Using photography and digital software as a method to assess marine fouling communities and changes in species growth patterns

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Introduction

Marine fouling communities are important, variable, and complex aggregations of colonizing species that provide valuable insight into the ecology of coastal waters. The abundance and distribution of these organisms are impacted by a variety of outside factors (Chang & Marshall, 2016) including the arrival of non-indigenous species, large-scale environmental changes, and seasonal variations (Altman and Whitlatch, 2007).

A commonly used methodology for studying these communities is to deploy settling plates which are suspended from docks (Altman and Whitlatch, 2007; Fuller, 2014; Chang & Marshall, 2016). These are removed at regular intervals and examined. Organisms growing on the tiles are identified and individual counts or the percent coverage are recorded. These assessments are traditionally performed by eye or occasionally with a microscope on site. Sometimes plates are transported in seawater back to labs for evaluation under a microscope and then returned to the site. In some studies, drawings are made with locations of organisms marked on a grid. Connell (1961) laid glass over the plates, marking individuals with a dry erase marker and then transferring that to a sheet of paper. Fuller (2014) and Altman and Whitlatch (2007) took photos of key features on plates for reference when they were back in the lab.

Digital photography and image processing software could aid in creating permanent records of the development and growth of organisms on settling plates along with documentation of ongoing changes in these communities. These records could easily be shared, revisited, and used in future studies. It also could increase the amount of data collected during field site visits as the analysis of the plates could be done at another time. The goal of this project is to determine if and how photography could be used as a data collection tool to identify organisms that grow on settling plates and monitor fouling community development and growth. Additionally, we hope to establish a consistent and repeatable protocol to facilitate the use of photography in collecting settling plate data.

Materials and Methods

Three sites with floating docks along the Connecticut coast of Long Island Sound were selected: University of Connecticut Avery Point Campus in Groton, National Oceanic and Atmospheric Administration (NOAA) Northeast Fisheries Science Center Milford Laboratory in Milford, and The Sound School in New Haven. During the week of June 10, 2018, four 10 centimeter (cm) by 10 cm PVC settling plates were deployed at each site. The plates were attached side by side to a twenty-inch section of PVC tubing using zip ties. A two-pound dive weight was attached to the bottom of each tube. The tubes were tied to rings or cleats on floating docks and suspended at a depth of about fourteen inches. The sites were visited once per week at which time the plates were removed and photographed.

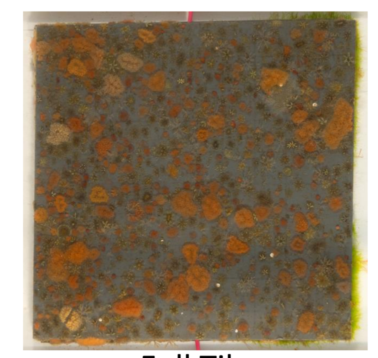
At the field sites, the camera was mounted to a darkroom enlarger adapter to serve as a photographic copy stand. The camera was aimed downward and oriented, so the image plane was parallel to the stand's base. A PVC frame was assembled around the base to hold a black fabric shroud and black foam board to shade the area where the settling plates would be photographed. The tiles are photographed in seawater in a shallow basin. Water from Long Island Sound was gravity filtered to remove particulates that could reduce image quality and stored in a five-gallon bucket with lid. Following this, the first two plates were carefully removed from the PVC tubing and placed into a holding bucket. Then the basin, which had a board to hold two plates, was filled with approximately 2" of the filtered water. The plates were placed into the basin and secured to the board. A piece of museum glass with a plastic frame was secured above the plates. The lower surface of the glass was in contact with the water to create a flat, undistorted interface. Its frame has raised sides to keep water from getting on the upper surface of the glass through which the photos would be taken. Any air bubbles that formed on the lower surface of the glass were removed. The basin with the settling plates and glass was placed on the copy stand. The plates were illuminated with two electronic flashes aimed at approximately a 45-degree angle to cover the entire plate surface but also to reveal textures and details. The black fabric shrouding the copy stand base shielded the plates and glass from reflections and glare from the sun. Photos were taken of each plate. They then were returned to the PVC tubing suspended from the dock and the process was repeated for the other two plates.

Each plate was photographed at two different magnifications. A full-plate photo was taken in which the plate filled as much of the frame as possible. Then a series of six photos of sections of the plate were taken at a higher magnification. The area covered in each photo overlapped adjacent areas.

A Nikon D3400 DSLR camera was used for this study. To maximize the detail captured, the exposure for each photo was bracketed, three exposures were made: one at the determined correct exposure, one overexposed, and one underexposed. The exposure was changed by adjusting the output of the two electronic flashes. This allowed settings that could affect the image, such as aperture and ISO, to remain consistent. The settings for the camera and flashes are shown in Table 1. A full-plate photo and six partial-plate photos, with overlapping edges so no areas were left unphotographed were taken of each plate. A Nikon 55-mm macro lens was used for the full-plate photos. A Nikon 105-mm macro lens was used for the partial-plate pictures and set to a specific magnification, therefore focus was adjusted by raising and lowering the camera on the stand. The Nikon D3400 has a crop frame sensor which increases the lens focal length by a factor of 1.5 and produces 24-megapixel (6,000 × 4,000 pixels) images. Additionally, some plates were photographed with an additional camera, producing images of different resolutions. The second camera being a Nikon D800, which has a full-frame sensor and produces 36-megapixel (7,360 × 4,912 pixels) images. The plates were photographed at different magnifications and with cameras that produced images of different resolutions for comparative assessment of the nature and quality of image detail. This was to determine the value of each as sources of data and help establish an appropriate protocol for data collection.

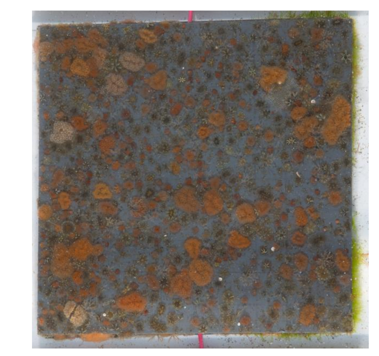
Camera and Partial Photo Comparison Site: Avery Point Tile: AP03

D3400

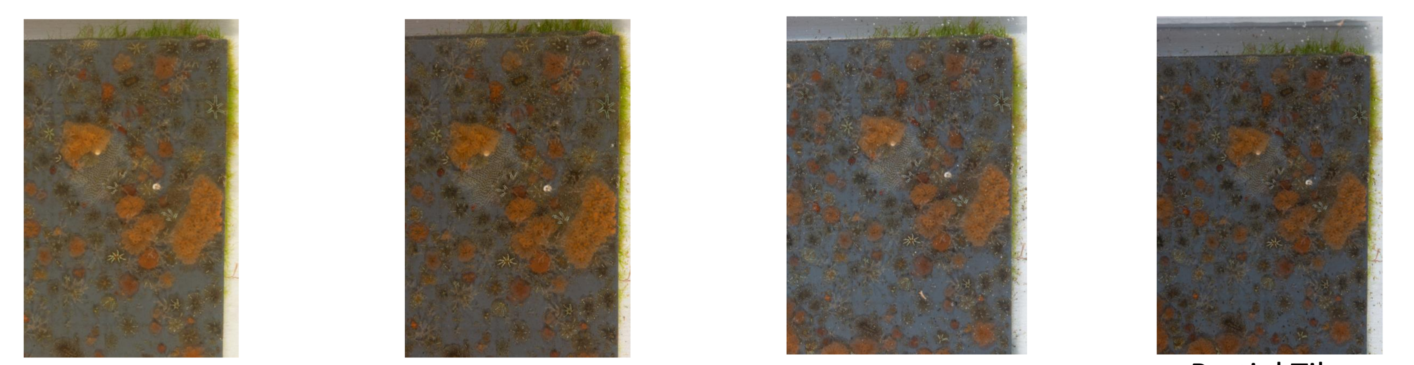


Full Tile

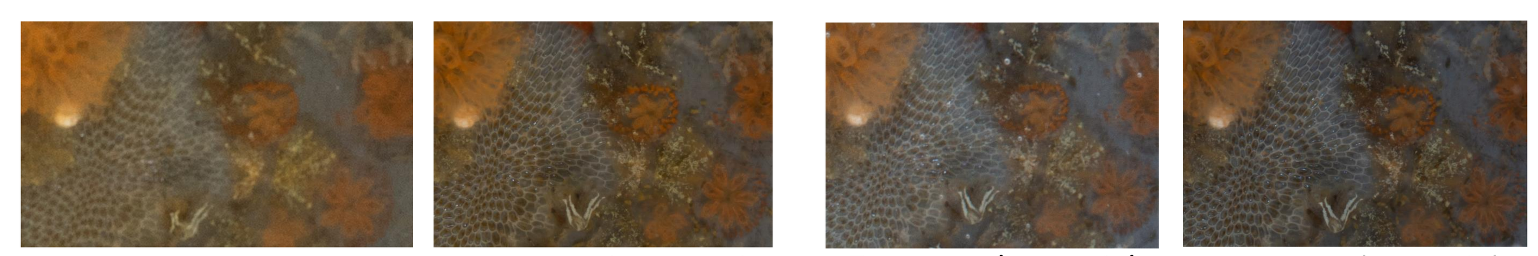
D800



Full Tile



Partial from the full tile photo | Partial Tile | Partial from the full tile photo | Partial Tile



Zoom on the partial from the full tile photo | Zoom on the partial tile | Zoom on the partial from the full tile photo | Zoom on the partial tile

Focus Points

Site: Sound School Tile: SS02

High Point of Focus

Low Point of Focus

Aperture Comparison Site: Milford NOAA Tile: MN04

f22 | f32 | f22 Zoomed | f32 Zoomed

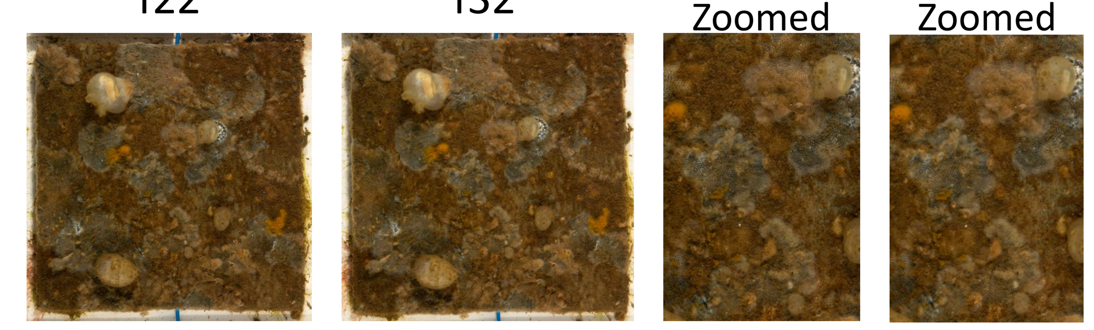


Table 1. Settings

Aperture	Shutter Speed	Flash Setting	ISO	Exposure
f22	1/125	1/8	200	Proper
f22	1/125	1/4	200	Over
f22	1/125	1/16	200	Under
f32	1/125	1/4	200	Proper
f32	1/125	1/2	200	Over
f32	1/125	1/8	200	Under

Table 1. This is the different camera settings that were used and the coordinating flash setting to achieve the desired exposure

Time Lapse Site: Sound School Tile: SS01

Reference | June 19, 2018 | June 25, 2018 | July 2, 2018 | July 10, 2018

July 18, 2018 | July 23, 2018 | July 31, 2018 | August 10, 2018 | August 15, 2018

Results

The images under *Camera and Partial Photo Comparison*, represent the results found when assessing resolution and overall quality between full-plate and partial-plate photos as well as differences between the two camera models With the full-plate photos, it is hard to discern a significant difference between the D3400 and D800 in the ability to identify species and follow community development. For the partial-plate photos, there is a slight improvement with the D800 having more detail that is discernable, which is apparent when zooming in on just a section. Also compared in this section are differences in resolution and quality between a partial-plate photo and the enlarged section of a full-plate photo. Additionally, enlarged sections of each of these are shown for further comparison. The partial-plate photo shows significantly better detail and overall quality than zooming in on a section of the full plate image.

In the Aperture Comparison section, the full plate is shown at both f22 and f32, along with an enlargement of a section of the plate. It is hard to distinguish any difference between the full-plate photos but, when zoomed in, the f22 photo is sharper than the f32 photo. Typically, lenses are less sharp at their maximum and minimum apertures, but depth of field will be greatest at the minimum-sized aperture. However, any greater depth of field at f32 is not appreciable in the photos.

In the Focus Points section, the point of focus on the plates was assessed. *Point of focus* is the place at which the lens is focused. This differs from *depth of field* which is the full area that is in sharp focus. When there was significant vertical growth on the plates some areas were physically too far apart to appear sharp even with the lens set to capture maximum depth of field. This was a greater problem when attempting to focus partial-plate images as depth of field is reduced as magnification increases. Initially only one focus point at the highest level of growth was needed but as the organisms grew the use of a high and a low focus point was assessed. As shown under *Focus Points*, both have some areas that are out of focus, as expected, but the two everything can be seen in sharp focus.

Conclusions

The D3400 produces images that are of sufficiently high resolution and quality, that many individual organisms can be identified from full-plate photos. The partial-plate photos significantly increase the ability to visualize detail and identify smaller organisms. Although the D800 produces higher resolution images, the quality of the images from the D3400 shows the organisms in sufficient detail for typical settling plate studies cataloging species and tracking plate growth. Both partial-plate photos and full-plate photos should be taken as partial-plate photos provide greater detail for identification of organisms while full-plate photos are crucial for monitoring community dynamics and allow overall assessment of the plate. An aperture of f22 should be used as it produces a sharper image and the greater depth of field available at f32 is not appreciable.

The protocol determined to be successful during this study is: use of a Nikon D3400 camera (or better/comparable) with fixed focal length lenses. The camera was set to ISO 200, f22, and with a shutter speed of 1/125th of a second. The camera should be on an adjustable stand, so it can easily be raised and lowered. A shroud cover should be used to block out natural light. Two flashes with adjustable output settings should be placed to the sides. These should be set at a level determined to yield good exposures and then varied to create a lighter and darker image. The variation used in this study was a one stop increment in each direction. This should be done for each photo. The plates should be photographed while submerged in filtered water, through a piece of museum glass that is in contact with the water. Any trapped air bubbles should be eliminated. The full-plate picture should be taken by adjusting the camera height and then focusing on the plate manually with the lens. The partial-plate photos should then be taken using a predetermined set magnification on the lens, and then focused manually by adjusting the camera height. The partial-plate photos should be taken so that there is overlap between one section and the next to assure complete coverage.

References

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