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Imaging Fluorometry at Abyssal Depths with a Bottom-Transecting Rover

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I. Introduction

The Benthic Rover (Fig. 1) is a bottom-crawling, autonomous vehicle capable of making continuous time-series measurements at abyssal depths up to 6000 m for periods of up to one year. The Rover carries a suite of instruments including two respirometer chambers to measure sediment community oxygen consumption, a visible-light camera and strobe light to capture seafloor images, a current meter to measure water currents and temperature, and an imaging fluorometer to detect phytodetritus—an important food source for benthic fauna.

Fig. 1 The Benthic Rover is launched from the R/V *Atlantis*.

II. Imaging Fluorometer System

The Rover uses a blue (460 nm) LED light to illuminate a small patch of seafloor (Fig. 2). Fluorescence is recorded by a 1.4 megapixel monochrome camera fitted with a red (675 nm) long-pass filter.

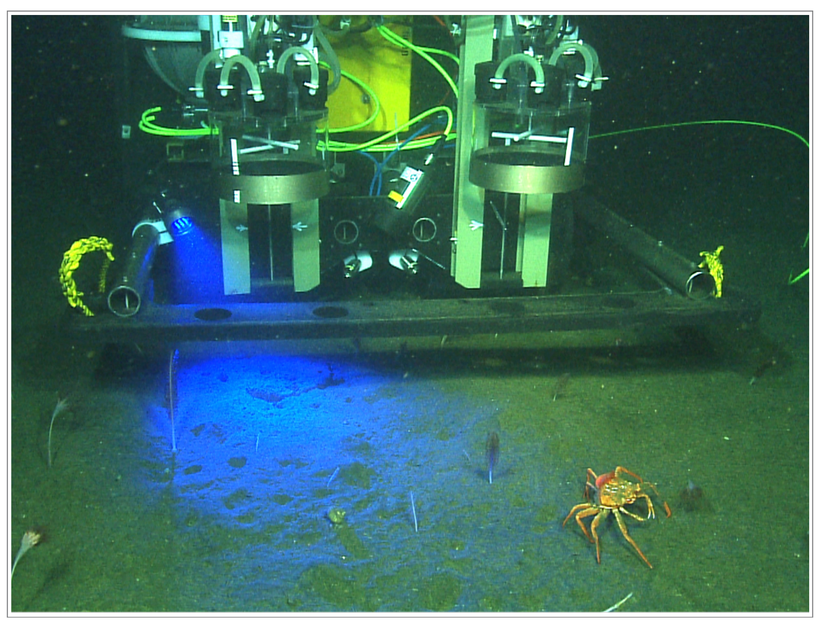

Fig. 2 The blue light activates fluorescence on the seafloor, which is imaged by the downward-pointing camera in the center of the Rover.

The resulting images (Fig. 3) reveal changes in the quality, quantity, and distribution of phytodetritus on the seafloor. Fluorescence can also be observed in the guts of animals that consume this food source.

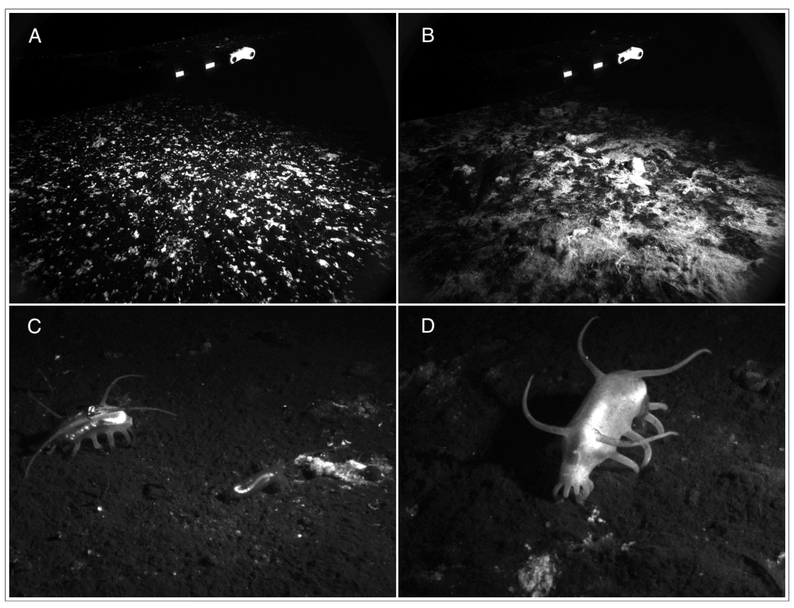

Fig. 3 A&B) Changes in the type and distribution of phytodetritus. The bright object at the top of the image is a calibration reference. C&D) Phytodetritus observed in the guts of feeding animals.

III. Image Analysis

Fluorescence images are recorded approximately every 2.5 days when the Rover transits to a new site 10 m away. We desire to quantitatively measure the images to determine the percent coverage of phytodetritus on the seafloor. Since we know the field-of-view, the height above the seafloor, and the tilt of the camera, we can correct for the oblique perspective of the images, converting them into images that would be obtained with the camera pointing straight down at the seafloor. We crop the image to the area sufficiently illuminated by the light source (Fig 4 A&B).

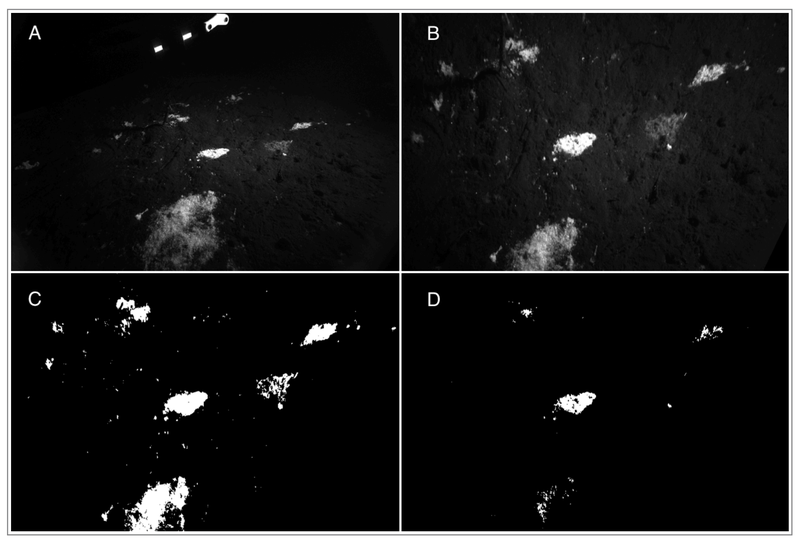

Fig 4 A) Original fluorescence image. B) Image corrected for perspective and cropped. C) Image thresholded to detect all phytodetritus. D) Image thresholded to detect fresh phytodetritus.

We then take the perspective-corrected-and-cropped image and apply a binary threshold to detect areas that are sufficiently brighter than the background to indicate fluorescent material. By using a higher threshold, we can also detect fresher material that is much brighter than older phytodetritus (Fig 4 C&D). Finally, we calculate the percent coverage of the seafloor by dividing the number of detected pixels by the total number of pixels in the image.

IV. Resulting Data

The Rover has been deployed at a 4000 m abyssal study site 225 km off the coast of central California since 2011. The five-year record for years 2016–2020 (Fig. 5) shows low background phytodetrital coverage punctuated by times of much greater deposition.

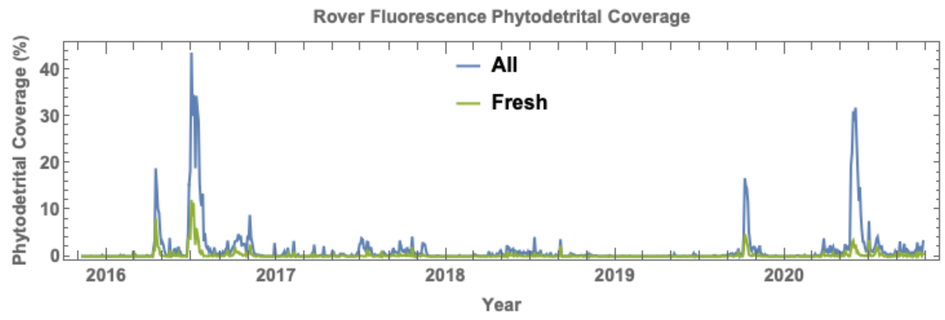

Fig. 5 Seafloor phytodetrital coverage measured by Rover fluorescence imaging.

Fig. 6 compares the POC as measured by contemporaneous sediment traps to the phytodetrital coverage. There is clear correspondence but many differences possibly due to the small sample area of the Rover (~0.25 m^2) and the distance between the instruments (kilometers).

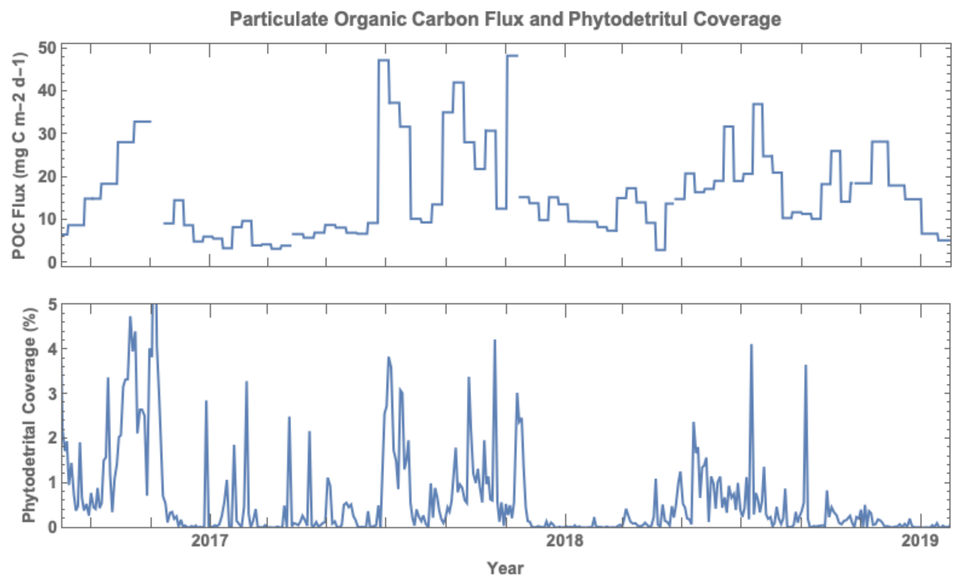

Fig. 6 A comparison of POC flux (top) to phytodetrital coverage (bottom).