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# Matching Science with Coastal Management Needs: The Search for Appropriate Coastal State Indicators

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**ABSTRACT**

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Through an analysis of the interaction between end users and researchers participating in the European Union–funded CoastView project (EVK3-CT-2001-0054), this article illustrates some of the difficulties associated with end user–oriented research. A way of structuring and focusing discussion between end users and researchers, which was applied and further developed during the course of the project, is suggested as a method to deal with these difficulties. The analysis in this article indicates that successful specialist support of decision making is related to the use of a systematic "frame of reference." This involves explicit definitions of both strategic and operational objectives applied in a four-step decision recipe consisting of (1) a quantitative state concept, (2) a benchmarking procedure, (3) a design procedure for measures or interventions, and (4) an evaluation procedure.

**ADDITIONAL INDEX WORDS:** *Coastal policy and management, strategic and operational objectives, coastal state indicators, benchmarking, evaluation, frame of reference, research management, coastal science, CoastView, Argus, communication, end users, gap.*

## INTRODUCTION

Since the beginning of the 20th century, coastal management has increasingly relied on science in the development of sustainable solutions to coastal problems. Literature shows that the cooperation between coastal science and coastal management is not without problems (*e.g.,* EUROPEAN COMMISSION, 1999; MULDER *et al.,* 2001). Researchers, on the one hand, are often of the opinion that their knowledge is not effectively implemented by coastal managers. End users of specialist knowledge, on the other hand, often claim that research findings cannot, or cannot easily, be put to practical use. A multitude of reasons for an ineffective transfer of knowledge have been suggested, blaming researchers as well as end users, ranging from a lack of consideration for the end users in research findings to unclear formulation of problems, and including lack of funding, time, effort, and skills. The causes that have been suggested so far, however, do not lead to constructive suggestions for ways to overcome the limited use and usefulness of coastal engineering research as it has been perceived in practice.

VAN KONINGSVELD *et al.* (2003) suggest "a divergence in the perceptions of coastal specialists and users of specialist knowledge of the problem at hand and the information that is needed to deal with it" as a fundamental mechanism responsible for increasing incomprehension. To defuse this mechanism, they suggest a balanced involvement of researchers and end users in driving the content of coastal research projects. MULDER *et al.* (2001) propose to organize the required "specialist–end user" communication in a *problem-driven* manner, in which end users and specialists jointly attempt to make the essential components of an eventual management decision *explicit* and use these as a starting point for eventual information-gathering strategies.

The explicit identification of the information that is needed to deal effectively with a given coastal problem is necessary to prevent miscommunication and divergence of perceptions. Neglecting this step can sometimes lead to significantly different conclusions regarding, for example, a project's effectiveness. A nourishment scheme, for instance, might be considered to be unsuccessful by those who derive their livelihood from the available recreational beach width. Coastal engineers, who designed the project from the perspective of coastal safety, may be of the opinion that the project *was* successful, because the nourished material is still part of the profile, albeit (partly) submerged. Joint identification of essential decision elements promotes the development of a shared perspective and provides a framework that both specialists and end users can refer to in their discussions. Throughout this article we shall refer to the collection of ex-

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plicit elements associated with a given problem as the "frame of reference" for communication about that problem. The philosophy of using this frame of reference as a communication tool shall be referred to as the "frame of reference methodology."

Obviously, concrete implementation of the methodology suggested by MULDER *et al.* (2001) yields different results for each management problem, each project type, and even each project phase. To get an idea of the "basic" elements that are associated with workable coastal management solutions, VAN KONINGSVELD and MULDER (2004) analyzed the crucial ingredients of the particularly successful coastal policy of "Dynamic Preservation" in the Netherlands. They showed how these "basic" elements could be used as a template to guide the further development of sustainable coastal policy in the Netherlands. This article assesses use and usefulness of this basic frame of reference in the context of a European coastal research project, *viz.,* the CoastView project.

The following sections provide a brief description of the CoastView project, its mission to develop useful information for coastal management, and the Argus technique that plays a central role in the project. An account of the initial efforts to develop useful indicators confirms the above-described need for a common framework to facilitate effective communication. The "basic" frame of reference, as described by VAN KONINGSVELD and MULDER (2004), is suggested as a useful framework for this purpose. After a concise description of the main components of this basic frame of reference, its use in support of the CoastView program is discussed.

## THE COASTVIEW PROJECT

### The Project

In order to be useful for decision making, the "right" elements of the complex state of a shoreline need to be delivered to coastal managers promptly and in a simplified form. CoastView, a coastal research project sponsored by the European Union under the Fifth Framework (EVK3-CT-2001-0054), directs its focus to physical problems associated with sedimentary coasts and hopes to link researchers and managers through the development of video-derived coastal state indicators (CSIs). The project adopted the following initial working definition of a CSI: "A reduced *set* of parameters that can simply, adequately, and quantitatively describe the dynamic-state and evolutionary trends of a coastal system." The expected benefits from the use of CSIs in the project are twofold, *viz.,* to reduce the complex reality of a coastal system and to facilitate communications between coastal managers and researchers. For a significant contribution to coastal management, the CoastView project aims to achieve the following two objectives:

1. To develop resource-related CSIs suitable for describing, in real time, the morpho- and hydrodynamic state of sedimentary coasts in support of coastal zone management
2. To develop and verify video-based monitoring methods and associated analysis techniques for the accurate estimation, monitoring, and interpretation of the dynamic significance of these CSIs

To develop schemes for the practical implementation of these objectives, research is performed at four morphologically distinct European field sites, *viz.,* a continuously undefended coastline at Egmond, The Netherlands; a continuously defended coastline at Lido Di Dante, Italy; a coastal inlet with a single bar or spit at Santander, Spain; and a coastal inlet with multiple complex bars at Teignmouth, United Kingdom (see Figure 1).

### The Process

The CoastView project adopts the following general process to obtain its objectives (see Figure 2). Starting from a (complex) coastal management problem, a first step is to reduce a specific coastal management problem to a coherent set of CSIs that are explicitly related to the practical problem. A next step is to select from these indicators a limited set that could be addressed by the research project at hand. Finally, the resulting information is communicated back to the coastal managers, where a new view of the problem may trigger a new information need. At the highest level of aggregation, a research project generally completes one cycle. At a more detailed level, the communication between coastal managers and researchers that is needed to "match research with end-user needs" requires several iterations.

The continuous cycle of discussion, depicted in Figure 2, may be driven by practical problems and technological possibilities. Although (innovative) technology-driven suggestions are obviously welcome in the discussions, the approach adopted in the CoastView project is explicitly *problem driven.* Concrete implementation of this approach means that the set of CSIs that will be addressed within the CoastView project is to be defined systematically based on an inventory of coastal management problems at each site (see elements a and b in Figure 2). After an initial and broad identification of problem-related indicators for each site, CSIs that can potentially be quantified in the CoastView project have to be selected. The resulting set of CSIs is supposed to represent the reduced information that can be used by coastal managers in dealing with their coastal management problems. Based on this selection, a field measurement campaign, customized to each site, can be designed to enable quantification and validation of the CSIs (element c in Figure 2). The remainder of the project can then be dedicated to the actual quantification of the CSIs in such a way that the project's end users would perceive them as useful (element d in Figure 2). To maintain the problem-driven approach throughout the project, end users will continually be involved to critically review the progress with respect to practical relevance.

### The Technology

An interesting aspect of the CoastView project—and the main focus of this article—is the rationalization of the practical use of specialist knowledge of coastal processes (element c in Figure 2) to the coastal management decision processes (element a in Figure 2), *i.e.,* establishing an active and viable communication process between researchers and users (elements b and d in Figure 2). This rationalization is particularly important in the early phases of end user–oriented re-


Figure 1. Orientation on the CoastView field sites.

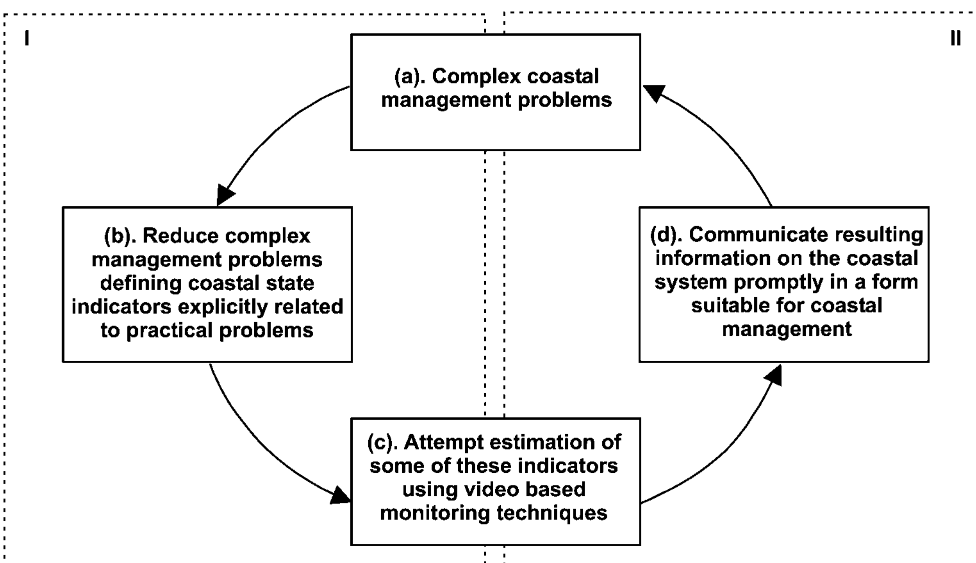


Figure 2. The CoastView approach.

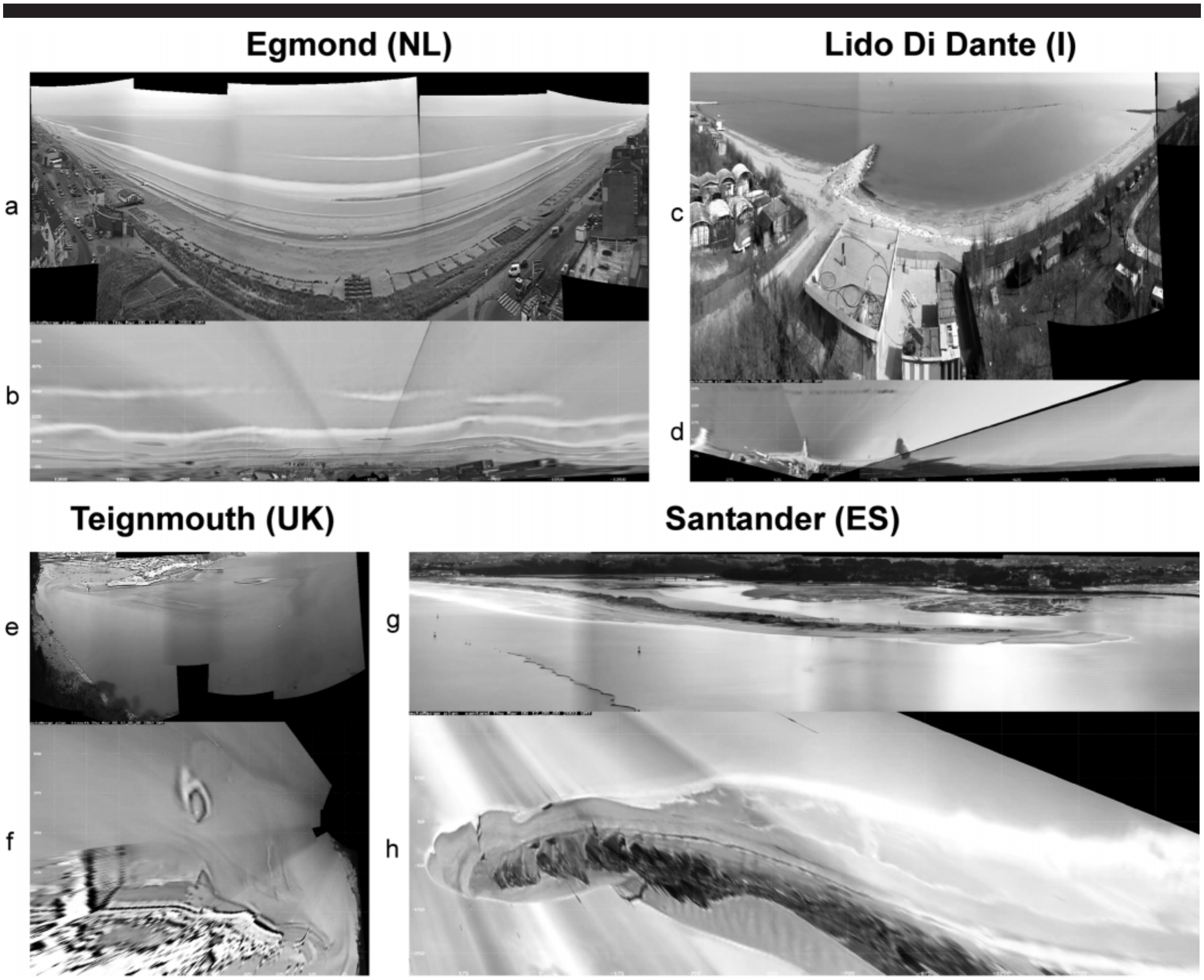


Figure 3. (a) Panoramic view of the site at Egmond, The Netherlands; (b) Plan view of the site at Egmond, The Netherlands; (c) Panoramic view of the site at Lido Di Dante, Italy; (d) Plan view of the site at Lido Di Dante, Italy; (e) Panoramic view of the site at Teignmouth, United Kingdom; (f) Plan view of the site at Teignmouth, United Kingdom; (g) Panoramic view of the site at Santander, Spain; (h) Plan view of the site at Santander, Spain.

search, when important decisions regarding the focus of the project are made. Obviously, a key element for this rationalization process is the coastal management problem at hand, because it dominates the information need of the end user (elements a and b in Figure 2). The available technology, on the other hand, is also important, because it dominates the potential supply of information (elements c and d in Figure 2). Thus, there must be a balance between what is optimal and what is possible.

The CoastView project proposed the reduction of complex information to a limited set of video-derived CSIs. For this purpose, remote video monitoring systems or Argus stations have been installed at each of the CoastView locations. These Argus systems consist of an array of stationary video cameras mounted on an elevated vantage point overlooking the coast region of interest (AARNINKHOF and HOLMAN, 1999; HOLMAN *et al.*, 1993). Through the use of surveyed objects with the cameras' field of view (ground control points), the oblique images can be merged (Figure 3a) and rectified, yielding an undistorted plan view of the observed area (HOLLAND *et al.,* 1997) (Figure 3b).

The combination of data collected by the Argus cameras and supporting field measurements enables quantitative statements to be made regarding coastal behavior observed in the video images. In principle, all visible features can be detected by the Argus technique, *e.g.,* shorelines, breaker patterns, wave directions, surface currents, *etc.* In practice, shorelines (AARNINKHOF, CALJOUW, and STIVE, 2000; KINGSTON, 2000; PLANT and HOLMAN, 1997) and bar patterns (HOLLAND *et al.,* 1997; VAN ENCKEVORT, 2001) have successfully been detected. Detection of other features, such as wave heights and surface currents, is currently at a much

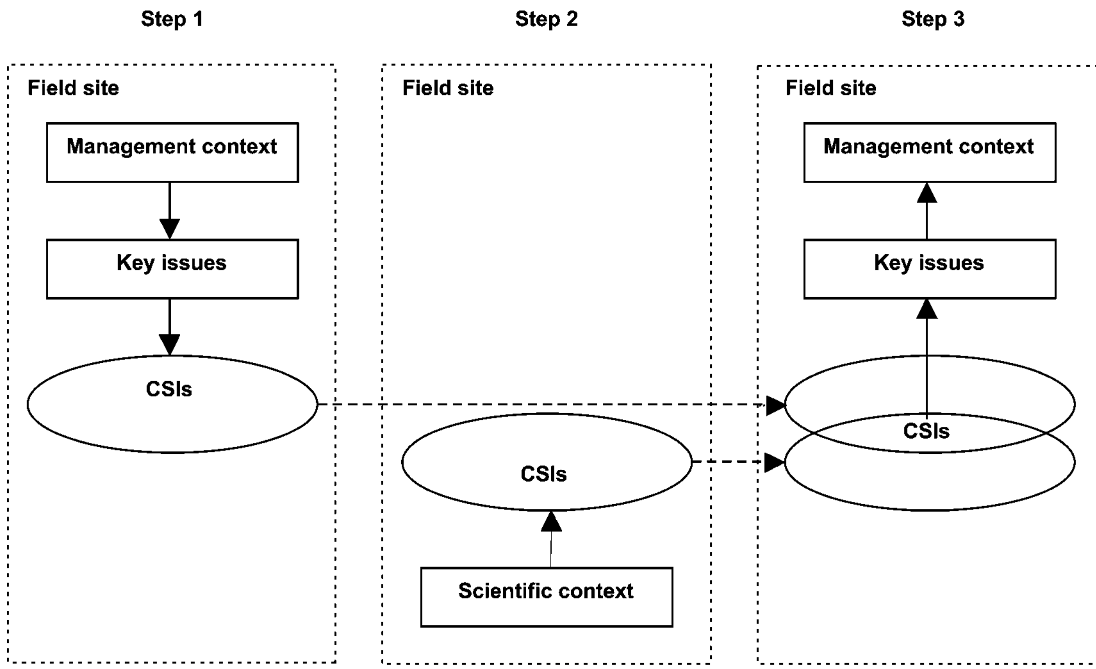


Figure 4. The three-step approach designed for the CoastView CSI workshop.

more experimental stage. Combining the detected features with field data and models enables not only qualitative but also quantitative analysis of morpho- and hydrodynamic phenomena, *e.g.,* the behavior of intertidal beach morphology (AARNINKHOF and ROELVINK, 1999) and bar behavior under different morpho- and hydrodynamic conditions (LIPMANN and HOLMAN, 1990). The main benefit of the Argus methodology over traditional *in situ* measurements is the relatively low-cost, nearly continuous (hourly) synoptic sampling and high spatial resolution/coverage, even during storm conditions. The robust nature of the video systems also permits long time-series of data, which are essential for the identification of trends in coastal evolution. As a result, the Argus methodology potentially enables the development of a broad range of CSIs. One of the most important challenges for the CoastView project is to design a process that effectively facilitates the selection of "appropriate CSIs," *viz.,* those that are explicitly related to a coastal problem and can be used by decision makers in the management of coastal resources.

## PROCESS DESCRIPTION: END USER–RESEARCHER NEGOTIATION

To stimulate the necessary interaction between end users and researchers, a total of seven formal meetings and plenary workshops, including the final workshop, have been planned during the 3-year duration of the CoastView project. In preparation for these plenary workshops, less formal local meetings take place involving local as well as national-scale coastal managers. This article focuses on the first year of the project, during which the pattern of interaction between researchers and end users was established. During the first year of the project, the meetings and workshops focused mainly on the *problem-driven* development of CSIs (Phase I in Figure 2). As an example, the kickoff workshop at the start of the project was designed around a joint definition of CSIs, reflecting the problem-driven approach of the project. This Coastal State Indicator Workshop, held in Egmond, The Netherlands, in May 2002, provided a rare and exceptionally valuable opportunity for coastal managers and coastal scientists to discuss the main coastal management issues at the different sites. The aim was to get a clearer understanding of managers' and scientists' respective approaches to coastal problems and through that process of dialogue to choose a set of "appropriate CSIs" based on user needs.

Because it was acknowledged that the first step in the process had to be a clear statement of user needs, the kickoff workshop was carefully structured to ensure that the user input remained foremost; the scientific drivers of CoastView should come only after the user-defined CSIs had been identified. The envisaged "realization process" consisted of a three-step approach (see Figure 4).

At the workshop, each participating field site was first to present its problem-driven coastal management issues and identify a set of relevant CSIs from this perspective (see Figure 4: Step 1). Next, the researchers were to present their process-based view of the system and identify a set of CSIs interesting and feasible from a scientific perspective (see Figure 4: Step 2). The final step was to take both sets and through a process of negotiation integrate them into a single approach (see Figure 4: Step 3). This would, however, prove to be easier said than done.

## STEP 1: A "PROBLEM-DRIVEN" SELECTION OF CSIs

### Identification of a "Management Context"

The starting point of the three-step approach was a recognition that management issues arise from distinct "management contexts." Many coastal management contexts may be identified. Within the CoastView project, four management contexts have been selected:

- Coastal protection
- Recreation
- Ecosystem protection
- Navigation

The information needs of managers dealing with problems within these different contexts are not necessarily independent. For example, beach width is relevant for coastal protection as well as for recreation. However, the management questions to be answered and the priority given to any particular source of information will tend to be different in each of these contexts. The decision was made, therefore, to treat each of the contexts separately and to seek common CSIs only at the end of the process.

### Identification of Related "Key Issues"

From each context, a series of "key issues" arose. During the workshop, it emerged that the clearest way to define these issues was as questions that managers or policy makers need to be asking about their sites. In Table 1, a summary is presented of the questions raised and thus, by implication, the key issues that CSIs ought to address if they are to be of use to coastal managers.

Obviously, the list in Table 1 is not exhaustive, and each site is likely to prioritize the issues differently. However, the list does include many of the issues that were identified as being generic, in the sense that they are likely to be of importance across a range of different sites and conditions.

Table 1. *Questions of key importance for coastal sites.*

| Management Context | Key Issues |
|---|---|
| Coastal protection | CP1: Are coastal defenses (including the natural beach) adequate for the range of conditions expected? |
| | CP2: What is the probability of defenses being breached? |
| | CP3: What infrastructure is at risk from flooding? |
| | CP4: What is the optimum replenishment scheme for my beach? |
| | CP5: Is dredging adversely affecting my beach, and can I suggest better alternative procedures? |
| | CP6: Can I predict beach behavior if I know something about the offshore bars? |
| | CP7: How can I optimize coastal defense in the long term? |
| Recreation | R1: Are beach users safe? |
| | R2: How do I identify/predict risks to swimmers? |
| | R3: When do I need to worry about a decreasing width of my beach? |
| | R4: Can I anticipate the occurrence of algal blooms or seaweed "attacks," and can I do anything to alleviate the problem? |
| | R5: What is the current usage of the beach? Where do people go (duration/location)? |
| Navigation | N1: Where is the navigation channel? |
| | N2: How is it likely to evolve? |
| | N3: What is the configuration of dangerous banks? |
| | N4: How can dredging be optimized (where, how much, how often, where should spoil go)? |
| Ecosystem protection | EP1: Is the state of dune vegetation a cause for concern? |
| | EP2: How can the effects of pollutants be mitigated effectively? |
| | EP3: How can problems for ecosystems be anticipated and avoided or minimized? |

## STEP 2: A "SYSTEM-DRIVEN" SELECTION OF CSIs

In the second step, each field site was to be described from a scientific point of view. The resulting presentations discussed the hydro- and morphodynamic characteristics of each site. From these scientifically observed characteristics, a set of CSIs could be derived that was considered relevant. In this context *relevant* means "related to significant physical phenomena, observed at each of the field sites." These system-driven, video-derived parameters provide descriptors or predictors of known dynamic elements of the coastal system that could potentially be useful to coastal management from the scientific perspective. The development of new technology, such as video, often presents new opportunities for monitoring and prediction of which coastal managers may currently be unaware. This step therefore would provide an important chance to test new CSIs in a coastal management context.

## STEP 3: FINAL SELECTION OF CSIs

The problem-driven CSIs and the system-driven CSIs derived in the first two steps were expected to be more or less comparable. Once all these CSIs were identified, the search for "appropriate CSIs" would be constrained by the need to find those that:

1. will help the coastal manager address a particular associated question, and
2. will be in a form that the manager will recognize as directly related to the question and will be able to use.

This next step was envisioned as a matter of selection. In line with the problem-driven approach, coastal managers were asked to prioritize the CSIs that they thought were most important. This would form the basis of the selection procedure. The resulting priority list was expected to contain both site-specific and generic CSIs. The selection of a provisional set of CSIs would form the initial focus of the project. However, it was recognized that this would only be the first step in the process. It was recognized that it would also be necessary to define acceptable resolution (spatial and temporal) and accuracy of CSIs as well as critical threshold values. The ground-truth data and fieldwork would form an important part of this process. In practice, the process of defining thresholds, accuracy, and resolution was possible only for those indicators that were currently in use by coastal managers. It was recognized that thresholds, accuracy, and resolution of new CSIs could be determined only via further experimentation.

## PROCESS ANALYSIS: PROBLEMS IN THE COMMUNICATION PROCESS

During the actual implementation of the aforementioned planned approach, a number of communication problems surfaced. Without being exhaustive, we discuss some of the recurring problems that seemed to have a significant impact on the effectiveness of the interaction between coastal managers and researchers.

### Incompatibility of Terminology

The actual application of the three-step method to derive suitable CSIs, although promising at first glance, gave rise to ample discussion. At each of the workshops, the general CoastView workshops as well as more informal preparatory local meetings between end users and researchers, discussions became confused because of implicit differences in interpretation of the word *CSI.* Coastal managers perceived CSIs as concepts that were directly related to their management problem, *e.g.,* swimmer safety, coastal safety, *etc.* Coastal scientists perceived CSIs as concepts that reflected the state of parts of the coastal system, *e.g.,* wave height, flow velocity, water levels, shoreline positions, *etc.* Although the results from Step 1 and Step 2 were both called CSIs, they proved to be incompatible. The science-driven CSIs resulting from Step 2 were more detailed than those derived in Step 1 by applying the problem-driven approach. How the CSIs from Step 2 could contribute to those derived in Step 1 remained unclear.

In order to deal with this communication problem, the term *CSI* was split up into two new terms after the first discussion, *viz.,* the Issue-Based CSIs (IBCSIs) and the Science CSIs (SCSs). The group defined IBCSIs as aggregated quantities that end users recognize as representative for a coastal management issue, whereas SCSIs were defined as individual parameters or indicators that the scientists recognize as objective measures of the physical state of the environment and that will generally be derivable from existing or planned measurement techniques. The IBCSIs would typically depend on an aggregation of the more basic SCSIs, weighted in an appropriate manner. The clearest example to emerge from the workshop was the use by some managers of a measure of beach volume (*e.g.,* to a subtidal depth of 4 meters). This example of an IBCSI depends upon a range of directly measurable SCSIs such as beach width, beach height, beach slope, subtidal water depth, and dune location. Not all IBCSIs will be aggregates, however. For example, "beach width" was identified as an IBSCI, but it is also a SCSI, being a directly measurable, simple scientific measure of beach state.

In line with the problem-driven approach of the project, the choice was made to focus discussions first and foremost on the identification of relevant IBCSIs and to derive from these the SCSIs necessary for quantification. In this context, the role of the SCSIs is to respond to the IBCSIs required by managers, and not to constrain the identification of IBCSIs.

### Science-Driven *vs.* Problem-Driven Interests

Another problem that surfaced during the discussions was the presence of implicitly conflicting project goals between the researchers and the end users involved in the project. During the first two workshops, for example, important discussions regarding what should and should not be measured, monitored, modeled, and developed took place. During these discussions, science-driven interests would sometimes implicitly emerge, *e.g.,* through suggestions to measure a certain physical phenomenon, to investigate a certain technical method, or to address a certain issue in the CSI effort. One of the important implications of adopting a problem-driven approach, however, is the explicit focus on solving coastal management problems. In the CoastView case, this materialized when the project managers stated that scientific interests could be pursued, but only if they could be linked explicitly to a coastal management problem and if an end user could be identified that would be willing to participate as a reviewer. This seemed to many participants to be a harsh prerequisite. Although one may disagree on whether a science-driven or a problem-driven approach to knowledge development is to be preferred, it seems clear at least that once a problem-driven approach has been adopted, a key issue is to maintain that approach in a balanced manner so that it may be recognized as useful throughout the project by the involved end users as well as the specialists. In research projects, the emphasis commonly tends to shift to the academic interests. This means that in order to balance the approach, more emphasis should be placed on the practical applications, at least in the early stages of a project.

### Short-Term Practical Use *vs.* Long-Term Benefits of Innovation

A discussion element that is closely related to the previous one is the question whether the project should focus on short-term practical use or on long-term benefits of more freely organized innovation. Both managers and scientists think naturally of small incremental changes to their current concepts. For example, managers will suggest improvements to the kind of products they are used to using. Scientists also find it hard to think of products not already being pursued or planned. Implicit differences in the ambition levels of the partners gave rise to another element hindering the progress of the project. Discussions were repeatedly triggered on whether or not it ought to be the purpose of the project to develop innovations for the short-term or the long-term benefit of coastal management. This resulted in a continual struggle to direct the project focus to topics closely related to *current* coastal management practice or to freely explore the potential of the Argus technique to provide the foundation for *future* coastal management innovations. This proved to be a recurring discussion that seems to surface in many other research projects as well (*cf.* VAN KONINGSVELD *et al.,* 2003). Without expressing a preference for either of these suggested foci, it is clear that to overcome this obstacle, again a clear decision has to be made. The CoastView project decided that it was *first* to attempt to address problems that may yield short-term solutions before tackling problems that demanded more "innovative" approaches. It is necessary to demonstrate to coastal managers the utility of video-derived CSIs; indeed, the success or failure of the project will be judged on how well this is done. It seems logical therefore to prioritize some of the more immediate and realizable goals in the first instance at least.

Although the scientists' perspectives may often seem oblique to coastal managers, whose focus is rightfully coupled closely with coastal management issues, it should be recognized that there is often real management value in emergent scientific ideas. For example, considering the management context of navigation, a coastal manager may be interested in the proximity of a hazardous sandbar to a shipping channel. Immediately, managers and scientists can agree that a direct measurement of the proximity of a bar to the channel is important. They may also be able to agree on a threshold value (or indicator standard) beyond which the channel should be modified or dredging should be undertaken. However, a suggestion from scientists that the dynamics of the sandbar system should be monitored in order to provide greater insight into, and predictability of, the temporal evolution of hazardous sandbars may seem to coastal managers to be more esoteric. Potentially, a predictive model for sandbar location could be a useful tool to predict at what time in the future sandbars may obstruct shipping and help to put contingency plans in place in advance. However, when asked "what CSIs are important?" coastal managers can draw only on knowledge of what is currently used and has been shown to be effective. Managers are often reluctant to incorporate new tools not currently used, not tested, and often much less obviously linked to the issues they wish to address.

### Local Site Interests *vs.* General Interests

Another issue that surfaced during the research-planning phase was how to deal with local site interests *vs*. general interests. On one occasion, for example, a CSI had been excluded based on the local interests at the Egmond site that was of interest for one or more of the other partners. The CSI in question was related to the monitoring of the recreational beach use. The partners from Spain and Italy that were interested in this CSI could not investigate this particular CSI themselves because of site characteristics of their local Argus stations. Of course, it would be possible for them to develop this CSI based on data from the Egmond location, but this could require, for example, a different (in this case temporal) sample resolution at the Egmond site. This illustrates how the very different approaches to coastal management used across Europe make the selection of "generic" CSIs difficult. Rather than focusing on generic CSIs, a focus on a generic approach to developing CSIs seems useful.

The aforementioned elements often led the discussions away from the most fundamental problem addressed in the CoastView project, *viz.,* to help the coastal manager make better-informed decisions. The problems outlined above clearly illustrate the need for a framework to guide the end user–researcher interaction in a more effective manner.

## THE "FRAME OF REFERENCE" AS A TOOL FOR COMMUNICATION

A promising methodology to facilitate the knowledge transfer process from research to coastal management was found in the "frame of reference" approach suggested by MULDER *et al.* (2001). In their approach, they aim to focus discussions by making the essential components of the end users' decision process explicit. This explicit "picture" of the problem, earlier defined as a "frame of reference," may then serve as a framework that both specialists and end users can refer to in their communication. VAN KONINGSVELD and MULDER (2004) applied the "frame of reference" approach in their description of the gradual changes in both the perspective and in the development process of coastal policy in the Netherlands over the last two decades. The latter mainly focused on the cooperation between science and coastal policy. Their analysis indicates that successful specialist support of decision making is indeed related to the use of a systematic frame of reference. As *basic* elements, they identified explicit definitions of both *strategic* and *operational* objectives applied in a four-step decision recipe of (1) a quantitative state concept, (2) a benchmarking procedure, (3) a procedure for coastal zone management measures or intervention, and (4) an evaluation procedure (see Figure 5).

### Strategic Management Objective

Strategic objectives provide the long-term context for coastal policy and management. They express the vision of the interdependencies of the natural and the socioeconomic systems and of the role of the human species therein. Strategic objectives tend to change only slowly. Nonetheless, they do have a profound impact on the kind of policy and management that is required and acceptable.

### Operational Management Objective

The operational objective expresses our vision on how to handle the interactions between the natural and the socioeconomic systems. As such, it is a concrete implementation of the strategic objective. Operational objectives are assumed to be related to the status of values and interests in the coastal zone. As such, the operational objective should include an explicit indication regarding the temporal and spatial scales involved. It may take more than one operational objective to cover the strategic objective.

### Decision Recipe

From the strategic and operational objectives follow our vision on potential and acceptable human interventions. A fully developed decision recipe for intervention coherently addresses the elements described in the following sections.

#### 1. Quantitative State Concept

To enable objective and reproducible decision making, a quantitative concept needs to be developed that describes the

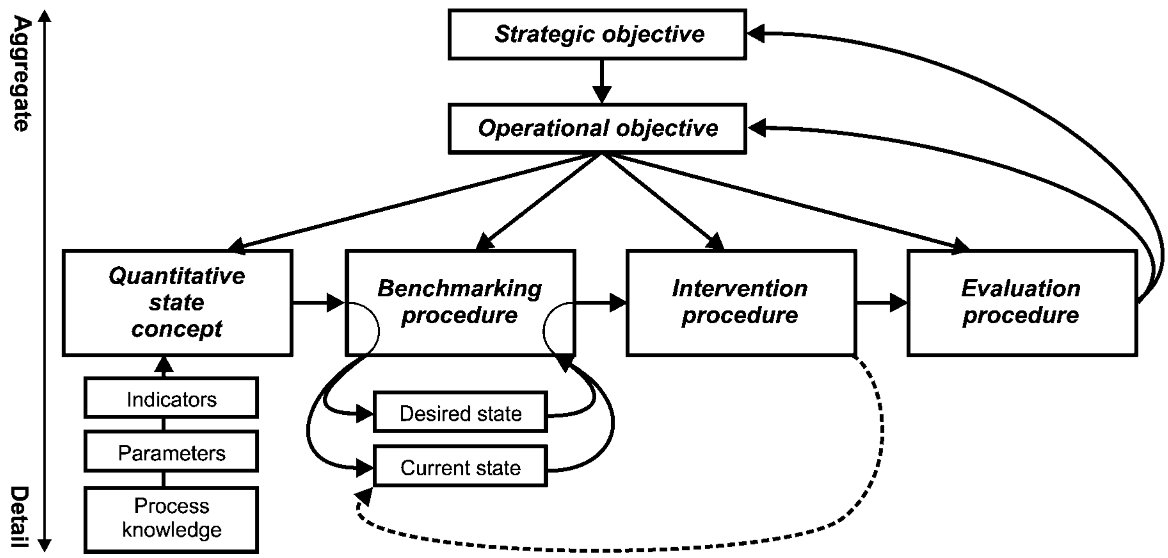


Figure 5. The "basic" frame of reference as a tool for policy development (Source: Van Koningsveld and Mulder, 2003).

state of the system or certain aspects thereof in an appropriate form. The appropriate form with respect to usefulness in decision processes is determined by the strategic and operational objective as well as by the next steps in the decision recipe. With respect to practical effectiveness there is a strong link with knowledge of the system's behavior.

### 2. Benchmarking Procedure

A benchmarking procedure is necessary so that we can systematically and objectively determine *when* to intervene in the system. Intervention is required when a discrepancy between the current system state and a desired or reference system state surpasses some predefined threshold. Implicit differences in the desired system state often trigger passionate discussions on what is in the interest of the management objectives and what is not. To facilitate useful discussions, the current as well as the (implicitly) desired state should be made explicit, preferably expressed in terms of the quantitative state concept chosen in the previous step. This element of the decision recipe often relies on measured or predicted trends in state descriptions, costs, and benefits.

### 3. Intervention Procedure

An intervention procedure specifies *how* we should manipulate (part of) the system in order to bring it to a desired state. It specifies not only the type of intervention but also the method to determine its design. Knowledge of the system, in particular regarding physical processes, plays a crucial role in this element. The design procedure should use the quantitative state concept as one of its primary building blocks. Furthermore, it should at least facilitate significant manipulation of the system's current state toward its desired state identified in the previous step.

### 4. Evaluation

The decision recipe and the effects of its application should be evaluated. This evaluation should take place in the development stage of a measure (expected effects), as well as after some period of application (actual effects). First of all, one needs to assess whether or not the operational objective is being sufficiently achieved. If this is not the case, the decision recipe may have to be changed. However, even if the operational objective is satisfactorily achieved, it is still necessary to evaluate the management efforts, but now against the wider perspective offered in the strategic objective. This may trigger modifications in the decision recipe, but it may also result in an adaptation of the current operational objective or the formulation of a new one (see Figure 6).

## Iterative Method of Application: Game, Set, and Match

Developing a "basic" frame of reference that can be used for coastal management and that is based on the best insights in coastal system behavior obviously requires many iterations, implying a lot of discussion. To prevent discussions from becoming too abstract, it is suggested to strive for a fully developed "basic" frame of reference using the "Game, Set, and Match" principle (Van Koningsveld, 2003).

During the "game" phase, some item of the frame of reference is discussed, preferably starting from the strategic objective and working one's way down (a top-down approach). After some discussion, the actor responsible for defining the coastal management issue, or some mediator, "sets" the problem at hand, summarizing the previous discussion and making the crucial elements as explicit as possible (state what you *do* know). The result is an explicit target for the participants to "match" their knowledge to. The "set" frame of reference may now be altered, broadened, or detailed by all par-

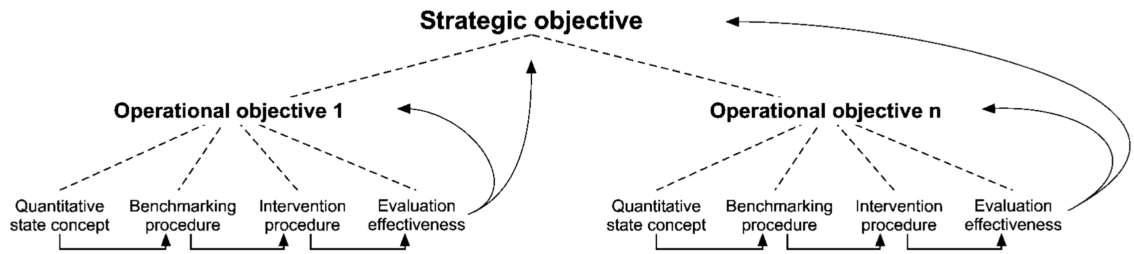


Figure 6. Several operational objectives dealing with one strategic objective (Source: Van Koningsveld and Mulder, 2003).

ticipants. With the resulting frame of reference, a new "game" phase may be initiated.

In the initiation phase, several iterations may be possible during one meeting or workshop. When, after a number of iterations, an initial coarse frame of reference has emerged, more time may be needed to actually match new specialist knowledge, because new technologies and algorithms may need to be developed and applied. When at a certain stage the interval between a "matching" phase and a new "game" of discussion becomes too large, it may be useful to apply the concept of pilot applications to maintain the necessary focus.

Working with the basic frame of reference promotes a greater involvement of the end users during research projects and facilitates a regular confrontation of research results with developing end-user needs. The notion in the frame of reference methodology of the need to explicitly break down strategic objectives into one or more operational objectives (see Figure 6), expressed in terms of quantitative state concepts, helps to stimulate and focus the discussions on new policies. A successful application of the suggested approach, however, requires an open and constructive attitude of both end users and specialists.

## DISCUSSION: BALANCED "DRIVE" THROUGH STRUCTURED APPROACH

VAN KONINGSVELD and MULDER (2003) have illustrated how the frame of reference approach described in the previous section represents a promising tool to stimulate and focus communication between coastal managers and coastal scientists of different disciplines and to facilitate effective research and technology transfer to the coastal management sector. So how may it be of use in end user–oriented knowledge development projects like CoastView?

### Improved Appreciation of the Communication Process

First of all, the frame of reference approach is of great use in the communication process, because it acknowledges the interests of both decision makers and researchers. Decision makers tend to identify with the strategic and operational objectives and the decision recipes, and they like to see these improved with specialist knowledge. Researchers recognize themselves in the quantitative aspects of the decision recipe and acknowledge the value of indicating explicitly where their knowledge may alter, broaden, or detail any given frame of reference. As a result, the different partners have gained an appreciation of how they each may contribute to better decision making. Furthermore, working with a frame of reference provides an explicit framework that structures previously confusing terminology. The IBCSIs can be associated with the quantitative state concept, whereas the SCSIs are the parameters associated with quantification of these IBCSIs. The frame of reference shows how both should be explicitly coupled with the operational objective on the one hand and the rest of the decision recipe on the other.

### A Better Match of Specialist Knowledge with End-User Needs

Besides a better understanding of the process, working with the frame of reference promotes a more explicit match of specialist knowledge with the information needs of the end users. The earlier approach resulted in questions, the answers to which would still be hard to use by coastal management. The questions in Table 1 related to coastal protection, for instance, seem almost impossible to answer usefully without at least some form of a frame of reference regarding the issue of coastal protection. Note that this is something quite different than simply providing any answers at all. Of course, most coastal researchers can provide all sorts of answers to these questions, but in doing so, they would have to implicitly assume their own frame of reference, making choices regarding what *they* consider to be, *e.g.,* an adverse effect on the beach or an optimal replenishment scheme. However, it is the responsibility of coastal management to make such choices, and as a result it is quite likely that the frame of reference implicitly assumed by the researchers differs from that held by the coastal managers. As a consequence it is not hard to imagine how such specialist answers could be hard to accept by decision makers.

### Guiding the Knowledge Development Process

The frame of reference approach is also helpful in guiding the knowledge development process. The earlier focus on CSIs (see Figure 7) was deliberately chosen as a context for the discussions between end users and researchers. At the same time, however, this focus diverted attention away from other potentially valuable contributions of the Argus technique. The focus on CSIs, for example, led to the wish of the Dutch end-user representatives to reproduce the quantitative state concept currently used in the Dynamic Preservation policy, *viz.,* the Momentary Coastline (MCL) (*cf.* VAN KON-

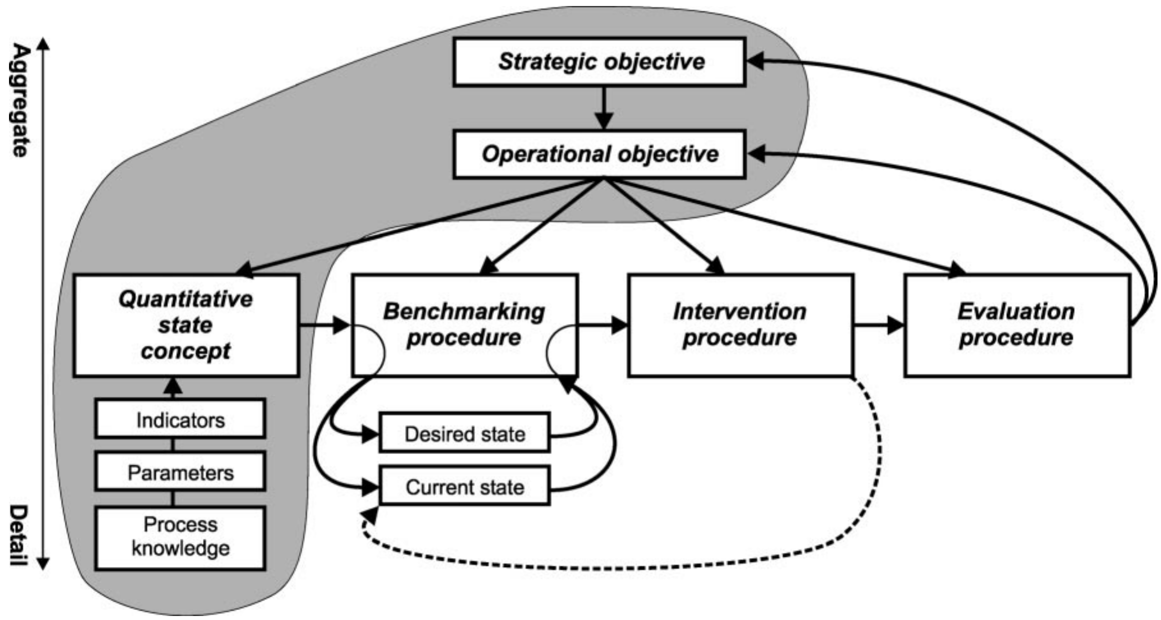


Figure 7. The CoastView "frame of reference."

INGSVELD and MULDER, 2004). The rationale behind this was that the MCL is currently used by coastal managers, and quantification of this IBCSI using the Argus technology would thus prove the usefulness of Argus to coastal managers. The MCL, however, is derived based on bathymetric profile measurements, an aspect of the coastal system that is currently hard to detect using the Argus method, although work regarding this aspect is currently in progress. Using the frame of reference, it was found that even though it would be very difficult to reproduce exactly the MCL using the Argus system, it could still be useful in detecting the *trend* in the coastline, which essentially forms the basis of the benchmarking procedure, the second step of the decision recipe. As such, the development of a new Argus-based quantitative state concept could still provide a useful tool in Dutch Dynamic Preservation policy.

Besides a contribution to the current operational objective of coastline maintenance, the CoastView project could also consider developing a new frame of reference for a smaller-scale operational objective, *e.g.,* related to recreation. The continuous synoptic monitoring of the coast provides higher-resolution data than the annual Jaarlijkse Kustlodingen (JARKUS) measurements, which are taken annually in cross-shore rays with 250-meter spacing. The basic frame of reference developed by VAN KONINGSVELD and MULDER (2004) may serve as a template to focus the efforts of researchers. The first phases of the CoastView project have focused on the shaded area of Figure 7 only. It is acknowledged that during the course of the project, attention should be focused toward completion of the frame of reference for a limited selection of operational objectives.

## Structured Discussions about Aggregation Problems

One of the problems that is associated with the development of useful CSIs is the problem of aggregation. The example of the application of the frame of reference to the Dutch situation, as described by VAN KONINGSVELD and MULDER (2004), is very clear and, especially in hindsight, may seem completely straightforward. However, depending on the issue at hand and depending on how far dealing with this issue in practice has been developed, it may not always be this easy. For example, calculation of the MCL involves the aggregation of specific measurements (or SCSIs) into an aggregated parameter (or IBCSI). In this example, the aggregation process is completely straightforward, but if we take another example, we may get a more complex picture. To illustrate this, we address the issue of swimmer safety. An initial attempt to create a frame of reference might yield:

**Strategic objective:** "To preserve swimmer safety at all times"
**Operational objective:** "To avoid swimming when *wave heights* are too dangerous, *currents* are too strong, or there is a risk of swimmers' being *cut off* by the tide"
**Quantitative state concept:** As SCSIs we might use wave height, longshore current velocity, rip currents (location/strength), tidal current velocity, location of hazardous sandbars, *etc.*

Do we try and aggregate each of these SCSIs into a single IBCSI? This is difficult, because they are not very compatible for aggregation! Or do we treat each of them under different operational objectives, with their own benchmarks, intervention procedures, *etc.,* and see how the separated decision recipes may be applied together? In that case, the strategic objective would remain "to preserve swimmer safety at all times," whereas the rest of the frame of reference might yield:

**Operational objective 1:** "To avoid swimming when wave heights are excessive"

**Quantitative state concept 1:**

*Knowledge:* Swimming is dangerous at this site when waves are above 1 meter.

*SCSI:* Wave height

**Benchmarking 1:**

*Current state:* Current wave heights

*Reference state:* Wave height = 1 meter, *etc.,* and the same for the other relevant SCSIs

**Operational objective 2:** "To avoid swimming when currents are excessive"

**Quantitative state concept 2:**

*Knowledge:* Swimming is dangerous at this site when currents are above 1 m/s.

*SCSI:* Current velocity

**Benchmarking 2:**

*Current state:* Current $u$, $v$

*Reference State:* $u = 1$ m/s and $v = 1$ m/s

The cutoff aspect would receive similar treatment. In the frame of reference approach, this separation of operational objectives is a means of clarifying otherwise potentially endless discussions. This is not to say that the aggregation problem will be easy to solve now. Rather, the frame of reference approach may help in focusing the inevitable discussions in a more productive manner.

### Controlled *vs.* Uncontrolled Discussions

It is the opinion of the authors that in end user–oriented knowledge development projects, it is necessary to invest a significant amount of the project time into discussions between project partners, and the frame of reference approach provides a useful context for this. An important challenge that remains is how these discussions may best be "controlled" to prevent the waste of valuable time while at the same time remaining focused on the main goal of these discussions, *viz.,* agreement on what should and should not be investigated. To prevent the discussions from becoming too abstract, the CoastView project applies the "Game, Set, and Match" principle to the iterations (Van Koningsveld, 2003). During the "game" phase of the workshop, approaches from the different field sites are presented. From these approaches some common or useful elements are selected and "set" as a proposed standard or method. Agreeing upon definition of terms is vital. Much discussion can be distracted by a lack of clarity in this respect. Finally, the group breaks up into subgroups, trying to "match" their local approach to the common approach. To keep a grip on the process, it seems that there is a functional limit to group size and a minimum timeframe that should be reserved for discussions to produce results as concrete as possible. The individual results are subsequently fed back in a plenary session, thus initiating another interaction.

## CONCLUSION

We expect that in the future, more research projects will have an explicit focus on end user–oriented knowledge development. From the experience in the CoastView project it became obvious that in knowledge development projects, it is very important to make clear choices regarding whether the project at hand is exclusively science driven or whether the project should concern end user–oriented knowledge development. When the latter is the case, it is important to balance the end user–researcher interaction. Applying a problem-driven approach, working toward an explicit "frame of reference" with an iterative "Game, Set, and Match" strategy has proven a promising approach in support of an effective knowledge transfer from coastal research to coastal management. It should be noted that at this moment CoastView is still in progress. Implementation of the approach discussed in this article has resulted in an encouraging start. Its continuing effectiveness will be monitored throughout the duration of the project.

## ACKNOWLEDGMENTS

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☐ SAMENVATTING ☐

Middels een analyse van de interactie tussen eindgebruikers en onderzoekers in het CoastView project, wordt in dit artikel geïllustreerd welke moeilijkheden kunnen optreden bij eindgebruiker georiënteerd onderzoek. Een methode om discussie tussen eindgebruikers te focussen, toegepast en verbeterd gedurende dit project, wordt gesuggereerd als een methode om met deze moeilijkheden om te gaan. De analyse in dit artikel geeft aan dat een succesvolle ondersteuning van eindgebruikers door specialisten samenhangt met het gebruik van een systematisch 'referentiekader." Karakteristiek zijn de expliciete definitie van zowel *strategische* als *operationele* doelen, toepasbaar gemaakt aan de hand van een vier elementen bevattend beslisrecept, te weten (1) een kwantitatief 'toestands'concept, (2) een afwegingsprocedure, (3) een interventie procedure, en (4) een evaluatie procedure.