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Promoting enriched coastal zone management: The role of boundary objects

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ABSTRACT

In coastal zone management (CZM), scientific knowledge can help enrich and underpin the development of policy options by providing insight into ecosystems and their management, the use of ecosystem goods and services, and ecological limits to the exploitation of natural resources. Due to the large array of interests and stakeholders involved in CZM, however, it is often complicated to produce and use knowledge which is perceived to be credible, legitimate and salient. The scholarly literature advocates employing collaborative and participatory approaches, such as the development and use of boundary objects, to enhance the production and use of knowledge in CZM with the aim of enriching decision-making processes. This paper empirically explores two assessment systems as boundary objects in order to address the question 'To what extent and in what way do boundary objects contribute to enriched coastal zone management?'. Our analysis suggests that for a boundary object to contribute to enriched CZM, the need for it to be credible is less important than the need for all stakeholders involved to perceive it and its development process as being legitimate to their interests. Secondly, without a direct 'policy window', the boundary object has little chance of directly enhancing decision-makers' knowledge.

1. Introduction

Coastal zone management (CZM) faces a number of challenges, among them sea level rise, acidification and overfishing (e.g. Cazenave and Cozannet, 2014; Gattuso et al., 2015). Interactions among ecological and economic interests are complex, not least because the different objectives of the broad array of stakeholders ranging from policy-makers, coastal managers and industry to researchers and civil society organisations, etc. can give rise to tension (e.g. Puente-Rodríguez et al., 2015). This presents challenges for the management of the physical coastal zone as well as the management of knowledge in this process (Giebels et al., 2013). Scientific knowledge can help enrich and underpin CZM by providing insights into and policy options for the management of ecosystems, the use of ecosystem goods and services, and the ecological limits to the exploitation of natural resources (Van Tatenhove et al., 2016: 377). However, the large array of interests and stakeholders involved in CZM often complicates the production and use of knowledge. In particular, tension may occur between science and policy: *'the former seeks unbiased, objective descriptions or reality, while the latter must incorporate various factors in its development, including values, ideologies, economics, biases, and emotions'* (Rose and Parsons, 2015: 71). It is also argued that often, *'the supply of scientific knowledge does not meet the requirements of users of knowledge in terms of the speed in which knowledge is delivered, its level of detail, its scale, its relevance or the extent to which uncertainties have been reduced'* (Van Tatenhove et al., 2016: 377).

In order to optimise the role of science in enriching and underpinning CZM, various authors have proposed employing collaborative and participatory approaches (e.g. Döring and Ratter, 2015; Runhaar et al., 2016; Seijger, 2014; Tompkins et al., 2008; Van Tatenhove et al., 2016; Vugteveen et al., 2015). Enriched decision-making can be understood to be the behaviour of decision-makers when influenced by their enhanced knowledge of the consequences of their decisions (Heink et al., 2015). To make this more tangible, in enriched decision-making, knowledge is used to arrive at a clearer picture of the problem setting, to underpin and implement policy and management measures, to explore policy options; it is also used in learning processes among policy-makers, scientists and stakeholders (e.g. Van de Riet, 2003; Van Tatenhove et al., 2016).

Our research focuses on a specific science–policy interface, or approach, for organising participatory knowledge development processes: the employment of boundary objects. Boundary objects are *'hybrid constructs that integrate elements from scientific and political worlds to facilitate the negotiation and exchange of multiple types of knowledge and action'* (White et al., 2010: 221), and *'can be used to transfer or communicate complex scientific information into understandable and tailored*

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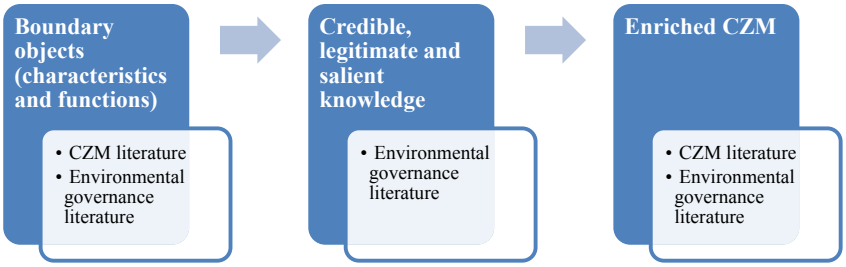

Fig. 1. Structure of the literature review on boundary objects in CZM.

information which is tacitly connected to the target group' (Van Pelt et al., 2015: 42). In the field of CZM, various boundary objects have been used to enrich decisions (e.g. Floor et al., 2016). For example, ecological indicators (e.g. Turnhout et al., 2007; Turnhout, 2009; Uehara and Mineo, 2017) can be used as boundary objects to measure the ecological quality of ecosystems. Another boundary object is the concept of 'significant effect' as a threshold when permitting human activities in protected marine areas (Floor et al., 2016). Döring and Ratter (2015) discuss the concept of 'Heimat' as a boundary object. This German word or concept encompasses a range of place-based meanings reflecting a spatially and socially experienced construct; it is used as a boundary object in science–policy interactions to create self and external perceptions of why and how people relate to a certain natural area, what is their mutual understanding and how and why they develop common goals (Döring and Ratter, 2015). Becker (2017) refers to climate scenarios as boundary objects: these are visualisations of scenarios based on scientific data, which should help communicate complex and nuanced information in a mode which people understand (Becker, 2017). The foregoing examples give some idea of the variety of boundary objects. More specifically, boundary objects are not so much physical objects per se as the end products or outputs of participatory processes. As can be seen from the examples, they can be presented in different ways. Irrespective of their forms, boundary objects have the common aim of bringing together stakeholders (scientists, policy-makers and others) within the coastal management arena who then collectively develop a knowledge-based boundary object, for example to assess the ecological state of a coastal zone area. Notwithstanding all of this, even though the literature presents us with examples of boundary objects, the questions of how they facilitate enriched decision-making in CZM, and to what extent, remain underexplored.

This paper aims to address the 'black box' in the literature on boundary objects in CZM. Our main research question is therefore: 'To what extent and in what way do boundary objects contribute to enriched coastal zone management?'. To address this question, we formulated three sub-questions: i) How does the scholarly literature characterise boundary objects in terms of their features and their functions? ii) How can the potential influence of boundary objects on enriched decision-making processes be determined? and iii) How, and to what extent do boundary objects contribute in practice to enriched coastal zone management?

To address the questions, we first analysed the scholarly literature on boundary objects to establish their features and functions. Next, we empirically explored two boundary objects intended to assess the current ecological state of the Dutch Wadden Sea area. The latter is a coastal zone of great ecological value due to its unique ecosystem (it was awarded UNESCO Heritage status in 2010), but it is also of great economic value due to its natural resources (e.g. gas and salt) and its harbours and tourism industry. Because of these contrasting interests, the management of the Wadden Sea area is beset by continuous sparring between ecological and economic interests that involves a large array of stakeholders ranging from industries to government (national, provincial and local), environmental agencies and research institutes (e.g. Floor et al., 2013; Heslinga et al., 2018; Runhaar and van Nieuwaal, 2010; Van Nieuwaal, 2011). The exploration of boundary objects by means of a case study enables analysis of how these objects function in practice and their contribution to enriched CZM (Yin, 2003). Analysing two cases will allow us to attempt to draw conclusions that can be generalised and to formulate hypotheses, thereby contributing to the scholarly literature on boundary objects in CZM. The two boundary objects we will analyse are assessments of the impact of human interference on the ecological state of the Dutch Wadden Sea: the Wadden Sea Barometer (hereafter WSB) and the Waddenhouse Deliberation ranking (hereafter WHD). We consider these assessments to be boundary objects since they have been developed in a participatory process with the aim of developing and communicating knowledge across boundaries among science, policy and practice, in order to support CZM in the Wadden Sea. Besides their similarities, there are notable differences between these two assessments: whereas the WSB had a descriptive approach, the WHD not only assessed but also ranked the ecological and economic impact of human activities on the Wadden Sea. Ranking activities in this way immediately impacts on the interests of involved stakeholders and can potentially give rise to the boundary object itself being contested.

2. Boundary objects and their contribution to enriched decision-making: a literature review

This section will address the first two sub-questions by providing a brief literature review on boundary objects (Fig. 1 shows the review's structure), addressing their characteristics and functions, and developing a framework that could be used to empirically analyse how and to what extent boundary objects can contribute to enriched decision-making processes. CZM literature provides few examples (empirical or otherwise) of boundary objects. To provide a more thorough and in-depth theoretical analysis of the functions of boundary objects and how they contribute to decision-making processes, we begin (section 2.1) by addressing how the scholarly literature characterises boundary objects in terms of the characteristics and functions presented in section 1 above. To do so, we not only use CZM literature but also broaden our perspective by including scholarly literature which discusses boundary objects within the field of environmental governance in general. This literature discusses issues closely related to CZM, such as water management (e.g. Lejano and Ingram, 2009; Van Pelt et al., 2015; White et al., 2010), and ecosystem management (e.g. Abson et al., 2014; Cortner, 2000; Uehara and Mineo, 2017). In section 2.2 we will look more closely at the contribution of boundary objects to enriched decision-making. As we will show, the literature on boundary objects provides us with limited guidance to analyse these contributions. We will therefore use the framework developed by Cash et al. (2003), who argue that if scientific knowledge is to enrich sustainable decision-making processes, it needs to be perceived by all stakeholders involved as credible, legitimate and salient. Briefly, these three criteria can be understood as follows: for knowledge to be perceived as scientifically credible, it needs to be scientifically adequate, accurate, trustworthy and of high quality (e.g. Buizer et al., 2005; Hegger et al., 2012; Van Enst et al., 2014; but see Dunn and Laing, 2017). Legitimacy is achieved

when the producers of the information are seen as unbiased and the knowledge produced respects the divergent values and beliefs of the stakeholders (e.g. Cash et al., 2003; Hegger et al., 2012). This increases the level of trust regarding the information and the likelihood that it will be used by the end-user (Cvitanovic et al., 2015). Finally, salience refers to the level of relevance of the scientific research to decision-makers and the given problem (e.g. Cash et al., 2003; Sarkki et al., 2015).

2.1. A boundary object: what are its characteristics and its functions?

Following Star and Griesemer, who are considered to be the instigators of the concept, boundary objects can be understood as objects which are *'plastic enough to adapt to the local needs and the constraints of the several parties employing them, yet robust enough to maintain a common identity across sites'* (1989: 393), or, more concretely: *'objects that are shared and shareable across different problem-solving contexts. (…) objects that work to establish a shared context that "sits in the middle".'* (Star, 1989: 47). For this purpose, they possess a certain interpretive flexibility. An object can be interpreted differently by various actors due to differences in use and interpretation, but it *'must provide a common focus'* (Feldman et al., 2006: 95). Star and Griesemer argue that the nature of boundary objects is *'reflected by the fact that they are simultaneously concrete and abstract, specific and general, conventionalized and customized'* (1989: 408). So, what, then, is considered to be a boundary object? As noted in section 1, concepts such as 'significant effect' (Floor et al., 2016), 'Heimat' (Döring and Ratter, 2015), or 'sustainability' (Brand and Jax, 2007) have been discussed as being boundary objects. In the sphere of classification systems, ecological indicators (e.g. Turnhout, 2009) are discussed like this. Furthermore, in a more concrete sense, examples of boundary objects include ecosystem services (e.g. Abson et al., 2014), simulation games (e.g. Van Pelt et al., 2015), scenarios (e.g. Becker, 2017; Chaudhury et al., 2013) and interactive simulation models (e.g. White et al., 2010). This list of examples, however, does not answer the question. Indeed, it might make it even more difficult to understand the idea of a boundary object. We have already noted that boundary objects are not physical objects. So, could it be that different authors attribute different meanings to the concept of 'boundary object'? A follow-up question could therefore be: what makes these objects 'boundary objects' and what are their common functions? In short: what does a boundary object do?

Based on our review of the scholarly literature on boundary objects we have identified at least three functions. First, as, Van Pelt et al. argue, boundary objects (in their case, simulation games) *'can be used to transfer or communicate complex scientific information into understandable and tailored information which is tacitly connected to the target group'* (2015: 42). In other words, boundary objects (such as assessments and rankings) aim to gather, combine and clarify scientific knowledge, making the information more understandable and useful for decision-making processes (e.g. Clark et al., 2016; Van Pelt et al., 2015; White et al., 2010). However, for a boundary object to fulfil this function, its development and use need to facilitate and structure the interactions and communication among stakeholders (e.g. Abson et al., 2014; White et al., 2010): this is the second function. The act of collectively developing the boundary object provides a concrete means for individuals to specify and learn about their differences and dependencies across a given boundary (Carlile, 2002). This development of a boundary object facilitates the negotiation and exchange of multiple types of knowledge (knowledge from different disciplines and/or knowledge from different domains) (e.g. Abson et al., 2014; Brand and Jax, 2007; White et al., 2010). After the boundary object has been developed, its amenability to flexible interpretation provides a common ground (without the need for consensus (Star, 2010)), or scope, which can be used as a starting point on which to base further interactions (White et al., 2010). The third function is also in line with this second function: boundary objects serve to establish a shared context that *'sits in the middle'* (Star, 1989: 47) by letting scientists from various disciplines cooperate (despite the tremendous differences) in order to create applicable science (Carlile, 2002). The interdisciplinary character of the knowledge on which boundary objects are based allows for this shared context.

Taking these actual and possible functions of boundary objects into consideration, to what extent do they contribute to enriched CZM? The literature reviewed provides little clarification on this: White et al. (2010), for example, describe how water managers evaluate a simulation model (the boundary object), but do not assess to what extent this model might influence their decision-making processes. We therefore propose to search for a framework which, hypothetically, could create a link between the functions of boundary objects and enriched CZM.

2.2. A boundary object: criteria leading to enriched CZM

As argued earlier in this paper, to overcome interaction barriers existing between science and policy and by doing so to enhance the use of scientific knowledge within these interaction processes scholars emphasise that *'the likelihood of success is enhanced via the implementation of collaborative and participatory approaches to knowledge exchange and scientific research'* (Cvitanovic et al., 2015: 29). An often-used framework to analyse this issue has been developed by Cash et al. (2003), who argue that decision-makers are more likely to use scientific knowledge in decision-making processes if the knowledge at issue is perceived as credible, legitimate and salient by the stakeholders involved. In turn, these criteria can be related to the three functions of boundary objects discussed in section 2.1. For example, the function of gathering, combining, clarifying and communicating complex scientific knowledge should (hypothetically) increase credibility because of the increased trustworthiness and accuracy of the combined knowledge, but the knowledge should also be more salient because then it will be more understandable and thus more likely to be applied. As for the facilitation and structuring of the interactions between the stakeholders involved (a more process-oriented function), hypothetically this will increase the legitimacy of both the process and the ultimate boundary object, because a process has been created that is inclusive and therefore respectful of the different values and beliefs of all stakeholders involved. Finally, the establishment of a shared context and a sharing of applicable knowledge could increase the credibility (since epistemological differences are being bridged), legitimacy (since the word 'shared' incorporates a certain inclusiveness of stakeholders' perspectives) and salience (because of the increased relevance this function aims to attain).

In order to analyse the credibility, legitimacy and salience of boundary objects, these criteria first need to be made operational. To do this, we rely on the work by Hegger and Dieperink (2014), who analysed joint knowledge production processes, White et al. (2010), who analysed the (perceived) credibility, legitimacy and salience of simulation models, and Heink et al. (2015), who researched how credibility, legitimacy and salience could serve as criteria for the effectiveness of science–policy interfaces. In line with these authors, we will review these criteria as perceived by participating key actors. The operational criteria should be considered to be sensitising concepts rather than definitive concepts: *'[S]ensitising concepts have no fixed operational definition, but provide the researchers a frame on "where to look"'* (Hegger and Dieperink, 2014: 34). In line with this, it needs to be stressed that concepts such as credibility, legitimacy and salience can be considered to have a variety of meanings and, as Heink et al. argue in their paper, these meanings can be ambivalent. They state that *'most knowledge and most decisions are credible, relevant or legitimate […]. For example, local knowledge is highly credible for stakeholders but often does not meet standards of scientific credibility.'* (2015: 686). Although we could agree on this example, we would argue that it is not a case of either/or. Since participatory processes are at the basis of the development of boundary objects, it would seem that for a boundary object to be credible, the knowledge on which it is based should not only meet scientific

Table 1
Indicators of and conditions for the credibility, legitimacy and salience of a boundary object.

Criteria	Making the criterion operational
Credibility	The technical evidence is scientifically valid[a, b, d] Epistemological differences are bridged[c] Different forms of knowledge are included[c]
Legitimacy	The boundary object is perceived as unbiased[a, b] The role of the stakeholders involved is clear during the development process of the boundary object[c] The boundary object includes divergent actor values and perspectives[a, b] Stakeholders agree that the right questions have been asked about the right problem[c] There needs to be active and inclusive communication among stakeholders[c]
Salience	The boundary object is perceived to be relevant to decision-makers[a, b, c, d] The language used decreases the complexity of the scientific knowledge, making it more accessible and understandable[c]

[a] Cash et al. (2003).
[b] White et al. (2010).
[c] : Hegger and Dieperink (2014).
[d] Heink et al. (2015).

standards, as Heink et al. put it, but should also include other 'types' of knowledge.

We combined the insights from the literature mentioned above to produce Table 1, which shows how credibility, legitimacy and salience can be operationalised. We used this approach when analysing our two case studies.

3. Methodology

In order to explore boundary objects in practice, we used the case study method (cf. Yin, 2003). We opted to examine two cases of boundary objects: the Wadden Sea Barometer and the Waddenhouse Deliberation ranking. Both boundary objects entail different types of knowledge (scientific and expert on the one hand, and multi-disciplinary on the other) and are political in nature, since their development was demanded by policy needs. The two boundary objects were developed in a participatory process with the aim of developing and communicating knowledge across the boundaries between science, policy and practice. Because of these characteristics, both cases can be classified as boundary objects (cf. White et al., 2010; Van Pelt et al., 2015). Because the two boundary objects were developed recently, we expected that the scientists and stakeholders involved would still have a good overview of the.

First, we conducted extensive desk research into the two boundary objects. The documents we consulted initially were predominantly in the public domain. Later, we obtained less accessible documents from actors who were involved in the developing and deploying of the two boundary objects. From this desk research we aimed to obtain a thorough idea of the content of the two boundary objects and of the processes which led to the final assessments. Second, during the Waddenhouse Deliberation held in February 2016, unstructured observation was conducted. Such observation is intended to *"record is as much detail as possible the behaviour of participants with the aim of developing a narrative account of that behaviour"* (Bryman, 2004: 167). Third, we conducted semi-structured interviews with key individuals in the two cases (project leaders and developers of the two objects and a CZM policy-maker). These interviews were used to gain an understanding of the processes which led to the final boundary objects themselves, so were therefore conducted with people close to the development of the assessments. The interviewees were chosen systematically, Finally, the interviews were augmented by information gathered by means of two online questionnaires (one per case study). These questionnaires, which were based on a set of statements and can be found in the supplementary material, were used to explore how credible, legitimate and salient the assessments were perceived to be by the stakeholders involved (scientists, policy-makers, representatives of environmental organisations, and representatives of Wadden Sea industry sectors). The statements in the questionnaire directly correspond with making the three criteria of credibility, legitimacy and salience operational. The statements were rated on a 6-point scale (ranging from strongly agree to strongly disagree in five steps; the sixth option was 'no opinion/do not know'). In both cases, we selected the respondents to the questionnaires based on the final assessment report. The Wadden Sea Barometer report indicated that 21 people (including scientists, experts, coastal zone managers, policy-makers, representatives of environmental organisations, representatives of industry) had been involved in developing the Barometer. In the case of the Waddenhouse Deliberation ranking, the final report names 48 people who contributed to the development of the ranking (range similar to the WSB). Nine of the total of 69 people were mentioned in relation to both boundary objects. We are aware that by using the stakeholders identified in the two reports, we might have overlooked other potential stakeholders who have been influenced by CZM decisions. Table 2 shows the response rate in both cases.

In the following analyses, references will be made to our data. We differentiate between interviewees, and respondents. The latter were given the opportunity to add comments to the questionnaire. Where these comments are quoted, they have been given the reference 'Resp.#X'. Where we refer to one of our interviews, the designation is 'Interviewee #X'.

4. The contribution of boundary objects in enriched coastal zone management: two cases from the Dutch Wadden Sea

4.1. Wadden Sea Barometer

The Wadden Sea Barometer (hereafter WSB) (developed in 2014–2015) can be defined as a monitoring tool for assessing the Wadden Sea region from the perspective of sustainable development. Its development, guided by Telos (a research institute connected to Tilburg University in the Netherlands), was a response to the need to monitor the area and to establish whether the management of the Wadden Sea region was 'on track'. The report of the WSB assesses the ecological, economic and socio-cultural state of the Wadden Sea area, based on a set of indicators. Furthermore, it reveals to what extent the area is developing (positively or negatively).

In the report on the barometer, Telos states that the process of developing the barometer was guided by a number of basic principles. Foremost among these was the need for commitment and engagement of stakeholders: the process was intended to create ownership of the barometer among the stakeholders. Furthermore, it was agreed that the data and indicators which were to guide the development of the barometer should be based predominantly on indicators and data already being used in the monitoring in the Wadden Sea region. In other words, the barometer should primarily be based on existing (scientific) data and indicators. A final basic principle was to be the transparency and

Table 2
Number of interviews per case and the response rate to the online questionnaire per case.

	Case	
	Wadden Sea Barometer	Waddenhouse Deliberation ranking
No. of interviews	2	3
No. of questionnaire respondents	9 (out of 21)	23 (out of 48)

Table 3
Telos's basic principles in relation to the functions of a boundary object.

Basic principles (developed by Telos)	Related functions of a boundary object
Commitment and engagement of stakeholders is needed	The object is the structuring and facilitation of interactions among stakeholders
Data and indicators used to develop the WSB are to be based on existing data and indicators being used in monitoring activities	Scientific knowledge is to be gathered and combined to create a shared context and applicable knowledge base
The process must be transparent and trustworthy	The object is the structuring and facilitation of interactions among stakeholders

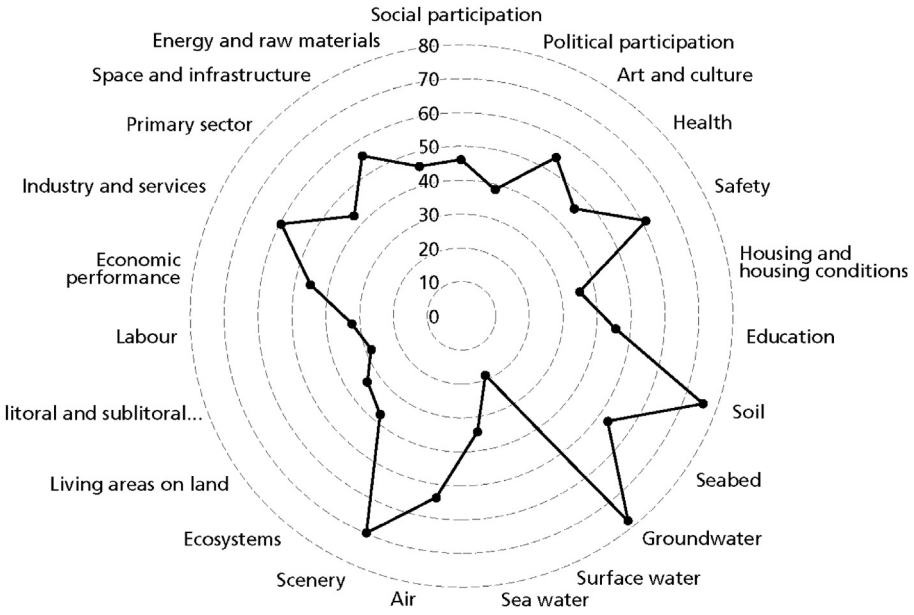

Fig. 2. Spider diagram, presented in the conclusions of the Wadden Sea Barometer report. It represents different indicators which, following the Telos method, assess the ecological, economic and socio-cultural state of the Wadden Sea region. The higher the score in the spider diagram, the higher the quality of the particular indicator.

trustworthiness of the process and therefore of the barometer: each indicator should be defined meticulously and should include evidence of the credibility of the data used. The functions of the barometer are summarised in Table 3:

The development of the barometer (presented in Fig. 2) started with conversations and interviews with a broad array of stakeholders, including scientists, policy-makers (including those making local policy), experts, environmental organisations and the private sector. These meetings had two purposes: to create the support for the barometer desired by the project leaders and to gather insights, knowledge and information to be input for the development of the indicators for the barometer. In relation to these activities, interviewee #2 noted that although people were cooperative and favourable to the development of such a boundary object, there was also some suspicion: because the WSB was 'not invented here', the barometer's ability to address the inner struggles and tensions among stakeholders, namely the industries and other interests in the region, was questioned.

In conclusion, and in relation to the functions of boundary objects discussed earlier, the aim of the WSB was to structure scientific knowledge and make it more usable for decision-makers. Furthermore, by using insights from various scientists and data from different scientific disciplines in the development of the barometer, the WSB was intended to create a shared context and, as interviewee #1 put it, to create support for the credibility of the boundary object. On a critical note, however, although interviewees #1 and #2 explained that interviews were held with stakeholders during the development of the barometer, the WSB did not seem to have as one of its aims to facilitate and structure interactions and communications *among* stakeholders as part of the process. Although attempts to do so were made later in the process, the interactions and communication were predominantly between individual stakeholders and Telos, rather than among stakeholders guided by Telos. This not only influences the contribution to an increase in interactions, but also influences the perception of 'shared context'. Shared, in this sense, means not only that the boundary object is capable of being interpreted in many ways, but also that its development process has been shared, creating ownership. In the case of the WSB, such ownership was also lacking, as will be further explained in the following section. So, after identifying these functions of the WSB, what does the questionnaire tell us about the perceived credibility, legitimacy and salience of the barometer?

4.1.1. Credibility, legitimacy and salience of the Wadden Sea Barometer

The results of the questionnaire on the WSB, presented in the supplementary material, suggests that overall, either the respondents were neutral (i.e. neither positive nor negative) to positive about the credibility, legitimacy and salience of the barometer, or they had no opinion. Before drawing conclusions on these findings, let us look more closely at the results. Although opinions on some topics vary, for example on the inclusion of non-scientific knowledge in the barometer or on whether the barometer is understandable to a broad audience, the overall outcome suggests that respondents who felt capable of assessing the barometer based on the statements feel that the barometer is relatively credible, legitimate and salient, which is in line with the barometer's intended functions. On the matter of legitimacy, however, some issues are noteworthy. The responses show that especially in relation to the criteria that the 'boundary object includes divergent actor values and perspectives' and whether 'all actors with an interest were able to be part of the process, at the appropriate time', most respondents have no opinion on the matter or lack the insights to respond to the statements. Indeed, nearly half, or more than half of the respondents responded 'no opinion/do not know' to almost all the statements. The identified stakeholders who declined to fill in the questionnaire responded that they did not feel entitled to express opinions on the statements. Their main argument was that they did not

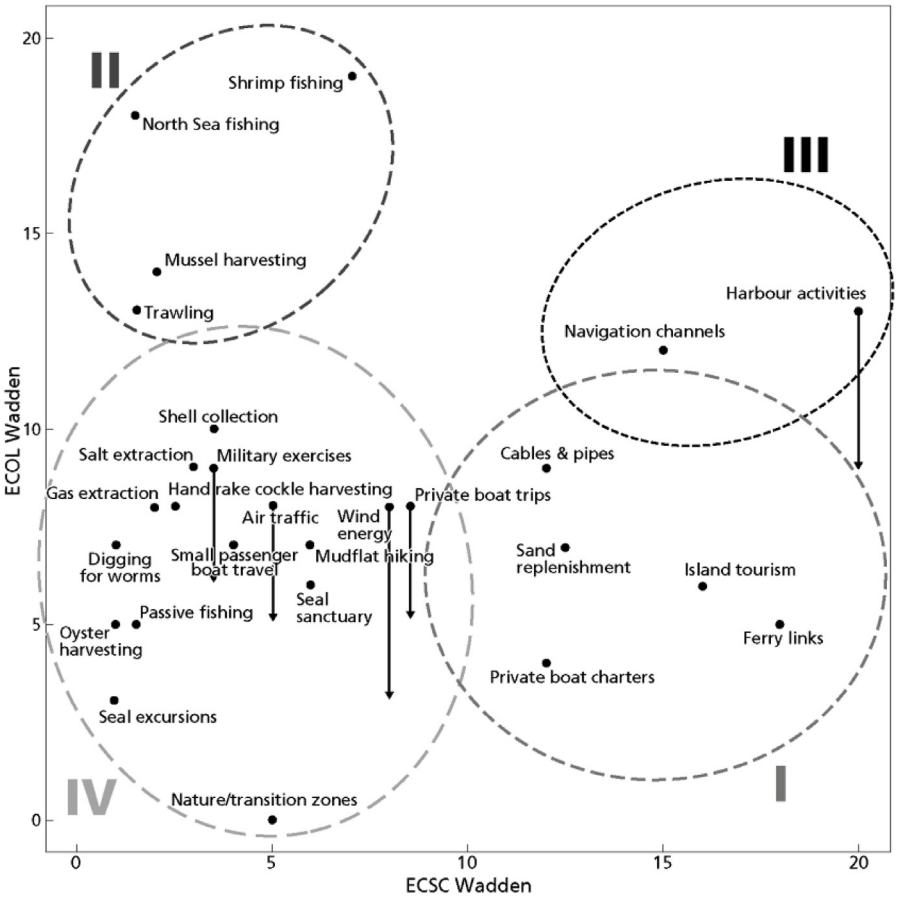

Fig. 3. Final panel scores of the Waddenhouse Deliberation, indicating the influence of human activities (explained in the ecological domain (vertical) and the socio-economic domain (horizontal)) on the state of the Dutch Wadden Sea area. The higher the score in the ecological domain, the more negative the impact of this activity is on the ecological state of the Wadden Sea. The higher the score on the socio-economic domain, the more positive the impact of this activity on the socio-economic state of the Wadden Sea. The graphic shows that the activities in 'zone' III impact relatively negatively on the ecological state but are important for the socio-economic state of the Wadden Sea region. The activities in 'zone' II, appear to have a similar impact on ecology, but are less important for the region's general socio-economic state.

recall having taken part in the barometer's development. The fact that only a handful of people feel entitled to assess the WSB's credibility, legitimacy and salience raises the question of to what extent the WSB has actually been developed in a participatory manner. Furthermore, it can be questioned to what extent one can create ownership of a barometer, if the individuals intended to be engaged with during the development of the barometer do not feel entitled to share their perception of the barometer's credibility, legitimacy and salience. As will be explained in the next paragraph, these issues influenced the contribution of the WSB to enriched decision-making.

4.1.2. Contribution of the Wadden Sea Barometer to enriched CZM

According to interviewees #1 and #2, who developed the WSB, this barometer made no contribution to enriching the Wadden Sea CZM, even though it could be considered to be credible, salient and to some extent legitimate. How can this be explained? Interviewee #1 explained that publication of the barometer attracted little interest or attention. This lack of attention, and hence the little use made of the barometer, can be attributed to the lack of ownership of the barometer among stakeholders in the Wadden Sea region. The lack of ownership can be ascribed to two factors. First, there was the problem of 'not invented here' (Waddenplein, IMSA, 2014). Even though people with strong ties to the region and who were in networks in the region were consulted during the barometer's development, the WSB was not developed in and by the Wadden Sea region. Second, there had been only limited interactions with and among the stakeholders in the region, and this led to little engagement and therefore little ownership. Interviewee #2 explained that a so-called 'consensus meeting' was proposed in which 'people with great track records in Wadden Sea affairs and ecology, or on account of their personal activities or networks could meet to validate, defend and disseminate the choices made among affiliated stakeholders'. Unfortunately, no such meeting ever took place. Furthermore, as interviewee #1 explained, by the time the prototype of the WSB was published, the political landscape of the Wadden Sea had changed. Whereas, at the start of the development of the WSB, the Waddenfund was one of the main drivers and one of the intended users (they wanted to use the barometer to assess the necessity and feasibility of funding requests), by the time the prototype of the barometer was published, the administrative structure of the Waddenfund had changed, making the need for the barometer less relevant or, in other words, less salient. 'This changed landscape was also the reason for not conducting the final step in the development of the barometer: the external validation' (interviewee #1), in which the barometer would be presented to a broad array of relevant stakeholders.

4.2. Waddenhouse Deliberation ranking

Despite the WSB, the need for an assessment of the impact of human activities on the Wadden Sea region remained. In addition, the Dutch Ministry of Infrastructure and the Environment wished to develop a new 10-year vision on the Wadden Sea policies. To accommodate this development, input was requested. The Wadden Academy and PRW acted on this request by initiating and funding the development of the Waddenhouse Deliberation ranking (hereafter WHD). The initiative was launched in 2015, the final report delivered in July 2016. The deliberation was organised in the context of the *'policy exploration regarding the future role and ambition of the national government and the region for the Wadden Sea area, for the purpose of possible adjustments of the Structural Vision for the Wadden Sea'* (Sas et al., 2016: 4).

The development of this boundary object was similar to that of the Cascade model. As interviewee #2 (who was also involved in the development of the WSB) and interviewee #3 both explained, it was expected that by using a similar methodology to that used in 2004 (i.e. scoring a broad range of human activities in the Wadden Sea, such as

harbour activities, tourism, gas and salt extraction, fishery activities, military activities), based on a set of pre-determined indicators, the final product would yield similar credibility, legitimacy and salience as had been obtained over a decade earlier.

The aim in developing this boundary object was to bridge the gap between science and policy in two stages. First, by organising deliberation, it was intended to mobilise the existing scientific knowledge to address policy-makers' existing demand for knowledge. The ranking was developed based on the scores given by a broad range of scientists and experts who were representatives of two domains: the ecological and the socio-economic (see Fig. 3). They were *'selected on the basis of their expertise in both domains and their independence'* (Sas et al., 2016), although how this independence was determined and which potential participants were left out because of these selection criteria was not described. In the second step, other stakeholders (e.g. representatives of the various economic sectors from the region (whether impacted or not), policy-makers and environmental organisations) were also involved, either by invitation from initiators of the WHD, or at their own request, with the aim of discussing and reflecting on the results of the deliberation. Between the WHD (February 2016) and the official presentation of the ranking (July 2016), preliminary reports were sent to the participants in the deliberation for review, and reflection sessions were held with the aforementioned stakeholders in order to present and discuss the results.

With regard to the functions of boundary objects we discussed above, the WHD seems partly to aim at addressing all three. By creating a ranking, it aimed to create more understanding and usability of the insights (scientific or otherwise) into the use of the Wadden Sea for decision-makers. The process chosen included a range of scientists from various fields and aimed to establish a shared context. On a critical note, however, the two groups of scientists and experts (natural and social sciences) had only limited interaction with each other. The combining of the different disciplinary fields was done by the organisers of the deliberation. And although the report implies that interactions and communications were facilitated and structured, in common with the WSB the interactions and communications were predominantly between the organisers of the deliberation and stakeholders, rather than among the stakeholders themselves.

4.2.1. Credibility, legitimacy and salience of the Waddenhouse Deliberation ranking

Based on the pooled answers of our 23 respondents, presented in the supplementary material, it can be concluded that although the answers are substantially spread across the possible answers, generally speaking the respondents predominantly perceived the WHD ranking as having limited credibility, legitimacy and salience. This also emerged in their comments. On the issue of scientific validity, one respondent said 'The lobby from the ecological movement was strong and dominant, and influenced the results. In that sense, it was not scientific but political' (Resp.#8). Another respondent noted that 'in science, conclusions are not based on a majority but on facts and scientific discussions (…). The number of people who support a certain interpretation should not matter' (Resp.#10). In relation to the process, one of the participants in the WHD stated that 'there was too much pressure to finish in one day, and this hindered an effective learning process' (Resp.#19).

The discontent about the ranking is already evident from these three statements (all made by participants in the WHD). On closer inspection, however, the stakeholder group seems to have a more negative perception of the ranking than do the participants in the WHD. An example of this can be seen in the evaluation of the level of salience (specifically regarding the perceived relevance of the boundary object), where the percentage of negative respondents is much higher in the group of stakeholders than in the group of participants in the WHD: 50% (4 out of 8) versus 20% (3 out of 15). A similar picture can be drawn in relation to the level of credibility: 4 out of 7 statements were responded to more negatively by the stakeholder group. How can we explain this? Do the presupposed criteria include indicators which can explain this outcome?

The literature review presented in section 2 revealed that one cornerstone for the development of a boundary object is its participatory process. Two statements related to this indicator were scored: i) all actors with an interest were able to be part of the process; and ii) all actors with an interest were able to be part of the process at the appropriate time. This second statement is an elaboration of the first one: we wanted to test whether the timing of possible participation had influenced the perception of legitimacy of the process. The responses are clear: the stakeholders give a highly negative evaluation: 5 out of 8 responded negatively to the statement about being involved at the appropriate time. Based on this, it could therefore be concluded that because these stakeholders became involved in the development of the ranking too late, they had too little influence on the process. This is reflected, for example, in the assessment of the level of credibility. Both groups of respondents agreed with the statement that the ranking incorporates scientific and non-scientific knowledge. However, 5 of the 8 respondents in the stakeholders group disagreed with the statement 'There is a balance between scientific and expert knowledge on the one hand, and practical knowledge on the other hand'. This could also explain the difference in attitude towards the statement that "the final ranking is relevant to policy-makers": 7 out of 15 participants responded positively to this statement (and only 3 of the 15 responded negatively), whereas 4 out of 8 of the other stakeholders responded negatively to this statement. Because the group of stakeholders was involved at a later stage than the group of participants in the WHD, by the time they came onto the scene the problem underlying the development of the ranking had already been defined.

4.2.2. Contribution of the Waddenhouse Deliberation ranking to enriched CZM

The outcome of the questionnaire administered to WHD participants and stakeholders suggests that they perceived the final ranking to be neither credible, legitimate, nor salient. According to Cash et al. (2003), this would limit the chances of the boundary object enriching decision-making processes. Furthermore, when the final ranking was presented, it generated very negative reactions, especially from the industries that were ranked high as negatively influencing the ecological state of the Wadden Sea. Interviewee #4 explained that the disaffection generated by this ranking had negatively influenced the WHD's usability to enrich decision-making processes. Our interviewee argued that even if a report is scientifically credible, when it gives rise to so much disaffection it is not possible to blindly make use of its analyses. This does not mean, however, that the WHD has been entirely unusable. The turmoil it caused centred predominantly on two industries: harbours and fishery activities. The rest of the ranking, which was less contentious, was used together with other reports on the Wadden Sea as input for the development of the Wadden Sea policies. However, due to the sensitivity of the WHD, our interviewee was unable to give specific examples on this matter. Here it must be noted that the establishment of the extent to which the WHD contributed to the enriching of decision-making is implicit and has been further complicated by a delay in the development of the new 10-year vision on the Wadden Sea policies. The enriched decision-making is therefore limited to the contribution the WHD made to creating a clearer picture of the problem setting and the exploring of policy options. At present it is not possible to determine how much this specific boundary object contributed to the underpinning and implementing of policy and management measures, or to the learning processes among policy-makers, scientists and stakeholders.

4.3. Comparative analysis

In both cases, the organising parties aimed to create an assessment of the Wadden Sea region in which the perspective of a broad array of

stakeholders was embodied. They aimed to develop this assessment based on scientific knowledge, but also attempted to negotiate with stakeholders with other (expert) knowledge and involve them in the processes. Still, in both cases, the respondents to the questionnaire and the interviewees were clear: neither of the two assessments was perceived to fulfil the criterion of being fully credible, legitimate and salient. Further comparison between these two cases raises some interesting issues.

First, with regard to the three functions of boundary objects discussed in the literature review section above, the empirical research suggests that both assessments aimed to meet the first and third functions (combining, clarifying and communicating knowledge; and establishing a shared context and applicable knowledge), but only addressed the second function (facilitating and structuring interactions) to a limited extent. Given that these two cases did not contribute to enriched CZM in the Wadden Sea, we suggest that these three functions are not a case of either/or, but that in order for an assessment to be a boundary object, it needs to fulfil at least the first function. Connecting these functions to the framework introduced by Cash et al. (2003) regarding the need for credible, legitimate and salient knowledge to enrich decision-making processes, we argue that without inclusive interaction and communication, a boundary object's legitimacy can be doubted.

Secondly, the two cases demonstrate that even when an assessment has been evaluated as being relatively credible and salient, it does not follow that it will automatically enrich decision-making processes in CZM; this is clear from the WSB case. On the other hand, in the case of the WHD, where only a minority of our respondents valued the ranking as credible, legitimate and salient, it was nonetheless argued that the ranking (in combination with other reports, which were not explicitly described as such) did enrich decision-making processes on the CZM of the Wadden Sea. Based on this, it seems that alongside the credibility, legitimacy and salience of the boundary object, other external factors also contribute to whether or not a boundary object enriches policy-making processes. In an earlier article on boundary organisations, Van Enst et al. (2016) refer to 'enabling factors' such as public and political debates which might (in this case) put pressure on policy decisions regarding CZM. The existence of a policy window at that time because a new Wadden Sea policy was soon to be developed by the Ministry of Infrastructure and the Environment, for which (scientific) input on the ecological state of the Wadden Sea was needed, might also have contributed to the fact that the WHD ranking did ultimately enrich the policy-making process. Furthermore, it could also be that even though on the whole the respondents in this research evaluated the level of credibility, legitimacy and salience of the WHD ranking as negative, parts of the assessment might have been contested less than others and were therefore more suitable for enriching the policy-making process.

Finally, the case of the WHD shows that there were differences (albeit limited) between the participants in the deliberation and the stakeholders who took no part in the deliberation in terms of how they evaluated the ranking. This could suggest that there is an *internal* perception of the credibility, legitimacy and salience of a boundary object (as perceived by those people who were closely involved in the development process), and an *external* perception of these same three criteria (as perceived by the stakeholders who were not closely involved in the development of the boundary object but who have been influenced by its outcome). This differentiation, however, could have been addressed had the development process been more inclusive, in which case the boundary object would have addressed its second function of facilitating and structuring interactions.

5. Conclusions and discussion

This paper set out to explore boundary objects and the extent to which they can contribute to enriched coastal zone management. As stated at the outset, in enriched decision-making, knowledge is used to arrive at a clearer picture of the problem setting, to underpin and implement policy and management measures, to explore policy options, and it is also used in learning processes among policy-makers, scientists and stakeholders (e.g. Van de Riet, 2003; Van Tatenhove et al., 2016). Because our exploratory study encompassed only two cases, we formulate our conclusions in terms of hypotheses rather than as generic findings. Based on our empirical findings, we suggest that for boundary objects to enrich CZM decision-making processes, it is crucial to be aware of external factors such as policy windows, which influence the a boundary object's ability to enrich decision-making processes. This, however, does not mean that the levels of credibility, legitimacy and salience, as presented in the framework devised by Cash et al. (2003) are of no influence on the usability of boundary objects. Rather, our empirical findings show that the boundary object and its development process need to be perceived as legitimate by all stakeholders. If a boundary object is credible and salient but lacks legitimacy, it will encounter difficulties in relation to enriching decision-making processes. In terms of the theoretical contribution of this research, the foregoing does not mean that the framework presented by Cash et al. (2003) is of limited use for examining the contribution of boundary objects to decision-making processes. As can be seen from other empirical research, the credibility, legitimacy and salience of the knowledge produced and used in these processes is of great importance. Our research does, however, suggest that in decision-making processes, specifically in the case of unstructured policy problems, knowledge is not all.

At this point, we wish to raise three hypotheses which could be used to structure further research into this subject.

1) Our findings suggest that for a boundary object to function as a means to facilitate and structure the interactions and communication among stakeholders, an inclusive process is of great importance, as it is for the acceptance of the knowledge generated by means of a boundary object, and thus for the perceived credibility of this knowledge. This is especially so when the boundary object places values on the assessment, turning it into a ranking (as was the situation with the WHD ranking). The comment of one of the respondents in this matter speaks volumes: *"This report (…) is based on opinions and preferences of various involved parties, without inviting the people who actually make a living in the Wadden Sea"*. The first hypothesis is therefore that if stakeholders believe that they have been involved in the process too late and have therefore had little to no influence on the evolution of the final ranking (from defining the problem to providing practical experience and expert knowledge, and to ranking the different indicators), they will tend to evaluate the boundary object finally arrived at not only as lacking legitimacy, but also as lacking credibility.
2) For the ranking system to be accepted for enriching policy-making processes and thus to have salience, our findings suggest that not only those stakeholders involved but also others influenced the need to have ownership of the boundary object. Our second hypothesis is that if ownership has not been created, either because the object was 'not invented here', or because there has been a lack of active and constant involvement of stakeholders, the boundary object loses its salience.
3) For the boundary object to have an influence on decision-making processes, this exploratory research suggests that a policy window is of great importance. Our empirical research shows that in the case of the WSB, this window was 'closed' due to changes in the policy landscape in the interim, and that this sharply reduced the relevance of the ranking system. In the case of the WHD ranking, the presence of a policy window made it necessary to establish a new set of guidelines concerning the governance of the Wadden Sea. As a result, even though the ranking lacked credibility and legitimacy due to procedural choices and even though the respondents did not perceive the final ranking as salient, in the end the boundary object

did enrich the policy-making process to some extent. Our third hypothesis is therefore that regardless of the quality of the boundary object (in terms of the three criteria), without a policy window, it will not contribute to enriched CZM.

Summarising: we started this paper by introducing it as exploratory research into two boundary objects within the field of CZM. In order to analyse the extent to which a boundary object could contribute to enriched decision-making, we introduced the framework created by Cash et al. (2003) and argued that insight into the involved stakeholders' perception of the credibility, legitimacy and salience of a boundary object might deepen understanding of that object's contribution to enriched CZM policy. In line with other recent work in this area, we found that the assumption that improving the credibility, salience and legitimacy of knowledge increases its usefulness for policy-makers as well as its actual use for enriching decision-making is oversimplistic and incomplete (compare: Sarkki et al., 2015; Dunn and Laing, 2017). However, since the application of this framework within the specific domain of CZM is relatively unexplored (with the exception of e.g. White et al., 2010), we urge that further research be done to establish the framework's value. With regard to the Wadden Sea, in this paper we have also shown that various boundary objects have been developed to contribute to the CZM of the area (e.g. Floor et al., 2016). We argue that boundary objects seem to be a promising approach for bridging science and policy with the aim of arriving at sound, well-received policy decisions about controversial issues for the CZM of the area. This paper should be understood as a step towards further understanding how this aim can be achieved.

Appendix A. Supplementary data

Supplementary data related to this article can be found at http://dx.doi.org/10.1016/j.ocecoaman.2018.04.001.

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