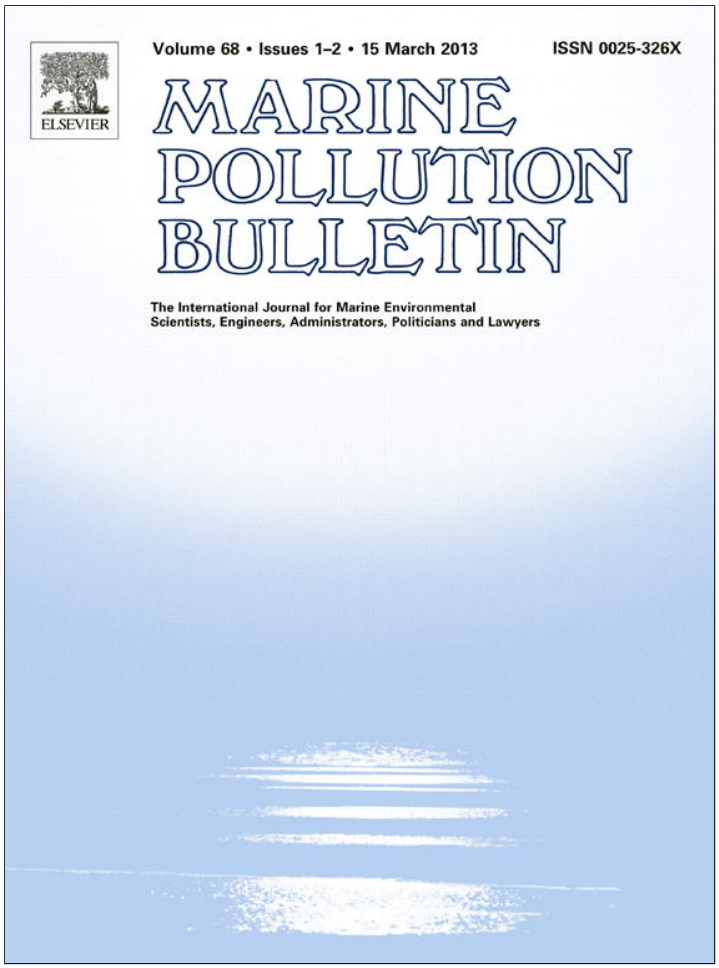

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Editorial

# Marine monitoring during an economic crisis: The cure is worse than the disease

Monitoring *sensu stricto* includes the rigorous sampling of a biological, physical and/or chemical ecosystem component for a well-defined purpose and against a well-defined end-point (McLusky and Elliott, 2004). That aim may be the detection of a trend or the non-compliance with a threshold, standard, trigger value or baseline, thus leading to a well-defined (and agreed in advance) policy action (De Jonge et al., 2006). In this way, aquatic and marine legislation worldwide requires adequate and rigorous monitoring at different spatial and temporal scales, such as in the Clean Water Act (CWA) and Oceans Policy (USA), the Oceans Act (Canada, Australia), the Water Framework Directive (WFD) and the Marine Strategy Framework Directive (MSFD) (Europe) (Borja et al., 2008).

Despite this, monitoring *sensu lato* has achieved many other meanings, many of which now codified in the above legislation. In a previous Editorial, we identified 10 types of monitoring (Elliott, 2011), covering everything from wide surveillance (for which a pre-determined endpoint may not have been defined), through operational monitoring (by an industry wanting to know or demonstrate its performance), to investigative monitoring (also called diagnostic monitoring, which is better regarded as applied research possibly to find the cause of a measured effect). Although making the concepts of monitoring more complex, each of these 10 types has been defined for a purpose – again with an intent to aid in management, to provide relevant and timely information. Similarly, we have indicated the 18 characteristics of monitoring programmes and the indicators of change detected during those programmes (Elliott, 2011). Hence, the need for a rigorous, scientifically and legally defendable approach and resulting data is clear. For example, most monitoring required by statutory agencies, especially that linked to conditions stipulated in licences/permits/consents/authorisations, have to stand up to legal scrutiny otherwise there will be legal challenges either on the developer (the industry or pollution discharger) or the regulator issuing the permissions to operate.

Many Editorials and papers in *Marine Pollution Bulletin* have emphasised the importance of monitoring in marine waters (e.g. Tanabe, 1993; Pearce, 1998; Wells and Sheppard, 2007). Our journal has published a total of 270 papers, having the word 'monitoring' in the title, since the first volume (Holden, 1970) to the recent ones (Purser and Thomsen, 2012). Despite the importance of monitoring, in terms of non-compliance with a threshold and the subsequent need for (expensive) policy and managerial actions, the current global economic crisis, and especially cuts in government spending, is leading many countries (and industries) trying to save money in their monitoring budgets. The ways to obtain this saving include reducing monitoring programmes and cutting the operational budgets of statutory bodies, such as Environmental Protection Agencies and Environmental and Nature Conservation Ministries; for example in the UK, Spain or Portugal, while the governments purport to have green credentials they have greatly reduced the budget of the environment ministry which in turn affects those of the environmental protection and nature conservation bodies (e.g. http://www.guardian.co.uk/environment/2010/oct/20/spending-review-cuts-environment). In various cases this cutting of budgets has reduced the number of sampling locations (De Jonge et al., 2006), frequency of sampling (Abramic et al., 2012, or required looking for cheaper assessment methods (Lampadariou et al., 2005). We accept that all fields include the 'law of diminishing returns', what may be called the 80/20 rule – in the first 20% of the time studying a problem then you obtain 80% of the information required, but to obtain the remaining 20% information then requires a disproportionate amount of time and energy. However, our fear here is that rather than scientific criteria being used to define the level of monitoring, it is economics – i.e. the 'bean-counters' are now dictating the science to be undertaken such that we will reach a stage where monitoring is not longer fit-for-purpose or even, paradoxically, value-for-money.

Biological/ecological monitoring is often centered on measuring the community composition of an area and detecting whether that has changed, for example due to pollution of the arrival of alien and invasive species (Gray and Elliott, 2009). One of the ways proposed for saving money is to use presence/absence of an ecological component instead of abundance (Bates et al., 2007) and another relates to the taxonomic sufficiency i.e. the use of high taxonomic levels (e.g. family instead of species), since its first formulation by Warwick (1988). This suggests that samples could be analysed to higher taxonomic levels, detecting the pollution effects on marine communities with similar statistical accuracy, and saving money because of the higher cost of identifying organisms at the species level (Dauvin et al., 2003; Dimitriou et al., 2012).

In this way, it is interesting to note that the analysis to family level is only cheaper if you are skilled to species level; if you do not train taxonomists (which is the current trend in all countries) then even family level identification is difficult and expensive. We are also amazed that managers are willing to spend thousands of euros/dollars on chemical analyses but then complain about biological samples (which require people with skills instead of machines) costing money. Secondly, while it has long been accepted that analytical quality assurance/quality control (AQC/QA) is required in chemistry laboratories, which may commit up to 40% of their time and budget to this, there has been resistance to adopting this in biological analyses (Elliott, 1993; Gray and Elliott, 2009).

The third point is what we could call the paradox of the precautionary principle – if there is not a full scientific understanding or, because of the noise/variability in the system, then you have to spend more effort (and thus more budget) to detect a change. The precautionary approach says that 'unless an activity can demonstrate that it is not having an impact then it should not be allowed'.

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Hence, you need more science to demonstrate that probably lack of impact in space or time but the budgets are being cut, so there is less science. As an example, a developer may be required to detect an impact of a given magnitude which, because of the inherent variability in the system, may require a large degree of replication but budgets will dictate that so few replicates are taken that there is no chance of detecting an effect (Gray and Elliott, 2009).

Given our comments above, we want to draw your attention to the fact that identifying organisms at family level, reducing AQC/QA and other methods of 'reducing' costs today, implies a 'short termism' and could be costly in coming years. There will be a shortening of monitoring series, an inability to detect both near and far field effects of an activity and the absence of adequate data to implement new requirements.

As a valuable example, in Europe there is a movement from a structural approach in the WFD and Habitats Directive to the functional approach of the MSFD; the former requires the species complement, abundance and/or cover to be monitored, whereas the MSFD if implemented effectively will require the functional aspects of the ecology to demonstrate Good Environmental Status (Borja et al., 2010a). Secondly, there is a change from the site specific to the whole seas approach; both are to be welcomed as long as we can get the monitoring right (Borja et al., 2010a). The use now of the taxonomic sufficiency reduction in some countries, within the WFD, is going to lead to an absence of suitable information for the MSFD implementation, which would require additional budget in the near future, when the monitoring programmes start in 2014. In the case of the MSFD, some information on indicators of several quantitative descriptors (such as biodiversity, alien species, food-webs, and seafloor integrity) is needed. Among these descriptors and indicators are some of those selected by the European Commission (2010), requiring species information: (i) biodiversity: distributional range, pattern and area covered by the species; population abundance, demography and genetic structure; condition of typical species and composition of species; (ii) non-indigenous species: trends in abundance, temporal occurrence and spatial distribution; ratio between invasive non-indigenous species and native species; impacts of non-indigenous invasive species at the level of species, habitats and ecosystem; (iii) Food-webs: performance of key predator species; abundance trends of functionally important species, and (iv) seafloor integrity: presence of particularly sensitive and/or tolerant species; multi-metric indices assessing benthic community condition and functionality, such as species diversity and richness, proportion of opportunistic to sensitive species; size spectrum of the benthic community.

Some of the above indicators require investigating the functioning of ecosystems (Cardoso et al., 2010; Borja et al., 2011). One of the ways to analyse functioning is the use of biological traits analysis, which requires information on species, not of families (Bremner et al., 2006). Hence, obtaining biological information to lower degree of taxonomic separation, reducing the needs of current monitoring (e.g. for the WFD), will result in the need to invest more money in the future to monitor the new issues required by new monitoring programmes (e.g. for the MSFD) or result in the monitoring being not fit-for-purpose. However, in the meantime, we will lose long-term monitoring series, which are necessary to study the effects of human activities on those descriptors, and especially the recovery of ecosystems, after human intervention (Borja et al., 2010b; Verdonschot et al., 2013).

Hence, the consequence of the choices made now, during times of economic crisis, mainly focusing on a selection of structure elements (and reducing them to high taxonomic levels), with only an indirect link to functioning and with the perceived aim of reducing as much as possible the cost of the monitoring programme (as stated also by De Jonge et al., 2006), is that the European countries will not able to meet the requirements as formulated by new directives, such as the MSFD, in terms of functioning of ecosystems.

Here we are not calling for monitoring at all costs, or for unrestricted or poorly defined monitoring in which data are collected just as a 'security blanket'. Almost two decades ago, we complained that monitoring was being done without thought, merely to give the impression that something was being done irrespective of whether the data were being used (Elliott and De Jonge, 1996). Our fear then, and needless-to-say many of those messages given then still apply, was that poor monitoring and/or poor use of the resulting data, would eventually give environmental managers the ammunition to remove monitoring on the basis that it was not and could not deliver useful information but really was a 'job-creation exercise' for marine scientists and technicians and so it could be cut without consequence. Now we feel that such a 'pruning' has gone too far and is reaching (or has already reached) the point when it cannot provide useful information for management. Hence, we are arguing, still, for a rigorous but scientifically defendable approach.

De Jonge et al. (2006) acknowledged that there is insufficient funding to measure and monitor everything and so there is the need to achieve cost-effective monitoring and thus to rely on surrogates for detecting change. This in turn implies that one still has to search for the most suitable system indicators and indices, requiring a thorough analysis of the biodiversity and the ecological food web of our systems over several years. This is a work that will be undertaken in coming years by the European project DEVOTES (DEVelopment Of innovative Tools for understanding marine biodiversity and assessing good Environmental Status; http://www.devotes-project.eu).

Therefore, in conclusion:

- We advocate that we should have an aim to gather data once but use them many times.
- We should also avoid duplication – at present in many countries at any particular point, we may have a nature conservation body gathering data for their purposes, an environmental protection agency for other purposes and a fisheries body for yet other purposes.
- As, for example, the MSFD will need data for whole sea areas rather than the WFD approach just looking in detail at a small area, we need smart ways of gathering relevant information quickly.
- We contend that there is a paradox in that legislation such as the WFD and MSFD are calling for more data (and more reliable data) while at the same time (a) governments are reducing budgets and (b) universities are not training suitable staff.
- We also contend that there is a paradox that monitoring and data-gathering is being cut back yet at the same time industries accused of degrading the marine environment will be considering legal proceedings to defend their actions (i.e. would the law be willing to base judgements on expert judgement rather than rigorous data collection and analysis?).
- There is the need for monitoring in real time to feed into management – it is no good if the data takes a year to obtain but a management decision is needed quickly or if the final data will not be fit-for-purpose.
- We emphasise that whereas recent legal initiatives emphasise a 'structural' approach (i.e. where the numbers of taxa, abundance, level of pollutant, etc.), others are suggesting a functional approach (e.g. WFD cf. MSFD, Borja et al., 2010a). We therefore emphasise that it is more valuable to determine whether an ecological system is working well and functioning rather than merely what (organisms) it contains. Consequently we need

rapid but still rigorous ways of getting information about functioning rather than just the structure of the system.

- We advocate that there is the need to close the 'skills-gap' in that with long experience we consider that there is insufficient training to make practitioners devise the best systems and use the data once they have taken it. This has a knock-on effect in QA/AQC (quality assurance/analytical quality control) so that even if analyses are performed they may not be to a sufficient standard.

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Ángel Borja
*AZTI-Tecnalia, Marine Research Division,*
*Herrera Kaia, Portualdea s/n,*
*20110 Pasaia, Spain*
*E-mail address:* aborja@azti.es

Mike Elliott
*Institute of Estuarine and Coastal Studies,*
*University of Hull, Hull HU6 7RX, UK*