The present invention pertains to a method for automatic sea lice monitoring in salmon aquaculture, the method comprising submerging a camera in a sea pen comprising salmons, using the camera to make an image of at least one of said salmons, analysing the image to differentiate between individual sea lice present on the salmon and the salmon itself and assessing the number of sea lice present on the salmon, wherein the camera is attached to a device for guiding the salmon along an imaging track, the camera being directed to the track.
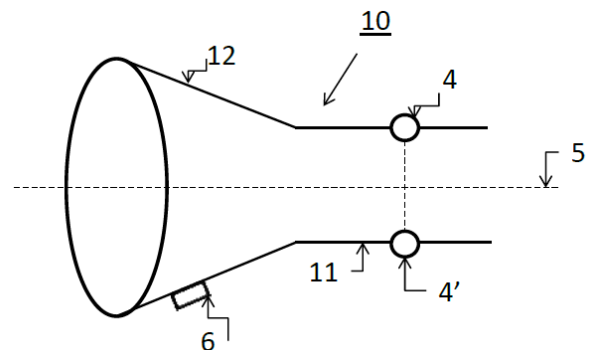
A METHOD FOR AUTOMATIC SEA LICE MONITORING IN SALMON AQUACULTURE

GENERAL FIELD OF THE INVENTION

The present invention pertains to a method for automatic sea lice monitoring in salmon aquaculture, the method comprising submerging a camera in a sea pen comprising salmons, using the camera to make an image of at least one of said salmons, analysing the image to differentiate between individual sea lice present on the salmon and the salmon itself, and assessing the number of sea lice present on the salmon. The invention also pertains to a system for use in salmon aquaculture to automatically monitor and report sea lice presence on salmons, and to a device for making images of salmons present in a sea pen.

BACKGROUND ART

Regular and accurate sea lice monitoring is a vital component to any effective integrated pest management regime targeted against one of the most costly ectoparasitic pathogens associated with modern salmon aquaculture. In most regions with substantial cultured salmon production, sea lice (mainly *Lepeophtheirus salmonis* and various *Caligus* species) continue to be one of the most important fish health concerns. Even in regions where significant infestations tend not to be experienced, such as British Columbia or the far north of Norway, it is important to monitor sea lice levels to mitigate any potential negative impacts for wild salmon. In addition to regular monitoring, the recent emergence in a number of regions of tolerance to certain chemotherapeutants has emphasised the importance of methods to obtain accurate sea lice estimates before and after treatment to properly assess the efficacy of any medication being used so as to gain early warning of tolerance issues. However, to date, this involves a manual process which is time consuming and dependent for its accuracy on the skill of the individual carrying out the count and their ability to access a range of sea pens. Crowding fish within pens to select a representative sample also imposes stress on these fish. Because of the time required only a small number of fish can be sampled. However as lice numbers have been driven down over the past decade, increasingly large samples are required to maintain the statistical reliability of any population-level estimates.

The use of underwater imaging has therefore been proposed as an automated and passive counting system. Creating an image of a salmon covered by sea lice (which image may be part of a video, which video technically is a series of images) provides the possibility of automatically monitoring the number of sea lice on salmons. It is possible to differentiate between individual sea lice present on a salmon and the (skin of the) salmon itself, thus to distinguish between individual sea lice present on the skin of a salmon and the skin of the salmon itself. This way, the number of sea lice present on one salon can be assessed. One of the key projects to practically develop such an imaging method was the Eurostars *VisuaLice* project, which was a follow up innovation of a pilot study by Scottish researchers in 2005-2007. As stated in the Executive Summary of the 2013 report of *VisuaLice* (*Population Interpretation of Passive Sea Lice Monitoring*, authors Cox and Revie) to the *Havbruksinstituttet* and *FHF Norway*, such a system can offer the benefits of enhanced repeatability and accuracy, larger sample sizes, continuous monitoring, lower costs and lower levels of disturbance to the fish. It was therefore proposed in the project to develop such a system to assess the relative value of this novel approach in comparison to traditional manual counting. However, although it appeared to be possible to distinguish individual sea lice present on the skin of a salmon using commonly known imaging techniques, results from experiments and field trials of the underwater imaging system were largely unsuccessful.

OBJECT OF THE INVENTION

It is an object of the invention to devise a method for automatic sea lice monitoring that can successfully be used to assess the number of sea lice present on salmons present in sea pen. It is another object of the invention to devise a system for use in salmon aquaculture to automatically monitor and report sea lice presence on salmons.

SUMMARY OF THE INVENTION

In order to meet the first object of the invention, a method as outlined in the GENERAL FIELD OF THE INVENTION section here above has been devised, wherein the camera is attached to a device for guiding the salmon along an imaging track, the camera being directed to the track. Using a prior art method, the principal problem is not that sea lice cannot be distinguished on a salmon for accurate counting, the problem is that the salmon do not appear on the images in a standardised way, for example, the angle and

distance may vary considerably depending on the spatial relationship between the camera and the salmon at the time of making an image. Also, in many instances far too many salmons appear on an image, partly overlapping each other. This on the one hand makes the automatic sea lice monitoring less easy, but more importantly, may prevent

5   that a complete side surface of a salmon can be assessed. All of this contributes to less reliability.

By using the device as specified, the camera holds a predetermined position with respect to an imaging track (i.e. a path or line along which a salmon may swim, to which

10   path or line the camera is directed to be able and image the salmon when actually passing). Even though the track may be wider than the width of just one salmon, this way the imaging of the salmons may take place with substantially improved reliability. This is because the distance and orientation of the salmons with respect to the camera is better controlled when compared to a method wherein a camera is simply submerged

15   in the sea, without being spatially positioned with respect to an imaging track and thus, with respect to a salmon to be imaged. Also, the chance that an image of salmons overlapping each other is made is decreased, also contributing to an improved reliability of the automatic monitoring method.

20   In order to meet the second object of the invention a system is devised comprising a central processing unit (CPU), and connected to the CPU a camera submerged in a sea pen comprising the salmons, the camera being devised to make images of said salmons, wherein the camera is attached to a device for guiding the salmons along an imaging track of this device, the camera being directed to the track, imaging software

25   running on the CPU to analyse images of the salmons made by the camera, to differentiate between individual sea lice present on each of the said salmons and the salmons themselves, and to assess the number of sea lice present on the salmons, and a reporting unit connected to the CPU, to display a results corresponding to said assessing. This system makes use of the same advantages of the imaging device as

30   described here above.

The invention also enables the use of a device for making images of salmons present in a sea pen, the device comprising a track for guiding a salmon through the device, the device comprising an enclosure that confines the track, wherein the camera is attached

35   to the enclosure and directed to the track.

DEFINITIONS

Automatic means without requiring operator intervention to perform the action. This does not exclude that an automatic action may be initiated (for example requested),
5   intervened or terminated by an operator.

Radial means heaving walls or borders arranged around a centre.

Assessing a number of items means to create a parameter that corresponds to that
10   number of items, for example by explicitly counting the number of items or by establishing the total weight of the items.

A *central processing unit* is a hardware system, programmed to process data. The hardware does not need to be one single unit, but may comprise several distributed
15   units operatively connected via for example wireless connections.

An *enclosure of a track* means that the items that should pass the track cannot freely cross the enclosure. This does not include that other material (for example units smaller than the items, or a liquid or gas) can cross the enclosure.
20

A *camera being directed to an item* means that the camera is positioned to be able and make an image of that item or a second item positioned in a straight line between the camera and the said first item.

25   **EMBODIMENTS OF THE INVENTION**

In an embodiment of the method according to the invention the device comprises a radial enclosure to confine the track. It was found that a very convenient and reliable way of guiding a salmon along an imaging track is to use a device that radially confines
30   the track. The width of the opening should be chosen such that the salmon is typically not hindered in swimming along the track, but also, not too big to prevent improper guidance. The actual measures to allow a salmon to swim through the device, and still give adequate guidance is believed to depend mainly on the age (size) of the salmons and the density of the salmons in the pen.
35

In another embodiment the enclosure is circular enclosure. A circular enclosure is easier

to position evenly around a longitudinal imaging track, increasing the reliability of the method. In yet another embodiment the enclosure is endless along its circumference, i.e. not having an opening to interrupt the circumference. This provides for an improved stability of the device. In still another embodiment the device is a circular frame. Such a frame has been found ideally suitable to guide a salmon over a track corresponding to the axis of the frame.

In an embodiment the device is spatially fixed with regard to one or more walls of the sea pen. Would the device be mechanically connected to a float, the submerged device would bounce with the amplitude of the waves. It is foreseen that this creates too much disturbance around the device, possibly keeping the salmons away from taking the imaging track (depending on the amplitude of the waves). By spatially fixing the device with respect to one or more walls of the pen, for example with respect to the bottom of the pen using an anchor that grasps this bottom, this potential problem may not arise.

In another embodiment the device comprises at least two cameras directed to the track. Using two or more cameras enables a greater surface of the salmon to be images, thereby increasing the reliability of the assessment of the number of sea lice present on the salmon.

In still another embodiment the device is provided with a thermometer to record the sea water temperature at the time the image is made. The seat water temperature is an important factor in sea lice infestations. By recording the sea water temperature, the relation between temperature and sea lice infestations can be better assessed.

In yet another embodiment, in addition to the number of sea lice present on the salmon, the size of these lice is assessed. This way, information about the stage of life of the sea lice can be obtained. This can be important information to optimize combatting an infestation of sea lice in a pen.

The invention will now be further explained using the following examples.

EXAMPLES

Figure 1 shows devices for use in the present method.
Figure 2 schematically shows a system according to the invention.

Figure 3 shows a device according to the invention, spatially fixed with regard to the walls of a sea pen for cultivating salmons.

Figure 1

5 Figure 1 shows three devices for use in the present method. In figure 1A a simple open triangle 1 is depicted, comprising two legs 2 and 3, having a length of about 50 cm. Within the try square of the triangle, imaging track 5 (which is viewed from the back in this figure) is depicted. Cameras 4 and 4' are directed to this track. The triangle legs will typically prevent that salmons will swim very close to the legs, they will keep a certain

10 distance. This distance is such that it coincides with the distance between the track and the two legs. This way, occasionally a salmon will swim along the imaging track. Upon passing the cameras, one or more pictures (or a short film) will be taken for image analysis.

15 An improved device is depicted in figure 1B. This device 10 has as a core part a cylindrical tube 11, which tube represents a radial enclosure to confine the imaging track 5. At its distal end, the tube 11 is provided with a funnel 12 to guide a salmon towards the tube 11. The diameter of the core is such that a salmon will not enter the core at the non-funnel side, since the salmon will notice the walls of the tube (for a salmon of 3-4 kg

20 this may be a diameter of about 20-25 cm). However, at the funnel side, once entered the device, a salmon will not turn when reaching the tube 11 and will swim through, in essence following the imaging track 5. Two cameras 4 and 4' are directed towards this track. The device is also equipped with a thermometer 6 to measure the temperature of the sea water at the time of taking pictures (images) of the salmon.

25

Another type of device is depicted in figure 1C. This device 100 comprises an endless circular frame enclosing an imaging track 5. To the frame are connected two cameras 4 and 4', and a thermometer 6, corresponding to the same elements as depicted in figure 1B. The diameter of the frame is chosen such that a salmon will swim through the

30 device from either side and be guided in essence along (*i.e.* coinciding with or at least adjacent) the imaging track. For a salmon having a weight of 3-4 kg, a typical diameter is 40-60 cm (depending also on the density of salons in the pen). In an embodiment (not shown), the frame is provided with means to adapt the circular width to the size of the salmons in a pen. At the bottom of the frame, indications of length 7 are provided to

35 serve as a ruler.

In particular for the devices having a radially enclosure for the imaging track, smaller versions may be made to learn young salmons in hatcheries to get comfortable with swimming through the device. This may lead to an ultimate device (*i.e.* a device for use in the actual sea pen to grow the salmons) having minimum radial dimensions, thereby
5   increasing the intrinsic reliability of the method.

Figure 2

Figure 2 schematically shows a system according to the invention. The system comprises a central processing unit (CPU) 200 and via data line 207 (which may be a
10   wireless connection) connected to the CPU the device 100 (see Figure 1C) submerged in a sea pen comprising the salmons (not shown; see Figure 3). The cameras of the device 100 are devised to make images of the salmons when they swim along the corresponding imaging track. The CPU comprises imaging software running on the CPU to analyse images of the salmons made by the camera, to differentiate between
15   individual sea lice present on each of the said salmons and the salmons themselves, and to assess the number of sea lice present on the salmons. For this, the CPU makes use of a memory 202 which via line 201 forms a part of the CPU as a whole. Data is reported via lines 203 and 205 to the regulating authorities 204 and/or farmer 206 respectively.

20

Figure 3

Figure 3 shows a device 100 according to the invention, spatially fixed with regard to the walls of a sea pen 300 submerged in the sea 301. The device 100 is coupled to an anchor 401 that is attached to the bottom of the sea pen 300. Next to this, the device is
25   coupled via two damped lines 402 and 402' to sites of the wall of the pen near the surface of the sea. This makes sure that the device will not bounce with respect to the pens itself, thereby increasing the chance that salmons will be guided along the imaging track.

CLAIMS

1. Method for automatic sea lice monitoring in salmon aquaculture, the method comprising:

- submerging a camera (4) in a sea pen (300) comprising salmons,
- using the camera to make a standardised image of at least one of said salmons,
- analysing the standardised image to differentiate between individual sea lice present on the salmon and the salmon itself,
- assessing the number of sea lice present on the salmon,

characterised in that the camera is attached to a device (1, 10, 100) for guiding the salmon along an imaging track (5), the camera being directed to the track.

2. A method according to claim 1, characterised in that the device comprises a radial enclosure (11, 101) to confine the track.

3. A method according to claim 2, characterised in that the enclosure is circular enclosure.

4. A method according to any of the claims 2 or 3, characterised in that the enclosure is endless along its circumference.

5. A method according to any of the claims 2 to 4, characterised in that the device is a circular frame (101).

6. A method according to any of the preceding claims, characterised in that the device is spatially fixed with regard to one or more walls of the sea pen.

7. A method according to any of the preceding claims, characterised in that the device comprises at least two cameras directed to the track.

8. A method according to any of the preceding claims, characterised in that the device is provided with a thermometer (6) to record sea water temperature at the time the image is made.

9. A method according to any of the preceding claims, characterised in that in addition to the number of sea lice present on the salmon, the size of these lice is assessed.

10. A system for use in salmon aquaculture to automatically monitor and report sea lice
5   presence on salmons, the system comprising

- a central processing unit (CPU; 200)
- connected to the CPU a camera submerged in a sea pen comprising the salmons, the camera being devised to make standardised images of said salmons, wherein the
10   camera is attached to a device for guiding the salmons along an imaging track of this device, the camera being directed to the track,
- imaging software running on the CPU to analyse the standardised images of the salmons made by the camera, to differentiate between individual sea lice present on each of the said salmons and the salmons themselves, and to assess the number of
15   sea lice present on the salmons,
- a reporting unit (204, 206) connected to the CPU, to display a results corresponding to said assessing.

11. A device for making standardised images of possibly sea lice infested salmons
20   present in a sea pen, the device comprising a track for guiding a salmon through the device, the device comprising an enclosure that confines the track, wherein the camera is attached to the enclosure and is directed to the track.

Krav

1. Fremgangsmåte for automatisk overvåking av fiskelus i laks akvakultur, hvor fremgangsmåten omfatter:

- å senke ned et kamera (4) i en merd (300) som inneholder lakser,
- å bruke kameraet for å lage et standardisert bilde av minst én av laksene,
- å analysere det standardiserte bildet for å differensiere mellom individuelle fiskelus som er tilstede på laksen og laksen i seg selv,
- å vurdere antallet fiskelus som er tilstede på laksen,

karakterisert ved at kameraet er festet til en anordning (1, 10, 100) for å styre laksen langs et avbildningsspor (5), hvor kameraet blir rettet mot sporet.

2. Fremgangsmåte ifølge krav 1, karakterisert ved at anordningen omfatter en radial innhylling (11, 101) for å begrense sporet.

3. Fremgangsmåte ifølge krav 2, karakterisert ved at innhyllingen er sirkulær innhylling.

4. Fremgangsmåte ifølge hvilket som helst av kravene 2 til 3, karakterisert ved at innhyllingen er endeløs langs sin cirkumferens.

5. Fremgangsmåte ifølge hvilket som helst av kravene 2 til 4, karakterisert ved at anordningen er en sirkulær ramme (101).

6. Fremgangsmåte ifølge hvilket som helst av de foregående kravene, karakterisert ved at anordningen er romlig festet med hensyn til én eller flere vegger av merden.

7. Fremgangsmåte ifølge hvilket som helst av de foregående kravene, karakterisert ved at anordningen omfatter minst to kameraer rettet mot sporet.
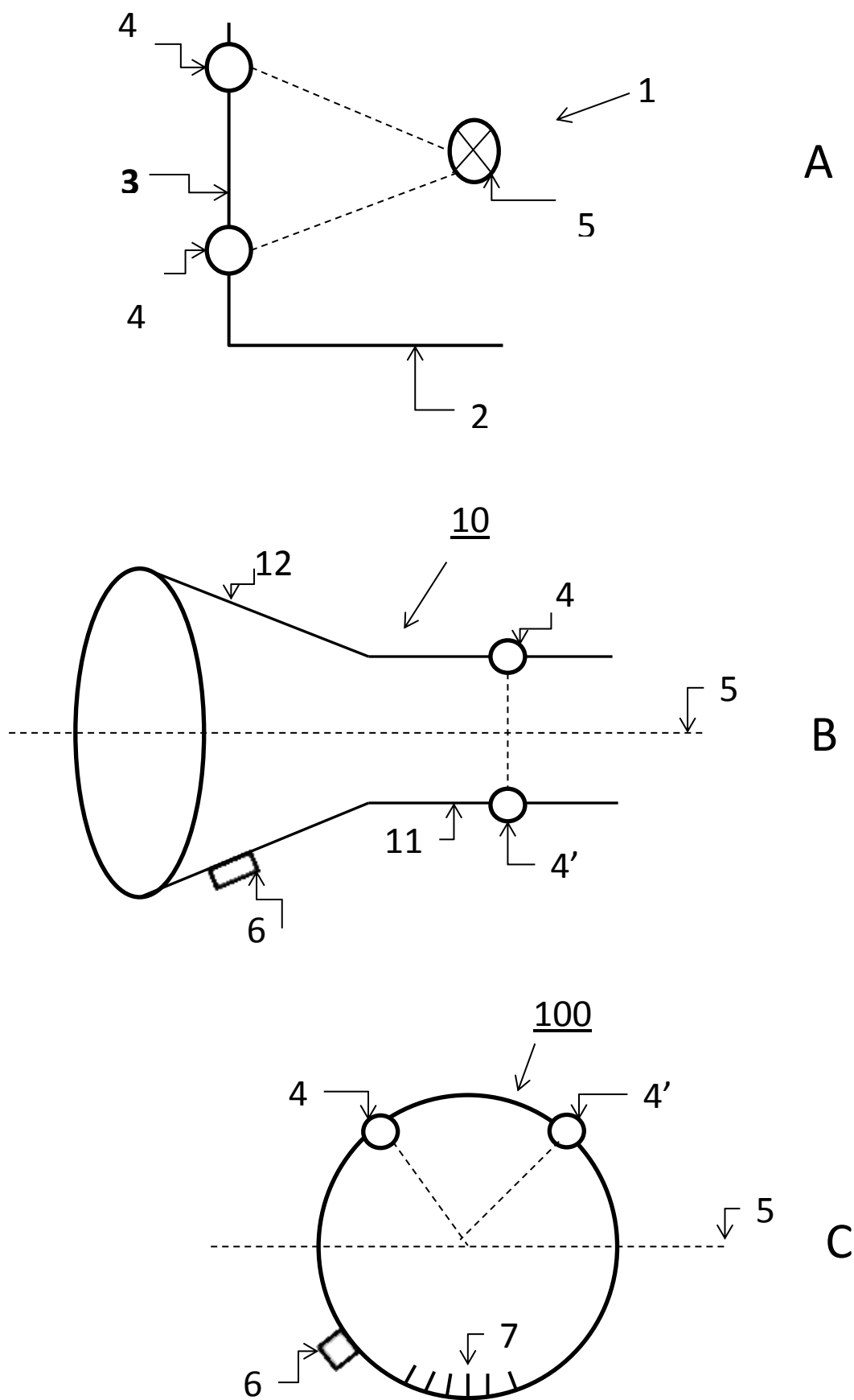
8. Fremgangsmåte ifølge hvilket som helst av de foregående krav, karakterisert ved at anordningen er forsynt med et termometer (6) for å oppta sjøvannstemperatur på det tidspunkt bildet er laget.
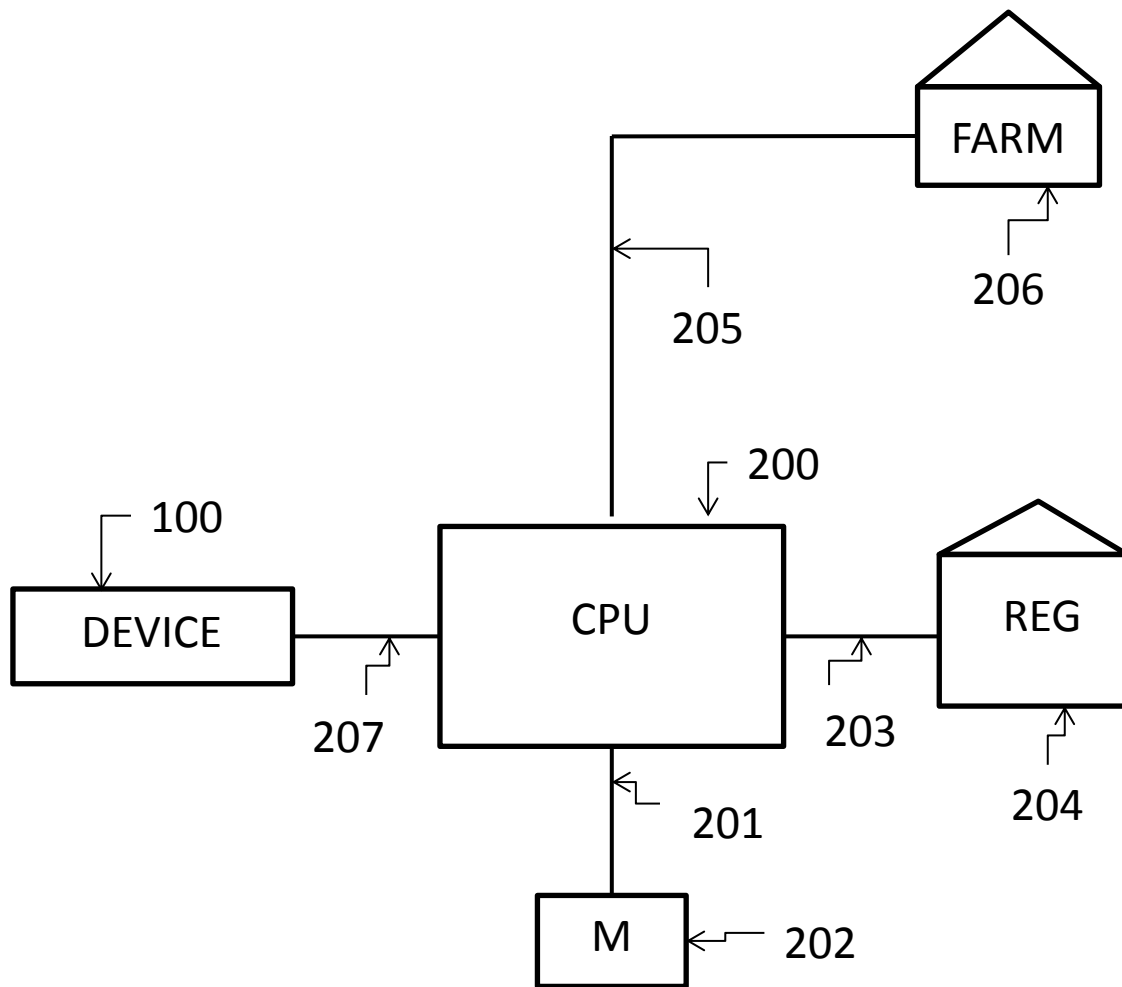
9. Fremgangsmåte ifølge hvilket som helst av de foregående krav, karakterisert ved at i tillegg til antallet fiskelus som er tilstede på laksen, størrelsen av disse lusene vurderes.
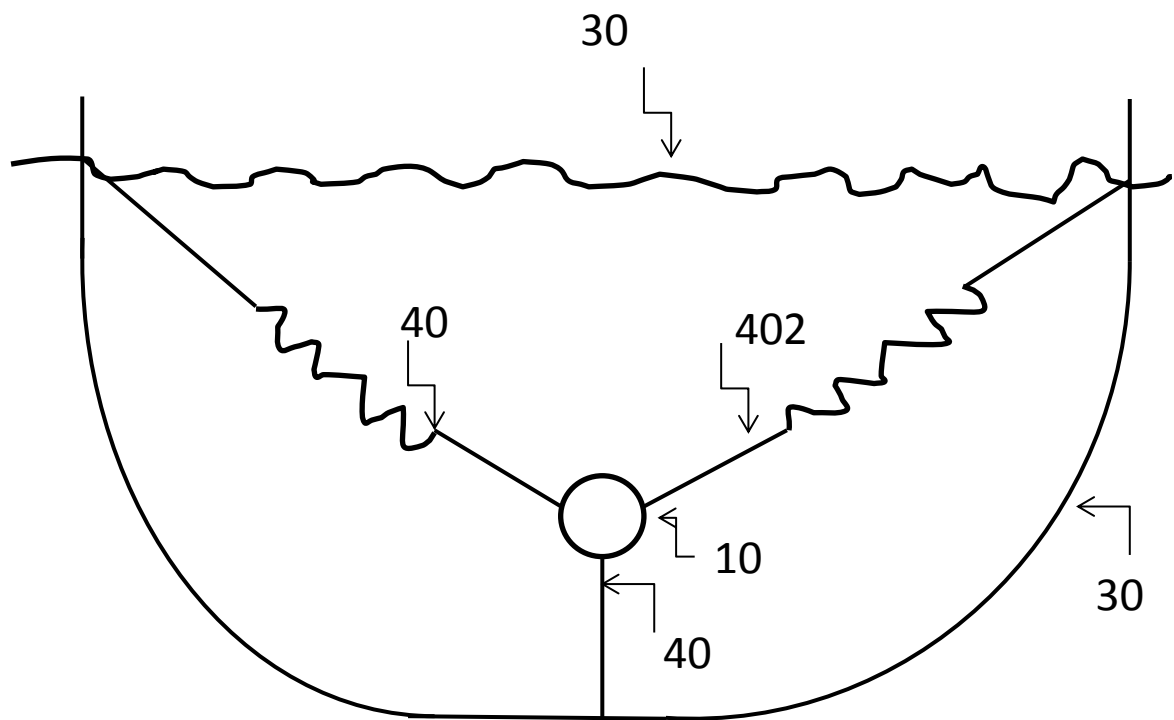
10. Et system for bruk i laks akvakultur for å automatisk overvåke og rapportere fiskelus tilstedeværelse på lakser, hvor systemet omfatter

- en sentral prosessorenhet (CPU; 200)

- koblet til CPU-en et kamera senket ned i en merd som inneholder laksene, hvor kameraet er utformet for å lage standardiserte bilder av laksene, hvor kameraet er festet til en anordning for å styre laksene langs et avbildningsspor (5), hvor kameraet blir rettet mot sporet,

- avbildnings programvare som kjører på CPU-en for å analysere de standardiserte bildene av laksene som er laget ved kameraet, for å differensiere mellom individuelle fiskelus som er tilstede på hver av laksene og laksene i seg selv, og å vurdere antallet fiskelus som er tilstede på laksene,

- en rapporteringsenhet (204, 206) som er koblet til CPU-en, til å vise resultater som svarer til vurderingen.

11. En anordning for å fremstille standardiserte bilder av muligens fiskelus plagete lakser som er tilstede i en merd, hvor anordningen omfatter et spor for å styre en laks gjennom anordningen, hvor anordningen omfatter en innhylling som begrenser sporet, hvor kameraet er festet til innhyllingen og er rettet mot sporet.

342604

Fig. 1

Fig. 2

Fig. 3