Zooplankton Ocean Observations and Modelling (ZOOM) Task Team.

Overview:

<table>
<thead>
<tr>
<th>Proposed task</th>
<th>Integrating zooplankton observations from multiple platforms with biogeochemical and ecosystem models</th>
</tr>
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<tbody>
<tr>
<td>Operating institutions</td>
<td>CSIRO, UNSW</td>
</tr>
<tr>
<td>Co-convenors</td>
<td>Mark Baird (CSIRO, TAS), Jason Everett (UNSW, NSW), Anthony Richardson (CSIRO, QLD)</td>
</tr>
<tr>
<td>Other participants</td>
<td>Iain Suthers (UNSW, NSW), Rudy Kloser (CSIRO, TAS), Beth Fulton (CSIRO,TAS), Jenny Skerratt (CSIRO,TAS), Claire Davies (CSIRO, TAS), Kerrie Swaddling (Utas, TAS), Paul van Ruth (SARDI, SA), Barbara Robson (CSIRO, ACT), Frank Coman (CSIRO, QLD), Ana Lara-Lopez (IMOS, TAS), Shane Griffiths (CSIRO, QLD), Richard Matear (CSIRO, TAS), Eva Plaganyi-Lloyd (CSIRO, QLD), Wayne Rochester (CSIRO, QLD), Natasha Henschke (UNSW, NSW), David McKinnon (CSIRO, QLD), Jessica Melbourne-Thomas (ACE CRC)</td>
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<tr>
<td>Timeframe</td>
<td>3 years</td>
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PROJECT DESCRIPTION

Background

Relative to our knowledge of the oceans’ phytoplankton and fisheries, we have little understanding of the zooplankton (from small nauplii @ 100 um to larval fish @ 1 cm) that link them. This is a major gap, as it is the zooplankton that graze the ocean phytoplankton (which provide ~50% of the oxygen we breathe), drive the production of our fisheries (Pauly & Christensen 1995), and play a key role in global carbon export (Buesseler et al. 2007). Irigoien et al. (2014) showed that the biomass of mid-trophic level fish (by far the most abundant fish on the planet) may be an order of magnitude higher than previously thought, and feed mainly on zooplankton (but see Davison et al., 2015). This potential enormous biomass of mid trophic level fish was kept hidden by our lack of knowledge of zooplankton and poorly constrained information on energy transfer through the zooplankton component of the pelagic food web. This knowledge gap hampers management of marine systems and needs to be resolved through advances in both observational and modelling research.

This knowledge gap is in part a legacy of the evolution of observational technology and oceanography – physical variables have been easier to collect so the true importance of these lower trophic level biological layers has not been directly appreciated until more recently. This gap in understanding has been exacerbated by the difficulty of measuring zooplankton and their phylogenetic complexity. Ultimately this has meant that available zooplankton observations are sparse in time and space, and come from a range of different observing methods, platforms and data types (biomass, abundance, carbon, size). We also have little knowledge of how these observations relate to each other. Without this fundamental knowledge, it is extremely challenging to make sure that the appropriate information is being used in numerical models for initialisation or validation. The physical ocean state (temperature, salinity, height, waves) and phytoplankton biomass can be assessed from satellite observations, and fisheries biomass can be derived from fishery catch reporting, but no such high frequency synoptic sampling method exists for zooplankton. Within numerical models, zooplankton parameters are nearly always poorly constrained due to the limited data available to modellers. In addition, many of
these data (such as growth rates) are derived from experimental work undertaken in the laboratory in small containers (<1 L). Zooplankton observations being undertaken within IMOS (and by IMOS scientists outside of the program) provide a unique opportunity to bring together discrete yet complementary observations at multiple scales to address these sources of significant uncertainty in ecosystem models (Table 1). Advances are being made in using IMOS acoustic data to assimilate into modelling micronekton but significant size class and energy transfer knowledge gaps within and between trophic levels remain (Lehodey et al. 2014). Because of the diverse types and nature of these zooplankton observations, and the different languages and backgrounds of the observational and modelling research communities, there has been little uptake of these IMOS observations into ecosystem models. (at least in a more sophisticated way than simple conditioning).

This Task Team will begin the process of systematically integrating these observations into ecosystems models.

Table 1 – Different instruments, data types and resolutions of zooplankton data collected within IMOS or being value-added by IMOS scientists.

<table>
<thead>
<tr>
<th>Instrument</th>
<th>Zooplankton Data Type</th>
<th>Horizontal Resolution</th>
<th>Vertical Resolution</th>
<th>Temporal Resolution</th>
</tr>
</thead>
<tbody>
<tr>
<td>1(^{st})National Reference Station Vertical Haul Nets</td>
<td>Taxonomic, Abundance, Biomass, Size, Stoichiometry</td>
<td>2 m</td>
<td>50 m</td>
<td>Minutes</td>
</tr>
<tr>
<td>2(^{nd})Nets/Trawls aboard SOOP (i.e RV Investigator)</td>
<td>Taxonomic, Abundance, Biomass, Size, Stoichiometry</td>
<td>10’s km</td>
<td>1000 m</td>
<td>Hours</td>
</tr>
<tr>
<td>1(^{st})Optical Plankton Counter (Triaxus/SeaSoar)</td>
<td>Abundance, Biomass, Size</td>
<td>1000’s km</td>
<td>200 m</td>
<td>Days</td>
</tr>
<tr>
<td>2(^{nd})ZooScan</td>
<td>Taxonomic, Abundance, Biomass, Size,</td>
<td>From Net Sample</td>
<td>From Net Sample</td>
<td>Minutes</td>
</tr>
<tr>
<td>1(^{st})Continuous Plankton Recorder</td>
<td>Taxonomic, Abundance</td>
<td>1000’s km</td>
<td>Surface</td>
<td>Days</td>
</tr>
<tr>
<td>1(^{st})Bioacoustics</td>
<td>Biomass, functional size, horizontal and vertical distribution</td>
<td>1’s km to 1000’s km</td>
<td>10 m</td>
<td>Hours</td>
</tr>
<tr>
<td>3(^{rd})Experimental Work</td>
<td>Rate Processes, Stoichiometry</td>
<td>N/A</td>
<td>N/A</td>
<td>Hours/Days</td>
</tr>
</tbody>
</table>

1 IMOS product; 2 Additional analysis/processing of IMOS collections not part of core IMOS activities; 3 Non-IMOS data available for Zoom TT.

Broadly there are three classes of biological models using zooplankton:

- Biogeochemical models
- Size-based ecosystem models
- Food web based ecosystem models

Each category has application in Australian waters, and can be improved through using IMOS data streams. It is probable that the optimal coupling point between biogeochemical models and food-web
based model is copepod-sized zooplankton. Thus the task team will be investigating both the use of zooplankton data for single classes of models, and for their coupling.

Models with zooplankton, and target applications in Australian waters, include:

- CSIRO Environmental Modelling Suite (EMS) – eReefs, south east Tasmania etc.
- WOMBAT – global runs.
- Atlantis – many regional applications (in Australia and around the world).
- Ecopath with Ecosim – many regional and global applications.
- MICE (Model of Intermediate Complexity for Ecosystem assessments) e.g. whale-plankton application by PhD student Viv Tulloch
- ROMS biogeochemistry – SA, WA, NSW.

Objectives:

1. Review existing literature on best-practice in how zooplankton observations are currently being used in ecosystem models
2. Summarise the strengths and weaknesses of IMOS and emerging zooplankton observation platforms in relation to their potential uptake in ecosystem models, and provide recommendations.
3. Develop zooplankton fields and datasets that are directly applicable in ecosystem models and make these available through IMOS and CARS (CSIRO Atlas of Regional Seas)
4. Initiate model developments that bring model outputs closer to observations (i.e. acoustics as a model output).
5. Develop techniques to incorporate individual zooplankton data streams (i.e. LOPC, CPR etc.) into models.
6. Use the models that have incorporated multiple individual data streams to investigate the synergies / agreement / correlation between data streams.
7. Outline recommended methods for using IMOS observations for assessing biogeochemical and ecosystem models.

Rationale:

Define the need for the task team project, how it addresses an important problem and how it relates to relevant IMOS Science and implementation plans and scientific questions.

Zooplankton observations are collected on a variety of platforms using multiple methods having different spatial and temporal scales, with little understanding of how they relate or compare. An expert task team is required to bring the knowledge of observational and modelling communities together to maximise the science undertaken from the continuous IMOS and intermittent non-IMOS zooplankton observations. As IMOS embraces numerical modelling as value adding to continuous observations and as it seeks to relate observations to environmental, social and economic values provided by, for example, carbon management and fisheries, the need for a co-ordinated expert zooplankton community increases.
Important research questions include:

1. How are zooplankton populations best quantified using the available observational platforms?
2. How are biogeochemical and ecosystem models best constrained by zooplankton observations?
3. How can observations and models be combined to better quantify secondary production and carbon storage and vertical fluxes mediated by the zooplankton community?
4. What is the relationship between physical variables and zooplankton distribution and productivity, and hence what are the implications for this through the foodweb?

It is also emerging that biogeochemical and ecosystem models are best combined with observations when they share common quantities. Thus, if a zooplankton observation quantifies population in size bins, then a model that is compared with this data stream should, as far as possible, also operate in size-classes. Experience shows that this level of match between observations and models can only be achieved when model outputs are described and quantified in the language of the observational community, requiring observational and modelling experts to work closely together.

**Benefits**

Describe the outputs that will arise from the project and how they will achieve the objectives of the project. Outputs may be knowledge, skills, processes, practices, models

1. Better understanding of the strengths and weaknesses of existing zooplankton data streams.
2. Recommendations of improved zooplankton sampling, either through gear selection or targeting appropriate space and time scales.
3. Increased use of zooplankton data in numerical modelling, and in the larger projects that require it (i.e. eReefs)
4. Improved models of zooplankton processes due to improved mathematical representation, and comparison with data.
5. Improved communication and collaboration between zooplankton observational and modelling research communities

These benefits will provide the foundation for better estimates of zooplankton mediation of carbon fluxes and fisheries production in the future.

**Required expertise**

Outline the capacity and capability that the task team will need to achieve the objectives of the project.

IMOS contains the required experts in zooplankton ecology and modelling, however they are spread across multiple nodes (i.e. NSW, SEA, QLD, WA, SA, Bluewater), facilities (i.e. AusCPR, SOOP, ANMN) and the wider IMOS community. The key goal for the Zooplankton Task Team will be to bring together experts with either observational or modelling expertise, to improve the communication and collaboration of observational and modelling communities. As far as practical, outputs from observational studies need to be provided to modellers in a format they can incorporate into their models as either data assimilation or model assessment. In reverse, model outputs need to be provided to zooplankton ecologists to provide additional information such as biomass estimates at larger spatial or temporal scales.
In addition, within each group (observationalists and modellers) we need to understand how the various estimates of zooplankton biomass and productivity compare between methods (LOPC vs Net Samples, or Atlantis vs WOMBAT). The ZOOM Task Team will specifically work to address these key goals with the team below:

1. Observational expertise:
   a. Net sampling (Suthers, Everett, Henschke, Richardson, McKinnon, Swadling, van Ruth, Lara-Lopez)
   b. Continuous Plankton Recorder (Richardson, Coman, Davies)
   c. Laser Optical Plankton Counter (Everett, Suthers, Baird, Richardson, McKinnon, Henschke)
   d. ZooScan (Richardson, Everett, Suthers)
   e. Acoustics (Kloser, Lara-Lopez)

2. Modelling expertise
   a. Biogeochemical modelling (Matear, Robson, Baird, Skerratt, van Ruth, Baird),
   b. Size-based modelling (Baird, Suthers, Everett, Blanchard)
   c. Ecosystem modelling (Fulton, Plaganyi-Lloyd, Griffiths, Bulman)

Methods

Outline the methods to be used including protocols or activities; the data to be obtained or knowledge, skills or capacity to be generated. Provide support for any new methods and/or techniques to be employed.

This task team will primarily bring existing methods of observation and modelling together, following the Objectives listed above.

Task team composition

Please specify the expertise of the different contributors and their responsibilities within the team and the level of involvement of the team members

Mark Baird (CSIRO) – Biogeochemical modeller – Baird will co-lead the Task Team. He will provide expertise in the analysis of size-based observation and size-based and biogeochemical models. He will co-ordinate reporting to IMOS central.

Jason Everett (UNSW) – Biological oceanographer – Everett will co-lead the Task Team. He will provide data from the optical plankton counters, and the tools to analyse them. He will co-ordinate the face-to-face meetings and teleconferences.

Anthony J. Richardson (CSIRO) – Quantitative ecologist – Richardson will co-lead the Task Team. He will provide expertise on the use of zooplankton taxonomic data and how these best be related to the modelling and size-based approaches. He will lead communication of opportunities and outcomes to the Australian science community through the AusCPR newsletter and other means.

Iain Suthers (UNSW) - Biological oceanographer - Will provide access to/expertise from net tows, and provide link to international community.
Rudy Kloser – Biological oceanographer – provide access to/expertise in acoustics, and link to international community.

Mode of operation for the task team

Specify how the activities of the task team will be undertaken, i.e. are there going to be any face to face meetings, or is it going to be by correspondence or teleconference. How many meetings will the task team envisage within the timeframe? How are the activities going to be coordinated?

Initially the ZOOM Task Team will meet through a series of focused teleconferences to take on milestones 1-3, followed by a face-to-face meeting in Hobart, where the bulk of the team resides.

Milestones

Indicate the timeframe required for this task team project and the milestones with information on the approximate time required to completing each activity

<table>
<thead>
<tr>
<th>Milestone</th>
<th>Due</th>
<th>Status</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Develop zooplankton fields based on existing observations</td>
<td>July 2016</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Summary of strengths and weaknesses of IMOS observations</td>
<td>September 2016</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Develop model parameterisations that mimic zooplankton observations</td>
<td>November 2016</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mid-term progress report to IMOS</td>
<td>December 2016</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Undertake simulations with new products and parameterisations</td>
<td>July 2017</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Report on strengths / weakness observations for improving simulation</td>
<td>September 2017</td>
<td></td>
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</table>

Deliverables

Please outline if there are other deliverables for this project beside a final report

Deliverables may include published data sets and papers, depending on progress.

As a foundation the ZOOM Task Team will provide a review of the existing observational series and their use, both empirically and in models. This will provide information sufficient for a gap analysis around the data itself, but also its use in modelling. If sufficient information is available to support model parameterisations (which existing preliminary scoping suggests it should be) then simulations using those new parameterisations will be undertaken as the basis of an analysis showing the value
added by the inclusion of the additional information. Further deliverables will be dictated by what is uncovered, but may include published data sets and papers, depending on progress.

Communication

Outline how the results from the task team will be communicated

We will communicate outputs from the task team through:

1. Regular newsletter articles for the IMOS Marine Matters newsletter
2. A review paper on best practice in the uptake of zooplankton data into numerical models
3. Inclusion of zooplankton fields for modelling in the IMOS data portal and CARS
4. Updates provided at the Australian Coastal and Oceans Modelling and Observations (ACOMO) workshop
5. A position statement on the value of zooplankton observations for numerical models.

The relatively small size of the Australian zooplankton community will make the ZOOM Task Teams undertaking easier.

Resources required

Costs could be minimised by timing meetings to link with other IMOS-related meetings (conferences, QC summits, etc.). However if there are any specific costs anticipated which cannot be covered under other funding sources, please detail here.

1. Costs for a 1-2 day meeting each year in Hobart, coinciding with other activities where possible. Indicative costs of 20 participants, $500 each $10,000.

References


