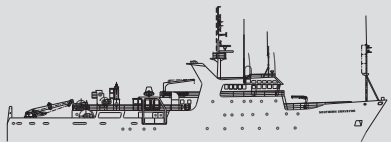

MARINE
NATIONAL FACILITY

2010 program

RV *Southern Surveyor*

CSIRO

voyage summary SS2010_v09

SS2010_v09

Impact of the East Australian Current on water chemistry, bio-optical properties and coastal primary productivity in the NSW region

Voyage period
Start: 15/10/2010
End: 31/10/2010
Port of departure: Sydney, Australia
Port of return: Sydney, Australia

Responsible laboratory
University of Technology, Sydney
PO Box 123 Broadway, NSW 2007 Australia

Chief Scientist
Chief Scientist – Dr. Martina Doblin, University of Technology, Sydney
Alternate Chief Scientist – Dr. Mark Baird, University of Technology, Sydney and CSIRO Marine and Atmospheric Research

Objectives and brief narrative of voyage

The East Australia Current is the single-most important factor affecting regional productivity along the eastern seaboard of Australia. This voyage sought to better understand the interaction of the EAC with the continental shelf in the area north and south of the EAC separation zone off NSW, an important region supporting almost 50% of Australians living near the coast. High-resolution data was collected to characterise the relationship between physical oceanography, water chemistry (e.g. nutrient distribution and light availability) and the productivity and diversity of bacterio- and phytoplankton in the EAC and across a partially flooded cold core eddy. In addition, bio-optical biogeochemical and aerosol properties were measured within and outside of four river plumes (Macleay, Clarence, Richmond, Shoalhaven) and will provide much needed data for the wider NSW scientific community to improve remotely-sensed estimates of ocean colour (chlorophyll-a biomass).

Traditional as well as innovative techniques were used to assess productivity (14-C uptake and bio-optical and fluorescence-based estimates of production) as well as grazing losses. Samples were taken to assess shifts in the composition and function of bacterial communities using metagenomic approaches and will be related to specific oceanographic features and phytoplankton community characteristics.

Nutrient and organic source (fulvic acid) enrichment experiments were carried out in the EAC and at the edge of a cold core eddy, and will provide insights about the role of nutrients and coastal inputs in controlling plankton biomass, diversity and activity. These experiments will gather knowledge not only on phytoplankton but also bacteria, and processes affecting coloured dissolved organic matter (CDOM) composition and its bio-optical signature.

Scientific Objectives

The overall scientific objective of this voyage is to provide a comprehensive description of the lower trophic level responses to EAC interactions on the NSW continental shelf, and establish linkages between the oceanography, nutrient and light climate and primary productivity.

Specifically this project will:

1: Undertake CTD measurements of water structure and chemistry in a set of transects traversing the continental shelf and slope and evaluating the biogeochemical signature of the EAC;

2: Identify the inter-relationships between water masses, nutrients, bacteria and phytoplankton diversity and primary productivity in the transition zone of the EAC;

3: Study critical processes in contrasted oceanographic features (EAC, upwelling and coastal / inner shelf regions) such as the impact of macronutrients, organic sources (reflecting coastal inputs) and grazing on microbial diversity and productivity;

4: Measure key parameters required in remote sensing algorithms and ecosystem models (e.g., NPZD models (e.g., Moore et al., 2007; Baird et al., 2008) and:

(i) In particular, the Particulate Organic Carbon (POC) to Chlorophyll a (Chl a) ratio.

(ii) Characterize the underwater light field using optical/biogeochemical (bio-optical) measurements (particulate absorption, attenuation, backscattering, scattering, radiance, irradiance, diffuse attenuation, coloured dissolved organic matter (CDOM), Dissolved Organic Carbon (DOC), phytoplankton pigment composition using High Performance Liquid Chromatography, total suspended solids, particle size distribution).

Voyage Objectives

This voyage proposed two sets of activities: transect stations and process stations (see Figure 1).

The transects conducted during this project allowed mapping of important biogeochemical parameters, whereas process stations provided information about (i) the main factors controlling biological stocks and activities and (ii) the vertical distribution of the parameters measured during the transects in the whole water column. The information gathered at the process stations will be critical to identifying key parameters and processes driving the control of primary productivity by macro-nutrients.

The following activities were conducted onboard the Southern Surveyor to meet our scientific objectives:

1) Deployed CTD rosette to obtain vertical profiles of bio-optical properties (including particulate backscatter, CDOM fluorescence, chl-a fluorescence), as well as photosynthetic rates and collected water samples for microbial, phytoplankton, and micro zooplankton assessment.

2) Undertook process studies, focusing on the EAC (nutrient poor), an upwelling zone (relatively nutrient-enriched) and inner shelf waters (intermediate) to understand the links between macro-nutrient availability, microbial diversity (bacteria and phytoplankton) and productivity of lower trophic levels.

3) Undertook perturbation experiments to assess parameters affecting the bio-optical signature of CDOM. Both biological transformation and photo-degradation will be investigated.

4) Undertook grazing experiments to determine the net phytoplankton production at process stations.

5) Deployed optical sensors in air and in the surface mixed layer of the ocean to measure optical properties and their variability.

6) Conducted above surface and in-water optical measurements (using both an underway and optical instrument package at CTD stations) to calibrate and validate satellite remote sensing products such as chlorophyll and primary production.

7) Conducted deployments of 'in situ chemotaxis assay' at process stations.

8) Collected CTD, Optical Plankton Counter and Ecotriplet data whilst undertaking process studies to assess spatial variability in the region.

Results

After the first day of the voyage when we experienced very rough weather, the voyage progressed smoothly with all scheduled operations completed.

The bio-optical sampling within northern NSW river plumes coincided with above-average rainfall in NSW and clear skies, so we were able to collect the most comprehensive optical dataset in NSW waters to date, which coincided with numerous satellite overpasses (Objectives 1, 5, 6).

The perturbation and grazing experiments were initiated with water from the EAC and the edge of a cold core eddy (CCE) and were incubated on deck in a mesh-covered incubator with flowing surface seawater (Objectives 2, 3, 4). The assemblages showed a positive response to nitrogen addition in the EAC and to iron addition in the CCE (as demonstrated by increased 14C fixation and increased colour on GFF filters). This adds to our knowledge of nitrogen limitation in the EAC (see Hassler et al. 2010) but suggests the importance of nitrogen fixers in NSW continental shelf waters requires further investigation.

Deployment of optical instruments associated with CTD stations went well (Objectives 1, 8), although there were issues with the Laser Optical Plankton Counter (LOPC) datalogger and Fast Repetition Rate Fluorometer (FRRF) batteries. It seems not all deployments were logged for the LOPC and we have about 50 profiles of FRRF data (out of 91 CTDs). Deployment of the optical cage was also successful, although battery power diminished towards the end of the voyage because of the large number of instruments drawing power. An option for future deployments is to power this optics cage using the ship's power.

In situ chemotaxis assays were undertaken in 3 different water-types: the EAC, at the shelf break and in coastal water near Jervis Bay (Objective 7).

Given the above, all voyage objectives were fulfilled. However, the only preliminary data available as we departed the ship were 14C carbon fixation estimates (Doblin) and photophysiological estimates of phytoplankton health (Petrou/Franklin).

Voyage Narrative

Friday 15 October: Bad weather day!
Departed Sydney 1000; dropped pilot off and transited to our first toolbox station 33° 40.90' 151° 48.00. The weather was too rough to deploy the CTD, so we transited overnight to Stockton Bight. Winds overnight were up to 50 knots.

Saturday 16 October: Stockton Bight
At 0600, the ship was sheltering in the lee of Stockton Beach (between Newcastle in the south and Port Stephens in the north) until 0730. The CTD was made ready but we decided to hold off deployment due to winds gusting > 40 knots. Scientists feeling ok but eating dry toast! Weather situation reviewed at 1030 and we proceeded with CTD001 at 32 ° 54.934 S 151 ° 56.994 E. We completed full biological sampling but didn't do any optical casts due to rough weather. CTD002 (hydrochem sampling only), and CTD003 (some biological sampling), were spaced to the east at 4 nm apart along the same latitude as CTD001. Given poor sea conditions, we decided to transit northward to Clarence Head (mouth of the Clarence River). Travelling at 8 - 9 knots, the master indicated it would take until 2100 tomorrow evening. The flowthrough system, with ac9 and acs went live at around 5 pm.

Sunday 17 October: Macleay River plume
With clear skies and a much calmer sea, we re-evaluated our plan to transit northward and deviated to the coast to sample the Macleay River plume, just north of Smoky Cape. Our first station (CTD004) was at 30 ° 51.793 S 153 ° 08.717 E, to coordinate with the 1030 satellite overpass. CTD005 (30 ° 50.942 S 153 ° 03.448 E) was closer to shore, and clearly within the river plume – we crossed a front where the water turned from blue to green. This coordinated with the 1400 satellite MODIS AQUA overpass. The weather stayed fine, so we continued sampling in the near shore. CTD006 (30 ° 47.017S 153 °02.517 ° E) was north of CTD005 but still within this green water mass; we were checking for variation in its optical properties. CTD007 was conducted east of CTD006, along the 100 m isobath at 30 ° 47.557 S 153 ° 11.425 E. The final CTD of the day (after sunset) was CTD008, located east of the 200 m isobath to sample more EAC-like water. The good news today was that the IOP profiler became fully operational and communications were established with the Satlantic radiometer (to be deployed at the bow of the ship). Overnight, we transited to Clarence Head.

Monday 18 October: Clarence River plume
Another clear sky day, so our objective today was to characterise the Clarence River plume near Yamba. The first CTD009 was east of the 50 m isobath (at approximately 0800). We then transited back towards shore and stopped for a 1030 CTD010 (plus optics cast, plus our first and successful Satlantic deployment), having crossed into brown water. Following CTD010, we went closer to shore, having observed another plume, which we assumed had just been exported from the river during low tide. We put the CTD and IOP cage in again (CTD011). We then steamed southward very slowly to find the edge of the plume, did another CTD012 and were squarely in river affected waters during the 1500 satellite overpass (CTD013). There was full biological sampling (including for 14C fixation), and a successful FRRF profile. Following the overpass, the Tow-yo CTD (Nacelle) was deployed and towed

southward. During this time, the optics team sampled surface water for TSS, chl-a and particulate absorption. At 29 ° 39.01 S 153 ° 25.09 E, the ship turned around, came back up the coast along the 100 m isobath to the Richmond River at Ballina.

Tuesday 19 October: Richmond River plume

Today's objective was to characterise the Richmond River plume near Ballina. Amazingly, this was our third consecutive day of clear skies, coinciding with some significant river outflows. The day began with a 0730 CTD014 offshore in approximately 100 m of water. We then transited towards shore, with a CTD in "blue water" for the 1030 overpass (CTD015) and several others (CTD016 and CTD017) as we moved towards the plume. The plume was smaller than the Clarence River, and interestingly, the CTD parameters showed no salinity decrease at the station adjacent to the plume front. A CTD and Optics station was completed at 1530 to coincide with the overpass of MODIS Aqua. The station was within the turbid plume which was only a few metres of fresh water floating over the saltier shelf water. Deploying the Satlantic from the bow was quite challenging as the ship drifted towards the shore with the wind and surface currents, but the deeper currents seemed to drag the instrument in the opposite direction. Following the 1530 overpass, we towed the Nacelle to capture the full length of the plume, ending towing at around 1930 before moving southwards to Evans Head and then transiting eastward to reach the East Australia Current for initiating our process study tomorrow morning.

Wednesday 20 October: EAC to Evans Head transect

The first CTD in the EAC (at 0630) was to collect water to initiate a nutrient enrichment experiment. After sampling the bottles as cleanly as possible (pseudo-trace metal clean), the rosette was ready to be redeployed at 0930. By then, we had drifted southwest (by 0.75 m s-1 with the current, plus additional wind drift). This was the beginning of our 9 station CTD transect along 29° 08.36 S, spanning the EAC and the nearshore region adjacent to Evans Head. The offshore stations were spaced 10 nm apart, and once on the shelf, they were spaced 6 nm apart. After finishing the transect (around 1930), the Nacelle was deployed and towed out to sea (at 100 m depth) along the same line of latitude, to 154° 19' where we began today's transect.

Thursday 21 October: EAC drift

Today we drifted in the EAC (CTD cast at 0830) to characterise the microbial and eukaryotic community in the surface and at the chlorophyll-maximum (75 m). The biologists initiated a grazing experiment using water from the chlorophyll-maximum while the optics group collected surface water to match the satellite overpass at 1030 and again at 1500. The FRRF was deployed in the deep chl-a maximum. There was a brief fire drill at 1300. A bottle wasn't opened before a late afternoon CTD deployment and we lost bottle 16 which was then replaced. Our last CTD037 station of the day (at 1900) went to 500 m, where we found a chlorophyll peak as deep as 215 m.

Friday 22 October: EAC drift

Another day drifting in the EAC... We collected water from a CTD cast at 0830 to characterise the microbial and eukaryotic communities. The FRRF was then deployed in the deep chlorophyll maximum (CTD039) before being sent down again during the CTD satellite match up cast at 1030. The biologists ended their grazing experiment and at 1600, a microsampler was deployed to investigate chemotaxis of microbes. The final CTD (CTD044) of the day was a deep cast to 500 m, where we found another deep chlorophyll peak (225 m).

Saturday 23 October: EAC drift and warm core eddy centre

We continued to drift in the EAC (which was actually part of a warm core eddy) and did CTD deployments at 0830 to characterise the microbial and eukaryotic communities, at 0935 to measure in situ photosynthetic rates (FRRF) and at 1020 for the satellite overpass at 1100. Immediately after the optics and Satlantic radiometer deployments, we steamed towards the centre of the warm core eddy. At 0230, we did a CTD (CTD048) for the satellite match up and found a 185 m mixed layer. The biologists ended their nutrient enrichment experiment and at 1730, we did CTD049 in the centre of the warm core eddy. The vertical profile was more complex than the previous CTD deployment, with 3 chlorophyll peaks (at 75, 150 and 275 m). Water was collected and the FRRF detected photosynthesis at the 275 m deep chlorophyll maximum. We also collected 2 vertical zooplankton net tows with the N70 net using the pot hauler winch. Overnight we towed the Nacelle towards the centre of the cold core eddy to our south, heading for 32 ° 10′ S 153 ° 50′ E.

Sunday 24 October: Cold core eddy

The Nacelle was towed until 1000 when it was brought up on deck to do a CTD (CTD050) for the satellite overpass at 1100. After our usual series of deployments (CTD, optical cast, Satlantic radiometer), we then modified our destination to 32 ° 35.484 ′ S 153 ° 38.85′ E, slightly further east. To increase ship speed, we didn't tow the Nacelle and while underway, examined the ADCP current velocities. They showed a complex pattern of velocities. On reaching what was estimated to be the centre, we deployed the CTD (CTD051), optics cage, Satlantic, then did two N70 net tows. With the oceanography more complex than anticipated, we kept our heading and travelled for another two hours before re-evaluating the current velocities and plotting a z-shaped transect northward to characterise the feature.

Monday 25 October: North-south transect across cold core eddy

The Nacelle was brought out of the water at around 0600 and the first CTD (CTD052) in our north-south transect began at 0730. CTD stations were spaced 6 nm apart, with CTD053 at 0920 and CTD054 at 1030 (satellite overpass). Following the Satlantic deployment, we did a second CTD at 1205 to collect water at the edge of the eddy for the second nutrient enrichment experiment. CTD056 was at 1425 (satellite overpass) and CTD057 at 1655, ending our transect 18 nm north of our planned finish, to allow time to tow the Nacelle and collect more velocity data. The eddy centre was estimated to be along 32 ° 17.7 ′ S, so we planned an offshore-onshore transect with CTD stations spaced 10 nm across the eddy, and 6 nm across the shelf. Overnight we transited to our starting position at 32 ° 17.7 ′ S 154 ° 17′ E.

Tuesday 26 October: East-west transect across cold core eddy

The To-yo/Nassal was retrieved in the early hours of the morning and the CTD transect begun further west of our original position at 32 ° 17.7 ′ S 154 ° E. CTD058 (0630) was followed by 8 more, heading closer to shore. At station CTD062, we saw Trichodesmium colonies evident on the water's surface. At CTD063 we collected water at the chlorophyll maximum to initiate a grazing dilution experiment at the eddy "edge". Given the late hour, we decided to make our final CTD (CTD066) of the day ~ 10 nm west of the shelf break.

Wednesday 27 October: east-west transect across the shelf and transit to Jervis Bay

The day began at the shelf break where we started our CTD transect to shore. We did a CTD and optics cast, N70 net tow and then a chemotaxis deployment for half an hour before moving onto the shelf for CTD068 in 125m of water. We made good time and reached the next station where the first CTD cast was abandoned due to a bottle misfire. CTD70 went smoothly before we moved

to our next station, well within sight of land. This last CTD of the day (CTD071) coincided with the satellite overpass and involved our usual series of operations. Immediately after this, the ship started its southward transit to the mouth of the Shoalhaven River. During the afternoon, the biologists finished the grazing dilution experiment while most others enjoyed the afternoon sunshine.

Thursday 28 October: characterising coastal water near the Shoalhaven River and visit to centre of warm core eddy

We arrived on station in time for the first satellite overpass at 1100. After our usual series of deployments, we started a box transect off the mouth of the Shoalhaven River, to characterise the optical variability of the water. The biologists finished their second nutrient enrichment experiment. The second overpass was at 1500 where we completed station 4 and then started our southeastward transit to the centre of the warm core eddy at 36 ° 05' S 151 ° 30' E. On arrival, we did a deep (500 m) cast (CTD076) to examine the vertical water column structure, then a shallower cast with the Ecotriplet sensor (CTD077). Water was collected at two deep chlorophyll maxima, to check for photosynthetic activity.

Friday 29 October: characterising coastal water near Jervis Bay and transit to Port Hacking

After transiting back from the warm core eddy, we arrived at 35 ° 14.91' S 150 ° 37.5' E (Sussex Inlet) to characterise the coastal water near Jervis Bay. Our first station was to the southwest of Jervis Bay (CTD078). We then started a perpendicular transect off Jervis Bay, with CTD079 more distant from shore, and CTD080 closest to shore for the 1500 satellite overpass. At this station, we completed our usual series of deployments but also launched the chemotaxis sampler. The ship drifted considerably due to strong currents. The final station (CTD081) in the series was completed before we started our northward transit to Port Hacking along the 100 m isobath while swath mapping.

Saturday 30 October: characterising optical variability at the Port Hacking National Reference Station

At 0900 we did a CTD cast to check water column structure in the vicinity of the Port Hacking 100 m station, and then did a test optical cast to check if the instruments had power. All was well, so we moved to the first station in our cross-shaped transect around PH100. Operations went quicker than expected, so the 6 pixel study was expanded to 9 pixels, with an optics and Satlantic radiometer cast at each of 9 stations. After dinner, we visited the PH50 m station and then moved off station to be in TV range (rugby test). The vessel transited slowly overnight to come to station at 0700 to start a CTD transect off Bondi.

Sunday 31 October: Sydney transect

We started the day with a CTD087 at the Ocean Reference Station and followed the tide out of Sydney Harbour along the National Reference Transect, sampling at two further stations before transiting to the pilot pick up location off Botany Bay. From there, we received permission to sample in the vicinity of Malabar deep water ocean outfall, where we did a CTD (CTD090). Our final station was at Sydney Harbour Heads where we did CTD091 and then transited back to port.

Summary

Overall, the voyage was a success; we benefited from very calm sea conditions and were thus able to deploy all of our equipment. The voyage clearly benefitted from the experience of the participants and collaborative work done at sea. Subsequent laboratory analyses are required to determine if we are successful in addressing our scientific objectives but the preliminary results are promising.

References:

Hassler, C., Djajadikarta, R.J., Doblin, M.A., Everett, J.D., Thompson, P. (2010) Characterisation of water masses and nutrient limitation of phytoplankton in the separation zone of the East Australian Current in spring 2008. Submitted to Deep Sea Research II, special issue on East Australia Current, *accepted 22 April, 2010*.

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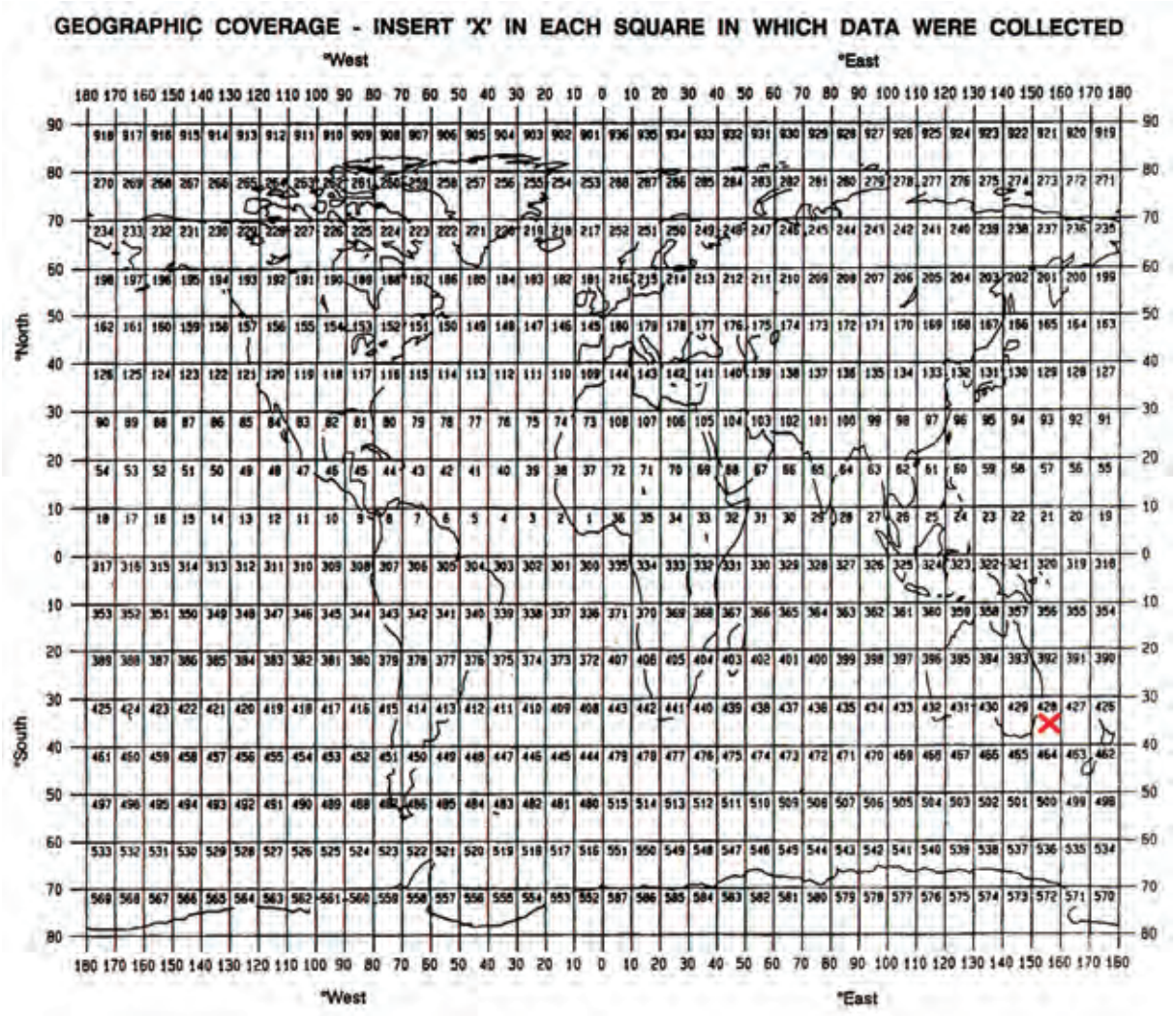
GEOGRAPHIC COVERAGE - INSERT 'X' IN EACH SQUARE IN WHICH DATA WERE COLLECTED
*West
*East
*North
*South

SUMMARY OF MEASUREMENTS AND SAMPLES TAKEN					
Item No.	**PI** see page above	**NO** see above	**UNITS** see above	**DATA TYPE**	**DESCRIPTION**
1	MNF	91	C	H10	Vertical profiles of Temperature, Salinity, Dissolved oxygen, fluorescence, transmissivity
2	MNF	91	C	H10	Temperature measurement at the top and bottom of each CTD
3	MNF	91	mg/L	H21	Salinity and dissolved oxygen to calibrate the sensors of the seabird 911, 2-3 sample per cast (depending on depth of CTD)
4	MNF	91	µg/L	H22, H24, H76, H26	Nutrients (NOx, Si, PO4 and NH4) associated with CTD deployment and incubation experiments done at Process stations.
5	A	27 48	mg C / ug chl-a/ m2/d	B01	Community 14C fixation at surface and fluorescence maximum (nominally chl-a maximum) for CTDs. Also, community 14C fixation for control (no addition), +NO3, +Fe, +Fulvic acid treatments for nutrient enrichment experiments done at Process stations. These require further analysis: the analysis of pigments (see below) and dissolved inorganic carbon concentration.
6	A, C	80	µg/L	B02	HPLC pigments from 4-6 depths at most CTD stations. These will be used to infer the biomass and the composition of the phytoplankton community. These samples were collected from the CTD deployments (top 100m) and incubation experiments done at process stations.
7	B	80		B09	Estimation of normalised size biomass spectrum (NBSS) present in the top 200 m from CTD deployment. There were problems with the data logger
8	A, C	80	µg/L	B71	Particulate carbon and nitrogen present at 2-3 depths from CTD deployments. These will need further analysis.
9	C	40	nM	H90, H30	Humic acid and total dissolved iron. These samples will require further analysis. Humic acid (µg/L) will be determined using electrochemistry. Dissolved iron (nM) will be analysed either by flow injection or by electrochemistry following UV-photo-oxidation.
10	H	15		B90	In situ vertical profiles measured with a Fast Repetition Rate Fluorometer. This estimates the optical properties of phytoplankton in terms of their capacity for photosynthesis.
11	H	30		B90	Measurements on discrete samples from numerous depths for most CTDs and for incubation experiments done at Process stations using a WaterPAM. These relate to photosynthetic health of the phytoplankton community and are used to infer nutrient limitation.
12	A and F	80	cells/mL	B90	Samples for the determination of picoplankton abundance using flow cytometry. These samples require further analysis. Samples were taken from the top 100m at CTD deployment and from incubation experiments done at Process stations.
13	D	15	µg C/ Chla d	B02	Measurement of surface HPLC pigments, particulate absorption, CDOM from CTDs coordinated with satellite overpasses (2 per day).
14	E			H17	Underway measurement of Salinity, temperature, chlorophyll fluorescence, turbidity, total absorption spectra, cdom absorption spectra, backscatter spectra.
15	F	80		B90	Prokaryotic diversity from discrete samples at 3 depths from CTDs as well as initial and final samples from nutrient enrichment experiments at process studies. Further analysis, whereby microbial DNA will be extracted from filters obtained during the voyage and community composition will be characterised using 16S rRNA tag pyrosequencing, will be completed during the next 6-12 months.
16	G	80		B08	Eukaryotic diversity from discrete samples at 3 depths from CTDs as well as initial and final samples from nutrient enrichment experiments at process studies. Further analysis is needed using 18S rDNA specific pyrosequencing tags and will be completed in the next 6-12 months.
17	MNF			H71	Underway data from To-yo/Nassal, measuring salinity, temperature
18	MNF			H71	Underway data from ship thermosalinograph, including salinity, temperature, chl-a fluorescence, pCO2

List of CTD locations

CTD	Date (UTC)	Time (UTC)	Latitude	Longitude
1	15-Oct-10	23:43:55	-32.9156	151.9499
2	16-Oct-10	1:35:25	-32.9184	152.0193
3	16-Oct-10	2:48:37	-32.9182	152.083
4	16-Oct-10	23:31:43	-30.8632	153.1453
5	17-Oct-10	2:39:10	-30.849	153.0575
6	17-Oct-10	4:36:32	-30.7836	153.0419
7	17-Oct-10	6:34:37	-30.7926	153.1904
8	17-Oct-10	8:26:55	-30.8121	153.3223
10	17-Oct-10	23:05:22	-29.3842	153.4334
11	18-Oct-10	0:42:41	-29.3762	153.4156
12	18-Oct-10	2:07:45	-29.3848	153.4067
13	18-Oct-10	3:28:44	-29.4068	153.3997
14	18-Oct-10	20:40:20	-28.8827	153.7929
15	18-Oct-10	22:23:28	-28.8787	153.7116
16	18-Oct-10	23:14:47	-28.8777	153.6349
17	19-Oct-10	0:32:30	-28.8825	153.635
18	19-Oct-10	1:41:53	-28.8798	153.6203
19	19-Oct-10	3:05:22	-28.8743	153.6263
20	19-Oct-10	4:06:13	-28.8701	153.6215
21	19-Oct-10	19:20:09	-29.146	154.3168
22	19-Oct-10	22:30:38	-29.1785	154.2584
23	19-Oct-10	23:19:56	-29.1912	154.2501
24	20-Oct-10	1:00:20	-29.1408	154.1473
25	20-Oct-10	2:28:49	-29.1436	153.982
26	20-Oct-10	3:16:20	-29.1445	153.9323
27	20-Oct-10	5:06:32	-29.1424	153.8164
28	20-Oct-10	6:25:47	-29.1484	153.7155
29	20-Oct-10	7:37:57	-29.1429	153.6162
30	20-Oct-10	8:36:29	-29.1411	153.5104
31	20-Oct-10	21:35:36	-29.1376	154.3147
32	20-Oct-10	23:02:37	-29.1541	154.2994
33	21-Oct-10	0:40:44	-29.1761	154.2756
34	21-Oct-10	3:30:32	-29.2388	154.2675
35	21-Oct-10	5:33:20	-29.2857	154.2354
36	21-Oct-10	7:12:25	-29.3293	154.2115
37	21-Oct-10	8:10:59	-29.3532	154.1946
38	21-Oct-10	21:37:03	-29.6547	154.1842
39	21-Oct-10	22:48:45	-29.677	154.1673
40	21-Oct-10	23:35:33	-29.6931	154.1598
41	22-Oct-10	3:23:11	-29.7826	154.1032
42	22-Oct-10	4:34:32	-29.8167	154.0895
43	22-Oct-10	6:34:32	-29.8791	154.0578
44	22-Oct-10	8:00:22	-29.9308	154.0323
45	22-Oct-10	21:31:53	-30.3287	154.0913
46	22-Oct-10	22:41:08	-30.3644	154.0849
47	22-Oct-10	23:29:56	-30.3926	154.0821
48	23-Oct-10	3:29:39	-30.8281	154.4767
49	23-Oct-10	6:55:41	-31.0155	154.6707
50	23-Oct-10	23:43:05	-32.0086	153.9599
51	24-Oct-10	4:51:11	-32.5922	153.6471
52	24-Oct-10	20:38:31	-32.1652	153.583
53	24-Oct-10	22:20:02	-32.2657	153.5839
54	24-Oct-10	23:31:49	-32.3682	153.5817
55	25-Oct-10	1:01:39	-32.3542	153.5811
56	25-Oct-10	3:44:02	-32.4568	153.5887
57	25-Oct-10	5:54:03	-32.5679	153.582
58	25-Oct-10	19:43:19	-32.2982	154.3888
59	25-Oct-10	21:38:10	-32.2965	154.1298
60	25-Oct-10	22:59:51	-32.2958	154.0039
61	26-Oct-10	1:17:23	-32.2932	153.8342
62	26-Oct-10	3:23:08	-32.2933	153.6177
63	26-Oct-10	4:33:10	-32.2727	153.6267
64	26-Oct-10	6:32:51	-32.2944	153.451
65	26-Oct-10	8:05:28	-32.3027	153.2802
66	26-Oct-10	10:01:31	-32.295	153.1164
67	26-Oct-10	20:33:35	-32.2942	152.9988
68	26-Oct-10	23:26:19	-32.2949	152.8994
70	27-Oct-10	1:35:46	-32.2983	152.7953
71	27-Oct-10	2:57:04	-32.2956	152.6919
72	27-Oct-10	23:29:18	-34.9007	150.8308
73	28-Oct-10	1:00:13	-34.8873	150.8901
74	28-Oct-10	2:05:39	-34.814	150.9656
75	28-Oct-10	3:59:54	-34.8131	150.8559
76	28-Oct-10	13:23:13	-36.0831	151.4999
77	28-Oct-10	14:26:32	-36.0845	151.4953
78	28-Oct-10	23:30:09	-35.248	150.6241
79	29-Oct-10	2:08:02	-35.1599	150.8751
80	29-Oct-10	3:30:13	-35.123	150.8162
81	29-Oct-10	6:50:55	-35.2165	150.9893
82	29-Oct-10	22:04:01	-34.1041	151.2249
83	29-Oct-10	23:27:52	-34.1145	151.218
84	30-Oct-10	3:32:45	-34.1146	151.2183
85	30-Oct-10	4:35:18	-34.1142	151.2186
86	30-Oct-10	7:02:55	-34.0897	151.2064
87	30-Oct-10	20:28:51	-33.898	151.3161
88	30-Oct-10	21:30:34	-33.9429	151.381
89	30-Oct-10	22:38:46	-33.9915	151.4549
90	31-Oct-10	2:04:01	-33.9891	151.3148
91	31-Oct-10	3:37:37	-33.8341	151.3063

CURATION REPORT	
Item No.	**DESCRIPTION**
1	The organisational unit is the Marine National Facility. Data will be made available after a 2-year embargo.
2	The organisational unit is the Marine National Facility. Data will be made available after a 2-year embargo.
3	The organisational unit is the Marine National Facility. Data will be made available after a 2-year embargo.
4	The organisational unit is the Marine National Facility. Data will be made available after a 2-year embargo.
5	The organisational units is the University of Technology Sydney. Data will be made available on national meta-database. A timeframe of 2 years is expected to analyse the samples and publish the results.
6	The organisational units is the University of Technology Sydney. Data will be made available on national meta-database. A timeframe of 2 years is expected to analyse the samples and publish the results.
7	The organisational unit is the University of New South Wales. Data will be made available on national meta-database. A timeframe of 2 years is expected to analyse the samples and publish the results.
8	The organisational units is the University of Technology Sydney. Data will be made available on national meta-database. A timeframe of 2 years is expected to analyse the samples and publish the results.
9	The organisational units is the University of Technology Sydney. Data will be made available on national meta-database. A timeframe of 2 years is expected to analyse the samples and publish the results.
10	The organisational units is the University of Technology Sydney. Data will be made available on national meta-database. A timeframe of 2 years is expected to analyse the samples and publish the results.
11	The organisational units is the University of Technology Sydney. Data will be made available on national meta-database. A timeframe of 2 years is expected to analyse the samples and publish the results.
12	The organisational units is the University of Technology Sydney. Data will be made available on national meta-database. A timeframe of 2 years is expected to analyse the samples and publish the results.
13	The organisational unit is the CSIRO Land and Water. Data will be made available on the CSIRO Bio-optics data base. Data will also be made available to NASA and ESA. after the 2-year delay.
14	The organisational unit is NSW Department Environment, Climate Change and Water and CSIRO Land and Water. Data will be made available via the IMOS bioptical database after 2 years for analysis and publication.
15	The organisational units are the University of Technology Sydney and the University of New South Wales. Data will be made available on national meta-database. A timeframe of 2 years is expected to analyse the samples and publish the results.
16	The organisational unit is the University of New South Wales. Data will be made available on national meta-database. A timeframe of 2 years is expected to analyse the samples and publish the results.
17	The organisational unit is the Marine National Facility. Data will be made available after a 2-year embargo.
18	The organisational unit is the Marine National Facility. Data will be made available after a 2-year embargo.

Voyage track

The following figure shows the entire voyage track, indicating significant coverage of the NSW coastline. The figures in the Appendix show CTD locations (see list above for exact latitude and longitude), showing our investigations of river plumes in northern and southern NSW, the EAC, a cold core eddy, two warm core eddies (one off Newcastle, the other off Batemans Bay), and several cross shelf transects.

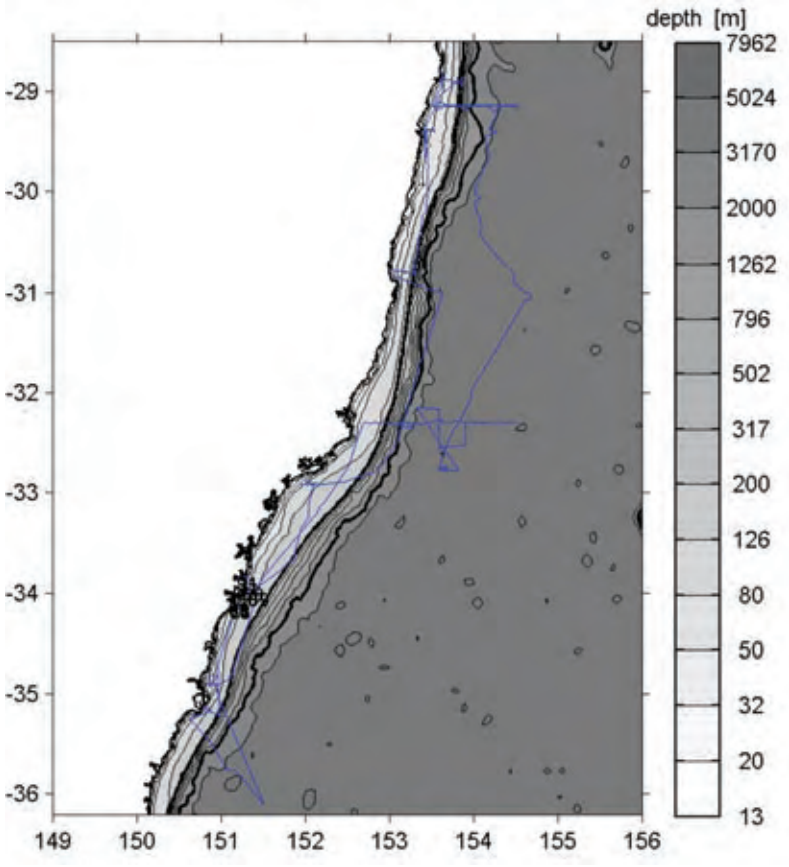

Figure 1: Voyage track. Figure produced by Mark Baird.

Personnel list

Scientific Participants

Name	Affiliation	Role
Martina Doblin	UTS	Chief Scientist – Biological Oceanographer / Biogeochemist
Mark Baird	UTS / CSIRO Marine and Atmospheric Research	Alternate Chief Scientist – Physical Oceanographer
Nagur Cherukuru	CSIRO Land and Water	Satellite Remote Senser / Modeller
Janet Anstee	CSIRO Land and Water	Satellite Remote Senser / Modeller
Peter Davies	NSW DECCW	Satellite Remote Senser / Biological Oceanographer
Justin Seymour	UTS	Microbial ecologist
Mark Brown	UNSW	Microbial ecologist
Jim Franklin	UTS	Optics specialist
Katherina Petrou	UTS	Biological oceanographer / PhD student
Massimo Pernice	University of Barcelona	PhD Student
Drew Mills	CMAR	MNF Electronic support
David Terhell	CMAR	MNF Hydrochemistry support
Peter Hughes	CMAR	MNF Hydrochemistry support
Hiski Kippo	CMAR	MNF Computing support
Don McKenzie	CMAR	MNF Voyage Manager

Marine Crew

Name	Role	Name	Role
Les Morrow	Master	Gareth Gunn	IR
John Boyes	First Mate	Mark Barnden	IR
Simon Smeaton	Second Mate	Jonathan Lumb	IR
Upendra Kapugeekiyana	Chief Engineer	Graham McDougall	IR
Paul Bucaille	1st Engineer	Alan Martin	Chief Steward
Graeme Perkins	2nd Engineer	Geoffrey Coulson	Chief Cook
Tony Hearne	Chief IR	Bruce Maher	2nd Cook

Acknowledgements

I would like to thank the voyage participants, including colleagues at UTS, CSIRO Land and Water, the NSW Department of Environment, Climate Change and Water and the University of New South Wales. The voyage would not have been possible without financial or salary contributions from all of the participating institutions as well as CSIRO Marine and Atmospheric Research, but Attila Brungs (DVCR, UTS) is especially thanked for covering ship hire and victualling costs. The Sydney Institute of Marine Science is thanked for use of the Fast Repetition Rate Fluorometer, Michael Ellwood (Australian National University) for use of the deckboard incubator, Brian Griffiths, Martin Lourey and James McLaughlin (CSIRO Marine and Atmospheric Research) for the primary productivity equipment, Paul Daniel and Rebecca Edwards (CSIRO Land and Water) for their assistance with optical instruments and calibration, Jason Everett for sending daily satellite images to the ship, Vinod Kumar, Marlene Zbinden and technical staff at UTS for assistance in voyage preparation and ship loading/unloading and Peter Ralph for professional and personal support.

I would like to thank the ARC Discovery Project scheme (DP 1092892) for funds to support the productivity and CDOM analyses.

The application for ship time was initiated by Dr Christel Hassler and Dr Michael Ellwood was one of the original PIs – both are thanked for their energy and collaboration.

I also would like to thank the MNF for their support on this research voyage, given the shift in emphasis from micronutrients to molecular analyses. Finally, I would like to thank all the Marine National Facility and their staff as well as the crew of the RV *Southern Surveyor* as without them this voyage would not have been possible.

Martina Doblin
Chief Scientist

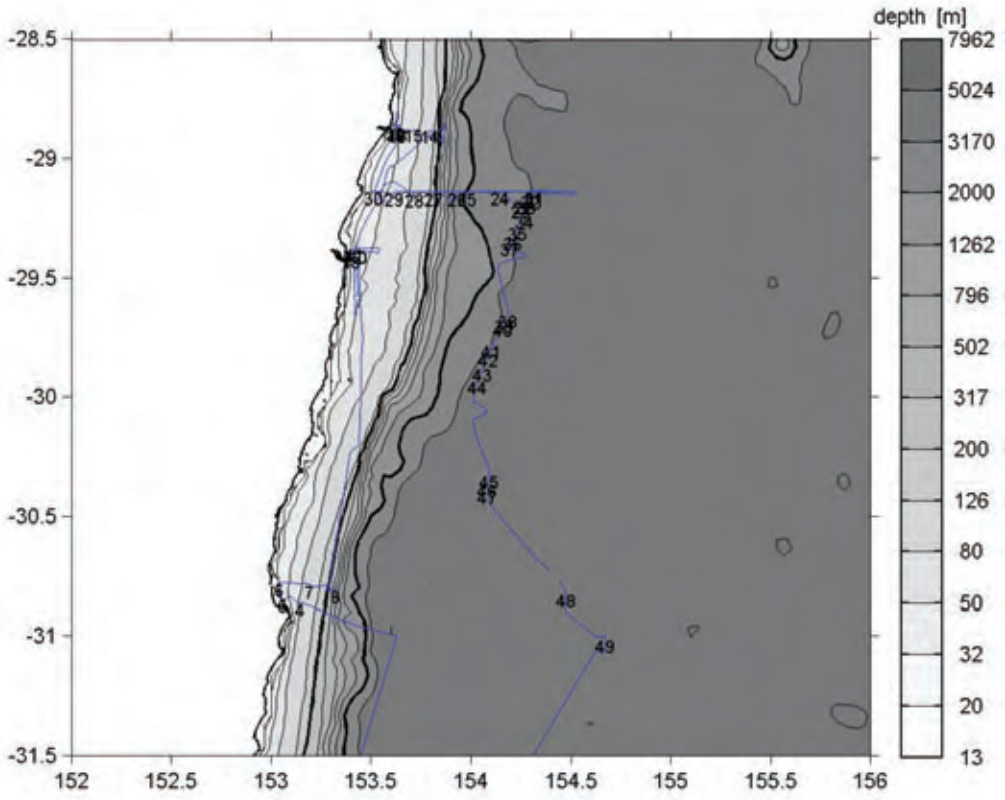

Figure 2: Northern investigations of the Macleay, Clarence and Richmond Rivers, East Australian Current and warm core eddy (CTD station 49 was eddy centre). Figure produced by Mark Baird.

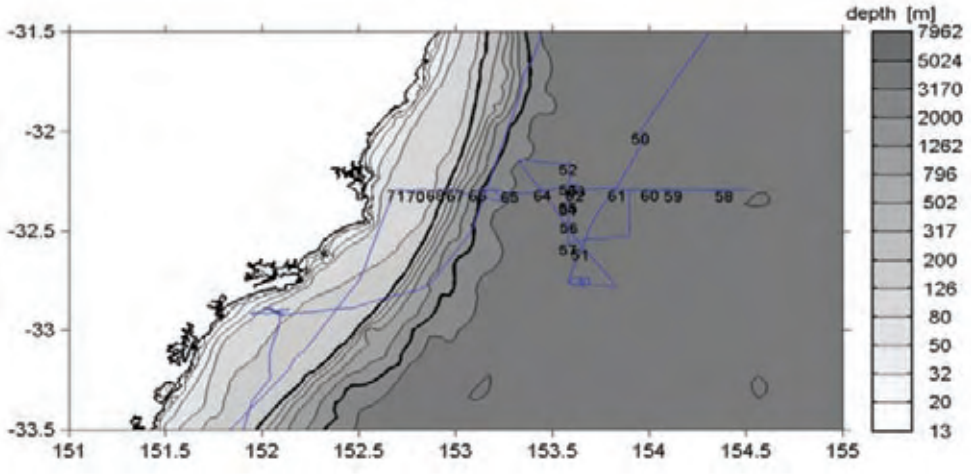

Figure 3: Investigations across a cold core eddy, partially flooded by the EAC. Figure produced by Mark Baird.

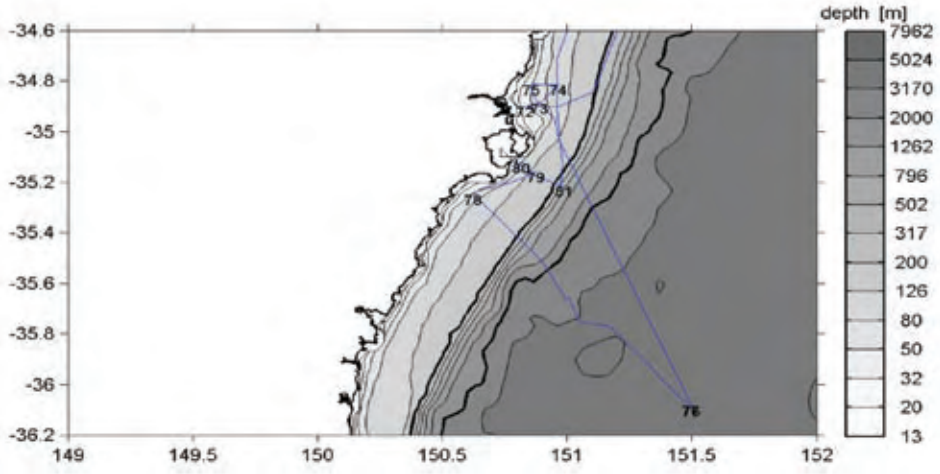

Figure 4: Southern investigations of the Shoalhaven River plume, and the centre of a second warm core eddy off Batemans Bay (CTDs 76 and 77). Figure produced by Mark Baird.

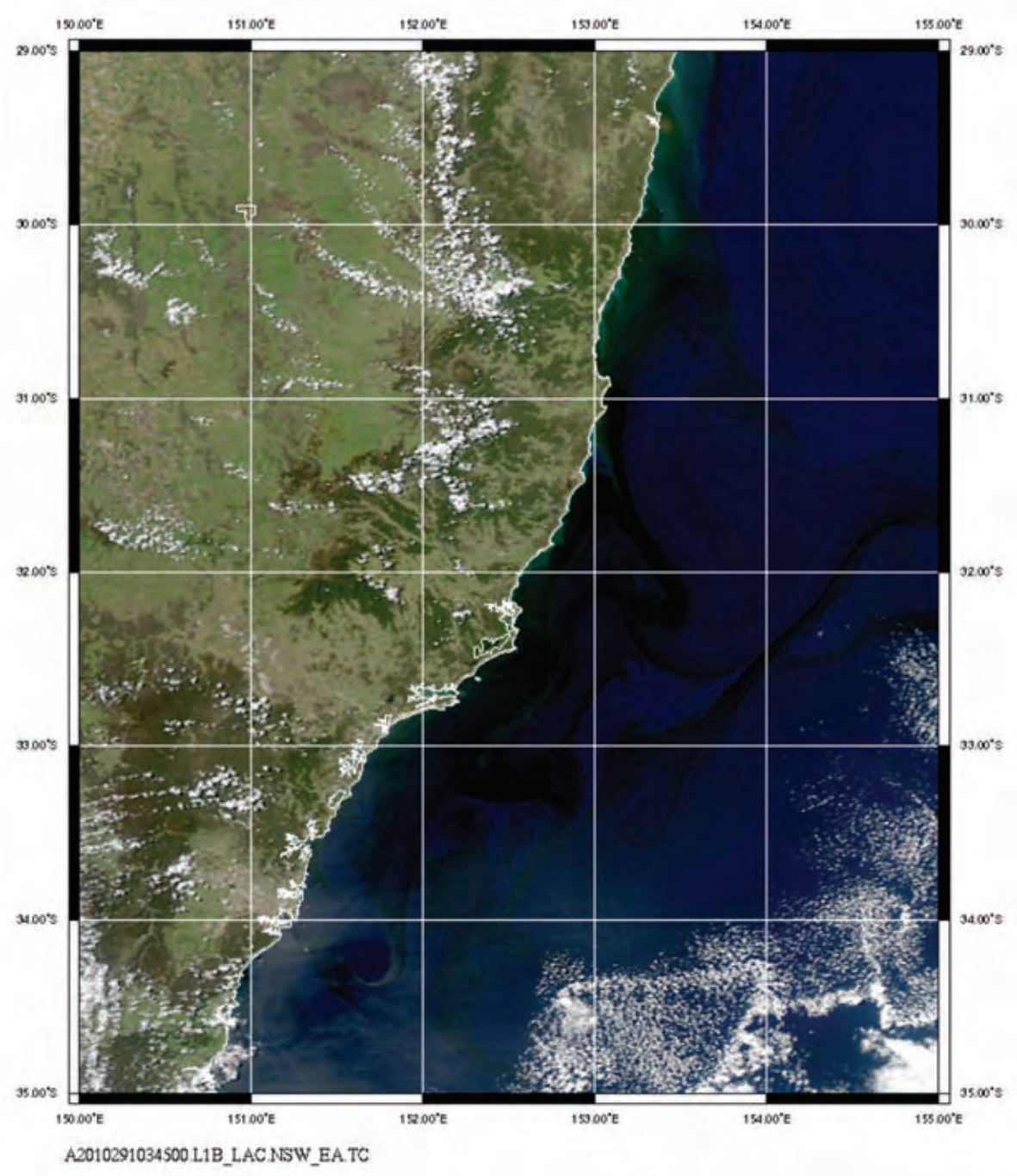

Figure 5: True colour image of NSW coast on 29 October, 2010.

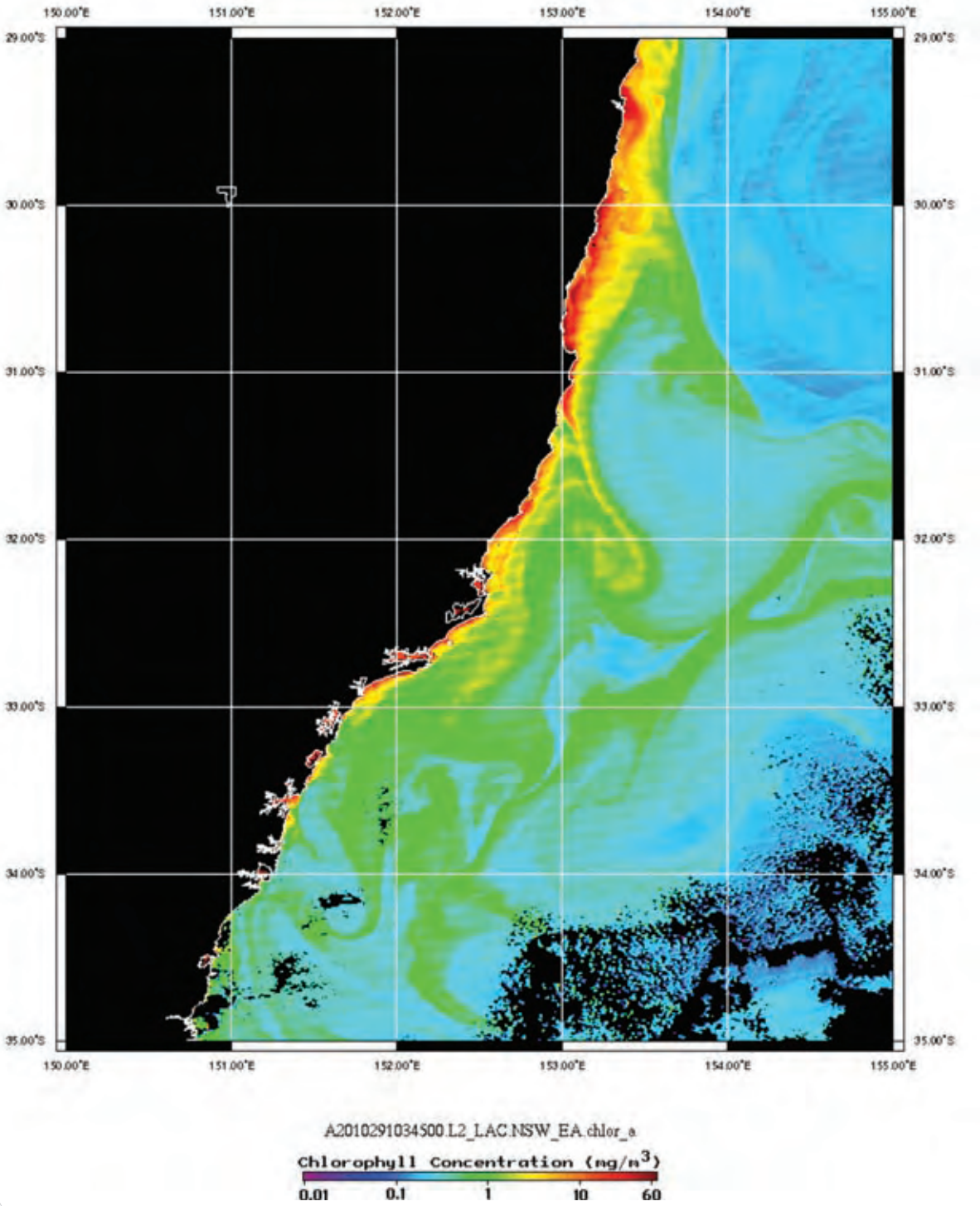

Figure 6: Ocean colour (surface chlorophyll-a) image of NSW coast on 29 October, 2010.

CSR/ROSCOP PARAMETER CODES

METEOROLOGY

M01 Upper air observations
M02 Incident radiation
M05 Occasional standard measurements
M06 Routine standard measurements
M71 Atmospheric chemistry
M90 Other meteorological measurements

PHYSICAL OCEANOGRAPHY

H71 Surface measurements underway (T,S)
H13 Bathythermograph
H09 Water bottle stations
H10 CTD stations
H11 Subsurface measurements underway (T,S)
H72 Thermistor chain
H16 Transparency (eg transmissometer)
H17 Optics (eg underwater light levels)
H73 Geochemical tracers (eg freons)
D01 Current meters
D71 Current profiler (eg ADCP)
D03 Currents measured from ship drift
D04 GEK
D05 Surface drifters/drifting buoys
D06 Neutrally buoyant floats
D09 Sea level (incl. Bottom pressure & inverted echosounder)
D72 Instrumented wave measurements
D90 Other physical oceanographic measurements

CHEMICAL OCEANOGRAPHY

H21 Oxygen
H74 Carbon dioxide
H33 Other dissolved gases
H22 Phosphate
H23 Total - P
H24 Nitrate
H25 Nitrite
H75 Total - N
H76 Ammonia
H26 Silicate
H27 Alkalinity
H28 PH
H30 Trace elements
H31 Radioactivity
H32 Isotopes
H90 Other chemical oceanographic measurements

MARINE CONTAMINANTS/POLLUTION

P01 Suspended matter
P02 Trace metals
P03 Petroleum residues
P04 Chlorinated hydrocarbons
P05 Other dissolved substances
P12 Bottom deposits
P13 Contaminants in organisms
P90 Other contaminant measurements