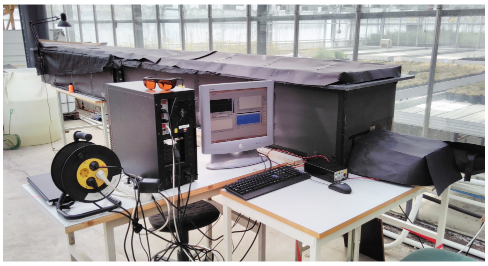
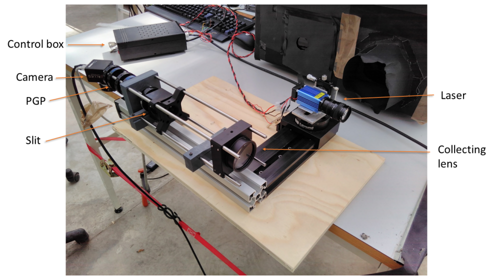
Monitoring plankon using a wavelength dispersed light-radar

We have investigated the possibility to use a hyperspectral light-radar for monitoring and classification of small aquatic organisms. The system is a first of its kind prototype but versatile and able to differentiate between labelled aquatic organisms as well as to perform spectral analysis of large objects such as trees.



(a) *The experimental setup, The large (covered) water tank with the (covered) LIDAR system at the end of the tank.*



(b) *The Lidar system without cover, the Prism-Grating-Prism (PGP) disperses the wavelengths and the signal is imaged on the camera chip.*

We have investigated a new method of monitoring zooplankton using a light-radar. Plankton are a key component in marine ecosystems and plankton studies can give indications of eutrophication, overfishing acidification and many other factors. The traditional way of performing these studies have been using nets and microscope to manually identify and count plankton. Since these methods are very time consuming and cumbersome, alternative methods have been developed. Most method are based on sonars where the acoustic back scattered signal is investigated. Acoustic methods have a large range in water but yields very coarse results where only the average biomass can be studied. In contrast, optical methods using sophisticated cameras gives detailed information about the plankton but can only probe a very small volume and are unsuitable for studies of larger areas.

We have investigated the possibility to use a LIDAR (light-radar) which aims to combine the large range from acoustic methods with the high resolution from optical methods. The LIDAR consist of a blue laser and a wavelength resolved detector, mounted in an trigonometrical arrangement called the Scheimpflug principle. This allows us to detect the distance to both the back scattered blue light from objects in the laser beam but also light with different wavelengths such as fluorescence and other optical phenomenons.

We evaluated the system and investigated its limits by performing experiments with the zooplankton genus *Daphnia Magna* and its natural predator, the mosquito larvae *Chaoborus*. We performed our experiments in a small water tank which was monitored with the system. We did not manage to differentiate between the two species with the current system since we did not discover any large differences in the back scattered signal. To be able to separate the signals from the different species, we labelled the plankton and larvae with fluorescent dye. This allowed us to develop an automatic method to detect and identify marked organisms in the beam.

We also used the wavelength resolved feature of the system to map the chlorophyll content of a plant. The strong laser beam triggers red fluorescence in the chlorophyll which allowed us to reconstruct 3d models of the plant, by sweeping the laser beam back and forth over the plant. If this technique is developed further, it could allow for forest monitoring or seabed investigations from airplanes, drones or submersible vehicles.

Klas Rydhmer, Alfred Strand, May 2016