

BOUSSOLE-AOPEX cruise

R/V « Le Suroît »

Depart : July 29, 2004, from “La Seyne / mer”

Return : August 17, 2004, to “La Seyne / mer”

Area of operation : Ligurian sea (BOUSSOLE site) and Tyrrhenian sea

Sponsored by : ESA, CNES, NASA, IFREMER (the ship), CNRS-INSU (personnel + equip.)

Participating entities :

- ✓ Laboratoire d’Océanographie de Villefranche (LOV), France
- ✓ Scripps Institution of Oceanography (SIO), San Diego, USA
- ✓ University of Miami, Rosenstiel School of Marine & Atm. Sciences (RSMAS), USA
- ✓ SouthEast Env. Res. Center, Florida Int. Univ., Miami, USA
- ✓ Laboratoire Interdisciplinaire des Sciences de l’Environnement (LISE)-PAMOC, Wimereux, France
- ✓ Plymouth Marine laboratory (PML), the UK
- ✓ Rutgers University and the Webb Research Inc., USA
- ✓ National Academy of Science of Ukraine, Marine Hydrophysical Institute (IFHM), Sebastopol, Ukraine
- ✓ NAVAIR, USA
- ✓ Université de Perpignan, France

Science personnel :

1	ANTOINE David	Chief scientist, AOPs	LOV
2	CHAMI Malik	AOPs (Licor) operations	LOV
3	MOREL André	AOPs (Licor) operations	LOV
4	RAS Joséphine	Filtration, HPLC, particle absorption	LOV
5	SCOTT Alec	AOPs (SPMR/SMSR) & buoy operations	LOV
6	TAILLIEZ Dominique	CTD casts, thermosalinograph, meteo	LOV
7	BECU Guislain	AOPs (SPMR/SMSR), CTDs	LOV
8	FROUIN Robert	Above-water AOPs, AOT, balloons	SIO
9	CHAPIN Albert	NuRADS radiance camera & Lidar	RSMAS
10	POTEAU Antoine	IOPs, AOPS, balloons	LISE-PAMOC
11	MOORE Gerald	IOPs, AOPs	PML
12	NIEWIASOMSKA Katarzyna	Glider operations, CTDs	Rutgers & Webb
13	SHYBANOV Evgeny	VSF measurements	IFHM
14	MARTYNOV Oleg	VSF measurements	IFHM
15	SCULLY Norman	CDOM absorption & characterisation	Florida Int. Univ
16	PRENTICE Jennifer	VSF measurements	NAVAIR, USA
17	AIT-AMEUR Nadira	CO ₂ parameters	Univ. Perpignan

Some of the objectives :

- ✓ Short time scale changes in IOPs and AOPs.
- ✓ Volume scattering function of marine particles.
- ✓ CDOM absorption and characterisation.
- ✓ Bidirectionality of the radiance field.
- ✓ Calibration / validation of ocean colour satellite sensors (MERIS, SeaWiFS, MODIS).
- ✓ Test of new measurement platforms (gliders).
- ✓ Optics closure.
- ✓ Atmospheric correction algorithms for satellite ocean colour observations.

Cruise Narrative

Thursday 29th July

All scientific equipment was loaded aboard and mostly installed by the evening.

Friday 30th July

Departure of Le Suroit from La Seyne sur Mer was at 07h30 with cloudless skies and just a light wind. However, during the normally picturesque transit between the islands around Toulon, visibility was poor due to the haze. Installation of equipment continued throughout the transit period to the bay of Villefranche. On arrival of Le Suroit in the bay at 16h30, the Villefranche research boat, Sagitta came out to the ship to deliver a package of Satlantic MDU-100 control units for the SPMR (acronyms at the end) and some water purification filters (and the VSF instruments !!!) that had both been delivered too late for the main embarkation.

After the brief delivery from the Sagitta, Le Suroit headed for Station 5 of the BOUSSOLE project transect and the start of the science. The first activity was a CTD profile to 400m with bottle fires at 5m as was repeated at each of the 5 BOUSSOLE transect stations at 5 mile separations on the route to the BOUSSOLE buoy site. After this first CTD profile, the Slocum glider was launched from the Zodiac. Initially, a buoy was attached during board and ballast testing but this was finally removed after the successful tests. A test run was performed with a triple yo-yo to six metres and all systems appeared to be working well.

The CTD profiles at each transect station continued into the night. Progress of the ship was a couple of knots slower than planned because, according to the captain, the hull was very biofouled after several weeks of sitting in port.

Saturday 31st July

The sky remained clear but hazy for most of the day and the sea conditions were calm. The schedule of activities for the day was typical in form for cruise days on station. However, for many of the operators, these first casts were more for testing their instruments and making any necessary adjustments.

The Villefranche SPMR and PML profiler of Gerard Moore were profiled simultaneously. The SPMR worked fine using a replacement deck box control unit as the regular unit was malfunctioning. The PML unit required some ballast adjustment but was seemingly well trimmed by the second of the two profiles. Meteorological balloons were released and the

7 CTD profiles were performed throughout the day but a problem developed during the 1900h cast, the 6th of the day. This became a recurrent problem that arose during the profile at around 200m and involved fuses burning out inside the deck box.

The dive boat, GGIX, pulled up alongside Le Suroit at 1800h with Leo Gimenez and his dive buddy Philippe. Alec Scott joined them on their boat, along with the necessary materials to go to the buoy site and repair some damage that occurred the previous week during the helicopter delivery of the upper buoy section.

The divers initially replaced the DACNet computer, 9m Data-100 and the cables for the fluorometer, transmissometer and power/telemetry. The system was tested after this reinstallation. All instruments appeared to be working except those connected to the 4m Data-100. A replacement unit was on the ship so was recuperated and installed by the divers in the last few minutes of daylight. Unfortunately, it became apparent later that there had been a mis-communication when briefing the divers and they had, in actual fact, replaced the 9m Data-100 a second time. They had not touched anything at 4m depth but had put the replacement 4m sensor at 9m and removed the one that had just been installed.

With the operation believed to have been successful at the time, the divers also fixed in the 4 shaft anodes that needed replacing above the sphere.

Due to the late hour, there was no time to test the buoy directly after the dive. A link was later established on the ship, which indicated the 9m OCPs working. Before the connection was broken because of distance from the buoy, using the communication indicator lights in the Satcon software, it was apparent that the OC4 was now communicating although it was not possible to view the data on Satview, suggesting a configuration problem. This, indeed, turned out to be because a different Data-100 than expected, was in place. The 4m OCP, however, was not showing any signs of working.

The Nurads camera was exhibiting problems with an internal filter wheel but this was resolved by switching to the second Nurads camera.

Sunday 1st August

Sky conditions were poorly suited for AOP work with over 50% cover of cumulus cloud. Throughout the day, the swell started to build from what had previously been very flat conditions and by the evening the wind had risen to around 20 knots with subsequently choppy seas.

The CTD rosette was continuing to be intermittently problematic and blowing fuses, as had been encountered the previous day. Throughout the day, the deckbox, cable, winch slip ring and rosette were all checked for problems.

In lab testing was performed on the recovered Dacnet.

Monday 2nd August

In the early hours of the morning, the CTD cable was cut by 430 meters and reterminated. However, the following profile still encountered the same problems, which were subsequently deemed likely to be in the Seabird itself. Hence, the decision was made to return to Villefranche and collect a replacement Seabird. In fact, conditions were cloudy and sea conditions rough so this visit was not so expensive in terms of measurement time.

Arrival in Villefranche was at around 0700 hours and by 1015 the new Seabird was given a test profile in the bay. This failed, thus suggesting that the problem was to do with the ship. A uninterruptible Power Supply was installed to power the deck box during the transit to 2000m water depth. Once ready, the CTD was tested again and failed. On route to the buoy site, the crane was dismantled and checked for electrical problems. A problem was found that requires a return to port for use of a spooling machine, which was estimated to take at least 48 hours to be available. Therefore, Le Suroit headed for the BOUSSOLE site to continue some science and check on the glider.

Next : connection to the buoy Ok.

PML IOP package deployed successfully, as a replacement of the still faulty CTD.

Crew electronician continues to work towards understanding of the cause(s) of the CTD failure. A successful test is finally performed during which the winch slip ring is bypassed, clearly indicating that this is the faulty part. Repair of the slip ring is performed, and a full CTD cast is achieved. The CTD problem seems to be solved...

Tuesday 3rd August

The day started very overcast with the occasional drop of rain providing conditions unfavourable for AOP measurements. However, the CTD was now functioning properly after the fault had been located in the slipping of the winch so the optimal schedule was able to continue.

The IOP instruments were deployed in the morning, including the optical grappes and the PML AC9. In the afternoon, the cloud cover reduced creating hot, humid and hazy conditions with sunny periods. This enabled

activities to commence with the AOP instruments, including the SPMR and PML profiler and the Nurad camera. Unfortunately, the cloud cover returned later in the afternoon preventing any worthwhile deployments of the Licor and Trios for the rest of the day.

Activities continued with the grappe and CTD throughout the day and into the evening.

Wednesday 4th August

The sea surface was very calm but the sky was slightly milky with and conditions were good but intermittent cumulus passing over the sun.

A pod of long-finned pilot whales congregated around the ship from 1100 hours. They seemed fairly restful with no clear direction of travel and stayed around the ship for most of the day. They were estimated to be between 40 and 50 in number with several young amongst them. It was a fascinating afternoon watching these animals and their highly social behaviour. Their communication could be heard clearly but unfortunately there was nobody aboard who spoke whalese.

In the afternoon, the ship located close to the buoy, to allow an attempt to repair the 4m optics system, which had not been working since its installation 2 weeks ago. Alec Scott and David Antoine were taken by the semi-rigid inflatable boat to the buoy. The Data-100 analogue-digital converter was replaced along with the cables to the Dacnet, fluorometer and transmissometer. There was the possibility that the Dacnet port AC for the OCP system at 4m was fused so the replacement cable and configuration was set to use the port AI instead.

The Slocum glider was recovered at 1700 hours as it appeared at the surface and was located as scheduled and without any difficulty in its recovery aboard the Zodiac.

The ship left the BOUSSOLE site at around 2200 hours to start the journey to the Tyrrhenian Sea study site

Thursday 5th August

The entire day was spent in transit although a stop was scheduled midway depending on the sky conditions being suitable for the optics work. As the day progressed sky conditions were not ideal but certainly acceptable for some AOP work. Unfortunately, upon arriving at the station a large frontal system could be seen heading in our direction with a wall of cumulo-nimbus cloud bearing occasional lightning flashes appeared larger and larger. At the time of stopping, conditions were still fair but the wind increased from light to over 30 knots within about a quarter of an hour. The station was cancelled. During the morning, the faulty Nurad camera was opened up and successfully repaired.

Friday 6th August

Arrival at the station was at 0300 hours and work started with the 0500 hours CTD profile. The sky was grey and heavy with cumulus and the sea conditions were fairly choppy with the residual swell from the winds during the night. These conditions delayed the start of any AOP optics measurements until 0800 hours. As the day progressed, the seas calmed and winds were light. The swell remained marginally too large to allow use of the pyramid with the SPMR. Despite some cumulus, there was plenty of clear and blue sky to allow all of the other instruments to measure. There was significantly lower chlorophyll content in the waters at this station so SPMR profiles were run to the full depth of 200m. The clear skies allowed for SPMR profiling to continue until 1900 hours. The Slocum glider was launched in the morning and reported throughout the day that it was correctly following its programmed trajectories. There were three Licor stations (1000, 1500 and 1700 hours) during the day but they were rather disturbed by the intermittent cloud cover

Saturday 7th August

The seas were calm first thing in the morning although the sky was very cloudy with a mix of cirrus and cumulus. Hence AOP measurements were limited in the morning, although some fairly successful SPMR

and PML profiles were performed before noon. During the afternoon, the clouds dispersed and the full suite of AOP and IOP packages (Nurad, Licor, SPMR, PML and Trios) were deployed. Towards the end of the afternoon, the cloud cover, though light, covered the majority with high humidity so the AOP work was stopped. Sea conditions were very calm. For the first SPMR cast of the day, the PRO-DCU deckbox unit would not work and blew the main internal fuse immediately each time it was powered up. The cables were reterminated to accommodate the MDU-100 cables, provided by Satlantic as backups for the mission. The radiometers worked without fault for the rest of the day after this repair.

Sunday 8th August

This was another day of very calm seas and very light winds. Conditions were very bright in the morning but a total cover of cirrus cloud slowly dispersed throughout the morning, enabling AOP measurements only to begin at around midday. The first of these activities was the SPMR with pyramid float. Unfortunately, the release mechanism failed on the float so the profile could not drop. The apparatus was brought back aboard and the SPMR was then deployed solo for two profiles hindered slightly by fine cirrus. Patchy cloud made conditions difficult and the quality of profile was likely to be mediocre. This session finished at 1300 hours in time for a CTD and the following two hours had fairly clear skies. Unfortunately, the IOP profile was deployed during this time and by 1500 hours, the cirrus cloud was starting to build and proved problematic for the following Licor measurements. The cloud mass increased and became largely cumulus so the AOP work was not able to continue. However, light-field-independent operations continued as provisioned.

The Nurads camera was lowered off the aft deck and left to measure at 30, 40 and 50 meters.

Monday 9th August

As dawn broke, the sky was cloudless and remained clear for the entire morning. These conditions enabled, for the first time, a full morning of ideal optics conditions, which were fully utilised, possibly with the most productive morning of optics so far in the cruise. All of the sensors were deployed at some point during this period. The weather continued fine into the afternoon but conditions became hazier and finally changed quite abruptly into cirrocumulus cover, confirming the forecasted arrival of a cold frontal system for the evening. From 1500 hours the sky had transformed from zero cloud cover but milky skies to complete and heavy cloud cover by 1700. All AOP experiments were stopped but the CTD and IOP continued as planned. The hazy conditions earlier were suspected to be partly contributed by a Saharan dust plume.

Tuesday 10th August

The conditions for the entire day were possibly the best that had been encountered yet in the cruise. From the first signs of daylight, the sky was clear of clouds, although a high altitude visible milky layer of what was assumed to be aerosols was visible by eye. The sea conditions remained very calm throughout the day. The complete set of AOP and IOP measurements was collected during the morning. Around midday, a few light cumulus appeared, creating doubts that the good conditions would last. However, the clouds dispersed by 1400 hours leaving a cloudless afternoon. The data were analysed later in the evening.

There was a collaborated effort between ship crew and scientists alike to observe directly AOPs. Some water samples were taken orally but these, unfortunately, were ingested or ejected before reaching analysis in the lab. All results indicated that the water was warm, blue with low attenuation, as expected for the Tyrrhenian Sea. Water collection apparatus were rinsed thoroughly afterwards with aperative solution.

Wednesday 11th August

The ship was in transit for the day between the Tyrrhenian Sea and BOUSSOLE study sites although the possibility of two stations was previewed, at 0800 and 1300 hours. The first station was dedicated to a CTD cast with surface water sampling for Andre Morel to perform some sensitivity analysis of various types of filter.

At 0900 hours, with the ship once again in transit, there was an informal scientific meeting for cruise members to discuss the project progress, preliminary results and scientific activities for the rest of the cruise. Chief Scientist, David Antoine gave an overview of the mission with a brief description of individual project activities from each of the scientists.

Despite seemingly building cloud cover around midday, by 1300 hours the clouds had dispersed and presented almost ideal conditions for optics, with exception to a slightly milky sky. However, seas were calm with very light winds and hot and humid conditions on deck. All the AOPs were deployed except for the Licor because of Andre Morel being engaged with filtration activities and to finish the station earlier to continue the route. After the second station, the SPMR and PML profiler were brought into the lab for relative intercomparison on the SQM. SQM is the SeaWiFS Quality Monitor calibration lamp designed by Satlantic Inc, requiring a 2-hour warm-up period. Only the higher light level calibration was performed because of setup problems with the two instruments. This took too long to be able to perform the low level calibrations in the same evening. This second part will hopefully be performed the next evening.

Thursday 12th August

Arrival at the BOUSSOLE site was at 0700 hours and the first measurements in the water were the CTD then IOPs. The Slocum glider was launched at around 0800 hours to start its scheduled grid pattern surrounding the buoy. As the sun angle became suitable for AOPs (around 20 degrees elevation) the sky was clear and so the Nurads, PML profiler and SPMR were deployed simultaneously with fairly good quality profile. The Licor was not deployed because cumulus cover was enough to prevent stable light conditions during a full profile. IOPs and CTDs continued as normal until the grappe AC9 of PML developed a cable problem at around 1700. This problem was still existing by the end of the day. An SPMR and PML profiler session was attempted in the afternoon but cast depths were reduced because of cumulus cloud cover during descents.

A weather forecast was received of strong SSW Mistral winds of Force 8 for the night and following day. The decision was made by the commandant, chief scientist and glider operator to recover the glider at 1800 hours and this was carried out successfully, despite mounting waves and increasing winds. A wing was fractured during the recovery but a spare was available.

By late evening the sea was well covered with whitecaps and the winds at 0200 hours Friday were at 22 knots and increasing. All the equipment in the lab and on deck had been secured in preparation for adverse conditions.

Friday 13th August

The winds continued to mount throughout the night and created big swell and wave conditions. The CTD was deployed throughout the night, the final profile being at 0600 hours. After this, there was time for a grappe deployment but the seas were too large to continue after this. Winds had increased up to 38 knots as the decision was made by the captain to head for the bay of Beaulieu to sit out the wind and wait for the weather forecast updates. As is typical for these events of Mistral wind, the sky was exceptionally blue, compared to the other days of the cruise. A couple of meteorological balloons were released during the transit, one of which burst during the difficult launch preparations. Arrival in the bay after a rough transit was at around 1200 hours and the Suroit remained on anchor for the rest of the day. Gerald Moore worked on repairing a problem with the AC9 on the IOP package but for most of the scientists it was a day of data processing and rest aboard.

Saturday 14th August

Departure from the bay of Beaulieu was at 0630 hours and arrival at the BOUSSOLE site at 1000 hours. The winds were light but the seas remained choppy throughout the day with a swell that was up to 1 metre in height. Following the mistral winds, the sky was very clear and blue the entire day with very few clouds and stable. Despite the swell, the first activity of the day was the redeployment of the glider, which was followed by the usual suite of AOPs, IOPs and CTDs. The SPMR profiles were successful although there is possibly

an intermittent problem in the electrical termination at the SPMR end of the cable. The pyramid was also capsized during the pulling in after a profile. However, the case for the release mechanism did not take on too much water so was quickly cleaned and greased.

The Nurad radiance camera and atmospheric optical thickness measurements with the SimbadA were continued to the lowest possible workable sun elevation angle to optimise on the unusually clear skies. The objectives of taking atmospheric measurements with the SimbadA and Cimels were to establish instrument calibration curves for the optical thickness calculations. The extended period of measurements for the Nurad was to observe the rarely measured angular radiance distribution for low solar elevation. The TSRB was also deployed late in the day for factor Q calculations.

The last grappe scheduled for the day did not happen because of technical problems, in particular, low battery voltage. Gerald Moore's IOP package was not deployed either and has been decommissioned for the rest of the cruise due to an internal fault in the AC9.

Sunday 15th August

Sea conditions could not have been any better throughout the whole day. During the first half of the morning there was some light cirrus present but this cleared late morning leaving a very blue coloured sky with low humidity and slightly cooler temperatures. Observations of the high altitude clouds and plane vapour trails indicated some instability at altitude. Unfortunately, the Meris pass for the day was a bad trajectory for the image with too much sunglint to be useable.

A complete session of AOP, IOP and CTD profiles was performed until 1800 hours when the end of cruise aperitif and barbecue started. The Nurad camera and TSRB were left in the water until 1900 hours and the SimbadA and Cimel measurements continued until sunset to optimise on the clear sky conditions.

The PML profiler was damaged during recovery of the afternoon and it was decided that the reparations were best left until after the cruise back at PML to ensure good post-cruise calibrations.

Monday 16th August

CTD profiles continued throughout the night as normal for the schedule. However, the CTD cast at 0400 was a deep cast to 2400m. Problems with the winch prolonged the duration of the following 400m cast at 0600, delaying the recovery operations of the Slocum glider.

Daylight sky conditions were scattered with cirrus although seas were very calm (oily appearance) with just an occasional breeze. No AOP data were collected due to time constraints and non-ideal conditions.

However, the glider recovery went well so there was time for one last grappe profile, terminating the science before starting the route to La Seyne at 0945 hours.

Arrival at the dock was at 1900 hours.

Acronyms

IOPs	: Inherent optical properties
AOPs	: Apparent optical properties
NuRADS	: A radiance camera that measures radiances in all upward directions (RSMAS prototype)
SPMR/SMSR	: SeaWiFS Profiling Multi-channel Radiometer / SeaWiFS Multi-channel Surface Reference (Satlantic instrumentation)
TSRB	: Tethered Surface Radiometer Buoy (hyperspectral radiometer, Satlantic instrumentation)
PML Pro	: The profiling radiometer that PML deployed on the cruise (Satlantic instrumentation)
SIMBADA	: A multi-channel radiometer to measure the water-leaving radiance from above the sea surface (prototype from the Laboratoire d'Optique Atmosphérique).
LIDAR	: Light Amplification by Stimulated Emission of Radiation (Micropulse Lidar)
CIMEL -317	: A portable multi-channel sun photometer (from the CIMEL company)
CTD	: Conductivity, Temperature and depth
AC9	: Wetlabs' Absorption & Attenuation meter at 9 wavelengths
AOT/AOD	: Aerosol Optical Thickness/Depth
LICOR	: The hyperspectral radiometer that LOV deployed during the cruise (Biospherical instrumentation)
HPLC	: High Precision Liquid Chromatography
VSF	: Volume Scattering Function
CDOM	: Coloured Dissolved Organic Matter
SQM	: Satlantic Quality Monitor (Satlantic instrumentation)
BOUSSOLE	: BOUée pour l'acquiSition de Séries Optiques à Long terme
TRIOS	: The hyperspectral radiometer that LISE deployed during the cruise (from the TRIOS company)

