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Putting on a bow-tie to sort out who does what and why in the complex arena of marine policy and management

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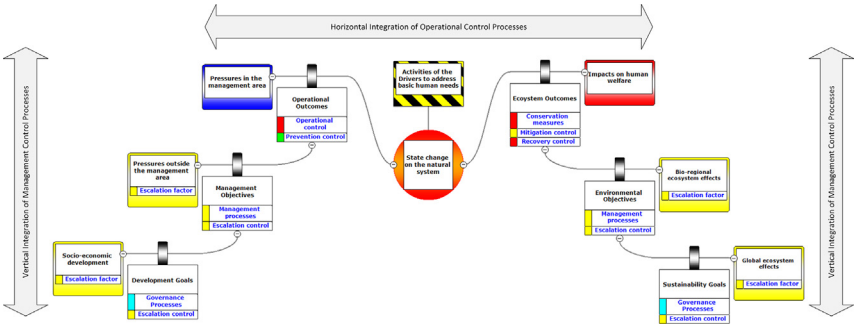
HIGHLIGHTS

- Marine risk management aims to achieve a vision and objectives through measures.
- Operational controls effect marine environmental policy objectives.
- Successful outcomes of sector and conservation controls need horizontal integration.
- Marine management needs vertical integration of outcomes, objectives and goals.
- Stakeholder roles have to be aligned with the horizontal and vertical processes.
- Integration of ISO standards into marine and coastal management is important.

GRAPHICAL ABSTRACT



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ABSTRACT

Marine policy and management has to cope with a plethora of human activities that cause pressures leading to changes to the natural and human systems. Accordingly, it requires many policy and management responses to address traditional, cultural, social, ecological, technical, and economic policy objectives. Because of this, we advocate that a fully-structured approach using the IEC/ISO 31010 Bow-tie analysis will allow all elements to be integrated for a cost-effective system.

This industry-standard system, described here with examples for the marine environment, will fulfil many of the demands by the users and uses of the marine system and the regulators of those users and uses. It allows for bridging several aspects: the management and environmental sciences, the management complexity and governance demands, the natural and social sciences and socio-economics and outcomes. Most importantly, the use of the Bow-tie approach bridges systems analysis and ecosystem complexity. At a time when scientific decisions in policy making and implementation are under question, we conclude that it provides a rigorous, transparent and defendable system of decision-making.

1. Introduction

The intent of the ecosystem approach is to ensure a coherent and integrated management of human activities to achieve desired objectives and reach societal goals in line with prevailing governance processes

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and the stakeholder consensus (Cormier et al., 2017). Even if many of the objectives are social and economic and not about the state of the ecosystem itself, delivery of social and economic goods and benefits depends on the sustained provision of ecosystem services (Elliott et al., 2017; IPBES, 2018). Thus, the ecosystem approach requires methods that should manage human activities to protect and maintain the ecological structures and functions while ensuring that the ecosystem continues to provide those ecosystem services and deliver societal goods and benefits (Elliott et al., 2017). Similarly, even if each sector is applying an ecosystem approach to achieve only sectoral goals, their achievement requires coherent measures and integration of management actions across sectors[1] (Garcia et al., 2014; IPBES, 2018). This article aims to show how an integrated and coherent framework for marine environmental management can be achieved despite the plethora of activities, uses and users, regulators and governance instruments and stakeholders and their interests.

For the marine environment, the ecosystem approach must be achieved through a background of extensive legislation, regulations, policies, standards and guidelines that are now used to manage all human activities (e.g. see the 'horrendograms' in Boyes and Elliott, 2014, 2015). Public perceptions of the causes of environmental change have driven our policymaking governance processes to adopt a plethora of complex management systems and processes dealing with human activities and environmental concerns (Lonsdale et al., 2017). These have generated sector-specific and ecosystem-specific legislation and policies, albeit largely independent from one another, for example fisheries or nature conservation (Garcia et al., 2014). Because of this, many management and conservation approaches have not produced adequate integrated frameworks for managing activities (Jameson et al., 2002; Ricketts and Hildebrand, 2011; McDorman and Chircop, 2012; Baker and Harris, 2012; Mach et al., 2017). Furthermore, the complexity and fragmentation of these management systems is considered a problem (Sardà et al., 2014; Alexander et al., 2015; Diehl et al., 2015) and made even more complex as not all so-called management tools actually manage an activity (Jessen, 2011; O'Boyle and Jamieson, 2006; Elliott, 2014; Cormier et al., 2017).

Even the term management can be confusing (Chun and Rainey, 2005; Loehle, 2006; Mingers and White, 2010) – it may refer to managing governance or planning processes, managing specific human activities, managing classes of pressures or stressors collectively, delivering desired results, or limiting impacts on the environment through management actions. It may aim to ensure coordination between authorities and jurisdictions as well as communication and consultation processes to engage stakeholders (Long et al., 2015; Creed et al., 2016). Thus the confusion can arise from mixing considerations of environment-management in contrast to people-management-measures adopted to guide human behaviour to produce the desired environmental outcome.

This confusion also arises through the use of other terms such as ecosystem assessments and environmental monitoring. Both are used to inform and show possible effects of management decisions and actions, although assessments and monitoring do not in themselves manage human activities (Browman and Stergiou, 2004), i.e. monitoring marine environmental quality only provides information to assess if management decisions are needed or are working. We often refer to environmental management as habitat compensation, offsetting, restoration as well as invasive species eradication; these are mitigation and remediation measures used to recover ecosystems from the damages caused by human activities whereby the measures do not manage the human activities *per se*. Although the form and magnitude of environmental changes are strongly influenced by past human activities making the measures necessary (Jones, 2016), the expected benefits from that remediation can be easily undone by other human behaviours not compatible with achieving the desired objectives. Hence, the links to managing human behaviours are pervasive, whether the 'management' intentionally focuses on the human behaviours or on the outcomes of those behaviours.

This confusion increases when the effectiveness[2] of the environmental management measures are not assessed appropriately. Consequently, management success typically is determined not by actually assessing the effectiveness of those measures in producing the intended outcome, but by monitoring the state of environmental variables relative to established thresholds or targets and inferring that deviations reflect ineffective measures (Noble and Birk, 2011; Cormier and Elliott, 2017). Conclusions may be wrong or misleading as the overall environmental status is the sum of the collective pressures and their measures superimposed on natural processes (Stelzenmüller et al., 2018). Failure to assess accurately the effectiveness of measures increases management shortcomings, firstly, by perpetuating inadequate measures which do not suitably change behaviour and sector practices to reduce collective pressures and reach the intended environmental outcome, and, secondly, possibly allowing an effective measure to be abandoned because some other factor is impeding achievement of the desired outcome. In addition, changes to the management of one activity can have unintended consequences for the effective management of other activities given the complexity and frequent lack of coherence between sector and conservation management systems (Boyes et al., 2016). For example, managing fish stocks to reduce the impact on non-target species may adversely affect seabird populations dependent on fish discarded as bycatch.

Although developing environmental goals and objectives is most effective if underpinned by scientific advisory and stakeholder engagement processes (Burgess et al., 2016), an operational-centric approach is needed to achieve the goals and objectives in an ecosystem approach (Gavaris, 2009; Murawski, 2007; Cormier et al., 2017). In organizational management (Anthony and Dearden, 1980; Chenhall, 2003), management control processes set objectives and manage the operations of the organization to reach the goals established by governance (e.g. integrated coastal and oceans planning processes, policies, politics, administration and legislation that set environmental objectives for a management area). As goals and objectives are intended to guide behavioural changes, operational control processes ultimately implement the controls needed to produce the expected outcomes that in turn achieve those objectives (Girling, 2013; Green, 2015; Hupe and Hill, 2016) (e.g. effluent discharge conditions in a pollution control permit). Operational controls are specifications, procedures and tasks that manage the daily activities of a given sector. For example, the programmes of measures implemented by Member States for the European Marine Strategy Framework Directive (MSFD) (EU, 2008) define the expected outcomes to achieve a Good Environmental Status within the overarching joint goals of the sustainable use of the seas and conserving marine ecosystems (Borja et al., 2010).

There is now substantial attention to vertical integration and coordination of development policies and sustainability policies, i.e. from local through national to international levels and vice versa. This paper explains the joint need for a horizontal integration of operational controls and conservation measures across sectors. We further explain why the Bow-tie analysis of IEC/ISO 31010 (IEC/ISO, 2009), one of the risk assessment techniques of the ISO 31000 risk management standard (ISO, 2018), is and efficient method well-suited to this role. We emphasise the value of the risk management process of ISO 31000 given that an analysis of the measures and actions is needed both to reduce the risks and horizontally to integrate operational controls and conservation measures. The Bow-tie analysis is also promoted here with the further benefit to analyse international conventions, legislation and

[1] Here, a sector is taken as a broad group of activities reflecting marine uses and users such as fishing, navigation, shipping, energy, etc.

[2] Effectiveness is the inherent capacity of a measure to reduce a pressure as specified at the outset.