough has a second deployment configuration in which:

the angle between the first direction and the second direction is reduced in comparison to the first deployment configuration; and

the drawbar is in a second deployment position, in which the drawbar is rotated forwardly in comparison to the first deployment position.

In certain examples the underwater plough of the fourth example of the disclosure includes all the features of the underwater plough of the first aspect of the disclosure.

As used herein, it would be understood that 'providing an elongated element into a submerged surface' in the present disclosure may be otherwise termed 'providing an elongated element in a seabed', 'guiding an elongated element onto a submerged surface or seabed' or 'guiding an elongated element into a trench formed in a submerged surface or sea bed'.

As used herein, it would be understood that the terms 'front' and 'back', with regards to an underwater plough are defined relative to the direction of plough movement during operation. Similarly it would be understood that the terms 'upstream' or 'downstream', with regards to an underwater plough are defined relative to the direction of elongated element deployment rather than the direction of plough movement.

As used herein, unless otherwise specified the features "at an angle" or "angled" (for example 'the second direction being at an angle to the first direction') refer to an angle when considering the side views of the underwater plough illustrated in the Figures – that is, angled within a substantially vertical plane through the underwater plough.

As used herein, it would be understood that the term 'underside' refers to the side of the underwater plough, or the body portion thereof, that faces downwardly towards the underlying submerged surface in use.

As used herein, it would be understood that 'an operational configuration for a ploughing operation' is a configuration, or particular arrangement of the features of the underwater plough, that allows it to perform a ploughing operation, i.e. to plough or cut a trench in a particular surface. This phrase may otherwise be termed 'wherein in operation the underwater plough is movable or configured in such a way that'. Similarly, a 'deployment configuration' is a configuration, or particular arrangement of the features of the underwater plough, that allows it to be deployed from a vessel.

Brief Description of the Drawings

Embodiments will now be described by way of example only with reference to the accompanying drawings in which:

Figure 1 illustrates a side view of a known underwater plough;

Figure 2 illustrates a side view of an underwater plough in a stowage configuration;

Figures 3 and 4 illustrate the underwater plough of Figure 2 in an operational configuration;

CLAIMS

1. An underwater plough for providing an elongated element into a submerged surface, the underwater plough comprising:

a body portion for receiving and guiding an elongated element therethrough, the body portion having:

a first end positioned at or towards the front of the underwater plough;

a second end positioned at or towards the rear of the underwater plough; and

a longitudinal axis along which the first end and second end are spaced;

a plough share extending from an underside of the body portion, the plough share comprising a cutting edge for cutting a bottom of a trench in which the elongated element is to be deposited;

support means for supporting the underwater plough with respect to a submerged surface, the support means comprising:

a first set of at least one support member extending from an underside of the body portion, the at least one support member of the first set having a contact portion for contacting the submerged surface; and

a second set of at least one support member extending from an underside of the body portion, the at least one support member of the second set having a contact portion for contacting the submerged surface, wherein the contact portion of the at least one support member of the first set and the contact portion of the at least one support member of the second set define a contact plane;

wherein the at least one support member of the first set is rotatable with respect to the body portion and the at least one support member of the second set is rotatable with respect to the body portion,

actuating means configured to rotate the at least one support member of the first set with respect to the body portion and/or to rotate the at least one support member of the second set with respect to the body portion,

wherein the underwater plough has an operational configuration for a ploughing operation in which:

the at least one support member of the first set extends from the body portion in a first direction;

the at least one support member of the second set extends from the body portion in a second direction, at an angle to the first direction;

the longitudinal axis of the body portion is angled with respect to the contact plane, with the longitudinal axis being closer to the contact plane at the first end of the underwater plough than at the second end of the underwater plough; and

the cutting edge is positioned so as to contact with the submerged surface or the bottom of the trench during the ploughing operation;

wherein the underwater plough is configured such that actuation of the actuating means within the operational configuration varies the first direction and the second direction changing the orientation of the longitudinal axis of the body portion with respect to the contact plane and/or the distance between the body portion and the contact plane while the underwater plough is supported by the support means.

2. The underwater plough of claim 1, wherein the underwater plough is configured such that, in the operational configuration, the at least one support member of the first set and the at least one support member of the second set contact the submerged surface such that the weight of the underwater plough on the submerged surface is supported by the at least one support member of the first set and the at least one support member of the second set so that the plough orientation and the depth of the resultant trench can be controlled by varying the first direction and second direction.

3. The underwater plough of any preceding claim, wherein the plough share comprises a heel portion extending rearwardly from the cutting edge, wherein in the operational configuration the heel portion is angled with respect to the contact plane so that the heel portion can remain elevated from the submerged surface or a bottom of the trench during the ploughing operation.

4. The underwater plough of any preceding claim, wherein the first direction is such that the at least one support member of the first set extends towards, or past, the front of the underwater plough.

5. The underwater plough of any preceding claim, wherein the second direction is such that the least one support member of the second set extends towards, or past, the plough share at the rear of the underwater plough.

6. The underwater plough of any preceding claim, wherein in the operational configuration the angle between the first direction and the second direction is from about 80 degrees to about 180 degrees.

7. The underwater plough of any preceding claim,
wherein a connection point between the at least one support member of the first set and the body portion is located towards, or proximal to, the first end of the body portion; and
wherein a connection point between the at least one support member of the second set and the body portion is located towards, or proximal to, the first end of the body portion.

8. The underwater plough of any preceding claim, wherein a connection point between the plough share and the body portion is located towards, or proximal to, the second end of the body portion.

9. The underwater plough of claim 7, wherein the at least one support member of the second set is sized so as to be able to extend from the connection point between the at least one support member of the second set and the body portion to the cutting edge of the plough share.

10. The underwater plough of claim 9, wherein in the operational configuration the at least one support member of the second set extends from the connection point between the at least one support member of the second set and the body portion up to, or past, the cutting edge of the plough share.

11. The underwater plough of any preceding claim, wherein the actuating means comprises:
first actuating means coupled to the body portion and the at least one support member of the first set, the first actuating means being configured to rotate the at least one support member of the first set with respect to the body portion; and
second actuating means coupled to the body portion and the at least one support member of the second set, the second actuating means configured to rotate the at least one support member of the second set with respect to the body portion.

12. The underwater plough of any preceding claim, wherein in the operational configuration, the orientation of the plough share with respect to the body portion is fixed.

13. The underwater plough of any preceding claim, wherein the plough share includes:
a main body from which the cutting edge extends; and

a rear surface along which, in use, the elongated element traverses as it passes from the body portion into the trench cut by the cutting edge.

14. The underwater plough of claim 13, wherein the underwater plough further comprises a depressor extending from the second end of the body portion, the depressor being configured to guide the elongated element into the trench cut by the cutting edge.

15. The underwater plough of claim 13 or claim 14, wherein a lower portion of the rear surface is convex.

16. A method of operating an underwater plough for providing an elongated element into a submerged surface, the method comprising:

providing a underwater plough comprising:

a body portion for receiving and guiding an elongated element therethrough, the body portion having:

a first end positioned at or towards the front of the underwater plough;

a second end positioned at or towards the rear of the underwater plough; and

a longitudinal axis along which the first end and second end are spaced;

a plough share extending from an underside of the body portion, the plough share comprising a cutting edge for cutting a bottom of a trench in which the elongated element is to be deposited;

support means for supporting the underwater plough with respect to a submerged surface, the support means comprising:

a first set of at least one support member extending from an underside of the body portion, the at least one support member of the first set having a contact portion for contacting the submerged surface; and

a second set of at least one support member extending from an underside of the body portion, the at least one support member of the second set having a contact portion for contacting the submerged surface;

wherein the at least one support member of the first set is rotatable with respect to the body portion and the at least one support member of the second set is rotatable with respect to the body portion,

actuating means configured to rotate the at least one support member of the first set with respect to the body portion and/or to rotate the at least one support member of the second set with respect to the body portion,

positioning the underwater plough on the submerged surface in an operational configuration in which:

the at least one support member of the first set extends from the body portion in a first direction, the first direction being angled away from the longitudinal axis of the body portion;

the at least one support member of the second set extends from the body portion in a second direction, at an angle to the first direction, the second direction being angled away from the longitudinal axis of the body portion;

the contact portion of the at least one support member of the first set and the contact portion of the at least one support member of the second set are in contact with the submerged surface;

the longitudinal axis of the body portion is angled with respect to the submerged surface, with the longitudinal axis being closer to the submerged surface at the first end of the underwater plough than at the second end of the underwater plough; and

the cutting edge is in contact with the submerged surface or the bottom of the trench;

performing a ploughing operation with the underwater plough; and

actuating the actuating means with underwater plough in the operational configuration such that the first direction and the second direction are varied to change the orientation of the longitudinal axis of the body portion with respect to the submerged surface and/or the distance between the body portion and the submerged surface while the underwater plough is supported by the support means.

17. The method of claim 16, wherein in the operational configuration, the at least one support member of the first set and the at least one support member of the second set contact the submerged surface such that the weight of the underwater plough on the submerged surface is supported by the at least one support member of the first set and the at least one support member of the second set so that the plough orientation and the depth of the resultant trench can be controlled by varying the first direction and second direction.

18. The method of claim 16 or 17, wherein the first direction is such that the at least one support member of the first set extends towards, or past, the front of the underwater plough.

19. The method of any of claims 16 to 18, wherein the second direction is such that the least one support member of the second set extends towards, or past, the plough share at the rear of the underwater plough.

20. The method of any of claims 16 to 19, wherein in the operational configuration the angle between the first direction and the second direction is from about 80 degrees to about 180 degrees.

21. The method of any of claims 16 to 20,
wherein a connection point between the at least one support member of the first set and the body portion is located towards, or proximal to, the first end of the body portion; and
wherein a connection point between the at least one support member of the second set and the body portion is located towards, or proximal to, the first end of the body portion.

22. The method of any of claims 16 to 21, wherein a connection point between the plough share and the body portion is located towards, or proximal to, the second end of the body portion.

23. The method of any of claims 16 to 22, wherein the at least one support member of the second set is sized so as to be able to extend from the connection point between the at least one support member of the second set and the body portion to the cutting edge of the plough share.

24. The method of any of claims 16 to 23, wherein in the operational configuration the at least one support member of the second set extends from the connection point between the at least one support member of the second set and the body portion up to, or past, the cutting edge of the plough share.