CORAMM
Coral Risk Assessment, Monitoring and Modelling

StatoilHydro

The CORAMM (Coral Risk Assessment, Monitoring and modelling) project

L Thomsen, R Abed[3], E Allers[3], **Melanie Bergmann[5]**, D de Beer[3], S Johnsen[7], F de Laender[4], A Larsson[8], T Lundälv[2], TW. Nattkemper[6], I Nilssen[7], D van Oevelen[4], J Ontrup[6], A Purser[1], I Rønning[7], M Smit[7], V Unnithan[1], H Wagner[1], T Wang[3]

Melanie.Bergmann@awi.de

[1-8] Author contact details given at the bottom of the poster.

INTRODUCTION

CORAMM aims to improve our knowledge of the impacts of high suspended sediment loads and drill cuttings on cold water coral communities. The project is multidisciplinary in approach, with sedimentologists, biologists, modellers and representatives from StatoilHydro all involved in furthering the current understanding of these ecosystems. CORAMM has 4 workpackages: WP1 concentrates on the development of novel video and image analysis tools to enable a better and faster evaluation of *Lophelia pertusa* community structure and health status. WP2 assembles and further develops sensor systems for environmental monitoring with special emphasis on particle dynamics. These systems can be used as autonomous stand-alone units or can be linked to the internet. WP3 carries out specific experiments with live coral colonies to elucidate and predict the effect of different particle size and microbial composition. WP4 will build advanced ecosystem models for cold water corals and use a physiology- based approach to predict the effect of different sediment loads on the performance of cold water corals. Here, we present the outcome of the first 18 months of research.

Workpackage 1

WP 1 aims to develop innovative video and image analysis techniques to improve assessments of coral community structure and reef health. Our work has focused on:

1) Developing methods to mosaic video and still images from coral reefs (from ROV, submersible,video sled) and import these mosaics into GIS maps.
2) Developing automated classification tools to assess reef health and distribution from still images (incl. still frames extracted from a video stream).

1) Automated estimation of coral coverage

The Alfred Wegner Institute and Bielefeld University have developed computer algorithms that can be trained to detect corals, other biota or substrates on images extracted from a video stream. In summary, the system relies on experts to identify areas of a set of images covered by a particular organism or substrate. Given a sufficiently high number of expert-identified features, the computer system, can 'learn' how this feature is distinguished from the remainder of the image. Once trained, a larger set of images can be fed to the system, which can then undertake an automated analysis of areas of each image covered by the features that it has previously *learnt* (Figs 1-4).

Processing stages

Fig. 1) Experts identify features (e.g. coral, sponges) on selection of images.

Fig. 2) Computer 'learns' from expert labels to identify image data with various features.

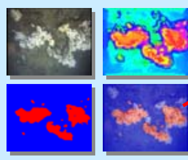


Fig. 3) 'Trained' computer examines other images in dataset and assigns identification names to features.

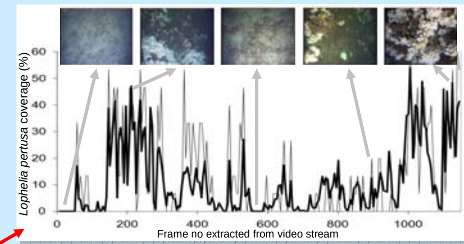


Fig. 4) Graphs can be produced (thick line) showing the percentage of images covered by coral over a transect. Coral coverage estimates from auto analysis and a manual 15-point methods (thin line) (Guinan *et al.* 2009) were similar.

2) Video mosaicking

Jacobs University, University of Gothenburg and the University of New Hampshire have been collaborating on developing novel computer mosaicking applications to produce composite images of reef structure. The aim of producing these images is to allow spatial information on coral distribution and condition to be more readily assessed than is possible from a set of individual images or video directly. In collaboration with Y. Rzhanov our workgroup has collected a range of video and still images from Norwegian *L. pertusa* reefs. Additional material was provided by StatoilHydro. Modifications to a *SPERRE 600* ROV (Fig. 5) have allowed the collection of high-quality, well-positioned video footage from the Tisler reef, which will be the focus of future work.

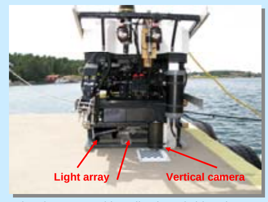


Fig. 5) ROV used in collection of video data from Tisler reef for mosaicking.

Fig. 6) The mosaic gained shows the variation in *L. pertusa* density across ~10m of the reef.

Workpackage 2

WP 2 focuses on testing, assessing and developing new sensor types for utilisation in the *L. pertusa* reef environment. Work has been carried out primarily at the Tisler reef (Fig. 7) and selected additional locations along the Norwegian margin. Lander systems (Fig. 9) were deployed at the Tisler reef, to collect time-series data on flow conditions, concentration and composition of particle size and chlorophyll, temperature, salinity and turbidity in the water column at the reef and in surrounding waters (Fig. 8). Different flow meters, sediment traps and landers were deployed, to allow recommendations to be made to government / industry as to the most useful designs and configurations for their requirements. Campaigns in spring/summer yielded temperature, salinity, chlorophyll, nutrient and oxygen concentration profiles of the water column above and around the reef.

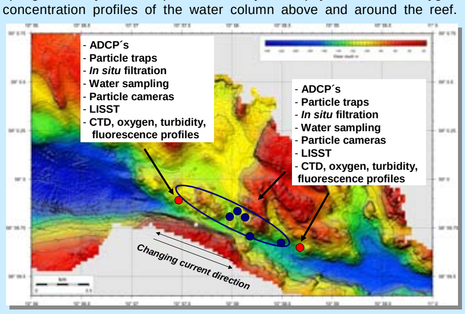


Fig. 7) Map of the Tisler reef and details of deployments. The reef has been damaged by trawling in the past, which was banned 5 years ago.

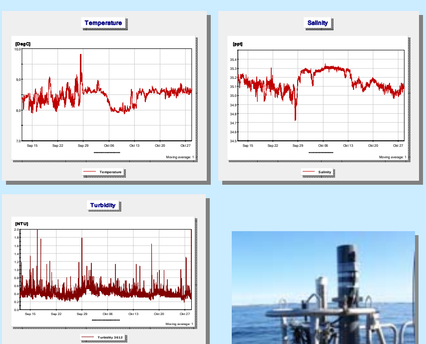


Fig. 8) Temperature, salinity and turbidity of bottom waters at the Tisler reef over 6 weeks in Autumn 2008.

Fig. 9) Custom-built long-term deployment lander fitted with a particle trap. Designed for deployment by small vessels equipped with ROVs for recovery.

Workpackage 3

This WP focuses on developing and running experiments in the laboratory to better understand the functioning of *L. pertusa.* We assess how particles from the water column interact with *L. pertusa.* All experimental work thus far has been done at the Sven Loven Centre of Marine Research. The work is co-ordinated by University of Gothenburg with researchers from the Max Planck Institute of Marine Microbiology and Jacobs University also contributing. *Lophelia* polyps collected from the Tisler reef were maintained in temperature-controlled laboratories supplied with running seawater from Kosterfjord.

Fig. 10) 3 assessments of polyp activity. A) Extended polyps, B) visible polyps, C) retracted polyps.

In the first 18 months, we investigated how bacteria from marine particles affect coral health, or damage coral tissue following smothering by particulate matter (sediments and rock chippings from drilling operations). Initial results indicate that bacterial attack has a low impact on *L. pertusa,* even when the coral branches are covered by large quantities of material. We also measured a build-up of anoxia over time within the smothering sediments (Fig.11).

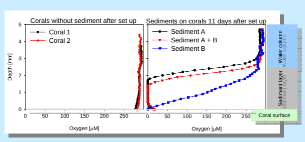


Fig. 11) O_2 concentrations in the boundary waters of coral fragments in aquaria under low flow conditions. Also shown: O_2 concentration in sediments deposited on corals in the laboratory after 11 days of coverage.

Recently, we assessed changes in the activity patterns of *L. pertusa* polyps after exposure to particulate matter of various size classes and composition. Our data suggest that a single dose (even at moderate concentration) causes a change in polyp behaviour for several days (Fig.12). Follow-up work to monitor polyp behaviour during periods of constant exposure to particles is in progress. Ongoing experiments include: coral respiration (Fig. 14), feeding and growth rates during starvation or exposure to particles of various composition.

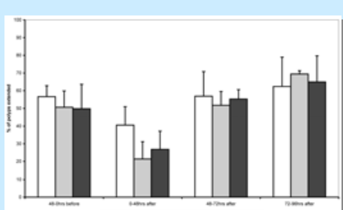


Fig. 12) Percentage of coral polyps 'extended', before and after exposure to a dose of sediment (simulating re-suspension of material by trawling).

Workpackage 4

WP 4 aims to adapt the Dynamic Energy Budget (DEB) model (Koojiman, 2000) to *L. pertusa.* This allows us to better understand how reef ecosystem performance is affected by changes in key parameters (Fig 13).

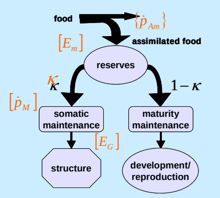
Stages in the development of a model for cold-water corals:

1. Model for healthy corals needed, but basic ecological knowledge is currently not available.

2. Estimation of parameters from dedicated experiments for a model of healthy corals.

3.Model and add effects of particle stress to healthy coral model.

The Centre for Marine & Estuarine Ecology lead this WP, but the interconnected nature of CORAMM encourages input from the other WPs. Model stage 1, for example, requires input from WP 2, whereas WP 3 feeds into modelling stages 2 and 3 (Fig. 14). Modellers interact regularly with other WPs who tailor experiments that provide exactly the data they need.



Primary parameter	
Symbol	Description
$\{\dot{p}_{Am}\}$	surface-specific maximum assimilation of energy
$[E_G]$	volume-specific costs of growth
$[E_m]$	maximum reserve density
$[\dot{p}_M]$	volume-specific maintenance rate
κ	partitioning parameter

Fig. 13) Simple description of the general DEB model and parameters.

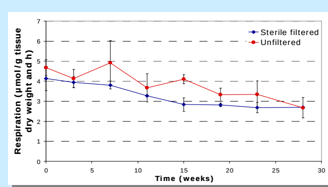


Fig. 14) Respiration of *L. pertusa* starved over 28 weeks. Data fed directly into DEB model.

Acknowledgements

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Author contact details

[1] Jacobs University, Campus Ring 1, 28759 Bremen, Germany
[2] Sven Lovén Centre for Marine Sciences - Tjarno, University of Gothenburg, Sweden
[3] Max Plank Institute for Marine Microbiology, Celsiusstrasse 1, 28359 Bremen, Germany
[4] NIOO-KNAW, Centre for Estuarine and Marine Ecology, Korringaweg 7, 4401 NT Yerseke, The Netherlands
[5] Alfred Wegener Institute for Polar & Marine Research, Am Handelshafen 12, 27570 Bremerhaven, Germany
[6] Bielefeld University, Faculty of Technology, Universitätsstr. 25, 33615 Bielefeld, Germany
[7] StatoilHydro, StatoilHydro ASA Arkitekt Ebbels veg 10, Rotvoll, NO-7005 Trondheim, Norway
[8] Department of Marine Ecology - Tjärnö, University of Gothenburg, Sweden