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Design and application of a portable, automated plankton sampler for the capture of the parasitic copepods Lepeophtheirus salmonis (Krøyer 1837) and Caligus elongatus (Von Nordmann 1832)

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SHORT COMMUNICATION

Design and application of a portable, automated plankton sampler for the capture of the parasitic copepods *Lepeophtheirus salmonis* (Krøyer 1837) and *Caligus elongatus* (Von Nordmann 1832)

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A battery-operated submersible pump sampler was designed for the collection of the parasitic marine copepods *Lepeophtheirus salmonis* and *Caligus elongatus* from Loch Shieldaig on the West Coast of Scotland. Results are given of testing and calibration *in situ*.

KEYWORDS: automated plankton sampler; sea lice; zooplankton

The salmon louse, *Lepeophtheirus salmonis* (Krøyer, 1837), is a pathogenic ectoparasitic copepod of marine salmonid fish, with other non-salmonid species of fish acting as possible peripatetic hosts (Pert *et al.*, 2006, 2009; Jones *et al.*, 2006). Other sea lice species of the genus *Caligus*, such as *Caligus elongatus* (Von Nordmann, 1832), are also important parasites of farmed salmonids; however, their host range is reported to be wider than that of *L. salmonis* (Kabata, 1979).

The life cycle of *L. salmonis* and *C. elongatus* is a direct one requiring no intermediate host and includes two free-swimming "nauplius" stages that are dispersed in the plankton followed by an infective "copepodid" stage. Following settlement on the host, the copepodid moults into the "chalimus" phase that comprises four stages. After the fourth chalimus stage of *L. salmonis*, two mobile "pre-adult" stages precede the definitive moult to the adult male or female. There is no "pre-adult" stage in the life cycle of *C. elongatus*.

The planktonic stages are critical for allowing lice to infect new hosts (Johnston and Albright, 1991). Gathering data on the distribution of the planktonic stages of *L. salmonis* and *C. elongatus* in the field, coupled with information on local environmental conditions from the same time point, is important to improve the understanding and modelling of the epidemiology and distribution of these species.

Obtaining viable and specific plankton samples from marine and freshwater environments is a technical problem for researchers (Waite and O'Grady, 1979).

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One such system of obtaining reliable samples is through the use of pump-based plankton samplers (Waite and O'Grady, 1979). These systems have gained popularity in recent years, owing to the simplicity of their operation and the precision and accuracy of the instrumentation (Nayer *et al.*, 2002).

In this note, we describe the development and deployment of a new submersible automated plankton sampler designed for the capture of the parasitic copepods *L. salmonis* and *C. elongatus*. The plankton samplers were deployed alongside sentinel cages (Pert *et al.*, 2008) holding Atlantic salmon (*Salmo salar*) in Loch Shieldaig (Fig. 1). Loch Shieldaig is one of three basins making up the Loch Torridon (57°35′0″ N, 5°46′0″ W) sea loch system on the north-west coast of Scotland. The aims for the new submersible automated plankton sampler design were as follows:

(i) to achieve a lightweight design to maximize ease of deployment;
(ii) to incorporate pump, power source and encased plankton net within a single submersible unit;
(iii) to develop a sampler that is easy to service and maintain in field conditions;
(iv) to create a basic design that can be readily modified for a variety of specific sampling requirements.

The submersible automated plankton sampler was developed at the Marine Scotland (Science) Marine Laboratory, Aberdeen, Scotland (Fig. 2), and was a modification of a ballast water sampling system (McCollin *et al.*, 2008). The pump for the plankton sampler was an Attwood® WaterBuster® cordless water Pump™ powered by three D cell alkaline batteries. The pump was adapted for connection to a plankton net chamber and without batteries weighed ~3 kg. The internal diameter of the inlet was 3.5 cm with a total area of 9.6 cm^2. To optimize plankton capture and to reduce the chance of escape of the target species, two cod ends, an inner cod end 17.5 cm and an outer cod end at 32 cm (mesh size 68–200 μm), were held within the net chamber. A coarse strainer at the inlet of the plankton sampler was developed to prevent debris and other materials (e.g. jelly fish) clogging the system. A calibration test was carried out to determine the mean discharge capacity (m^3) of the Attwood® WaterBuster® pump when attached to the plankton sampler. The filtration ratio (mesh aperture to mouth area) was 10:1.

The plankton sampler was suspended at a depth of 1 m by attachment to a dhan buoy situated ~10 m from the sentinel fish cages. The plankton samplers were held vertically with a small weight in the water at a depth of 1 m below the surface and run for two periods of 3.5 h separated by one battery change. The

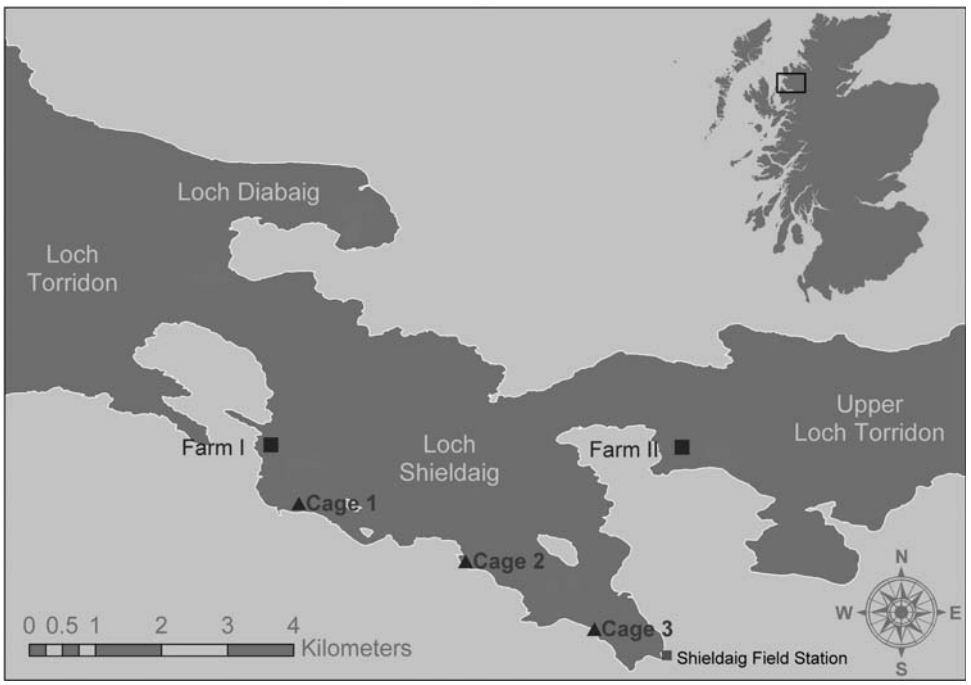

Fig. 1. The Loch Shieldaig study site with the three sentinel cages (filled triangle, cages 1, 2 and 3) locations, MS field station/fishtrap (Shieldaig Field Station) and marine aquaculture sites (filled square, farms I and II) marked.

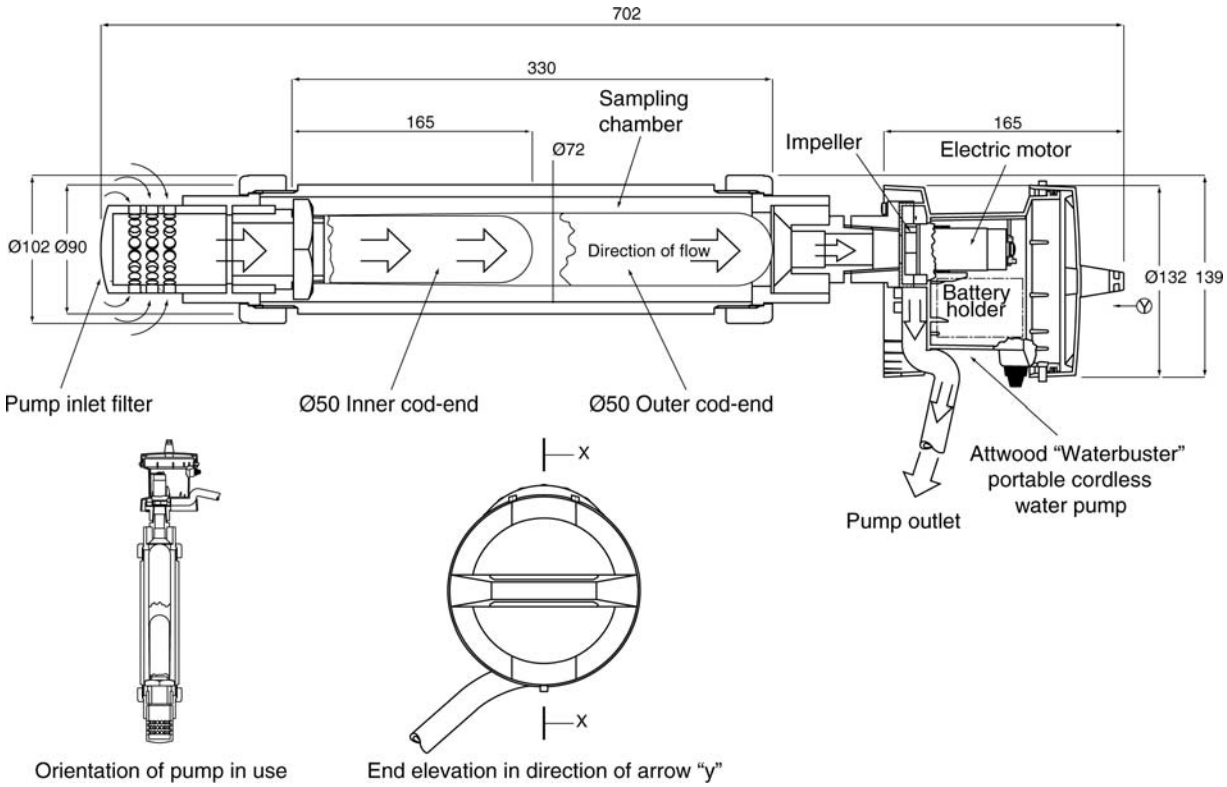

Fig. 2. Plankton pump design and apparatus.

captured plankton were then stored in 70% ethanol and returned to the Marine Laboratory for the detection of *L. salmonis* and *C. elongatus* through real-time PCR assay developed by McBeath *et al.* (McBeath *et al.*, 2006).

The mean output with one set of three D cell batteries running for 5 h was 2.5 m^3 (SD 0.04 m^3) of water. The maximum pumping was 0.2 L s^{-1} (mean 0.18 L s^{-1}, SD 0.01 L, $n = 3$). Taking into account the internal diameter, the fluid velocity was 0.208 ms^{-1} at the inlet. During the study period, the plankton sampler collected 172 plankton samples, 25 of which were positive through real-time PCR for the presence of *L. salmonis*. *Caligus elongatus* was not detected through real-time PCR.

The submersible automated plankton sampler described herein has proved to be a very reliable and easy to operate sampling apparatus for sampling of zooplankton, in particular the sea louse *L. salmonis*, over 42 months of field-testing.

The disadvantages of conventional sampling methods for zooplankton collection include the destruction of larger animals, size selectivity, time required to collect the samples (Omori and Ikeda, 1984) and clogging of plankton nets lowering the filtration efficiency (Smith *et al.*, 1968). The advantages of sampling zooplankton with pumps in marine systems over towed nets include reliable measurements of filtered water volume, depth control and control of the filtering process with the possible use of several mesh sizes (Miller and Judkins, 1981; Dixon and Robertson, 1986).

The flexibility of the apparatus described in this note allows the option of changing the mesh sizes of the cod ends, making it ideal for the collection and study of other organisms that are dispersed in the plankton, e.g. the larvae of barnacles and bivalve molluscs. As these plankton samplers are low cost, a number of plankton traps could be deployed to sample zooplankton at discrete depth zones at different sites. This could be an approach to allow researchers to explore the spatial variation of *L. salmonis* and *C. elongatus* in the water column.

Hence for stationary sampling, the submersible plankton sampler described in this note is light weight, inexpensive to develop, can be easily operated from a pier, boat, dhan buoy or other fixed structure in the water and can be easily modified for the collection of other animals with a planktonic dispersal from coastal marine and freshwater habitats.

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