Marine Policy 96 (2018) 65–71

Contents lists available at ScienceDirect

Marine Policy

journal homepage: www.elsevier.com/locate/marpol

Systematic exploration of actors in society who influence the input of nutrients into the sea

Anders Grimvall*, Eva-Lotta Sundblad, Are Wallin

Swedish Institute for the Marine Environment, P.O. Box 260, SE-40530 Gothenburg, Sweden

ARTICLE INFO

Keywords:
Marine environments
Management
Material flows
Actors
Behavior
Indicators

ABSTRACT

General governance frameworks and ecological models need to be complemented with concrete working processes to efficiently mitigate environmental problems caused by a large number of actors in society. This article, which focuses on marine environmental problems, presents a procedure in which relevant flows of goods and substances in society are linked to the behavior and activities of actors. The exploration of actors is more comprehensive than in currently used procedures which may expand the range of intervention options. Market actors that are normally overlooked in life cycle assessments are disclosed and actors primarily working with information flows are also explored. The implementation of the proposed procedure is strengthened by systematic use of performance indicators. The concrete examples in the present article refer to nutrient inputs into the sea. Management of marine litter and drug residues are two other areas in which a systematic exploration of substance flows and influential actors is likely to be fruitful.

1. Introduction

The human impact on marine ecosystems is extensive and multifaceted. This has created a strong need for scientific frameworks that recognize both the full array of interactions within a natural ecosystem and the role of humans as ecosystem components [1]. Moreover, it has become increasingly clear that many issues surrounding ecosystem management are as much social, political, economic, and cultural as they are ecological [2–6]. The scientific community has responded by making considerable efforts to expand the scientific basis of marine environmental management [7–12]. However, the fact that the human pressure on many marine environments remains unacceptably high [13,14] indicates that there is a need to further strengthen this basis. There is a particularly strong need to complement existing ecological models and governance frameworks with new procedures that can help expand the range of intervention options to reduce the human pressure on marine ecosystems. The present article opens for new intervention options by presenting methods to systematically explore the set of actors in society who can influence undesirable inputs of substances into the sea by changing their behavior or activities.

The current input of substances into the sea is directly or indirectly influenced by a large number of actors. Some of them, like fishermen, farmers, and managers of industries and sewage systems, are responsible for physical activities directly influencing the input or removal of substances or organisms into or from the sea. Other actors influence such flows indirectly through their consumption patterns or their behavior as professional buyers, sellers, or supply chain managers [15,16]. Yet others are active in media, interest organizations, or NGOs. Accordingly, it appears obvious that efficient environmental management requires active involvement of a wide range of actors. This is also underscored in some of the *Sustainable Development Goals* (SDGs) recently adopted by the United Nations [17]. It is especially worth noting that SDG 12, *Responsible Consumption and Production*, emphasizes the crucial role of both consumption and production. Large and transnational companies can make a difference by adopting sustainable practices, public procurement can further promote such practices, and consumers have a responsibility provided that they are given access to relevant information.

Systematic exploration of actors who can influence the pressure on the sea requires some kind of overarching and management-oriented description of the links between human and marine systems. Over the past decades, substantial efforts have been made to describe such links. Several of the most common approaches originate from ecological modeling. Other approaches take governance frameworks as the point of departure.

The ecological modeling track can be exemplified by Ecosystem-

* Corresponding author.
E-mail addresses: anders.grimvall@havsmiljoinstitutet.se (A. Grimvall), eva-lotta.sundblad@havsmiljoinstitutet.se (E.-L. Sundblad), are.wallin@gmail.com (A. Wallin).

https://doi.org/10.1016/j.marpol.2018.07.014
Received 10 November 2016; Received in revised form 18 July 2018; Accepted 18 July 2018

Based Management (EBM). Rather than focusing on a single service or activity, EBM addresses ecosystem health and the sum of ecosystem services and benefits desired from the environment [18]. To further increase integrative skills in marine management, the National Oceanic and Atmospheric Administration (NOAA) has elaborated EBM into Integrated Ecosystem Assessment (IEA) [9]. The use of IEA to introduce management perspectives in the scientific analyses of marine ecosystems is also permeating the current strategic plan for the International Council for the Exploration of the Sea (ICES) [19].

The governance framework track can be exemplified by the widely used DPSIR (Driver, Pressure, State, Impact, Response) framework developed by the European Environmental Agency [20]. A similar framework, BPSIR (Behavior, Pressure, State, Impact, Response) [15], emphasizes the importance of identifying relevant actors and their behavior. By introducing a *behavior* node in the conceptual governance model and considering both direct and indirect actors, a wide range of actors and their behavior can be made visible.

Pressure maps make up a third type of description of the links between human and marine systems. The most widespread global pressure maps provide quantitative information about activities that take place in or on the sea and the magnitude of various forms of chemical and biological inputs into the sea [13,14]. The same holds true for regional pressure maps underlying compilation of pressure indices, such as the Baltic Sea Pressure Index (BSPI) [21] and the North Sea Pressure Index (NSPI) [22].

Although the abovementioned efforts to link human and marine systems constitute considerable achievements, the methods currently used to guide future management options can be improved. In many cases, there is a considerable risk that the list of actors who can influence the inputs into the sea becomes incomplete. The status of the sea is not only influenced by activities on the interface between society and the natural environment. Consumers of goods, supply chain managers, importers, wholesalers and retailers, public procurers, and environmental managers are examples of actors who also can make decisions that lead to increased or decreased pressures on valuable marine ecosystems.

The main objective of the present study is to propose a systematic working process that can facilitate comprehensive analyses of actors and behaviors influencing the pressure on marine environments. More specifically, the following four steps are presented to systematically explore a wide range of actors and their activities and behavior and to suggest how changes over time can be monitored:

1. Systems analysis of the flow of relevant substances and goods in society.
2. Linking of actors and behaviors to physical flows of goods.
3. Identification of additional actors by social network analysis.
4. Selection of indicators that could be used to monitor changes.

The proposed systems analysis of substances and goods in society builds on methods developed in industrial ecology and reviewed by Bacchini and Brunner [23]. However, the analyses presented here differ from conventional analyses of physical flows by being more actor oriented. This leads naturally to the second step of the working process, in which individual actors or actor groups are linked to specific goods. In particular, this step pays attention to actors who influence physical flows by acting as supply chain managers, wholesalers, retailers, and consumers.

Social network analysis (SNA) is a widely used method to study relationships between members of social systems. In its more advanced form, SNA has a theoretical basis of graph theories [24]. In the proposed working process, the main objective of SNA is to identify actors that otherwise could have been overlooked, and the gathering of information is primarily based on interviews with actors already identified in previous steps of the working process.

Indicators are widely used in a variety of contexts to convert complex or scattered information into a small number of key variables [25]. Here, it is focused on indicators related to the flow of substances and goods in society and the behaviors of people and organizations that may influence the pressure on marine environments.

The remainder of this paper is organized as follows:

Sections 2.1–2.4 describe the methods proposed to carry out the four abovementioned steps to explore actors who influence the input of substances into the sea and to select performance indicators. Section 3 is devoted to a general discussion of the proposed methods and their relationship to currently used methods and frameworks in marine environmental management. Finally, Section 4 summarizes strengths and weaknesses of the proposed methods and ends with some concluding remarks.

2. Methods

The working process and methods described below constitute a general procedure to facilitate comprehensive identification of actors and management options for a great variety of pollution problems. However, for the sake of clarity the description of methods is accompanied with concrete examples of activities and actors that influence Sweden's input of nutrients into surrounding marine waters. The description of methods is also accompanied with some examples of what conclusions can be drawn from application of the methods under consideration.

2.1. Systems analysis of the flow of substances and goods in society

The pressure on the marine environment can in many cases be described as a flow of substances or materials through society into the sea. To enable rigorous assessments of such physical flows, a number of systems analysis tools have been developed in industrial ecology, and specifically in life cycle assessment (LCA). Typically, these tools focus on physical flows of energy, substances, or products along entire production chains, including transport and use of products and handling of waste. However, from a societal perspective, a substance flow is not only a physical flow but also a result of a number of activities and behavioral patterns of institutions, organizations, and individuals. This fact calls for a set of tools that can help disclose and describe links between physical flows and processes in society. The conceptual flow model illustrated in Fig. 1 represents a first step toward this goal. The model is generic in the sense that it can be applied to flows of substances as well as products and to systems delineated by different types of boundaries. Furthermore, the model emphasizes the key role of trade and consumption of products and opens for systematic analyses of behaviors and actors that shape the market of consumer products.

The case of phosphorus flows through Sweden can illustrate how the model in Fig. 1 should be interpreted and used. Starting in the upper left corner of the graph, the node labeled *Trade: inputs* illustrates that phosphorus fertilizers are imported to Sweden and sold to farmers. The farmer then uses the fertilizer to produce crops (an activity in the *Production* node) that after various types of processing (additional activities in the *Production* node) are brought to a wholesaler or grocery store that markets the products (*Trade: finished goods*) to the consumer (*Consumption and use of goods*). Alternatively, if the crop is used as animal feed, the farmer brings the harvest to meat farmers (trade within the *Production* node). After the animals are slaughtered and the meat processed, merchant actors bring the products to the consumers. After human consumption of the food, the resulting waste is handled in municipal or on-site systems for liquid or solid wastes (*Waste management*). A substantial fraction of the phosphorus that is not recirculated into new production will leach to aquatic environments and finally reach the sea.

In the example just discussed, a national boundary was used as system boundary. Another option is to combine a geographical boundary with a sectorial boundary. For example, the study of