Harmful Algal Blooms research as a focus for the Integrated Marine Observing System (IMOS)

Natta Room L2, IMAS waterfront building, Hobart Tasmania

21 November 2016


IMOS is particularly interested in enabling the combined power of in situ observations, remote sensing and modelling/forecasting to come together and deliver impact. HABs have been an increasingly significant issue for the aquaculture and fishing industries and they would clearly benefit from a forecasting capability that can enable them to prepare and manage these events. The potential for IMOS for underpin research into HAB forecasting was explored at this meeting. The meeting objectives were:

- Share information about current research and existing initiatives on HABS research;
- Identify which observations (IMOS and non-IMOS included) and data sets currently available would be important in a HABS forecast scenario, and identify gaps;
- Discuss ways to address the gaps including the role of new sensors;
- Agree on next steps to carry this initiative forward.

In order to get as much information as possible, all participants were asked to provide a 1-2 page summary of their research and activities with respect to HABS before the meeting and to prepare a presentation that addressed the question “In your experience what will be the most challenging part for achieving HAB forecasting and how do you think your research can play a part in overcoming this challenge?” The summaries and a PDF of the presentations can be found in the adjunct document.

Key points from the presentations included:

- In-depth eco-physiological knowledge of individual HAB SPECIES (micronutrients, life cycle, thin layers, toxicology) is needed
- On-shelf monitoring needs improvement with many phyto/HAB data lacking appropriate temporal resolution (NRS monthly data).
- Industry would like a forecasting system that could ID new species of concern and an in-situ sensor that can detect HABs (PST, DST, AST) at low concentrations before the bloom, with delivery via internet or smart phone
- There is a lot of HAB data, it is important to make it public so it can be harvested
- It is important to understand the natural succession in phytoplankton community as context for HAB predictions, as well as understanding of the environmental conditions that favour HAB blooms
IMOS data provides some spatial large scale context (AusCPR) and some local data of HABs, including BGC and environmental, through the NRS network.

The goal of the forecasting system needs to be clear, i.e. if it is to increase scientific understanding or to inform management response.

The Microbial Oceanography Biosensing Instrument (MOBI) which is being developed by CSIRO may be able to help in-situ HABs observations.

Issues with HAB forecasting is that modelling needs species specific information and long term data sets. Perhaps predicting the likelihood of a HAB occurring (risk) rather than modelling them could be a better and easier option.

For some species of HAB there are satellite algorithms that can help discriminate them, such as Karenia brevis. However, for satellites to be helpful it has to be a HAB species that forms dense enough blooms to cause a characteristic colouring of the surface water.

During the open discussion session, the participants were asked to provide in writing the three most important gaps/opportunities. Their inputs were clustered into six main groups shown below:

1) HAB species. Physiology/population information:
   - 3D biogeochemical. Process models that target HAB specific ecology (life cycles, migration, nutrient preferences, cysts, triggers).
   - Identify 5 key species that we have enough life-cycle and physiological information to begin to populate models
   - Agreement on top priority species
   - Unknown optical properties of HAB
   - Diurnal properties of HAB species

2) Data inputs/need/prioritisation:
   - Access existing non-IMOS data on HABS (cell counts, genomics)
   - Integrate existing HAB/toxin data with a biophysical or statistical model of estuaries and coastal circulation
   - Building the national database “as we go” by partnering with SQAP’s, related programs, industry
   - Coordinate and assemble all HAB and phytoplankton data from Australia. Break down confidentiality clauses etc. Do more with Australian Phytoplankton Database.
   - More data AODN
   - Unlock data archives

3) Priority regions:
   - Identify when regions have best existing relevant datasets or existing monitoring programs that have the capacity/capability for HAB specific monitoring
   - Prioritise region/problem, can’t do this everywhere
   - Look at a specific region to test all the capabilities on. Limit the study to just one area rather than solve everything for everyone
   - Estuarine biological observations and coastal
   - Estuarine blooms are important and in areas of high population, e.g.: NSW coastline (tourism, safe food, recreation, fishing)

4) The Methods cluster was subdivided into three groups:
   - Event sampling:
- Develop and event based sampling capability

**Satellite:**
- EO HAB discrimination algorithms
- Remote sensing spectral characterisation of surface waters linked to 3D water column model of vertical distribution of optically active constituents; for better characterisation of algal blooms
- We need integration of satellite RS + field obs + models (this is quite stating the obvious, but probably good to emphasize anyway; IMOS is particularly well designed in this respect)
- Validation of satellite PFT/HABS algorithms is absolutely needed if we want to progress on that side (and become more credible)
- Synergy approach of different satellite sensors, including radar
- Operations forecast system including data assimilation of discriminated HAB + particle tracking
- EOS algorithm development + applications (atmospheric correction, in water properties, machine learning. Verification)

**In-situ and use of models**
- Develop a sampling program which goes beyond a “bloom event” Sample before a bloom starts and after it ends to determine real effects
- Develop hypotheses to guide monitoring and modelling programs from existing data
- HAB species identification in real time is an imperative (taxonomy, molecular ID and species specific toxicity)
- Investigate environmental correlates and statistical models of productivity
- Environmental drivers for HABS. Very few modelling studies are species specific. Appropriate temporal/special scales
- Rapid identification of any presence of new species of concern (highly toxic) across multiple stakeholder groups across different regions nationally
- Combine methods that integrate/link spatial coverage with species resolution
- Process-based sampling (not prioritise sampling over space or time but through potential drivers – e.g. stratification)
- Use hydrological models to identify areas of phytoplankton (HAB and non HAB taxa) retention/water column stability as a focus for helping to prioritize sampling
- In-situ cytobot type measurements to capture life cycle of blooms
- Determine accuracy requirements for RS + in-situ products within forecasting frameworks
- Better characterisation of in-situ phytoplankton (HAB) populations (sampling the right parameters at appropriate time/space scales)
- Instruments like the IFCB (mentioned in the discussion already) or the one mentioned by Lesley are one solution

5) **Ecology:**
- Microbial community dynamics around HAV events

6) **Client delivery** was subdivided into:

- **Products:**
  - Identify sector/region of aquaculture and fisheries sector that would most benefit from forecasting capability
- Alexandrium PSP forecasting (for TAS, NSW, Vic, SA) relevant to shellfish, abalone, lobster and salmon industries (needs autonomous species monitoring)
- Design prototype risk assessment system to guide design of monitoring modelling strategy
- HAB forecasting: 1) real-time information in relation to the presence of HABs of interest to marine industries, 2) through automated system
- End to end prototype (NRT + forecast) system that allows us to have a place to refine from and focus research efforts
- Develop ability to provide early warning of the likely occurrence of a HAB, in-situ sensors
- Likelihood risk assessment based on EO + model forecast and traffic light system sector specific
- Test predictive model, improve, refine, release
- Provide uncertainty estimates for all remote sensing and in-situ obs. required for error analysis of products
- Create a BoM type HAB weather forecast to generate public and industry interest in e.g. Noctiluca blooms (the good) and seafood closures, beach closure, etc (the bad).
- Development of decision support system and data visualisation interface for end-users

- Stakeholder engagement
  - Lots of capability in many areas. Look at links, compatibility of techniques, instrumentation, etc. between different groups/agencies to give the most benefit to possibly forecasting
  - IMOS as a partner “umbrella” for HABs technology/forecasting?
  - Stakeholder engagement to determine most relevant pilot study area focus

It was agreed that of all the gaps and opportunities identified a priority list of HAB species will be completed before Christmas. ACTION: Gustaaf (lead), Penny, Ruth, Martina and Chris to draft a list of HAB priority species with input from Karen, Scott, Thomas and Neil, and provide this list to Tim Moltmann.

With respect to priority regions it was agreed to focus on East Coast Tasmania to start with, but it was also agreed that other priority areas affected by HABs are NSW estuaries and Port Lincoln in SA. The species of interest for Tasmania is Alexandrium tamarenses. Some of the current capability and data in the east coast of Tasmania includes a hydrodynamic model, data from industry monitoring in the nearshore regions (cell counts, environmental variables and nutrient data) and an unfinished satellite algorithm using MODIS data from 2002-2012. Some of the gaps in this region are linking modelling with satellite remote sensing, limited information on in situ HABS and ocean currents on the shelf and the need of weekly monitoring of toxins and cell counts.

ACTION: Peter Thompson, Roger Proctor and Tim Moltmann to provide advice to Neil Stump about which data from industry they would like to have access to.

ACTION: Thomas Schroeder to provide costings to complete the satellite algorithm for east coast Tasmania

The Methods gaps and opportunities cluster was summarised as follows:
1) Satellite HAB discrimination algorithms (link with in-situ)
2) Operational forecast with data assimilation
3) Environmental co-variates
4) Better characterisation of in-situ HABs, sensors
5) Real-time HABS observations
6) Event based sampling

Some discussion was attempted to see if there were some priorities within this cluster that the group would like to progress. However, there was not a lot of agreement on priorities and thus this discussion may need to continue at a later stage.

There was some discussion on sensors, particularly around the ESP and the Flowcytobot. There was agreement that the image Flowcytobot was a good sensor with support from Gustaaf, Martina and David Antoine. The location of deployment for this instrument was very important as well.

The assessment of the ESP was that it was too expensive and it needed a lot of effort in interpreting the data from this sensor.

Another sensor that was discuss was the Cytosense, which is a sensor that could be used in the lab as well as in-situ. It is a good sensor to work with cultures but it is labour intensive to work with in the field.

**ACTION:** the group to provide Ana with input about the different in-situ sensors currently available to detect HABs so she can take their feedback to the ACT meeting in Moss Landing.

The group agreed that it was important to continue this initiative and to meet again next year and report on the Moss Landing meeting, as well as progress on the action items from this meeting.

The meeting was wrapped up at 5:30 pm
APPENDIX 1. Agenda

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Agree on next steps to carry this initiative forward.
<table>
<thead>
<tr>
<th>TIME</th>
<th>TOPIC</th>
<th>CONTENT – KEY POINTS</th>
<th>RESOURCES/PROCESS</th>
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<tbody>
<tr>
<td>8.15am</td>
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<td>Whiteboard, video conference, data projector</td>
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<td>8.30 am</td>
<td>Welcome introductions</td>
<td>• Welcome (Tim Moltmann, 10 mins.)</td>
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<td>• Round table introduction (2 min each)</td>
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<td>• Agenda (Ana, 5 mins)</td>
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<tr>
<td>9:15-9:45</td>
<td>Vision Tim and Ana</td>
<td>• IMOS Five Year plan 2017-2022 and main drivers (10 mins)</td>
<td>Slide presentation</td>
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<td>• Significance of HABS (5 mins)</td>
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<td>• IMOS potential to underpin research into HABS forecasting (10 mins)</td>
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<td>• A vision for a HABS forecasting system (5 mins)</td>
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<td>9:45-10:00</td>
<td>Questions</td>
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<td>10:00-10:15</td>
<td>Morning tea</td>
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<td>10:15-10:50</td>
<td>Why is it important</td>
<td>• Overview of HABS around the world and in Australia. Gustaaf Hallegraeff (20 mins).</td>
<td>Slide presentations</td>
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<td>• Issue of HABS for Tasmanian oyster industry. Neil Stump (15 mins)</td>
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<td>10:50-11:15</td>
<td>Questions</td>
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| 11:15-12:15 | What are we currently doing and what are the challenges | • 10 minute presentations from participants with a focus on: What are the main challenges to achieve HABS forecasting and can they be solved? | 10 min presentations:  
1) Peter A Thomson: (11.15-11.25)  
2) Anthony Richardson (11.25-11.35)  
3) Ruth Erikstein (11.35-11.45)  
4) Chris Bolch (11.45-11.55)  
5) Martin Otrowski (11.55-12.05)  
6) Lev Bodrossy (12.05-12.15) |
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<thead>
<tr>
<th>Time</th>
<th>Session</th>
<th>Details</th>
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<tr>
<td>12:15-12:45</td>
<td>Questions and Discussion</td>
<td>30 minutes for questions and discussion</td>
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<td>12:45-1:30</td>
<td>Lunch</td>
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<td>1:30-2:20</td>
<td>What are we currently doing and what are the challenges continuation</td>
<td>• Continuation of 10 minute presentations from participants</td>
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<td>10 min. presentations:</td>
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<td>1) Thomas Schroeder (1.30-1.40)</td>
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<td>2) Rob Johnson (1.40-1.50)</td>
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<td>3) Roger Proctor (1.50-2.00)</td>
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<td>4) Scott Condie (2.00-2.10)</td>
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<td>5) Karen Wild-Allen (2.10-2.20)</td>
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<td>2:20-2:50</td>
<td>Questions and discussion</td>
<td>30 minutes for questions and discussion</td>
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<td>2:50-3:05</td>
<td>Afternoon tea</td>
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<td>3:05-4:30</td>
<td>Where are the GAPS and what do we need to do?</td>
<td>• Open discussion to ID gaps</td>
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<td>Time for brainstorming. The discussion should consider presentations</td>
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<td>and written material (1-2 pager of research)</td>
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<td>4:30-5:30</td>
<td>Next steps</td>
<td>• International meeting “Opportunities for improving our technical</td>
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<td>ability to detect harmful algae and their toxins across the marine-</td>
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<td>freshwater” continuum and for a range of applications (10 mins)</td>
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<td>• What are the next steps? (40 mins)</td>
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<td>• Wrap up (10 mins)</td>
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