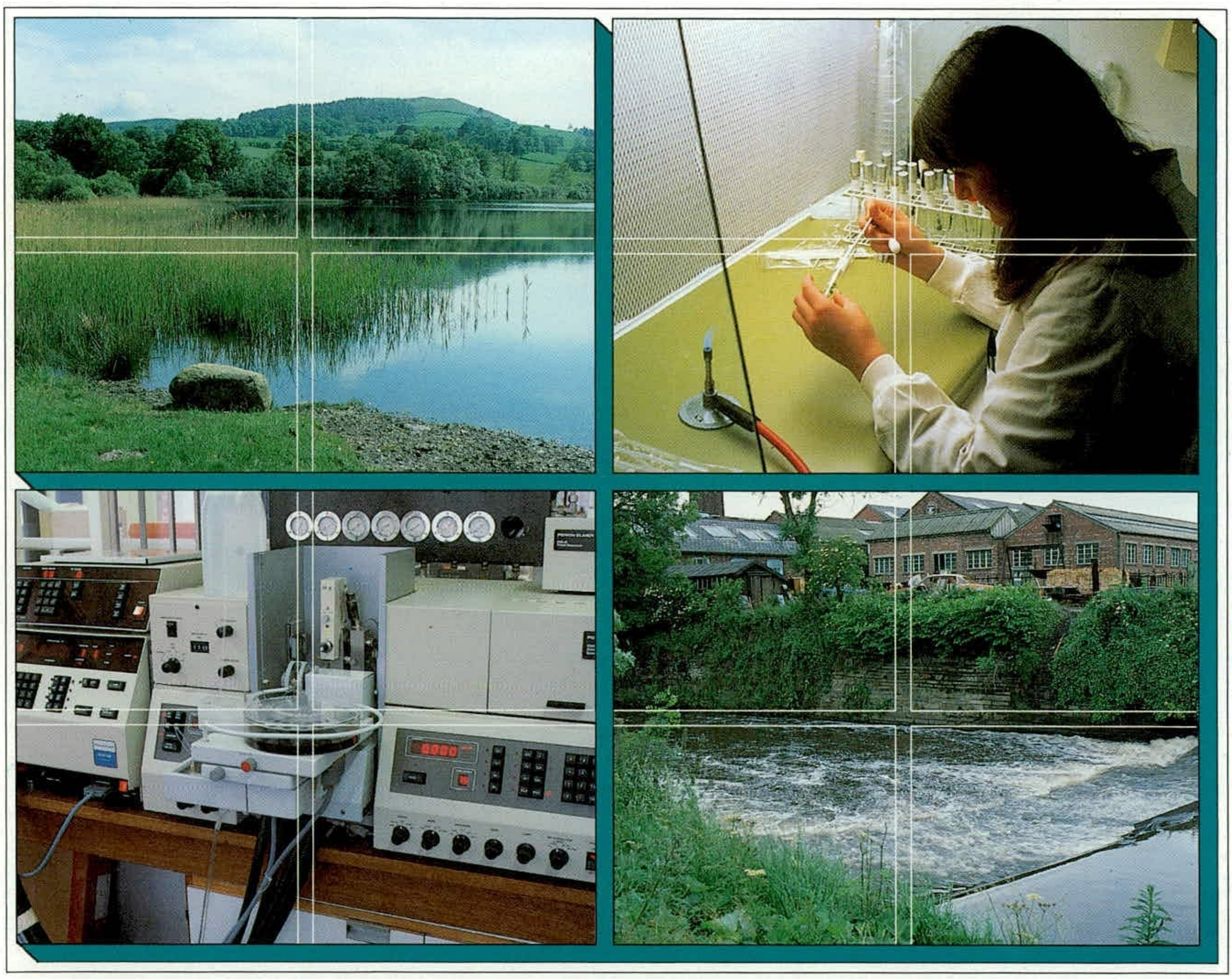
Institute of Freshwater Ecology

Water quality in the Loch of Cliff (Unst, Shetland) corresponding to an incidence of salmon fry gill damage in the Quoys hatchery

Principal investigators:

A Kirika
A E Bailey-Watts, BSc, PhD, MIWEM

Report to Fish Farming Development Limited
(March 1993)



Natural Environment Research Council

WATER QUALITY IN THE LOCH OF CLIFF (UNST, SHETLAND) CORRESPONDING TO AN INCIDENCE OF SALMON FRY GILL DAMAGE IN THE QUOYS HATCHERY

Institute of Freshwater Ecology
Edinburgh Laboratory, Bush Estate, Penicuik
Midlothian EH26 0QB, Scotland

Telephone: 031 445 4343; Fax: 031 445 3943

WATER QUALITY IN THE LOCH OF CLIFF (UNST, SHETLAND) CORRESPONDING TO AN INCIDENCE OF SALMON FRY GILL DAMAGE IN THE QUOYS HATCHERY

Project Manager: A E Bailey-Watts

Report to Fish Farming Development Limited
(March 1993)

This is a confidential report

Principal Investigators:

A Kirika
A E Bailey-Watts, BSc, PhD, MIWEM

Contract Completion Date: 31 March 1993
TFS Project No: T11055c1
ED/T11055c1/1

The Institute of Freshwater Ecology is part of the Terrestrial and Freshwater Sciences Directorate of the Natural Environment Research Council.

Samples received and the analyses done

The main focus of this report is on the three 1-litre water samples which were received on 20 March 1993; they had been collected on 18 March from the following places:

- the intake to the drum filter; this represents Arm of Quoys loch water prior to any filtration
- the outlet from the drum filter - representing water between the drum filter and the sand filter
- the outlet from the sand filter ; this is the water heading for the hatchery.

These samples were processed and analysed for (i) the concentrations of dissolved and particulate fractions of both phosphorus (P) and silica (SiO_2) (ii) chlorophyll *a* levels (iii) the abundance of carotenoid pigments (relative to chlorophyll), and (iv) phytoplankton species composition and population abundances - and information on other microscopic particles and organisms present. The P and SiO_2 data allow the levels of nutrients in phytoplankton cells or those associated with other particles, to be compared with the concentrations remaining in the water outside. Chlorophyll determinations provide an index of total phytoplankton abundance, while the carotenoid data when considered alongside the chlorophyll figures, give some idea of the relative 'health' of the phytoplankton, or conversely, the incidence of dead algae and other sediment material that might be re-suspended from the deposits in windy weather.

A pair of samples of material trapped on the screens over the fry hatchery tanks was also received, for microscopic examination.

A further 3 water samples were taken from the points relating to the drum sand filters as outlined above, on 22 March; these were received on 24 March. They have been submitted to chlorophyll analysis only.

The chemical and biological analyses follow techniques and procedures most of which have been described in earlier reports. However, extra cell preparations have been made in response to a request for views on the identity of the major diatoms found throughout the system (loch, filters, trough screens and fry gills).

Results

Drum filter performance (18 March)

A wide variety of the analyses carried out illustrate the improvement in water quality brought about by drum filtration. The filtered water is firstly, far less laden with material (**Table 1**). This is well reflected in removal of *ca* 60% of the total P (all fractions i.e. particulate and dissolved), and 63% of the particulate P (in mineral and organic detritus, and plankton), and of the particulate silica (primarily as opaline silica

Table 1: The quality of (loch) water recieved by the drum filter compared to that of the filtered water.

incoming water	determinand	filtered water
110	μg total phosphorus l^{-1}	<u>45</u>
95	μg particulate phosphorus l^{-1}	35
8.4	mg particulate silica l^{-1}	3.1
46	μg chlorophyll$_a$ l^{-1}	27
1.27-1.30	carotenoid/chlorophyll(480nm:665nm abs. ratio)	1.13-1.15
12500	no. unicellular Centrales ml^{-1}	5100
320	no. *Asterionella* colonies ml^{-1}	<30
960	no. *Asterionella* colonies ml^{-1}	<90
570	no. *Aulacoseira* filaments ml^{-1}	120
120	no. *Synedra* cells ml^{-1}	60
'high'	organic/mineral content	'low'

Table 2. The quality of water passing onto the sand filter compared to that of the filtered water.

incoming water	determinand	filtered water
45	μg total phosphorus l^{-1}	<u>38</u>
35	μg particulate phosphorus l^{-1}	27
3.1	mg particulate silica l^{-1}	0.8
27	μg chlorophyll$_a$ l^{-1}	22
1.13-1.15	carotenoid/chlorophyll(480nm:665nm abs. ratio)	1.17-1.19
5100	no. unicellular Centrales ml^{-1}	5600
<30	no. *Asterionella* colonies ml^{-1}	<30
<90	no. *Asterionella* colonies ml^{-1}	<30
120	no. *Aulacoseira* filaments ml^{-1}	320
60	no. *Synedra* cells ml^{-1}	*ca* 30
'low'	organic/mineral content	'lower'

in the cells of living and dead diatoms). Pre- and post-filtration chlorophyll values of 46μg l^{-1} and 27μg l^{-1} respectively, also indicate that algae (dead or alive) are being removed, although the decrease through the filter amounts to 41% which is considerably less than the removal achieved for particulate P and SiO_2. However, the ratio of the spectrophotometric absorbance at 480nm (orange-yellow carotenoid pigments) to that at 665nm (green chlorophyll *a*) also decreases - from *ca* 1.28:1 to 1.14:1. This indicates that the material in the filtered water contains relatively less detritus and more healthy algae. Detritus in the form of dead plant matter (including algae) contains relatively more carotenoid pigment (high carotenoid:chlorophyll ratio) than fresh phytoplankton. This is because chlorophyll degrades more rapidly than carotenoid material, and indeed in sediments this ratio increases with depth. Algal count data in **Table 1** confirm that algae are removed by the drum filter. Data on the 4 dominant types of algae (all diatoms) are shown: *Synedra ulna* (probably var. *danica*), *Asterionella formosa*, *Aulacoseira subarctica* (formerly *Melosira italica* var *subarctica*) and an assemblage of unicellular centric (pill-box) forms, dominated here by *Cyclotella radiosa* (Grunow), *C. meneghiniana* Kutzing and *Stephanodiscus* (mainly forms of *S. hantzschii*) complex. Apart from *Synedra* which is a long but very slender unicellular diatom, significant retention is indicated. The filter removes *Asterionella* fairly efficiently, because this diatom exists mainly as colonies in which the cells are splayed out rather like the spokes of a rimless cartwheel, joined to each other at the 'axle' end, but forming a shallow spiral, not an enclosed circle. *Aulacoseira subarctica* is a filamentous form, somewhat thicker than *Synedra* and often curved rather than straight like that diatom. The filter has removed some 60% (similar to the figures given above for total and particulate P, and for SiO_2) of the *Cyclotella* and *Stephanodiscus* cells; yet, at *ca* 5-17μm in diameter, these are considerably smaller than the other diatoms (70μm to 100μm and more). However, in addition to the cells themselves, the accompanying detritus load would tend to block the rotary screen (before each back-washing) and increase filtration efficiency.

While no gravimetric and chemical analyses of detritus have been attempted, there are two further observations suggesting that the drum filter does remove a significant amount of this material. Firstly, there are the visual impressions gained from the microscopic examination. While phytoplankton are outnumbered considerably by detrital particles, detritus is not as concentrated as it is in the raw loch water. Secondly, it can be calculated from the results in **Table 1**, that the filter removed from each litre of water, some 60μg particulate P, 5.3mg particulate SiO_2 and 19μg chlorophyll *a*. The ratios of the P and the SiO_2 values to that of chlorophyll *a* are thus approximately 3:1 and 300:1. Both exceed those to be expected of reasonably 'clean' diatom-dominated populations, and especially the SiO_2:pigment ratio.

Sand filter performance (18 March 1993)

In contrast to the values obtained for the samples taken either side of the drum filter, the concentrations of the P fractions and chlorophyll in the sand-filtered water (**Table 2**) are somewhat similar to those measured in the water going onto the sand filter (i.e. that exiting from the drum filter - right-hand column, **Table 1**). However, reductions of 16% (total P), 23% (particulate P) and 17% (chlorophyll *a*) are calculated.

Meanwhile, the estimated densities of the individual algal species in the sand-filtered water are not significantly different from those obtained for the water passing though the first filter. This is to be expected, considering that the difference in chlorophyll levels is only 17%. Larger *counts* of algae would reduce the confidence limits on the counts; indeed, statistically different results could be obtained with more effort in this area, but it is unlikely that this would alter the general view that this filter is removing *ca* 20% of these algae. Contrastingly, the results for particulate SiO_2 suggest a very considerable retention of this fraction by the sand filter (77%). [Meanwhile, as expected, dissolved SiO_2 levels are much the same at all stages of the water treatment i.e. 6.92mg l^{-1} (pre-drum), 7.13mg l^{-1} (post-drum/pre-sand) and 7.14mg l^{-1} (post-sand).] The two filters would appear therefore, to have reduced a considerable proportion of the silica in e.g. dead diatoms.

Drum and sand filter performance (22 March) - chlorophyll results only

Chlorophyll concentrations in the pre-drum, post-drum and post-sand waters, were 24.1μg l^{-1}, 17.0μg l^{-1} and 14.7μg l^{-1} respectively. Thus, on this occasion, the raw water algal concentration was approximately one-half of that measured 4 days previously. As proportions of the concentrations of chlorophyll received, the drum filter removed 29% (*cf* 41% on 18 March), and the sand filter held back 14% (*cf* 17% on 18 March).

Material from the fry-rearing trough screens

Organic and mineral detritus (including diatom shells) and phytoplankton featured in the water samples, was also observed in the material taken from the rearing trough screens. In addition, a higher incidence of Protozoa - especially *Vorticella* sp - and filamentous bacteria (and possibly cyanobacteria) was noted.

Concluding remarks

Some thought should be given to reducing the chances of drawing in water that is occasionally very heavily-laden with particulate matter. At present water is drawn off from the end of a pier quite near the shore, where wave and wind will tend to re-suspend sediment. This must contribute to gill damage. In any event too, this site is at the top end of the Arm of Quoys which has been shown to produce higher crops of algae than the main basin of the loch which is more open, somewhat deeper, and better-flushed. Perhaps an extension of the inlet pipe to more open water, where the intake could be buoyed to move with changing loch level and wave height at 0.5 to 1.0m below the surface. If this is not feasible, another source of water for the hatchery may have to be sought.*

* Note added in press: we have received a pair of water samples taken from the Quoys Quarry which is being considered as an alternative supply. An initial inspection of the material in this water revealed a very low level of chlorophyll *a* - *ca* 2.5μg l^{-1} and a modest, almost pure crop of *Synedra ulna*, with occasional specimens of another diatom, *Tabellaria fenestrata*. In terms of both concentration and this species dominance, the water would be classed as low trophic status. It is very likely to be far less laden with either algae or nutrients than the Loch of Cliff.

Natural
Environment
Research
Council