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Editorial

Open your minds: Technological development and job opportunities from marine environmental legislation

Recent marine legislation worldwide (e.g. Oceans Act in USA, Australia or Canada; Water Framework Directive (WFD) and Marine Strategy Framework Directive (MSFD) in Europe, and National Water Act in South Africa) has been developed in order to protect and restore ecological quality or integrity within estuarine, coastal and offshore systems (Borja et al., 2008, 2010).

Now, with the world economy facing a deep crisis, perhaps this marine environmental legislation can be a source of technological development and job opportunity in different marine sectors. Hence, the European Maritime Policy recognises that the maritime industries and services encompass a wide range of sectoral economic activities, from shipbuilding to shipping and ports, to fisheries and aquaculture, to recreational activities and tourism, to offshore energy exploration and extraction, and to a large number of related technical and economic services.

Our responsibility, as marine scientists, is to provide information to these sectors on which different issues within this legislation worldwide need technological development supported with job opportunities. As an example, this editorial leads with the European MSFD, although any other marine environmental legislation could be analysed in the same way.

The MSFD presented 11 descriptors which need to be assessed (for details, see Borja et al. (2010)): (1) biodiversity; (2) non-indigenous species; (3) exploited fish and shellfish; (4) food webs; (5) human-induced eutrophication; (6) sea-floor integrity; (7) hydrographical conditions; (8) contaminants in water and sediment; (9) contaminants in fish and shellfish; (10) marine litter; and (11) introduction of energy/noise. Taking into account the extent of our oceans, and the need to monitor all of them, better developments in marine observation and sampling are needed, to be implemented together with the classical monitoring surveys. Examples are shown below (the potential related descriptors, as numbered above, are shown between parentheses).

(i) Development of physico-chemical and biological sensors, to measure new variables (i.e. a variety of pollutants, different nutrients, etc.), including low-cost sensors to be included in automatic stations and oceanographic buoys (1, 2, 4, 5, 7, 8, 9). Until now, most of the automatic devices are high-cost, so routine and extensive monitoring will require a reduction of costs. In this way, the recent European initiative 'Marine Knowledge 2020' (http://ec.europa.eu/dgs/jrc/index.cfm?id=2820&dt_code=HLN&obj_id=533) tries to collect data and observations from our seas, to facilitate access to data layers of comparable and compatible parameters; and to apply this information for improving our knowledge of marine waters.
(ii) Development of algorithms to measure sea surface variables from satellite devices in a more efficient way (1, 5, 7). We should profit from the currently available platforms (i.e. MODIS, MERIS, etc.), but creating new products for more accurate chlorophyll measurements, may be able to distinguish between some important taxonomic groups, etc. Also the use of airborne devices, such as laser (i.e. bathymetric LiDAR) should be extended.
(iii) Improvement of submarine observation and recording (video, photograph) (1, 3, 4, 6, 10). A better and less expensive way to observe and map submarine communities, with good positioning is desirable.
(iv) Development of new software and models integrating hydrodynamics (physical environment) and ecological processes, including habitat modelling suitability (1, 3, 4, 5, 6, 7, 8). One of our challenges is the integration of physics and dynamics in our ecological models (or the ecology in our hydrodynamic models).
(v) Improvement of acoustic/laser devices for submarine transfer of information, submarine positioning, etc. (1, 2, 3, 6, 7, 8, 9, 11). Easier, cheaper and more accurate information transfer should be designed in coming years, for a better assessment of large marine areas.

After obtaining the information, some new technologies (or improvement of those existing) for analysis and integration of the information are needed, as shown below (the potential related descriptors, as numbered above, are shown between parentheses).

(i) Development of automatic identification and counting of species, and use of genetics in identification (1, 2, 3, 6). There is an increasing need for rapid assessment of marine systems, which probably will require fast automatic taxonomic identification, at least to family level.
(ii) Improvement of analytic methodology for contaminants, improvement of detection limits, passive samplers, etc. (5, 8, 9). The low concentration levels of some pollutants in marine systems will require higher performance analytical devices.
(iii) Accreditation and normalization of sampling and analysis (1, 2, 4, 5, 6, 7, 8, 9), for greater comparability across different countries.

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(iv) Improvement of software for information integration (GIS, etc.), exchange of information, database management, etc. (all descriptors). The need of integration for an ecosystem-based approach management, and the huge amount of information to be processed, should encourage the development of more powerful software tools.
(v) Development of bio-economic tools, for goods and services valuation, and bio-technologies for marine ecosystems health and welfare (all descriptors).

In addition, as these descriptors are used to assess environmental status, especially in relation to the human pressures to which our oceans are being affected, there is also a need of new methods and technologies for restoration of degraded ecosystems. Minimization of impacts could be undertaken by means of Marine Spatial Planning (Ehler and Douvere, 2009), to avoid accumulation of pressures in key areas. Some of the most important human pressures (Claudet and Fraschetti, 2010) in open waters are listed below (not exhaustive), together with some suggestions on technologies to remove or reduce them.

(i) Fishing: minimization of fuel consumption (design of new engines, software for route optimization, etc.), added value for by-catches (transformation, new products, etc.), design of more selective fishing gears, polyvalent fishing boats (i.e. able to catch different species, using different gears), marine reserves creation and management, etc.
(ii) Maritime transport: better management of ballast water (reducing alien introductions), reduction of noise produced by boats, reduction of residues from boats, design of more efficient boats in terms of fuel consumption and reduction in gas emissions.
(iii) Urban and industrial discharges: reduction of contaminants, more efficient and new methods of water treatment, including emerging chemicals, such as pharmaceuticals.
(iv) Aquaculture: reduction of wastes, including pharmace uticals, reduction of fishing dependency for feeding captive animals, reduction of fish escapees to the wild, better pre-selection of aquaculture sites to reduce impacts.
(v) Renewable energies: reduction of electromagnetic impacts, minimization of noise, more efficient devices (for wind, waves, tides, currents, etc.).
(vi) Maritime engineering works: development of soft technologies to avoid strong impacts on marine ecosystems, favouring water exchange in port construction, minimizing dredging, sediment disposal and suspended solids increase, compensation measures, reduction of noise, etc.
(vii) Extraction of oil and gas: changes in drilling mud composition, recycling of wastes.

Of course, this is not an exhaustive list of technologies, but it can be taken as a brain-storming exercise to think about the opportunities that new marine environmental legislation offers for research and development worldwide.

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