Australian participation in KEOPS:

1. Science

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Overview

- Slide 3. List of participants and their research areas
- Slide 4. List of major equipment
- Slides 5-17. Brief descriptions of research projects
- Slides 18-19. References cited – available as .pdfs

Australian participation

- Tom Trull (ACE CRC)
  - δ^{13}C-DIC, δ^{13}C-POC, δ^{15}N-NO_3, δ^{15}N-PON
  - size-fractionated suspended particles, sinking particles
  - contribution to new/recycled/exported production estimates
- Andrew Bowie (ACE CRC)
  - size-fractionated dissolved and particulate iron, contribution to iron budgets, tracers for aerosol iron inputs
- Brian Griffiths (CSIRO)
  - ^{14}C primary production, bio-optics, CDOM samples
- Leanne Armand (CSIRO)
  - diatom taxonomy, fluorescent tracers of species-specific silicification
- Lisette Robertson (ACE CRC)
  - trace-metal clean “fish”, pump, and trap deployments; sample processing

Australian major equipment

- National Facility Trace Metal Clean Laboratory Container
- ACE/AAD/CMR Radioisotope Laboratory Container
- Trace-metal clean towed “fish” underway sampler
- Trace-metal polycarbonate hydrocast samplers (10x6L)
- Submersible pump for large volume particle sampling in top 120m - returns 50 L/min to deck via hose, distributed to 5x142mm filter rigs for size fractions (200, 55, 20, 5, 1 microns) - water available to others - Ba, REE, DMSP, POC/^{234}Th, etc.
- Free-drifting surface tethered, Argo-GPS, McLane 13-cup sediment trap for sinking particles (trace-metal clean). Particles available to others - Ba, REE, DMSP, POC/^{234}Th (*This replaces the earlier proposed moored sediment trap*).

Trull science synopsis 1

- Identification of phytoplankton responsible for export
- Contribution to KEOPS Objective 2.2 “Export”
- Method:
  - Comparison of ^{13}C-POC compositions of different size fractions (200, 55, 20, 5, 1 µm) with ^{13}C-DIC enrichments in surface waters produced by seasonal DIC depletion
- Reference:
  - Trull, T.W., and L. Armand, Deep-Sea Research II, 48 (11/12), 2655-2680, 2001
- Samples:
  - ^{13}C-DIC profiles from CTD Niskins, 6 sites, 12 depths, 250mls
  - ^{13}C-DIC surface samples from CTD Niskins, ~30 sites, 250mls
  - ^{13}C-POC samples on size-fractions from submersible pump, 6 sites, 5 depths
  - ^{13}C-POC samples from free-drifting conical-trap
- Cooperation:
  - Conical-trap and size-fractionated suspended particles available for Ba, POC/^{234}Th, etc., Comparison to DIC and POC measurements (OISO, F.Diaz)

Trull science synopsis 2

- Examination of new versus recycled production
- Contribution to KEOPS Objective 3. “Biogeochemical Processes”
- Method:
  - Comparison of ^{15}N -NO_3 and ^{15}N -PON compositions to distinguish new vs. recycled production, and possible response to Fe - new production is ^{15}N rich, and increases with Fe availability.
- Reference:
  - Karsh, K.L., T.W. Trull, M.J. Lourey, and D.M. Sigman, Limnology and Oceanography, 48, 1058-1068, 2003.
- Samples:
  - ^{15}N -NO_3 profiles from CTD Niskins, 6 sites, 12 depths, 250mls
  - ^{15}N -NO_3 surface samples from CTD Niskins, ~30 sites, 250mls
  - ^{15}N -PON samples on size-fractions from submersible pump, 6 sites, 5 depths
  - ^{15}N -PON samples from free-drifting conical-trap
- Cooperation:
  - Comparison to ^{15}N incubation-based estimates of new and recycled production
  - Benefits from ammonium determinations – if these are planned?

Trull science synopsis 3

- Calibration of ^{13}C and ^{15}N signatures of biological pump strength
- Contribution to KEOPS Objective 2.2 "Export"
- Contribution to KEOPS Objectives 3. "Biogeochemical Processes"
- Method:
  - Comparison of ^{15}N N-PON compositions with seasonal nitrate depletion
  - Comparison of ^{13}C-POC compositions with surface pCO_2 values
  - Comparison of Fe-rich KEOPS results with Fe-poor SAZ results
- References:
  - Lourey, M.J., T.W. Trull, and D.M. Sigman, Global Biogeochemical Cycles, 17 (3), 1081,doi:10.1029/2002GB001973, 2003
  - Lourey, M.J., T.W. Trull, and B. Tilbrook, DSR I, 51 (2), 281-305, 2004
- Samples:
  - Conical-Trap and size-fractionated suspended particles
- Cooperation:
  - Requires pCO_2 determinations from OISO team, and CTD nitrate analyses

Bowie science synopsis 1

- Size-fractionated filtration: soluble and colloidal iron distribution
- Extends preliminary iron distribution studies above the Kerguelen plateau
- Compare physical speciation: Kerguelen plateau & open Southern Ocean
- Lab-based aluminium measurements for use as tracer of aerosol iron
- Hypothesis:
  - #1: In productive waters above the Kerguelen plateau, colloidal iron dominates the dissolved pool
  - #2: During phytoplankton growth, the dominant form of dissolved iron shifts from soluble to colloidal species
- Contribution to KEOPS objectives:
  - 1: Which mechanisms are responsible for deep waters iron enrichment, and subsequent upward transfer to the surface layer?
  - 2: Aerosols as a source of iron to the ocean
  - 3: Remineralisation and iron speciation

Bowie science synopsis 2

- Soluble and colloidal iron distribution
- Sampling
  - Underway: near-surface water using polyurethane coated towed torpedo fish and trace metal clean pumping system
  - Water column: vertical profiling by hydrocast using trace metal clean Go-Flo bottles/polycarbonate samplers deployed off Kevlar hydroline
- Processing and analysis
  - Nitrogen gas over pressurisation, sequential filtration through 0.02 (Anotop), 0.2 and 0.4 micron filters
- Analysis
  - Shipboard flow injection with luminol chemiluminescence detection, (Bowie et al. 1998)
  - Aluminium by FIA-fluorescence

Defined Fe fraction	*Size-fraction*
Truly soluble	<0.02 µm
Colloidal	0.02-0.4 µm
Dissolved	<0.4 µm
Total dissolvable	Unfiltered, TDFe
Labile particulate	Unfiltered - dissolved

Bowie science synopsis 3

- Iron content & nutrient ratios (Fe:C) of suspended and sinking particles
  - Size-fractionated trace metal distribution in 4 fractions
- Removal of surface-bound iron from phytoplankton
  - Use of novel trace metal clean reagents (Tovar-Sanchez et al., 2003)
- Improvement of ecosystem structure within biogeochemical models
  - Mass balance of export enables us to close the iron budget
- Hypothesis:
  - #1: Iron is effectively removed from the dissolved (soluble) phase during bloom conditions and bound up in biogenic particles associated with large phytoplankton species
  - #2: Iron is retained in the mixed layer via efficient trophic cycling within the food-web, and Fe:C ratios increase due to alleviation of Fe limitation
  - #3: During bloom senescence, biogenic iron is exported to depth and predominantly associated with large sinking particles
- Contribution to KEOPS objectives:
  - #2.2: Quantification of carbon flux exported below the depth of the winter mixed layer.
  - #3: Remineralisation and iron speciation

Bowie science synopsis 4

- Sampling: suspended particulate material
  - Clean seawater supplied via towfish and/or polycarbonate hydrocast samplers
  - Sequential filtration through four 47 mm filters (210, 55, 20, 2 micron) held in a Teflon PFA stack (Savillex)
- Sampling: sinking particulate material
  - Free-floating time-series funnel-type sediment trap
  - 150-300 m (?) depth, sample collection every 3 days
  - Cups filled with a brine solution; organic poison used as a preservative
  - Material filtered through a sequence of size-fractionated filters housed in a polypropylene stack (see above)
- Digestion and analysis
  - Teflon PFA bombs (Savillex) using H_2O_2 (organics) and HNO_3/HF at 120°C for 4 h (marine particles)
  - High resolution ICP-MS of up to 10 elements

Griffiths science synopsis 1

- P vs E Hypotheses:
  - Primary production, photosynthetic parameters, and DOC production rates will be higher in areas naturally enriched with iron than non-enriched areas.
- Methods: small-bottle, P vs E incubations

  (Griffiths et al, JGR 104(D17) 21649-21671,1999).
- Sampling:
  - Standard P vs E: 250ml from 6 depths in mixed layer, one depth below. Samples from CTD casts or trace-metal clean bottles.
  - DOC release rates: 500 ml from 2 depths in mixed layer, one below. Samples from CTD or trace-metal clean bottles.
  - One station per day
- Cooperation or other data needed:
  - Chlorophyll at each sampling depth; fluorometer profiles.
  - Production data available to other participants.
- Contribution to KEOPS Objectives 2.2 and 3.1

Griffiths science synopsis 2

- Measurement: Size-fractionated primary production by simulated in-situ deck incubations.
- Hypothesis:
  - Regions with naturally high iron will have higher gross and net primary production, and a higher portion of the primary production in the largest phytoplankton size classes.
- Sampling:
  - Incubations using water from six depths with about 2.5 litres per depth.
  - Gross (daytime) and 24 hour production to be measured.
  - Require water to be taken from CTD cast before dawn.
  - Need chlorophyll concentration for each depth (fluorometry?)
  - Provide deck incubator, but need 5-10 l minute^{-1} seawater for cooling.
- Method: Standard JGOFS Protocol
- Contribution to KEOPS Objectives 2.2 and 3.1

Griffiths science synopsis 3

- Nutrient limitation studies
  - Contrast possible nutrient limitation, particularly silicate, in phytoplankton by measuring the fluorescence response to nutrient addition.
  - Determine if nutrient limitation is occurring in some of the OBEX incubation studies, or if nutrient limitation has relaxed following amendment treatments (possible collaboration area).
  - Experimental technique being developed.
  - Require 25 ml samples from CTD casts or incubation bottles.

- Underway Measurements
  - Distribution of CDOM in surface waters via fluorometry.
  - Determine contribution of CDOM to remotely sensed chlorophyll-a
  - Diel patterns in photosynthetic characteristics and fluorescence in surface waters in relation to PAR
  - More realistic representation of diel patterns in photosynthetic rate in models of primary production.
  - Sampling: need to be able to put two fluorometers and a Fast repetition-rate fluorometer in-line with thermosalinograph.

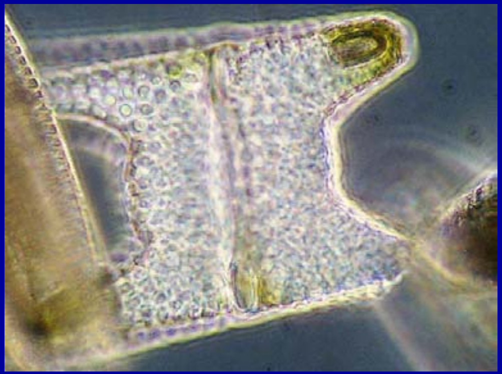
- Contribution to KEOPS Objective 3.1

Griffiths science synopsis 4

- Explore factors impacting on primary production models.
  - Diel patterns in photosynthetic parameters measured by P vs E and Fast repetition-rate fluorometer (FRRF) methods for P^{b}_{opt} type primary production models.
  - Determine the contribution of coloured dissolved organic matter (CDOM) to remotely sensed chlorophyll-a.
  - Measure spectral absorbance of phytoplankton and FRRF methods for input into quantum yield type primary production models.
- Sampling
  - Photosynthetic parameters from ^{14}C small bottle incubations.
  - CDOM via continuous underway sampling or 100ml samples from CTD.
  - Spectral absorbance: 1-2 litres at 4 depths in the mixed layer (same depths as P vs E samples).
  - FRRF profiles on the CTD.
- Cooperation
  - Chlorophyll-a and pigments for the spectral absorbance samples.
  - Mounting FRRF and battery pack on the CTD rosette
  - The fraction of primary production in the largest phytoplankton size classes will be greatest in regions of highest iron concentration.

- Contribution to KEOPS Objective 2.2

Armand science synopsis 1



- Identification of Diatoms
- Contribution to KEOPS Objectives:
  - 3.1 Structure of Phytoplankton communities
  - 2.2 Export
- Method:
  - Qualitative assessment via semi or permanent smear slide analysis.
  - Quantitative assessment through lab-based silica selective treatments (based on Schrader and Gersonde, 1978) (restricted capacity, known volume sampling/splits required, pursued only in cooperation).
- Samples:
  - As provided by Australian and French team during various sampling protocols (eg. ~10-50ml per depth per CTD-max 3 depths, sediments 1cm^3).
- Cooperation:

Please raise your anticipated needs for identification or quantitative analysis now!

Armand science synopsis 2

- Silica Uptake Kinetic Experiments -
  (under the Quéguiner program umbrella)
- Contribution to KEOPS Objectives:
  - 3.1 Structure of Phytoplankton communities
- Method and samples:
  - Under guidance of B. Quéguiner (LOB)
- Cooperation:
  - Dependent on EU funding.

References (available as .pdfs)

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