Interactive comment on “Bridging the Gap between Observational Oceanography and Users” by Christiane A. Eschenbach

Anonymous Referee #1
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Author’s comments

Many thanks for your comments and suggestions!

Does the paper address relevant scientific questions within the scope of OS?
Especially the question of applicaton-oriented marine science and marine monitoring is a question of main interest for OS. “Bridging the Gap between Observational Oceanography and Users” tries to figure out the development process of COSYNA, the Coastal Observing System for Northern and Arctic Seas. The abstract states, that the analysis of data download has proved impact beyond academia.

→ In fact, the text is more guarded and says: „Analysis of data download provided some evidence for impact beyond academia.“

And this study should contribute to the emerging knowledge on integration of science and end-users.

Does the paper present novel concepts, ideas, tools, or data and are substantial conclusions reached?
The paper does not show an ex ante prepared scientific investigation process. But the author tries to bridge this gap by borrowing theoretical approaches from other disciplines, such as the iterative management method PDCA (plan–do–check–act or plan–do–check–adjust) and using approaches of transdisciplinary research and stakeholder interaction.

→ Also review 2 asks for more information on the PDCA cycle and the outline of a designed assessment. Therefore, an explanatory paragraph has been included (p 4, line 26):

„*The PDCA methodology is a tool to incorporate feedback and to break down the development, implementation, and continuous improvement of processes or products into small manageable steps. When applied to the life cycle of coastal scientific products, such as COSYNA products, stakeholder interaction would ideally be assessed in the following way.The first step would be to identify possible stakeholders by means of a stakeholder mapping exercise. During the initial phase of problem definition, consensus should be reached on the research question and the objectives of the project by all parties concerned, e.g. through a series of stakeholder workshops. It is essential that scientist and practitioners contribute their specific knowledge and speak to each other as equals. After common understanding is achieved during the „Planning“ phase, potential solutions should be generated and tested on a small scale ("Do" phase). For an initiative such as COSYNA this means to start with the development of one typical product. Thus, measuring and modelling concepts and devices are developed and established and a parameter field, e.g. current fields in the German Bight, is provided at a pre-operational level. During the „Check“ phase potential users would be asked for evaluation of and feedback on the pre-operational product. Assessment data should be gathered on a statistically sound basis with potential users from different groups. However, lack of resources often constrains the ideal number of stakeholders to involve and the activities that can be carried out. The results of structured quantitative and qualitative analyses should be fed back into the development cycle, meaning that aspects mentioned by potential users should really influence further product development. The "Do" and "Check" phases could be repeated several times to polish the product and its usability until all the stakeholders agree on the usefulness of the final product. Finally, the improved solution is fully implemented („Act“). Any evaluation of products and stakeholder processes requires success criteria and indicators that need to be set in advance (ideally with stakeholders).”*

A critical reading comes to the conclusion, that a requirements analysis for the dataportal COSYNA – and the described activities are not more or less such a requirement analysis - is declared in the article as a “stakeholder interaction process”.

→ In order to emphasize the fact that the whole process is important and that all the activities from the initial survey through to the external evaluation, interviews, workshops etc. are essential components of the COSYNA stakeholder interaction concept, the following sentences were added:

„The COSYNA stakeholder interaction concept follows a structured process encompassing a broad range of different interaction activities. The stakeholder interaction process continued as the initiative progressed and developed further with the development of the products. As is well known for projects, interactions in the beginning (initial survey, external evaluation etc.) had more influence on the design of the whole COSYNA initiative than later steps. During the initial phases data demands related e.g. to accuracy, data resolution and the design of measurements and approaches were a greater focus. During later stages, feedback of (potential) users on the pre-operational products, data presentation in the data portal and the user interface played a more important role. Later, during the implementation phase, interaction activities concentrated on fine-tuning and improving the usability of the products. During the course of the project the range of stakeholders changed accordingly: The range of interest groups addressed was broad in the beginning and later increasingly focused on key stakeholders. However, all the interest groups involved during the different phases contributed their specific practitioners’ experiences, and their specific demands regarding oceanographic data products, e.g. concerning parameters, types, resolution etc.. Thus, real-world questions were taken into account in the design of the COSYNA initiative.“

But stakeholder interaction would mean, that the stakeholder itself would directly influence the system and the kind of data, provided by the portal. But there is no indication, that such a real interaction process has taken place.

→ In order to make the stakeholder influence on COSYNA’s portfolio clear, the following sentence was included at the end of the section „Requirements of potential national and regional user groups“:

Thus, the COSYNA approach combining measurements and modelling was designed to meet these requirements. In accordance with the outcomes of the survey, the first COSYNA products to be realized were maps and forecasts of surface current fields in the German Bight. Data products on waves, temperature and salinity were next in COSYNA’s portfolio.

→ To point to the influence of the external evaluators, the following sentence was included at the end of the section „External evaluation of COSYNA products“:

Consequently, efforts were made to achieve more user-friendly data presentations and download possibilities (see section 3.3 and Breitbach et al. this volume).

Furthermore stakeholder interaction within a transdisciplinary process would mean, that different groups of stakeholders, e.g. NGO0s, public administration, citizen, tourism, fishermen would have been involved into a problem-centered investigation process, to come to a common solution.

→ In order to point to the different groups addressed in COSYNA, the following sentence was added into the section „Requirements of potential national and regional user groups“:

The initial survey addressed a broad range of organisations including science (universities and other research institutions), federal and state authorities, public administration, tourism, nature conservation, international and regional NGOs, private enterprises, fishermen, consulting groups, engineering companies etc..

In the discussion (p. 10) is stated, that stakeholder interaction and transdisciplinary orientations would have been established, during the planning process. The same abstract defines the objective of transdisciplinarity: “The core idea of transdisciplinarity is that different academic disciplines work jointly with practitioners to solve a real-world problem (Häberli et al. 2001)”. At least these objectives cannot be gained, just by involving the offshore wind energy into the consultation process as the paper shows in the Case Study. If there have been additional activities to work into broader scope towards

transdisciplinarity, these activities have to be pointed out. Otherwise the used concept of transdisciplinary research would not be adequate for the described activities.

→ As I'm well aware that our activities do not fulfill the criteria of real transdisciplinary research, I've been carefully using the term „transdisciplinary orientation" (instead of TDR). However, for those readers who might not be familiar with the concept of transdisciplinarity, I added some information on the core idea.
There was more than only the case study and I hope this is made clear now by the sentences added (see above).

The given reference to the process of product life cycle respectively PDCA just shows, that needs a continuing improvement, has to run through such an process. But where is the scientific value of this procedure? The scientific methods and assumptions are on different levels and do not always support the interpretations and conclusions.
Reading the article I steadily wondered , what could be the news from a scientific point of view. The Workflow process just led to a requirement analysis for data products. The following stakeholder interaction process has just been evaluating the provided data. And no wonder - business and science like to have good pre-processed no-cost data. At least the article contains no new findings or knowledgments, that are worth to be published in a high-ranking scientific journal.

→ Concerning the „lack of scientific value": This is a common, well-used argument levied against results derived at the interface of different scientific disciplines, and has often been criticized in the literature. Recently, some endeavours have been undertaken at national and international levels to identify appropriate success criteria and indicators.
I agree that the study is not a typical paper for a journal like OS. However, it adds valuable insights that are complementary to the overall COSYNA picture, so I would consider it worthwhile to include a paper looking beyond strict oceanography.

All the activities to develop the COSYNA dataportal are described in a well-structured and well readable form.

→ Of course, the stakeholder interactions described are related to the COSYNA data products - and these are presented in the data portal. However, in my opinion, this does not justify a description of these interactions only as „a requirements analysis for the data portal COSYNA".

The used literature is comprehensive and up-to-date. The objective of the paper – driving the ocean-monitoring more into a transdisciplinary and application-orientated direction – is creditable. But the scientific basis of the paper is weak. So I recommend to reject the paper.

Interactive comment on Ocean Sci. Discuss., doi:10.5194/os-2016-21, 2016.

Anonymous Referee #2

Author's comments
First, I would like to express my thanks for the valuable and helpful comments.

Review
Bridging the Gap between Obserevational Oceanography and Users

Summary:
The paper is a narrative in describing attempts for stakeholder involvement within the COSYMA project. As such it is not a typical scientific paper. There are weaknesses in the assessment which lacks a designed and quantitative component. This refers to a need for more structured data gathering as a precondition for a more structured analysis.

Also, there is a focus on what can be considered key stakeholders. This actual focus does not meet conditions described in the introduction basically seeking input from a diverse group of stakeholders. This should be addressed in a revision.
→ In order to point to the broad range of interest groups/stakeholders addressed, several sentences were added. See comments on review1

On the other hand, a summary of the stakeholder involvement process outside a preconceived scientific project is quite valuable and such a summary cannot scientifically cover all aspects of a PDCA assessment that may be should have but in fact has not accompanied the process. I would therefore recommend to retain the paper as a valuable summary of outreach activities within the COSYNA project, in spite of the fact that it is narrative and by itself clearly does not provide a scientific analysis of the stakeholder consultation process. In this context, I recommend the author to outline in some detail what could be a designed assessment for such a complex process such as COSYMA.
→ A description of the PDCA cycle and an outline of a designed assessment were included into „COSYNA product life cycle", see comments on review1.

More detailed recommendations include:

1. Introduction

Quite complete, provides a very good literature base

Omit page 3 lines 26-30 (redundant)
→ Sorry, I don't understand which statements are redundant - if they are I'll be happy to remove them.

Omit page 4 reference to citizen science - does not seem to really fit the topic
→ The reference to citizen science was included at so.'s suggestion during the revision process. Therefore, maybe it should be kept – but I have no problem with removing it.

page 4 lines 12 to 13 moderate statement "Consequently ..... et al, 2012) - standards and evaluation criteria may not be well developed for marine systems, specifically. But does this matter? How would such methods be different from the evaluation of participatory processes in general?
→ Yes, text was unclear and was changed to:
"Quality standards and evaluation criteria for transdisciplinary processes are widely lacking (e.g. Jahn et al. 2012)."

2. The COSYNA product life-cycle

Consider elaboration of PDCA approaches - as is they are mentioned but no background is provided (basic information).
→ A paragraph was added to explain the PDCA and the outline of a designed assessment (see above and comments on review 1).

3. Steps of the COSYNA L8ife cycle

3.1. Initial surveys
Appropriate description of the initial surveys

3.2. Mathematical-technological realisation
not the focus in this paper, relies on reference to previous publications
page 6, line 15: I presume resolution should be 1 km² (not one km)
→ one km is ok.

3.3. Free access to data
not the focus in this paper, relies on reference to paper in the same volume

3.4. External evaluation
No NGOs participated in evaluation, missing a potentially important target group.
not the focus in this paper, summary sufficient
→A sentence was included to justify the selection of the evaluators:
„The evaluators were selected according to the outcomes of the initial surveys. These showed that NGOs or fishermen were less interested in oceanographic data such as currents and waves, but that scientists were a priority user group. Therefore, four evaluators were chosen, representing the user groups of administration, private enterprise and science.

except it would be nice to have an explanation for discrepancies between Science1 and Science2 and possible rankings below 4 in general
Table 1: Needs explanation of terms Science1 and Science2
→ A sentence was added to explain the difference between Science 1 and Science2:
The two science representatives substantially differ in their fields of interest: (1) numerical ocean models and data assimilation, and (2) coastal observation with the aim of understanding the system and the influences of forcing factors.“

3.5. Interviews and workshops with stakeholders
Purely descriptive, lacks attempts for prioritization.
→ The following paragraph was added at the end of the case study section:
„To summarize and rate the outcomes of the case study for COSYNA purposes, the most important finding was that COSYNA current and wave data, and in particular forecasts, would be the most welcome output. Safety of operations emerged as the overarching issue, meaning that reliability and completeness of data sets are indispensable – a requirement to be met by 24/7 services. With respect to usability, a good user interface is essential, although the different specifications for “good” cannot easily be served by a single approach. In the context of collaboration, many enterprises would welcome data exchange and even joint measurements in wind farms; these were generally considered possible. Specific endeavours, however, were blocked.“

4. Impact evaluation
was conducted via evaluation and feedback sheets. However, results of evaluations are not presented.
Figure 4 provides results from download. These should be described and possible patterns discussed (high proportion of science downloads, private enterprises and industry only in December 2014 and 2015 etc).

→ In order to explain, some sentences on Fig. 5 (data download) were added:
As COSYNA is committed to an open data policy and does not collect any personal user data, any information on users is limited to download rates and information provided voluntarily on user categories. On average, about 19 GB of COSYNA data was downloaded per month from November 2014 until March 2016. Users from the category of science downloaded the highest proportion of data, followed by users from „administration". During some months, however, other user groups used COSYNA data for specific purposes. In December 2015 for example, private enterprises used data to validate their model. Whether the greater diversity of data users in December 2014 is a direct result of the workshops cannot be validated.

5. Discussion
Suggest to remove introductory paragraph or integrate with introduction
→ ok.

5.1. The usability of the products
page 10, line 20: How did you rank the questions in order to come to the most interesting questions for the offshore wind energy sector - should the deduction of interesting have a database in the results?
→ Some sentences on the deduction of the conclusions from interviews (and workshops) were added to the results section (see above 3.5).

page 11, line 1: the use needs a description in the results section and an explanation in the discussion - is the download from those administrations that provide the services?
→ see above, 4.

page 11, line 23: usefulness to potential users - what are the potential users beyond the administration - business nexus
→ We consider the range of interest groups mentioned in the introduction and exemplarily interviewed for the initial survey to be the main potential users.

5.2. The stakeholder process
page 11, lines 29 - 31: Not sure enough is provided in the preceding chapters to warrant the conclusion that the process was successful. Table 1 in particular does not support that conclusion
→ In order to better explain that the process (!) was successful, the text was changed to:
„Through the various interactions with different stakeholders the COSYNA products could be improved substantially. In addition, especially the interaction with the key stakeholders from the offshore energy sector led to essential insights into the demands and constraints concerning the use and usability of COSYNA products, and identified new research questions. Although the most challenging steps of co-operation or collaboration could not be achieved, the entire process of stakeholder interaction should be considered successful."

It is also not clear to me whether co-operation or collaboration was achieved or how it is supposed to be achieved. Is a statistics on data exchange (e.g. number of relevant events) feasible in this context?
→ In order to be more clear, the following sentence was added (but see also p12, line 6 and page 9, line 14-16)
„Internal constraints of the offshore wind energy sector, however, prevented the interaction process from being truly collaborative. „

A new paragraph was added to section 5.2 stakeholder process:
"Revisiting the ideal assessment design of stakeholder interaction outlined above, we acknowledge that this ideal was not fully achieved for the COSYNA products. This is partly due to limited resources, but also to the fact that the products developed by a research institute cannot always be tailored to

the specific demands of every individual user. It would have been useful to include a larger number of stakeholders in the later stages of the process, however this was not possible due to limited resources. Overall, the constraints experienced highlight the challenge of finding an acceptable balance between idealistic expectations on the one hand and realistic capacities on the other."

page 12, lines 2-3 suggestion to rephrase;
"The "consultation" indicates ...." change to "The "consultation" encompasses ..."
→ ok.
"... and was fulfilled via ..." change to "...and was specifically addressed through ...."
→ ok.

5.3. Contribution to impact evaluation

page 12, line 16, suggestion to rephrase
"... or what might be the possible criteria for success."
→ ok.

Main concern is that stakeholder integration usually is restricted to government agencies, i.e. those funding the according research. This appears to be too narrow. In general this point of rather narrow stakeholder participation should be discussed. Proposals how to solve this may be helpful including approaches to broaden input, but also approaches to prioritize (identify key stake-holders).
As is the promise in the introduction to look for broad stakeholder participation is not really met. Stakeholder participation is very much targeted at industry.
→ I agree with your general concern on restricted stakeholder interaction. In COSYNA we initially dealt with a broad range of stakeholders and during the course of the initiative increasingly focused on key-stakeholders – which is hopefully more clearly shown in the paper now (owing to your comments, thank you!). The paragraph on „designed assessment" also refers to this point.

Bridging the Gap between Observational Oceanography and Users

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Abstract

In order to ensure relevance and societal impact of research and to meet the various requirements of different target groups the Coastal Observing System for Northern and Arctic Seas (COSYNA) developed and pursued a broad range of activities for knowledge transfer and stakeholder interaction. Potential user groups of data and data products include, but are not limited to science, administration, renewable energies, engineering, tourism, and nature conservation. COSYNA data and data products are publicly accessible and available free of charge via the Internet (data portal, www.cosyna.de).

The stakeholder interaction is integrated into the COSYNA product life cycle outlined here and the steps undertaken are exemplified for the product "Surface Current Fields in the German Bight": Initial surveys revealed COSYNA's potential relevance in the national and international context. After the mathematical-technological realisation of high quality parameter fields, external experts evaluated the scientific value, informational value, innovative leap, cost/benefit aspects, operability etc. of the data products. In order to improve products and their usability and to pave the way for future co-operation, interviews and workshops with potential users from the offshore wind energy industry were conducted. The stakeholder interaction process was successful, revealing relevant insights into user demands and usability of (possible) products. Analysis of data download provided some evidence for impact beyond academia. Other criteria for the increasingly demanded evaluation of impact of coastal research are discussed. By sharing first hand experiences this study contributes to the emerging knowledge on integration of science and end-users.

Keywords

Coastal Observing System, COSYNA, data products, current fields, stakeholder interaction, transdisciplinarity, evaluation

1 Introduction

Integrating stakeholder perspectives from outside academia is of increasing importance in ocean and coastal science. The role of science in society has been changing considerably during recent decades. Scientists are increasingly asked to consider the salience of their work in relation to the needs of the public and its legitimacy among stakeholders beyond their scientific peers (e.g., Cash et al. 2003, Welp et al. 2006, Allen et al. 2013, von Storch et al. 2015). Knowledge on transdisciplinary approaches is considered to benefit from project experiences (Jahn et al. 2012, Bergmann et al. 2016) and "more guidance grounded in actual project experiences is needed" (DeLorme et al. 2016). Thus, the purpose of this study is to convey first hand experiences on stakeholder interaction and transdisciplinary orientations from the Coastal Observing System for Northern and Arctic Seas (COSYNA).

COSYNA has been established in the German North Sea and off Spitsbergen to describe, analyse and predict the environmental status of coastal waters. Combining observations, numerical modelling, data management, and outreach activities, the system provides data and knowledge tools to help science, public administration, industry and the public make informed decisions (see also Baschek et al. this volume).

The COSYNA mission meets the societal requirements for sustainable future developments of marine and coastal regions as set forth, for example, by the Marine Strategy Framework Directive (MSFD, Directive 2008/56/EC) and the Copernicus Marine Environment Monitoring Service (CMEMS), the latter striving to implement services coupled with efficient downstream processing to support marine applications. Using this approach, observation methodologies developed in COSYNA support monitoring strategies and can contribute to 'Good Environmental Status' (GES) and sustainable development of the North Sea. Because the North Sea is one of the most heavily used coastal areas in the world, lessons learned in this region may serve as a role model for similar challenges and interactions in other coastal regions worldwide.

In order to ensure relevance and societal impact and to meet the various requirements of different target groups, a broad range of activities for knowledge transfer and stakeholder interaction was developed and pursued. Stakeholder feedback was and is necessary to further improve the COSYNA products.

While considerable expertise has been developed by now in delivering services in other fields of natural science, such as in climate services (McNie 2013, Vaughan & Dessai 2014, Bowyer et al. 2015), marine and coastal products and services are still in their infancy (e.g., Kourafalou et al. 2015a, v. Storch et. al 2015). Societal benefits of coastal ocean observing systems have, for example, been demonstrated in the U.S. to support marine safety, water quality and effective coastal management decision making (Buskey et al. 2015, Porter et al. 2015, Simoniello et al. 2015). In Europe, the Marine Strategy Framework Directive provides the background in supporting the need for stronger and more effective oceanographic research interaction with the (often conflicting) interest groups, using various marine or coastal resources. Concerning the marine area, collaborative research is most common in fisheries (e.g., Mackinson et al. 2010). However, in the coastal area, we can still observe a mismatch between knowledge production in academia and knowledge requests for solving societal problems (Hoffman-Riem et al. 2008, Diedrich et al. 2010, Kourafalou et al. 2015b).

In order to overcome this mismatch products and services concerning the state of the North Sea were developed for various users of oceanographic data and forecasts (Fig. 1). COSYNA products range from time series at various locations and regular maps of parameters such as currents, waves, salinity, temperature, chlorophyll, oxygen, etc., to routine short-term forecasts (days) for these parameters.

Potential ~~U~~users include, but are not limited to, those from science, administration, renewable energies, tourism, and nature conservation. For example, the Federal Maritime and Hydrographic Agency (Bundesamt für Seeschifffahrt und Hydrographie, BSH) measures and calculates sea surface temperatures, waves, currents as well as current and wave predictions from their operational observation and model systems and make them available to the various users and the public. An improvement of these services is considered through further development of COSYNA measurements and products.

This study, in particular, focuses on interest groups from the offshore wind energy sector. Offshore wind energy farms are a recent addition to human utilisation in the North Sea, an area with strong offshore wind potential in Europe. In the context of global climate change and in order to reduce CO_2 emissions resulting from human activities, the number and size of offshore wind energy farms have significantly increased in recent years. Germany's offshore wind farms have generated 1.3 % of the overall energy produced nationwide in 2015, a 550 % increase compared to a 0.2 % contribution by offshore wind turbines in 2014 (http://www.offshorewind.biz/2015/12/21/, according to data from the German Association of Energy and Water Industries, accessed January 6, 2016). Currently there are approximately thirty-six offshore wind farm projects either in operation (12), under construction (5), or licensed (19) in the German North Sea (http://www.wab.net/images/stories/Offshore_Wind_Farms_in_the_German_North_Sea.pdf, accessed January 6, 2016). As offshore wind energy is rapidly proliferating in Germany and Europe (Renewable Energies Act 2000, Commission of the European Communities 2007, Pineda 2015), and this development points to a global trend, businesses and other stakeholders from the wind energy sector are important (potential) users of oceanographic data and forecasts. The new and intensified use of wind energy brings benefits and new challenges. The latter includes coping with harsh environmental conditions in the

North Sea and ensuring safe, but efficient and effective maintenance and operation of the wind farms, while at the same time minimising the environmental impact. ~~Planning, construction, operation and maintenance procedures under difficult weather and oceanographic conditions in the North Sea might considerably profit from COSYNA products on currents and waves.~~ The potential influence of offshore wind farms on North Sea ecosystems and the aim of preserving fragile ambient ecosystems is not the subject of this study (see e.g. Bailey et al. 2014, Clark et al. 2014).

Figure 1: The integrated COSYNA approach: Combination of observations and numerical modelling, data management and stakeholder interactions (COSYNA presentation, www.cosyna.de)

In general terms, transdisciplinary approaches mean that researchers from different academic disciplines work together with stakeholders. Different intensities of interaction between science and stakeholders can be differentiated: information, consultation, co-operation, collaboration and empowerment form a sequence from low to high intensity in transdisciplinary approaches (Brinkmann et al. 2015, Stauffacher et al. 2008, Wiek 2007). There are numerous definitions for transdisciplinarity in literature, but a generally accepted definition is still not available. Generally agreed upon main features are: addressing a real-world problem, integrating different disciplines, involvement of non-academic stakeholders (Bergmann et al. 2016, DeLorme et al. 2016, Jahn et al. 2016, Hirsch Hadorn et al. 2008). Transdisciplinarity combines interdisciplinarity (collaboration between researchers from different disciplines aimed at a synthesis and integration of knowledge; Bernstein 2015) and interactions with extra-academic interest groups, for example from industry, governments, and non-governmental organisations. Little experience in transdisciplinary approaches exists in coastal research. Marine or coastal topics are, for example, lacking in the *Handbook of Transdisciplinary Research* (Hirsch Hadorn et al. 2008). However, some overlapping of transdisciplinarity and the nowadays flourishing field of citizen science exists, as both are dealing with participation of non-scientists or non-academic scientists. In recent years thousands of volunteers ("citizen scientists") have participated in marine research activities (Thiel et al. 2014). Citizen science can support integration in transdisciplinary endeavours (Pettibone & Lux, 2015).

In terms of stakeholder interactions, it is helpful to distinguish between the product (e.g. data products or new technologies; concerning the "what?") and the process (dealing with the "how?"). While this study tackles both these components, it focuses, however, on the process. For improving the process, it is essential to answer the question on whether stakeholder interactions did in fact work and achieve their goals. Agreed upon processes for collaboration, in particular in the field of coastal ocean observing systems, are still fragmentary (e.g. Liu et al. 2015, DeLorme et al. 2016). ~~Consequently, q~~Quality standards and evaluation criteria for transdisciplinary processes are widely lacking (e.g. Jahn et al. 2012). As evaluation criteria for the impact of (successful) stakeholder interactions are absolutely essential they are a matter of active discussion. Outcomes of this study are expected to support criteria development and contribute to the on-going discussion.

Thus, the focus of the study is threefold:

- to improve the COSYNA products by stakeholder interaction,
- to share a practice example on transdisciplinary orientations in coastal research,
- to contribute to criteria development for impact evaluation.

2 The COSYNA product life cycle

In order to identify and depict those phases of the COSYNA product development procedure that are the relevant for stakeholder interaction an iterative multi-step cycle was developed. The conceptual framework is based on two approaches used in business:

(1) According to the product life concept (usually referred to as a life cycle, e.g. Rebitzer et al. 2004) every product has a "life", starting with design and development, followed by production, provision and use and end of life activities. The development of a pre-operational integrated COSYNA product comprises different aspects and can be depicted as the "COSYNA product life cycle" (Fig. 2): While the product realisation (B, C) is mainly a mathematical-technological challenge, development of the product idea (A), product evaluation (D), interviews, workshops (E) and impact evaluation (G) require stakeholder interaction. Effort at these phases of the product life cycle is required to initiate and maintain a two-way information flow, where potential users and external evaluators provide feedback. The product application (F) in political or management decisions by authorities, enterprises, and other users is subject to other driving forces and not part of COSYNA. In order to improve the products and to ensure they are useful and applicable interaction with (potential) users was established step-by-step.

(2) The iterative management method PDCA (plan–do–check–act or plan–do–check–adjust~~) is used in industry for the control and continuous improvement of processes and products.~~ is a tool to incorporate feedback and to break down the development, implementation, and continuous improvement of processes or products into small manageable steps.

When applied to the life cycle of coastal scientific products, such as COSYNA products, stakeholder interaction would ideally be assessed in the following way.The first step would be to identify possible stakeholders by means of a stakeholder mapping exercise. During the initial phase of problem definition, consensus should be reached on the research question and the objectives of the project by all parties concerned, e.g. through a series of stakeholder workshops. It is essential that scientist and practitioners contribute their specific knowledge and speak to each other as equals. After common understanding is achieved during the „Planning"phase, potential solutions should be generated and tested on a small scale ("Do" phase). For an initiative such as COSYNA this means to start with the development of one typical product. Thus, measuring and modelling concepts and devices are developed and established and a parameter field, e.g. current fields in the German Bight, is provided at a pre-operational level. During the „Check" phase potential users would be asked for evaluation of and feedback on the pre-operational product. Assessment data should be gathered on a statistically sound basis with potential users from different groups. However, lack of resources often constrains the ideal number of stakeholders to involve and the activities that can be carried out. The results of structured quantitative and qualitative analyses should be fed back into the development cycle, meaning that aspects mentioned by potential users should really influence further product development. The "Do" and "Check" phases could be repeated several times to polish the product and its usability until all the stakeholders agree on the usefulness of the final product. Finally, the improved solution is fully implemented („Act")." Any evaluation of products and stakeholder processes requires success criteria and indicators that need to be set in advance (ideally with stakeholders).

~~The development of a pre-operational integrated COSYNA product comprises different aspects and can be depicted as the "COSYNA product life cycle" (Fig. 2): While the product realisation (B, C) is mainly a mathematical-technological challenge, development of the product idea (A), product evaluation (D), interviews, workshops (E) and impact evaluation (G) require stakeholder interaction. Effort at these phases of the product life cycle is required to initiate and maintain a two-way information flow, where potential users and external evaluators provide feedback. The product application (F) in political or management decisions by authorities, enterprises, and other users is subject to other driving forces and not part of COSYNA. In order to improve the products and to ensure they are useful and applicable interaction with (potential) users was established step-by-step.~~

In practice, ~~T~~the steps depicted in Figure 2 and described in detail in the following sections were performed during the development of an integrated pre-operational COSYNA product.

Figure 2: COSYNA product life cycle depicted for the COSYNA product "Surface Current Fields in the German Bight" as an example: (A) Initial surveys reveal COSYNA's potential relevance. (B) The mathematical-technological realisation provides optimised parameter fields for currents, waves, temperature, etc. (C) The data are freely accessible via the COSYNA data portal.

(D) External evaluation of COSYNA products. (E) Interviews and workshops with stakeholders from the offshore wind sector. (F) Improved COSYNA products are available to users. (G) Evaluation of impact.

3 The steps of the "COSYNA product life cycle" in practice

The COSYNA stakeholder interaction concept follows a structured process encompassing a broad range of different interaction activities. The stakeholder interaction process continued as the initiative progressed and developed further with the development of the products. As is well known for projects, interactions in the beginning (initial survey, external evaluation etc.) had more influence on the design of the whole COSYNA initiative than later steps. During the initial phases data demands related e.g. to accuracy, data resolution and the design of measurements and approaches were a greater focus. During later stages, feedback of (potential) users on the pre-operational products, data presentation in the data portal and the user interface played a more important role. Later, during the implementation phase, interaction activities concentrated on fine-tuning and improving the usability of the products.

During the course of the project the range of stakeholders changed accordingly: The range of interest groups addressed was broad in the beginning and later increasingly focused on key stakeholders. However, all the interest groups involved during the different phases contributed their specific practitioners' experiences, and their specific demands regarding oceanographic data products, e.g. concerning parameters, types, resolution etc.. Thus, real-world questions were taken into account in the design of the COSYNA initiative.

3.1 Initial surveys (A)

International dimension

A feasibility study on COSYNA's international dimension (Laane 2010, HZG internal report) was conducted with special attention to the planned networking activities and to assess the international scientific contacts and connections with networks, organisations and projects. The study stated that "coastal observatories are nowadays the backbone for scientific exploration, operational information and management of coastal ecosystems" and that COSYNA fits very well within the worldwide development of coastal observatories. According to the study, the COSYNA strategy to improve and streamline access to high quality marine data should be completed with tailor-made communication plans for communicating to the various end users. The study concludes that COSYNA's goal, to collect information and data to understand the short and long-term dynamics in coastal ecosystems fulfils the need of international EU directives, conventions and agreements.

Information on user requirements at a European level was also available from the "Operational Oceanography: Data Requirements Survey" (sample from 155 organisations in six countries, Fischer and Flemming 1999) conducted by the association of European national agencies for developing operational oceanographic systems and services in European seas (EuroGOOS). COSYNA products were to cover these requirements to a large extent. This applies to the parameters measured (e.g., current, waves, sea surface temperature, salinity, wind, bathymetry, sediment and some biogeochemical parameters), the geographical coverage (coastal and shelf areas), the spatial (and temporal) resolution, and the product types, such as processed data, hindcasts and forecasts.

Requirements of potential national and regional user groups

During COSYNA's early stages, a second survey provided information on the specific demands and requirements of potential national and regional user groups in the northern German coastal area (Ahrendt & Wesnigk 2009, HZG internal report). The initial survey addressed a broad range of organisations including science (universities and other research institutions), federal and state authorities, public administration, tourism, nature conservation, international and regional NGOs, private enterprises, fishermen, consulting groups, engineering companies etc. The interviewees were ~~selected to~~

categorized to represent four interest groups, namely (number of responses in parenthesis): Authorities (10), nature conservation, tourism and other NGOs (10), science (universities and other research institutions, 18), and businesses (with focus on offshore wind energy, 21). A majority of the interviewees (71 %) use external data from other organisations with a preference for processed (30 %) and cleansed data (31 %) over raw data. The study identified meteorological data, current, waves, bathymetry, turbidity and water temperature as the most useful parameters to potential national and regional users. Data on salinity, nutrients, oxygen, chlorophyll and higher trophic levels (marine mammals, fish, birds) were also often in demand. Forecasts and simulations (81 %), oceanographic modelling data (76 %), meteorological modelling data, reconstructions of storm surges, waves, water level, and mathematical modelling of habitats were in high demand (for more details see Eschenbach 2013). Thus, the COSYNA approach combining measurements and modelling was designed to meet these requirements. In accordance with the outcomes of the survey, the first COSYNA products to be realized were maps and forecasts of surface current fields in the German Bight. Data products on waves, temperature and salinity were next in COSYNA's portfolio.

3.2 The mathematical-technological realisation provides optimised parameter fields (B)

The COSYNA product "Surface Current Fields in the German Bight" may serve as an example (for details on measurements, modelling and data assimilation, see Schulz-Stellenfleth et al. 2010, Stanev et al. 2011, Stanev et al. 2015). The product "Surface Current Fields in the German Bight" is the first pre-operational analysis system for surface currents based on real-time HF radar data. Currents are provided in real time, for the last eighteen hours and as a six-hour forecast. The maps and forecasts are updated hourly. The resolution in the area of the German Bight is 1 km and the product deviation from the measured HF radar current data is typically about 0.1 m/s, with large regional deviations

Figure 3: COSYNA product "Surface Current Fields in the German Bight" (snapshot 4-6 April, 2016, COSYNA data portal, based on the algorithm described in Stanev et al. 2015)

3.3 The data are made freely accessible via the COSYNA data portal (C)

The COSYNA data portal (codm.hzg.de, see also www.cosyna.de) presents all COSYNA data and metadata comprehensively, free of charge and is made available to everyone. The data portal serves as the user interface for data retrieval and presentation and aims at multi-purpose data use. The user can select parameter, data sources, time range and presentation type (overlay raster map or time series diagram) and can download the selected data. Thus, for example, maps of current fields can be inspected and time series of current maps (in netCDF format) are publicly available for download. For details about the numerous distinctive features of the COSYNA data portal, see Breitbach et al. (this volume).

3.4 External evaluation of COSYNA products (D)

After realisation but before implementation of the first product, "Pre-operational Surface Current Fields", and during detailed planning of the second product, "Temperature & Salinity", a group of national and international evaluators were asked for their expert opinion on the COSYNA products. The evaluators were selected according to the outcomes of the initial surveys. These showed that NGOs or fishermen were less interested in oceanographic data such as currents and waves, but that scientists were a priority user group. Therefore, four evaluators were chosen, representing the user groups of administration, private enterprise and science. ~~The group comprised of four representatives of the user categories administration, private enterprises and science.~~ The two science representatives substantially differ in their fields of interest:

(1) numerical ocean models and data assimilation, and (2) coastal observation with the aim of understanding the system and the influences of forcing factors.

The evaluators were asked to fill a multiple choice questionnaire, to provide detailed written statements, and to present and discuss their results during a one-day workshop. The criteria for the evaluation were: scientific value, informational value (as compared with other existing informational sources), innovative leap, potential users and target groups, cost/benefit aspects, operating reliability/availability, and user interface/operability of the COSYNA products, in particular of the current product. The evaluators identified the scientific-technical value as high and the informational value and innovative leap as above average and saw proper potential applications and usages. They recommended, however, improvement of the user interface (Tab. 1). Consequently, efforts were made to achieve more user-friendly data presentations and download possibilities. New features increased the usability of the data portal (see section 3.3, and Breitbach et al. this volume).

Table. 1: Evaluator feedback on the product "Pre-operational Surface Current Fields" (values from 1 (bad/low) to 5 (good/high)).

3.5 Interviews and workshops with stakeholders: Case study "Offshore wind energy" (E)

During implementation, COSYNA interacted with different interest groups in order to support the applicability and usability of its products. This study, in particular, focuses on interest groups from the offshore wind energy sector. Planning, construction, and operation of offshore wind farms as well as maintenance procedures under difficult weather and oceanographic conditions in the North Sea might considerably profit from COSYNA products on currents and waves. The offshore wind energy sector is multidisciplinary and heterogeneous in itself, including specialists of very different fields, such as operators, insurance companies, consultants or divers. As the interaction with stakeholders from the offshore wind sector may serve as a case study, it is described in detail in the following. The focus is on interviews and workshops.

Jointly and in co-operation with the Federal Maritime and Hydrographic Agency (BSH) and the German Weather Service (DWD), we contacted offshore wind energy organisations, such as operators, consultants, insurance companies and others aiming at a two-way information flow, co-operation or collaboration. The purpose of the interaction with stakeholders from the offshore wind energy sector from our point of view was threefold: (1) First, to improve existing COSYNA products through interaction with potential users, to demonstrate their applicability for real life situations, and to gather further information on products to be developed (e.g., information on parameters, spatial and temporal resolution, and accuracy). (2) Secondly, we proposed to exchange existing data with wind farm operators for mutual benefit. (3) The third idea was to possibly take measurements within wind farms and use these measurements to obtain data that are otherwise rarely available to science.

As the wind energy industries could likewise benefit from our measurements, models and improved analysis and prognosis tools as well as from obtaining weather and oceanographic data free of cost, we expected to generate a win-win situation.

The following major efforts were undertaken to establish and maintain interactions with potential COSYNA product users from the offshore wind energy sector:

- participation in offshore wind exhibitions and public events to make contacts,
- first series of interviews in order to prepare for the first workshop,
- realisation of a user workshop with approximately 100 participants,
- evaluation of the workshop outcomes and post-processing (wrap up),
- second series of interviews in order to prepare for the second, more topic-oriented, workshop,
- realisation of the second workshop with a limited number of participants and focusing on currents and waves,
- meetings with representatives of offshore wind energy companies to arrange concrete collaborations,
- evaluation of the outcomes of the interaction efforts.

The listed efforts were undertaken jointly and in very fruitful co-operation with the Federal Maritime and Hydrographic Agency (BSH) and the German Weather Service (DWD). In the following, I focus on the interviews and workshops.

3.5.1 Interviews

Through personal contacts, literature and internet research, potential interested parties from the offshore wind energy industrial sector were identified. The first series of interviews was conducted with representatives of nine companies from the construction, operation and maintenance, and consulting areas. The second series comprised seven interviews with selected participants of the first workshop. All the interviews were guideline-based and in-depth. In preparation of the actual interviews a set of potential guiding questions was identified. During the interviews, the initial and guiding questions were tailored according to the interviewees. Their answers in large parts shaped subsequent questions. The interviews were conducted face-to-face or (a few) via phone, and all of them took approximately one hour or more. The information gathered during the interviews was compiled and analysed. The general interviewing process followed the steps identified by Kvale (1994).

Concerning data use and requirements, major results of the first series of interviews showed that most enterprises use two or more weather forecasts, including oceanographic data, and would be interested in additional high quality and freely available data. Most business enterprises working in the offshore wind sector have their own measurement equipment in situ. This is especially true for those who employ workers, such as divers, who vitally depend on these measurements.

Data use and requirements of the different companies span a wide range, from raw to processed and evaluated data in various formats, which should be provided through a variety of user interfaces. Forecasts for several hours were mentioned as most welcome. Forecasts of extreme events, e.g. storm surges, were also requested. In general, consistent and complete datasets (without gaps) are essential. In addition, accurate and reliable data are particularly needed when weather and oceanographic conditions, such as wave heights, impede continuation of work. Under these circumstances, data quality is a liability issue.

User-friendly interfaces with elaborated filter functions would be helpful. Time slots with certain weather conditions should easily be identified: for example, a 6-h time slot with wave heights below 2.5 m might be necessary for certain maintenance operations. Several interviewees expressed a considerable willingness for co-operation concerning oceanographic measurements within wind farms and data exchange.

From the second series of interviews, after the first workshop and in preparation for the second workshop, a considerable demand for high quality meteorological and oceanographic data and forecasts was confirmed. Data on current and wind fields are of special importance. The data should be provided 24/7 and with warranty. Some companies seriously considered exchanging their data for COSYNA and BSH data and allowing measurements within the wind farms.

3.5.2 Workshops

As we learned from the interviews that Environmental Protection, Health Management and Safety (EHS) play a pivotal role, the safety aspect became an integral part of the first workshop entitled “New Products for Offshore Wind Energy Support. More Safety and Efficiency through Detailed Condition Assessment and Predictions“. The program comprised the four sections “introduction”, “risk assessment”, “state description”, and “forecasts”, with each section covering presentation of (scientific) data products, related user statements and discussion. Ninety-two representatives from thirty-three different organisations participated: scientists, engineers, representatives of regulatory bodies, insurance companies and offshore wind energy enterprises discussed questions concerning measurements and forecasts of currents, wind and waves. The feedback on the workshop, gathered via feedback sheets (Fig. 4) was very positive. For example, most participants intended to use the data products presented at the workshops in future. It was suggested that the subsequent meetings should allow more time for discussion, resulting in ”real” workshops. Thus, the second workshop was designed to be product-oriented and only a limited

number of participants were invited to participate, ensuring a focus on discussions. The topical focus was on "Waves and Currents, Measurements and Forecasts".

Follow-up meetings with representatives of individual enterprises promised collaboration and possibilities for undertaking measurements within a wind farm. Unfortunately, before becoming reality, the wind energy firms halted these collaborative endeavours due to internal constraints.

Figure 4: Feedback sheet as an example

To summarize and rate the outcomes of the case study for COSYNA purposes, the most important finding was that COSYNA current and wave data, and in particular forecasts, would be the most welcome output. Safety of operations emerged as the overarching issue, meaning that reliability and completeness of data sets are indispensable – a requirement to be met by 24/7 services. With respect to usability, a good user interface is essential, although the different specifications for "good" cannot easily be served by a single approach. In the context of collaboration, many enterprises would welcome data exchange and even joint measurements in wind farms; these were generally considered possible. Specific endeavours, however, were blocked.

4 Impact evaluation (G)

Finally, the question is how to measure the impact of data products for users or for society. In order to evaluate whether and when the COSYNA oceanographic products as well as the stakeholder interaction process were more or less successful, we used direct and indirect indicators. In order to assess the interaction process, direct feedback from involved stakeholders was gathered via evaluation and feedback sheets, during interviews and workshops. The unforeseen high participation numbers in the workshops also indicate a successful interaction process.

Concerning the products, the demands derived from the initial surveys and interviews are generally met by COSYNA observational and modelled data, which have attained a high scientific standard and provide a high degree of accuracy. Concerning data availability, (potential) users from the offshore wind energy sector referred to continuity and reliability as essential. COSYNA provides free public access to its data and metadata. As bound into the research context, it cannot, however, guarantee that data are available twenty-four hours a day and seven days a week (24/7) without fail. The COSYNA Data Disclaimer states "no warranty is made, expressed or implied, regarding the accuracy or validity of the data, or regarding the suitability of the data for any particular application".

We know from the recently introduced COSYNA data portal user registration that users from industry and private enterprises (small and medium enterprises, SME) account only for a small portion of the data download (Fig. 5). As COSYNA is committed to an open data policy and does not collect any personal user data, any information on users is limited to download rates and information provided voluntarily on user categories. On average, about 19 GB of COSYNA data was downloaded per month from November 2014 until March 2016. Users from the category of science downloaded the highest proportion of data, followed by users from „administration". During some months, however, other user groups used COSYNA data for specific purposes. In December 2015 for example, private enterprises used data to validate their model. Whether the greater diversity of data users in December 2014 is a direct result of the workshops cannot be validated

Figure 5: COSYNA data download sorted by user categories (November 2014 until March 2016, data provided by G. Breitbach)

5 Discussion

~~Stakeholder interaction and transdisciplinary orientations were established COSYNA in order to close, or at least diminish, the gap between the increasing store of scientific data and metadata held in the data portal and the knowledge generated from, and decisions made on the basis of these data.~~

COSYNA represents scientific knowledge production in the field of coastal research, however according to the societal demands, e.g. reflected by the mission of the Helmholtz Association (www.helmholtz.de/en/), it must also meet knowledge requests for solving societal problems~~. In order to meet these challenges, COSYNA has undertaken a number of efforts towards transdisciplinary orientations. The core idea of transdisciplinarity is that different academic disciplines work jointly with practitioners to solve a real world problem (Häberli et al. 2001).~~ The type of topic addressed in COSYNA, i.e., coastal oceanographic research, is still new to transdisciplinary approaches. Thus, these studies are at the interface of transdisciplinary and coastal science research, and the COSYNA experiences can contribute new practical examples to both fields.

5.1 The usability of the products

COSYNA products can support different interest groups from the offshore sector in overcoming the challenges related to ensuring safe, efficient, and effective maintenance and operation of the windfarms. From the interviews and the workshops we found that, for the offshore wind energy sector, the most interesting questions in COSYNA context are: When do currents, waves and wind enable safe construction and maintenance operations? Can time slots with certain suitable weather and ocean conditions, i.e., wave height < 2.5 m, be forecast with sufficient accuracy? What are the sea and wave conditions along the shipping routes that will be regularly travelled to perform maintenance of realised or planned offshore wind farms? Can new technologies or observational concepts be deployed to protect wind turbines in case of sudden wind gusts?

The utility of products in large part is a question of the parameter, scale, accuracy and availability fit. In order to gather the respective information on (potential) user demands and to improve the products accordingly, a dialogue with interest groups is indispensable. From the various surveys and stakeholder interactions it is clear, that there is a considerable demand for meteorological and oceanographic data and forecasts, and COSYNA meets these requirements well. On the other hand, from the case study, it can be concluded that COSYNA products in their recent form do not completely fit the specific demands of the offshore wind sector. These findings are in agreement with the fact that COSYNA products are mainly downloaded from the data portal by users from science, and to a lesser extent by those from administration and rarely from business enterprises.

As COSYNA products are developed in a research context, they cannot meet the whole palette of users' wishes and demands. For example, they cannot be provided 24/7 and with warranty (as, for example, required by the offshore wind energy sector). Certainly, asymmetries exist in perspective, functions and agendas between scientists and business enterprises. The primary institutional commitment of scientists in traditional academia is to produce data that can be published and used for further research in the international scientific community while enterprises seek economically sound solutions (see also Wiek 2007).

The aim of a transdisciplinary approach is to open up traditional roles. User-oriented approaches became common, for example, in the field of climate research. The term "climate services" was used for the "generation, provision, and contextualization of information and knowledge derived from climate research for decision making at all levels of society" (Vaughan & Dessai, 2014). The concept of "products" and "services" is closely aligned, but there is a distinct difference: products are tangible (including digital) outputs, but a service produces an intangible benefit and satisfies an identified need. The roles in the science-society system should be considered in discussion of achievements and further desirable products and services: COSYNA develops data and data products and provides these products on a pre-operational level to be of use for multiple interest groups in science, industry, agencies, politics, environmental protection or the public. On the other hand,

the national monitoring authorities, such as the Federal Maritime and Hydrographic Agency (Bundesamt für Seeschifffahrt und Hydrographie, BSH) provide services working in an operational mode (24/7). COSYNA research activities are regarded as improving these services: The COSYNA pre-operational products can be taken over and utilised on an operational basis by the government agencies. Due to their "public status", neither COSYNA nor national monitoring authorities can offer concrete services for single enterprises in the offshore wind energy sector – or any other sector.

In accordance with the PDCA approach and the life cycle concept, the COSYNA products and their presentations are still undergoing improvement to attract more/further interest as well as to be more useful to (potential) users. For example, potential benefits can be assumed for resource management and sustainable development of the North Sea (according to MSFD).

5.2 The stakeholder process – push or pull strategy?

During the process studied here, a complete set of stakeholder interactions was applied, ranging from initial situational analysis through external evaluation, interviews and workshops with potential users, to meetings focused on data exchange and joint measurements. ~~Through this process, essential insights into demands and constraints concerning use and usability of COSYNA products were achieved and new research questions could be identified~~. Through the various interactions with different stakeholders the COSYNA products could be improved substantially. In addition, especially the interaction with the key stakeholders from the offshore energy sector led to essential insights into the demands and constraints concerning the use and usability of COSYNA products, and identified new research questions. Although the most challenging steps of co-operation or collaboration could not be achieved, the entire process of stakeholder interaction should be considered successful. ~~Thus, the entire process should be considered successful.~~

Different interaction intensities, such as "information", "consultation" and "co-operation" are possible between science and stakeholders (Brinkmann et al. 2015, Stauffacher et al. 2008, and Wiek 2007). One-way information from COSYNA to the stakeholders was provided via traditional media, such as brochures, flyers, website, attendance, booths at exhibitions, and presentations during workshops. The "consultation" encompasses~~indicates~~ one-way communication through questionnaires/surveys and was specifically addressed through~~fulfilled via~~ face-to-face interviews. Requirements for content and presentation of data products from the offshore side and the capabilities of the coastal science side were successfully worked out. The subsequent steps, "co-operation" and "collaboration", aim at exchange. In one case, decisions are made by the scientific partner and in the other, both partners collaborate equally. Co-operation or collaboration was the aim in follow-up meetings, concretely focusing on data exchange between COSYNA and offshore wind enterprises and on joint measuring activities within wind farms. Internal constraints of the offshore wind energy sector, however, prevented the interaction process from being truly collaborative. Revisiting the ideal assessment design of stakeholder interaction outlined above, we acknowledge that this ideal was not fully achieved for the COSYNA products. This is partly due to limited resources, but also to the fact that the products developed by a research institute cannot always be tailored to the specific demands of every individual user. It would have been useful to include a larger number of stakeholders in the later stages of the process, however this was not possible due to limited resources..

COSYNA experiences underpin the fact that long-term contacts are necessary to allow for intensification of stakeholder involvement and to enable co-operation or collaboration. Stakeholder interaction has so far applied more or less a "push" strategy, where the idea is to promote products by pushing them toward people. In order to adopt the idea of pull marketing (to establish a loyal following and draw consumers to the products), long-term contacts with stakeholders and potential users of science products need to be established.

5.3 Contribution to impact evaluation – "the product has to be attractive for the stakeholder, not only for the scientist"

COSYNA has articulated high expectations for scientific and societal impact. A major question still remains: How can the impact be assessed and what might be the possible criteria for success. ~~be?~~

Certainly, assessment of success strictly depends on what is considered successful as a scientific research undertaking. The criteria are, or seem to be, clear as long as only the closed system of traditional academia is taken into consideration: the main or single criterion is the number of peer-reviewed scientific articles in international English-speaking journals (see also Wiek 2007). In addition, the perception of what would constitute success of a research project does not only vary between scientists and stakeholders, but may also considerably differ between scientific peers (e.g. Allen et al. 2013). However, the scope of impact evaluation of research has become wider and the societal impact of research is an increasingly important factor (e.g. Godin & Doré 2007, Bornmann 2012, 2013). For transdisciplinary approaches the relationship between different collaborative methods, processes or concepts and the desired effects are less clear. Quality standards and evaluation criteria are a matter of research and discussion in the respective scientific communities (e.g. Bergmann et al. 2016). Experiences from projects are considered to contribute to their development and establishment. In COSYNA data download values are used to indicate application of data (for example for model validation, December 2015). The level of awareness (indicated by number of visits to the website) and the rate of data download can be considered preconditions for usage and societal impact of COSYNA data products. Whether or not the data downloaded are really used and helpful in supporting decision making cannot be assessed in this study. It is, however, the subject of on-going research and discussion.

In the context of COSYNA and partner and predecessor projects, a number of initiatives can be identified, where success and impact of oceanographic science research efforts can be demonstrated. All these successful initiatives have in common that stakeholders were integrated from the beginning of the project. Some examples include:

- Technological developments, such as new (automated) sensors or underwater node technologies have been handed over to other institutions for regular measurements (Marine Environmental Remote-controlled Measuring and Integrated Detection, MERMAID, Contaminants and Nutrients in Variable Sea Areas, CANVAS) and
- in order to improve their regular monitoring, national authorities have adopted observation strategies that are based on a scientifically improved understanding of the ecosystems (MERMAID, CANVAS; Knauth et al 1997, Nies et al. 1999).
- Calibration and maintenance procedures have been harmonised within the framework of a joint EU-project and are now used by a broad range of European institutions (JERICO, http://www.jerico-fp7.eu/, Petihakis et al. 2015).
- Cooperation exists with operational agencies to improve ocean wave forecasting services (e.g., Behrens 2015).
- With the model-based database coastDat many aspects of marine climate (such as storms, waves, surges, etc.) over many decades are reconstructed. The data set is used by more than eighty users with about 47 % of them located in industry, 15 % in government bodies and 38 % in other research institutes (www.coastdat.de/, Weisse et al. 2008, Weisse et al. 2015).
- Data management methods developed in COSYNA are a relevant part of a larger networked coherent data portal (MaNIDA, www.manida.org/)

From these examples taken from oceanographic research, the following criteria for success and (societal) impact of products or services can be derived: (1) Awareness of the necessity for system understanding is being increased. (2) Observational approaches, (3) technological developments, (4) modelling components or (5) data products have been taken over by national authorities, business enterprises or other research institutions.

Experiences from this study can contribute to identifying a structured process, how to integrate transdisciplinary approaches into coastal oceanographic research and how to further develop evaluation criteria for the multi-attributive assessments needed in such “non-linear” science endeavours.

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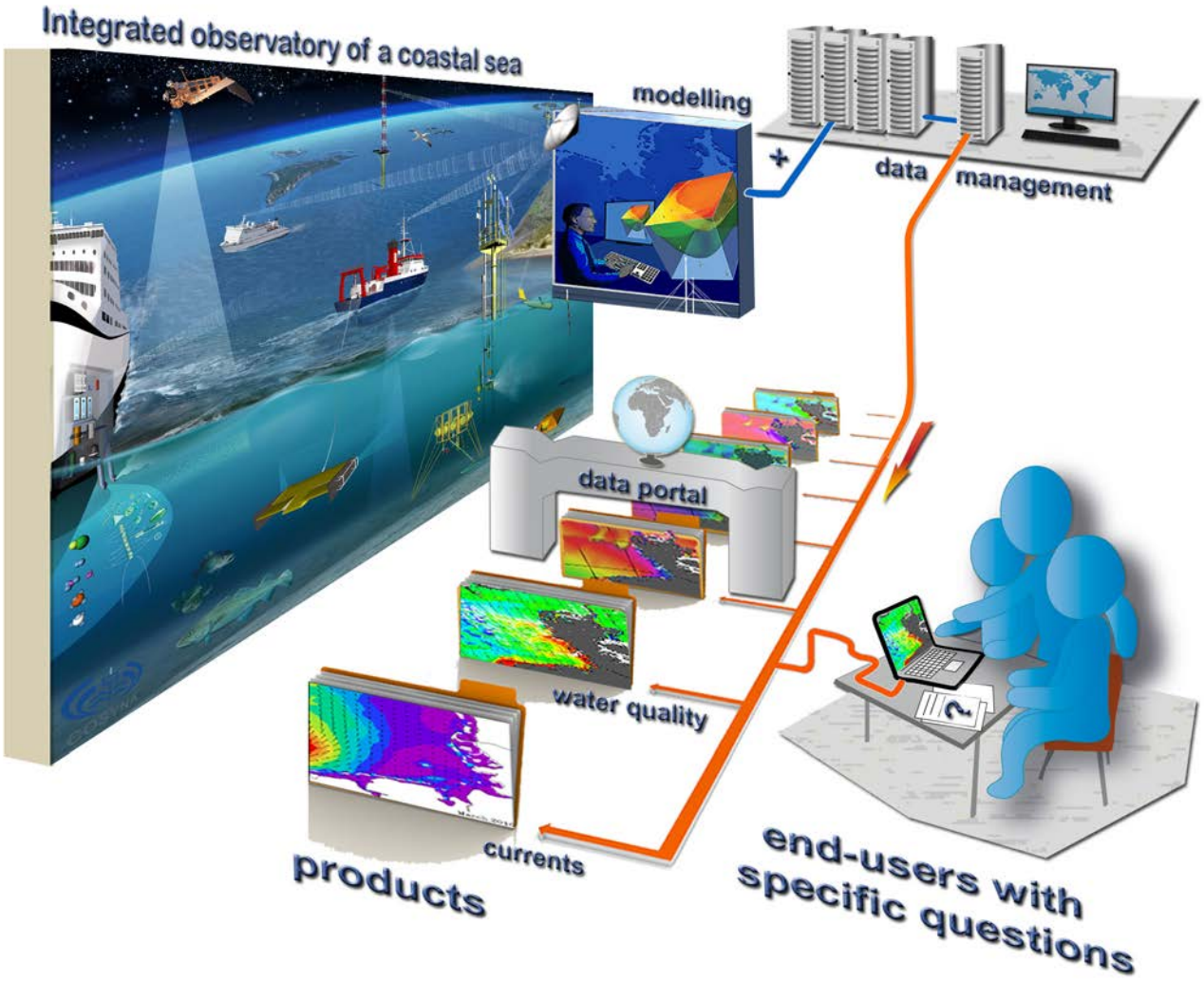
Table 1: Evaluator feedback on the product "Pre-operational Surface Current Fields" (values from 1 (bad/low) to 5 (good/high)).

	Administration	Private enterprises	Science1	Science2
Scientific- technical value	5	5	3	5
Information	4	4	4	4
Innovation	4	4	3	5
Cost/benefit	3	4	4	4
Operating reliability	4	4	3	-
User interface	3	3	4	-
Match user needs	4	3	4	-

5



5

Figure 1: The integrated COSYNA approach: Combination of observations and numerical modelling, data management and stakeholder interactions (COSYNA presentation, www.cosyna.de)

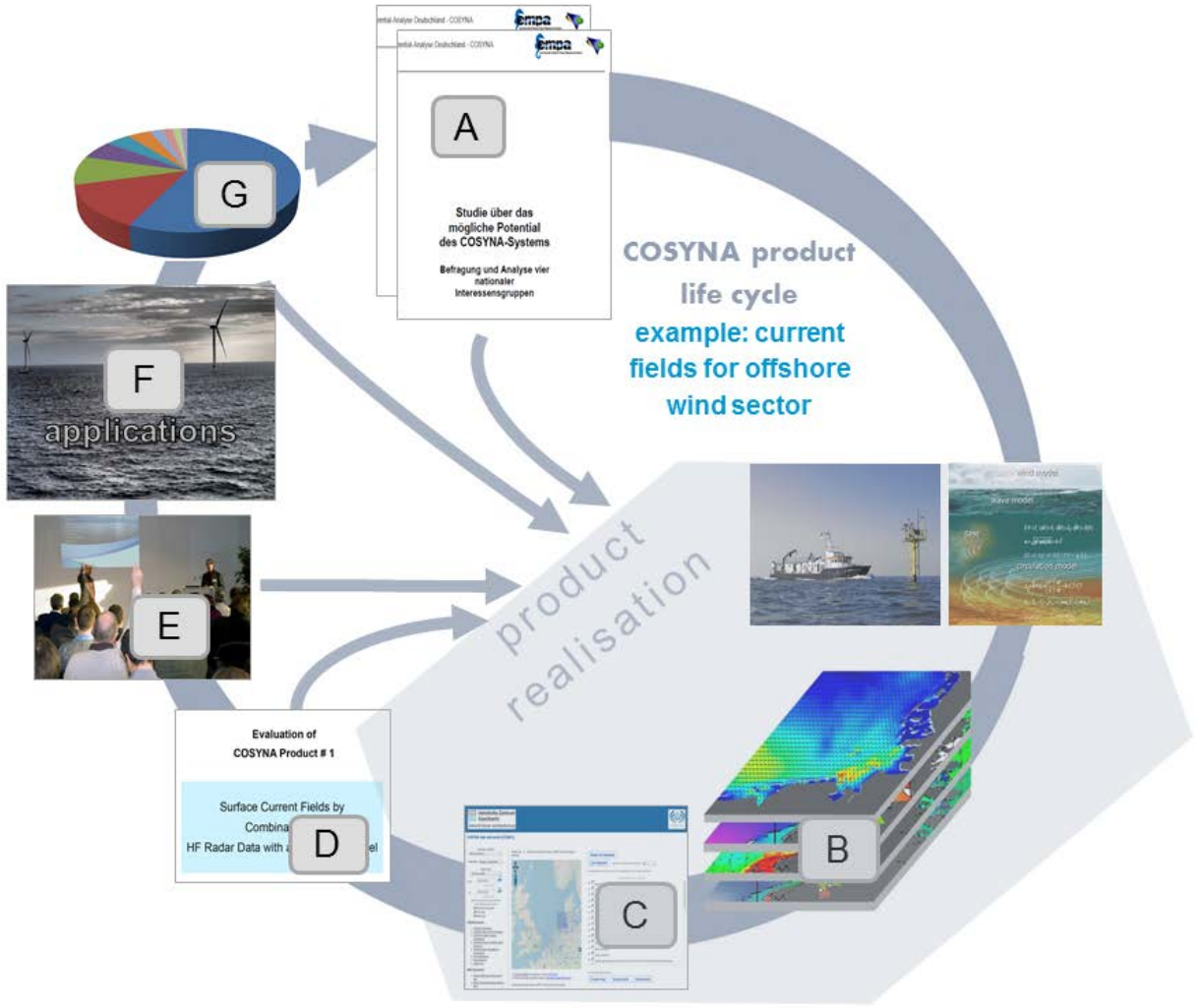


Figure 2: COSYNA product life cycle depicted for the COSYNA product "Surface Current Fields in the German Bight" as an example: (A) Initial surveys reveal COSYNA's potential relevance. (B) The mathematical-technological realisation provides optimised parameter fields for currents, waves, temperature, etc. (C) The data are freely accessible via the COSYNA data portal. (D) External evaluation of COSYNA products. (E) Interviews and workshops with stakeholders from the offshore wind sector. (F) Improved COSYNA products are available to users. (G) Evaluation of impact.

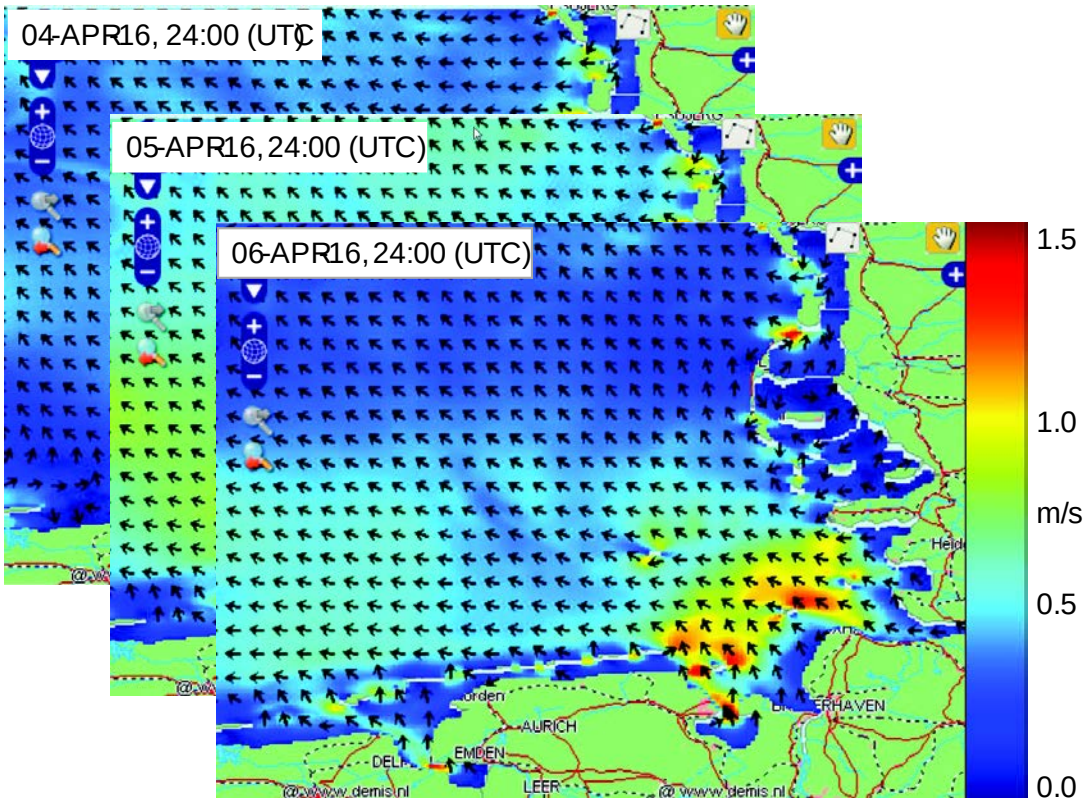
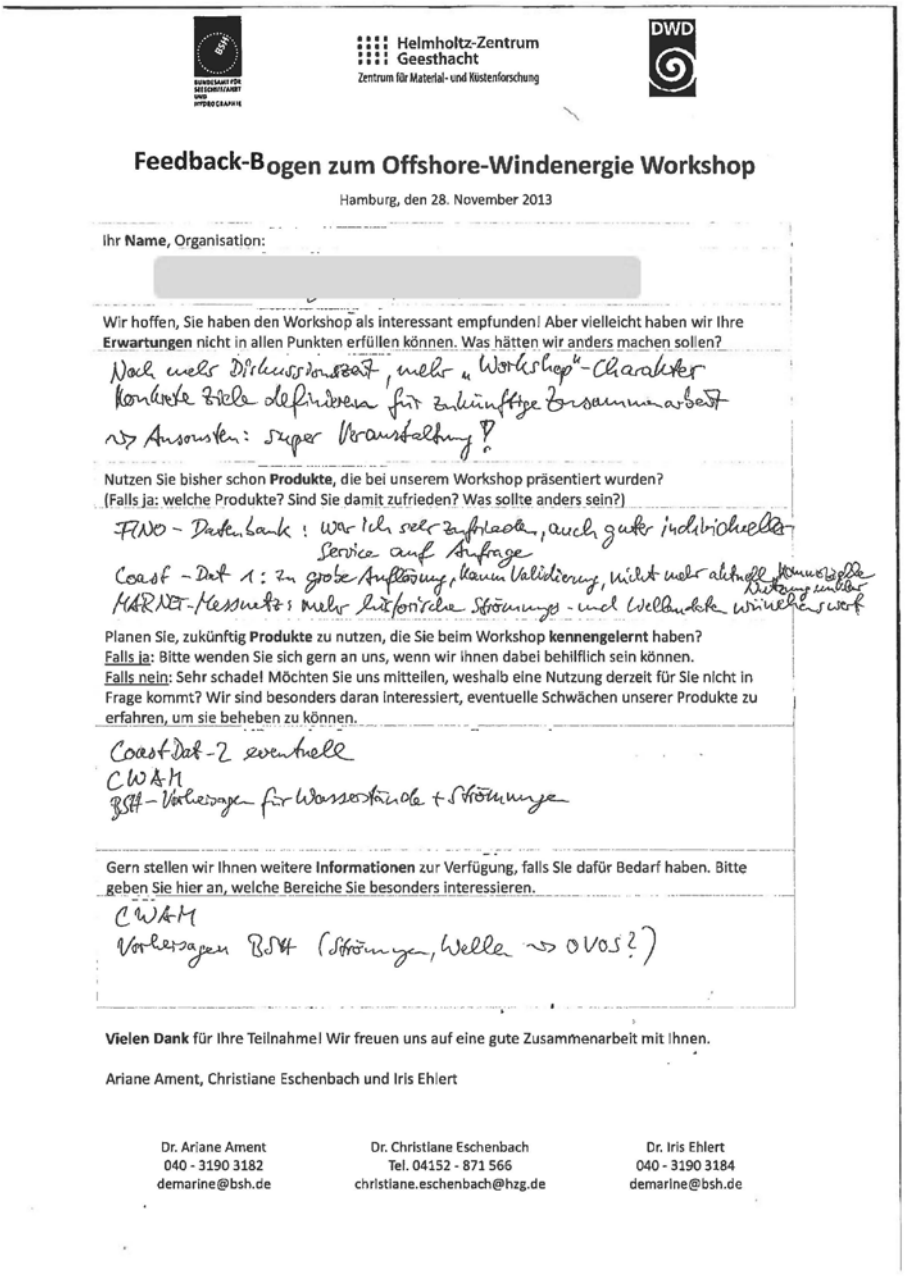


Figure 3: COSYNA product "Surface Current Fields in the German Bight" (snapshot 4-6 April, 2016, COSYNA data portal, based on the algorithm described in Stanev et al. 2015)



Helmholtz-Zentrum Geesthacht
Zentrum für Material- und Küstenforschung

DWD

Feedback-Bogen zum Offshore-Windenergie Workshop

Hamburg, den 28. November 2013

Ihr **Name**, Organisation:

Wir hoffen, Sie haben den Workshop als interessant empfunden! Aber vielleicht haben wir Ihre **Erwartungen** nicht in allen Punkten erfüllen können. Was hätten wir anders machen sollen?

Noch mehr Diskussionszeit, mehr „Workshop"-Charakter
Konkrete Ziele definieren für zukünftige Zusammenarbeit
⇝ Ansonsten: super Veranstaltung!

Nutzen Sie bisher schon **Produkte**, die bei unserem Workshop präsentiert wurden?
(Falls ja: welche Produkte? Sind Sie damit zufrieden? Was sollte anders sein?)

FINO-Datenbank: war ich sehr zufrieden, auch guter individueller Service auf Anfrage
Coast-Dat 1: zu grobe Auflösung, kaum Validierung, nicht mehr aktuell, kommerzielle Nutzung unklar
MARNET-Messnetz: mehr historische Strömungs- und Wellendaten wünschenswert

Planen Sie, zukünftig **Produkte** zu nutzen, die Sie beim Workshop **kennengelernt** haben?
Falls ja: Bitte wenden Sie sich gern an uns, wenn wir Ihnen dabei behilflich sein können.
Falls nein: Sehr schade! Möchten Sie uns mitteilen, weshalb eine Nutzung derzeit für Sie nicht in Frage kommt? Wir sind besonders daran interessiert, eventuelle Schwächen unserer Produkte zu erfahren, um sie beheben zu können.

Coast Dat-2 eventuell
CWAM
BSH-Vorhersagen für Wasserstände + Strömungen

Gern stellen wir Ihnen weitere **Informationen** zur Verfügung, falls Sie dafür Bedarf haben. Bitte geben Sie hier an, welche Bereiche Sie besonders interessieren.

CWAM
Vorhersagen BSH (Strömungen, Wellen ⇝ OVOS?)

Vielen Dank für Ihre Teilnahme! Wir freuen uns auf eine gute Zusammenarbeit mit Ihnen.

Ariane Ament, Christiane Eschenbach und Iris Ehlert

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Figure 4: Feedback sheet as an example

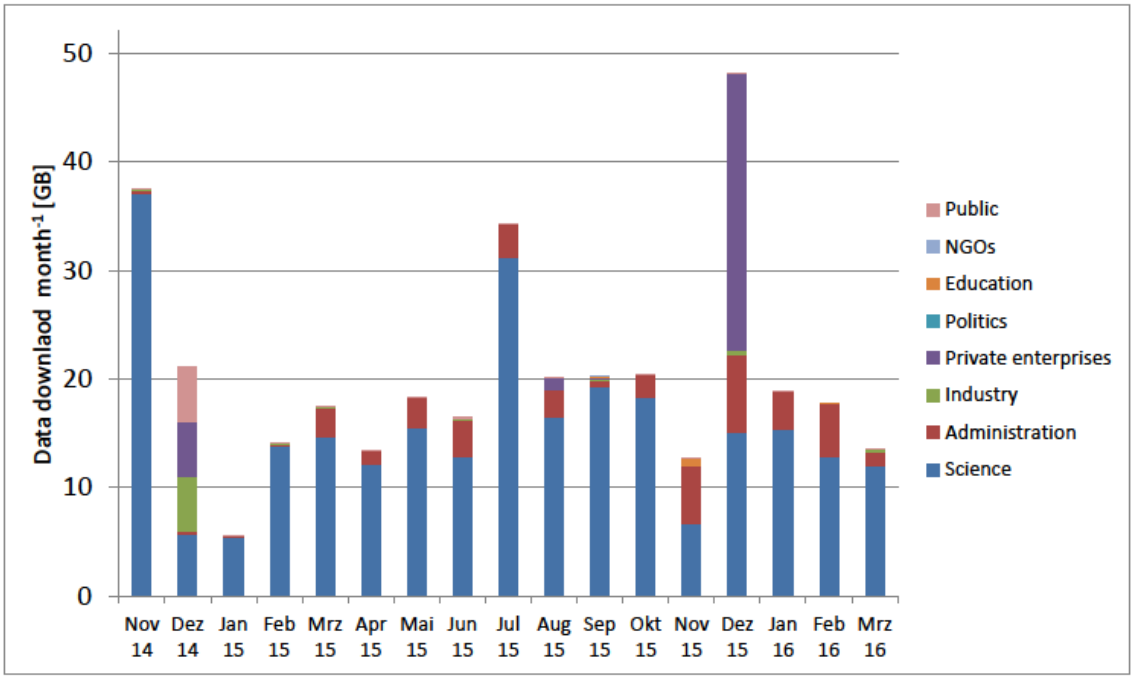

Figure 5: COSYNA data download sorted by user categories (November 2014 until March 2016, data provided by G. Breitbach)