CRUISE REPORT OF RESEARCH SHIP R/B NORPPA

Daily cruises between July 1st and October 30, 2008 to the Tisler Reef

1. NAME OF RESEARCH SHIP R/B Norppa CRUISE NO. 2008-07

2. DATES OF CRUISE From 2008-07-01 To 2008-10-30

3. OPERATING AUTHORITY:
Jacobs University Bremen
TELEPHONE: +49-421 200 3254

TELEFAX: +49-421 200 3229

Email: l.thomsen@Jacobs-university.de

4. OWNER (if different from no. 3)

5. PARTICULARS OF SHIP:

Name:	Research Boat NORPPA
Nationality:	German
Overall length: (in metres)	6.4 m
Maximum draught: (in metres)	0.5 m
Net tonnage:	1.6 tons
Propulsion e.g. diesel/steam:	Gasoline
Call sign:	
Registration port and number (if registered fishing vessel)	

6. CREW

Name of master: Laurenz Thomsen

Number of crew: 1

7. SCIENTIFIC PERSONNEL

Name and address of scientist in charge: Laurenz Thomsen and Hannes Wagner
Jacobs University Bremen, OceanLab, Campusring 8
D- 28759 Bremen
Tel/telex/fax no.: +49-421 200 3254, +49-421 200 3229
No. of scientists: 1-4

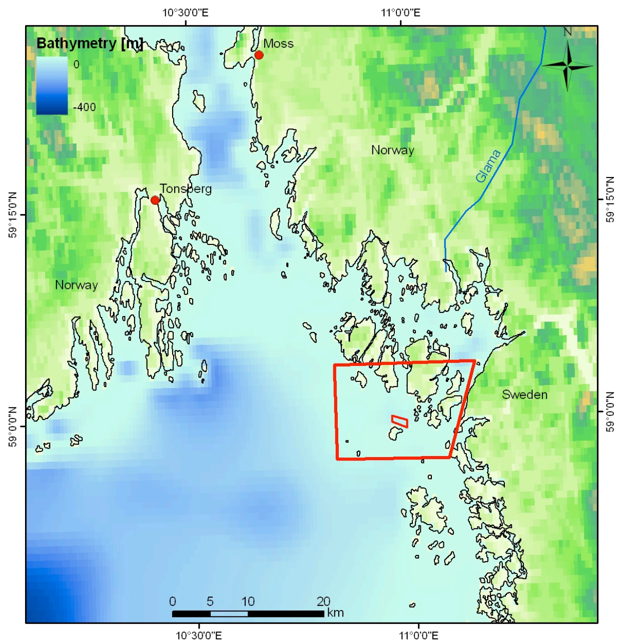
8. GEOGRAPHICAL AREA IN WHICH SHIP OPERATED (with reference to latitude and longitude)
Polygon, with limitations given below.
59° 03´,90 N, 10° 49´,45 E; 59° 03´,90 N, 11° 08´,76 E;

58° 57´,10 N, 10° 49´,45 E; 58° 57´,10 N, 11° 04´,90 E

9. BRIEF DESCRIPTION OF PURPOSE OF CRUISE
1. EU FP6 project HERMES. Interaction between cold-water coral reefs and passing water bodies
2. Education and Training for graduate students at TMBL for the HERMES project
3. Project in collaboration with Statoil: Effects of particulate matter on cold-water coral ecosystems

a) PURPOSE OF RESEARCH
1. EU FP6 project HERMES. Interaction between cold-water coral reefs and passing water bodies
2. Education and Training for graduate students at TMBL
3. Project in collaboration with Statoil in HERMES: Effects of particulate matter and sedimentation on cold-water coral ecosystems
b) GENERAL OPERATIONAL METHODS (including full description of any fish gear, trawl type, mesh size, etc.)

Camera-transects for studies on quality and quantity of benthic fauna. Studies will only be conducted in areas selected from bathymetric conditions. Camera-aided deployment of recording instruments. The following types of equipment will be used:
Hummingbird Echosounder with GPS
Olex navigational system
Mini-ROV Camera type GNOM (max depth 200 m)
Aanderaa RCM 9 Recording instrument (salinity, temperature, current, turbidity) and Aanderaa ADCP 600 (recording profiling current meter)
Llist particle sizer
Particle traps
Time-lapse cameras
Particle-Cameras
Small Water sampler



The daily cruises were aimed to investigate fluxes of particulate matter along the Tisler reef. The work concentrated on the development of new video and image analyses to better and faster evaluate coral community structure and varying health status of corals. Further on New sensor systems for environmental monitoring of coral reefs with special emphasis on particle dynamics were tested and deployed.

During four major field campaigns a total of 81 guided water samples from different depths (1 m to 5 m above bottom) and different locations across the reef (NW & SE of main reef structure, and mid-reef) for later C, N and Amino Acids analyses were taken. The field campaign data are currently being analysed.

Results and Discussion

Sensor reliability and applicability

The Nortek ADCP and Aanderaa ADCP/turbidity, oxygen, fluorescence sensor-package have been found to operate well at the Tisler Reef. The LISST particle sizer is an essential tool to model particle transport behaviour of fine material within the reef. It is is still undergoing testing to determine its applicability in monitoring coral reef environments. Equipment necessary for video-mosaicing has been successfully tested. The work with filming and identifying areas with different coral health status will now begin in close collaboration with the TMBL labs. We will estimate health status by looking at e.g. proportion of dead/live polyps, overgrowth by other organisms and sediment coverage. After identifying areas where corals seem more healthy and less healthy, instruments to record hydrodynamics, particle fluxes, oxygen etc were deployed by TMBL in 2008.

Experiments under both *in situ* and laboratory conditions allowed to estimate how corals react on changing food supply. PhD student Hannes Wagner further investigated the alteration of lateral transported particulate matter by cold water coral reefs and analyzed the composition, quantity and temporal variability of particulate organic matter (POM) exported from cold water coral reefs**. T**he Tisler CWC reef solves as a perfect case study site for these objectives. The reef has an oval shape with the major axis running NW-SE. Due to bathymetric circumstances, a strong current either to the NW or to the SE is the normal case at the Tisler reef. Due to its location in the Koster Fjord, the main deepwater flow over the Tisler reef was running either towards NW or SE. This was recorded by two long-term records from ADCPs (Aanderaa RDCP 600 2 months of record and Nortek Aquadopp 4 months of record) deployed by TMBL. Velocities in the Benthic Boundary Layer 4 meters above seafloor reached up to 60 cm/s in the middle of the reef (Aanderaa ADCP; Figure 1) and up to 80 cm/s on the NW side of the reef (Nortek ADCP). Because of small scale bathymetric features within the reef, flow conditions in the Benthic Boundary Layer in the first few meters above the reef were more complicated. Even when the main at 15 m hab was NW/SE directed, the flow in the BBL 4 m hab in the middle of the reef changed frequently in direction. This is clearly show in the below Rose graphs (Figure 2).

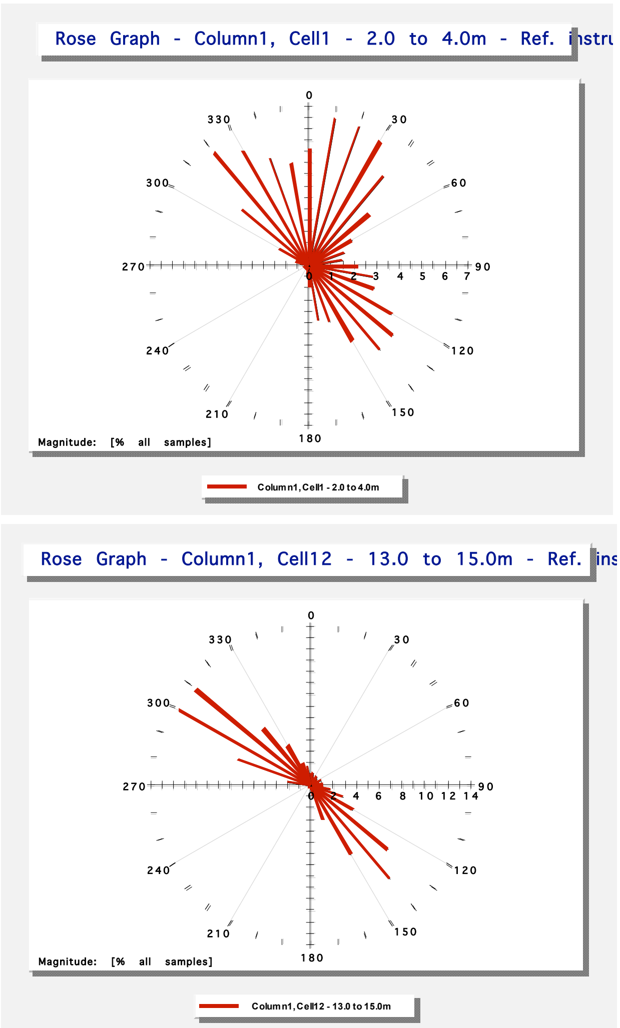


Figure 1: Rose graphs for the middle of the reef at 4 m hab and 15 m hab (record of Aanderaa RDCP 600).

Aggregation

The percentage of large aggregates (> 425 microns) on the total particle concentration in the BBL increased with increasing particle loads. Figure 2 shows an example of that for the first 24 hours of one record. Even more pronounced is the decrease in percentage of the fine particulate fraction (2,5 – 11 microns) on the total particle concentration with increasing particle load. This process is a clear indication of particle aggregation within the reef under specific flow conditions.

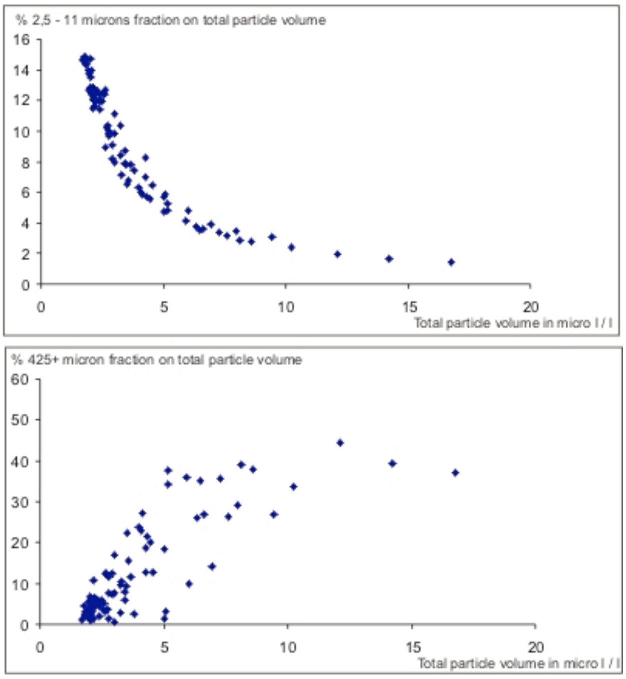


Figure 2: Percent of the fractions 2,5 -11 microns (left graph) and 425+ microns (right graph) on the total particle volume concentration for the first 24 hours of the long-term LISST deployment.

Further analyses showed that the bioavailability of particles at the downstream site of Tisler was higher than at the upstream site indicating fresher material entering the reef during the passage of a water mass.

Data analysis

<u>CTD profiles</u>

During the two field campaigns at Tisler in August and September 2008 special emphasis was drawn on the validation of following hypothesis:

A turbulent "canopy layer" is created above and especially towards the downstream site of a CWC reef. Through downward water motion the turbulence brings fresh organic material from upper water layers down to the reef. Special hydrodynamic conditions which create such a "reef-self-feeding" mechanism seem to occur at CWC reefs like the one at Tisler due to two facts:

i) The turbulence is created by bathymetric features (like the sill in Koster fjord) which strong bottom currents have to overflow

ii) The turbulence is also created (or intensified) by the three-dimensional reef structure itself. The turbulent zone thickens towards the downstream site and thus the reef is mainly supplied by fresh water masses (with eventually chlorophyll) at the downstream side.

That this hypothesis holds true could be clearly shown by various CTD profiles made during the August and September campaigns on both sides of the reef. Examples are shown in Figures 1 and 2. At the downstream side (either at the NW or the SE edge of the reef, depending on the current direction) the water was always much warmer and less saline then on the upstream side. Most interesting are the chlorophyll profiles: Chlorophyll is transported into much deeper water layers at the downstream side compared to the upstream side. Profiles from the middle of the reef (which are not shown here for better visibility in the graphs) show intermediate chlorophyll depth.

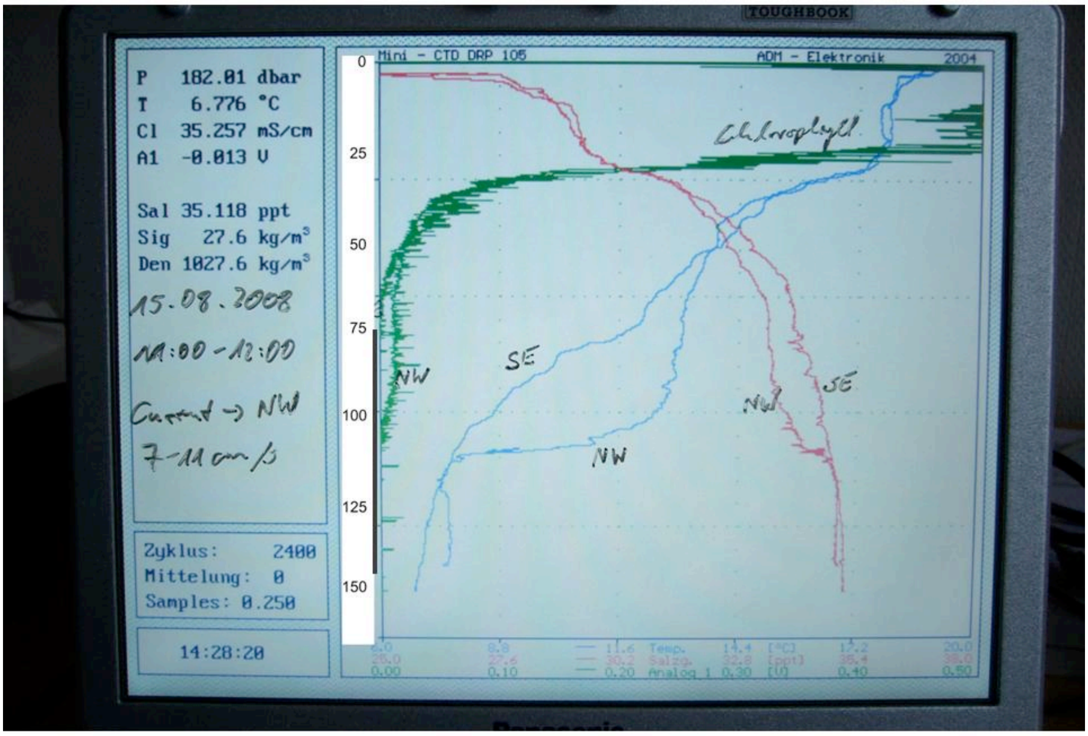


Figure 1: CTD profiles at the NW and at the SE side of the reef made on 15.08.2008 during a 7-11 cm/s strong bottom current towards the NW. Blue lines show the water temperatures, red lines show salinity and green lines show chlorophyll. The Y-axis shows the water depths in meter. The black bar marks the reef extent from 75 – 145 m water depths. In 100 m water depth, for example, the temperature is 12,5°C at the downstream side (NW) compared to 8,7°C at the upstream side (SE). Together with this downward motion of warmer water, chlorophyll is transported down to 110 m depths (downstream) compared to only 70 m depths (upstream). Single chlorophyll peaks were even measured down to 140 m at the downstream site of the reef.

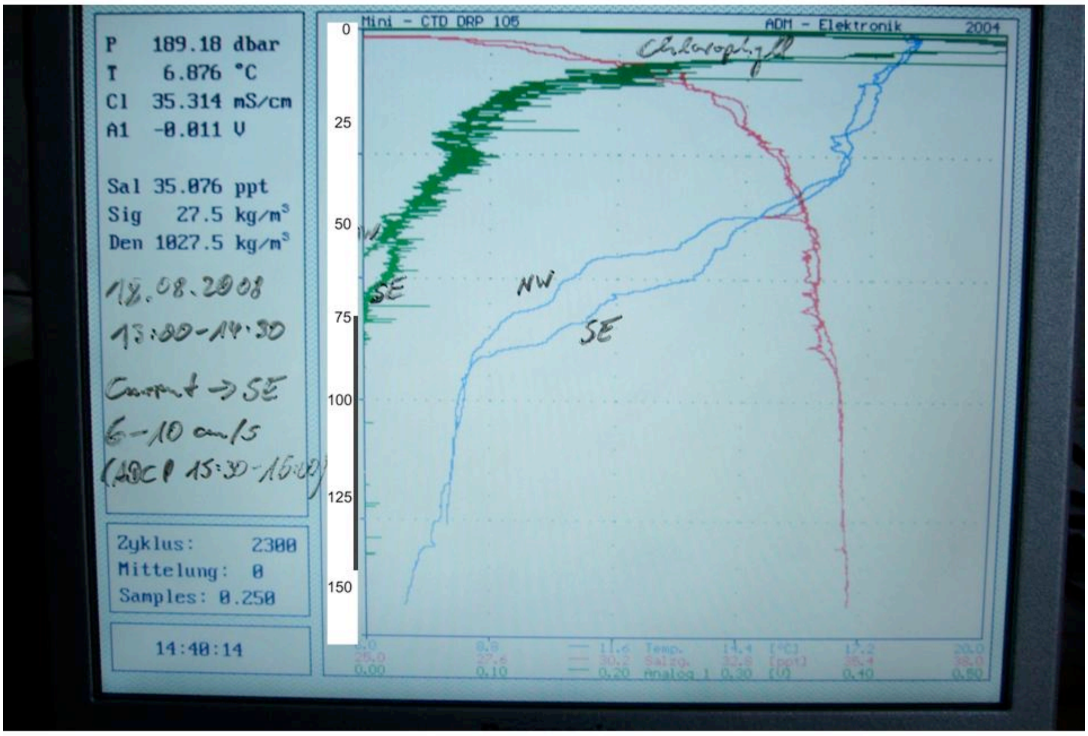


Figure 2: CTD profiles at the NW and at the SE side of the reef made on 18.08.2008 during a 6-10 cm/s strong bottom current towards the SE. Compared to Figure 1, here the current is going towards the other direction. Note that in this case the SE side of the reef is the one with warmer and less saline water and the one where chlorophyll reach deeper water layer (75 m compared to 60 m upstream). Even so Chlorophyll did not reach the reef during that time, the mechanism is the same: Through the turbulence, chlorophyll is transported into deeper water layers towards the downstream side of the reef.

<u>High water temperatures</u>

Exceptionally high water temperatures were measured during the Lander deployment from 29.09. – 23.11.2008. Figure 3 shows the temperature record from the Nortek ADCP at the NW side of the reef in 130 m water depth. The corals had to suffer temperatures up to nearly 14°C. This was never observed at Tisler reef at that water depth before. The temperature stayed at high levels between 10°C and 14°C for a period of 12 days. Very pronounced are also fast fluctuations, e.g. a dropdown in temperature from 13,5°C to 8,5°C and back to 13,5°C within one day in mid October. The very high temperatures can have two different reasons: Either the bottom water temperatures were really higher than normal or the downward water motion of warmer water, created by the above described turbulence processes, was more intense. The downward water motion is most likely intensified with increasing current velocities. If this explanation holds true, water temperatures at CWC reefs in the future might be even more affected through Global Change by changing current speeds rather than by changing bottom water temperatures. Unfortunately, because the Lander tilted over, we do not have the current data for this period and cannot say if the currents were exceptionally high during the warm water period and if the NW side, where the Lander was placed, was the downstream side at that time.

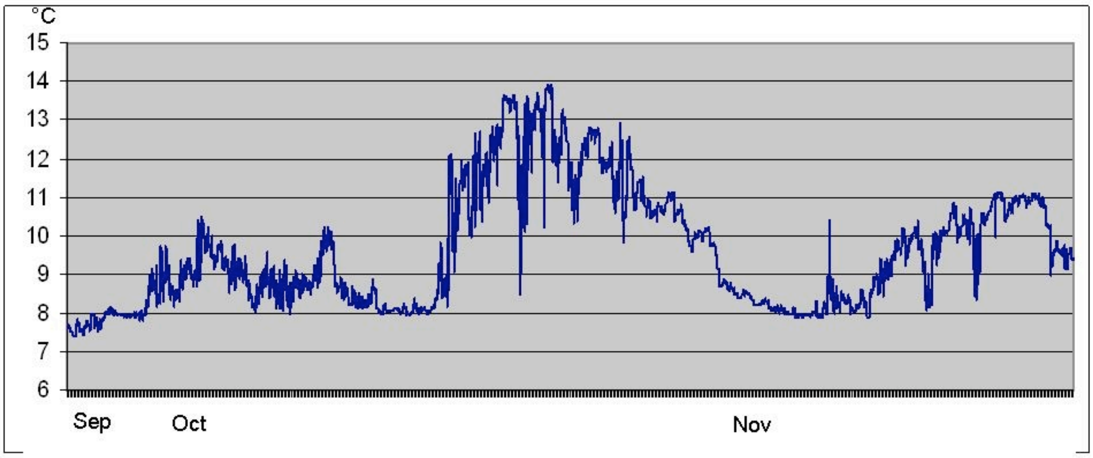


Figure 3: Temperature record from the Nortek ADCP at the NW side of the reef in 130 m water depths for the period 29.09. – 23.11.2008.

<u>Fluxes of particulate matter at Tisler reef</u>

So far, 40 water samples from the Benthic Boundary Layer (BBL) have been analysed for concentration of total particulate matter (TPM) and 22 from these samples have so far also been analysed for organic and inorganic carbon and for nitrogen content. The 40 samples are to approximately equal proportions from the NW side, the middle, and the SE side of the reef. Figures 4 and 5 show the results for TPM concentration and particulate organic carbon (POC). POC is shown as percentage from TPM. TPM is mostly in the range between 1 and 3 mg/l with min/max values of 0,69 and 11,61 mg/l. Particulate organic carbon (POC) mostly lies between 3 and 5 % of TPM with min/max values of 0,45 and 11,27 %. Horizontal and vertical carbon fluxes are currently been calculated, using these data together with current data and the results from the sediment trap hydrodynamic validation. TPM and POC values are also currently analysed for their location of occurrence, e.g. upstream/ downstream, to estimate the overall effect of the reef on particulate fluxes, especially carbon fluxes. Amino acid and C/N analyses are also in further progress and it seems that the hypothesis mentioned in the last report and mentioned above can be strengthen. Through the downward water motion on the downstream side of the reef, water masses there have not only a higher chlorophyll content but also higher Degradation Index values, which stand for a higher bioavailability, calculated from the amino acid composition of the particulate organic matter (POM).

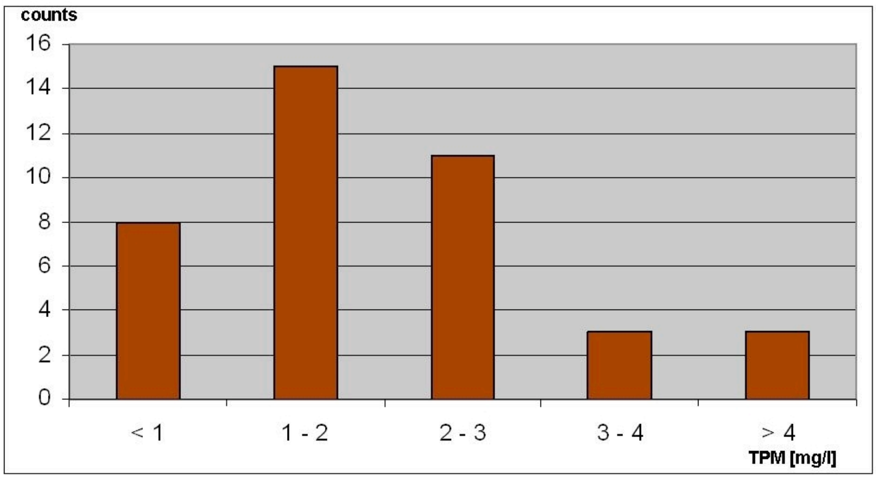


Figure 4: Total particulate matter (TPM) concentration in mg/l in the water of the Benthic Boundary Layer at Tisler reef (n=40)

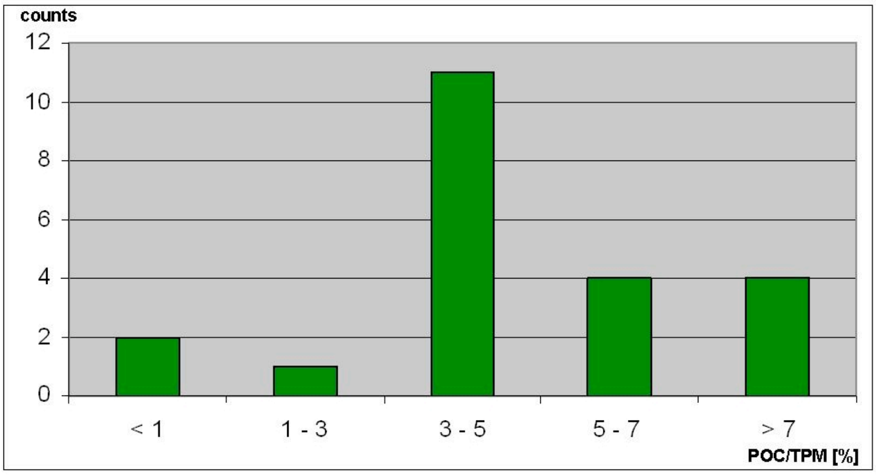


Figure 5: Particulate organic carbon (POC) content as percentage from TPM (n=22)

- **CONCLUSIONS**

- **All the data imply that**
  - **a coral reef acts as particle trap for organic material,**
  - **a downwelling of surface waters above the reef can occur, transporting material vertically into the reef.**
  - **within the reef, aggreation takes place, creating larger particles of higher settling velocities**
  - **the corals biodeposit most of the material and release organic mucus**
  - **in case of pollutant input in surface waters, this would mean that these pollutants will probably aggregate to the organic matter and subsequently be transferred into the reef. If the pollutants are fine grained, they will aggregate with the organic matter (phytoplankton) and subsquently transferred into the reef.**

- **Final testing of this new hypothesis of enhanced vertical transport is urgently needed. Results were only interpreted the last few weeks. We therefore apply again for 2009 on shorter notice. A PhD thesis will then be available in May 2010 for submission to the authorities.**

Tisler Stations

Name	**Lat**	**Lon**	**Depth (m)**	**WP Norppa**	**Description**
A	58°59.688	10°58.020	107	116	middle edge near small island "Baskjne";
B	58°59.584	10°58.550	150	122	**near SE reef corner; ~ 40 m outside**
C	58°59.858	10°57.443	130		**from NW reef corner ~ 180 m to the SW**
D	58°59.660	10°58.340	~144		Big Tripod BoBo Lander in Mar 2007
E	58°59.817	10°57.839	100		In Situ Filtration in May 2007
F	58°59.822	10°57.953	116		ADCP Aanderaa Sep 2007
G	58°59.799	10°58.001	110	125	**middle of reef**
H	58°59.820	10°57.546	129		near Station C; deployment of Hydrobios Trap
J	58°59.604	10°58.491	147		near Station B; deployment of NTTA Trap Sep 2007
K	58°59.705	10°58.020	110	128	near Station G
L	58°59.879	10°57.753	80	71	shallowest reef patch
M	58°59.552	10°58.881	170	162	300 m SE of Station B
N	58°59.879	10°57.171	170	163	250 m W-NW of Station C

Norppa Tisler Deployments 2008

Station	Lat	Lon	Depth (m)	Device	Time	
					August	
K	58°59.705	10°58.020	110	ADCP Aanderaa	05.08.2008	14:54:00 h
C	58°59.858	10°57.443	130		05.08.2008	17:01:00 h
B	58°59.584	10°58.550	150		06.08.2008	09:10:00 h
K	58°59.705	10°58.020	110		06.08.2008	11:34:00 h
C	58°59.858	10°57.443	130		09.08.2008	10:27:00 h
K	58°59.705	10°58.020	110		09.08.2008	12:09:00 h
B	58°59.584	10°58.550	150		09.08.2008	13:32:00 h
C	58°59.858	10°57.443	130		12.08.2008	10:02:00 h
F	58°59.822	10°57.953	116		12.08.2008	12:07:00 h
K	58°59.705	10°58.020	110		12.08.2008	13:25:00 h
B	58°59.584	10°58.550	150		12.08.2008	14:14:00 h
B	58°59.584	10°58.550	150		15.08.2008	10:12:00 h
C	58°59.858	10°57.443	130		15.08.2008	12:03:00 h
B	58°59.584	10°58.550	150		15.08.2008	15:44:00 h
B	58°59.584	10°58.550	150		18.08.2008	13:18:00 h
C	58°59.858	10°57.443	130		18.08.2008	15:20:00 h
K	58°59.705	10°58.020	108	Water Sampler	05.08.2008	15:45:00 h
C	58°59.858	10°57.443	128		05.08.2008	17:18:00 h
C	58°59.858	10°57.443	128		05.08.2008	17:43:00 h
B	58°59.584	10°58.550	148		06.08.2008	09:21:00 h
B	58°59.584	10°58.550	148		06.08.2008	10:22:00 h
B	58°59.584	10°58.550	148		06.08.2008	10:50:00 h
K	58°59.705	10°58.020	108		06.08.2008	12:16:00 h
C	58°59.858	10°57.443	128		06.08.2008	12:39:00 h
K	58°59.705	10°58.020	108		06.08.2008	14:24:00 h
B	58°59.584	10°58.550	148		07.08.2008	14:15:00 h
B	58°59.584	10°58.550	148		07.08.2008	14:40:00 h
B	58°59.584	10°58.550	148		07.08.2008	15:06:00 h
C	58°59.858	10°57.443	128		07.08.2008	15:38:00 h
C	58°59.858	10°57.443	128		07.08.2008	16:05:00 h
C	58°59.858	10°57.443	128		07.08.2008	16:25:00 h
C	58°59.858	10°57.443	128		09.08.2008	10:36:00 h
C	58°59.858	10°57.443	128		09.08.2008	10:55:00 h
C	58°59.858	10°57.443	128		09.08.2008	11:35:00 h
K	58°59.705	10°58.020	108		09.08.2008	12:25:00 h
K	58°59.705	10°58.020	108		09.08.2008	12:46:00 h
B	58°59.584	10°58.550	148		09.08.2008	13:36:00 h
B	58°59.584	10°58.550	148		09.08.2008	13:57:00 h
C	58°59.858	10°57.443	128		12.08.2008	10:24:00 h
C	58°59.858	10°57.443	128		12.08.2008	10:46:00 h
K	58°59.705	10°58.020	108		12.08.2008	12:17:00 h
K	58°59.705	10°58.020	108		12.08.2008	12:49:00 h
K	58°59.705	10°58.020	108		12.08.2008	13:35:00 h
B	58°59.584	10°58.550	148		12.08.2008	14:20:00 h
B	58°59.584	10°58.550	148		12.08.2008	15:25:00 h
C	58°59.858	10°57.443	128		15.08.2008	14:22:00 h
C	58°59.858	10°57.443	128		15.08.2008	14:43:00 h
B	58°59.584	10°58.550	148		15.08.2008	15:52:00 h

B	58°59.584	10°58.550	150	CTD	15.08.2008	10:35:00 h
C	58°59.858	10°57.443	130		15.08.2008	11:31:00 h
K	58°59.705	10°58.020	108		15.08.2008	12:23:00 h
B	58°59.584	10°58.550	150		18.08.2008	12:44:00 h
K	58°59.705	10°58.020	108		18.08.2008	13:29:00 h
C	58°59.858	10°57.443	130		18.08.2008	14:10:00 h
C	58°59.858	10°57.443	130		18.08.2008	15:36:00 h
K	58°59.705	10°58.020	108		18.08.2008	15:56:00 h
B	58°59.584	10°58.550	150	Fluorometer	15.08.2008	10:35:00 h
C	58°59.858	10°57.443	130		15.08.2008	11:31:00 h
K	58°59.705	10°58.020	108		15.08.2008	12:23:00 h
B	58°59.584	10°58.550	150		18.08.2008	12:44:00 h
K	58°59.705	10°58.020	108		18.08.2008	13:29:00 h
C	58°59.858	10°57.443	130		18.08.2008	14:10:00 h
C	58°59.858	10°57.443	130		18.08.2008	15:36:00 h
K	58°59.705	10°58.020	108		18.08.2008	15:56:00 h
					September	
B	58°59.584	10°58.550	150	ADCP Aanderaa	25.09.2008	13:36:00 h
B	58°59.584	10°58.550	150		26.09.2008	09:00:00 h
K	58°59.705	10°58.020	110	Particle Camera	25.09.2008	15:59:00 h
B	58°59.584	10°58.550	150		26.09.2008	09:35:00 h
F	58°59.822	10°57.953	116		26.09.2008	09:59:00 h
C	58°59.858	10°57.443	130		26.09.2008	11:11:00 h
B	58°59.584	10°58.550	150		26.09.2008	11:42:00 h
C	58°59.858	10°57.443	130		26.09.2008	12:10:00 h
B	58°59.584	10°58.550	150	CTD	26.09.2008	13:32:00 h
K	58°59.705	10°58.020	108		26.09.2008	14:01:00 h
C	58°59.858	10°57.443	130		26.09.2008	14:22:00 h
L	58°59.879	10°57.753	78		26.09.2008	14:45:00 h
M	58°59.552	10°58.881	170		26.09.2008	15:04:00 h
N	58°59.879	10°57.171	170		26.09.2008	15:39:00 h
B	58°59.584	10°58.550	150	Fluorometer	26.09.2008	13:32:00 h
K	58°59.705	10°58.020	108		26.09.2008	14:01:00 h
C	58°59.858	10°57.443	130		26.09.2008	14:22:00 h
L	58°59.879	10°57.753	78		26.09.2008	14:45:00 h
M	58°59.552	10°58.881	170		26.09.2008	15:04:00 h
N	58°59.879	10°57.171	170		26.09.2008	15:39:00 h

(Principal Scientist)

Dated_______18.03.2009