MARINE
NATIONAL FACILITY

2006 program

RV Southern Surveyor

CSIRO

voyage summary SS03/2006

SS03/2006

PULSE: Role of mixed-layer dynamics in Southern Ocean plankton production and carbon transports, including air-sea exchange of carbon dioxide and particulate carbon fluxes to the ocean interior.

Itinerary

Departed Hobart 1000 hrs, Tuesday, 28 March 2006

Arrives Esperance 0800 hrs, Monday 10 April 2006

Principal Investigators

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Scientific Objectives

The Subantarctic Zone (SAZ) of the Southern Ocean is a major sink for atmospheric carbon dioxide. Transfer of the CO2 to the ocean interior involves both physical and biological processes. Transfer of the CO2 through the ocean surface mixed layer (~ top 100m) is a highly dynamic process that varies dramatically on seasonal and shorter timescales. The transfer occurs via two 'pumps' - the physical pump consisting of dissolution and subsequent water mass subduction and the biological pump consisting of phytoplankton production and subsequent sinking of organic matter. The controls on these processes are difficult to assess from short-term ship-based observations because of their temporal variations.

The primary objective of this multi-year project is the development and deployment of a mooring, known as PULSE, with automated sensors and samplers to obtain a full annual time-series of physical and biological parameters important to these carbon pumps. This mooring will provide information on surface ocean processes at similar temporal resolution to the measurement of deep ocean particle fluxes obtained with the already implemented SAZ sediment trap mooring. In concert with this deployment, additional measurements were made to inform the interpretation of the mooring based measurements. Key measurements include dissolved nutrients, dissolved carbon dioxide (DIC) and oxygen concentrations and bio-optical measures of phytoplankton and suspended particulate organic matter. In addition samples were obtained to assess the availability of trace elements important to phytoplankton health.

Voyage Objectives

1. Deployment of the PULSE mooring in the SAZ near 140oE, 47oS in ~4500m water depth (P.I: T. Trull, F.B. Griffiths, B. Tilbrook).

The PULSE mooring is an experimental mooring with a small spherical surface float decoupled from a sub-surface instrument package by an elastic line (bungee). The mooring is currently undergoing testing in coastal waters south of Hobart. The final instrument configuration will depend on the results of these tests. The available suite of instruments includes:

i) temperature loggers spaced along the mooring at 10m intervals to determine mixed layer depth.

ii) a CTD to determine mixed layer depth

iii) two PAR sensors and a spectral radiometer to determine the light environment

iii) a fluorometer to estimate phytoplankton abundance

iv) a water sampler to obtain weekly samples for nutrient and dissolved CO2 analyses

2. Recovery and re-deployment of the SAZ sediment trap mooring near 141oE, 47oS (P.I: T.Trull)

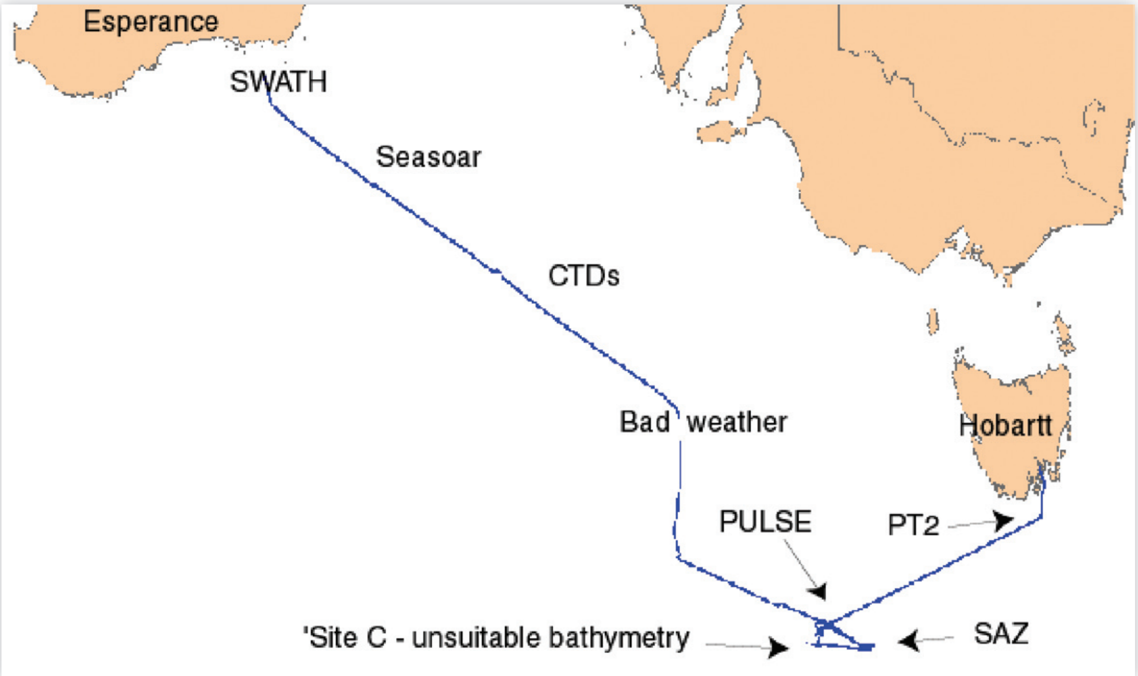
3. Deployment of the CTD-Rosette at and along the transects to and from the PULSE mooring site to obtain sensor profiles of fluorescence, oxygen, and transmission, and water samples for oxygen, nutrient, DIC, chlorophyll-a (all P.I), and also for trace-element analyses (P.I: E Butler).

4. Deployment of the SEASOAR undulating towed-vehicle equipped with a PAR sensor, oxygen optode, fluorometer and transmissometer (in addition to its normal paired CTDs) to determine mixed layer and sub-mixed layer oxygen and particle distributions north and west from the PULSE mooring site (P.I: T. Trull, B. Tilbrook, L. Pender, T. Fitchett).

5. Deployment of 1 ARGO profiling float equipped with an oxygen optode and transmissometer at the mooring site. (P.I: T. Trull, B. Tilbrook).

6. Deployment of 5 standard ARGO floats along the transect west from the mooring site to Esperance. (P.I: T. Trull, M.Rosenberg).

7. Measurement of underway biogeochemical and bio-optical properties underway along the entire transect using the ship's clean scientific seawater supply, including CO2 partial pressure (pCO2) (P.I: B Tilbrook), fluorescence, fast-repetition-rate fluorometry (FRRF) (P.I: B Griffiths), particulate organic matter (POM) (P.I: T. Trull, T. Fitchett), and trace-element samples (P.I: E Butler, M Grose).



Voyage Track

Figure 1: Voyage track with locations of main operations (PT2 indications communication with PULSE-Test-2 mooring)

Results

1. The PULSE-1 mooring was successfully deployed in the Sub-Antarctic Zone at:

46° 19.743' S, 140° 40.871'E

Triangulation and Swath bathymetry suggest a final anchor depth of 4285m, very close to the final deployment design depth of 4280m.

PULSE-1 has a relatively small set of instruments as summarized in Figure 2, which will increase in future deployments.

The bathymetry of the PULSE-1 site is shown in Figure 3.

The surface float GPS/Iridium telecommunications system functioned correctly after deployment.

2. The SAZ sediment trap mooring was successfully recovered (SAZ-B9a) and redeployed (SAZ-B9b) at:

46° 49.93' S, 141° 53.03'E

Triangulation and Swath bathymetry suggest a final anchor depth of 4510m.

Figure 4 shows the SAZ mooring configuration.

On recovery the IRS-Sinking Velocity Trap was found to have suffered failure of a pressure compensating membrane and subsequent seawater ingress and loss of the motor driving its Indented Rotating Sphere. This could not be repaired at sea, and thus this trap was not redeployed. The other two recovered traps had functioned correctly and were redeployed.

3. The planned deployment of the CTD-Rosette and bio-optical instruments along the transects to and from the PULSE mooring site was strongly limited by the rough weather. Table 1 lists the successful CTD and bio-optical cast locations. Water samples were analysed for salinity, nitrate, nitrite, phosphate, silicate, and oxygen concentrations by the onboard MNF hydrochemistry staff. Additional samples were collected by project staff for land-based analyses for:

1. dissolved inorganic carbon and alkalinity (K. Berry and B. Tilbrook)
2. phytoplankton pigments and spectral absorbance (B. Griffiths)
3. particulate organic carbon (T. Fitchett and T. Trull)
4. methyl halides and cell counts (M. Grose)
5. trace elements (E. Butler)

4. The planned deployment of the SEASOAR undulating towed-vehicle equipped with a PAR sensor, oxygen optode, fluorometer and transmissometer (in addition to its normal paired CTDs) near the PULSE mooring was not achieved. This was primarily owing to rough weather, but also to problems with the SeaSoar cable, processors, and mechanical systems, including damage to the SeaSoar during loading. We were only able to carry 2 of the 4 bio-optical sensors, and did achieve some short transects with either the optode-transmissometer or optode-fluorescence pair. This work was done in sub-tropical waters towards the end of the cruise and thus did not contribute to the sub-Antarctic focused cruise objectives, but was helpful in preparing for doing this work in 2007.

5. The planned deployment of 1 ARGO profiling float equipped with an oxygen optode and transmissometer at the mooring site was not undertaken, owing to concerns about float control following loss of a similar float deployed in late 2005. This float will be deployed at a later time after further testing.

6. Deployment of 5 standard ARGO floats along the transect west from the mooring site to Esperance was successful. Table 2 lists their deployment locations.

7. Measurement of biogeochemical and bio-optical properties underway along the transect using the ship's clean scientific seawater supply was largely successful. This included:

1. temperature and salinity (MNF Seabird thermosalinograph)
2. fluorescence (MNF fluorometer)
3. CO2 partial pressure (K.Berry and B. Tilbrook system with Licor IR detector),
4. oxygen (K. Berry and B. Tilbrook Aandera optode O2 detector)
5. total dissolved gas pressure (PSI GTD sensor),
6. Fast-repetition-rate fluorometry (B. Griffiths, Chelsea FRRF),
7. spectral absorbance measurements (B. Griffiths, Wetlabs ACS).
8. collection of samples for inorganic iodine analyses (E.Butler)
9. collection of samples for methyl halide analyses (M. Grose)

The clean seawater supply was only marginally sufficient for this work – providing 2 to 3 litres per minute at the main-deck level from the de-bubbler on the forecastle deck. A larger flow and greater pressure supply would be advantageous. Rough weather also compromised some of this work because of surging and high bubble contents in the supply.

8. Deployment of the ship's boat was successfully undertaken to obtain trace-element clean samples away from the ship for comparison to trace-element samples collected from the ship at: 45° 50.55′ S, 139° 08.64′ E

9. Acoustic communication was established with the of lost PULSE-Test-2 mooring in shelf waters south of Tasmania at:

44° 2.77′ S, 149° 26.28′E

Approaching nightfall precluded its recovery. This will be undertaken separately from Hobart using a coastal vessel.

Voyage Narrative

We departed Hobart on 28 March in good weather and successfully communicated with the previously unresponsive PULSE-Test-2 mooring 5 hours south of Hobart. We continued to the PULSE-1 mooring deployment site in worsening weather, but managed to complete a test CTD cast on 29 March. We then entered a 2.5 day period of very rough weather during which we could not undertake any over the side operations (30 March through 1April). During this time we carefully mapped the bathymetry at the PULSE-1 site, and also looked at 3 other possible sites nearby. We settled on the original target site, and after the weather improved and we completed a CTD to get a precise sound speed estimate, we deployed the PULSE mooring on 2 April. We then continued to the SAZ mooring and recovered it the same day, turned it around and redeployed it the next day. We then had a brief period of weather good enough to permit us to launch the ship's boat to collect trace-element samples and to undertake a comparison CTD cast. Very rough weather from late in the day on 4 April through 6 April again prohibited CTDs or SeaSoar tests. The sea-state during this time precluded proceeding directly towards Esperance and instead we ran north with the waves until they eased enough to let us return to our planned direct course, and to obtain a few more CTDs. Given the difficult conditions, the ship and personnel performed admirably.

Summary

The voyage succeeded in its primary objectives. Secondary objectives were partially achieved, but limited by time lost to rough weather. Personnel

Science Contingent

1	Tom Trull	CMAR/UTAS/ACE	Chief Scientist
2	Brian Griffiths	CMAR/ACE	Mooring and underway bio-optics
3	Edward Butler	CMAR/ACE	trace-elements
4	Mark Rosenberg	ACE	Mooring, ARGO float operations
5	Lindsay Pender	CMAR	Mooring, CTD, SEASOAR Operations
6	Kate Berry	CMAR	pCO2, DIC, carbon system measurements
7	Michael Grose	IASOS UTAS	trace-element and halocarbon sampling
8	Tory Fitchett	IASOS UTAS	POM, transmissometer, O2 optodes
9	Tom Remenyi	ACE	Mooring, sediment trap operations
10	Tom Kazarian	IASOS UTAS	trace-elements
11	Pamela Brodie	MNF/CMAR	Voyage Manager and Computing Support (SST)
12	Drew Mills	MNF/CMAR	Electronic support (SST)
13	David Terhell	MNF/CMAR	Hydrochemistry - nutrients, oxygen (SST)
14	Alicia Navidad	MNF/CMAR	Hydrochemistry Support
15	Ian Hawkes	MNF/CMAR	Systems analyst

Marine Crew

1. Ian Taylor	Master
2. Samantha Durian	First Mate
3. Brent Middleton	Second Mate
4. Roger Thomas	Chief Engineer
5. Robert Cave	First Engineer
6. Chris Heap	Second Engineer
7. Mal McDougall	Boatswain
8. Paul Hansen	Integrated Rating
9. Reuben Ifil	Integrated Rating
10. Mark Jaques	Integrated Rating
11. Phil French	Integrated Rating
12. Charmayne Aylett	Chief Steward
13. Andy Goss	Chief Cook
14. Jason Phillips	Second Cook

We thank the Officers, Crew, and especially the Cooks and Steward of the Southern Surveyor and the Marine National Facility staff for their efforts to make this voyage a success in very trying circumstances. The smooth coordination and safe working practices of the bridge, deck, and ops-room personnel made the precision deployment of the PULSE-1 mooring and the rapid turnaround of the SAZ sediment trap mooring (recovery of SAZ-B9a, deployment of SAZ B-9b) possible. The voyage involved long hours for many staff and their efforts are much appreciated.

Tom Trull
Chief Scientist
April 9, 2006

Tables

Table 1. CTD deployments

CTD#	Latitude	Longitude	Cast Depth	Water Depth	Comments
1	-45.4611	143.2304	1000	4490	test station
2	-46.3345	140.6481	2250	4340	full sample set
3	-46.324	140.7118	500	4310	full sample set and trace elements
4	-46.7908	141.8604	2250	4580	aborted-no samples
5	-46.7908	141.8604	2250	4580	full sample set
6	-45.845	139.1416	2250	4300	aborted-no samples
7	-45.8893	139.14	2000	4180	full sample set and trace elements
8	-39.1562	130.754	1000	5550	full sample set and trace elements
9	-38.274	128.9999	1000	4960	full sample set
10	-37.2995	126.9957	1000	5560	full sample set and trace elements
11	-35.4697	123.4146	1000	4580	bulk water collection only
12	-35.4653	123.4192	1000	4580	full sample set

Table 2. ARGO float deployments

Float	Argos	Long. E.	Lat. S.	UTC time/date
2323	60381	139 08.64	45 50.55	00:05 4 Apr 2006
2174	57740	135 00.45	41 14.00	01:44 6 Apr 2006
2175	57741	131 00.05	39 16.75	21:42 6 Apr 2006
2173	57589	125 07.75	36 23.38	15:14 8 Apr 2006
2167	57589	123 03.96	35 09.68	05:12 9 Apr 2006

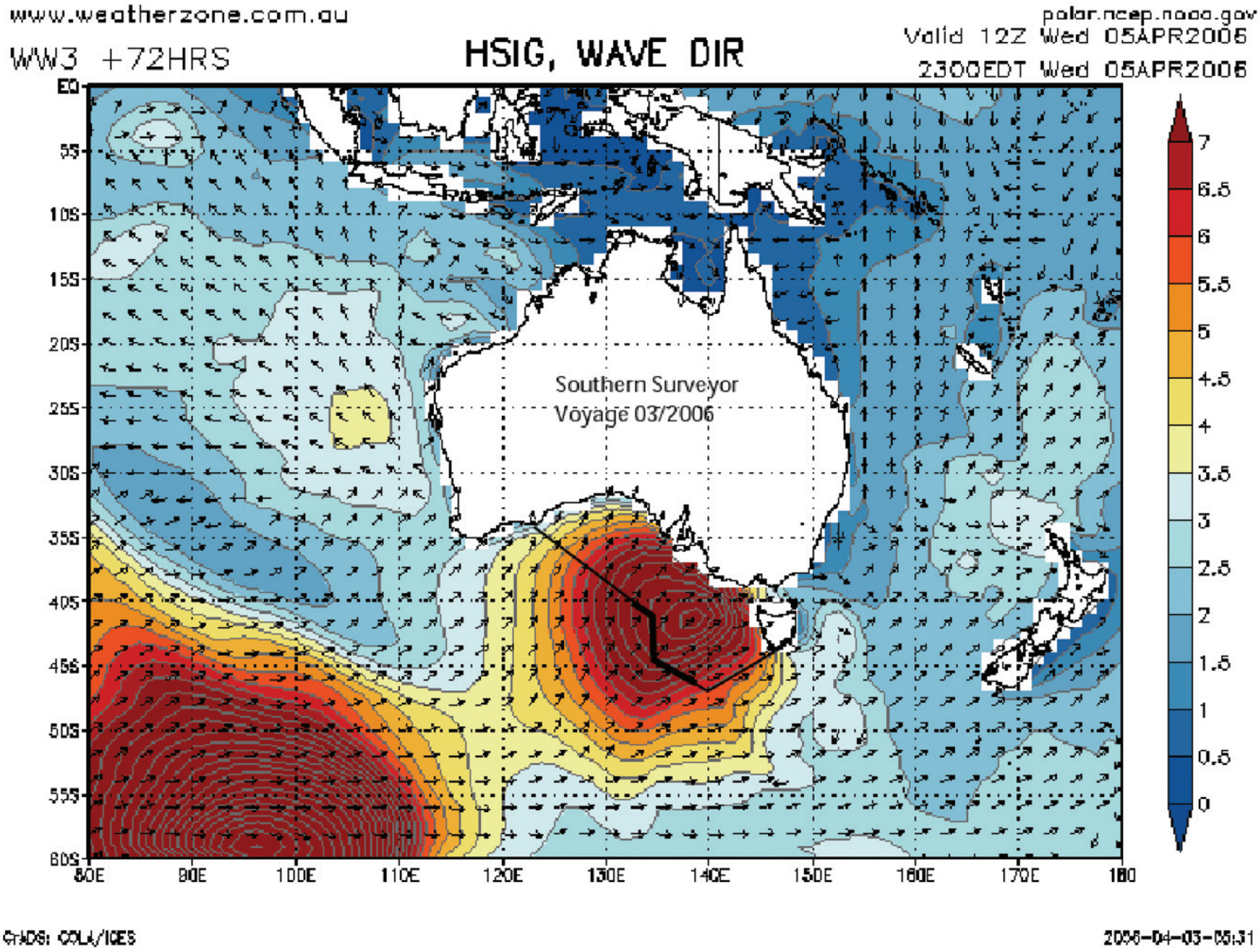


Figure 2. Rough weather encountered after completing the mooring work prevented CTDs, SeaSoar and work in the portion of the track indicated by the thick black line. Similar rough weather occurred at the PULSE mooring site during the prolonged bathymetric survey.

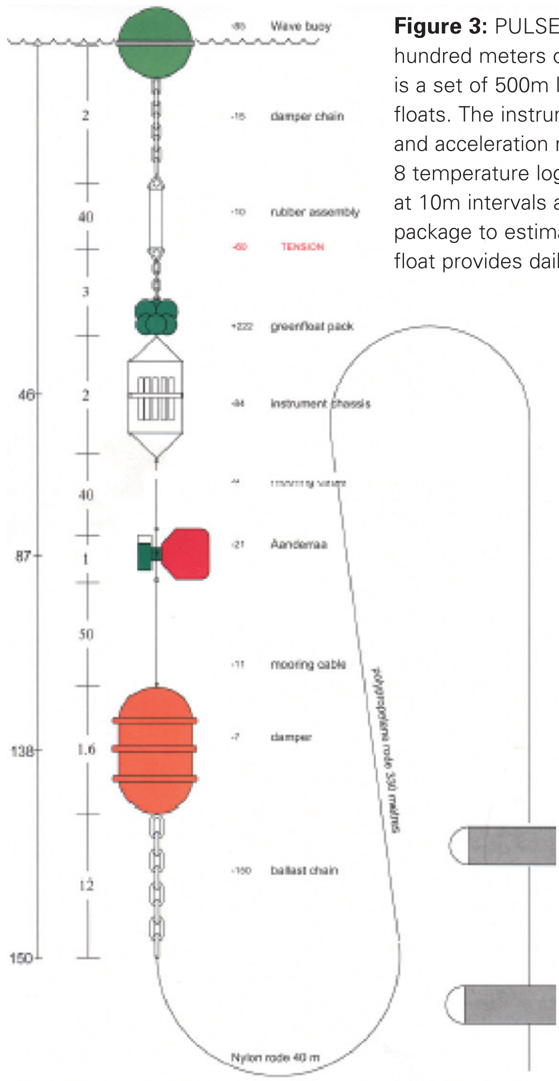


Figure 3: PULSE-1 mooring design. Only the top few hundred meters of the design is shown. The bottom 4 km is a set of 500m lengths of 5mm wire buoyed by glass floats. The instrument package contains only pressure and acceleration recorders this year. Not shown are 8 temperature loggers and 2 pressure loggers placed at 10m intervals along the line below the instrument package to estimate mixed layer depth. The surface float provides daily Iridium/GPS communication.

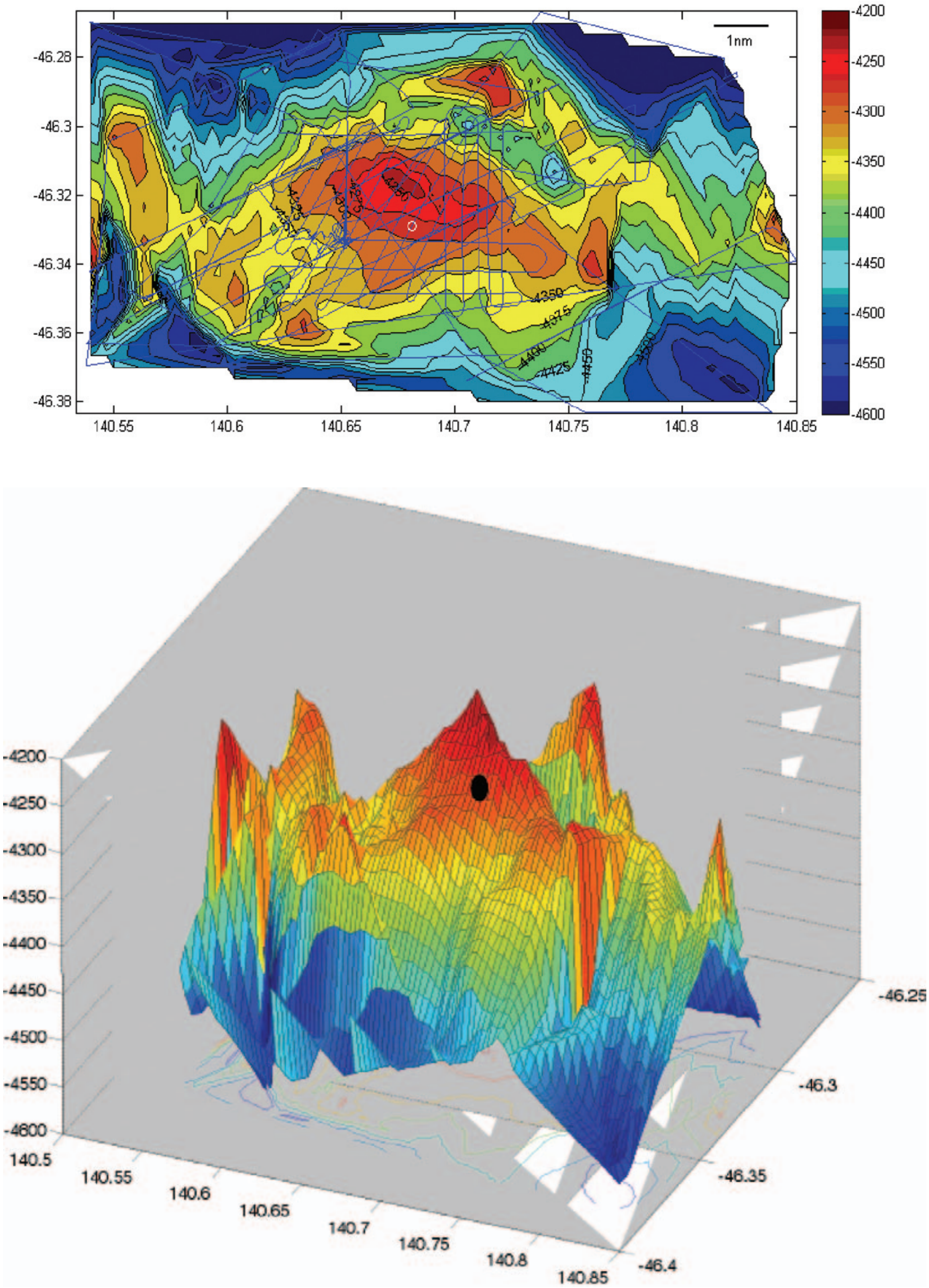


Figure 4: Bathymetry at PULSE mooring deployment site. Survey tracks are shown in 2-D view. Mooring position is marked by white circle in 2-D view and black ellipsoid in 3-D view.

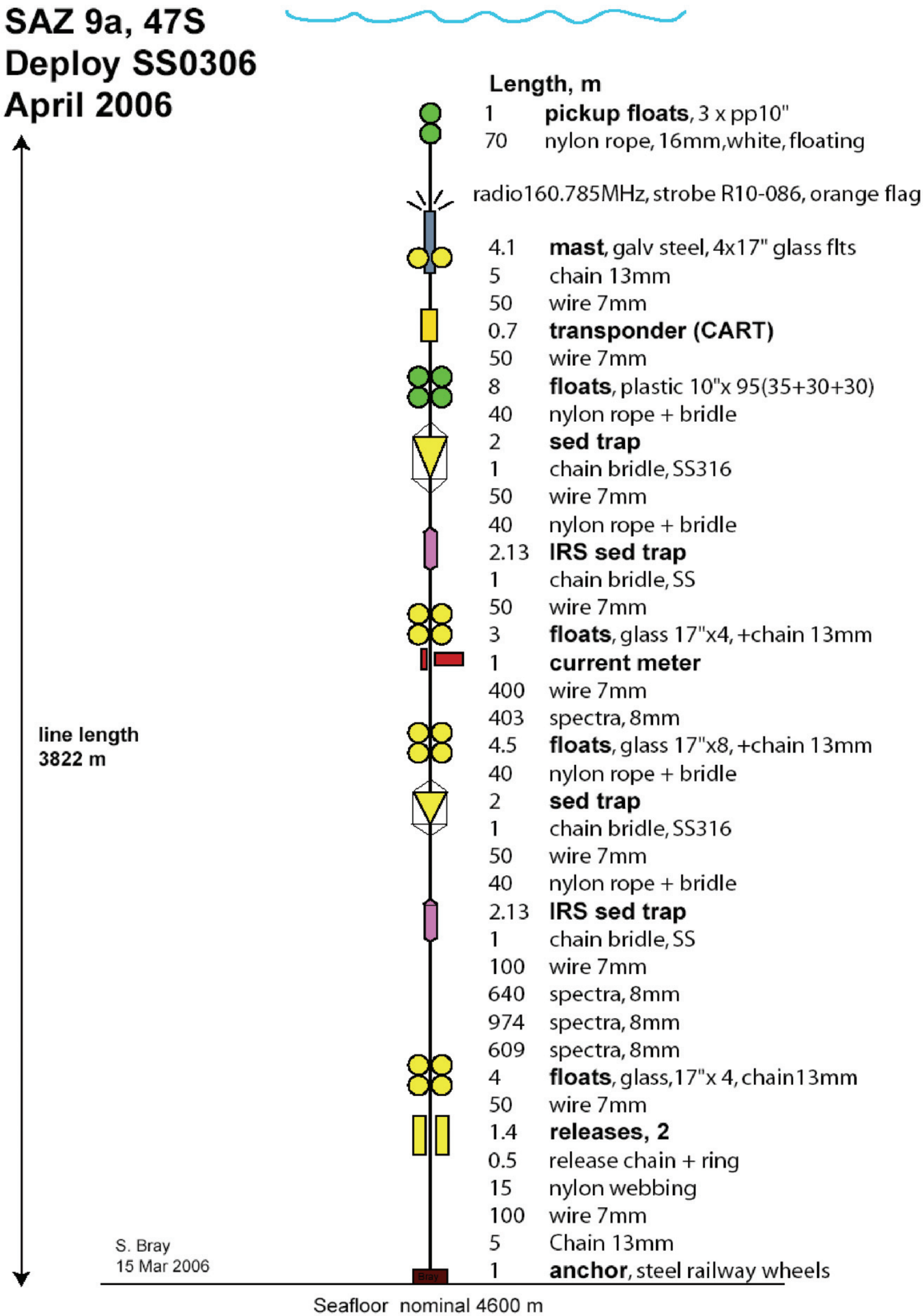


Figure 5: SAZ mooring design