EPJ Web of Conferences 266, 13002 (2022) https://doi.org/10.1051/epjconf/202226613002
EOSAM 2022

Fluorescence for non-contact detection of salmon lice in fish farms

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Abstract. This work presents a promising method for automatic non-contact detection and counting of salmon lice infested on salmon in an aquacultural farm setting. The method uses fluorescence in the visual part of spectrum to enhance the contrast between fish skin and lice. The wavelengths used are compatible with an underwater measurement system.

1 Introduction and background

The densities of salmon (Salmo salar) in fish farms makes them ideal for the parasite salmon lice (Lepeophtheirus salmonis) to infect and reproduce [1]. This is the number one threat to Norwegian Aquaculture. There are governmental requirements to count and register lice in fish farms to ensure control with the parasite. Continuous surveillance helps in deciding on taking measures to reduce the lice infestation on salmon.

It is difficult to get good images of salmon skin due to its semi specular nature, and varying colouring. The lice are semi-transparent and changing in appearance and size (see Fig. 1), and it is desirable to detect and count lice in early stages (1-2 mm size) as well as late life stages (5-8 mm size). Several solutions based on underwater camera are granted dispensations from the manual counting regime by the Norwegian Food Safety Authority – Aquabyte, Stingray and Createview – none of these have published peer review papers on their systems or their performance.

The lice have an exoskeleton made by chitin protecting the lice against its surroundings [2]. Using optical methods that enhance the appearance of the chemical components of chitin is preferable. Chemical components can typically be detected using spectroscopy or fluorescence.

We have characterized the lice optical properties using several methods (polarisation, spectroscopy, fluorescence) in the lab. The results are evaluated with the purpose of making a measurement setup possible to industrialize and implement in the aquaculture industry. In this abstract we present our findings on fluorescence properties.

2 Methods and experiments

We had access to newly slaughtered salmon with living lice which was delivered in seawater. Properties of lice, fish skin and seawater were investigated.

Fig. 1. Images of salmon lice, late stages (5mm and 8mm).

2.1 Fluorescence properties of salmon and lice

To assess the fluorescence properties, narrowband light sources were used for excitation. Both a spectrometer and a camera with excitation blocking filter, were used for emission detection. We tested UV and 532nm excitation. Four lice were measured in the 532nm fluorescence setup. The resulting fluorescence was recorded by an Ocean Optics VIS spectrometer, see Fig. 2. All the observed lice give fluorescence from major parts of the body (red curve). The tail of the largest lice (blue curve) did however not give a signal that could be separated from fish skin (black curve).

Fig. 2. Fluorescence signals using 532nm excitation.

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Images of lice illuminated with 532nm and imaged through filters are shown in Fig. 3.

a) b)

Fig. 3. Fluorescence from a) lice on plastic, illuminated with 532nm, imaged through a long pass filter (lower cut off at 600nm) and b) Four lice on salmon from a 2-meter distance, imaged using a mobile camera though laser goggles (black and white image.)

2.2 Water properties

For continuous lice monitoring in a salmon farm relevant distance to the fish is 1-2 m.

The seawater's absorption and scattering coefficients as a function of wavelengths are varying in Norwegian fjords during an annual cycle. They depend on e.g., the type of coastal water, the mixing ratio between freshwater and seawater, the concentration of chlorophyll and yellow substance [3]. In Fig. 4 we show the measured transmission spectrum taken through the seawater that came with the salmons and lice used in our experiments.

Fig. 4. Transmission measured through 69mm (blue curve) and calculated for 1m (green curve) of seawater in a salmon farm

The measured transmission is a snapshot of seawater transmission from this specific sample – it is included to illustrate that selection of wavelength in underwater measurement system needs considerations. For longer wavelength the measured water transmission is in good agreement with the findings in literature [3], which show that above 700nm the mean free optical path is <1m. If this wavelength range is used under water, the distance between sensor and object must be kept short and controlled, to enable correcting the optical effects of the water itself.

We observe a steep gradient in transmission for wavelengths below 500nm, and very low transmission below 450nm.

3 Results and discussion

The shell of the lice is chitin [2]. It produces a fluorescence signal when excited with green light (532nm) This is in accordance with our observations of fluorescence signal from the lice body. The peak wavelength of the fluorescence emission varies over the group of lice from 600nm to 650nm. The reason for these differences is unknown at this stage. The fish skin is not fluorescent when excited at 532nm.

Measuring fluorescence emission in the 550-700nm range to separate lice and fish skin is promising. Both the illumination/excitation wavelength of 532nm and the fluorescence emission wavelengths are within the range were seawater have low absorbance.

4 Conclusions

Methods for salmon lice detection have been investigated, and a main prerequisite have been to search for a method which can be applicable in the aquacultural industry.

Based on our experiments, we propose a system using illumination at 532nm and detection using an underwater camera with a filter blocking the illumination source. This system will have a more complicated light source than existing underwater camera systems, and it enhances the difference between lice and fish skin. Lice can then better be separated regardless of salmon skin colour, lice colour and lice transparency – since it is the chemistry of the lice's exoskeleton that is imaged. This will reduce the computational complexity needed for online automatic lice counting.

Next step in realizing this measurement system will be more experimental work in a larger scale, including measurements in water tank with seawater, living lice and living salmon.

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