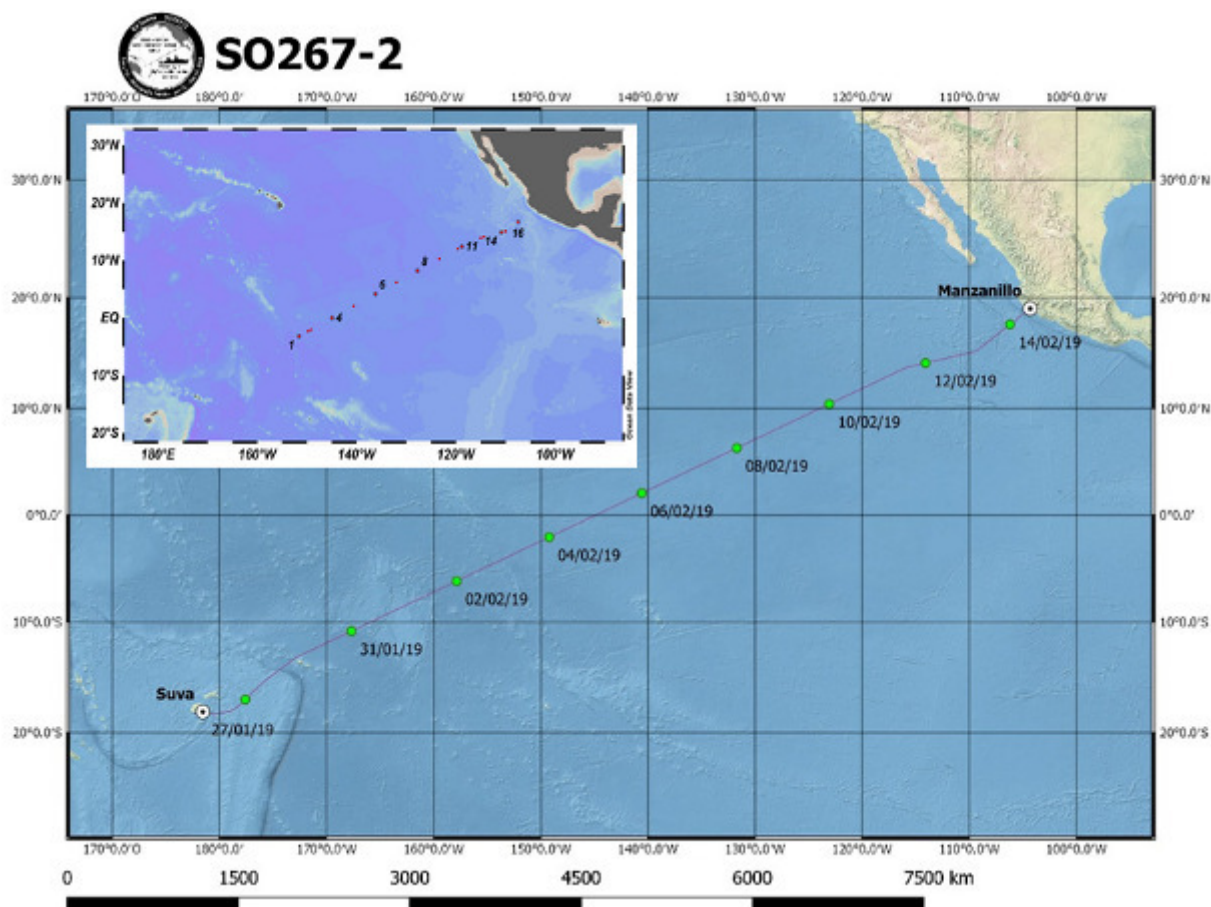


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Short Cruise Report
RV SONNE SO267/2
OceanLight / EqPac co-limit / MORE-1
Suva, Fiji – Manzanillo, Mexico
28.01.2019 – 14.02.2019
Chief Scientist: Daniela Voß
Captain: Lutz Mallon



Objectives

The overall aim of the RV SONNE cruise SO267/2 can be separated in three different discrete projects, led by three principal investigators from ICBM, GEOMAR and MPI.

OceanLight (ICBM): The research cruise with RV SONNE from SUVA (Fiji) to Manzanillo (Mexico) lies under the focus of shipborne ocean color remote sensing. Data can be used for comparison with SO245/SO248/SO254. For the Pacific Ocean area less or no data are available concerning point measurements of the above and underwater light field. Observations can help to support satellite remote sensing. General research topics to answer are the following: (1) How is light propagated in the UV to visible spectrum in the transect surface waters? (2) How are light measurements of surface waters related to flow-through measurements (FerryBox)? Can we derive useful algorithms to predict observed variables? (3) How accurate are satellite observations of these waters when compared to above-water radiometry?

A second focus of the cruise lies on the validation of the recently installed underway system of RV SONNE. As home institute of the RV SONNE the intention of ICBM is to validate the functionality of the on board system by reference sensors and intensive sampling. Therefore, each day outside the EEZs, one to two salinity samples were taken from the on board flow-through system and will be analyzed in the laboratory after the cruise.

EqPac co-limit (GEOMAR):

Phytoplankton, photosynthetic microbes, are the base of marine food webs and sequester atmospheric carbon. Nutrient availability regulates growth rates of marine phytoplankton and recent work has shown that multiple nutrients can 'co-limit' phytoplankton, but the distribution, causative mechanisms, and biogeochemical impacts of co-limitation are poorly constrained. On the RV SONNE SO267/2 cruise across the Equatorial Pacific we cross strong gradients in availability of the growth-limiting nutrients, nitrogen, iron, and cobalt. We conduct a set of nutrient addition bioassay experiments on the cruise to directly test for nutrient (co-) limitation. Experiments are integrated with measurements of microbial proteins, biophysical fluorescence signatures, community structure, and accurate low-level (micro)-nutrient concentrations.

MORE-1 (MPI): During the cruise, atmospheric properties of aerosol, clouds and trace-gases are collected, as reference data coverage over the Pacific is sparse. The data serves as (1) calibration data for satellite remote sensing retrievals and (2) as evaluation data for (global) modelling. Atmospheric data are sampled with a NASA sun-photometer (aerosol), a camera system of the MPI-M and a ceilometer of the MPI-C (clouds), and MAX-DOAS of MPI-C and KNMI.

Narrative

RV SONNE left the port of Suva in Fiji on Monday 28th of January 2019 setting course for Manzanillo in Mexico. On this cruise, 16 scientists from the institutes of ICBM, GEOMAR and MPI with the affiliate institutes HCU, FU Berlin and KNMI conducted various underway and in-situ measurements. Scientific aims of the Pacific Ocean cruise SO267/2 were a combination of three different projects. The OceanLight project (ICBM) aimed to collect above- and underwater optical measurements, as there is little to no hyperspectral as well as bio-optical data available for the Pacific Ocean. Findings from this campaign are expected to contribute towards validation of satellite remote sensing end-products and expanding the optical knowledge-base of these waters.

Furthermore, the project will validate the on board Underway system (FerryBox) of RV SONNE. The EqPac co-Limit project (GEOMAR) integrated experimental, proteomics and fluorescence approaches to investigate the nutrient co-limitation of phytoplankton productivity in surface waters of the Equatorial Pacific.

Within the MORE-1 project (MPI) atmospheric properties of aerosol, clouds and trace-gases were collected and will serve as calibration for satellite remote sensing retrievals and evaluation of global modelling.

Further investigations included the preparation of bathymetric data for international databases. Before first measurements could be conducted a transect of 1500 nm was sailed across the Pacific islands EEZs. During this cruise the first priority was to set up all scientific equipment and labs of the different groups. With regards to the diversity in research interests and project goals of the cruise was also used to familiarize with the fields of work of each group by undertaking a "scientific tour" through the labs. RV SONNE reached the open-waters (EEZ borders of the Pacific islands) on Saturday, 02nd of February, shortly before midnight. The Towfish was successfully deployed to continuously sample the surface waters along the cruise track to Manzanillo. The device remained in the water until the EEZ of Mexico. The Towfish was attached to the crane at small distance away from the ship and at a fixed depth so that contamination free surface samples could be taken every 4 hours. In the lab, a so-called "clean room" was set up to collect and process samples for trace elements, and dissolved in-/organic nitrogen with minimal contamination.

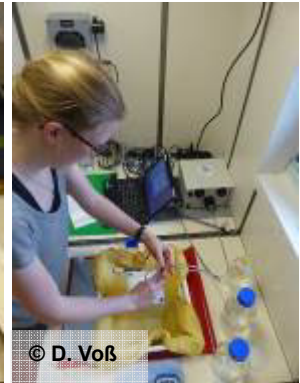
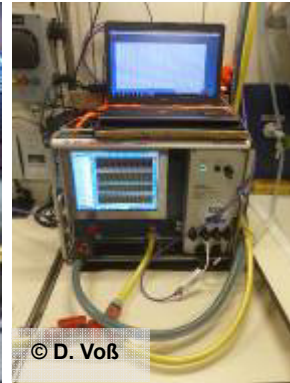
In addition, chlorophyll samples were taken and measured fluorometrically on board. A set of samples will be analysed at the home labs at GEOMAR (incl. biogenic silicate, particulate organic carbon, nutrients). Bathymetric measurements were also started underway when reaching international waters on the 2nd of February close to midnight. Continuous inherent and apparent optical properties (IOPs / AOPs) as well as meteorological observations commenced early Sunday morning, 03rd of February. The first underwater light field station was done on the same day at 10:20 a.m. (BT). A Satlantic free falling profiler was deployed up to a depth of 200 m, at a distance of ~ 50 m away from the vessel to mitigate data contamination from possible ship structure perturbations namely ship shadow or noise. Those daily underwater light profiling at the stern of

Tuesday, 4th of February right on the equator. As the equator was crossed, the inter-tropical convergence zone was entered and the weather situation began to change significantly. For some distance the weather changed to cloudier and windy conditions with episodes of strong rain. The scientific work of this cruise was characterized by a daily routine of underway and in-situ measurements. The underway systems measured oceanic properties continuously along the route. Radiometric quantities were collected at 5-minute intervals by a set of two irradiance and four radiance radiometers installed at the ships bow. A global radiation reference was installed in the fore mast on the upper deck. Furthermore, samples were taken from the underway system of RV SONNE and the Towfish to determine the absorption properties. Besides validation of the ship system by one to two salinity reference samples each day for reference measurement in the lab after the cruise, continuous PSICAM measurements were done in the lab on board to get more information about light influencing parameters within surface waters. The meteorology group (MPI) collected measurements at a time specific interval. With a ceilometer the cloud height was determined every 15 seconds. These measurements were supported by a cloud camera capturing images every 10 seconds. Information on aerosols in the atmosphere were collected with a MAXDOAS generating a profile every 15 minutes. When a clear view to the sun was available, profiles with two solar photometers were generated every 20 minutes. Processing and evaluation of collected data was already started on board. From the 10th of February the ship stopped twice a day for a light field station. All scientific work stopped shortly before entering the EEZ of Mexico, in the morning of 13th of February. On this cruise, a total of 15 light field stations, 68 contamination free surface samples from the towed device aside the ship and five 48h incubations experiments were conducted. Reflectance measurements, FerryBox measurements (temperature, salinity, fluorescence, absorption/attenuation) and meteorological observations took place within a fixed interval of a few minutes on the days of the cruise in international waters before reaching the Mexican EEZ.

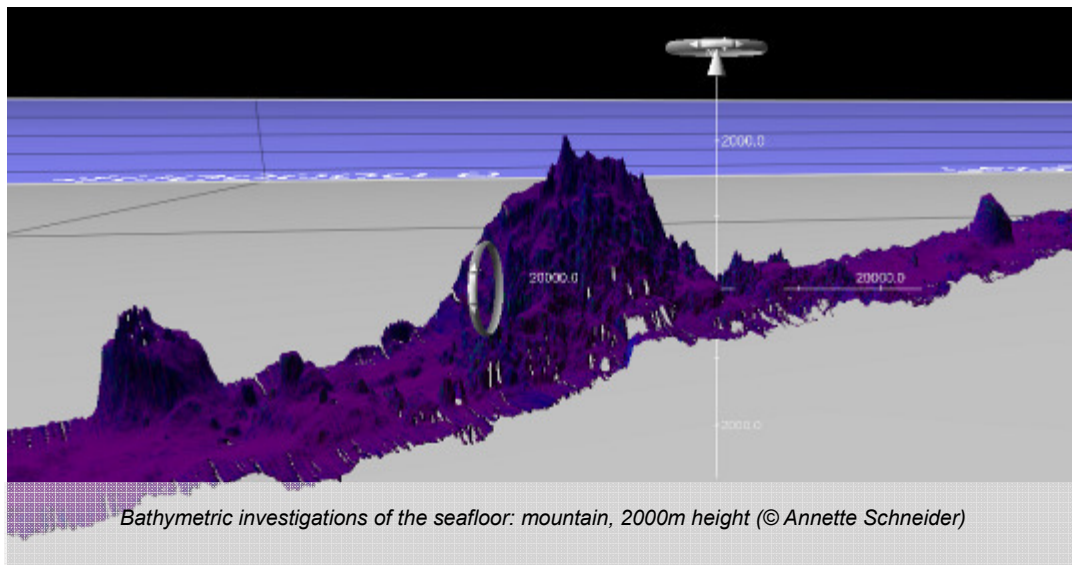


Additional picture of the cruise SO267/2

Towfish of the GEOMAR / FerryBox system for validation / PSICAM measurements in the lab



Sunphotometer (MPI) / Hyperspectral light field profiler (ICBM) / Radiometric setup (ICBM)



Acknowledgements

We would like to express our sincere thanks to captain Lutz Mallon and his crew for the ever-present and always friendly support of our research activities. We thank all the shore-based technicians, administrative personnel and scientists involved in the cruise. The German Federal Ministry of Education and Research (BMBF) is gratefully acknowledged for the funding of the three cruise projects ('OceanLight', 'EqPac co-limitation', 'MORE-1').

Participants

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Station list

Station ID	Date / Time [UTC]	Device	Latitude	Longitude	Depth [m]
SO267/2_1-1	03.02.2019 09:50:29	Towfish deployment	03° 11.780' S	151° 37.391' W	4787.2
SO267/2_2-1	03.02.2019 20:25:52	Light / Optics	02° 18.014' S	149° 45.186' W	4714.8
SO267/2_3-1	04.02.2019 00:08:48	Light / Optics	02° 02.884' S	149° 13.580' W	4703.7
SO267/2_4-1	04.02.2019 23:42:20	Light / Optics	00° 00.075' N	144° 56.401' W	4272.0
SO267/2_5-1	05.02.2019 23:18:20	Light / Optics	02° 04.014' N	140° 36.953' W	4380.7
SO267/2_6-1	06.02.2019 23:01:34	Light / Optics	04° 09.744' N	136° 12.683' W	4395.1
SO267/2_7-1	07.02.2019 22:00:03	Light / Optics	06° 10.988' N	131° 58.872' W	4280.5
SO267/2_8-1	08.02.2019 22:00:01	Light / Optics	08° 11.399' N	127° 44.996' W	7057.4
SO267/2_9-1	09.02.2019 22:02:00	Light / Optics	10° 16.379' N	123° 20.236' W	4392.3
SO267/2_10-1	10.02.2019 17:22:22	Light / Optics	11° 59.722' N	119° 39.759' W	4268.6
SO267/2_11-1	10.02.2019 22:24:57	Light / Optics	12° 24.113' N	118° 47.501' W	4127.4
SO267/2_12-1	11.02.2019 18:01:12	Light / Optics	13° 56.869' N	114° 59.644' W	3968.8
SO267/2_13-1	11.02.2019 22:26:06	Light / Optics	14° 06.454' N	114° 17.696' W	3892.9
SO267/2_14-1	12.02.2019 17:20:13	Light / Optics	14° 53.193' N	110° 53.000' W	0.0
SO267/2_15-1	12.02.2019 22:24:26	Light / Optics	15° 04.685' N	110° 02.652' W	3409.2
SO267/2_16-1	13.02.2019 15:30:09	Light / Optics	16° 41.305' N	107° 27.955' W	3474.2

Towfish Sampling

Date	Time	Lon (°E)	Lat (°N)
03/02/19	10:45:00	-151.52	-3.15
03/02/19	11:25:00	-151.40	-3.09
03/02/19	16:05:00	-150.54	-2.68
03/02/19	19:55:00	-149.82	-2.33
04/02/19	01:05:00	-149.17	-2.03
04/02/19	04:00:00	-148.64	-1.77
04/02/19	08:00:00	-147.90	-1.42
04/02/19	12:05:00	-147.14	-1.05
04/02/19	16:05:00	-146.39	-0.69
04/02/19	19:55:00	-145.65	-0.34
04/02/19	23:05:00	-145.03	-0.05
05/02/19	04:00:00	-144.22	0.34
05/02/19	08:30:00	-143.37	0.75
05/02/19	09:04:00	-143.26	0.80
05/02/19	11:40:00	-142.78	1.03
05/02/19	15:20:00	-142.10	1.36
05/02/19	19:10:00	-141.38	1.70
05/02/19	22:40:00	-140.72	2.02
06/02/19	02:55:00	-140.03	2.35
06/02/19	06:50:00	-139.30	2.69
06/02/19	11:00:00	-138.51	3.07
06/02/19	15:10:00	-137.70	3.46
06/02/19	19:10:00	-136.94	3.82
06/02/19	22:45:00	-136.25	4.15
07/02/19	02:55:00	-135.61	4.46
07/02/19	06:48:00	-134.83	4.83
07/02/19	07:25:00	-134.70	4.89
07/02/19	10:40:00	-134.04	5.20
07/02/19	14:15:00	-133.33	5.54
07/02/19	18:15:00	-132.61	5.89
07/02/19	21:30:00	-132.06	6.14
08/02/19	02:00:00	-131.34	6.49
08/02/19	06:00:00	-130.61	6.83
08/02/19	09:50:00	-129.92	7.16
08/02/19	14:10:00	-129.12	7.54
08/02/19	18:00:00	-128.44	7.86
08/02/19	21:30:00	-127.82	8.16
09/02/19	01:50:00	-127.15	8.48
09/02/19	06:05:00	-126.36	8.85

09/02/19	07:04:00	-126.18	8.93
09/02/19	10:15:00	-125.57	9.22
09/02/19	14:10:00	-124.83	9.57
09/02/19	18:00:00	-124.09	9.92
09/02/19	21:25:00	-123.43	10.23
10/02/19	02:00:00	-122.70	10.57
10/02/19	06:00:00	-121.93	10.93
10/02/19	09:25:00	-121.25	11.25
10/02/19	14:20:00	-120.26	11.72
10/02/19	16:45:00	-119.76	11.95
10/02/19	21:00:00	-119.06	12.28
11/02/19	01:00:00	-118.38	12.59
11/02/19	05:30:00	-117.48	13.01
11/02/19	06:08:00	-117.36	13.07
11/02/19	09:00:00	-116.79	13.34
11/02/19	13:10:00	-115.97	13.72
11/02/19	16:30:00	-115.29	13.88
11/02/19	21:00:00	-114.55	14.05
12/02/19	01:00:00	-113.89	14.20
12/02/19	05:00:00	-113.13	14.37
12/02/19	09:00:00	-112.38	14.54
12/02/19	13:15:00	-111.61	14.72
12/02/19	16:45:00	-110.97	14.87
12/02/19	21:00:00	-110.29	15.02
13/02/19	01:00:00	-109.63	15.17
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13/02/19	08:05:00	-108.49	15.90
13/02/19	12:10:00	-107.89	16.36
13/02/19	15:00:00	-107.52	16.65