(54) Title of the Invention: **Deterring underwater animals from an underwater region**

Abstract Title: **Deterring underwater animals from an underwater region**

(57) In order to deter underwater animals from an underwater region such as adjacent the entrance to an outtake pipe or channel from a river, sound and light are produced in the underwater region and are intermittently pulsed and/or at least one characteristic of the sound and light is repetitively modulated. At least some of the pulses of light and/or the occurrences of at least one feature in at least some of the light modulation repetitions are substantially synchronised with at least some of the pulses of sound and/or the occurrences of at least one feature in at least some of the sound modulation repetitions. For example, the sound may be frequency modulated, and the light may be pulsed when the sound frequency reaches its minimum. It is believed that this synchronisation of light and sound has a synergistic effect.

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**FIG. 5A**

Time | Sound Frequency | Light State
---|---|---
| | | 1

$F_{\text{MAX}}$ = Minimum frequency
$F_{\text{MIN}}$ = Maximum frequency
$T_0$ = Base period
FIG. 3

FIG. 4

MIN. FREQ. SET
F_{MIN}

MOD. WAVEFORM SET

MAX. FREQ. SET
F_{MAX}

SOUND WAVEFORM SET

MOD. WAVE GENERATOR

MOD. RATE SET
F_{MOD}

CLOCK

PULSE GENERATOR
T_{P}

PULSE WIDTH SET

SOUND WAVE GENERATOR

AUDIO AMP.

SPEAKER(S)

LED AMP & REGULATOR

LED(S)
Deterring underwater animals from an underwater region

This invention relates to a system for and a method of deterring fish and other underwater animals from an underwater region.

It is well known to draw vast quantities of water from rivers, lakes and the sea in order, for example, to cool thermal power stations, to drive hydroelectric power stations and to provide irrigation and drinking water. Underwater animals can be drawn with the water, with the possible consequences of death and injury to the animals and damage to, and increased required maintenance of, plant and machinery.

A partial solution to this problem is to provide a physical screen or mesh across the offtake for the water. However, being pulled against or into the screen can cause death or injury to underwater animals. Also, the screen provides a good hunting ground for predators. Furthermore, the screen may become blocked by debris and will require regular maintenance.

Another partial solution to the problem is to deter the marine animals from the water offtake using behavioural screening. More particularly, the underwater region immediately upstream of the water offtake is bathed in an aversive stimulus, so that animals approaching the region find the stimulus unpleasant and turn away from the region. One known aversive stimulus is loud noise produced by an underwater loudspeaker. Another known aversive stimulus is formed by brilliant flashes of light produced by an underwater strobe discharge tube. Strobe discharge tubes of the type used for this purpose, produce a very bright flash of light for a very short duration, typically a few nanoseconds. Neither of these behavioural screening methods has proven to be completely effective. Furthermore, strobe discharge tubes have a limited life and require regular replacement.

An aim of the present invention, or at least of specific embodiments of it, is to provide a system for, and method of, deterring underwater animals from an underwater region which is more effective than the methods discussed above and which requires minimal maintenance.
In accordance with a first aspect of the invention, there is provided a system for deterring underwater animals from an underwater region, comprising: means for producing sound in the underwater region; means for producing light in the underwater region; and means for driving the sound and light producing means. The sound and light producing means are driven so that: the sound is intermittently pulsed and/or at least one characteristic of the sound is repetitively modulated; the light is intermittently pulsed and/or at least one characteristic of the light is repetitively modulated; and at least some of the pulses of light and/or the occurrences of at least one predetermined feature in at least some of the light modulation repetitions are substantially synchronised with at least some of the pulses of sound and/or the occurrences of at least one predetermined feature in at least some of the sound modulation repetitions.

It is believed that the synchronisation of the light and sound pulses and/or modulation repetitions has a synergistic effect in deterring underwater animals from the region. One possible explanation for this is as follows. A human may well find the sound alone of a nearby explosion frightening and want to move away from it, but be unsure of the direction in which to go. Also, a human seeing a bright flash of light nearby may find it startling, but not so frightening as the sound of the explosion, and they may not take any immediate action unless the flash of light is repeated and becomes annoying. However, if the explosive sound and the bright flash of light are combined, it is likely that the human reaction will immediately be to move in a direction away from the source of the light flash.

Preferably, the light is intermittently pulsed. The beginnings of at least some of the pulses of light may be substantially synchronised with the sound. However, in the case where each pulse of light has a duration which is less than the duration between the pulses of light, the pulses of light generally may be substantially synchronised with the sound. Each pulse of light preferably has a duration of at least 1 ms. The light producing means preferably comprises at least one LED, which typically has a longer life and requires less complex driver circuitry than a strobe tube emitting an equivalent amount of light energy but with pulses of far shorter duration. Alternatively, the light producing means may comprise at least one cold cathode light, halogen light or fluorescent light.

Alternatively or additionally, at least one characteristic of the light, such as its brightness or possibly its colour, may be repetitively modulated. The, or at least one of the, repetitively modulated characteristics of the light may be varied in value progressively. In this case, at least some of the maxima and/or minima in the value of the repetitively modulated characteristic of the light are preferably substantially synchronised with the sound.
Alternatively, the, or at least one of the, repetitively modulated characteristics of the light may be varied in value in a stepwise fashion. In this case, at least some of the step changes in the value of the repetitively modulated characteristic of the light are preferably substantially synchronised with the sound.

Preferably, at least one characteristic of the sound, such as its pitch (i.e. frequency), volume or waveform, is repetitively modulated. In the case of waveform modulation, the waveform may be modulated between at least two of the following: a sine wave; a chopped sine wave; a square wave; a triangular wave; and a sawtooth wave. The, or at least one of the, repetitively modulated characteristics of the sound may be varied progressively. In the case of, for example, pitch or volume modulation, at least some of the maxima and/or minima in the value of the repetitively modulated characteristic of the sound may be substantially synchronised with the light. For example, the pitch of the sound may be progressively modulated between a high frequency and a low frequency, and a flash of light may be produced when the sound hits the high frequency. In the case of, for example, waveform modulation, at least some of repeating predetermined stages in the modulation repetitions of the sound may be substantially synchronised with the light. Alternatively or additionally, the, or at least one of the, repetitively modulated characteristics of the sound may be varied in a stepwise fashion. In this case, at least some of the step changes in the repetitively modulated characteristic of the sound may be substantially synchronised with the light.

Alternatively or additionally, the sound may intermittently pulsed. In this case, the beginnings of at least some of the pulses of sound may be substantially synchronised with the light. However, in the case where each pulse of sound has a duration which is less than the duration between the pulses of sound; the pulses of sound generally may be substantially synchronised with the light. For example, each pulse of sound, such as a crash, a bang or a sweep of a sine wave, may be synchronised with a flash of light.

The sound and/or the light is/are preferably modulated and/or pulsed at a modulation and/or pulse frequency no greater than 50 Hz. At higher modulation frequencies of the light, it is expected that underwater animals would not be able to perceive the modulation.

One pulse or modulation repetition of the sound may be provided for each pulse or modulation repetition of the light. Alternatively, a plurality of pulses or modulation repetitions of the sound may be provided for each pulse or modulation repetition of the light. For example, the pitch of the sound may be progressively modulated between a frequency note and a low frequency, and a flash of light may be produced every other time that the sound hits the high
frequency. Alternatively, one pulse or modulation repetition of the sound may provided for a plurality of pulses or modulation repetitions of the light. For example, only one in three flashes of light may be accompanied by a crash of sound, or three flashes of light may occur as the sound is modulated between low and high frequencies, one being synchronised with the sound hitting the high frequency.

The pulsing and/or modulation of the sound and light may have a constant rate so as to be cyclic. On the other hand, the pulsing and/or modulation of the sound and light may have a modulated rate. It is believed that this may prevent habituation of the underwater animals to the light and sound produced by the system. Alternatively, the pulsing and/or modulation of the sound may be pseudo-random, with the light being substantially synchronised to the sound. On the other hand, the pulsing and/or modulation of the light may be pseudo-random, with the sound being substantially synchronised to the light. For example, the system may be arranged to produce flashes of light at pseudo-random intervals, with crashes of sound accompanying some, but not all, of the flashes of light in a regular or pseudo-random manner. Again, it is believed that this may prevent habituation of the underwater animals to the light and sound produced by the system.

In a particularly preferred embodiment of the invention, the driving means drives the sound and light producing means so that: the light producing means repetitively produces pulses of light; each light pulse has a duration of at least 1 ms; the pulses of light have a pulse frequency no greater 50 Hz; the sound producing means produces sound having its volume and/or pitch repetitively modulated; and at least one feature in each sound modulation repetition is substantially synchronised with the pulses of light.

The sound and light may be generated above the water and projected into the water, but the sound and light are preferably generated underwater in the region from which the underwater animals are to be deterred, in which case the sound and/or light producing means is/are preferably adapted to be usable underwater. The sound producing means and the light emitting means are preferably disposed adjacent each other. The underwater animals can therefore associate the light and the sound with each other.

In accordance with a second aspect of the invention, there is provided a method of deterring underwater animals from an underwater region. The method comprises producing sound in the underwater region and producing light in the underwater region. The sound is intermittently pulsed and/or at least one characteristic of the sound is repetitively modulated. The light is intermittently pulsed and/or at least one characteristic of the light is repetitively
modulated. At least some of the pulses of light and/or the occurrences of at least one feature in at least some of the light modulation repetitions are substantially synchronised with at least some of the pulses of sound and/or the occurrences of at least one feature in at least some of the sound modulation repetitions.

The method of the second aspect of the invention preferably includes any of the steps or functions described above as provided by the system of the first aspect of the invention.

Specific embodiments of the present invention will now be described, purely by way of example, with reference to the accompanying drawings, in which:

Figures 1A-C are schematic cross-sectioned, longitudinally-sectioned and plan views, respectively, of a river having an offtake pipe installed with a fish deterrent system;

Figures 2A-C are schematic cross-sectioned, longitudinally-sectioned and plan views, respectively, of a river having an offtake channel installed with a fish deterrent system;

Figure 3 is a schematic isometric view of a combined sound and light producing unit of a fish deterrent system;

Figure 4 is a schematic diagram of one embodiment of driving circuit for the sound and light producing unit(s);

Figures 5A & B are wave diagrams illustrating two different modes of operation of the circuit of Figure 4;

Figure 6 is a schematic diagram of another embodiment of driving circuit for the sound and light producing unit(s);

Figure 7 is a wave diagram illustrating operation of the circuit of Figure 7;

Figure 8 is a schematic diagram of a further embodiment of driving circuit for the sound and light producing unit(s);

Figure 9 is a wave diagram illustrating operation of the circuit of Figure 8;

Figures 10 & 11 illustrate a modification to the arrangement of Figures 8 and 9; and
Figures 12-15 are wave diagrams illustrating alternative operations of the driving circuit.

Referring to Figures 1A-C, in one example of installation of a fish deterrent system, a river 10 has an underground offtake pipe 12, through which water is drawn to an irrigation system (not shown). A combined sound and light producing unit 14 is mounted on a post 16 set into the river bed 18 adjacent the inlet end of the offtake pipe 12 and is connected by a cable 20 to a driver unit 22 disposed on the river bank 24. In use, the sound and light unit 14 radiates synchronised sound and light away from the inlet end of the offtake pipe 12 over a wide angle of, for example, 180 degrees, with the primary axis of radiation approximately aligned with the offtake pipe 12. The synchronised sound and light deters fish in the river 10 away from the inlet end of the offtake pipe 12.

Referring to Figures 2A-C, in another example of installation of a fish deterrent system, a river 10 has an offtake channel 26, along which water is drawn to power station (not shown). Seven combined sound and light producing units 14 are mounted on posts 16 set into the river bed 18 or channel bed adjacent the inlet end of the offtake channel 26 and spread across the inlet end of the offtake channel 26. The sound and light producing units are connected by a cable 20 to a driver unit 22 disposed on the river bank 24. In use, the sound and light units 14 radiate synchronised sound and light away from the inlet end of the offtake channel 26 over a wide angle of, for example, 180 degrees. As shown in Figure 2C, the sound and light producing units 14 may be oriented so that their primary axes of radiation are not parallel so as to improve the distribution of sound and light. The synchronised sound and light deter fish in the river 10 from the inlet end of the offtake channel 26.

Referring to Figure 3, each sound and light producing unit 14 comprises a waterproof cabinet 28 containing a waterproof loudspeaker 30 and a number of LEDs 32 which have their electrical connections protected from the water. The loudspeaker 30 is sufficiently powerful to produce a sound level of about 160dB re 1uPa. Although four LEDs 32 are shown in the drawing, a considerably larger number of LEDs 32 may be included in the unit 14, for example eighty. Each LED 32 might typically have a power consumption of 2W. The LEDs 32 may be arranged all to radiate light in the same direction, or they may be at various angles in order to obtain a required light distribution pattern. The LEDs 32 may produce white light, but other colours of light may also be effective. The connecting cable 20 for the sound and light producing unit 14 carries a drive signal for the loudspeaker 30 and a separate drive signal for the LEDs 32.
Referring to Figure 4, in one example of the driver unit 22, a modulation rate setting device 34 produces a signal representing a desired modulation rate $F_{\text{MOD}}$ in the range, for example, between 1Hz and 50Hz, which is supplied to a clock 36 and to a modulation wave generator 38. The clock 36 produces a square wave signal at the modulation rate $F_{\text{MOD}}$ which is supplied to a pulse generator 40 and to the modulation wave generator 38. A pulse width setting device 42 produces a signal representing a desired pulse width $T_p$ for the light pulses, for example between 1ms and 500ms (and more preferably about 20ms) and less than the inverse $1/F_{\text{MOD}}$ of the modulation rate $F_{\text{MOD}}$. The pulse generator 40 produces a series of rectangular pulses at the modulation rate $F_{\text{MOD}}$, each pulse beginning with a positive-going transition in the clock signal, and each pulse having the pulse width $T_p$. The series of pulses is supplied from the generator 40 to an amplifier and regulator 44 which drives the LEDs 32 at their appropriate current so that they flash with each flash beginning with a positive-going transition in the clock signal, and each flash having the pulse width $T_p$. A minimum sound frequency setting device 46 and a maximum sound frequency setting device 48 produce signals representing the minimum sound frequency $F_{\text{MIN}}$ and the maximum sound frequency $F_{\text{MAX}}$, respectively, and these signals are supplied to the modulation wave generator 38. The minimum and maximum sound frequencies $F_{\text{MIN}}$, $F_{\text{MAX}}$ may, for example, be 10Hz and 500Hz, respectively. Also, a modulation waveform setting device 50 produces a signal representing whether the sound modulation is to have a sine waveform, a square waveform, a triangular waveform, a sawtooth waveform or a more complex waveform, and this signal is also supplied to the modulation wave generator 38. The modulation wave generator 38 produces a sound-frequency signal $F_s$ which: (a) is modulated between the minimum sound frequency $F_{\text{MIN}}$ and the maximum sound frequency $F_{\text{MAX}}$ at the modulation rate $F_{\text{MOD}}$; (b) has a waveform as indicated by the modulation waveform setting device 50; and (c) has a particular feature in the waveform (such a maximum, a minimum or a step change) synchronised with a positive-going transition in the clock signal from the clock 36. The sound frequency signal $F_s$ is supplied to a sound wave generator 52, as too is a signal from a sound waveform setting device 54 representing the waveform of the required sound, such as a sine waveform, a square waveform, a triangular waveform or a sawtooth waveform. The sound wave generator 52 produces an audio signal having a waveform as indicated by the sound waveform setting device 54 and a frequency as indicated by the sound-frequency signal $F_s$. The audio signal is supplied to an audio amplifier 56 which amplifies the signal to a level suitable for supply to the loudspeakers 30.

Figure 5A illustrates an example where the modulation waveform as set by the device 50 is a sine wave which has its minimum synchronised. The frequency $F_s$ of the sound produced
by the loudspeaker(s) 30 is therefore swept up and down sinusoidally between a maximum
frequency \( F_{\text{MAX}} \) and a minimum frequency \( F_{\text{MIN}} \) at a modulation rate \( F_{\text{MOD}} \), and each time the
sound frequency \( F_s \) is a minimum the LEDs 32 produce a flash of light having a flash duration
\( T_P \). It should be noted that Figure 5A shows the frequency of the sound, and not the audio
waveform nor the audio volume. The audio waveform is as set by the setting device 54.

Figure 5B illustrates another example where the modulation waveform as set by the
device 50 is a triangular wave which has its maximum synchronised. The frequency \( F_s \) of the
sound produced by the loudspeaker(s) 30 is therefore modulated linearly at a modulation rate
\( F_{\text{MOD}} \) between a maximum frequency \( F_{\text{MAX}} \) and a minimum frequency \( F_{\text{MIN}} \), and each time the
sound frequency \( F_s \) is a maximum the LEDs 32 produce a flash of light having a flash duration
\( T_P \).

Referring to Figure 6, another embodiment of the driver unit 22 is similar to the unit
described with reference to Figure 4, except that it modulates the volume of the sound.
Specifically, the minimum and maximum frequency setting devices 46,48 are replaced by
minimum and maximum volume setting devices 58,60 which provide signals \( V_{\text{MIN}} \), \( V_{\text{MAX}} \),
respectively, representing the minimum and maximum volume of the sound. The modulation
wave generator 38 therefore produces a sound volume signal \( V_s \), which (a) is modulated
between the minimum sound volume \( V_{\text{MIN}} \) and the maximum sound volume \( V_{\text{MAX}} \) at the
modulation rate \( F_{\text{MOD}} \); (b) has a waveform as indicated by the modulation waveform setting
device 50; and (c) has a particular feature in the waveform (such a maximum, a minimum or a
step change) synchronised with a positive-going transition in the clock signal from the clock 36.
The sound volume signal \( V_s \) is supplied to a volume input of the audio amplifier 56. The device
54 sets not only the desired waveform of the sound, but also its frequency.

Figure 7 illustrates an example where the modulation waveform as set by the device 50
is a sawtooth wave which has its maximum synchronised. The volume \( V_s \) of the sound produced
by the loudspeaker(s) 30 therefore increases linearly over a period \( 1/F_{\text{MOD}} \) from a minimum
volume \( V_{\text{MIN}} \) to a maximum volume \( V_{\text{MAX}} \), and each time the maximum volume \( V_{\text{MAX}} \) is
reached, the LEDs 32 produce a flash of light having a flash duration \( T_P \), and the volume \( V_s \)
immediately drops back to the minimum volume \( V_{\text{MIN}} \).

A further embodiment of the driver unit 22 is shown in Figure 8. A modulation rate
setting device 34 produces a signal representing a desired modulation rate \( F_{\text{MOD}} \) between, for
example, 1Hz and 50Hz, which is supplied to a clock 36. The clock 36 produces a rectangular
wave signal at the modulation rate \( F_{\text{MOD}} \) and with a small mark:space ratio, which is supplied to
a pulse generator 40 and a noise generator 64. A pulse width setting device 42 produces a signal representing a desired pulse width $T_l$ for the light pulses, for example between 1ms and 500ms and less than the inverse $1/F_{MOD}$ of the modulation rate $F_{MOD}$. The pulse generator 40 produces, for each clock pulse received, a rectangular pulse which has a pulse duration $T_l$ and which is passed to the LED amplifier and regulator 44 and then to the LEDs 32. A further pulse width setting device 65 produces a signal representing a desired pulse width $T_s$ for the sound, for example between 1ms and 500ms and less than the inverse $1/F_{MOD}$ of the modulation rate $F_{MOD}$. The noise generator 64 produces, for each clock pulse received a burst of noise which has a pulse duration $T_s$ and which is passed to the audio amplifier 56 and then to the loudspeaker(s) 30, which produce a burst of audio, for example sounding like a bang or a crash. Therefore, as shown in Figure 9, for each clock pulse produced by the clock 36 at the frequency $F_{MOD}$, the LEDs 32 produce a flash of light of duration $T_l$ and the loudspeaker 30 produces a burst of noise of duration $T_s$, with the beginning of each burst of noise being synchronised with the beginning of a flash of light.

A development of the embodiment of Figures 8 and 9 is shown in Figures 10 and 11. In this case, a pair of random switches 60,62 are disposed between the clock 36 and the pulse and noise generators 40,64, respectively. The random switches 60,62 independently and randomly decide whether or not to pass the pulses of the clock signal to the pulse generator 40 and the noise generator 64. Therefore, as shown in Figure 11, for each clock pulse produced by the clock 36 at the modulation rate $F_{MOD}$, there is one of four outcomes:

1. the LEDs 32 produce a flash of light of duration $T_l$ and the loudspeaker 30 produces a burst of noise of duration $T_s$ synchronised with the flash of light;
2. the LEDs 32 produce a flash of light of duration $T_l$ but the loudspeaker 30 is quiet;
3. the loudspeaker 30 produces a burst of noise of duration $T_s$, but the LEDs 32 do not flash; or
4. the LEDs 32 do not flash, and the loudspeaker 30 is quiet.

It will be appreciated that many modifications and developments may be made to the embodiments described above.

For example, in the circuits of Figures 4 and 6, the type of modulation waveform, the type of sound waveform, and the maximum and minimum sound frequencies $F_{MAX}$, $F_{MIN}$ may be permanently set. In the circuits of Figures 4, 6 and 8, the light pulse width $T_P$ or $T_l$ may be permanently set. In the circuit of Figure 8, the sound pulse width $T_s$ may be permanently set.
In the circuits of Figures 4 and 6, the sound frequency need not be progressively swept; instead, as shown in Figure 12, the sound frequency may hop between two or more different frequencies, with a light pulse being synchronised with all of the frequency hops, as shown in Figure 13, or only some of the frequency hops, as shown in Figure 14. In this case, different frequency hops may be synchronised with light pulses of different pulse widths. Also, as shown in Figure 15, in addition to the synchronised light pulses 66, other light pulses 68 of the same or a different duration may also be included.

In the circuits of Figures 4 and 6, instead of modulating the frequency or volume of the sound, the waveform of the sound may be modulated, for example by hopping between a sine waveform and a square waveform, or progressively changing between sine and square waveforms.

Although the circuits of Figures 4, 6 and 8 produce sharp pulses of light, the brightness of the light may instead be progressively modulated in a similar fashion to the sound volume modulation described with reference to Figure 6. Also, the colour of the light may be modulated in addition to, or instead of, the brightness.

In the circuits described above, the modulation rate $F_{\text{mod}}$ need not be constant. Indeed, it may be varied so much, especially in the case of the circuit of Figure 8 that the pulses of light and bursts of sound become quasi random, but with at least some of the pulses of light be synchronised with some of the bursts of sound.

It is possible that underwater animals exposed to any repetitive sound and light combination may become habituated if they stay in the vicinity of the outtake 10,26 for a prolonged period. In other words, their response to the stimulus may become reduced in time as they become used to the stimulus. In this case, it may be useful to change the lights and sounds from time to time, or to vary them over a long time. For example, in the circuits of Figures 4 and 6, the modulation rate $f_{\text{mod}}$, the maximum and minimum frequencies $F_{\text{max}}$, $F_{\text{min}}$, the modulation waveform, the sound waveform, the light pulse width $T_p$ and/or the maximum and minimum volumes $V_{\text{max}}$, $V_{\text{min}}$ may be varied progressively with time, or changed from time to time.

In the embodiments described above, the flashes of light have a relatively short duration $T_p$, and the synchronising feature of the sound is synchronised with the beginning of each light flash. The synchronising features of the sound (i.e. a minimum, a maximum, or a step change) may, instead be synchronised with the middle or the end of each light pulse.
It should be noted that the embodiments of the invention have been described above purely by way of example and that many other modifications and developments may be made thereto within the scope of the present invention.
1. A system for deterring underwater animals from an underwater region, comprising:
   means for producing sound in the underwater region;
   means for producing light in the underwater region; and
   means for driving the sound and light producing means so that:
   the sound is intermittently pulsed and/or at least one characteristic of the sound
   is repetitively modulated;
   the light is intermittently pulsed and/or at least one characteristic of the light is
   repetitively modulated; and
   at least some of the pulses of light and/or the occurrences of at least one
   predetermined feature in at least some of the light modulation repetitions are
   substantially synchronised with at least some of the pulses of sound and/or the
   occurrences of at least one predetermined feature in at least some of the sound
   modulation repetitions.

2. A system as claimed in claim 1, wherein:
   the light is intermittently pulsed.

3. A system as claimed in claim 2, wherein:
   the beginnings of at least some of the pulses of light are substantially synchronised with
   the sound.

4. A system as claimed in claim 2, wherein:
   each pulse of light has a duration which is less than the duration between the pulses of
   light; and
   the pulses of light are substantially synchronised with the sound.

5. A system as claimed in any of claims 2 to 4, wherein:
   each pulse of light has a duration of at least 1 ms.
6. A system as claimed in any preceding claim, wherein:
   the light producing means comprises at least one LED.

7. A system as claimed in any preceding claim, wherein:
   at least one characteristic of the light is repetitively modulated.

8. A system as claimed in any of claim 8, wherein:
   the, or at least one of the, repetitively modulated characteristics of the light is the
   brightness of the light.

9. A system as claimed in claim 7 or 8, wherein:
   the, or at least one of the, repetitively modulated characteristics of the light is varied in
   value progressively.

10. A system as claimed in claim 9, wherein:
    at least some of the maxima and/or minima in the value of the repetitively modulated
    characteristic of the light are substantially synchronised with the sound.

11. A system as claimed in claim 7 or 8, wherein:
    the, or at least one of the, repetitively modulated characteristics of the light is varied in
    value in a stepwise fashion.

12. A system as claimed in claim 11, wherein:
    at least some of the step changes in the value of the repetitively modulated characteristic
    of the light are substantially synchronised with the sound.

13. A system as claimed in any preceding claim, wherein:
    at least one characteristic of the sound is repetitively modulated.
14. A system as claimed in any of claim 13, wherein:
   the, or at least one of the, repetitively modulated characteristics of the sound is the pitch
   of the sound.

15. A system as claimed in any of claim 13 or 14, wherein:
   the, or at least one of the, repetitively modulated characteristics of the sound is the
   volume of the sound.

16. A system as claimed in any of claims 13 to 15, wherein:
   the, or at least one of the, repetitively modulated characteristics of the sound is the
   waveform of the sound.

17. A system as claimed in claim 16, wherein:
   the waveform of the sound is modulated between at least two of the following:
   a sine wave;
   a chopped sine wave;
   a square wave;
   a triangular wave; and
   a sawtooth wave.

18. A system as claimed in any of claims 13 to 17, wherein:
   the, or at least one of the, repetitively modulated characteristics of the sound is varied
   progressively.

19. A system as claimed in claim 18 when dependent on any of claims 13 to 15, wherein:
   at least some of the maxima and/or minima in the value of the repetitively modulated
   characteristic of the sound are substantially synchronised with the light.
20. A system as claimed in claim 18 when dependent on claim 13, 16 or 17, wherein:
   at least some of repeating predetermined stages in the modulation repetitions of the
   sound are substantially synchronised with the light.

21. A system as claimed in any of claims 13 to 20, wherein:
   the, or at least one of the, repetitively modulated characteristics of the sound is varied in
   a stepwise fashion.

22. A system as claimed in claim 21, wherein:
   at least some of the step changes in the repetitively modulated characteristic of the
   sound are substantially synchronised with the light.

23. A system as claimed in any preceding claim, wherein:
   the sound is intermittently pulsed.

24. A system as claimed in claim 23, wherein:
   the beginnings of at least some of the pulses of sound are substantially synchronised
   with the light.

25. A system as claimed in claim 23, wherein:
   each pulse of sound has a duration which is less than the duration between the pulses of
   sound; and
   the pulses of sound are substantially synchronised with the light.

26. A system as claimed in any preceding claim, wherein:
   the sound and/or the light is/are modulated and/or pulsed at a modulation and/or pulse
   frequency no greater than 50 Hz.

27. A system as claimed in any preceding claim, wherein:
one pulse or modulation repetition of the sound is provided for each pulse or modulation repetition of the light.

28. A system as claimed in any of claims 1 to 26, wherein:
   a plurality of pulses or modulation repetitions of the sound are provided for each pulse or modulation repetition of the light.

29. A system as claimed in any of claims 1 to 26, wherein:
   one pulse or modulation repetition of the sound is provided for a plurality of pulses or modulation repetitions of the light.

30. A system as claimed in any preceding claim, wherein:
   the pulsing and/or modulation of the sound and light has a constant rate.

31. A system as claimed in any of claims 1 to 29, wherein:
   the pulsing and/or modulation of the sound and light have a modulated rate.

32. A system as claimed in any of claims 1 to 29, wherein:
   the pulsing and/or modulation of the sound is pseudo-random; and
   the light is substantially synchronised to the sound.

33. A system as claimed in any of claims 1 to 29, wherein:
   the pulsing and/or modulation of the light is pseudo-random; and
   the sound is substantially synchronised to the light.

34. A system as claimed in claim 1, wherein:
   the driving means drives the sound and light producing means so that:
   the light producing means repetitively produces pulses of light;
   each light pulse has a duration of at least 1 ms;
the pulses of light has a pulse frequency no greater 50 Hz;
the sound producing means produces sound having its volume and/or pitch
repetitively modulated; and
at least one feature in each sound modulation repetition is substantially
synchronised with the pulses of light.

35. A system as claimed in any preceding claim, wherein:
the sound producing means is adapted to be usable underwater.

36. A system as claimed in any preceding claim, wherein:
the light producing means is adapted to be usable underwater.

37. A system as claimed in any preceding claim, wherein:
the sound producing means and the light emitting means are disposed adjacent each
other.

38. A system for deterring underwater animals from an underwater region, substantially as
described with reference to the drawings.

39. A method of deterring underwater animals from an underwater region, comprising:
producing sound in the underwater region; and
producing light in the underwater region;
wherein:
the sound is intermittently pulsed and/or at least one characteristic of the sound
is repetitively modulated;
the light is intermittently pulsed and/or at least one characteristic of the light is
repetitively modulated; and
at least some of the pulses of light and/or the occurrences of at least one feature
in at least some of the light modulation repetitions are substantially
synchronised with at least some of the pulses of sound and/or the occurrences of
at least one feature in at least some of the sound modulation repetitions.
40. A method as claimed in claim 39, wherein:

the method includes any of the steps or functions provided by a system as claimed in
any of claims 1 to 38.

41. A method of deterring underwater animals from an underwater region, substantially as
described with reference to the drawings.
Amendments to the claims have been filed as follows

CLAIMS

1. A system for deterring underwater animals from an underwater region, comprising:
   means for producing sound in the underwater region;
   means for producing light in the underwater region; and
   means for driving the sound and light producing means so that:
   the sound is intermittently pulsed and/or at least one characteristic of the sound
   is repetitively modulated;
   the light is intermittently pulsed and/or at least one characteristic of the light is
   repetitively modulated; and
   at least some of the pulses of light and/or the occurrences of at least one
   predetermined feature in at least some of the light modulation repetitions are
   substantially synchronised with at least some of the pulses of sound and/or the
   occurrences of at least one predetermined feature in at least some of the sound
   modulation repetitions.

2. A system as claimed in claim 1, wherein:
   the light is intermittently pulsed.

3. A system as claimed in claim 2, wherein:
   the beginnings of at least some of the pulses of light are substantially synchronised with
   the sound.

4. A system as claimed in claim 2, wherein:
   each pulse of light has a duration which is less than the duration between the pulses of
   light; and
   the pulses of light are substantially synchronised with the sound.

5. A system as claimed in any of claims 2 to 4, wherein:
   each pulse of light has a duration of at least 1 ms.
6. A system as claimed in any preceding claim, wherein:
   the light producing means comprises at least one LED.

7. A system as claimed in any preceding claim, wherein:
   at least one characteristic of the light is repetitively modulated.

8. A system as claimed in any of claim 7, wherein:
   the, or at least one of the, repetitively modulated characteristics of the light is the
   brightness of the light.

9. A system as claimed in claim 7 or 8, wherein:
   the, or at least one of the, repetitively modulated characteristics of the light is varied in
   value progressively.

10. A system as claimed in claim 9, wherein:
    at least some of the maxima and/or minima in the value of the repetitively modulated
    characteristic of the light are substantially synchronised with the sound.

11. A system as claimed in claim 7 or 8, wherein:
    the, or at least one of the, repetitively modulated characteristics of the light is varied in
    value in a stepwise fashion.

12. A system as claimed in claim 11, wherein:
    at least some of the step changes in the value of the repetitively modulated characteristic
    of the light are substantially synchronised with the sound.

13. A system as claimed in any preceding claim, wherein:
    at least one characteristic of the sound is repetitively modulated.
14. A system as claimed in any of claim 13, wherein:
   the, or at least one of the, repetitively modulated characteristics of the sound is the pitch
   of the sound.

15. A system as claimed in any of claim 13 or 14, wherein:
   the, or at least one of the, repetitively modulated characteristics of the sound is the
   volume of the sound.

16. A system as claimed in any of claims 13 to 15, wherein:
   the, or at least one of the, repetitively modulated characteristics of the sound is the
   waveform of the sound.

17. A system as claimed in claim 16, wherein:
   the waveform of the sound is modulated between at least two of the following:
   a sine wave;
   a chopped sine wave;
   a square wave;
   a triangular wave; and
   a sawtooth wave.

18. A system as claimed in any of claims 13 to 17, wherein:
   the, or at least one of the, repetitively modulated characteristics of the sound is varied
   progressively.

19. A system as claimed in claim 18 when dependent on any of claims 13 to 15, wherein:
   at least some of the maxima and/or minima in the value of the repetitively modulated
   characteristic of the sound are substantially synchronised with the light.
20. A system as claimed in claim 18 when dependent on claim 13, 16 or 17, wherein:
   at least some of repeating predetermined stages in the modulation repetitions of the
   sound are substantially synchronised with the light.

21. A system as claimed in any of claims 13 to 20, wherein:
   the, or at least one of the, repetitively modulated characteristics of the sound is varied in
   a stepwise fashion.

22. A system as claimed in claim 21, wherein:
   at least some of the step changes in the repetitively modulated characteristic of the
   sound are substantially synchronised with the light.

23. A system as claimed in any preceding claim, wherein:
   the sound is intermittently pulsed.

24. A system as claimed in claim 23, wherein:
   the beginnings of at least some of the pulses of sound are substantially synchronised
   with the light.

25. A system as claimed in claim 23, wherein:
   each pulse of sound has a duration which is less than the duration between the pulses of
   sound; and
   the pulses of sound are substantially synchronised with the light.

26. A system as claimed in any preceding claim, wherein:
   the sound and/or the light is/are modulated and/or pulsed at a modulation and/or pulse
   frequency no greater than 50 Hz.

27. A system as claimed in any preceding claim, wherein:
one pulse or modulation repetition of the sound is provided for each pulse or modulation repetition of the light.

28. A system as claimed in any of claims 1 to 26, wherein:
   a plurality of pulses or modulation repetitions of the sound are provided for each pulse or modulation repetition of the light.

29. A system as claimed in any of claims 1 to 26, wherein:
   one pulse or modulation repetition of the sound is provided for a plurality of pulses or modulation repetitions of the light.

30. A system as claimed in any preceding claim, wherein:
   the pulsing and/or modulation of the sound and light has a constant rate.

31. A system as claimed in any of claims 1 to 29, wherein:
   the pulsing and/or modulation of the sound and light have a modulated rate.

32. A system as claimed in any of claims 1 to 29, wherein:
   the pulsing and/or modulation of the sound is pseudo-random; and
   the light is substantially synchronised to the sound.

33. A system as claimed in any of claims 1 to 29, wherein:
   the pulsing and/or modulation of the light is pseudo-random; and
   the sound is substantially synchronised to the light.

34. A system as claimed in claim 1, wherein:
   the driving means drives the sound and light producing means so that:
   the light producing means repetitively produces pulses of light;
   each light pulse has a duration of at least 1 ms;
the pulses of light has a pulse frequency no greater 50 Hz;
the sound producing means produces sound having its volume and/or pitch repetitively modulated; and
at least one feature in each sound modulation repetition is substantially synchronised with the pulses of light.

35. A system as claimed in any preceding claim, wherein:
    the sound producing means is adapted to be usable underwater.

36. A system as claimed in any preceding claim, wherein:
    the light producing means is adapted to be usable underwater.

37. A system as claimed in any preceding claim, wherein:
    the sound producing means and the light emitting means are disposed adjacent each other.

38. A system for deterring underwater animals from an underwater region, substantially as described with reference to the drawings.

39. A method of deterring underwater animals from an underwater region, comprising:
    producing sound in the underwater region; and
    producing light in the underwater region;
    wherein:
    the sound is intermittently pulsed and/or at least one characteristic of the sound is repetitively modulated;
    the light is intermittently pulsed and/or at least one characteristic of the light is repetitively modulated; and
    at least some of the pulses of light and/or the occurrences of at least one feature in at least some of the light modulation repetitions are substantially synchronised with at least some of the pulses of sound and/or the occurrences of at least one feature in at least some of the sound modulation repetitions.
40. A method as claimed in claim 39, wherein:
   the method includes any of the steps or functions provided by a system as claimed in
   any of claims 1 to 38.

41. A method of deterring underwater animals from an underwater region, substantially as
described with reference to the drawings.
Application No: GB1013714.9  Examiner: Nicola Payne
Claims searched: 1-41  Date of search: 31 August 2010

Patents Act 1977: Search Report under Section 17

Documents considered to be relevant:

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<td>CN 101331870 A (FISHERY MACHINERY) See especially WPI abstract Accession No. 2009-E01345 [08]</td>
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Field of Search:

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Worldwide search of patent documents classified in the following areas of the IPC

A01M

The following online and other databases have been used in the preparation of this search report

WPI, EPDOC, BIOSIS & Internet
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