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# TECHNICAL NOTE

# FIELD METHOD FOR MONITORING VALVE MOVEMENTS OF BIVALVED MOLLUSCS

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**Abstract**—A simple system for the remote monitoring of the valve movement of bivalved molluscs was developed by utilising a.c. techniques to ascertain the logical state of two conductors attached to a bivalve; the method enables bivalves to move freely in their natural environment. A large number of bivalves can be monitored simultaneously over long distances and the system proved suitable for long term studies under field conditions. At present the method is used in fresh water but it can easily be converted for use under sea water conditions.

*Key words*—bivalved molluscs, valve movements, environmental monitoring, field method

## INTRODUCTION

Bivalved molluscs display rhythmic activity of adductor muscles that can be correlated with both internal (Barnes, 1955) and external (Salánki and Véró, 1969) factors. The filtration rate depends on the opening and closing of the valves due to adductor activity. Bivalves can circulate several tens of litres of water on a daily basis thus enriching concentrations of pollutants in tissue to between 1000 and 10,000 times that in the surrounding water (Pynnönen, 1990), and have been used as indicators of water quality and level of pollution (Kramer *et al.*, 1989). The efficiency of water filtration (and degree of gaping of the valves) greatly affects both the enrichment rate of pollutants and the sensitivity of bivalves as environmental monitor. Since most experiments on the behaviour of the bivalves have been carried out artificially, under laboratory conditions, it has been taken for granted that the behaviour is the same for both artificial and natural conditions.

Hitherto several methods have been used for monitoring valve movements of marine and fresh water bivalves. Mechanical methods have been presented by Barnes (1955; 1962), Salánki and Balla (1964) and Morton (1970). Their experiments have been carried out under laboratory conditions, and the methods are likely to disturb the test animals. A more sophisticated method, based on electromagnetic induction, has been implemented by Véró and Salánki (1969); other versions have also been developed, but are clearly unsuitable for routine use.

The above methods have not been suitable for field studies in view of the difficulties involved in the transmission of analog signals. We have developed a simple digital system for the monitoring of valve movements of bivalves. This new method is suitable for the continuous monitoring of valve movements both in the laboratory and in the field; it is possible to monitor over 100 animals simultaneously.

## METHODS

A switch made of silver wire is attached to the bivalve by a small plastic plate; the plate is fixed to the shell with super glue (e.g. Loctite super glue gel) (Fig. 1). The sensing wires are insulated with the exception of the contact areas and when the bivalve opens its valves, the switching action causes a small reactive pressure. The animal, however, is unlikely to detect this pressure as the opening of the shells is passive. Every animal is connected to the monitoring cable by means of flexible wires anchored to the bottom of the lake.

There are two major problems caused by aquatic milieu. The first problem is due to the effects of electrolysis by the use of direct current (d.c.) techniques; debris accumulates on the contact surfaces of the sense wires and prevents the flow of current. The second problem is poised by the conductivity of the water; when the switch changes state the level change is not very fast. Aquatic milieu problems are greatly reduced by the use of alternating current (a.c.) techniques. The a.c. sense current is generated by the square wave oscillator (Fig. 2; 100 Hz equal mark/space ratio, 100 mV ptp). The sensed signal is amplified by an operational amplifier, and by means of a smoothing circuit it is converted to a d.c. signal; the buffer converts the signal to TTL level prior to interfacing it to the I/O port.

Valve movement can also be measured more accurately by means of two switches, rather than one, on each animal. The

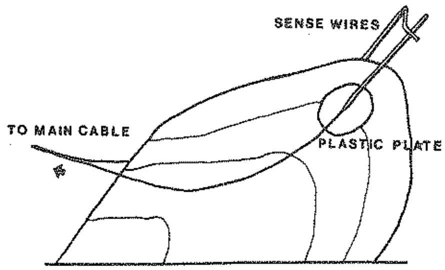



Fig. 1. The components and method of attaching the switch to the mussels valve.

switches provide a tri-state output to denote that the valve aperture is either closed, half open or open. Acquiring the raw data is a straight forward operation with the minimal of computer requirements. If the requirements, however, include the acquisition and the graphical representation of data in real time then a 386-based computer is required.

## RESULTS

We have tested our system for 3 months in 2 lakes (specific conductivities 7 and 10 mS/m at 25°C) using two freshwater mussel species (*Anodonta anatina* (Linné) and *Unio tumidus* Philipsson, Unionidae). Figure 3 illustrates an example for the behaviour of *U. tumidus* over a period of 3 weeks. The system worked without problems; debris on the sense wires did not impede its performance.

The system was also tested in brackish water (salinity about 0.7%) under laboratory conditions. For sea water use, the system can be easily modified. The monitoring station has been ca 50 m from the lake. If longer distances (or cables) are required the cable capacitance must be taken into the account. A low loss cable is recommended and in some cases it may be necessary to reduce the frequency of the sense current. The amount of acquired data depends on the software. If all movements are to be monitored, roughly 1–5 kilobytes per animal per day are required.

On some occasions when a switch oscillates at high frequency between the two states, the electronic filtering of the intermediate currents may not be very effective. One can assume that any logical state lasting for less than 100 ms, does not represent a valid mussel movement. This can be verified by observing mussels in an aquarium; hence we decided to filter out the short events by means of the monitoring software.

## DISCUSSION

In a system based on electromagnetic induction, the valve movements of bivalves can be measured fairly accurately. However, if long term field studies are taken into consideration, the analogue signal presents two problems. First, if an accurate study of valve movement is needed, the amount of data will be massive. This is not, however, a serious problem, provided that enough hard disk capacity is available. Second, without amplification, an analog signal cannot be transferred over the type of distances needed for field studies. Underwater circuits, including amplifiers are always a problem.

These problems do not apply to our system. As it has been already mentioned, both the volume of acquired data and the length of the cable proved satisfactory. This system is fairly simple and easy to

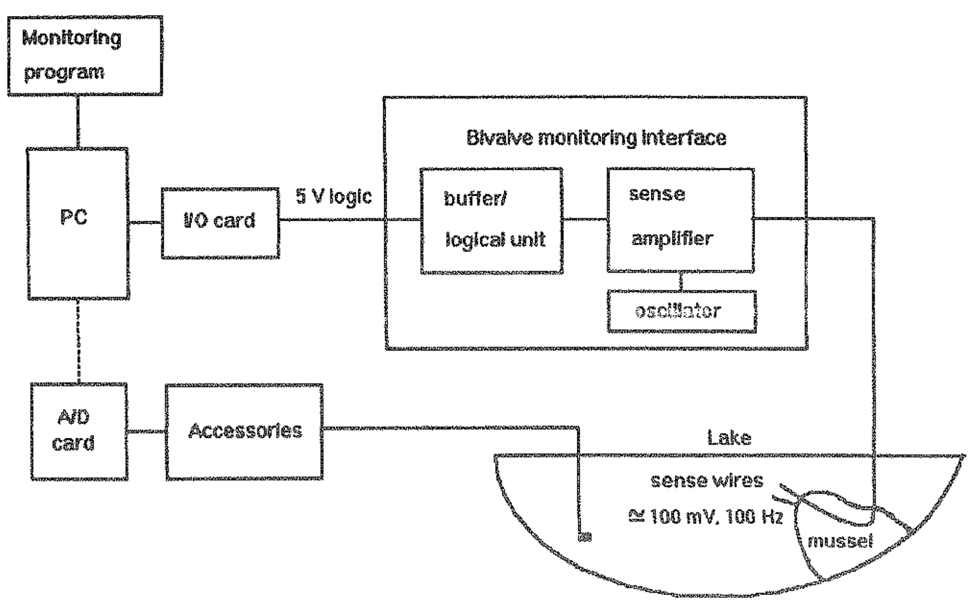
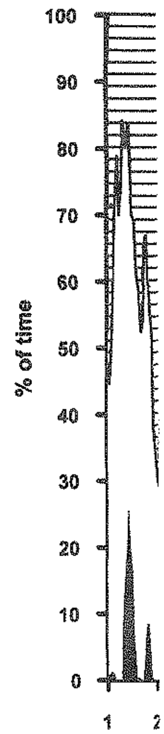



Fig. 2. Block diagram of the bivalve monitoring system. Via an A/D card, some accessories, for example a thermometer, can be connected to the system.

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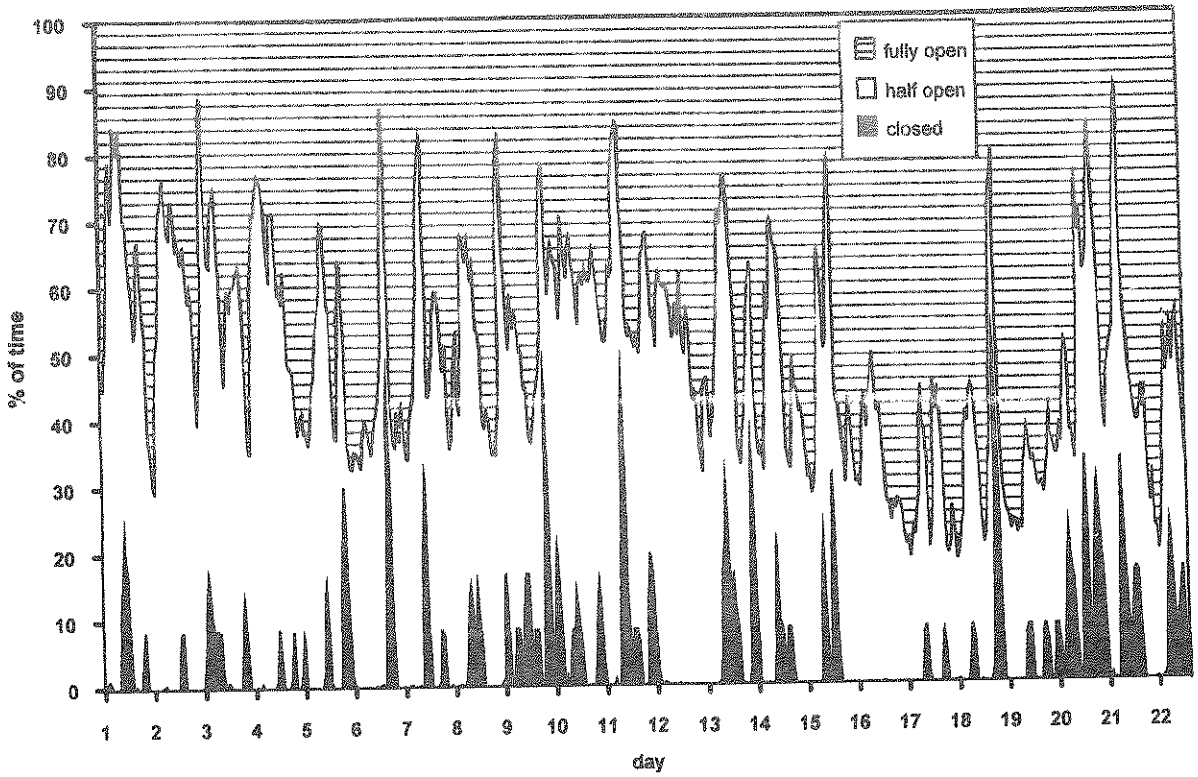


Fig. 3. The behaviour of *Unio tumidus* during a three week period. The graph illustrates the average of twelve animals.

construct with added benefit of low cost I/O card rather than an expensive A/D card. The animals are able to move freely within the area determined by the length of the wires and the anchor. This system is suitable for monitoring any underwater switch.

The method enables workers to monitor high numbers of bivalves. The adjustment of sense wires varied between individuals and from species to species; the underwater adjustment is best carried out by a scuba diver. If the sense wires are not free to move and touch each other, the system will not work properly; the movement may be restricted by debris and accumulation of weed, or even from animals burrowing into the sediment.

An important question has been the effect of the weak electric currents between the sense wires and the animal. When the system was turned on and off, repeatedly, we could not detect any visible reactions of the freshwater mussels in an aquarium. However, in sea water this may be a more serious problem. More attention must be paid to the insulation of the sense wires, and they may be placed well apart from siphons.

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