IOCCG/GEOHAB Working Group
on Harmful Algal Blooms and Ocean Colour

Report from First WG Meeting, August 2010, Schulphoek, South Africa

October 2010, Stewart Bernard

Working Group Members Present: Stewart Bernard (Chair, Council for Scientific and Industrial Research, South Africa), Raphael Kudela (University of California Santa Cruz, USA), Suzanne Roy (Universite du Quebec a Rimouski, Canada), Michel Starr (Ministère des Pêches et des Océans, Canada), Mark Dowell (Joint Research Centre, European Commission), Tim Moore (University of New Hampshire, USA), Pat Glibert (University of Maryland, USA), Grant Pitcher (Department of Agriculture, Forestry and Fisheries, South Africa), Mark Matthews (University of Cape Town, South Africa) ,
Working Group Members Absent: Jeremy Werdell (NASA Goddard Space Flight Center, USA), Claudia Giardino (Consiglio Nazionale delle Ricerche, Italy), Stefan Simis (Finnish Environment Institute, Finland), Yu-Hwan Ahn (Korea Ocean Research and Development Institute, Korea), Chuanmin Hu (University of South Florida, USA), Tiit Kutser (Tartu University, Estonia)
Local Observers: Christo Whittle (University of Cape Town, South Africa), Lisl Robertson (University of Cape Town, South Africa)

1. Summary

The meeting, attended by ± 10 people, resulted in extremely good progress in determining the main focus, outputs and desired impact of the WG; and the structure and focus areas of the IOCCG/GEOHAB monograph as the first major output of the WG. Key considerations of the WG activities were determined as follows:

- A core aim of the WG is provide a resource that greatly improves communication between the ocean colour and harmful algal bloom scientific communities: informing the HAB community of the options, benefits and limitations of available ocean colour techniques; and informing the ocean colour community of the wide variety of HAB types, means of classifying them, and options for ecosystem-specific contextualisation of ocean colour data. The resource should also address the needs of non-specialist scientists, students, environmental and resource managers, and decision- and policy- makers.

- The ecological/regional contextualisation of ocean colour techniques and products is extremely important for most effective HAB application of ocean colour data: such consideration is consistent with the regional approaches needed for any effective ocean colour utilisation in optically complex coastal and inland waters.

- The GEOHAB comparative ecosystem approach is important and useful, and provides a means of classifying ocean colour techniques with regard to major organism type, impacts, geographical distribution, and ecosystem/ecological function.

- The case studies will form a valuable part of the WG output in demonstrating ocean colour utility and performance of both commonly available and emerging ocean colour techniques for specific bloom/ecosystem examples.

An example of the consensus perspective adopted by the group on the importance of ecosystem/ecological characterisation, and the amenability of bloom types to detection through ocean colour radiometry, is briefly presented below. The Margalef mandala is a

common way of examining algal succession by characterising the ecological niche in which different species or groups are most likely to proliferate (Margalef 1978, *Oceanol. Acta* 1:493-509). The variety of blooms that will be focused on in the case studies are shown in the mandala in Figure 1A. Many harmful algal species can have impact at very low cell concentrations, as a minor component of the algal assemblage, or as subsurface blooms with no bio-optical surface expression. Viewing the mandala from an ocean colour perspective (Figure 1B), it is clear that only high nutrient-demand/biomass blooms are likely to be directly detectable using ocean colour - regardless of the algorithm type or technique used. Using ocean colour as one component of a multi-parameter ecosystem classification - effectively using the mandala to create an earth observation based metric - will potentially allow the detection of some other bloom types.

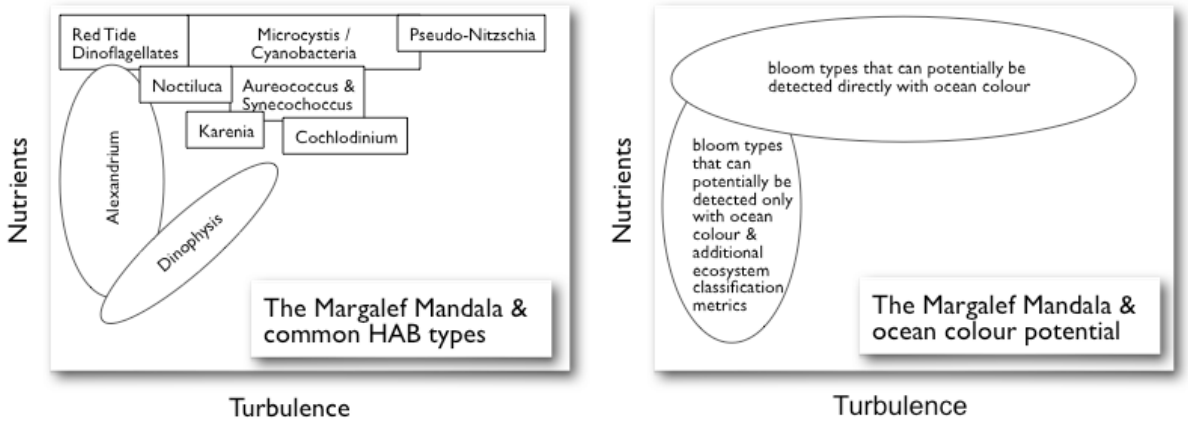

Figure 1. The Margalef mandala, with bloom types corresponding to the case studies (A, left), and the ecological spaces in the mandala amenable to observation with ocean colour radiometry alone, and with additional ecological information (B, right).

2. Meeting Structure

A brief outline of the meeting structure is given below.

Tuesday, 24th August

Introduction & overview of the WG, with review of terms of reference. Introduction to ocean colour and algorithm types. Ocean colour, (Harmful) Algal Blooms and bio-optics: assessing the assemblage related information content. Assessment of the IOCCG Phytoplankton Functional Type WG and mandate differences. Spectral classification of ocean colour water types. Introduction to GEOHAB Core Research Projects. Introduction and discussion of aims and objectives of case studies. HABS in upwelling systems: examples and potential case studies from the Benguela and California systems, with discussion of additional studies.

Wednesday, 25th August

Approaches to earth observation based ecological classification. HABs in eutrophic systems: examples and potential case studies from the Chesapeake Bay, Korean and inland systems, with discussion of additional studies. HABs in stratified systems: examples and potential case studies from the California system, with discussion of additional studies. HABs in fjords and coastal embayments: examples and potential case studies from the St. Lawrence, with discussion of additional studies.

Thursday August 26th

Further review of terms of reference, objectives and deliverables. Options for monograph format and journal special issue. The Margalef mandala and ocean colour: determining

classification options for case studies. Design of monograph structure and assigning chapters/sub-chapters to WG members. Design of case study formats, determination of potential case studies, assigning case study leads to WG members. Determination of final work plan, timelines and options for next WG meeting.

The potential case studies, highlighted as a central component of the monograph and subsequent outputs, are shown below in Table 1. Case study selection, here classified by causative organism, shows the focus on the comparative ecosystem approach, the importance of high quality *in situ* data, and the broad geographical representation of the events the WG hopes to use to examine bloom relevant ocean colour techniques. Many of the case studies are “Champion User” sites in the ESA CoastColour project, and discussion has started with CoastColour as to how to use this overlap to both group's advantage.

Table 1. Proposed HAB case studies by genus or group, the ecosystems and dates of blooms which will be targeted, the GEOHAB Core Research Program (CRP) classification of the ecosystem, the potential suitability of the bloom for ocean colour based observations, and the availability of in situ data for the bloom period.

Genus/Group	Ecosystem	Date	CRP	OCR suitability	In Situ Data
Cochlodinium	Chesapeake Bay	August 2008	Eutrophic	2	4.5
	Korea	tbd	Eutrophic	4	tbd
	Gulf of Oman	August 2008–May 2009	Eutrophic	4	3
Alexandrium	St Lawrence	August 2008	F & CE	3	3.5
	Chile	tbd	F & CE	3	2.5
	Gulf of Maine	tbd	F & CE	1	3.5
	California	tbd	Upwelling	5 & 1	4 – 5
	Benguela	October 2002	Upwelling	5 & 1	3
Pseudo-Nitzschia	California	tbd 2002-2006	Upwelling	5 & 1	5
	Benguela	March 2006	Upwelling	5	3.5
Red Tides	California	tbd 2002-2006	Upwelling	5	4 – 5
	Benguela	February – May 2009	Upwelling	5	4
	Peru	tbd	Upwelling	5	tbd
Aureococcus	Chesapeake	tbd	Eutrophic	2	4
Synecochoccus	Florida Bay	tbd 2005 -2008	Eutrophic	4	4
Karenia	Florida	tbd	Eutrophic	5	3
	East China Sea	May – July 2005	Eutrophic	5	3.5
	New Zealand	tbd	Eutrophic	?	tbd
Cyano/Microcystis	Europe (Scape-M)	tbd	Inland	4	4
	Lake Taihu	tbd	Inland	4	tbd
	Zeekoevlei	April 2008	Inland	4	4
	Baltic	tbd	Eutrophic	5	4 – 5
Noctiluca	Arabian Sea	tbd	Eutrophic	5	3.5
Phaeocystis	Channel/Belgium	tbd	Eutrophic	5	3.5

1 = OC unsuitable or poor data , 5 = OC highly suitable & extensive data available e.g. bio-optics, overflight, etc

3. Planned Deliverables, Timelines

The two primary deliverables of the WG will be an IOCCG/GEOHAB monograph, followed by a special issue in a peer reviewed journal, potentially Marine Ecology Progress Series. Information and data for the case studies, and detailed chapter structure and preliminary material for these chapters will be prepared for the next meeting of the WG, preliminarily identified as at Plymouth Marine Laboratory in May 2011, to follow the planned meeting of the GEOHAB Scientific Steering Committee. The draft structure of the monograph chapters is presented below

Preface. IOCCG & GEOHAB backgrounds, mandate

1. Introduction. Significance, background, rationale type structure as per IOCCG. HABs as part of ecosystem function; different types of HABS across systems; increased eutrophication/climate change outlooks & societal impact; methodological challenges for OC; larger context of operational, research, and integrated applications including multi-sensor approaches, etc.

2. HABs and Ecosystems. Use of GEOHAB science plan intro (variety, impacts, drivers, etc), into programme elements & with focus on observation & prediction, into mandala/intaglio (with shortcomings for this application) and focus on ecological niche => regional/ecosystem approach needed. Given OC complexity, need for same regional/ecosystem approach....lead into OC chapter....

3. Introduction to Ocean Colour in Coastal and Inland Waters. Challenges in coastal zone etc. OC technical issues – visual guide from case study showing AC/algorithm failure, flagging etc. Sensitivity study to phytoplankton community composition => causal IOPS => ocean colour. Overlay PFTs onto mandala, optical water types

4. Ocean Colour and Detecting Phytoplankton Biomass and Community Dynamics. Value of various approaches ranging from empirical to analytical, potential and possible approaches to realistically detecting community change with examples e.g. IOP, spectral discrimination, size, other PFT types, fluorescence. Use of HAN type algorithm/approach framework. Emerging algorithm types....

5. Ecological Classification. OC & multi-sensor time series, Eco classification. Extending ecosystem and mandala based approach to realising full value of OC observations. Multi-sensor and -temporal analyses of ecological drivers and response for example systems, demonstrating the value of routine synoptic data as opposed to the “event scale” case studies. Ecosystem mapping or “mapping the mandala”....

6. Case Studies
Structure (see Table 1):

i) organism, impacts, ecological niche wrt CRP type, global distribution map
ii) bio-optical & ecophysiological characterisation table: mugshot, size, marker pigments, mixotrophy and/or nutrient preferences, motility, ultrastructure, IOPs
iii) specific bloom event detail: frequency of occurrence, drivers, event history, amenability to OC
iv) comparative algorithms (including default) & optimal products
v) value add: societal benefits, emerging application & specific recs

7. Emerging & Future Considerations. Hyperspectral, inclusion of modelling, integrated obs and prediction systems. Identification of primary challenges and prognostics.

8. Summary & Recommendations