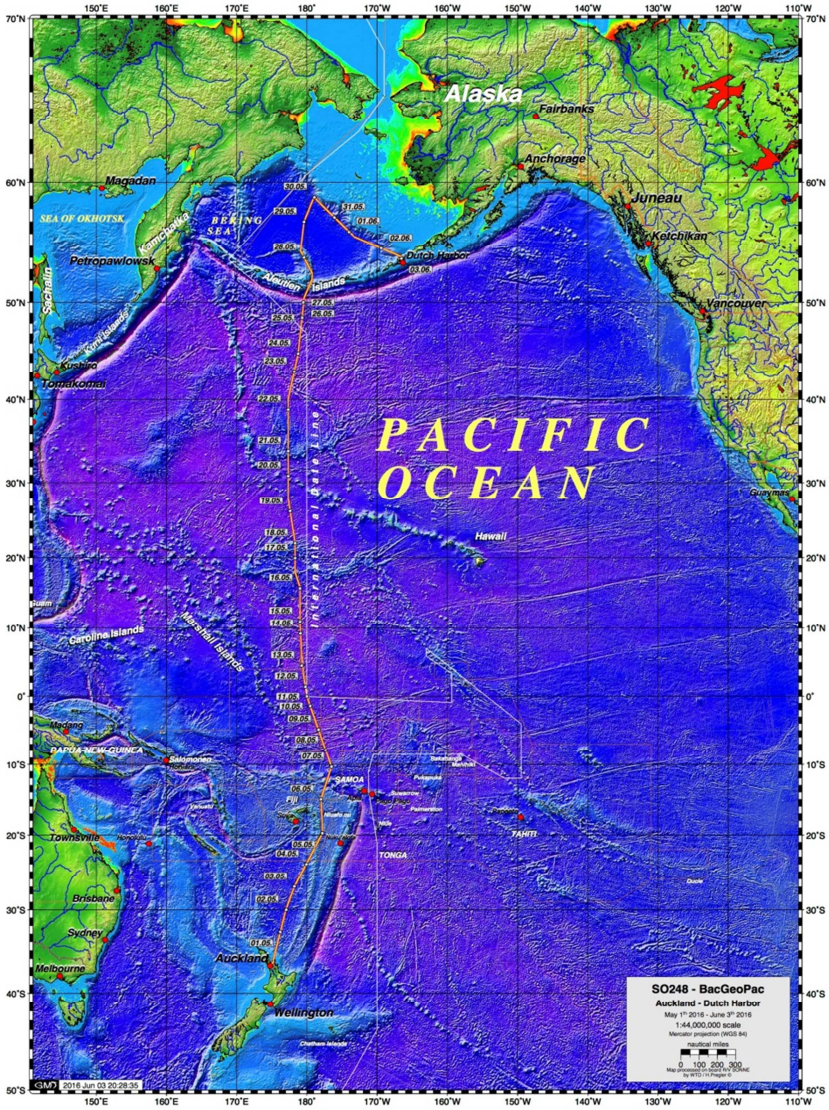
Meinhard Simon
Institute for Chemistry and Biology of the Marine Environment
University of Oldenburg
D-26111 Oldenburg

Tel. +49(0)441-798-5361
Fax +49(0)441-798-3438
Email: m.simon@icbm.de

Short Cruise Report RV Sonne SO248
BacGeoPac
Auckland, New Zealand – Dutch Harbor, Alaska/USA
May 1, 2016 – June 3, 2016
Chief Scientist: Meinhard Simon
Captain: Lutz Mallon



Objectives

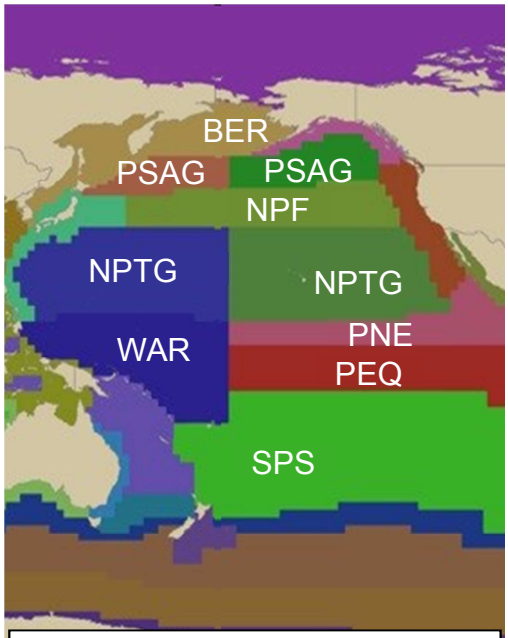


Fig. 1: Biogeographic provinces in the Pacific visited. For abbreviations see text.

The Pacific Ocean between the subpolar regions of the northern and southern hemisphere stretches over distinct biogeographic provinces which differ with respect to water masses, hydrography, nutrients and plankton communities (Fig. 1): Subantarctic, south subtropical convergence, south Pacific subtropical gyre (SPS), Pacific warm pool (WAR), Pacific equatorial current (PEQ), south and north Pacific equatorial counter current (PSE, PNE), north Pacific subtropical gyre (NPTG), north Pacific polar frontal region (NPF), Pacific subarctic region (PSAG), Bering Sea (BER). In order to investigate these differences between SPS and BER, also with respect to growth properties and the composition of the bacterial and archaeal communities and the dissolved organic matter (DOM) pool, the BacGeoPac cruise investigated a transect from the western edge of the SPS at 30°S to the BER at 59°N around the 180th longitudinal degree. Besides growth activities, substrate preferences and the composition of the bacterial and archaeal communities, the phytoplankton communities, nutrient concentrations and the DOM composition were studied comprehensively for the first time on such a long transect in the Pacific. The investigation included 19 stations, 11 deep stations from the surface to the sea floor, including the surface sediment, and 8 shallow stations from the surface to 1000 m depth.

Sampling included extensive CTD-casts throughout the water column, bio-optical characterization of the euphotic water column, horizontal and vertical plankton net tows, collection of microplastic particles, in situ pump deployments in near surface waters, sediment sampling with a Multi Corer (MUC) at all deep stations. In the PEQ and NPF 24 hour time series analyses were conducted to assess the response of the bacterial communities do diurnal changes in irradiance, primary production, DOM supply and mortality by grazing and virus infection. A special focus was on assessing the differences in the functional properties and the composition of the bacterial communities and their main players in the different biogeographic provinces in the water column and as a function of the composition of the DOM pool. Therefore, samples were collected for later analyses of the metagenome, metatranscriptome and metaproteome of the bacterial communities and from 1000 m and below also for the archaeal communities. Further, samples were collected for a refined assessment of the population genomics of two distinct phylogenetic lineages of the Roseobacter clade. In order to embed the assessments of the prokaryotic communities into functional processes, radio-labeled and stable isotope tracers were used to experimentally examine key microbiological and biogeochemical processes. The investigations were complemented by three mesocosm experiments on board, one with water of the SPS, one with water from the PNE and one with water from the NPF. The aims of the mesocosm experiments were to examine the growth response of the ambient bacterioplankton communities to additions of diatom-derived labile DOM, alginate and vitamin B12 and a B12 precursor. These manipulations allow a more refined insight into the functional properties and substrate preferences of the bacterial communities.

Most of the investigations were carried out in the frame work of the DFG-funded Collaborative Research Center Roseobacter (TRR51).

Narrative

On Sunday, May 1st around 9:00 am local time Research Vessel Sonne with the embarked 40 scientists and 30 crew members left the port of Auckland for the BacGeoPac cruise to head to the first station at 30°S, 177°E, where we arrived in the morning of May 3rd. Three 20 foot-containers and air fright boxes with scientific equipment had arrived in time so that everything we needed was on board. As the scientists came on board on April 30th we had plenty of time to set up the labs and get ready for the first station work. This station was particularly exciting for us because we tested our brand new CTD-rosette with 24 20-Liter Niskin bottles. The instrument was designed and constructed in the ICBM workshop and only tested once very briefly before shipping it to Auckland. Because of the large water demand during this cruise we had decided in October 2015 to build this new instrument in order to optimize water collection and to save time. It worked perfectly right away and during the entire cruise without any malfunctioning. At station 1, a shallow station at the eastern edge of the ultra-oligotrophic SPS where we collected water to a depth of 1000 m, we also deployed a McLane in situ pump at 60 m for three hours to collect water for bacterial population genomics studies, collected zooplankton to isolate bacteria by a vertical haul and microplastic by a horizontal tow with the Bongo net and carried out bio-optical measurements (Secchi-depth, hyperspectral und multispectral light field measurements (UV/VIS)). The next station 2 at 25°S, 179°E, still in the SPS, was a deep station where, in addition to the work at station 1, we collected water all the way to the sea floor and surface sediment with a MUC. We used a brand new prototype-like instrument which worked perfectly during the entire cruise without any flaw or sediment loss due to incomplete closure of the lids at the bottom of the plexiglass tubes. In addition we collected water for our first mesocosm experiments. These types of samplings became the routine at the following stations which usually alternated between shallow and deep stations along the transect. Thanks to the large volume CTD we usually needed only one shallow and one deep cast, but in quite a few instances one or two extra casts for special needs.

The stations along the transect were selected such that we aimed at visiting at least two stations, one shallow and one deep, in each biogeographic province. This aim was achieved in all provinces except in the PSE and PNE which are very narrow so that we had only one station in each of these provinces. Hence the distance between the stations was about 4 to 6° latitude. Unfortunately, we could not visit a planned station in the SPS at 20°S which is situated in the EEZ of Fiji Islands. We had applied to work in Fiji's EEZ well in time but never received any response from the authorities and thus had to skip this station.

According to temperature and salinity in the near-surface layer we could clearly identify the water masses and biogeographic provinces. Water temperatures steadily increased from the SPS to the PEQ from 23° to 30°C and further north decreased again to 22° at the northern edge of the NPTG. The NPF was characterized by a strong decrease in temperature such that in the PSAG and BER temperature ranged between 4° and 6°C (Fig. 2). Salinity exhibited strong differences in the various biogeographic provinces, in particular in the equatorial region and the NPF (Fig. 3). From the deep CTD casts we could identify the characteristic water masses in the deep Pacific (Fig. 4). The water masses with the highest density at all stations was the central deep water (CDW). Overall, the tropical and subtropical water masses were clearly distinguished from those of the north Pacific (St. 14-19).

In the permanently stratified warm provinces the deep chlorophyll maximum was situated between 60 and 120 m with the deepest extension in both subtropical gyres (Fig. 2). In the equatorial upwelling it was uplifted to 70 m. Well pronounced phytoplankton blooms were only established north of 40°N and in particular north of 50°N.

North of 5°N between depths of 200 and 1700 m extensive oxygen minimum zones were established with remaining oxygen concentrations of only about 15% of surface values (Fig. 5).

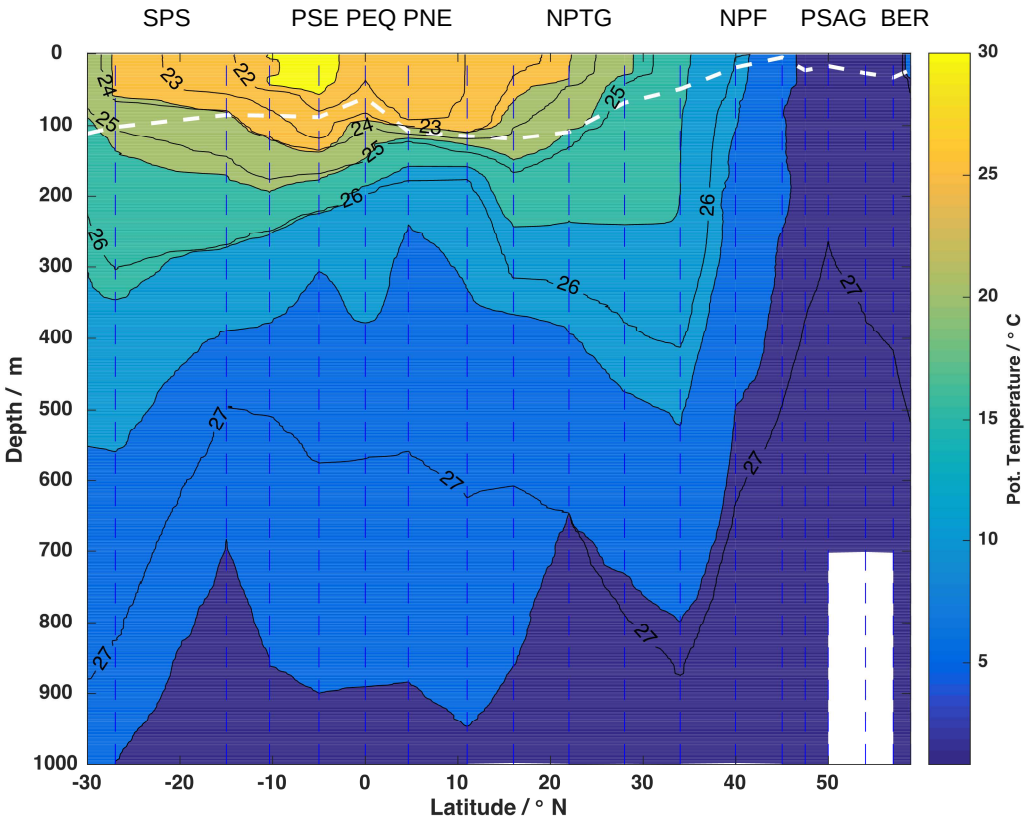


Figure 2: Contour plot of the potential temperature distribution along the meridional transect during SO248 and biogeographic provinces (for abbreviations see Fig. 1 and text). Black lines indicate the isopycnals, white dashed line the position of the chlorophyll maximum and the vertical blue dashed lines the positions of the stations (T. Badewien et al. unpubl.).

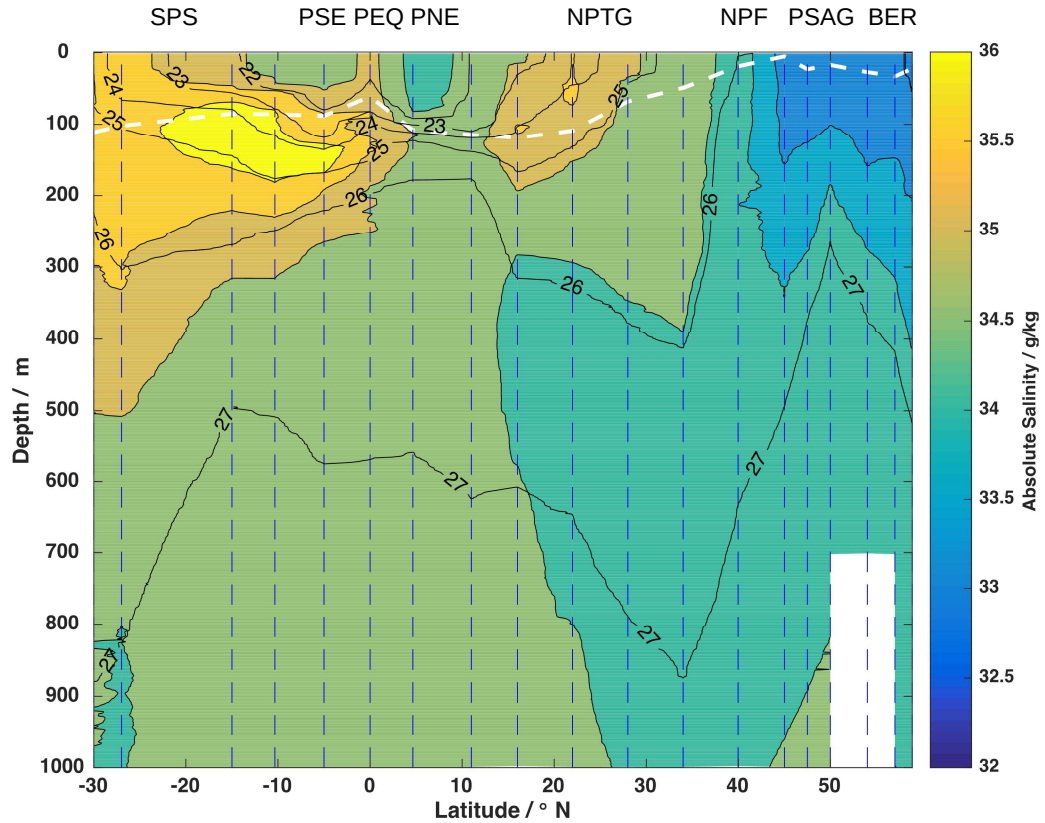


Figure 3: Contour plot of the absolute salinity distribution along the meridional transect during SO248 and biogeographic provinces (for abbreviations see Fig. 1 and text). Black lines indicate the isopycnals, the white dashed line the position of the chlorophyll maximum and the vertical blue dashed lines the positions of the stations (T. Badewien et al. unpubl.).

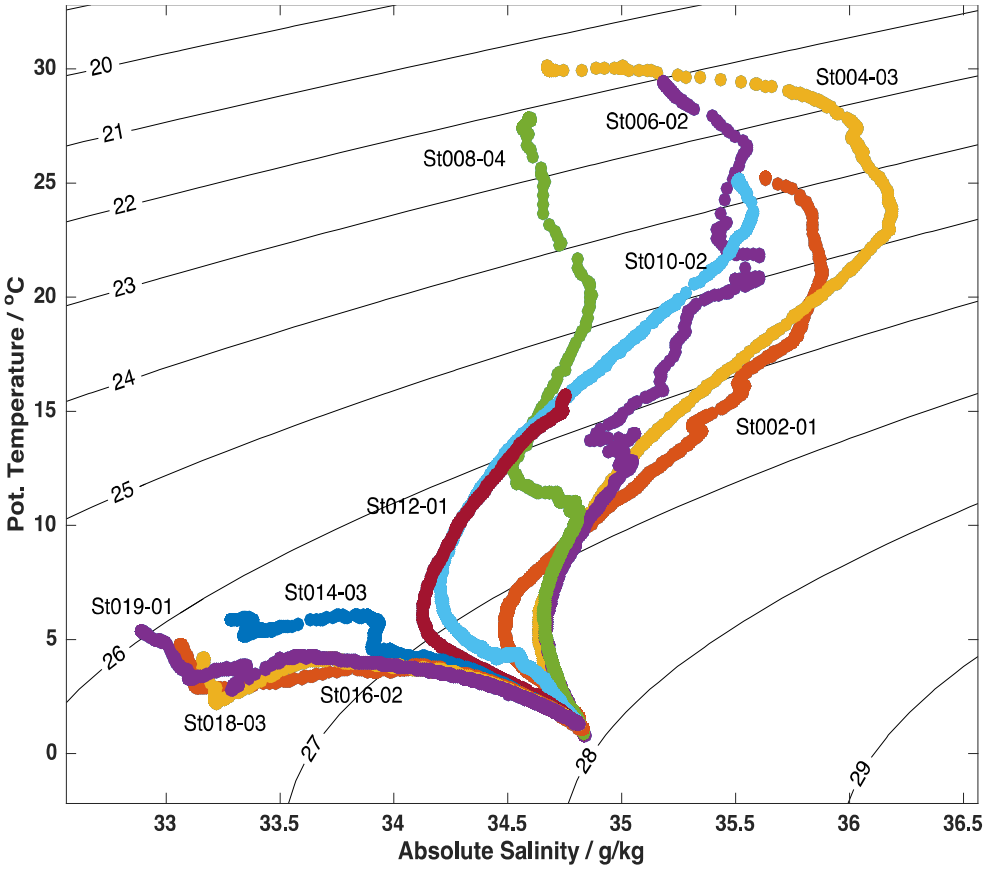


Figure 4: T-S-Diagram (potential temperature versus absolute salinity) of all deep stations during SO248 (T. Badewien et al. unpubl.).

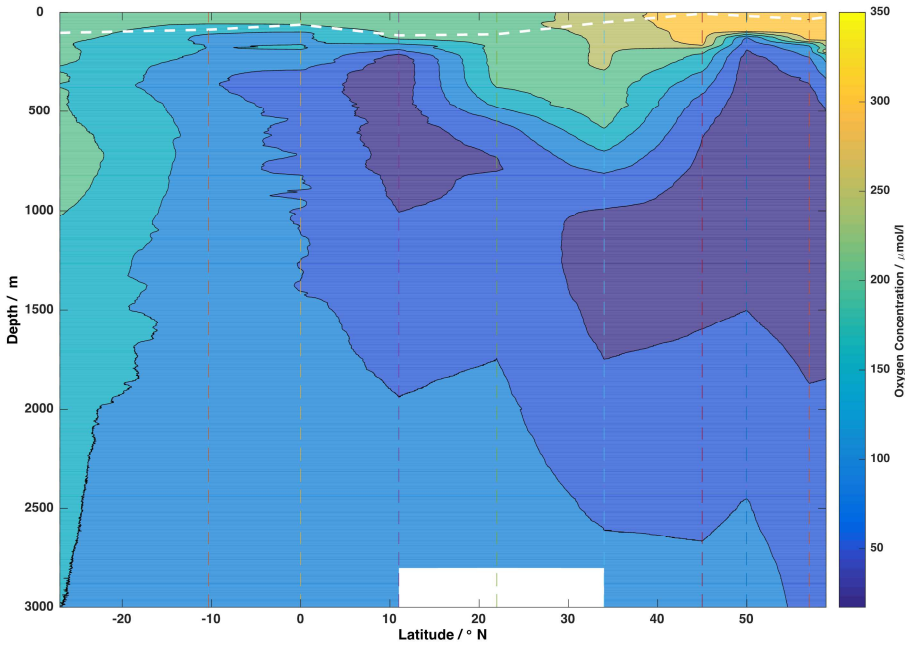


Figure 5: Contour plot of the oxygen distribution along the meridional transect during SO248. Black lines indicate the isopycnals and the white dashed line the position of the chlorophyll maximum (T. Badewien et al. unpubl.).

The microbial parameters assessed reflected well the different water masses and partially the biogeographic provinces. Final interpretation of the data, however, is only possible when we will have analyzed all the samples for the prokaryotic community and the DOM composition.

Prokaryotic abundance in the upper 100 m, assessed by flow cytometry on board, ranged between 2 and 22x10^5 cells ml^{-1} with continuously increasing values from south to north and highest numbers in the PSAG and BER. Bacterial biomass production, assessed by incorporation of ^{14}C-labelled leucine, in the upper 100 m was highest in the SPE and NPE and much lower in the other provinces. Community growth rates in these provinces ranged between 1 and >2 per day but were much lower, usually not exceeding 0.4 per day, in the other regions. Turnover rates of dissolved free amino acids basically covaried with rates of biomass production but those of glucose and acetate exhibited different patterns with continuously increasing rates north of the equator and highest values in the PSAG and BER. Preliminary results of hydrolytic enzyme activities of various polysaccharides and peptidases exhibited distinct patterns for the various provinces. In particular the peptidolytic activities reached highest values in the SPE, PEQ and NPE, in line with the data of bacterial biomass production.

The mesocosm experiments at the station in the SPS (station 2), the NPE (station 7) and the NPF (station 14), exhibited strikingly different growth responses of the ambient bacterial communities to the various substrate and vitamin B12 additions. At SPS the responses were generally slow. At NPE they were almost immediate with high responses in all treatments whereas at the NPF they were intermediate.

As quite a few prokaryotes and in particular Archaea in the deep sea are chemoautotrophic CO_2 dark fixation was assessed. Highest rates were measured in the equatorial region but in some regions further north values reached 50% of the equatorial maxima. Values at 1000 m were usually, but not always, higher than at 2000 m.

The surface sediment along the transect exhibited quite variable structures and textures. This was already obvious from the color (Fig. 6). Bacterial abundance at the sediment surface ranged between 10^8 and 10^9 cell cm^{-3} with continuously increasing values north of the equator. At 20 cm below the seafloor cell numbers were about one order of magnitude lower. Alkaline phosphate activities were highest in the region 6 to 20°N whereas aminopeptidase activities peaked between 34° and 50° N, the northern edge of the NPTG and the PSAG, regions of a pronounced oxygen minimum zone and a high sinking flux.

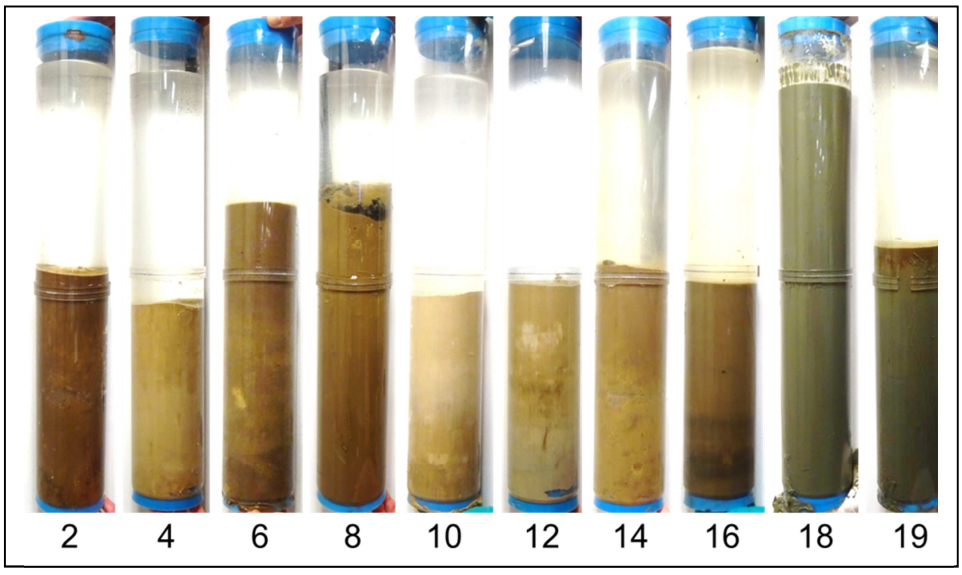


Figure 6. Representative sediment cores from the Pacific transect. Numbers correspond to the station numbers. At station 18, the surface layer was lost due to overfilling the core-liner.

According to the preliminary data we were able to collect already during the cruise we are very confident that the BacGeoPac cruise was very successful and that we can reach the goals we set for this comprehensive study. However, to achieve them all the samples stored frozen in the home labs need first to be analyzed.

On May 31st we finished the work at the northernmost station. This left us enough time to finish the last incubations, pack all material and equipment before we reached the final destination, Dutch Harbor, on Unalaska one of the Aleutian Islands, Alaska. Our cruise was generally blessed with good weather even though we had to pass through two storms, one in the southeastern Trade Wind region, and one in the north Pacific polar frontal region. Despite a swell of 5 to 7 m during these storms the ship operated smoothly and we could carry out our work as usual. In fact, we did not have any interruption of our work due to weather conditions or any malfunctioning of instrumentation or ship equipment.

Dutch Harbor as final destination of this cruise was a challenge and resulted in some inconveniencies which were out of our control. It is the major fisheries harbor of the US and very much focused on services to the fisheries industries. Dutch Harbor is only reachable by small airplanes, but not during bad weather conditions, or in summer twice a month by a ship. In order to ship our frozen samples back to Germany the responsible carrier needed to charter a special airplane to Dutch Harbor. Further, the harbor can only handle 40 ft but not 20 ft containers. Therefore, our three containers needed to remain on board until RV Sonne reaches a port in Japan in mid-August or even only in September.

Acknowledgements
We would like to thank very much Captain Lutz Mallon and his crew for their excellent, always present and very friendly support of our research activities on board RV Sonne. The German Federal Ministry of Education and Research (BMBF) generously provided the main funding of this expedition. As this research cruise was a core project of the Transregional Collaborative Research Center *Roseobacter* (TRR51) in its second funding phase Deutsche Forschungsgemeinschaft also contributed substantially to funding of this cruise. Further support came from the German State of Lower Saxony, the US National Science Foundation and the Austrian Fund for Scientific Research (FWF).

Participants

No.	FAMILY NAME, given name	Type of work	Affiliation
1	Prof. Dr. SIMON, Meinhard	Chief Scientist	ICBM
2	ARNT, Kim	CTD	ICBM
3	Dr. BADEWIEN, Thomas	CTD	ICBM
4	Dr. WINKLER, Holger	CTD	ICBM
5	HENKEL, Rohan	Bio-Optics	ICBM
6	MEIER, Daniela	Bio-Optics	ICBM
7	VOSS, Daniela	Bio-Optics	ICBM
8	BAKENHUS, Insa	Pelagic Microbiology	ICBM
9	BERGEN, Nils	Pelagic Microbiology	ICBM
10	Dr. BILLERBECK, Sara	Pelagic Microbiology	ICBM
11	Dr. GIEBEL, Helge-Ansgar	Pelagic Microbiology	ICBM
12	KÜRZEL, Birgit Marita	Pelagic Microbiology	ICBM
13	MILKE, Felix	Pelagic Microbiology	ICBM
14	WIENHAUSEN, Gerrit	Pelagic Microbiology	ICBM
15	WOLTER, Laura	Pelagic Microbiology	ICBM
16	WOLTERINK, Mathias	Pelagic Microbiology	ICBM
17	Dr. TOMASCH, Jürgen	Pelagic Microbiology	HZI
18	Prof. Dr. WAGNER-DÖBLER, Irene	Pelagic Microbiology	HZI
19	Dr. DOGS, Marco	Polymer Microbiology	ICBM
20	Dr. WIETZ, Matthias	Polymer Microbiology	ICBM
21	Prof. Dr. ARNOSTI, Carol	Polymer Microbiology	UNC
22	BALMONTE, John Paul Piso	Polymer Microbiology	UNC
23	Dr. FREESE, Heike	Population Genomics	DSMZ
24	Dr. LEPLEUX, Cendrella	Population Genomics	DSMZ
25	METHNER, Anika	Population Genomics	DSMZ
26	von HOYNINGEN-HUENE, Avril	Metagenomics	G2L
27	Dr. WEMHEUER, Bernd	Metagenomics	G2L
28	Dr. WÖHLBRAND, Lars	Metaproteomics	ICBM
29	DEGENHARDT, Julius	Sediment Microbiology	ICBM
30	Dr. ENGELEN, Bert	Sediment Microbiology	ICBM
31	POHLNER, Marion Gertrud	Sediment Microbiology	ICBM
32	Dr. ARMANO Chie	Deep Sea Microbiology	UVI
33	BARANYI, Christian	Deep Sea Microbiology	UVI
34	BAYER, Barbara	Deep Sea Microbiology	UVI
35	Dr. HANSMAN, Roberta	Deep Sea Microbiology	UVI
36	Dr. REINTHALER, Thomas	Deep Sea Microbiology	UVI
37	PINTO GOMES RIBEIRO TEIXEIRA, Maria	Microplastic	UVI
38	HEINRICHS, Mara Elena	Dissolved Organic Matter	ICBM
39	Dr. NIGGEMANN, Jutta	Dissolved Organic Matter	ICBM
40	NORIEGA ORTEGA, Beatriz	Dissolved Organic Matter	ICBM

Participating Institutions

ICBM
Institut für Chemie und Biologie des Meeres
Universität Oldenburg
Carl von Ossietzky Str. 9-11
D-26129 Oldenburg,
Germany
www.icbm.de

HZI
Helmholtz-Zentrum für Infektionsforschung
Department Microbial Communication
Inhoffenstr. 7
D-38124 Braunschweig
Germany
http://www.helmholtz-hzi.de

DSMZ
Deutsche Sammlung von Mikroorganismen und Zellkulturen,
Inhoffenstraße 7B
D-38124 Braunschweig
Germany
www.dsmz.de

G2L
Göttingen Genomics Laboratory
Institut f. Mikrobiologie u. Genetik
Georg-August-Universität Göttingen
Grisebachstr. 8
D-37077 Göttingen
Germany
www.appmibio.uni-goettingen.de/

UVI
Microbial Oceanography Group
Department of Limnology & Bio-Oceanography
University of Vienna
Althanstrasse 14
A-1090 Vienna
Austria
http://www.microbial-oceanography.eu/

UNC
Department of Marine Science
University of North Carolina
3202 Venable and Murray Halls, CB 3300
Chapel Hill, North Carolina 27599-3300
USA
http://marine.unc.edu/people/faculty/arnosti-2/

List and details of stations

Station	Start Day / Time UTC	End Day / Time UTC	Latitude	Longitude	Depth (m)
SO248-01	02.05.2016 18:03:17	03.05.2016 01:20:55	29° 59,969' S	176° 59,890' E	4280
SO248-02	03.05.2016 18:00:44	04.05.2016 06:06:18	26° 59,557' S	178° 12,795' E	4202
SO248-03	06.05.2016 22:12:54	07.05.2016 00:15:12	15° 00,002' S	178° 00,044' W	1527
SO248-04	07.05.2016 23:17:24	08.05.2016 10:58:41	10° 20,005' S	176° 30,002' W	4140
SO248-05	09.05.2016 17:46:07	09.05.2016 22:46:03	04° 59,749' S	178° 19,081' W	6031
SO248-06	11.05.2016 09:00:38	12.05.2016 17:10:02	00° 00,015' N	180° 00,000' E	5262
SO248-07	13.05.2016 17:57:42	14.05.2016 00:14:31	04° 39,306' N	179° 23,861' E	6265
SO248-08	15.05.2016 12:55:03	16.05.2016 01:16:00	10° 58,020' N	179° 00,095' E	5469
SO248-09	17.05.2016 01:13:32	17.05.2016 05:31:43	16° 00,096' N	178° 59,642' E	5237
SO248-10	18.05.2016 09:20:35	19.05.2016 02:25:35	21° 57,941' N	178° 19,054' E	3250
SO248-11	20.05.2016 07:45:32	20.05.2016 08:56:17	28° 00,018' N	177° 19,867' E	5162
SO248-12	21.05.2016 15:58:00	22.05.2016 00:57:15	34° 00,002' N	177° 20,010' E	3514
SO248-13	23.05.2016 05:07:01	23.05.2016 08:36:02	40° 00,175' N	177° 19,997' E	5667
SO248-14	24.05.2016 09:00:35	25.05.2016 00:12:27	45° 00,061' N	178° 45,011' E	5915
SO248-15	25.05.2016 16:00:13	25.05.2016 17:02:05	47° 29,988' N	179° 07,989' E	5841
SO248-16	26.05.2016 08:36:58	28.05.2016 03:18:29	50° 00,019' N	179° 33,019' E	5625
SO248-17	28.05.2016 23:06:01	29.05.2016 04:29:05	54° 00,805' N	179° 34,135' E	732
SO248-18	29.05.2016 19:06:54	30.05.2016 05:12:51	57° 00,084' N	179° 34,884' E	3811
SO248-19	30.05.2016 15:10:42	31.05.2016 03:39:02	58° 54,021' N	179° 00,157' W	3352