Marine genomics for Users Workshop report

The Potential of Genomics Technology for Marine Monitoring and the Marine Strategy Framework Directive (MSFD)

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Sarah Bourlat
Matthias Obst
John Benzie
Maria O'Mahoney
Johanna Wesnigk

Contact
Matthias.Obst@bioenv.gu.se
Department of Biological and Environmental Sciences
University of Gothenburg, Sweden

Workshop report

The program featured short scientific talks on the cutting edge of genomic methods, as well as overviews of current monitoring approaches in Europe and the USA, with emphasis on critical knowledge bottlenecks. The talks were followed by two breakout sessions and panel discussions. The first breakout had three parallel groups and was chaired by scientists. Here, the aim was to identify genomic methods and applications with high potential to fill bottlenecks in descriptors of the MSFD. The second breakout had two parallel groups and was chaired by the policy representatives. Here, the aim was to draw a roadmap on how high potential genomic methods can be integrated into marine monitoring programs in Europe.

Background. The MSFD is a legal framework that demands a repertoire of knowledge from the European member states centered around the descriptors of 'good environmental status' (GES). The descriptors, together with associated 'criteria' and 'indicators' will be used to decide on the status of marine ecosystems, and how GES can be achieved and maintained in the future. On this basis, the member states have to provide the 'initial assessment' (of current status) and national determination of GES for their waters, including the nationally relevant targets and indicators. The member states are currently in the process of reporting these marine strategy elements to the Commission, and these will be the basis for their national monitoring programs from 2014 onwards. Using this framework, the European Commission and the regional sea conventions will work towards coherence and standardization of MSFD indicators and descriptors among national monitoring programs. In this process, member states have a duty to use the regional seas conventions OSPAR, HELCOM, BARCELONA, and BUCHAREST as frameworks to achieve regional coherence. Currently there is a strong focus on three issues, (i) data, (ii) methods to turn data into knowledge, and (iii) boundaries between 'good' and 'no good' status. Indicators that support MSFD descriptors will be revised latest in 2016 and a new round of national assessments, GES determination and target setting will take place in 2018 and then every 6 years.

The policy representatives gave an overview of the major European marine organizations present at the meeting (EC DG JRC, OSPAR, HELCOM, BONUS) and their affiliated monitoring programs. The talks highlighted that there are still significant knowledge gaps in the understanding of marine ecosystems, especially when following an ecosystem-based approach. It was also highlighted that in many cases important baseline knowledge that is necessary to define the GES of European marine waters is missing. Currently there are no genomic and few genetic methods considered for contribution to the MSFD indicators. It was explained that the trajectory from a 'promising new monitoring technique' to regular use in a country's national monitoring program requires a number of steps that are similar to any 'innovation' project.

The scientific talks featured examples from the scientific community and described the status of routine genomic methods in scientific work and their

potential use in monitoring. Examples showed that a number of genomic methods are either very near or in the process of being transferred to monitoring programs (e.g. qPCR methods for beach quality assays, SNP based methods for tracing the origin of fish, barcode analysis of stomach contents for analyzing food webs, microarrays for harmful algal bloom (HAB) detection). These examples are viable feasibility studies that can be used to quantify how much better, cheaper, and/or faster knowledge can be produced in comparison with conventional methods. They can also be used as starting points to draw a roadmap with guidelines on how such methods can be used in a standardized manner and how they can be integrated with the existing methods.

Conclusions

The group concluded that genomic methods with high potential fall into four categories:

1) Methods that generate the same knowledge faster, cheaper, and/or better compared to conventional methods, e.g. species identification using marker genes (e.g. barcoding), qPCR for water quality assays, microarrays for detection of HABs.
2) Methods that allow us to do things we could not do before, i.e. give us new knowledge (e.g. metagenomics to study the biodiversity and function of whole ecosystems)
3) Methods that allow us to go from patterns to processes and unravel causalities (e.g. transcriptional response of species to chemical exposure)
4) Methods that have no alternative aside from molecular methods (e.g. SNPs for tracing populations of species and barcoding for analyzing food webs)

It was agreed that genetic and genomic methods have a high potential to address many descriptors in a standardized way. Also, the fact that there are currently no genetic or genomic standards in the monitoring programs will make it relatively straightforward to introduce the standards developed by the Genomics Standards Consortium (GSC) into Marine Monitoring.

The methods that meet the above criteria, are routinely established, and have existing pilots are (i) qPCR, (ii) barcoding using marker genes, (iii) SNPs, and (iv) microarrays. These methods cost-efficiently add significant knowledge to the descriptors D1 (Biological diversity), D2 (Non-indigenous species), D3 (Populations of fish and shellfish), D4 (Food webs), and D5 (Eutrophication), and D6 (Seafloor integrity). There are more methods with high potential in development such as microbial metagenomics, transcription analysis, and others.

The entry point for these methods into regular monitoring programs should be at the national level, and for this genomics scientists should partner with national institutes that currently implement the MSFD indicators. At the same time a strong network should be developed in order to communicate the

benefit of genomic tools to national environmental agencies, and to design pilot programs on the national and regional level. The network should include programs like the COST action EMBOS, the MicroB3 action Ocean Sampling Day, the FP7 project DEVOTES, the Genomic Observatories initiative, the Genomics Standard Consortium, the EMBRC infrastructure, FP7 Project STAGES[1], and European marine GEO-BON initiatives.

MG4U will circulate and assemble a document with guidelines for the integration process, aiming to have a final version by December 2012. This paper will then be used as a 'living document' for communication with organizations involved in monitoring. The document will have a major focus on methods that can perform better/cheaper/faster compared to conventional methods, as inferred from feasibility studies and ongoing pilots. For that purpose it will also include a prioritized list of genomic methods, matched up against the MSFD indicators, with important annotations (e.g. priority, matureness, cost-effectiveness, limitations, next steps). In addition, there will be focus on methods that can bring about new knowledge, with the potential to create new indicators of GES. Finally, the document also needs to consider the role of infrastructure required for genomic methods to enter marine monitoring programs. The primary target audience(s) of the document is the national environmental agencies working with the MSFD, but it will also speak to the Regional Seas Conventions, and to the EU commission level (e.g. DG Environment, DG Research, DG Mare). The document will try to collect input and feedback from all workshop participants as well as related networks in order to assemble a broad and community wide opinion on the matter.

Supplementary material

Slides of presentations and other further source material (e.g. collected papers) are available from ***Matthias.Obst@bioenv.gu.se***. Further information, including the guideline paper described above will be available at http://msfd2012.sciencesconf.org/.

List of workshop participants

1. Neil Davies, University of California Berkeley, USA
2. Chris Meyer, Smithsonian National Museum of Natural History, Washington, USA
3. Dawn Field, Oxford University, UK
4. Jack Gilbert, Argonne National Laboratory, USA
5. Frank Oliver Glöckner, Max Planck Institute for Marine Microbiology and Jacobs University Bremen, Germany
6. Sarah Bourlat, University of Gothenburg, Sweden
7. Matthias Obst, University of Gothenburg, Sweden
8. Martin Taylor, Bangor University, UK
9. Jan-Bart Calewaert, Marine Board-ESF
10. Anke Kremp, HELCOM

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11. Berit Johne, JPI Oceans
12. Andris Andrusaitis, BONUS
13. Catherine Dreanno, IFREMER
14. Gert Verreet, OSPAR
15. Johanna Wesnigk, Environmental & Marine Project Management Agency, GE
16. Naiara Rodríguez-Ezpeleta, Marine Research Division, AZTI-Tecnalia, ES
17. Teresa Lettieri, European Commission, DG JRC, Institute for Environment and Sustainability, IT
18. Angel Borja, FP7 project DEVOTES coordinator, AZTI-Tecnalia, ES
19. Tim Bean, Centre for Environment, Fisheries and Aquaculture Science, CEFAS/DEFRA, UK
20. John Benzie, University College Cork, IR
21. Linda Amaral-Zettler, Woods Hole Marine Biological Laboratory, LTER/MIRADA, GEO-BON, USA
22. Isabelle Gailhard, Station Biologique Roscoff, MSFD-France
23. Nathalie Simon, Station Biologique Roscoff, MSFD-France
24. Stephen Weisberg, Southern California Coastal Water Research Project (SCCWRP) and Western Association of Marine Labs (NAML/WAML), USA
25. Saskia Wesnigk-Wood, Communications officer EMPA, Brighton, UK
26. Nikolaos Zampoukas, DG JRC Water Resources Unit, European Commission
27. Arianna Broggiato, Université catholique de Louvain, Louvain-la-Neuve, BE
28. Francesco Falciani, University of Birmingham, UK
29. Dan Faith, Australian Museum, GEO BON, AU
30. Peter Meintjes, Biomatters, New Zealand
31. Chuck Cook, EMBRC, EMBL-EBI Hinxton, UK