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Making coastal research useful — cases from practice

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Summary Coastal research deals with that part of the sea, which is significantly affected by the land, and the part of the land, which is significantly affected by the sea. Coasts are in most cases densely populated, and the activities of people are shaping and changing the land/seascape of the coast. Thus, coast encompasses the coastal sea, the coastal land, coastal flora and fauna, and people. Since peoples' economic and political preferences change and compete, the human impact on the coast changes is contested and subject to societal decision making processes.

While some coastal research can help informing and constraining such decisions, many legitimate scientific efforts have little bearing on society. All decision making processes are political, so that scientific knowledge is not the dominant driver in such processes. Using cases from the Institute of Coastal Research of Helmholtz Zentrum Geesthacht, we describe some of these potentially useful parts of science, and discuss under which circumstances the potential usefulness transform into real utility. These cases do not span the full range of coastal science.

Important issues are the recognition of alternative knowledge claims, the inevitableness of uncertainties and incompleteness of scientific analysis, the acceptance of the political nature of decisions and the ubiquitous presence of social values. Modesty, self-reflexivity and skepticism are needed on the side of science and an organized exchange with stakeholders and public through designated "border" services.

1. Societal utility — bugaboo or reality?

It is nowadays a common requirement when preparing scientific proposals that the project is generating societally useful knowledge or skills. Thus, almost all proposals feature a section or at least a paragraph which describes "outreach", "knowledge transfer" or "stakeholder-interaction". In many cases, the proposers and reviewers have only lay-concepts for doing so, and the activity goes rarely beyond giving a few

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talks on public events and a press release, while others generate advanced web-pages ("tool boxes" and "roadmaps") for the public and policy makers.

Thus, the reference to stakeholders and decision making is often merely rhetorical and is not backed by thought-through concepts and approaches, but are based on naïve "linear" models operating with superior knowledge, which needs to be filled in stakeholders, who ask for enlightenment (e.g., van der Sluijs, 2010).

Many scientifically legitimate and valid questions or answers have no direct bearing for any stakeholder. Therefore it is not surprising that the stakeholder-interaction is often not taken seriously. Indeed, most scientific achievements will have no significant direct applications, but contribute "merely" to the overall understanding of a complex and multi-faceted natural and social milieu. Indeed, it is one of the narratives of the logic of funding science, which some relate to the US thinker Vannevar Bush (1945), that a few supported efforts of many will result in very useful offsprings, such as the famous Teflon pan. In this logic, the cost—benefit balance of funding science is positive because of some practical hits, while most efforts result in scientifically exciting insights with little relevance for anything except for a better understanding of often remote niches of reality. Since nobody knows, which of the many efforts will prove useful, it is best to fund all of them, as long as they are "scientifically good". Whether this strategy is realistic is another question, and other thinkers contend that science, which is based on the desire for being able to explain our natural and social environment, is just a fundamental need of western civilization and culture.

Admittedly, some of these scientific insights provide clues for a better understanding or better modeling of the system at hand. In the spirit of Vannevar Bush, some of these improvements turn out being useful in decision processes at a later time. However, it is not so that science would solve societal conflicts and would lead to sustainable "solutions", such as how to use certain areas, or how to decide about conflicting usages of coastal seas, such as off-shore wind energy, fishing and natural conversation.

In the end, all decisions about solutions are political. They are related to and associated with socially constructed values, preferences and interests. But science can help to determine which probable or possible consequences the different options may have ("recursive model", cf. Weingart, 1999). By answering "if—then" questions and dealing with options of decision making, science can contribute valuably to quality of life, both in terms of "making sense" of a complex environment and practical management. This is particularly so with respect to coastal sea systems.

The body of potentially useful knowledge about the state, the development of the coast, about options for managing the coast, needs a sustainably managed infrastructure. This infrastructure comprises coastal observatories, process and simulation models, tools for dynamical and statistical analysis of change, interdisciplinary exchange between the involved disciplines from physics to geology, from engineering to ecology, and socio-economic assessment methods for the integration of relevant data and expert judgments. Useful coastal science must be based on a solid scientific basis.

But such a basis is not enough for making coastal science "useful". The attribute "scientific" is not sufficient for an analysis to gain acceptance in the public and among stakeholders. This is clearly demonstrated by the public debate about the reality of man-made climate change. Instead, scientifically legitimized knowledge is just one form of knowledge, which has to compete with other forms of knowledge in the public domain (von Storch, 2009).

Stakeholders, including the public and media, are often confronted with developments and events in coastal environments that appear hazardous, alarming or promising. Some events are noticed only by a few decision makers, who ask for intensity, spatial and temporal extension, for options, systematic changes and perspectives. In other cases, the general public is getting involved, and the issue becomes a legal or political one. In both cases, coastal science is asked for answers, orientation and, when societal interests are involved, provision of a broader context. However, stakeholders have already knowledge what is going on; sometimes this understanding is consistent with scientific insights, but often it is partially or even completely inconsistent. For placing consolidated scientific knowledge in such a "knowledge-environment", scientific actors need to understand these "other" knowledge about the dynamics, statistics and conditioning of the coastal sea environment. We come back to this issue in the concluding section.

For this purpose, we not only need "border organizations", which identify the utility of scientific achievements for societal needs, but also apprehend societally relevant questions. These border organizations nowadays go often with the concept of "services". A successful service needs a rooting in scientific concepts, in understanding social dynamics, and in an exchange with stakeholder perceptions (von Storch and Stehr, 2014).

Under the headline of servicing, political manipulation in favor of specific "solutions" may take place. The issue of blending the roles of activists and scientists, for instance in the form of stealth activist scientists (Pielke, 2007) is a significant challenge, also for coastal science. Some political and economic actors appreciate favorable support by such stealth advocate scientists for pushing their views and interests. It seems that many in the scientific community have little reservation with such activities.

In this situation it makes sense to think about and discuss, in which way coastal science can become useful. What are the typical types of knowledge, which provides utility in real-world problems, tasks and decisions? For doing so, we first sketch five categories. These categories are not independent of each other. Also, they may be considered of different epistemological levels; they address different stakeholder groups.

1. "**Making sense**" refers to the scientific understanding of complex phenomena, and its use for supporting societal framing and decision making. Examples are consequences of eutrophication or the manifestation of natural system variations vis-a-vis anthropogenic climate change. Novel or recurrent but threatening events in complex coastal environments can attract considerable attention in stakeholder groups and the public. Meaning-providing frames, which allow for causal interpretation and understanding, satisfy not only curiosity, but allow for engineering preparedness and options for specific stakeholders. A significant constraint is that science is