LISA - a lander for ion-selective analysis in freshwater systems

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Intense biogeochemical processes at the sediment-water interface of lakes typically occur within a surface layer of the top few mm and cm (Furrer and Wehrli, 1996). Dialysis plates and more recently gel samplers (Davison *et al.* 1994) have been developed in order to characterize and quantify these microbial and geochemical transformations. Gel samplers offer a resolution on the mm scale. However, their use is limited to rather shallow water bodies, since rapid reequilibration destroys sharp gradients if the retrieval and sampling procedure cannot be performed within minutes (Davison *et al.* 1994). Ion selective electrodes (ISE) based on neutral carrier ligands offer the possibility to analyse the porewater gradients of different dissolved ions in-situ. Interesting reactants and products of biogeochemical reactions which are analytically accessible with ISE are H^+, Ca^{2+}, CO_3^{2-}, NH_4^+ and with some limitations NO_3^- (Müller *et al.* 1998).

In oceanography an *in situ* profiling instrument for the deep sea with O_2 microelectrodes was first introduced by Reimers (1987). In the meantime several profiling landers have been built mostly for obtaining high resolution profiles of O_2 and pH in marine systems (Tengberg *et al.* 1995). Here we discuss the design and functioning of a benthic profiling lander for studies in freshwater lakes.

Design goals

Benthic lander systems in oceanography are built as autonomous instruments which descend to the sea floor, perform the profiling measurements, release some ballast weights and ascend again to the surface (Tengberg *et al.* 1995). On lakes benthic lander systems can be operated with a winch. This offers the possibility to keep the bottom lander on-line during measurements. Transmitting electrode signals and video images of the sensors in real time solves the problem of detecting the exact position of the sediment-water interface and greatly improves the reliability of the instrument. Large lakes in Europe are up to 300 m deep. Working with a video cable and data transmission line limits the accessible range of water depths. The design goals for the LISA system were:

maximum water depth 400 m,

on-line operation with RS-232 from laptop computer on ship board,

on-line video endoscopy with fiber optic light source in order to observe the sensor position in real time,

accommodation of different sensor types like O_2-microelectrodes and potentiometric ISE,

positioning of sensors with variable step size and a mechanical resolution better than 20 μm,

power supply from batteries,

modular design in order to facilitate transport.

Based on these guidlines a benthic lander system optimized for limnological work was developed.

Technical solution and functioning

Figure 1 illustrates the instrument which is now fully operational. The tripod is built around an aluminum frame with three feet which spread apart 2 m with large bearing surfaces to prevent the device from sinking into the soft sediment of eutrophic lakes. One pressure casing contains the power supply which is mainly defined by the requirements of the light source.

The optical part consits of a fiber optic waveguide which provides a well focused light beam. A Sony CCD camera with a pressure tight endoscope optics yields black and white video at a resolution of 570 lines. The video image allows the positioning of the sensors at the sediment-water interface. It yields qualitative information on bottom currents, benthic fauna and sediment heterogeneity.

The third pressure casing contains a custom made signal conditioning module for the datalogger (Campbell Scientific). It can accomodate 10 potentiometric electrodes and 2 O_2 micorelectrodes. One chanel is occupied by a solid-state Ag/AgCl reference. The datalogger is linked by modem to a laptop computer on the ship. It can be programmed

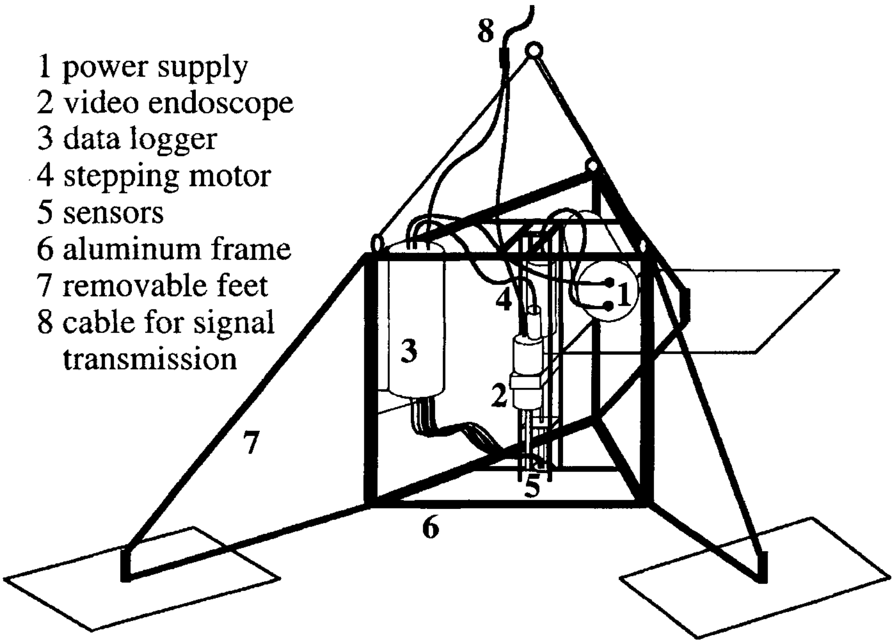

FIG. 1. Sketch of the lander for ion-selective analysis (LISA).

interactively to trigger the stepping motor and to scan the different sensors at variable time intervals.

During a cycle of field tests the potentiometric measurement system had to be carefully isolated from other voltage sources and the ship. The sensors now yield reproducible results. Usually two sensors of the same kind are operated in parallel in oder to determine the reproducibility of the signals. Typical ISE profiles from mesotrophic Lake Alpnach in central Switzerland are reported by Müller *et al.* (1998).

References

Davison, W., Zhang, H. and Grime, G. W. (1994) *Environ. Sci. Technol.*, **28**, 1623–32.

Furrer, G. and Wehrli, B. (1996) *Geochim. Cosmochim. Acta*, **60**, 2333–46.

Müller, B., Stierli, R. and Wehrli, B. (1998) *Miner. Mag.*, this issue.

Reimers, C. E. (1987) *Deep-Sea Research*, **34**, 2019–35.

Tengberg, A. *et al.* (1995) *Progr. Oceanogr.*, **35**, 253–94.