Remote monitoring of bio -and morphological developments - ArgusBio

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Type: Hardware and Software

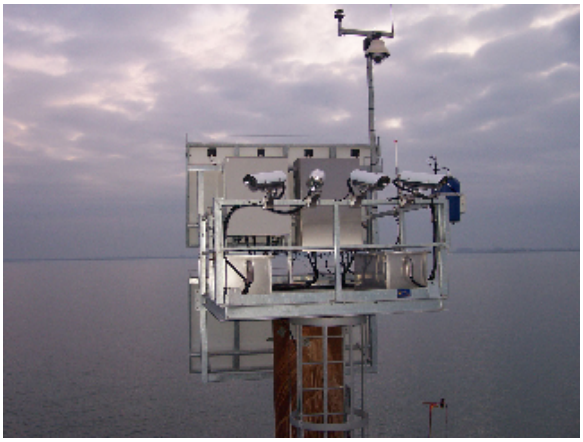
Project Phase: Planning and Design, Construction, Operation and Maintenance

Purpose: Remote and continuous monitoring of intertidal flats (morphology, flora and fauna)

Requirements: Installation of monitoring stations, processing of geo-referenced images

Relevant Software: Delft 3D-Suite, contact Deltares for use of automated algorithms

About



Monitoring the morphological and biological developments of intertidal areas is crucial to understand the functioning of the biogeomorphological system and effectively manage this system. This applies to both short- and long-term management (months to years vs. years to decades) to assess the direct impacts of interventions (eg. nourishments, structures), as well as to assess coastal safety and comply with regulations (eg. EU Bird/ and Habitats Directive) over time. The ArgusBio monitoring stations provide the possibility for remote and continuous monitoring in form of geo-referenced JPEG-images taken by different types of cameras.
Traditionally, monitoring requires regular visits of project sites in order to assess e.g. changes in bed level, the number of birds, or the (re)colonisation by benthic animals and vegetation. Most tidal flats however, are difficult to access and therefore expensive to visit, especially in averse weather conditions. Consequently, the monitoring frequency may be too low to capture the relevant dynamics of the system. Additionally, field monitoring methods tend to focus on one system component at a time, i.e. birds are counted at a different time than benthos is sampled or the bathymetry is measured. This makes it more difficult to interpret the data in terms of relations between these components. As an alternative, remotely controlled and continuously operating monitoring systems can provide valuable, comprehensive and high-resolution information about the development of intertidal areas.

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Knowledge - Biogeomorphological effects of nourishment, NL

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Sand nourishment - Sand Engine Delfland, North Sea, NL

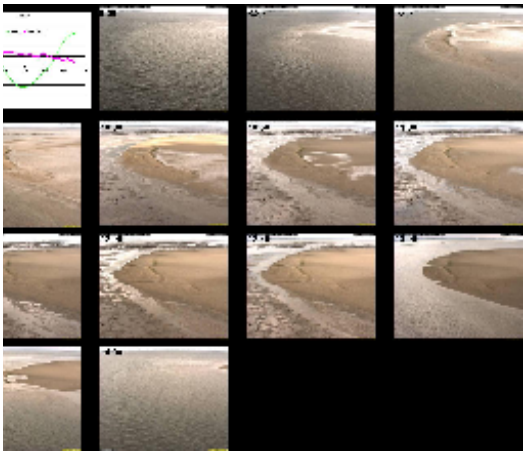
Shellfish reefs as shoreline protection - Eastern Scheldt, NL

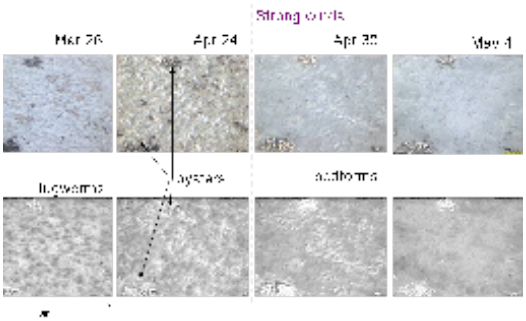
Tidal flat nourishment - Galgeplaat, NL

Related Tools

Monitoring swimmer safety


x 50' fixed HD Argus cam




Strong winds
Mar 26
Apr 24
Apr 28
May 1
bayside
oceanside

Tool description

The ArgusBio monitoring station uses multiple geo-referenced cameras to observe the environment. Listed below are the layout and settings as used to observe the dynamics of the Tidal flat nourishment - Galgeplaat, NL in the Eastern Scheldt, the Netherlands (note: station removed 2012 at the end of the Galgeplaat project). Note that the system was built early 2009; nowadays cameras with better specifications are available at the same cost. Also note that different locations and/or different interests might ask for different equipment.

- 4x Traditional Argus cameras (fixed position, 1.2 megapixel) make time-exposures (pictures at multiple time-steps merged into one) every 3 minutes to observe changes in bathymetry, inundation time and surface soil moisture. The field of view of these cameras covers the nourishment and its close surroundings, i.e. an area of roughly 500 x 500 m. Due to the oblique orientation, the resolution close to the station is much better than farther away. The latter is too low to recognize birds, for instance.
- 1x Pan/tilt/zoom camera (security camera, 0.5 megapixel) that scans five areas of interest of 50 x 50 m, all 50-150 m from the station, every 15 minutes during low water. The main objective of this camera is the observation of birds from day to day and during a tidal period. Close to the station the resolution is even sufficient to observe lugworms.
- 1x Multi-spectral camera with one RGB-sensor (red, green, blue; normally visible light) and two NIR (near infrared) sensors pointed at a fixed area of 4 x 4 m very close to the station to observe macroalgae, diatoms and macrofauna. The NIR sensors enable the identification of chlorophyll-a, a component that distinguishes algae from other features such as a bare bed or bivalve shells. Images are taken every half hour, theoretically enabling the quantification of diatom abundance throughout a tidal period. So far, only daily values have been used.

All these cameras are fixed in waterproof housings on a 15 m high platform mounted on a steel pile of 1 m diameter, which was drilled 12 m into the sand. The station is also equipped with solar panels and batteries for power supply, a water level sensor, a lightning conductor, a thermometer, a computer for data acquisition and equipment for data storage and communication. The data produced by ArgusBio are essentially geo-referenced JPEG-pictures (or movies), saved in the Argus-database together with information on time and camera settings. Interpretation of this data requires a substantial amount of human labour or algorithms for automated recognition. Tools have been developed for the automated recognition of shorelines, the detection of wet, dry or moist areas, birds and microphytobenthos (diatoms). See 'practical applications' for more information.

How to Use

An ArgusBio monitoring station can be used at various locations: coasts, bays, estuaries and rivers. The area that can be monitored by one station depends on the quality of the cameras, the required level of detail (i.e. the features under observation) and the height of the observation post. An ArgusBio station can be used for monitoring before, during and after construction activities, or for long-term monitoring.

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Before a station is fully functional, the following steps need to be taken:

- Who wants to use the results, and for what? As data are scarce and monitoring expensive, there may be multiple users (possibly willing to co-finance the facility or to buy the data;
- Define the monitoring purpose and determine the spatial and temporal resolution accordingly: short/long-term, high/low spatial resolution (i.e. only morphology or also smaller biologic features), high/low temporal resolution;
- Determine whether a monitoring station provides more value than traditional monitoring; compare the expected costs and benefits of both options;
- Design a suitable structure (vibrations, durability, robustness, protection against vandalism, height for field of view) and select the equipment (resolution, durability, power consumption);
- Arrange permits for e.g. temporary structures, working in or near protected areas or shipping lanes, communication equipment;
- Set up a storage system (database) for the images;
- Test the functioning of the entire system at a land-based testing location, preferably for a longer period of time and under difficult conditions (does it have enough power? Do data connections and protocols work properly? Do the indicators for malfunctioning work properly? Can errors be corrected remotely?);
- Install the system in the field; take measurements for geo-referencing of images, position the sensors and cameras on the platform, test connections;
- Be ready to visit a couple of times for corrections; camera positions may have changed;
- Gather samples/data for validation of the camera observations, e.g. in-situ samples of diatoms and a traditional bird count from the station;
- Perform regular inspections and maintenance, 1-2x per year;
- Continuously analyse images to get results, and translate these results into understandable and meaningful information for the user(s).

After the desired operational period, which can range from several months to (possibly tens of) years, the station can be removed and be re-used at another location. Since ArgusBio is a modular system, specific components can be upgraded or added, depending on the requirements for the new location. As new equipment may cause a discontinuity in the dataset and is likely to require new calibration measurements, upgrades can best be combined with relocation, unless there is an urgent need. The life span of an ArgusBio station strongly depends on the quality and durability of its components, as well as the local weather conditions. With good protection against rain, salt spray, lightning and bird excreta, most electronic components will last several years. Heat, cold, moisture and sudden power shortages likely shorten the life span of these components as compared to regular indoor use.

Practical Applications

The data produced by ArgusBio are essentially geo-referenced JPEG-pictures (or movies). Interpretation of this data requires substantial human effort, or algorithms for automated recognition. Algorithms for automated data processing and analysis existed for bathymetric monitoring, but not for monitoring birds, macrofauna or algae. Therefore, the following tools were developed:

1. Morphology
2. Birds
3. Macroalgae and microphytobenthos (diatoms)

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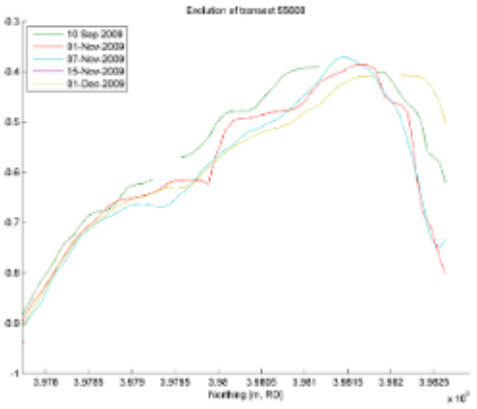
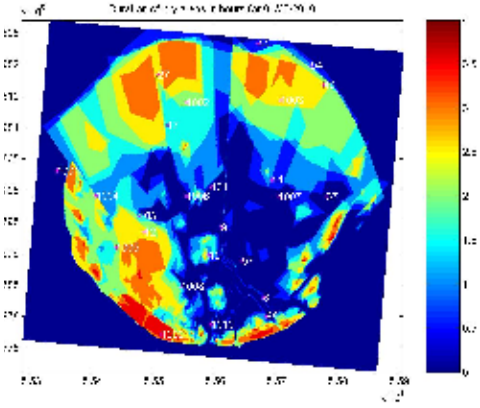
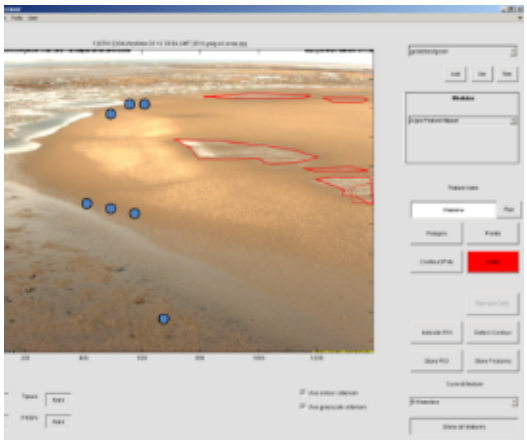
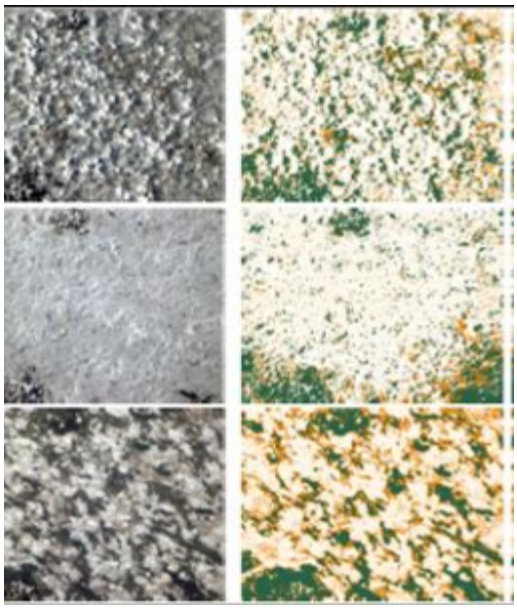
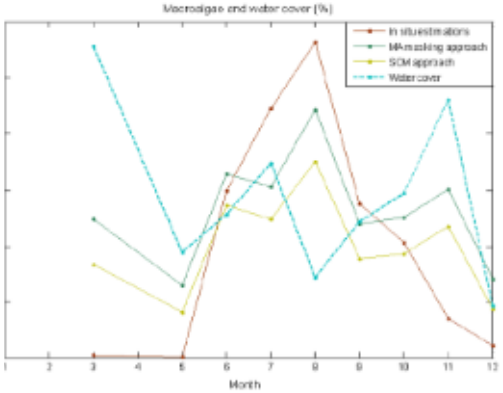

Evolution of transect 55000
10 Sep 2009
31-Nov-2009
07-Nov-2009
15-Nov-2009
01-Dec-2009
Northing (m, RD)









Use and evaluation of results

The ArgusBio monitoring station has been used to monitor the morphological and biological development of the Tidal flat nourishment - Galgeplaat, NL. The monitoring of morphological developments showed very little changes in morphology, which was confirmed by visual inspection and accurate RTK-DGPS topographic surveys. The novel application of the monitoring system to detect which areas were wet, moist or dry during low tide, and how this pattern developed over the years proved to be very useful for linking micro-topography to the re-colonisation of benthos (see Galgeplaat nourishment). More experimental applications were the use of the system to assess the presence of macroalgae and diatoms over time using a multi-spectral camera (van der Wal et al., 2011, subm., Rammos, 2012) and to count birds (Baldi, 2010 and Rammos, 2012) using the pan/tilt/zoom camera. These experiments were predominantly performed to further develop the possibilities of ArgusBio, and were not directly linked to other projects.

Practicability

Most algorithms are part of the Matlab-shell around the Argus database located at Deltares, which is under license from Oregon State University and therefore not readily available to others (for more information on use and licensing options: contact Deltares). The tools that aid manual identification of bed moisture levels and birds are easy to use and require no other specific knowledge than basic ornithology. The automated recognition algorithms require more expert knowledge to set all parameters that enable identification correctly.

Due to the complexity of the ArgusBio monitoring station (many components, limited power to supply all components simultaneously) and the natural system under observation, installation is a task for experts: the cameras need to be geo-referenced, the sequence of image acquisition needs to be tuned to the expected dynamics of the environment (light, tide, occurrence of relevant features) and the available power supply or communication bandwidth. Experience shows that this is an iterative process that can take considerable time and resources: analysis of a series of images, sometimes spanning a spring-neap cycle can be necessary to see whether the settings are right. As ArgusBio is a monitoring system based on visual observations, the availability and quality of its data strongly depend on the light conditions, i.e. weather and the day/night rhythm. Since this day/night rhythm differs from the tidal rhythm and changes through the seasons, it is not always easy to gather a consistent and well-structured data set.

Application

The ArgusBio monitoring station can be a useful tool in situations where high-resolution data in space and /or time are required, or for projects where simultaneous data on several biological features and their environment are needed. These can be research projects about the functioning of the natural intertidal system (e.g. foodweb studies, salt marsh development) or projects that closely study the process and effects of altering the system (e.g. the Galgeplaat nourishment and other Building with Nature pilots). Another advantage of ArgusBio is its possible application at remote locations. Due to the effort related to installation, their application is more economic in long-term projects than in short-term projects. The high time-resolution means that ArgusBio gives more detailed information about e.g. the dynamics of bird occurrence than traditional counts. How this high-resolution data compares to the traditional low-resolution data is yet unknown. Moreover, the high frequency is not compatible with current environmental regulations and management practices.

Application provides the most valuable information if the station is operational well in advance of the execution of a project, such that a representative baseline or reference is obtained. Depending on the dynamics of the natural or altered system, the station should remain operational for several years; macrofauna on the nourishment on the Galgeplaat had not yet fully recovered after three years. The ArgusBio monitoring system can also be applied in a customized 'light' version, i.e. only a pan/tilt/zoom camera if birds are of main interest, or only a multi-spectral camera for algae. The images from ArgusBio are very suitable to explain what is happening to the general public.

Lessons Learned

The application of the ArgusBio monitoring station near the Galgeplaat nourishment had the goal to monitor morphological changes and the presence of algae, macrofauna and birds. Several lessons were learned, e.g.:

Do's:

- Select a test location that can serve various purposes: more people are interested, and permits might be easier to obtain;

- Secure budget for the analysis of the data: people do not want only pictures, but information. This translation takes a lot of work and requires comparisons (=validation) with traditionally acquired field data;
- Communicate about the required information and pictures: system programmers and bird watchers do not understand each other automatically.

Don't's:

- Do not install a not completely finished or tested system on a location that is difficult to reach;
- Do not try to integrate too much in one system; failure of one component may affect others.

References

>> Read more

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