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(54) BIOSENSOR DEVICE, SYSTEM AND METHOD FOR MONITORING A DEEP-WATER SEA-FLOOR

BIOSENSORVORRICHTUNG, SYSTEM UND VERFAHREN ZUR ÜBERWACHUNG EINES TIEFSEEOZEANBODENS

DISPOSITIF DE BIOCAPTEUR, SYSTÈME ET PROCÉDÉ POUR SURVEILLER UN FOND MARIN EN EAU PROFONDE

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Description

TECHNICAL FIELD

[0001] The present disclosure relates generally to the field of biosensors and more particularly to biosensors for monitoring biological patterns on a deep-water sea-floor.

BACKGROUND

[0002] Because of requirements on Oil and Gas (O & G) operators, typically from environmental authorities to monitor environmental impacts during Oil and Gas (O & G) drilling activities in sensitive environments such as a deep-water sea-floor with corals, there is a need to monitor coral status and impact on this environment, especially during such activities. Guidelines have been prepared to mitigate the environmental risk of drilling activities in areas with coral populations (Den Norske Veritas, DNV, 2012). In areas where drilling activities are close to coral populations, such as areas with coral reefs, the O&G operators typically have to apply costly mitigation actions to protect the corals. This often leads to applying a precautionary principle as there is no current technology known to document impact and monitor coral, or other deep-sea species, status during drilling activities.

[0003] ROBERTS J M ET AL: "A new laboratory method for monitoring deep-water coral polyp behaviour", HYDROBIOLOGIA, vol. 471, 1 March 2002, pages 143-148, DOI:10.1023/A:1016513607002; discloses a lab based method for recording polyp behaviour using a time-lapse video camera. Silhouettes of coral polyps were produced allowing polyp extension to be measured under laboratory conditions only.

[0004] Until now, according to our best understanding, there are no known techniques to measure the effect on coral status or other deep-sea species continuously. Current techniques to assess impact of drill cutting plumes used by O&G operators are based on current measurements, turbidity measurements, sediment traps, sediment samples and visual mapping, all techniques typically not being continuously.

[0005] References describing known techniques and background are listed under the heading "list of references" in this disclosure.

[0006] Regarding monitoring such as visual mapping, for instance, the Guidelines (DNV, 2012) states that in general it is difficult to find an appropriate parameter for monitoring directly of corals, which will reflect any influences from drilling activities. High resolution still photos have from experience not been able to identify change in polyp behaviour on corals such as *Lophelia pertusa* when exposed to drill cutting sedimentations such as drill cutting plumes.

[0007] In particular, none of the known techniques are providing an actual measurement of the impact or changes of coral end-points from drill cutting sedimentations, but are only proxy measurements of drill cutting potential exposure, not their effect.

SUMMARY

[0008] According to the independent claims the present invention is concerned with a biosensor device arranged to perform in situ monitoring of deep-water sea-floor coral nubbins. The biosensor device comprises a plurality of cameras and a lighting system. A plurality of coral nubbins with a plurality of polyps are prepared and fixed to a biosensor platform of the biosensor device with a distance to each other, of the coral nubbins, such that there is no overlap on a picture frame thereof. The cameras and the lighting system are arranged so as to take coral-silhouette-pictures of the plurality of nubbins in the picture frame.

[0009] Herein, the term "biological pattern" includes, without limitation, corals and other species.

[0010] According to an embodiment, the present invention is related to a system which comprises at least one bio sensor device (10) according to independent claim 1.

[0011] The biosensor device comprises or is connected to an analytical system for in situ processing of coral data based on the coral-silhouette-pictures.

[0012] In this way, there is provided a biosensor device based on coral, or other deep-sea species, behavioural for surveillance and monitoring of a deep-water sea-floor, in particular for monitoring biological patterns on a deep-water sea-floor.

[0013] According to another illustrative embodiment, the present invention is related to a method for monitoring deep-water sea-floor biological patterns with a biosensor platform comprising a plurality of cameras and a lighting system. A plurality of coral nubbins with a plurality of polyps are prepared and fixed to the biosensor platform with a distance to each other such that there is no overlap on a picture frame thereof. The cameras and the lighting system are arranged so as to take coral-silhouette-pictures of a plurality of nubbins in the picture frame. The method further comprises taking coral-silhouette-pictures followed by measuring the coral silhouettes of each coral nubbin in an analytical system, typically including an expert analytical unit, for in situ processing of coral data including at least the coral silhouette.

[0014] In this way, a device system and method in accordance with the independent claims are provided that achieve monitoring and measuring biological patterns, in particular coral polyp activity, continuously and assess changes related to environmental parameters. This has not been disclosed until now.

BRIEF DESCRIPTION OF DRAWING FIGURES

[0015] The foregoing and other features of the present disclosure will become more fully apparent from the following description and appended claims, taken in conjunction with the accompanying drawings. Understanding that these drawings depict only several embodiments in accordance with the disclosure and are; therefore, not to be considered limiting of its scope, the disclosure will be described with additional specificity and detail through use of the accompanying drawings.

FIG. 1a is a schematic sectional view of a biosensor device in accordance with an illustrative embodiment on a deep sea-floor in the vicinity of a coral reef, and FIG. 1b, an enlargement of part of the biosensor device 10 shown in FIG. 1a;
FIG. 2 is a schematic view of a system comprising at least one biosensor device as illustrated in FIG. 1a-b in accordance with an illustrative embodiment;
FIG. 3 is a flow-chart of a method according to an embodiment;
FIG. 4a is a view of a picture window (frame) taken from the corals on the platform, FIG. 4b is an enlargement of the picture window and FIG. 4c shows pixel area calculation per coral branch; and
FIG. 5a-b show time-lapse-video-on/off laboratory experiment during 1 month.

DETAILED DESCRIPTION OF EMBODIMENTS

[0016] In the following detailed description, reference is made to the accompanying drawings, which form a part hereof. In the drawings, similar symbols typically identify similar components, unless context dictates otherwise. The illustrative embodiments described in the detailed description, drawings, and claims are not meant to be limiting.

[0017] According to an aspect of the disclosure, a time-lapse camera system was used to continuously record pictures of corals nubbins having coral polyps placed on the biosensor platform of the biosensor device as described above in a deep-water sea-like environment. Studies showed that polyp activity of coral nubbins is changing relatively fast due to changes from their environment and that drill cuttings sedimentation affect their behavior. This may have important consequences for the coral physiological state as deep-sea corals are completely dependent on catching organic particles from their environment which they do by extending their tiny tentacles when food is available. Experiments showed that coral polyp activity may either increase or decrease significantly during and following an exposure to drill cutting sedimentation reflecting a disruption in their ability to catch prey.

[0018] Referring to FIG. 1a, a schematic sectional view of a biosensor device 10 in accordance with an illustrative embodiment is shown on a deep-sea sea-floor 30 and to FIG. 1b, an enlargement of part (biosensor platform) of the biosensor device 10 is shown.

[0019] The present disclosure is directed to a biosensor device 10 for in situ monitoring of deep-water sea-floor coral polyp activity, typically in real-time. The biosensor device 10 comprises a plurality of cameras 12, typically high resolution (HD) cameras, and lighting system 14. A plurality of coral nubbins 16 with a plurality of polyps 18 are prepared and fixed to a biosensor platform 11 of the biosensor device 10 with a distance to each other such that there is no overlap on a picture frame 22 (see FIG. 1a) thereof. The bio sensor platform 11 can be a grid or any other surface onto which coral nubbins 16 can be placed and live. Typically, the coral nubbins 16 comprise 4 to 8 polyps 18 and have a tree-like structure, but also other structures are possible depending on environment. As shown in FIG. 1a, there can be more than one platform 11, for instance two as shown, but any number of platforms 11 is possible, including also one only. According to an embodiment, the biosensor device comprises nubbins from deep-sea corals positioned "adequately" (See FIG. 1b) on the platform 11 of the biosensor device 10 which may be part of a conventional rig, such as a benthic rig structure, for deep-sea measurements and having low-power low light sensitive underwater HD cameras to measure and analyse coral polyp behaviour in real-time, typically in vicinity of corals, such as a coral reef. Herein the term "adequately" means that the coral nubbins 16 with a plurality of polyps 18 are prepared and fixed to a biosensor platform 11 of the biosensor device 10 with a distance to each other such that there is no overlap on a picture frame 22. Also conventional sensors such as sensors for measuring turbidity, CTD may be provided on the biosensor device 10. Since these are well known for the skilled-person they are not described in more detail.

[0020] As shown in FIG. 1b, which is an enlargement of part of the biosensor device 10, one of the platforms 10, the cameras 12 and the lighting system 14 are arranged so as to take coral-silhouette-pictures of the plurality of, or at least several, nubbins in the picture frame. In FIG. 1b two lighting systems 14 are shown only as an illustrative example. The number of cameras 12 will typically depend on space available, power requirements and number of coral nubbins.

[0021] Typically, the biosensor device 10 comprises coral nubbins from a deep-sea coral such as Lophelia pertusa positioned adequately on the platform of the biosensor device 10, such as a rig, and underwater HD-cameras that measure and analyse coral polyp activity in real-time. However, without departing from the disclosure, also other herein not explicitly stated biological patterns can be monitored.

[0022] The biosensor device 10 may also comprise a picture processing unit 19 for time-lapse picture shooting, and in situ processing, typically pre-processing, of the pictures taken to measure the whole coral nubbin silhouette, typically an area thereof, which will change over time. These changes, for instance of the coral silhouette area, will reflect the activity of the polyps in relation to their environment over time, which will be described in more detail as follows. The processing unit 19 may also be used for communication with a system for processing coral and/or picture data, including an expert analytical unit, which will be described below with reference to FIG 2.

[0023] Now is also referred to FIG. 2, which shows a schematic view of a system for monitoring deep-sea-floor biological patterns and to FIG. 3, which is a flow-chart of a method for monitoring deep-sea-floor biological patterns according to an embodiment of the disclosure.

[0024] According to an embodiment, in a biosensor system 20 for monitoring deep-water sea-floor biological patterns more than one biosensor device 10 may be provided. Typically, offshore, the biosensor devices 10 are deployed on the sea-floor at a natural site for a coral reef (See FIG. 1a) and at a distance between 300 and 500 meters or any other distance considered safe by regulation for instance.

[0025] The biosensor system 20 further comprises an analytical system, typically an expert analytical unit, 21for in situ processing of coral data received from the biosensor device(s) 10. The analytical unit 21 may also transmit other data, such as control data to the biosensor device 10. The biosensor system 20 may also further comprise a communications unit 23 adapted to transmit coral data including at least measured coral silhouette CS data, to an operational centre 26 that can communicate with the biosensor system 20. The system 20 may be partly or wholly provided separately from the biosensor device 10, typically over sea.

[0026] The analytical system, including the expert analytical unit, 21 is arranged to give each coral nubbin 16 a unique identification ID, and the coral silhouette picture CSP and its coral silhouette area CSA thereof is arranged to be recorded automatically with shooting time. This is schematically shown in FIG. 2, in that data for a first coral, Coral 1 is separated from data for another coral, Coral X.

[0027] Now is also referred to FIG. 4a is a view of a picture window taken from the corals on the platform, FIG. 4b is an enlargement of the picture window and FIG. 4c shows pixel area calculation per coral branch.

[0028] Typically, the lighting system 14 and the cameras 12 are adapted to be turned on during a period of time of 1 to 5 minutes so as to reduce power consumption and coral light-exposure. When operating, the biosensor device 10 including the lighting system 14 will be kept most of the time in the dark, which is normal for corals at this depth, and to reduce power consumption, lighting will be turned on only during shorter periods (say 2 minutes) to take (shoot) 120 a picture 22 (See FIG. 3) for measurement. Typically, a principle of the measurement will be based on regular time-lapsed picture shooting, acquisition and in situ processing of the picture 22 to measure the whole coral nubbin silhouette, in short "coral silhouette", CS. For each picture 22, the coral silhouette CS will be measured, typically calculated in the analytic system 21 after pre-processing of the picture in the processing unit 19.

[0029] As an example, corals are collected from a clean site and maintained in a laboratory under field conditions for acclimation. Inshore, coral nubbins 16 with 4 to 8 polyps are prepared and fixed 110 on the biosensor device 10 on the platform 11. The shape of the coral nubbins 16 are typically "tree-like" (dichotomy) and each nubbin is placed at a distance allowing no overlap on the picture frame 22.

[0030] Changes of the coral silhouette CS over time T can be measured 130 by the calculation of a silhouette perimeter or total coral silhouette area CSA, for instance by pixel area calculation per coral branch. These changes will reflect the activity of the coral polyps in relation to their environment over time. The shooting will depend on the power requirement and the picture processing capacity. Each coral nubbin will be given an ID and the coral silhouette measurement recorded automatically in an excel format file with shooting time. The file can be transmitted to a shore station or the operational centre 26 of an O&G rig, and the data downloaded by end-users where they can be visualized. The data from contextual sensors like turbidity, added to the rig, will also be processed by the rig expert analytical unit 21 and accessible by end-users at the operational centre 26. The changes of coral polyp activity will be related to environmental event and on-going industrial activities. Critical decisions relative to industrial discharge and operations will be made depending on the effect observed.

[0031] Now is referred to FIG. 5a-b, which show time-lapse-video-on/off experiment during 1 month time.

[0032] Typically, according to an embodiment, for each picture, the coral silhouette CS is measured after pre-processing of the picture in the processing unit 19. This can be analysed by plotting "polyp activity" i. e. coral silhouette changes as measured in pixels, over time and assess a deviance to normal base line activity. In FIG. 5 is shown a rapid response of polyp activity following DC exposure. As shown a gradual recovery post-exposure will be negatively following sedimentation. Exposure w3 following sedimentation shows that the corals have been negatively influenced and will not recover w4 as good as before since the recovery has decreased, i. e. recover w4 is lower than recover w2.

[0033] The embodiments of the disclosure system will be particularly useful to document no harmful effect on coral during the whole life cycle of a production field. Particularly the embodiments will be useful to monitor effects on corals during exploration drilling and production, to comply with existing regulation requiring documentation, to minimize the impact of drilling activities and protect environmentally sensitive habitats at the seafloor.

LIST OF REFERENCES

[0034]

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Claims

1. A biosensor device (10) arranged to perform in situ monitoring of deep-water sea-floor coral polyp activity, which biosensor device (10) comprises a time-lapse-camera system having a plurality of high resolution (HD) cameras (12) and a lighting system (14), **characterised in that** a plurality of coral nubbins (16) with a plurality of polyps (18) are prepared and fixed to a platform (11) of the biosensor device (10) with a distance to each other such that there is no overlap on a picture frame (22) thereof, and wherein the cameras (12) and the lighting system (14) are arranged to continuously take coral-silhouette-pictures (CSP:s) of the plurality of nubbins (16) in the picture frame (22), so as to perform in situ measurements of the coral silhouettes of each coral nubbin in an analytical system, typically including an expert analytical unit, and arranged to perform in situ processing of coral data including at least the coral silhouette, wherein the expert analytical unit (21) is arranged to give each coral nubbin (16) a unique identification ID (CSP), and its total coral silhouette area (CSA) thereof to be recorded automatically with shooting time.

2. The biosensor device (10) according to claim 1, wherein the coral nubbins (16) comprise 4 to 8 polyps.

3. The biosensor device (10) according to claim 2, wherein the coral nubbins (16) have a tree-like structure.

4. The biosensor device (10) according to any one of the previous claims, further comprising picture processing and a communication unit (19) arranged to communicate data for in situ pre-processing and measuring coral silhouettes (CS) of each coral nubbin (16) in the analytical unit (21) for processing coral data including at least the coral silhouette (CS).

5. The biosensor device (10) according to any one of the previous claims, wherein the lighting system (14) and the cameras (12) are adapted to be turned on during a period of time of 1 to 5 minutes so as to reduce power consumption and coral light exposure.

6. A biosensor system (20) arranged to perform in-situ monitoring of deep-water sea-floor coral nubbins (16) which biosensor system (20) comprises at least one biosensor device (10) according to any one of the claims 1-5.

7. The biosensor system (20) according to claim 6, comprising a plurality of biosensor devices (10) that are spaced apart at a distance of 300 to 500 meters on the deepwater sea-floor (30).

8. The biosensor system (20) according to claim 6 or 7, further comprising an analytical unit (21) for in situ processing of coral data received from or transmitted to the biosensor device(s) (10).

9. The biosensor system (20), according to claim 8, further comprising a communications unit (23) adapted to transmit coral data including at least measured coral silhouette (CS) data, to an operational centre (26) that can communicate with the biosensor system (20).

10. A method for monitoring deep-water sea-floor coral nubbins (16)) with a
biosensor device (10) comprising a time-lapse camera system having a plurality of high resolution (HD) cameras (12) and a lighting system (14), **characterised in that** a plurality of coral nubbins (16) with a plurality of polyps (18) are prepared and fixed (110) to a platform (11) of the biosensor device (10)
with a distance to each other such that there is no overlap on a picture frame (22) thereof,
and wherein the cameras (12) and the lighting system (14) are arranged so as to continuously take coral-silhouette-pictures (CSP:s) of a plurality of nubbins (16) in the picture frame (22), the method comprising taking (120) coral-silhouette-pictures (CSP:s);
followed by
measuring (130) the coral silhouettes (CS) of each coral nubbin (16) in an analytical
unit (21) for in situ processing of coral data including at least the coral silhouette (CS) wherein the expert analytical unit (21) is arranged to give each coral nubbin (16) a unique identification ID (CSP), and its

total coral silhouette area (CSA) thereof to be recorded automatically with shooting time..

11. The method according to claim 10, wherein the step of preparing and fixing (110) nubbins (16) includes first collecting corals from a clean site and second acclimatizing them back under field conditions.

12. The method according to claim 10 or 11, wherein the lighting system (14) and the cameras (12) are turned on (140) during a period of time of 1 to 5 minutes so as to reduce power consumption and coral light-exposure.

13. The method according to any one of the claims -, 10-12 wherein an alarm is given (150), when a particular threshold value (TV) including deviating from baseline values or for too small coral silhouette area is passed.

Patentansprüche

1. Biosensorvorrichtung (10), die angeordnet ist, eine in-situ-Überwachung der Aktivität von Korallenpolypen auf einem Tiefsee-Ozeanboden durchzuführen, wobei die Biosensorvorrichtung (10) ein Zeitraffer-Kamerasystem mit einer Vielzahl von Kameras (12) mit hoher Auflösung (HD) und ein Beleuchtungssystem (14) umfasst, **dadurch gekennzeichnet, dass** eine Vielzahl von Korallennubbins (16) mit einer Vielzahl von Polypen (18) hergestellt und an einer Plattform (11) der Biosensorvorrichtung (10) mit einem Abstand voneinander befestigt werden, sodass es in einem Bildrahmen (22) keine Überschneidung gibt, und wobei die Kameras (12) und das Beleuchtungssystem (14) angeordnet sind, um kontinuierlich Korallenumrissbilder (CSP:s) der Vielzahl von Nubbins (16) in dem Bilderrahmen (22) aufzunehmen, um in-situ-Messungen der Korallenumrisse jedes Korallennubbins in einem Analysesystem durchzuführen, das typischerweise eine Expertenanalyseeinheit beinhaltet und angeordnet ist, um eine in-Situ-Verarbeitung von Korallendaten, die mindestens den Korallenumriss beinhalten, durchzuführen, wobei die Expertenanalyseeinheit (21) angeordnet ist, um jedem Korallennubbin (16) eine eindeutige Identifikations-ID (CSP) zu geben, und der gesamte Korallenumrissbereich (CSA) davon automatisch zum Zeitpunkt der Aufnahme aufgezeichnet wird.

2. Biosensorvorrichtung (10) nach Anspruch 1, wobei die Korallennubbins (16) 4 bis 8 Polypen umfassen.

3. Biosensorvorrichtung (10) nach Anspruch 2, wobei die Korallennubbins (16) eine baumartige Struktur aufweisen.

4. Biosensorvorrichtung (10) nach einem der vorstehenden Ansprüche, weiter umfassend Bildverarbeitung und eine Kommunikationseinheit (19), die zum Kommunizieren von Daten für die in-situ-Vorverarbeitung und zum Messen von Korallenumrissen (CS) jedes Korallennubbins (16) in der Analyseeinheit (21) zum Verarbeiten von Korallendaten angeordnet ist, die mindestens den Korallenumriss (CS) beinhalten.

5. Biosensorvorrichtung (10) nach einem der vorstehenden Ansprüche, wobei das Beleuchtungssystem (14) und die Kameras (12) während eines Zeitraums von 1 bis 5 Minuten eingeschaltet sind, um den Energieverbrauch und die Aussetzung der Koralle mit Licht zu reduzieren.

6. Biosensorsystem (20), das angeordnet ist, die in-situ-Überwachung von Korallennubbins (16) auf einem Tiefsee-Ozeanboden durchzuführen, wobei das Biosensorsystem (20) mindestens eine Biosensorvorrichtung (10) nach einem der Ansprüche 1-5 umfasst.

7. Biosensorsystem (20) nach Anspruch 6, umfassend eine Vielzahl von Biosensorvorrichtungen (10), die in einem Abstand von 300 bis 500 Metern auf dem Tiefsee-Ozeanboden (30) beabstandet sind.

8. Biosensorsystem (20) nach Anspruch 6 oder 7, weiter umfassend eine Analyseeinheit (21) zur in-situ-Verarbeitung von Korallendaten, die von der/den Biosensorvorrichtung(en) (10) empfangen oder an diese übertragen werden.

9. Biosensorsystem (20) nach Anspruch 8, weiter umfassend eine Kommunikationseinheit (23), die zum Übertragen von Korallendaten einschließlich der mindestens gemessenen Korallenumriss (CS)-Daten an ein Operationszentrum (26) ausgelegt ist, das mit dem Biosensorsystem (20) kommunizieren kann.

10. Verfahren zum Überwachen von Tiefsee-Ozeanboden-Korallennubbins (16) mit einer Biosensorvorrichtung (10), umfassend ein Zeitraffer-Kamerasystem mit einer Vielzahl von Kameras (12) mit hoher Auflösung (HD) und ein Beleuchtungssystem (14), **dadurch gekennzeichnet, dass** eine Vielzahl von Korallennubbins (16) mit einer Vielzahl von Polypen (18) hergestellt und an einer Plattform (11) der Biosensorvorrichtung (10) mit einem Abstand voneinander hergestellt und befestigt (110) werden, sodass es in einem Bildrahmen (22) davon keine Überschneidung gibt, und wobei die Kameras (12) und das Beleuchtungssystem (14) angeordnet sind, um kontinuierlich Korallenumrissbilder (CSP:s) einer Vielzahl von Nubbins (16) in dem Bildrahmen (22) aufzunehmen, wobei das Verfahren Aufnehmen (120) von Korallenumrissbildern (CSP); danach Messen (130) der Korallenumrisse (CS) jedes Korallennubbins (16) in einer Analyseeinheit (21) zur in-situ-Verarbeitung von Korallendaten, einschließlich mindestens des Korallenumrisses (CS) umfasst, wobei die Expertenanalyseeinheit (21) angeordnet ist, um jedem Korallennubbin (16) eine eindeutige Identifikations-ID (CSP) zu geben, und der gesamte Korallenumrissbereich (CSA) davonautomatisch zum Zeitpunkt der Aufnahme aufgezeichnet wird.

11. Verfahren nach Anspruch 10, wobei der Schritt des Herstellens und Befestigens (110) der Nubbins (16) erstens das Sammeln von Korallen von einer sauberen Stelle und zweitens das Akklimatisieren derselben unter Feldbedingungen beinhaltet.

12. Verfahren nach Anspruch 10 oder 11, wobei das Beleuchtungssystem (14) und die Kameras (12) während eines Zeitraums von 1 bis 5 Minuten eingeschaltet werden (140), um den Energieverbrauch und die Aussetzung der Koralle mit Licht zu reduzieren.

13. Verfahren nach einem der Ansprüche 10-12, wobei ein Alarm ausgegeben wird (150), wenn ein bestimmter Schwellenwert (TV), der ein Abweichen von den Grundwerten oder einen zu kleinen Korallenumrissbereich beinhaltet, weitergegeben wird.

Revendications

1. Dispositif de biocapteur (10) agencé pour effectuer une surveillance in situ de l'activité de polypes coralliens de fond marin en eau profonde, lequel dispositif de biocapteur (10) comprend un système de caméra à prise de vue accélérée ayant une pluralité de caméras à haute résolution (HD) (12) et un système d'éclairage (14), **caractérisé en ce qu'**une pluralité de protubérances coralliennes (16) avec une pluralité de polypes (18) sont préparées et fixées à une plate-forme (11) du dispositif de biocapteur (10) avec une distance les unes des autres telle qu'il n'y a pas de chevauchement sur un cadre d'image (22) de celles-ci, et dans lequel les caméras (12) et le système d'éclairage (14) sont agencés pour prendre en continu des images de silhouettes coralliennes (CSP:s) de la pluralité de protubérances (16) dans le cadre d'image (22), afin d'effectuer des mesures in situ des silhouettes coralliennes de chaque protubérance corallienne dans un système analytique, incluant typiquement une unité analytique experte, et agencés pour effectuer un traitement in situ de données de corail incluant au moins la silhouette corallienne, dans lequel l'unité analytique experte (21) est agencée pour donner à chaque protubérance corallienne (16) une identification ID (CSP) unique, et sa surface totale de silhouette corallienne (CSA) à enregistrer automatiquement avec le temps de prise de vue.

2. Dispositif de biocapteur (10) selon la revendication 1, dans lequel les protubérances coralliennes (16) comprennent 4 à 8 polypes.

3. Dispositif de biocapteur (10) selon la revendication 2, dans lequel les protubérances coralliennes (16) ont une structure de type arbre.

4. Dispositif de biocapteur (10) selon l'une quelconque des revendications précédentes, comprenant en outre un traitement d'image et une unité de communication (19) agencée pour communiquer des données pour un prétraitement in situ et une mesure de silhouettes coralliennes (CS) de chaque protubérance corallienne (16) dans l'unité analytique (21) à des fins de traitement de données de corail incluant au moins la silhouette corallienne (CS).

5. Dispositif de biocapteur (10) selon l'une quelconque des revendications précédentes, dans lequel le système d'éclairage (14) et les caméras (12) sont adaptés pour être activés pendant une période de temps de 1 à 5 minutes afin de réduire la consommation d'énergie et l'exposition du corail à la lumière.

6. Système de biocapteur (20) agencé pour effectuer une surveillance in situ de protubérances coralliennes (16) de fond marin en eau profonde, lequel système de biocapteur (20) comprend au moins un dispositif de biocapteur (10) selon l'une quelconque des revendications 1 à 5.

7. Système de biocapteur (20) selon la revendication 6, comprenant une pluralité de dispositifs de biocapteur (10) qui sont espacés à une distance de 300 à 500 mètres sur le fond marin en eau profonde (30).

8. Système de biocapteur (20) selon la revendication 6 ou 7, comprenant en outre une unité analytique (21) pour un traitement in situ de données de corail reçues depuis ou transmises vers le ou les dispositifs de biocapteur (10).

9. Système de biocapteur (20), selon la revendication 8, comprenant en outre une unité de communication (23) adaptée pour transmettre des données de corail incluant au moins des données de silhouette corallienne (CS) mesurées, à un centre opérationnel (26) qui peut communiquer avec le système de biocapteur (20).

10. Procédé pour surveiller des protubérances corallien-

nes (16) de fond marin en eau profonde avec un dispositif de biocapteur (10) comprenant un système de caméra à prise de vue accélérée ayant une pluralité de caméras à haute résolution (HD) (12) et un système d'éclairage (14), **caractérisé en ce qu'**une pluralité de protubérances coralliennes (16) avec une pluralité de polypes (18) sont préparées et fixées (110) à une plate-forme (11) du dispositif de biocapteur (10) avec une distance les unes des autres telle qu'il n'y a pas de chevauchement sur un cadre d'image (22) de celles-ci, et dans lequel les caméras (12) et le système d'éclairage (14) sont agencés afin de prendre en continu des images de silhouettes coralliennes (CSP:s) d'une pluralité de protubérances (16) dans le cadre d'image (22), le procédé comprenant la prise (120) d'images de silhouette corallienne (CSP:s) ;
suivi par
la mesure (130) des silhouettes coralliennes (CS) de chaque protubérance corallienne (16) dans une unité analytique (21) pour un traitement in situ de données de corail incluant au moins la silhouette corallienne (CS) dans lequel l'unité analytique experte (21) est agencée pour donner à chaque protubérance corallienne (16) une identification ID (CSP) unique, et sa surface totale de silhouette corallienne (CSA) à enregistrer automatiquement avec le temps de prise de vue.

11. Procédé selon la revendication 10, dans lequel l'étape de préparation et de fixation (110) des protubérances (16) inclut premièrement la collecte de coraux à partir d'un site propre et deuxièmement leur acclimatation dans des conditions de terrain.

12. Procédé selon la revendication 10 ou 11, dans lequel le système d'éclairage (14) et les caméras (12) sont activés (140) pendant une période de temps de 1 à 5 minutes afin de réduire la consommation d'énergie et l'exposition du corail à la lumière.

13. Procédé selon l'une quelconque des revendications 10 à 12 dans lequel une alarme est donnée (150), quand une valeur seuil (TV) particulière incluant un écart par rapport à des valeurs de référence ou pour une surface de silhouette corallienne trop petite est dépassée.

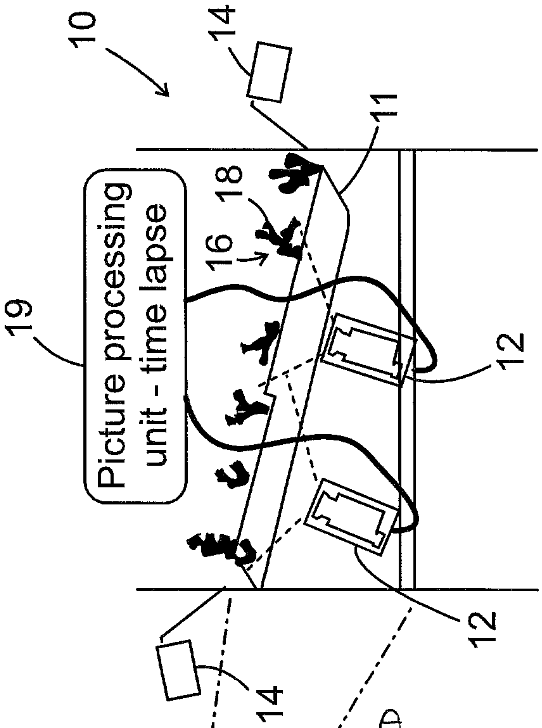
10
14
11
18
16
19
Picture processing unit - time lapse
12
12
14

FIG. 1b

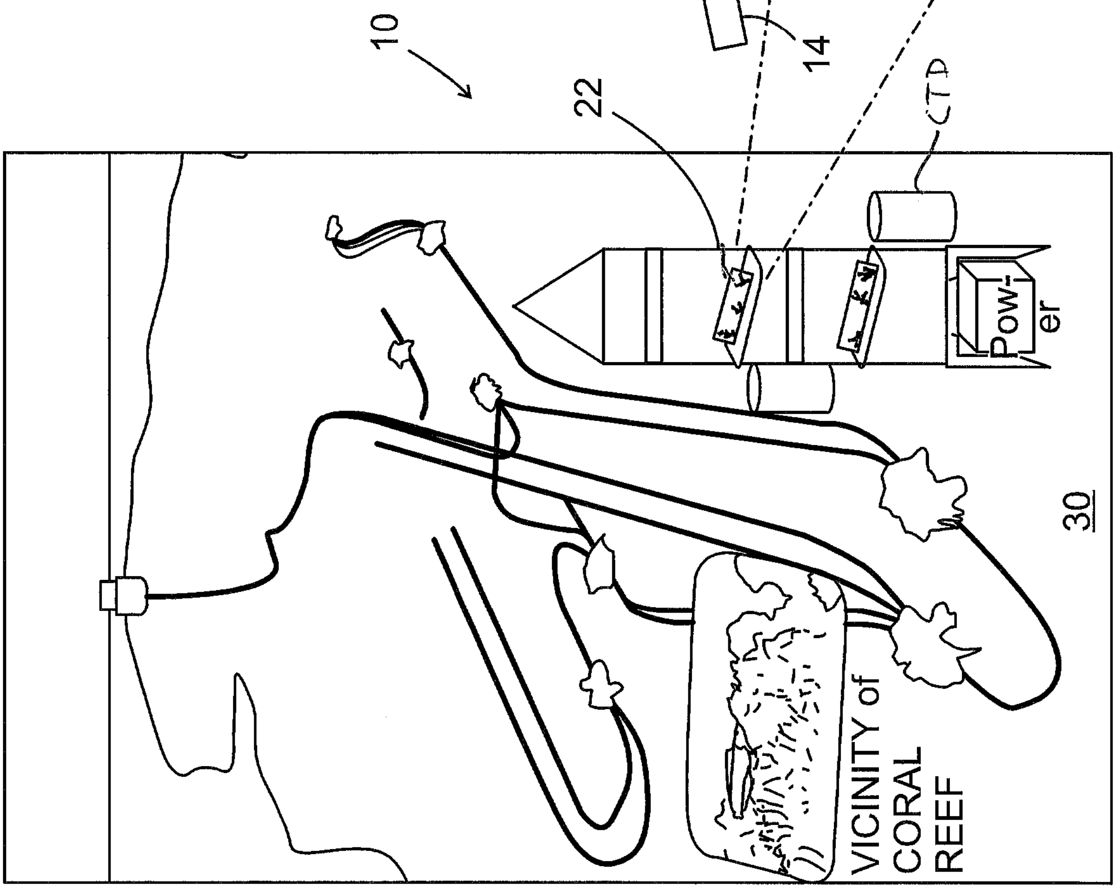
10
22
CTD
Pow-er
30
VICINITY of CORAL REEF

FIG. 1a

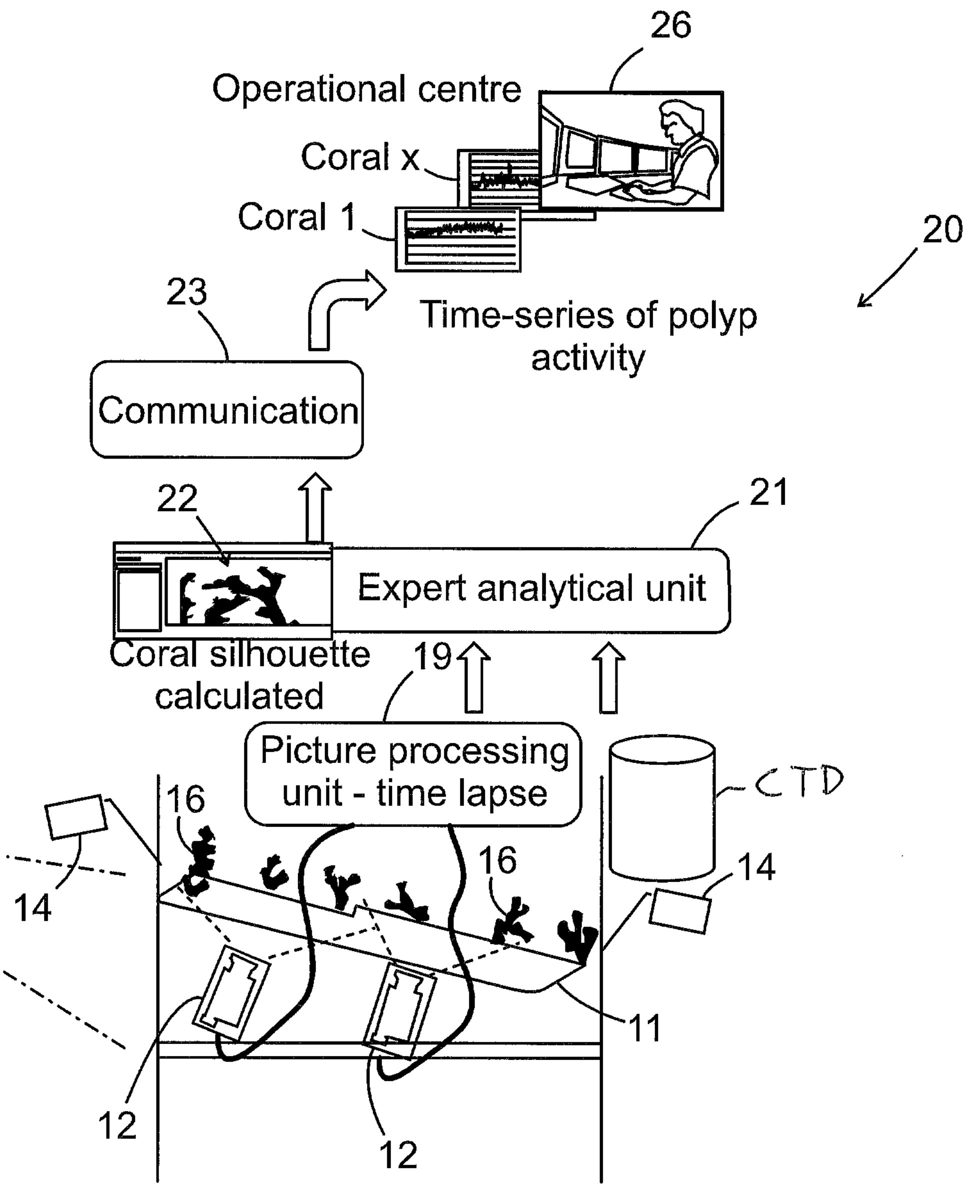
26
Operational centre
Coral x
Coral 1
20
23
Time-series of polyp
activity
Communication
22
21
Expert analytical unit
Coral silhouette
calculated
19
Picture processing
unit - time lapse
CTD
16
16
14
14
11
12
12

FIG. 2

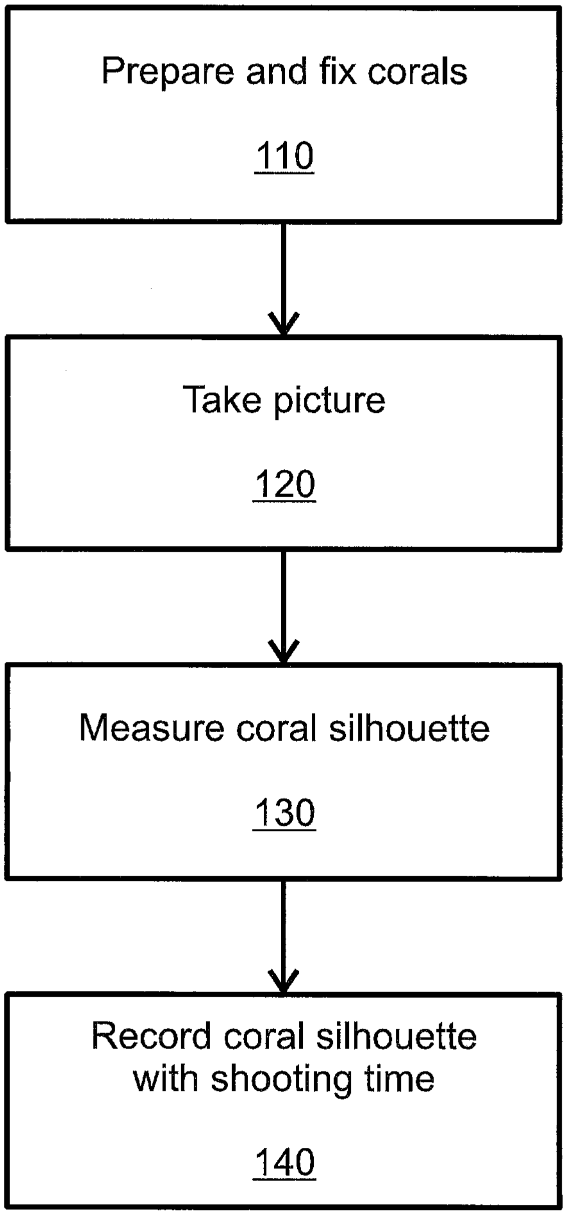
Prepare and fix corals
110
Take picture
120
Measure coral silhouette
130
Record coral silhouette with shooting time
140

FIG. 3

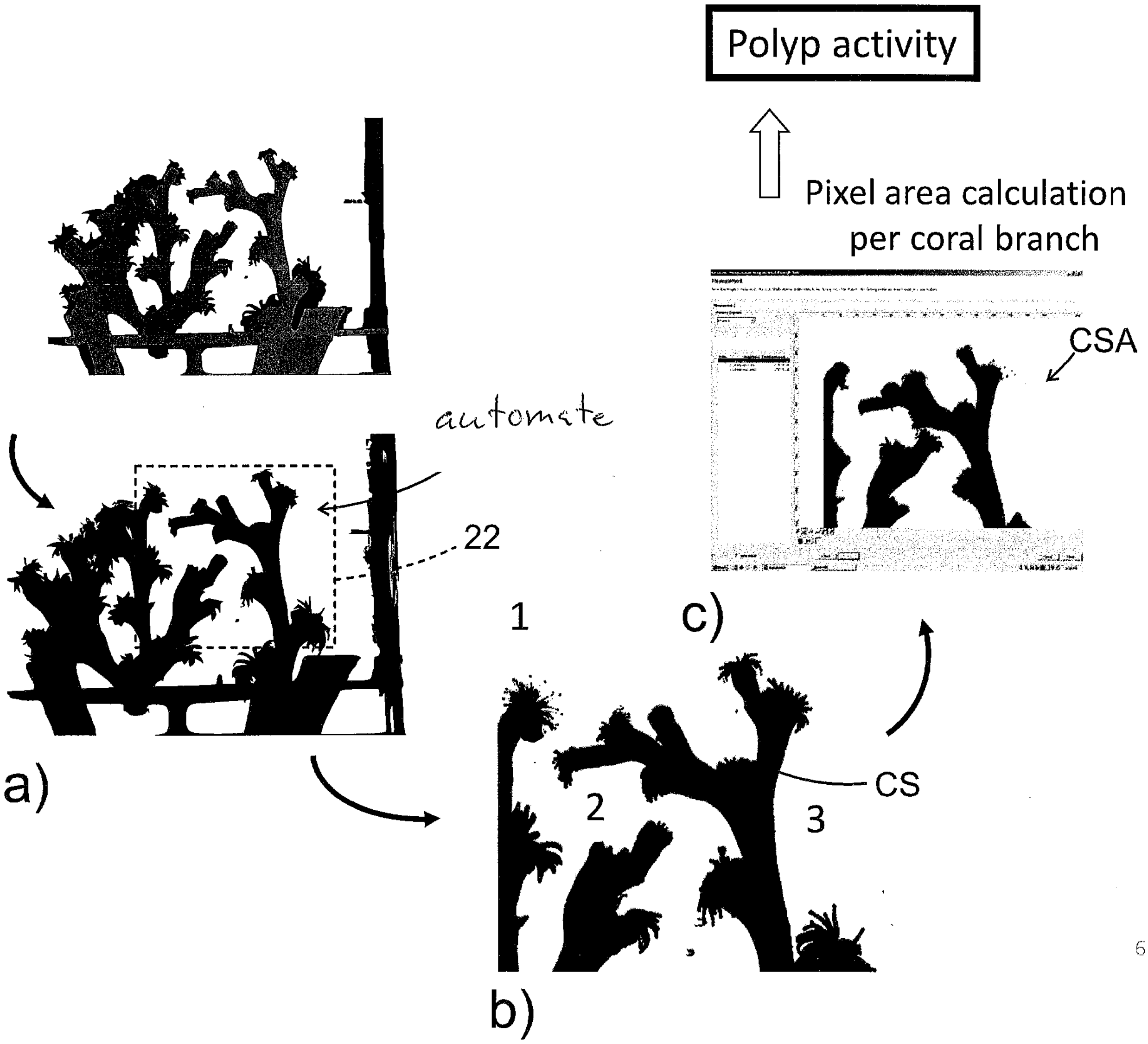
Polyp activity
Pixel area calculation
per coral branch
CSA
automate
22
1
c)
2
CS
3
a)
b)
6

FIG. 4

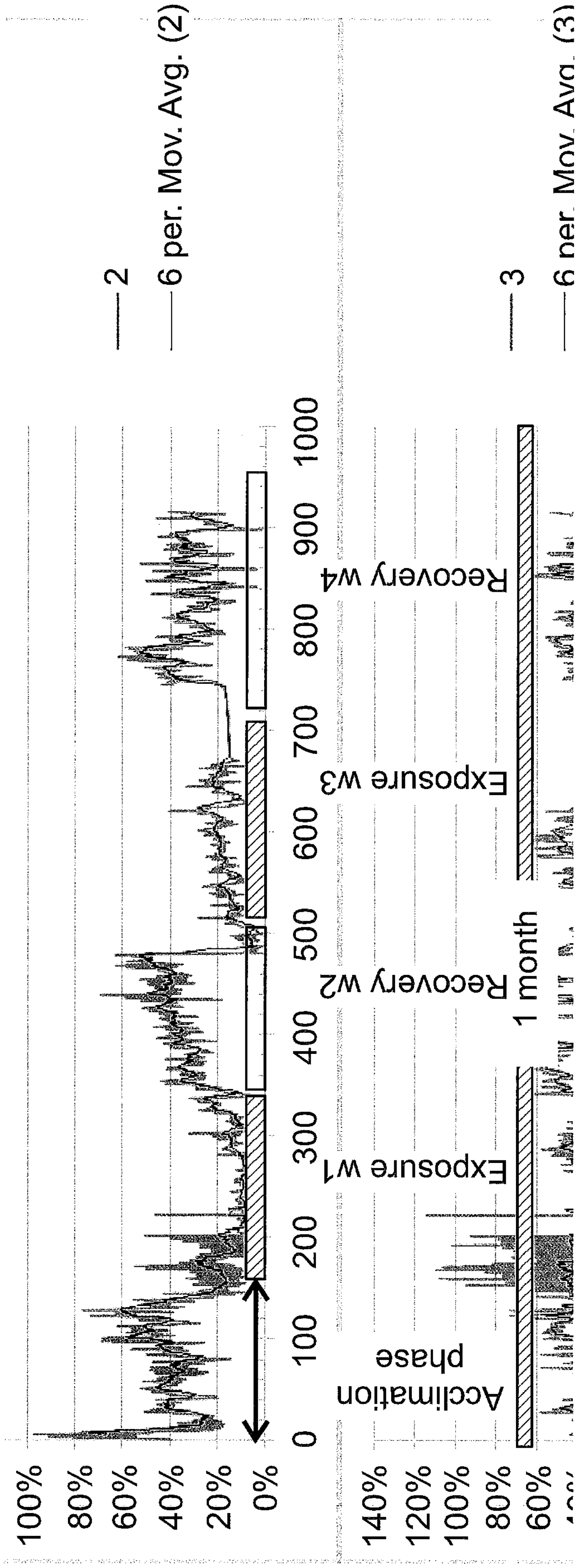
2
6 per. Mov. Avg. (2)
3
100%
80%
60%
40%
20%
0%
140%
120%
100%
80%
60%
0
100
200
300
400
500
600
700
800
900
1000
Acclimation phase
Exposure w1
Recovery w2
Exposure w3
Recovery w4
1 month

FIG. 5 a-b

REFERENCES CITED IN THE DESCRIPTION

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- Impact of water-based drilling mud in the Barents Sea: a study using the epibenthic coral species Lophelia pertusa. *NFR "Havet & kysten" 184699/S40* **[0034]**
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