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Progress in Marine Conservation in Europe 2015

Federal Agency for Nature Conservation

BfN-Skripten 451

2016

4th International Conference on

Progress in Marine Conservation in Europe 2015

Proceedings of the Conference
Stralsund, Germany, 14 - 18 September 2015

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Federal Agency for Nature Conservation

Cover picture: Conference poster (© M. Putze, C. Pfützke, S. Gust, F. Graner, S. Bär)

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Further information on the actual status and background of marine protected areas under the Habitats Directive and the Birds Directive of the EU in the German Exclusive Economic Zone (EEZ) can be found on the BfN web page www.bfn.de/meeresnaturschutz.html.

This publication is included in the literature database “DNL-online” (www.dnl-online.de)

BfN-Skripten are not available in book trade. A pdf version can be downloaded from the internet at: http://www.bfn.de/0502_skripten.html.

Publisher: Bundesamt für Naturschutz (BfN)
Federal Agency for Nature Conservation
Konstantinstrasse 110
53179 Bonn, Germany
URL: http://www.bfn.de

Printed by the printing office of the Federal Ministry for Environment, Nature Conservation, Building and Nuclear Safety

Printed on 100% recycled paper.

ISBN 978-3-89624-188-7

Bonn, Germany 2016

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Acknowledgements

The 4th International Conference on Progress in Marine Conservation in Europe 2015 and the corresponding proceedings are the outcome of the joint efforts and intensive work of various speakers and others. Many chapters benefited from the valuable comments of BfN colleagues in the review process, whom we would like to thank for all their efforts.

The organisers of the conference would like to sincerely acknowledge the support of all involved both up front and behind the scenes, including of course any we may have forgotten to mention specifically.

Director Dr. Harald Benke and his team of the German Oceanographic Museum (DMM) and OZEANEUM GmbH Stralsund provided again the very attractive environment and the infrastructure for the conference.

Stralsunder Werkstätten served excellent catering during the first two conference evenings with a great service team. We also would like to thank Pausch Gastronomie with their courteous team who were responsible for the coffee breaks during the conference week.

Finally, we are grateful for the support of the German Federal Agency for Nature Conservation (BfN) and especially the colleagues in the Marine Nature Conservation Division and the team of EEZ-Project 8 ‘Communication’ for their help in preparation and the staging of the conference as well as in the article review process.

Special thanks go to Andreas Essenberger, Simone Eisenbarth, Arne Peters and Katharina Maschner, as well as to Ulrike Ruffani, Sandra Käning and Ute Herrmann, who helped to make the conference a success.

Preface / Introduction

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The 4th International Conference on Progress in Marine Conservation in Europe 2015 was held from 14-18 September 2015 and hosted by the German Federal Agency for Nature Conservation (BfN) in cooperation with the German Oceanographic Museum (DMM). The conference took place in Stralsund, Germany, at the OZEANEUM, which is an outstanding complex of the German Oceanographic Museum with modern aquaria and exceptional exhibitions, located directly at the harbour front, thus constituting the perfect environment for an international marine conference.

The conference offers a regular international forum for discussions on important current marine conservation issues in Europe, with occasional contributions from beyond. The 4th International Conference, once again financed by the German Federal Agency for Nature Conservation (BfN), was a continuation of the three international conferences held, likewise in Stralsund, in 2012, 2009 and 2006. The conferences each invite a wide range of participants and organisations such as international conventions and agreements, policy makers, conservation managers, scientists, inter-governmental organisations and NGOs. The 2015 conference attracted some 180 experts from 19 countries.

These international experts covered new and emerging issues in European marine nature conservation, discussed recent research findings and identified promising approaches for making progress in marine nature conservation. The special programme structure – no parallel talks or working groups, a single conference room for lectures on a variety of topics and most of all ample time for questions and comments between talks, an afternoon for organised excursions and also a film evening – enabled the participants to gain a deep insight into various thematic areas and to engage in intensive discussion. These are important criteria for many experts to take part in this conference series.

The excellent presentations and lively discussions by very engaged participants during the four days of the 2015 conference focused on a range of topics:

- The current status of implementation and management of Marine Protected Areas (MPA) and Ecologically and Biologically Significant Areas (EBSA) networks, primarily in European waters;
- Anthropogenic impacts on the marine environment and their management with a strong focus on fisheries (e.g. management measures and alternative fishing gear) and on the effects of offshore windfarms and shipping;
- Current protection status and new research results on threatened or declining marine species and habitats, including seabirds, harbour porpoises and other cetaceans, reefs and deep sea canyons, and the European Oyster;
- Marine nature conservation in marine policy: the European Marine Strategy Framework Directive (MSFD); the economic value of ecosystem services;
- New research and marine monitoring methods such as sediment and benthic mapping, digital aerial surveys, and fish and harbour porpoise monitoring.

The detailed programme of the 2015 Conference can be found on page 254 ff, the table of contents on pages 3-6.

For the first time, we also integrated a film evening during the conference. After a brief introduction, seven presentations of varying lengths were shown. These covered a wide range of projects, habitats and species from coastal regions to the deep sea, and from the Baltic to the Black Sea. The films and project presentations were: BfN: 'Protected Areas – safeguarding marine biodiversity'; The UNDINE Project – a Danish-German Interreg Project; Whale and Dolphin Conservation: 'The last memory'; EU Life Projects – some examples; Agence des Aires marines protégées: 'Iroise Marine Park' and 'Mission Canyon'; CoCoNet: 'From hotspots to a network of MPAs in the Black Sea'.

Even after a twelve-hour conference day, some 50 participants took the opportunity to experience this important medium in environmental education and information. Films help to raise sensitivity and awareness for marine nature conservation issues, to show what is hidden under the oceans´ surface, and to increase knowledge about species, habitats and current research issues. Films, particularly on websites and in nature information centres, can provide easy access to such issues, especially for younger generations. We saw some interesting and inspiring examples.

Regarding the proceedings in this publication, the chapters that follow reflect the presentations of the conference week. Speakers were asked to submit an article or extended abstract of their talk. Only a small number of speakers were unable to contribute to our written proceedings because they already had a publication on the way in another journal. In such instances we have incorporated a short abstract, in some cases including a link to the publication.

We would like to thank all speakers for their efforts enabling the editors to compile these proceedings. The articles underwent only a brief and superficial review process by experts in the BfN Marine Nature Conservation Division, that were followed by minor adjustments made by the authors or with their consent.

The editors would like to clarify that the contributions do not necessarily express the opinion of the German Federal Agency for Nature Conservation (BfN).

We wish you informative reading and hope to welcome you at the next International Conference on Progress in Marine Conservation in 2018.

Prof. Dr. Henning von Nordheim
Katrin Wollny-Goerke

(Editors)

Welcome Speech: Current developments in marine conservation

State Secretary Jochen Flasbarth
Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety

I am delighted to be here today and welcome so many marine conservationists from Germany and abroad to the 4th International Conference: Progress in Marine Conservation in Europe 2015 here in Stralsund. The oceanographic museum with its many exhibits showcasing marine life is the ideal setting for your discussions on a wide range of topics related to marine biodiversity in Europe. I would like to thank the Director of the museum, Dr Harald Benke, for hosting us once again this year.

It is always a special treat to visit Stralsund with its world cultural heritage, to experience the cultural heritage of the Hanse first hand, and to explore one of the nature conservation areas nearby, such as Jasmund National Park. I hope that your discussions will leave enough time for you to enjoy the cultural and natural gems of this region.

In 2006 the Federal Agency for Nature Conservation organised the first „Marine Nature Conservation in Europe“ conference. I remember this meeting very well, as I had the pleasure of welcoming the participants in my then role as Director-General for nature conservation. Marine conservation is playing a much more prominent role today than it did at the time, and it has become firmly established on the political agenda. It is now on more of an equal footing with terrestrial nature conservation in terms of the political attention it receives. The fact that the Federal Environment Ministry has just established a division specifically dedicated to marine conservation and that the Federal Agency for Nature Conservation will soon have a Directorate-General on marine conservation echoes this development. In my opinion, the „Marine Nature Conservation in Europe“ conferences have played a key role in enhancing the visibility of marine conservation and awareness of its importance.

It is good that these events have become a regular item in our calendars, this being the fourth time we are meeting in Stralsund at the invitation of the Federal Agency for Nature Conservation.

Whilst this is all very encouraging, there is no reason for us to sit back and relax. The latest report of the European Environment Agency (EEA) on the state of nature in the EU has shown that only a small number of marine species enjoy a good conservation status or good environmental status. Biological diversity of marine and coastal waters is declining, jeopardising vital ecosystem services. The reasons given in the report include overfishing, damage to the seabed, pollution caused by nutrients and harmful substances (and also by marine litter and underwater noise), invasive alien species and acidification.

This shows us that there is a strong need for action if we want to conserve marine biodiversity in the long term. This is why, for instance, we want to swiftly adopt regulations for fishing in Germany‘s Natura 2000 sites in the Exclusive Economic Zone (EEZ) in the North and Baltic

Sea. In this context, it is particularly important for us to lay down restrictions on the use of bottom trawl nets and set gillnets in these protected areas and ensure effective enforcement. The Federal Environment Ministry and the Federal Agriculture Ministry have established a joint steering group to address this and agreed on an ambitious schedule.

The good news is that we are not starting from scratch: We have already reached an agreement with our colleagues from the agriculture ministry on the rules to be applied in the North Sea. The next steps will be formulating a joint declaration as a basis for consultations with neighbouring countries and the Commission and developing provisions for the protected areas in the Baltic Sea.

To effectively prevent by-catch of harbour porpoises and sea birds, set gillnets will be completely banned in certain areas whilst in other areas their use will be frozen at the current - very low - level. We also plan to set up cameras to monitor catches.

To protect reefs and sandbanks from damage caused by bottom trawls, fishers will not be allowed to use harmful fishing gear in vulnerable areas.

However, we have not yet reached a final agreement with the Federal Agriculture Ministry on the monitoring and control measures to be applied. We know that even a single incident of illegal bottom trawling has the potential to destroy years of protection efforts. This is why strict monitoring is so important.

Once we have agreed on a common approach at national level, we need to coordinate our proposal with our neighbours in the EU, whose fishing interests might be affected. This is a requirement under EU law. We expect strong resistance from our neighbouring countries, mainly for economic reasons. However, we will do everything we can to ensure that sound rules are adopted to enhance nature conservation.

In the Baltic Sea, harbour porpoises are the most endangered species, and fishing with set gillnets is still widely practiced. This makes it particularly difficult to find a solution that serves the interests of both nature and fishers. Aside from „classic“ protective measures, I believe developing and promoting alternative, nature-friendly fishing techniques could be a very important approach and would also be helpful in achieving MSC certification for herring fisheries, which the fishing sector is striving to obtain. We want to cooperate very closely with the fishing community to make use of their practical experience.

We will also work on a noise protection scheme for the Baltic Sea over the coming months in order to protect harbour porpoises from excessive noise emissions from the construction of wind farms. In the North Sea, this kind of noise protection scheme has proven very effective.

In addition to this the BMUB is pressing ahead with the adoption of ordinances for the Natura 2000 sites in the EEZ that were reported as early as 2004. In early February this year we started the coordination process on the respective draft ordinances within the German Government. During this process, it was established that an amendment to the Federal Nature Conservation Act would be required to extend our authorisation to issue ordinances to be able to go beyond the immediate implementation of EU law. Implementing the provisions of the Marine Strategy Framework Directive MSFD alone will require us to protect additional assets and take more protective measures. So as to avoid delaying the adoption of the ordinances on protected areas in the EEZ for months, we decided to start by issuing those ordinances for which we are authorised under the currently applicable legal provisions. Our goal is to adopt the ordinances by the end of 2015. This is also necessary to avert the infringement procedure launched by the EU Commission for the areas falling under the Federation‘s jurisdiction. As a next step, we will implement the requirements laid down in these ordinances by developing management plans for each area.

To meet our international obligations, especially those under the regional marine protection conventions for the North and Baltic Seas (OSPAR and HELCOM), and to make our contribution to the establishment of a coherent and representative network of marine protected areas as called for in the MSFD, we want to use the further MSFD implementation process to go beyond the assets protected under the Natura 2000 Directives and establish a protection regime comparable to that of the Habitats Directive for additional endangered species.

We are currently preparing the programme of measures under the MSFD to achieve a good environmental status in the German parts of the North and Baltic Seas by 2020, as the Commission must be notified soon. Many of you are probably doing the same and are well aware that the negotiations with the various stakeholders are not always easy. Broad public participation and intensive dialogues, as provided for in the MSFD, are very helpful and important to ensure that we end up with a programme of measures that is acceptable for all and can be put into practice. Having said this, it is also clear that the discussion partners, especially on the user side, will have to make significant concessions, and I hope they will use their good judgement.

Naturally we will be continuing our international activities!

Despite their vital role our seas still remain the least protected areas on Earth. As I am sure you all remember, in 2002 the sustainability summit in Johannesburg adopted the goal of establishing a global network of marine protected areas, including on the high seas, by 2012. This goal was included in the Strategic Plan for Biodiversity 2011-2020, which provides for the designation of protected areas on at least 10 % of the world‘s marine area by 2020. We should do everything we can to make sure we at least come close to reaching this goal. Right now, we still have a very long way to go.

This is why we are supporting partner countries in achieving this goal through our International Climate Initiative (ICI). Over the past years including 2014, the BMUB funded 27 projects for the protection and sustainable use of ecosystems in coastal and marine areas with a total of over 100 million EUR. Another eight projects with a volume of 30 million EUR are currently undergoing the review and approval process.

We will also continue to actively advance the identification and description of ecologically or biologically significant marine areas under the Convention on Biological Diversity, CBD. We should all be proud of this successful process which is receiving widespread international attention. So far, more than 200 such ecologically and biologically significant areas have been recognised and included in the CBD Depositary. This means that for 70 % of the oceans we have identified those areas where protection is desirable. I hope that we will be able to add more areas at the next meeting of the Conference of the Parties to the CBD in Mexico in December 2016. After all, there is a strong interest, regionally and internationally, to identify EBSAs in other marine regions. The CBD has already planned further workshops.

As you probably already know, the EBSA database will be made available to the UN General Assembly, UN organisations and regional organisations.

We consider this the right step, as we expect this sharing to give positive impetus to the establishment of an implementing agreement under the United Nations Convention on the Law of the Sea (UNCLOS). While the 1982 Convention does include some general provisions on the protection of the marine environment, there are still considerable gaps in its implementation. For example, it is not possible to designate marine protected areas on the high seas that are accepted by all countries. To close this implementation gap, Germany and the EU have been pushing, for many years, for negotiations on a binding implementing agreement to ensure the protection and sustainable use of biodiversity in areas beyond national jurisdiction.

A breakthrough was finally achieved this year: The United Nations General Assembly (UNGA) has adopted a resolution on the development of a legally-binding instrument under the United Nations Convention on the Law of the Sea on the conservation and sustainable use of marine biological diversity of areas beyond national jurisdiction. A preparatory committee will draft elements of the text and report to the General Assembly on its progress by the end of 2017. By August 2018 the UNGA will decide whether and when to convene an intergovernmental conference to negotiate the agreement. We see this as this an important step forward for global marine conservation.

The 2030 Agenda for Sustainable Development is another key milestone for marine conservation worldwide. With this global agenda, we now, for the first time, have a roadmap for the development of all countries that encompasses environmental protection, social well-being and economic development in an overarching, comprehensive approach, generating the necessary pressure for a change of course towards sustainable development worldwide.

The catalogue of 17 sustainable development goals and 169 specific targets has been approved. In our opinion, it is an excellent set of goals, in particular for marine conservation. These goals include reducing marine litter by 2025; ensuring the protection of marine ecosystems by 2020; minimising marine acidification, stopping overfishing by 2020 and expanding marine protected areas. If we succeed in putting these goals into practice, this will be a huge achievement for marine conservation.

If I may, I would like to briefly talk about our regional cooperation mechanisms for the protection of the Northeast Atlantic and the Baltic Sea, OSPAR and HELCOM. Some may think that the regional scope of these two organisations is too narrow to be truly effective in our increasingly globalised world. I am convinced, however, that they continue to be the focal points for marine conservation in Europe, despite or maybe precisely because of the fact that we now have a European Marine Strategy Framework Directive. Their work is followed with great interest internationally. Thanks to these conventions, the implementation of the MSFD does not have to start from scratch, but can draw on decades of experience in marine conservation. These regional instruments also provide platforms for the coherent implementation of the directive by countries in the same marine region. It is only by making use of the conventions that we can effectively comply with the directive and achieve the good environmental status of the marine environment by 2020, as called for in the MSFD.

These regional cooperation mechanisms are increasingly becoming key pillars of our work. To give you just one example: OSPAR‘s commitment has been instrumental in the designation of 10 marine protected areas to date which form the world‘s first network of marine protected areas on the high seas, beyond national jurisdiction.

The work of OSPAR for the designation of a protected area in the Arctic is still in its early stages, but is currently receiving a lot of attention from the media. Germany is campaigning for further progress in the designation of this protected area next year. Let us wish those colleagues involved in this important process - and some of them are in the audience today - every success in the negotiations!

Another focus of ours is addressing the drastic increase of marine litter, in particular plastic waste. The situation is deteriorating and the public has become aware of the problem as well, though I am certain the full scale of this problem has not yet been understood. I am thinking in particular of the threat posed to our marine ecosystems by microplastics and larger plastic waste, e.g. from packaging or fishing nets. You will certainly remember that this was even a priority item on the agenda of the G7 meeting in Germany this June.

To combat the current trend, we need more research projects to enhance our data basis, but above all we need the willingness of all - governments and civil society - to exchange views, to learn from each other, share best practices and to identify and take effective action. I am therefore very pleased that OSPAR adopted a Regional Action Plan on marine litter in June 2014 that includes a range of regionally coordinated and voluntary national measures to combat marine litter (both from land- and sea-based sources) and is now in the implementation phase. The Baltic Sea cooperation is making equally good progress. HELCOM agreed on a Regional Action Plan on marine litter in June 2015. Germany is determined to continue its active support of these two regional processes.

The Baltic Sea with its particularly sensitive ecosystem is also suffering from very high concentrations of nutrients and organic material from the atmosphere, rivers and point sources. I strongly support HELCOM‘s continuous efforts for improving water quality.

Ladies and Gentlemen, as you can see, the list of topics under the heading of marine conservation is almost endless, the issue is being discussed in many national, regional and international fora and the need for action is great. Please use this week here in Stralsund for open and bold discussions on the marine conservation challenges we are facing and give the political players the information and recommendations we need to take the right decisions for the sake of marine biodiversity.

Opening Speech and Introduction: Progress in marine conservation in Europe – a current overview

Prof. Dr. Beate Jessel,
President of the German Federal Agency for Nature Conservation (BfN)

Dear State Secretary Mr. Flasbarth, dear Ladies and Gentlemen,

marine conservationists, marine scientists and marine managers from European Seas and beyond, welcome again to Stralsund on behalf of the Federal Agency for Nature Conservation and to our fourth Conference „Progress in Marine Conservation in Europe 2015".

In line of three successful conferences, this year about 200 participants from 21 different countries meet within the next four days. Here in the wonderful OZEANEUM, we come together again to share experiences in marine conservation, to discuss research results and to get impulses for our future work.

I will seize the opportunity to take a look on some important marine conservation milestones and developments of the last years with a focus on the international perspective.

First let us remember three years ago, at the last PMCE Conference, we discussed some necessary steps against the loss of marine biodiversity and ecosystem degradation in our seas - milestones, well known as "2012-Targets" like you see it on the screen. We must state that at the end of 2012, not all of these targets had been achieved. But since then, a lot of work has been done and certain milestones contributed strongly to progress in marine conservation issues:

Regarding the network of MPAs, new milestones were the Conferences of Parties of the CBD 2012 in India and 2014 in Korea. In this context, a lot of regional workshops within the ongoing process of identification of ecologically or biologically significant areas in the oceans, also in areas beyond national jurisdiction, were held all around the world. GOBI, the global oceans biodiversity initiative, supported by BfN, with its international scientific network, contributed intensively to this process.

Additionally, in the OSPAR and HELCOM maritime area a lot of MPAs have been designated; but I will come to that later on again.

Regarding the Marine Strategy Framework Directive, the international cooperation within OSPAR and HELCOM and with the EU Commission has been strengthened, especially in defining and establishing criteria for the assessment of the good environmental status and the environmental targets. For Germany, BfN and its partner institutes are very engaged in this process and we can say - we are on a good way now!

One of the most important milestones might be the new EU Common Fisheries Policy of 2013 / beginning of 2014. After long and difficult consultations, the reform encompasses promising approaches for fishery management and sustainable fishery. We really hope that overfishing, by-catch and negative impacts due to gillnet and bottom trawl fishery in European waters will be more and more reduced from now on.

Now, let us take a closer look on the current situation in marine conservation and on the subjects of this conference.

Assessing and designating 'EBSAs' – ecologically or biologically significant areas – across the various marine regions is a complex process involving regional workshops all over the world. Our next speaker will talk about it in his presentation. About 200 EBSAs have been identified so far, the last years were quite successful. Turning EBSAs into globally respected protected areas, especially in marine regions outside of national jurisdiction, needs good international cooperation. State Secretary Flasbarth referred to this aspect in his speech.

According to the Convention on Biological Diversity, the representative worldwide network of Marine Protected Areas should encompass at least 10 % of the world´s oceans by 2020. But until now, only 2.8 % of the oceans are protected and many MPAs are located in nearshore or coastal waters. Completing the network, especially in the High Seas, and achieving coherence and efficiency of MPAs are still great challenges for the future.

Regarding the MPA situation in European marine regions, e.g. the North East Atlantic and the Mediterranean, we have noticed important progress within the last three years, including the High Seas. Several new MPAs have been designated in Portuguese, Spanish, French and UK Waters. Therefore, we are glad to welcome colleagues from the UK, France and Portugal – they will give us a closer insight in these processes later on today. In the OSPAR regions, we are getting closer to reach the 10 %-target for 2020: by the end of 2014, 5.8 % of the OSPAR maritime area was protected. However, there is still a lot of work to do to achieve the ecological coherence and a good management of MPAs. In the HELCOM maritime Area, the MPA process is even more advanced than in the OSPAR. The CBD target was already met by the Baltic Sea Protected Area network in the year 2010. This year, 11.9 % of the maritime area is now covered by MPAs. Within the relevant working groups and in the different countries bordering the Baltic Sea, further work will have to be done to solve the existing problems of representativity and connectivity. All in all we can state, that in Europe and also globally, significant progress is being made. But to reach the targets, we still have to increase our efforts, especially regarding the management of MPAs.

Regarding fisheries management, this may be the greatest future challenge in marine conservation. State Secretary Falsbarth still put a focus on our current activities for fishery management – let me make some additional remarks about the need for an effective management: Fishery still is the human activity with the most severe impacts on marine ecosystems. Negative effects of fisheries on stocks of commercial fish species and on the environment like destruction of benthic habitats or by-catch of threatened species critically endanger natural marine biodiversity. Significant reductions of the present intensive fishing pressure are urgently needed. The reform of the European Common Fisheries Policy is a great chance to move forward to sustainable fisheries in Europe. Fishery management, especially in marine protected areas, is an important instrument to protect marine biodiversity as well as commercially used fish stocks. We are glad that we will get some interesting examples at this Conference from our neighbouring countries. I am sure that we can expect many impulses and encouragement from these presentations.

However, as State Secretary Flasbarth pointed out already, also in Germany, we are at least on a good way to effective fishery management measures in our German MPAs. And we really hope that in some years, we will recognize spill-over-effects for different fish species from the MPAs to the adjacent areas as it is being observed in other regions of Europe and the world.

As you have seen, there is a focus in our conference programme on fishery. We appreciate that we have so many presentations on fishery topics. Some of them are dealing with alternative or more selective fishing gear. As other countries since many years, Germany is very engaged in developing more selective techniques and testing ecosystem-friendly alternatives to gillnets, helping to stop endangered species ending up as by-catch. State Secretary Flasbarth mentioned it before: further research and field tests are needed. But the projects hopefully lead to better cooperation between the fishing industry, fisheries research and nature conservation.

Furthermore, monitoring fish and controlling fisheries is an important goal within marine nature conservation, regarding different aspects. New technologies are necessary. Some of them seem to be very encouraging. The basis for conservation and protection measures in marine nature conservation is a good marine monitoring programme to recognize positive and negative developments in marine biodiversity at an early stage. We are obliged to monitor various marine biodiversity parameters under numerous European Directives as well as international Conventions and Agreements, for instance the Habitats and Bird Directives, the MSFD as well as OSPAR- and Helsinki-Conventions. The coordination of the marine monitoring in the German EEZ is an important element within the work of our agency. Current monitoring programmes encompass the monitoring of harbour porpoises by aerial surveys and acoustic monitoring, the aerial and ship surveys of seabirds and the monitoring of benthic habitats.

For the understanding of ecosystem functions and the effects of anthropogenic impacts, we realized that we still need more information about benthic habitats in the marine environment. Within the last years, we made every effort concerning the mapping of benthic biotopes and habitats monitoring in the North and Baltic Seas – one of the most complex benthic monitoring programmes in Europe. The overall goal is to produce high-resolution biotope maps, allowing a better understanding of the direct linkage between the substrate and its related macrobenthic communities. The involved institutes will present the techniques and some new results on Thursday.

Marine Monitoring is still a major challenge because of wind, weather, seastate, location of sites far away in the ocean, water depth, techniques and costs. The need for actual and reliable data is even growing and consequently, the development of new monitoring techniques, equipment and hardware has evolved rapidly. Within the frame of this conference, it is therefore just adequate to give the possibility to present such new techniques. There will be some very interesting talks presenting innovative and modern technology as well as methods of modelling or data management.

Regarding a more theoretical background, we need to take the tasks of the Marine Strategy Framework Directive into account. The MSFD is finally - after many good but sectoral approaches – the first integrative framework for the European Seas. The EU-Member States are given a unique, challenging and complex task to perform: to reach a good environmental status of the European Seas by 2020. The roadmap of the MSFD is ambitious, State Secretary Flasbarth previously named some aspects like the programme of measures.

The initial assessment according to the MSFD has revealed that our parts of the North and Baltic Seas despite all efforts in the past do not yet show a good environmental status. We are interested to hear the NGO perspective but also experiences from other European countries on this topic. Regarding the implementation of the MSFD, the assessment of ecosystem services, the maintenance costs of marine ecosystems get more and more important. These topics are seldom considered, but it is of great need to get more experience. Therefore, I am delighted that we will hear two presentations with examples from France.

When talking about protection of endangered marine species and habitats, we have to take a closer look on the criteria for categorizing threats and protection levels. The Red lists of marine species and habitats are an important instrument showing threat categories and health status of a great number of species and biotopes. The HELCOM Red lists of Baltic Sea species and of Baltic Sea underwater biotopes, habitats and biotope complexes, both published in 2013, are still an important tool for protection measures for the Baltic Sea environment. HELCOM is now working on recommendations for the conservation of these species.

In 2014, BfN published the first Red List of marine organisms in the German North and Baltic Seas. Disillusioning conclusion: of all analyzed species comprising fish, (benthic) invertebrates and large algae in German coastal and offshore waters, 30 % are indicated as threatened in their population. This is a similar amount as we have for our terrestrial species. But what is still more alarming is that there is a lack of information on about one another third of the species that can therefore not be assigned to any threat category. Only 31 % of the analyzed marine species were assessed as not being threatened.

Let´s in this context take a closer look on the European Oyster *(Ostrea edulis)*, an example for a highly endangered benthic species. In fact, there are no viable populations of the European Oyster in the German Bight left. Due to overfishing in the 19th and the first half of the 20th century, the populations have collapsed in the North Sea. But the European Oyster is considered as a key species in the marine ecosystem of the North Sea. Currently, our agency reviews the feasibility of the restoration and re-introduction of the European flat oyster in the German part of the North Sea. On Thursday, one of our research partner institutes will present the outcome of the relevant feasibility study.

Healthy benthic underwater habitats are very important for many seabird species which are resting, feeding and overwintering in European waters. The results of the Seabird monitoring show substantial differences in the occurrence and distribution of different species, among others depending on seasonal patterns. What are the parameters influencing long-term population trends, how substantial are anthropogenic impacts like fishery activities, disturbances by shipping, oil spills? What part are human threats playing in breeding grounds or overwintering area?

On Thursday, we will get answers to these questions, regarding some selected seabird species in the North Sea and long-tailed ducks in the Baltic Sea. The impressive results will show us: changes in seabird numbers and biology are suitable and early indicators of pressures and changes in the marine environment. Moreover these results imply the following: species protection can only be successful if the ecosystem approach is consequently applied to all human activities in all kinds of habitats that the respective species demand during their life cycles.

Talking about increasing human activities in our seas, we also have to take a closer look on the impacts on harbour porpoises.

Especially in the Baltic Sea, there is still a high risk for harbour porpoises of getting caught as by-catch in gillnets. Extremely critical is this problem for the highly endangered population of the eastern Baltic Sea. According to the results of our so-called SAMBAH-project, only about 500 individuals of these harbour porpoises have been left. On Friday, we will hear about fundamental new European research and monitoring results concerning the different populations of harbour porpoises in the Baltic Sea.

Offshore Windfarms, shipping, seismic investigations - there is a strong increase of underwater noise emanating from various sources and we know that harbour porpoises – like all whales and dolphins – are seriously affected. They have a very sensitive hearing which is essential for their survival. Current research projects have proven changes in the behavior of harbour porpoises due to shipping activities - a severe problem in the southern Baltic Sea. Especially the Fehmarn Belt and Kadet Trench are affected which are – on the one hand - important migration routes for whales, but on the other hand intensive shipping routes, with for instance more than 63,000 ship movements in the Kadet Trench every year, which also is a Natura 2000 site.

Offshore wind energy is currently - besides fishery and shipping - the most prominent example for human activities claiming more and more space of our seas. Surveys during the construction of various wind farms in the German Bight provided evidence that there are avoidance reactions of harbour porpoises to the pile driving noise. Some years ago, German scientists were able to determine the acoustic tolerance limit of harbour porpoises. It was the basis for the threshold of 1600 dB (SEL) set by the German Federal Maritime and Hydrographic Agency for acoustic emissions during the pile driving of wind turbine fundaments. This threshold can only be kept when technical mitigation measures are applied. In different research studies, quieting technologies for offshore pile driving and their effectiveness were analyzed. This is also a field where due to a close cooperation between science, administration and technology a lot of progress has been made, and let me say that these technical achievements have been made due to powerful environmental specifications and because their compliance was secured.

But even after the installation process, running wind farms and related activities in their surroundings, such as shipping, seem to have avoidance effects on harbour porpoises. Also certain sea bird species and migrating birds are affected by offshore windfarms, e.g. due to disturbances by construction activities, risks of collisions and barrier effects. There is still a big gap, a lack of information on these topics, and also on cumulative effects of wind farms in bird and bat migration routes at sea. Consequently it is of great interest to further continue and to intensify our research efforts on the effects of offshore wind farms.

Thus, one of our future challenges is a responsible marine spatial planning which also takes into account the bearing capacity of the marine ecosystems, like the most important migration routes of birds in offshore wind energy planning for example in the Baltic Sea.

Finally I hope that this conference will again bring us a lot of examples of best practice, new ideas and fruitful dialogues for an ongoing progress in marine nature conservation and I wish us all a successful conference.

Global Ocean Process of Identifying Ecologically and Biologically Significant Areas (EBSAs) – what now, what next?

David Johnson

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1. Data challenges

Deep-sea and open ocean ecosystems remain under-sampled and under-protected. Several key challenges contribute to this situation. Firstly, data collection is too fragmented. It is expensive and logistically complicated to undertake research in the deep oceans. To fill data gaps requires a targeted approach, making best use of collective global resources, taking account of grey literature and encouraging scientists to contribute information from disparate sources to a central respository. Furthermore, data needs to be continuous across national boundaries and beyond them into Area Beyond National Jurisdiction (ABNJ).

Secondly, it is important to refine and establish marine biogeographic classifications. These are needed at a variety of scales (e.g. Watling et al. 2013) and modeling should be used more and more effectively. However, current knowledge is limited about how environmental factors like habitat heterogeneity affect deep-sea biodiversity. A third key challenge relates to evaluating ecological coherence. An understanding of connectivity between populations and for all life stages is needed but will be costly and time consuming to achieve. Related to this is the need to decide on indicators that reflect the integrity of ecosystems and ecological processes. Such indicators are needed to measure the health of ecosystem processes and functions and also recovery of ecosystems from impacts of human pressures. Finally, it is vital to consider emerging issues such as accounting for ecosystem shifts due to climate change and at the same time ensuring we do not destablilise the ability of marine ecosystems to sequester 'blue' carbon (Olsen et al. 2013).

2. The EBSA Process

In recent years Contracting Parties to the Convention on Biological Diversity (CBD) have sought to address this through commitments to bring information together, as part of a scientific and technical process, reliant upon expert judgment using agreed criteria. This process described by Dunn et al. (2014), can trace its origins to commitments made at the Rio Earth Summits in 1992 and 2002. In 1992 Agenda 21 called upon States to 'identify marine ecosystems exhibiting high levels of biodiversity and productivity and other critical habitat areas' and to (…) 'provide necessary limitations to use in these areas through, inter alia, designation of protected areas'. Then in 2002 the Johannesburg Plan of Implementation confirmed the need to 'maintain the productivity and biodiversity of important and vulnerable marine and coastal areas, including in areas within and beyond national jurisdiction'. Dunn et al. (2014) also recall the Canadian national effort to advance integrated marine management, as mandated under the Canada Oceans Act 1996, by identifying areas requiring more risk-averse management using Canadian Ecologically or Biologically Significant Areas (EBSA) criteria.

At its tenth meeting, the Conference of the Parties to the Convention on Biological Diversity (COP 10) requested the Executive Secretary to work with Parties and other Governments as well as competent organizations and regional initiatives, such as the Food and Agriculture Organization of the United Nations (FAO), regional seas conventions and action plans, and, where appropriate, regional fisheries management organizations (RFMOs) to organize, including the setting of terms of reference, a series of regional workshops. The primary objective of these is to facilitate the description of ecologically or biologically significant marine areas through the application of scientific criteria in annex I of decision IX/20 as well as other relevant compatible and complementary nationally and inter-governmentally agreed scientific criteria, as well as the scientific guidance on the identification of marine areas beyond national jurisdiction, which meet the scientific criteria in annex I to decision IX/20 (paragraph 36 of decision X/29).

CBD COP guidance on the regional workshop process as well as the potential contribution of the scientific information produced by the workshops emphasizes that:

a. The Conference of the Parties to the Convention, at its tenth meeting, noted that the application of the scientific criteria for the identification of ecologically or biologically significant areas (annex I of decision IX/20) presents a tool which Parties and competent intergovernmental organizations may choose to use to progress towards the implementation of ecosystem approaches in relation to areas both within and beyond national jurisdiction, through the identification of areas and features of the marine environment that are important for conservation and sustainable use of marine and coastal biodiversity (paragraph 25, decision X/29);
b. The application of the EBSA criteria is a scientific and technical exercise, and the identification of EBSAs and the selection of conservation and management measures is a matter for States and competent intergovernmental organizations, in accordance with international law, including the United Nations Convention on the Law of the Sea (paragraph 26, decision X/29);
c. The EBSA description process is open-ended, and additional regional or sub-regional workshops may be organized when there is sufficient advancement in the availability of scientific information (paragraphs 9 and 12 of decision XI/17; paragraph 6 of decision XII/22);
d. Each workshop is tasked to describe areas meeting the scientific criteria for EBSAs or other relevant criteria based on best available scientific information. As such, experts at the workshops are not expected to discuss any management issues, including threats to the areas; and
e. The EBSA description process facilitates scientific collaboration and information-sharing at national, sub-regional and regional levels.

Guidance on application of the criteria states that:

a. The EBSA criteria can be applied on all scales from global to local. Once a scale has been selected, however, the criteria are intended to be used to evaluate areas and ecosystem features in a context relative to other areas and features at the given scale;
b. Relative assessments are necessarily scale dependent. Relative significance of areas has generally been viewed from regional or large sub-regional scales;
c. There are no thresholds that must be met and judgements are comparative to adjacent areas, and the current ranking system (e.g., high, medium, low, no information) for assessing the areas meeting each EBSA criteria is devised to facilitate better understanding of available scientific information in describing the areas with regard to the extent to which they meet different criteria. The current ranking system, however, does not intend to com-

pare the importance of each criterion;

d. Areas may meet multiple criteria, and that is important, but meeting just one strongly is also important;
e. Areas described to meet the EBSA criteria have ranged from relatively small sites to very extensive oceanographic features; and
f. Areas described to meet the EBSA criteria can be overlapped or nested[1].

This process of description of EBSAs has made rapid progress since 2011, with to date 12 Regional Workshops in 5 years being held to facilitate EBSA descriptions. Parties to the CBD have recognized 204 EBSA descriptions in the period up to COP12 in 2014. Those involved have gained experience in applying the EBSA criteria. Consistency and quality control has been exercised by the CBD Secretariat and the Technical Resource Teams (CSIRO, Australia and Duke University, USA). Training opportunities and pre-Workshop preparations and events have helped build capacity and confidence of Workshop participants. For example an intensive training was organized for West African States in advance of the South East Atlantic Regional EBSA Workshop (Johnson et al. 2014).

This 'so called' State-based regional approach, involving nominated experts from over 100 governments, has been made possible by support from the Japanese Biodiversity Fund and the European Union, the proactive role of the CBD Secretariat and the willingness of Parties and international organisations. Dunn et al. (2014) consider this approach to be consistent with the working methods of Regional Seas Conventions and Regional Fisheries Management Organisations making it ecologically and politically coherent. However, there is little doubt that the CBD process is strongly influenced by political considerations, at times weakening the scientific integrity of overall outcomes. Furthermore, the intensity of EBSA Regional Workshops, with limited time to develop and agree EBSA descriptions has advantages and disadvantages. Consequently a number of critical issues remain to be addressed including:

a. Omissions resulting from the 'bottom up' buy-in of a collective expert-led process rather a strategic systematic scientific planning process. Ban et al. (2014) advocated the latter and some scientists have been critical of the EBSA process for omitting well-known areas or species groups;
b. Encouraging scientists to bring new information to the process. Bax et al. (2015) highlight both data accessibility issues and data gaps and deficiencies especially in the open ocean and southern hemisphere regions;
c. The need to test how such new and/or revised information can be added. Any such information will not have been through the CBD process unless another round of regional EBSA workshops is contemplated (paragraphs 9 and 12 of decision XI/17; paragraph 6 of decision XII/22). A 'new round' is unlikely until the utility of the current suite of EBSAs has been demonstrated. Questions remain about how the EBSA Repository and Information Sharing Mechanism should function; and
d. Integration of national EBSA processes with the CBD Regional workshops needs to be tackled. This has been achieved successfully by some States (e.g. Japan) but not all. For example, Canada who like several other countries opted not to include their EEZs as part of the global considerations have yet to nominate their national EBSAs for inclusion by CBD.

Regions where the EBSA process remains incomplete include the North-East Atlantic (which

1 Note: These two paragraphs are standard text drawn directly from CBD EBSA Reports e.g. UNEP/CBD/EBSA/WS/2014/2/4.

is subject to an on-going process) and regions yet to participate (Black Sea/Caspian Sea; Southern Ocean; and SW Atlantic).

3. Role of the Global Ocean Biodiversity Initiative

e. The Global Ocean Biodiversity Initiative (GOBI), an international partnership advancing the scientific basis for conserving marine biological diversity, supported financially by the German Federal Agency for Nature Conservation, has played a key role providing guidance on how the CBD's scientific criteria can be interpreted and applied. Since 2009 GOBI has helped countries as well as regional and global organisations to use and develop data, tools and methodologies to describe and identify EBSAs. Key issues concerning the strengths, challenges and limitations of data availability and scientific understanding can influence the EBSA process and interpretation of the seven EBSA criteria. GOBI is also active within the UN explaining the value of EBSAs for benthic and pelagic systems, as well as promoting the EBSA Repository as a resource providing ecological baseline information for broader ecosystem-based marine spatial planning.

There is a high degree of compatibility between the EBSA criteria and other sets of criteria agreed to determine area-based conservation planning measures. This is no surprise as the EBSA criteria considered extant systems and experts attending the Regional EBSA Workshops are familiar with these other systems. GOBI representatives have participated in all the Regional EBSA Workshops to date providing practical examples from review of scientific literature, ensuring consistency, identifying gaps and assisting State parties. Examples against each of the EBSA criteria are shown in Table 1.

Table 1: EBSA Criteria and examples of data to support expert judgment

Criterion	Interpretation	Examples of data to support expert judgment
1. Uniqueness or rarity	Areas contain either (i) unique ("the only one of its kind'), rare (occurs only in a few locations) or endemic species, populations or communities, and/or	Presence of unique or extremely rare species and habitats and outstanding examples of ecosystems such as isolated seamounts and hydrothermal vents.
	(ii) unique, rare or distinct, habitats or ecosystems; and/or (iii) unique or unusual geomorphological or oceanographic features	
2. Special importance for life-history stages of species	Areas that are required for a population to survive and thrive	Survey data, tracking data and models showing relative time spent by species in spawning areas, feeding areas and breeding areas.
3. Importance for threatened, endangered or declining species and/or habitats	Area containing significant assemblages or is critical for the survival and recovery of endangered, threatened, declining species and/or habitats	Concentrations of IUCN Red List species in a given area, persistence of use by a threatened or endangered species.

Criterion	Interpretation	Examples of data to support expert judgment
4. Vulnerability, fragility, sensitivity, or slow recovery	Areas that contain a relatively high proportion of sensitive habitats, biotopes or species that are functionally fragile (highly susceptible to degradation or depletion by human activity or by natural events) or with slow recovery	Species with low reproduction rates or habitats with slow potential recovery from perturbation. Predictive models to locate potential areas of interest can be important e.g. models of reef forming cold water corals.
5. Biological productivity	Area containing species, populations or communities with comparatively higher natural biological productivity	Highly productive regions are assumed to provide core ecosystem services. Upwelling, currents, eddies and frontal aggregations often support high abundance.
6. Biological diversity	Area contains comparatively higher diversity of ecosystems, habitats, communities, or species, or has higher genetic diversity	Evidence of high relative taxonomic or habitat diversity using range maps, OBIS data, and species distribution models.
7. Naturalness	Area with a comparatively higher degree of naturalness as a result of the lack of or low level of human-induced disturbance or degradation	Mapping of human activity and impact in order to compare with other sites. Remoteness combined with historical catch data can be useful.

4. Future considerations

Although the process has been remarkable rapid by inter-governmental standards, describing EBSAs has taken up half the time from the commitments set at COP 10 in Nagoya, where Parties agreed on a Strategic Plan for Biodiversity 2011-2020. The Plan set out 20 Aichi Biodiversity targets, organized under five strategic goals to achieve biodiversity conservation. Target 11 is within Strategic Goal C: To improve the status of biodiversity by safeguarding ecosystems, species and genetic diversity. It states that:

“By 2020, at least 17 per cent of terrestrial and inland water areas and 10 per cent of coastal and marine areas, especially areas of particular importance for biodiversity and ecosystem services, are conserved through effectively and equitably managed, ecologically representative and well-connected systems of protected areas and other effective area-based conservation measures, and integrated into the wider landscape and seascape.”

The urgency now is that it often takes at least five years to conceive and declare a marine protected area. For offshore areas this can be even longer. For example, the network of High Seas MPAs in the wider North-east Atlantic (O’Leary et al. 2012) took the OSPAR Commission 6-10 years depending on how long one accounts for ‘socialising’ the concept. Lack of time threatens the utility of EBSAs as a tool to help meet Aichi Target 11. CBD expert meetings took place in February 2016 to provide guidance on ways forward and serious consideration must be given to how to inject the momentum needed to translate scientific findings into protective measures that match political commitments by the end of the decade. Next steps will require States and competent international organisations to acknowledge EBSA descriptions, recognize areas where biodiversity values may be compromised, and make arrangements to secure protection where needed. Further efforts are needed to both understand and secure ecological coherence and achieve well-managed networks.

For Area Beyond National Jurisdiction consensus at the UN to negotiate a legally binding agreement to protect biodiversity is a positive move, however, any Implementing Agreement will likely take years to formally adopt. The deep and open oceans are home to a major part of the world's biodiversity. They support an enormous wealth of productive ecosystems, specialized habitats and individual species. GOBI plans to continue to improve the scientific basis of CBD decisions, UN Resolutions, and other measures through the application of analyses, network design, training and capacity building. Ecological baseline data of this nature and encouraging encouraging partnerships, including those that will help incorporate traditional knowledge, is vital to inform area-based management approaches and tools. Dunstan et al. (2014) propose an adaptive hierarchical approach as a basis for developing the basis of marine spatial planning for the open ocean, relating pressures and threats posed by human uses to the ecological or biological significance highlighted by EBSAs. In Europe implementation of the Marine Strategy Framework Directive, and through similar national exercises elsewhere (e.g. Australia (Hayes et al. 2015)), systems to maintain ecological values (Good Environmental Status) by setting targets and establishing indicators for marine areas are likely to deliver the most sustainable and cost-effective solutions.

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The MPA Networks of HELCOM and OSPAR by 2015

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1. Introduction

The incentive for developing a network of Marine Protected Areas (MPAs) in the OSPAR and HELCOM maritime areas can be traced back to various milestones, which constitute the basis for current work. In this context the World Summit on Sustainable Development in Johannesburg (2002) can be considered as the basic reference point for all global programmes, activities and initiatives concerning marine biodiversity conservation through establishment of marine protected areas for individual states, international organisations, institutions and NGOs (von Nordheim et al. 2011, von Nordheim 2016, in press). In addition, the following milestones are considered vital in this process:

- HELCOM Recommendations 15/5 (HELCOM 1994) and 35/1 (HELCOM 2014) recommending that Contracting Parties of the Helsinki Convention take all appropriate measures to establish a system of Coastal and Marine Baltic Sea Protected Areas (former BSPA; now „HELCOM MPA“);
- OSPAR Ministerial Meeting in Sintra (1998) agreed to promote establishing a network of MPAs in the OSPAR maritime area;
- The world summit on sustainable development (WSSD in 2002) agreed to establish a comprehensive and representative worldwide network of MPAs by 2012 and further agreed a plan to start improving the status of oceanic biodiversity (Johannesburg Plan of Implementation; WSSD 2002);
- Joint work programme on Marine Protected Areas that was agreed at the first (and only) joint meeting of the HELCOM and OSPAR Commissions in Bremen (2003) (see also OSPAR 2003, Recommendation 2003/3). The envisioned network of MPAs in the HELCOM and OSPAR maritime areas should be ecological coherent by 2012 and well-managed by 2016. It was the first common programme for these regional seas conventions;
- CBD Parties confirmed the ´10 %-target´ at COP 10 in Nagoya 2010: the worldwide representative network of Marine Protected Areas should encompass at least 10 % of the world’s oceans. At the same time, the target year to fulfil this goal has been shifted from 2012 to 2020 (CBD 2010, Decision X/2).

2. HELCOM MPA network

This Regional Sea Convention on the protection of the marine environment of the Baltic Sea area has been established in 1974 to protect the marine environment from every source of pollution through intergovernmental cooperation. The convention is being governed through the Baltic Marine Environment Protection Commission - Helsinki Commission (HELCOM) and its subordinate bodies.

As part of their work, the HELCOM bodies have made substantial progress in the designation and implementation of HELCOM MPAs and and thus the establishment of a MPA network in the Baltic Sea during the past years. Since 2009 the improvement of the network has been particularly great as site numbers have nearly doubled. The CBD-10 %-target was reached in 2010 already. In 2015, 11.7 % of the HELCOM maritime area was covered by a total of 174 MPAs (Figure 1).

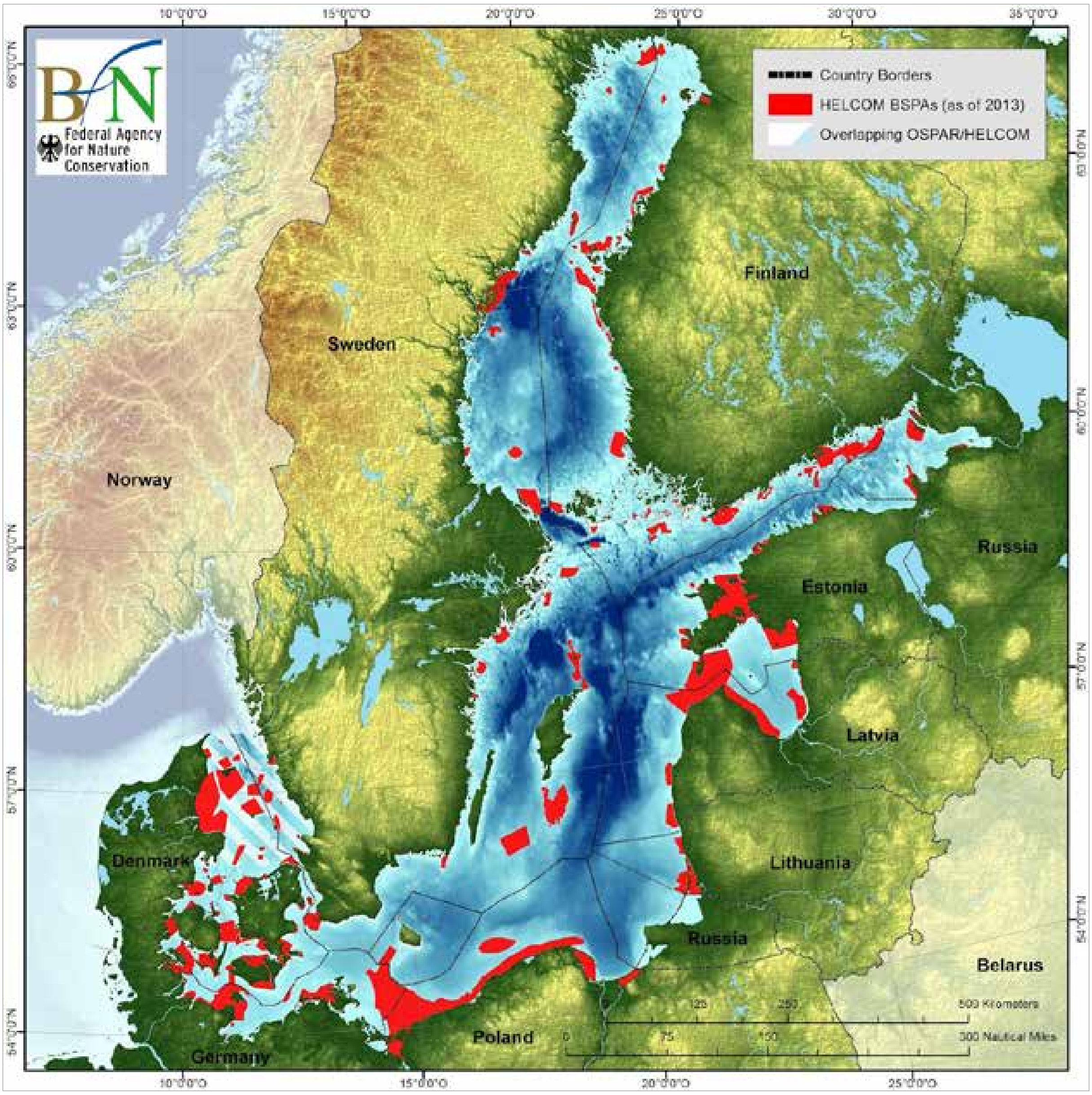

Figure 1: HELCOM MPA network 2015, (map designed by BfN 2015, data source: HELCOM MPA data base)

Nevertheless several gaps within the network of MPAs across the Baltic Sea area still remain. The overall percentage of MPA-coverage is very different across the biogeographic regions of the Baltic Sea and there is also a distinct lack of MPAs in offshore areas.

In 2015, for example, only about 5 % of the Gulf of Bothnia was protected by MPAs, which, compared to other regions of the Baltic Sea, is a relatively low coverage and stems from the fact that not much progress could be made between 2009 and 2013. In addition, the MPA coverage along the south-eastern coastline of Sweden is comparatively low, but in contrast a high number of MPAs have been established along the Polish coastline for example. As a result some MPAs in the Baltic Sea are isolated spatially and thus their connectivity is not satisfactory (see also chapter 3).

3. Effective management and ecological coherence of the HELCOM MPA network

The HELCOM Ministerial Conference during their meeting in 2013 made a political commitment that the HELCOM network of MPAs should be well-managed by 2015. Another conclusion of the Ministerial Conference was to set up effective management plans for all "old" MPAs by 2015. For any new areas to be designated afterwards, management plans should be in force at the latest 5 years after establishment. Although none of those targets have been fully met yet, 65 % of MPAs do have a management plan in place, 26 % have a plan in preparation and only 9 % have no management plan (Figure 2).

Effective protection of the marine ecosystem can only be achieved by effectively managing anthropogenic activities and their impacts. Even with management plans in force this effective management and resulting protection are not necessarily achieved. Therefore the focus should not only be on implementing management plans as a paper exercise, but rather implementing effective plans and resulting management measures addressing the main threats and impacts with the key target to fulfil the conservation objectives for the individual sites.

Within the established management plans a wide range of human activities are considered. Some activities with a relatively high impact on marine ecosystems like laying of cables and pipelines, dredging, constructions of wind farms and extraction of resources need permissions by a relevant body before they can take place in quite a high number of areas. However, only in a few cases a restriction or prohibition of said activities within the area of an established MPA is applicable (Figure 3).

As is the case for the majority of MPAs globally, the management of fisheries activities within their boundaries seems to be the most significant problem to be dealt with within the Baltic Sea. So, fisheries activities are obliged to obtain a permission or under other restrictions in less than a third of the areas. Fisheries prohibition and the establishment of No Take Zones are only valid in two MPAs in the Baltic Sea (Figure 3).

Ecological coherence

With respect to ecological coherence of the HELCOM MPA / BSPA network an assessment has been made in 2015 concluding, that the network cannot be considered as ecologically coherent for the time being. The assessment considered representativity, replication, adequacy and connectivity. Two of them, adequacy and connectivity, did not yet fulfil the HELCOM criteria of ecological coherence (HELCOM 2016). As pointed out above however, the 10 %-target for spatial MPA coverage of the HELCOM maritime area has been achieved across the Baltic Sea, but not in all HELCOM subregions or individual Contracting Parties waters. There still is a strong bias of spatial coverage towards nearshore waters, there are very few offshore sites and there is an unequal distribution of MPAs across the HELCOM area. Additionally, the total area of many HELCOM MPAs is below the recommended minimum size of 3000ha (HELCOM, 2010).

Further, the MPA database underpinning all designations still lacks adequate information and data for many sites, especially regarding protection status and measures taken, but also regarding the distribution of species and habitats or biotopes.

A lot of work will have to be undertaken to assess to what extend the MPA network is ecologically coherent and well managed and to solve the problems mentioned above within the next years in relevant working groups under the HELCOM framework as well as in the individual countries bordering the Baltic Sea.

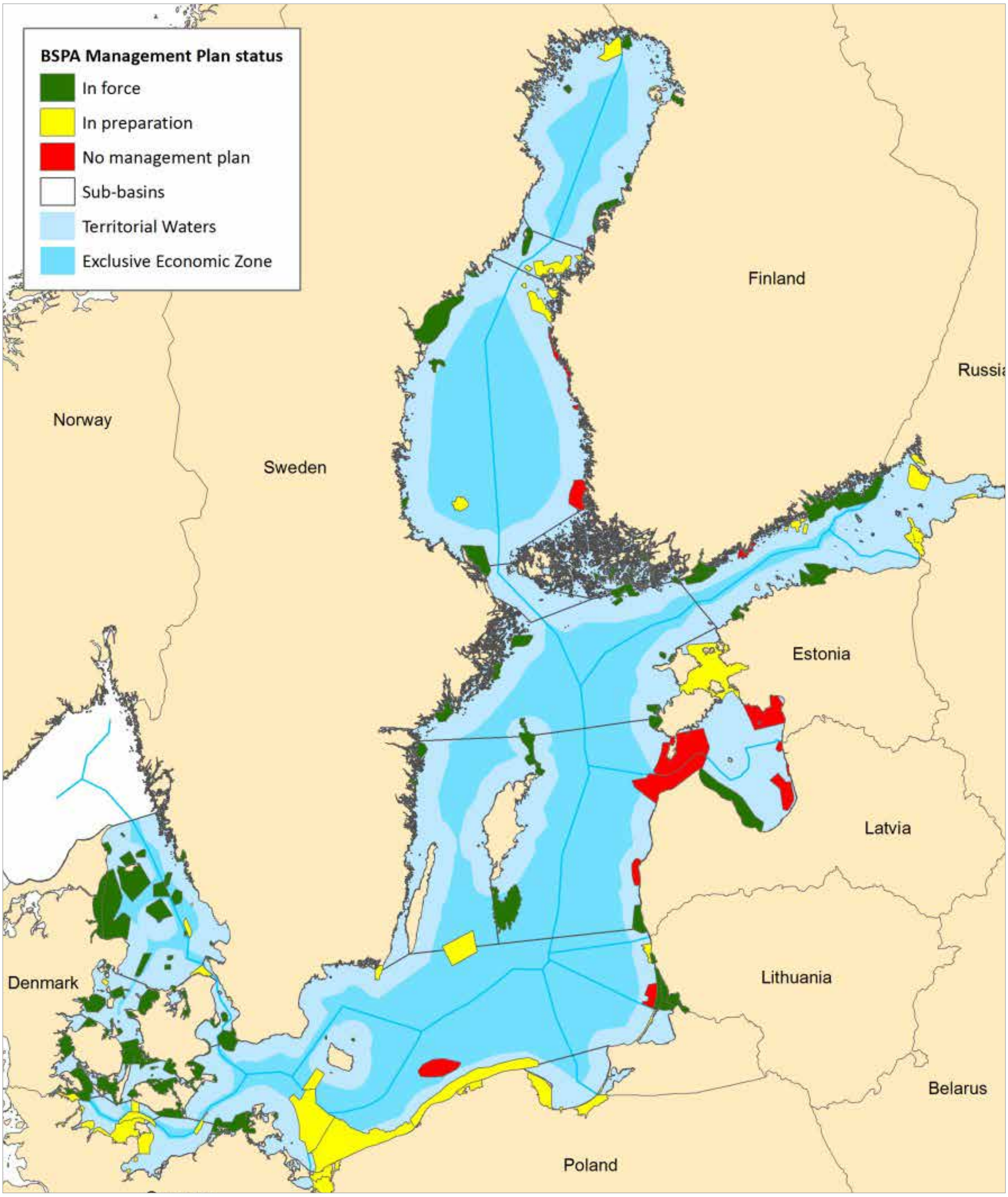

Figure 2: BSPA Management Plan Status 2015, map designed by HELCOM (data source: HELCOM MPA data base)

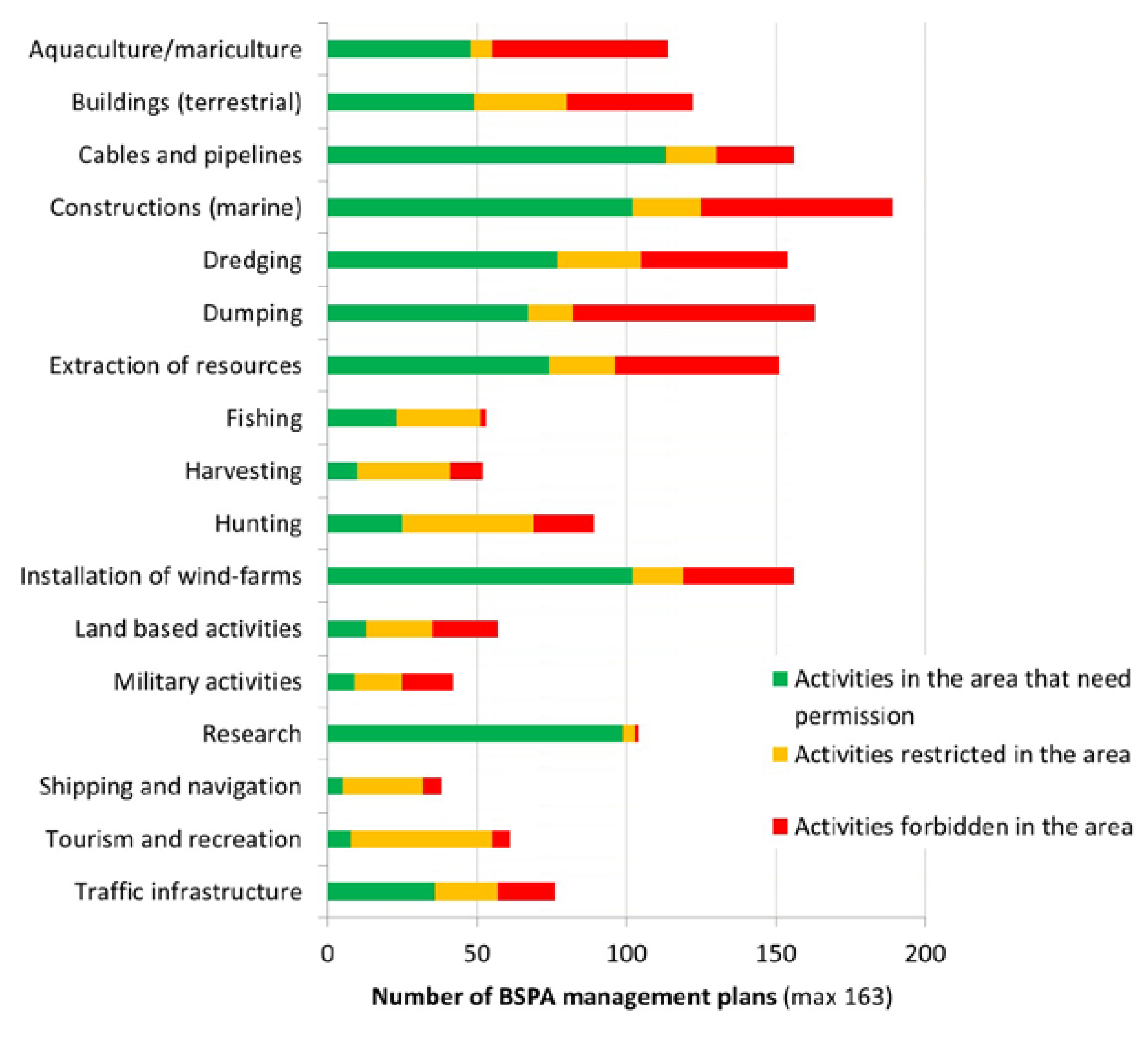

Figure 3: Contents of management plans of HELCOM BSPAs (HELCOM 2013)

4. OSPAR MPA network

Great progress has been made in the designation and implementation of MPAs in the North East Atlantic region in the OSPAR maritime area within in the last few years (OSPAR 2010, OSPAR 2012, OSPAR 2014). For instance, in 2014 alone, 77 MPAs were added to the OSPAR network, covering about 90,000 km² (Figure 4). Substantial improvements were made in Portuguese, Spanish, French and UK waters.

Almost all of the OSPAR MPAs are located in territorial waters (or in the EEZ of Contracting Parties). Remarkably 10 MPAs are in Areas beyond National Jurisdiction (ABNJ), covering up to 9 % of this important zone. Regardless of their seemingly small number, some MPAs are quite large and these MPAs represent the world's first MPA network in ABNJ and OSPAR thus developed ground breaking activities on a global scale. Especially the High Seas Areas along the Mid Atlantic Ridge play a model role in the international context (for MPAs in the High Seas and ABNJ see also Gjerde 2012, Ban et al. 2013). By the end of 2015, 5.8 % of the whole OSPAR maritime area was protected comprising of 423 designated MPAs. Therefore, the 10 %-target has not been reached, yet.

5. OSPAR MPA network - effective management and ecological coherence

When analysing the OSPAR network in terms of management effectiveness of individual sites and individual Contracting Parties, the emerging picture remains diverse. To gain a better insight and an international standard for what "effective management" of MPAs consists of, the relevant OSPAR group first drafted two basic questions:

1. What does "well-managed" mean in practice?
2. Which criteria are relevant for assessing management effectiveness?

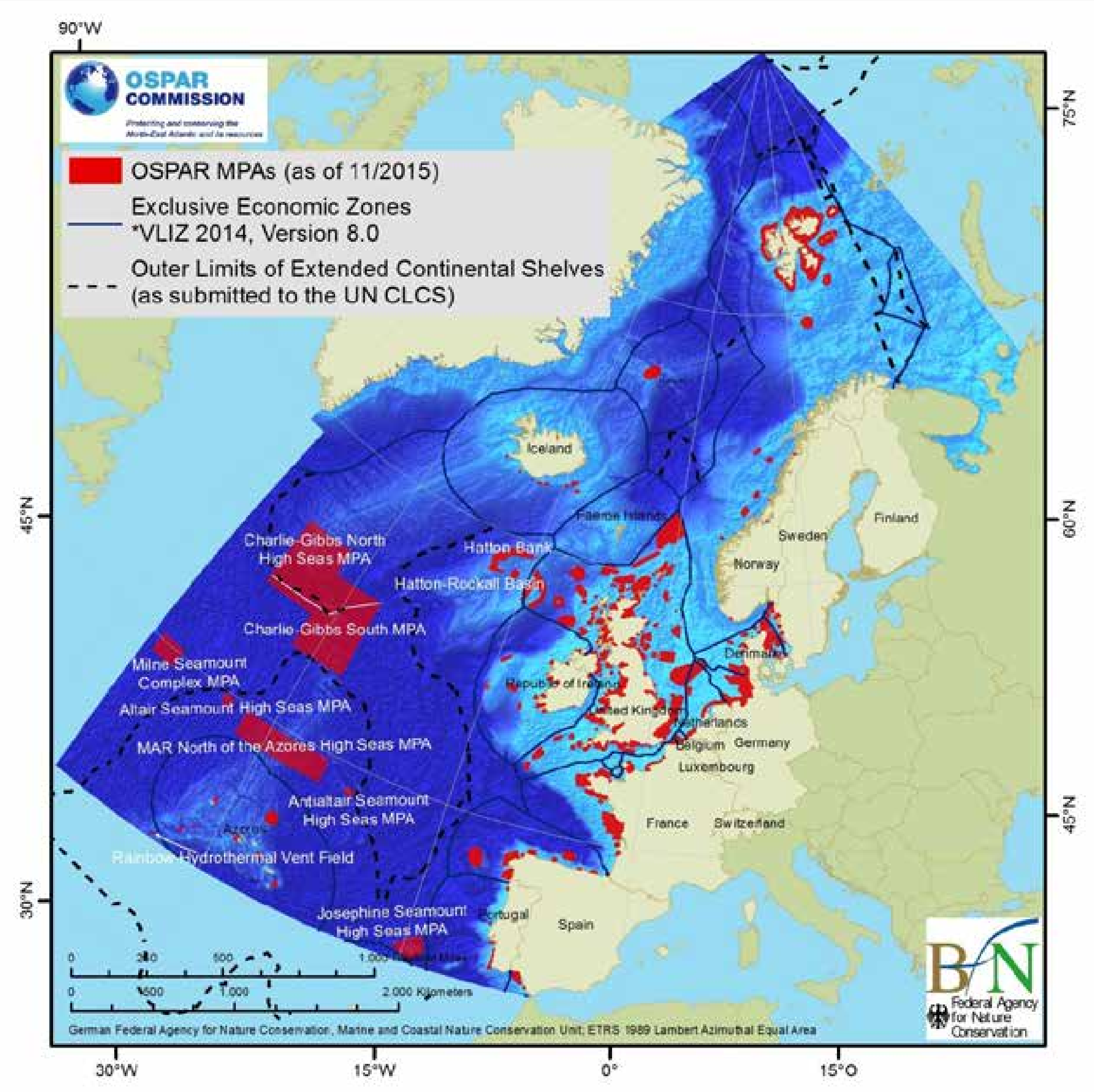

Figure 4: OSPAR MPA network (map designed by BfN 2015)

The OSPAR task group is currently developing a methodology to assess management effectiveness of MPAs based on the outcomes of the analysis of information received and will subsequently be working on a common criteria catalogue.

As preliminary conclusions on the management of OSPAR MPAs as of 2015, we can state:

- a number of OSPAR-MPAs are subject to general or specific management regulations, including conservation objectives and management plans, but detailed and comprehensive information on the effectiveness of these measures has not been made available to OSPAR so far;
- for many sites though, management regimes, including plans, are still under preparation;
- OSPAR member states are at different levels in progressing the implementation of management plans;
- for Areas Beyond National Jurisdiction (ABNJ) OSPAR works intensively towards an international cooperation with other relevant competent authorities.

There is a strong need for cooperation or joint management plans with other institutions with global competence like the International Seabed Authority (ISA), the International Maritime Organisation (IMO) or the regional fisheries authorities / commissions like the NEAFC for MPAs in ABNJ. To achieve this cooperation OSPAR works through agreements like Memoranda of Understanding or collective arrangements on the management of MPAs, which help immensely with making progress towards effective management in the High Seas MPAs. In this context in the past years, OSPAR was very active and has already developed e.g. recommendations on management measures for awareness raising, information building and marine research. The cooperation with the North East Atlantic Fisheries Commission (NEAFC) for the High Seas MPAs is globally without precedence and is regarded as particularly important e.g. around the Mid Atlantic Ridge, which led to a number of temporary closures for bottom trawling fisheries in sensitive areas like seamounts, cold water corals or areas, which host endangered fish species and marine mammals.

Ecological coherence

Regarding the ecological coherence of the OSPAR MPA network, a lot of different approaches have been taken to date.

A trial assessment of ecological coherence was set up at the end of 2012 (OSPAR 2012) based on a set of „three initial OSPAR tests“ (Ardron 2008). During this trial, two broad levels of spatial tests were utilised: broad-scale tests across the OSPAR Maritime Area as level 1 and detailed tests at the regional and sub-regional scale as level 2. The conclusion of the first assessment was that the OSPAR network of MPAs as a whole was not ecologically coherent, but there were positive signs of movement towards coherence at that time.

A second assessment was set up in 2014 (OSPAR 2013, 2014), using again the three initial spatial tests. The conclusion of this second assessment was that the majority of sites generally lay in coastal waters, particularly in the Greater North Sea and the Celtic Seas. However, OSPAR MPAs particularly in the Greater North Sea, in the Celtic Seas, along the coastline in the northern part of OSPAR Region IV, around the Azores archipelago and in ABNJ in the Wider Atlantic formed a network which showed first signs of sufficient ecological coherence.

Thus, the work on improving the assessment of ecological coherence of the OSPAR MPA network has clearly to be further developed and is currently ongoing. Further, regarding the different marine regions within the network representativity of MPAs in some of the regions is not sufficient, as there are still gaps. In future, the focus for additional MPA designation therefore has to be on those regions which are not fully represented by now.

6. Extension of network – arctic waters & others

There is a strong need for more MPAs in the "High Seas" of OSPAR and for more MPAs with a focus on seabird protection, which will have to be established in the near future. Currently new proposals for such MPAs sites are being developed based on recently collected data allowing new insights into bird abundance and distribution across those areas.

So far, a number of existing MPAs protect the water column and seabed in ABNJ (e.g. submarine canyons and sea mounts within fishable depths). In the past, quite large areas like the Charlie-Gibbs-Fracture-Zone, areas around the Azores or the coastal area around Svalbard have been protected. However, the Mid Atlantic Ridge remains a "promising" area where additional MPAs might be established.

The outcome of a joint OSPAR/NEAFC workshop with the attendance of CBD, on the descrip tion of Ecologically and Biologically Significant Areas (EBSAs) in the OSPAR High Seas has shown in 2011 that there are still highly valuable and sensitive areas and structures, which need further protection, for example the OSPAR Region I Arctic Waters. For political reasons though, some OSPAR Contracting Parties were not prepared to agree on MPAs that overlay sea floor areas on their extended continental shelfs (as submitted to the "Commission on the limits of continental shelfs", CLCS).

Currently a draft proposal for an "Arctic Ice High Seas MPA" is discussed by OSPAR Contracting Parties. This proposed MPA, which is constituted of a majority of permanently ice-covered waters of the Central Arctic Basin, is designed to protect the ecological features of the water column and on / above the ice, not the seafloor (Figure 5).

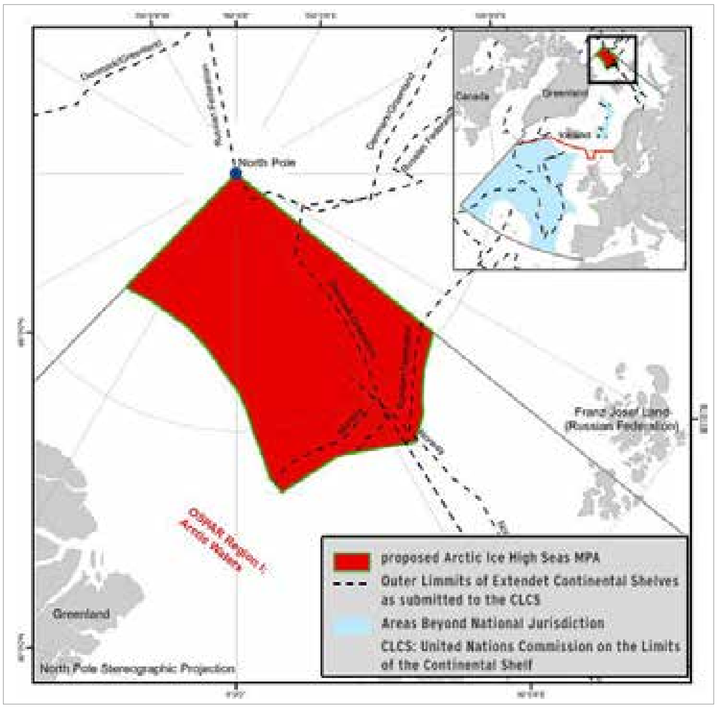

Figure 5: Proposed Arctic Ice High Seas MPA, (Source: „WWF/ Sabine Christiansen" Please note that this map shows the first proposal of such site which has been further developed until to date).

7. Conclusion

Summarising the points made above, substantial progress has been made in designating and managing a network of Marine Protected Areas in a European context under the OSPAR and Helsinki Conventions. This progress is particularly remarkable if it is compared to other efforts on a global scale, where implementation of such networks has often been more problematic and slower. The spatial coverage of MPAs in the OSPAR and HELCOM maritime areas is substantial (> 5 % of OSPAR waters; > 11 % of HELCOM waters) and especially the designation of sites in "Areas Beyond National Jurisdiction" should be highlighted as an outstanding achievement of the efforts undertaken within the OSPAR framework. Thus, while there are still gaps remaining and issues to be tackled in the future, the achievements made to date can serve as a great example to other international bodies and cooperations.

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Evaluating progress towards meeting MPA commitments: experience from the UK

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1. Introduction

The UK marine area covers an area three times greater than its land mass. It is an extremely rich and diverse marine environment containing more than 8,500 species (UK Marine Monitoring and Assessment Strategy (2010).

UK Governments confirmed their commitment towards an ecologically coherent marine protected area (MPA) network in the North-East Atlantic in 2012 (Department for Environment Food & Rural Affairs, Department of the Environment Nothern Ireland, Scottish Government and Welsh Government, 2012). To achieve this goal, policy makers, scientists and practitioners face conceptual and practical challenges around the interpretation of 'ecological coherence'. Devolution within the UK has meant that each of the UK's Administrations took forward projects to identify new MPAs to contribute to an ecologically coherent network. Scottish Ministers have responsibility for marine nature in the inshore and offshore of Scottish waters; the Department for Environment, Food and Rural Affairs (Defra) have responsibility for inshore waters around England and offshore waters around England, Wales and Northern Ireland; Welsh Government have responsibility for nature conservation in inshore Welsh waters and Northern Irish Government for inshore waters around Northern Ireland. The Joint Nature Conservation Committee (JNCC) has responsibility for identifying MPAs in the offshore area of UK waters and responsibility for this work in inshore waters lies with the relevant country conservation agency. JNCC plays a key role in the UK's offshore marine environment from 12nm out and has close to 15 years experience providing conservation advice to UK Government on the offshore environment. This includes the identification of MPAs in the offshore, provision of advice on the selection of these sites and conservation of their protected features, site monitoring and providing advice on management. JNCC also has a UK coordination role providing advice at a UK level, European and international levels.

The current network of existing MPAs within UK waters (see Figure 1 below) has made significant progress towards the UK MPA network commitments (see above). The UK MPA network originally started off with the identification and selection of Natura 2000 sites under European legislation. As not all habitats and species in UK waters are covered by EU Nature Directives, national MPA programmes were established by each of the UK Administrations under domestic legislation to identify further MPAs to contribute to an 'ecologically coherent network'. In September 2015, approximately 16 % of UK waters were within 277 MPAs[1] of which 244 represent the UK's contribution to OSPAR MPAs.

1 Please note that since this presentation was given at PCME in September 2015, a further 23 MPAs have been designated in UK waters resulting in these figures changing and this percentage figure increasing to 17 %.

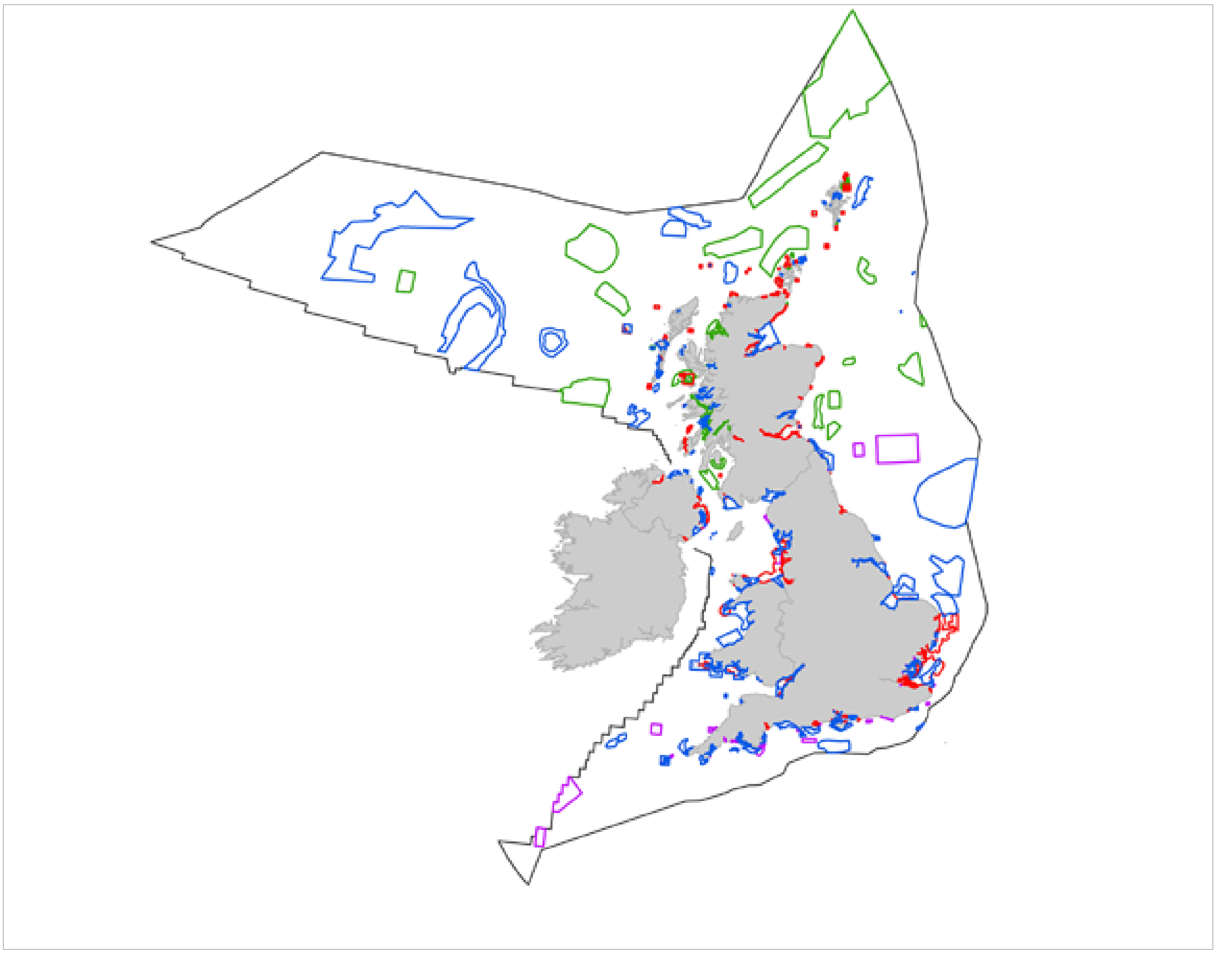

Figure 1: The UK MPA network in September 2015. Blue sites = Special Areas of Conservation under the EU Habitats Directive; Red sites = Special Protection Areas under the EU Wild Birds Directive; Green sites = Scottish Nature Conservation MPAs under the UK Marine and Coastal Access Act and Marine (Scotland) Act; and Purple sites = Marine Conservation Zones under the UK Marine and Coastal Access Act.

2. How to evaluate our progress towards various MPA commitments?

During 2013 and 2014 both Defra and Scottish Government designated a suite of national MPAs within their waters which had been selected using guidance which embodied the OSPAR network principles to enable them to make their contribution to the MPA network in the north-east Atlantic.

To monitor progress towards meeting their commitments, the UK Governments commissioned JNCC to produce a catalogue of UK MPAs and their protected features. JNCC has been working with the UK country agencies to compile the necessary data and information in a standardised format. The work was termed a 'UK MPA stocktake'.

Following this, in autumn 2013, Defra requested JNCC use the evolving UK MPA stocktake information to identify any potential "big gaps" in the MPA network in the waters they are responsible for around England and offshore waters between Wales and Northern Ireland. Defra requested this information to assist their planning of future tranches of national MPA designations to deliver their contribution to the MPA network in the north-east Atlantic.

2.1 The UK MPA Stocktake

The UK MPA stocktake is an ongoing piece of work to produce a standardised catalogue of UK MPAs and their protected features at the UK level. This has proven to be quite complex, in particular because of the different approaches adopted within each country to identifying MPAs.

An important first step of the UK MPA stocktake has been a compilation of all the designated features across UK MPAs, followed by a second step involving the translation of those features to features listed on a standardised UK-level MPA network features list. This UK MPA network features list has been developed to help any assessment of what features are being protected at a UK scale, overcoming the differences between designation types and approaches taken within individual countries. This is essential to building an inventory at a UK level, to avoid 'double counting' the same or very similar features that had different names by virtue of the legislation under which they were designated.

To assist the process for identifying sites and features which contribute to the MPA network, a number of methods and approaches have had to be agreed between JNCC and the country agencies to ensure consistency. This work has included the development of the UK level MPA Network Features List. This list of features will allow comparison across all of the MPAs that contribute to the UK MPA network. The list was developed using all 'listed' features for which MPAs are designated in the UK as a starting point but as the list needs to be standardised, it was refined to only include the following types of features: EUNIS level 3 habitats, OSPAR Threatened and/or Declining habitats and species and UK Natural Environment and Rural Communities Act 2006 (NERC) (or equivalent) habitats and species, Annex II species listed in the EU Habitats Directive, and Annex I species listed in the EU Birds Directive and Regularly Occurring Migratory Species. A range of agreed approaches and guidance have also been developed to help consistently define national sites with 'marine biological components' contributing to the UK MPA network; define the different types of protection for features in existing MPAs; and identify marine geo-features.

All of this data is being collated into a purpose-built UK MPA database that will provide a central repository for attribute data for all UK MPAs for the purposes of reporting on the MPA network in the UK.

2.2 Assessment of the progress of the MPA network in the sea around England and offshore Wales and Northern Ireland

As explained above, JNCC was requested to use the evolving data being collated through the UK MPA stocktake to undertake an assessment of progress of the MPA network in the sea around England and offshore Wales and Northern Ireland (JNCC, 2014). Please note that this study did not include Scottish waters or inshore Welsh or Northern Irish waters.

The aim of the work was to first assess what was being protected by the existing MPA network, then to identify any big gaps using a high level set of criteria and finally to assess options for filling any of the gaps identified in the network.

For this assessment JNCC developed an assessment methodology that used criteria (see Table 1) which took into account both the OSPAR MPA network principles (OSPAR, 2006) where appropriate information was available, and wider advice in associated OSPAR guidance. The main principle set out in OPSAR guidance on an ecologically coherent network includes Features, Representativity, Resilience, Connectivity and Management. The OSPAR Convention provides a framework for assessment through its network principles, but its application to meet marine policy aspirations faces a number of challenges. For the purposes of the assessment, it was necessary to develop a broader understanding of how to apply some of OSPAR guidance in the context of the work, particularly on how to deal with biogeographic variation and what features to consider in the analysis.

OSPAR guidance (OSPAR 2006) suggests that an ecologically coherent network should take into consideration biogeographic variation. As such biogeographic regions identified in the UK through previous work were used for the assessment. Appropriate data were only available for three UK MPA designation types at the time of assessment and so only these could be considered. Data for the other designation types contributing to the network are being collated through the ongoing UK MPA stocktake but were not available at the time of this assessment. As data were not available for MPA designations that protect substantial areas of the intertidal zone, JNCC decided that an assessment of big gaps in the intertidal area would provide an unrealistic picture of the current levels of protection within the network. Consequently, the assessment focussed on identifying big gaps for subtidal features within the network. As Defra was seeking advice to support planning of future tranches of national MPAs in waters around England and offshore England, Wales and Northern Ireland; we only included those features considered appropriate for protection within those waters. Following OSPAR guidance, (OSPAR 2006), EUNIS Level 3 habitats were used as a proxy for the range of biodiversity within the study area, ensuring that the full breadth of biological communities would most likely be represented within the MPA network. As some habitats are known to occur at a large range of depth and energy levels the assessment considered the protection of habitats within sites by several depth and energy categories in an attempt to further ensure the full range of biodiversity is included within the MPA network.

Information box 1: Assessment criteria used to identify 'big gaps'.

What was considered a 'big gap'?

JNCC developed broad benchmarks for the minimum requirements for an ecologically coherent MPA network which were based on a mixture of existing scientific understanding and OSPAR guidance.

A "big gap" was considered to exist when the existing MPAs in a region did NOT collectively:

- Protect two examples of each feature - This criterion is relevant to the OSPAR principles of representativity, features and resilience.
- Protect 10 % by area of each habitat - This criterion is relevant to the OSPAR features principle.
- Protect sites with the same EUNIS Level 2 habitat less than 80 km apart - This is relevant to the OSPAR connectivity principle.

These were high level criteria reflecting the minimum thresholds to identify 'big gaps'. The criteria also only reflected some aspects of the OSPAR MPA network principles and so meeting the minimum criteria alone did not necessarily ensure the MPAs in that area make an appropriate 'full' contribution to the creation of an ecologically coherent network of MPAs.

The analysis generated a considerable amount of results for each feature in each region where it occurred. Information had to be disseminated in a way which ensured that complex criteria were readily understood by policy makers using simplified criteria (see example in Table 1). Summarising these down into key headlines, presented in a clear fashion, was imperative to assisting the decision makers' understanding of the outputs. The analysis generated a considerable amount of results for each feature in each region where it occurred. Information had to be disseminated in a way which ensured that complex criteria were readily understood by policy makers using simplified criteria (see example in Table 1). Summarising these down into key headlines, presented in a clear fashion, was imperative to assisting the decision makers' understanding of the outputs.

Table 1: An example summary results table.

Broadscale habitat	**Represented?**	**Replicated?**	**Comments**	**10 % protected?**	**Comments**
Region X					
Moderate energy circalittoral rock	YES	YES		YES	
Subtidal coarse sediment	NO	NO	This feature is currently not protected anywhere within the existing MPA network in this region and so there is a gap in relation to meeting the criteria of Representativity and Replication.	NO	This feature is currently not protected within the existing MPA network in this region and so there is a gap in in relation to meeting the criteria of Adequacy.

The first stage of the analysis focussing on identifying 'big gaps' faced constraints and limitations, particularly around the data available to input into the analysis. As explained, appropriate data were only available for certain existing MPA designations and so an assessment of big intertidal gaps was not possible. Additionally, a lack of mapped data for some areas of UK seas, including within some MPAs meant that the extent of some features could not always be confidently calculated and consequently the presence and/or extent of these habitats may be underestimated, and the presence and/or extent of other habitats may be erroneously exaggerated. At the time of the assessment, only high level EUNIS level 3 habitats were mapped consistently across UK waters, albeit at a relatively coarse resolution with large areas based on modelled or interpolated information where there may be limited ground truthing and/or acoustic data. Habitats typically occurring at a fine scale were therefore likely to be under-represented in these maps and their extent underestimated in the analysis. Similarly, limited distribution data, particularly for sparsely distributed species and habitats outside of MPAs, can hinder the understanding of how many or what extent of different features types occur in the UK.

Once we had identified gaps in the network we assessed the potential options for filling these gaps. Remaining site options previously identified through the stakeholder-led process (Natural England and JNCC, 2010) but not yet designated were evaluated to see which might best fill the gaps. This considered and combined three gap criteria (see Information box 2) at the site level, and by integrating these benchmarks we could answer the overarching question of whether the site filled a 'big gap'. While these qualifying criteria formed the major basis of our site assessment, it was not always clear cut and the combination of different factors and site options meant that some degree of expert judgement was often needed.

It was also a complex task to reflect how a site and its features could contribute to the network as a whole in respect to all three principles simultaneously. We adopted an approach which provided high level summaries, deduced by assessing each site against the questions outlined above. For example "This site is one of two options that could provide a replicate for the feature 'Sea-pen and burrowing megafauna communities' which is currently only afforded protection within one existing MPA within the network in the region." Or "The site could substantially contribute to increasing the percentage of the feature 'Subtidal mud' afforded protection within the region (currently only 2.2 % of the known area), as well as filling a spatial connectivity gap in the region for the feature 'Subtidal sediments'." This approach simplified the key messages, making them clear and accessible for decision makers.

Information box 2: Site option assessment criteria.

Does the site option fill a 'big gap' in the network?

Yes

- Is the only site option to fill a gap
- Fills several gaps
- In the top 3 sites to increase quantity of habitat protected

Maybe

- Fills gap(s) but other similar options available

No

- Does not fill any gaps
- Fills gap(s) but only to minor extent
- Fills gap(s) but other options fill this and other gaps

3. Lessons learnt

There are a number of lessons that can be learnt from our experience undertaking this analysis:

- Whilst the OSPAR network principles and guidance provide a framework for assessing progress, it was necessary to develop more pragmatic benchmarks appropriate to a regional scale within the UK, based on the type of data available to complete the assessment. Ecological coherence is a broad and sometimes ambiguous concept but it can be broken down to create meaningful network assessments and deliver accessible advice to government.
- We used straightforward criteria and methods to interpret ecological coherence, this was necessary because of data and time constraints but this was also a pragmatic decision to support decision-makers with the most clear and concise information possible. In a policy context it is often not pragmatic to adopt complex, highly sophisticated approaches as there may not be the time, data or demand unless it can be applied very practically.
- Even with available datasets on habitat distribution within the UK marine area, it remains difficult to carry out an assessment of the MPA network with a high degree confidence in its final conclusions and it can be difficult to determine whether the full range of habitats is being protected within the UK MPA network.
- To ensure that our advice is used by decision-makers it is very important that results are presented in the most appropriate way for policy, being clear, unambiguous, succinct, as simple as possible and directed at exactly the right level or scale that the decisions will be taken.
- There is scope to increase the breadth of these assessments, such as bringing in other cri-

teria of ecological coherence, or using more refined ecological thresholds, but these must be balanced with the limitations of the available data and their pragmatic value.

These experiences and lessons learnt have been shared by the UK with other contracting parties of OSPAR in an attempt to both share experiences but also help to develop thinking around ecological coherence in the north-east Atlantic.

4. Conclusions

Key messages from the UK's experiences thus far –

i. Use simple criteria (based on the detail) - Simple relevant criteria should be used for any assessment but based on more detailed guidance;
ii. Be aware of data limitations - Limitations of data should be considered ahead of the assessment to help inform both the selection of criteria and analysis method and also the presentation of results; and
iii. Select the most important results for a simple message - Network assessments can generate a vast amount of results.

The key messages should be selected and presented in a clear and accessible manner.

While these studies have advanced the use of the OSPAR ecological coherence framework and directly informed marine policy, challenges still remain when applying the network concept more broadly. In particular, scientific advisors face the challenge of balancing uncertainties in ecological thresholds, species' occurrences and data limitations while also providing unambiguous conclusions to policy makers under tight timescales. Nevertheless, further work is needed to develop collective thinking around what an ecologically coherent network looks like, and how it can be described and evaluated in a practical way for policy makers and stakeholders.

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Progress in the implementation of the French strategy for the creation and management of Marine Protected Areas

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1. Introduction

In France, the implementation of the national policy concerning Marine Protected Areas is framed by the national strategy established by the Ministry of Ecology, Sustainable Development and Energy. We present here the results of the 2015 assessment regarding the implementation of the current strategy (for the French mainland waters only in the present paper). This assessment aims at enlightening progresses made at mid-term of the strategy which was elaborated for the 2012-2020 period and it has fostered the third national congress for Marine Protected Areas, which was held in October 2015. Taking place every 4 years, the national congresses are important milestones, and the 2015 debate has concentrated on the governing principles of this strategy, building upon the assessment carried out in 2015.

Accordingly, the assessment follows these governing principles, plus priority operational areas for the development and management of the French MPA network.

2. An overview of the French MPA network in metropolitan waters

The 2006 law defined what a Marine Protected Area in France is and was later completed by an administrative order in 2011 to take into account international designations. In metropolitan waters, the main categories are: Natural Reserves (NRs), National Parks (NPs), Marine Natural Parks (MNPs) and Natura 2000 sites (see Figure 1). The coverage of metropolitan waters by MPAs reaches 23 % in 2015, but goes down to 13 % if we except the Pelagos Sanctuary (MPA under the Barcelona Convention). If we consider only areas where all ecological compartments (bottom, water column and surface) are protected, the proportion decreases to around 12 %.

3. Assessment of the implementation of the governing principles of the national MPA strategy in the French metropolitan waters

The French MPA strategy is structured around five governing principles which are acting as "timeless laws" and must guide the development of the MPA network both in terms of creation and management.

3.1. A network that is integrated into a general mechanism for gaining knowledge of and monitoring the marine environment and its uses

The MPA network development has triggered several knowledge programs dedicated to marine habitats, marine mammals or seabirds. Those programs are at the heart of new MPA designations or the management of existing MPAs, but they have also strengthened and structured

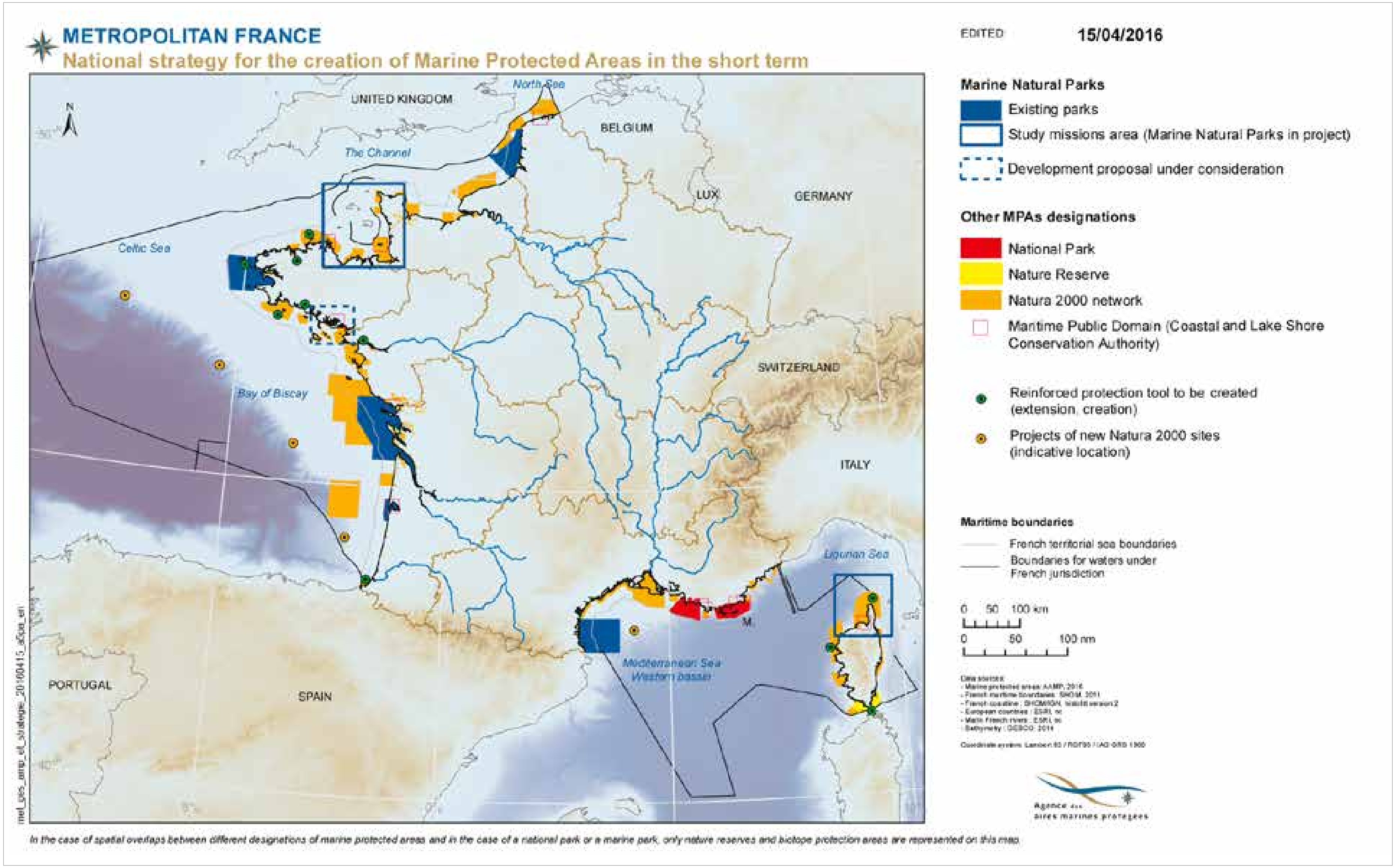

Figure 1: The map shows the French MPA network in June 2015, colours mark the main different types of MPAs.

the knowledge on the marine environment, especially regarding offshore species and habitats and in the context of the Marine Strategy Framework Directive. The French Agency for Marine Protected Areas (AAMP) will indeed coordinate the topics regarding seabirds, marine mammals and marine turtles.

Besides national surveys, the MPA network also plays the role of a knowledge network. For instance, the coastal birds' observatory has been initiated by MPAs managers. The observatory aims at gathering information collected at the MPA level, and is now the reference dataset for those species and fosters the development of status indicators for those species. The observatory is currently being expanded to create the same kind of network for subtidal habitats, but further work is needed for the other ecological compartments. The surveys at the MPA level are sometimes complemented by technological experiments and several techniques have been tested in collaboration with MPAs managers like shallow habitat mapping using hyperspectral sensors.

Trough the different knowledge acquisition programs, the MPA network has fed the national reference portal (https://inpn.mnhn.fr/accueil/index?lg=en) for natural heritage and contributed to the spread of information on marine species and habitats. Furthermore, the availability of information about MPAs (delineation and regulation for instance) has significantly progressed in the recent years. The development of citizen sciences is also often facilitated by the presence of MPAs and their managers.

The development of knowledge about maritime human activities and their impact on the marine environment is also an important work area. Several background documents were produced to improve the management of various human activities: professional fishing, aquaculture, sports and leisure at sea and military activities and fisheries factsheets are produced at the MPA level which is often the relevant scale in terms of social and economic aspects for this activity. An EU LIFE project is currently under way to improve recreational fishing by hand.

MPAs appear to be areas of particular interest for marine research. They have privileged bilateral or multilateral collaborations with scientific organisations and MPAs are often included in national or international research programmes. Furthermore, the French MPA Agency launched a group of scientific interest (a typical status in France), HomMer, dedicated to marine social sciences and aiming at gathering scientists with different backgrounds working on those issues. Last, but not least, the MPA network has enabled to develop new research areas such as the assessment of marine ecosystem services, the maritime cultural heritage or underwater landscapes.

3.2. A network that contributes to the good environmental status of marine ecosystems

In line with works about ecological coherence of MPA networks carried out at the international level, the French MPA network, in mainland marine waters, has been assessed against usual criteria (OSPAR Commission, 2013) such as: representativeness, replication, adequacy, viability, connectivity.

The work explored national datasets issued from the national knowledge programs mentioned above: CARTHAM (for marine habitats, http://cartographie.aires-marines.fr/?q=node/43), PACOMM (for seabirds and marine mammals, http://cartographie.aires-marines.fr/?q=node/45); but it also took advantage of the national network for seabirds (nesting datasets, waders), broadscale datasets such as bathymetry and predictive habitats maps (EUSeaMap) and previous works on the same topic (MAIA, http://www.maia-network.org/homepage/documents/273_1527/maia_database_first_analysis___impac3_posters and PANACHE, http://www.panache.eu.com/upload/iedit/12/pj/2257_6095_shortversionreportWP1GB.pdf projects). Not surprisingly, the assessment highlighted significant gaps of the MPA network in offshore areas:

- deep-sea habitats, in particular several canyons and cold water corals associated with reefs;
- cetaceans in general and especially the common bottlenose dolphin and the harbour porpoise which are targeted by the Habitat Directive;
- seabirds which can have a pelagic behaviour such as shearwaters, storm petrels, auks, the northern fulmar, the gannet and the black-legged kittiwake;
- elasmobranchs, which in facts represent mainly knowledge gaps.

On the other hand, the MPA network meets most of the criteria for coastal ecosystems like nesting areas for seabirds and coastal birds, coastal habitats, seals and anadromous or catadromous fishes. Of course some gaps or uncertainty remain (like feeding areas for seals but a study in the Iroise Marine Natural Park indicate that the movements of the colony are well covered by the MPA network), and in general for those species or groups of species, it is considered that the MPA network could contribute to improve the conservation status, as long as it is adequately managed.

Last, the assessment of connectivity is still challenging, a geometric approach enables to highlight the main gaps and more in-depths studies exists, but it hardly captures the whole range MPA networks objectives. Of course, the few analyses conclude that the connectivity is likely for coastal features but uncertain otherwise.

Strategic area – Strengthen the creation of natural reserves or highly protected areas

Only one natural reserve has been created since 2012, although more than 20 projects exist. Apart from the creation of new "highly protected" MPAs (such as natural reserves or national parks core areas), the development of highly protected areas has been very slow too (areas where one or many activities are regulated and controlled). In mainland waters, the coverage of highly protected areas reaches 0.26 % overall; and 0.54 %, 0.11 % and 0.22 % for the subregions (respectively Channel, Atlantic and Mediterranean).

Furthermore many gaps exist in terms of coverage, several features are not replicated (e.g. maerl beds or zostera beds) or even not represented (e.g. sabellaria reefs, cold water corals) in the highly protected areas.

Strategic area – Monitor and assess management outcomes

The implementation and the spreading of the **dashboard method** aim at providing a systematic approach to MPAs, in order to be able to assess the progress of the MPA network. The dashboard reports the progress made by the MPA towards its objectives. To date, around 20 MPAs are involved in the process (MNPs, NRs and an experiment was trialled in two Natura 2000 sites). The Iroise MNP is the only MPA to have a fully operational dashboard: the indicators have been assessed on a yearly basis for 5 years (it now covers more than 75 % of the indicators foreseen by the management plan). Important methodological work has been carried out to facilitate the implementation of effectiveness assessment by MPA managers and this topic is now part of the national guidelines to elaborate management plans for Protected Areas. The methodology has proved to be fundamental for MPA management, from setting up objectives to the use of the indicators results, the dashboard is at the heart of the management process. An indicator catalogue is in progress, to disseminate and standardize the indicators; and to enable network assessment in the long run.

The **IUCN green list** represents prospects to broaden the framework and especially to take into consideration the governance aspects. 3 French MPAs (one overseas) have been part of the first global tranche of 23 Protected Areas to be labelled by the green list.

3.3. A network that contributes to the maintenance or sustainable development of maritime economic activities

To a wide extent MPAs are not synonymous with important bans of human activities. This principle suggests that human activities can cohabit with MPAs and sometimes MPAs can even provide social or economic benefits.

In most cases, the role of the MPA (or MPA manager) is to enhance **the compatibility between the human activities and the ecological objectives**. A wide range of tools are available to allow this compatibility, from regulation to contractual or non-contractual:

- Regulation: as detailed previously (in the Highly Protected Areas section), the proportion of MPAs that is regulated is quite small. In such cases, stakeholders are always consulted and where possible, specific procedures are put in place to accompany changes in activities.
- Notices: under various mechanisms, several MPAs categories are entitled to formulate notice for the marine activities which can have potential impacts within their perimeters. Those notices can be informal or prescriptive and they are in general favourable. In MNPs for instance, the rate of negative advices stands below 5 %. The main reason is that MPA managers often work in collaboration with project's holder to enhance the quality of the project before the submission.
- Charter (contractual or not): in Natura 2000 sites, charters consist in a commitment by project's leaders to comply with the conservation objectives of the site. It prevent project's leaders from doing appropriate assessments, for instance for the organisation of nautical events. This mechanism is frequent but can be demanding for MPAs managers in administrative terms, and progresses can be made in experience sharing.
- Certification: for activities that are not compelled to carry out impacts assessments, certification is an opportunity to encourage best practices, bearing in mind that it might contribute to develop the activity. Labels are put in place for diving clubs for instance.
- Awareness-raising: this can be directed to professional or non professional sea users and can take various formats: training, leaflets, spread out of specific tools (like measures devices for recreational fishing).
- Training: a dedicated body is in charge of the training of Protected Areas managers and delivers specific training on the marine environment.
- Consultation: all MPAs have their own management board which aims at representing the different users involved in the use of the area. It is the forum where measures are discussed before they are proposed and endorsed by the competent authorities. Prior to the MPAs designations as well, stakeholders are specifically consulted and citizen via public inquiries.
- Partnerships: the French MPA Agency is bound by several conventions with national re-

presentatives of various human activities such as professional fishing, recreational fishing, scubadiving, leisures boat, sailing or kitesurfing.

The Natural Marine Parks (MNPs) and the National Parks (NPs) represent two particular MPAs categories as they can provide active **support to the development of human activities** (financially for instance), as long as they respect the objectives of the MPAs of course. This support tends to be directed more frequently to fishing activities in the MNPs: for instance scientific programmes targeting exploited species like bass or lobster tagging. On the other hand, within the NPs, sustainable tourism benefits from several actions such as quality labels for whale-watching activities or the brand Esprit parc national for several touristic activities.

The assessment of **ecosystems services** remains rare in MPAs and in the marine environment in general. In French metropolitan waters, two main projects have contributed to develop this approach in MPAs: an assessment of the total economic value in the National Parks and the Valmer Interreg project with UK partners in 6 pilot sites in the Channel and the Atlantic. The exercise in the NPs shows that benefits associated with the area located within the MPA exceed by far the costs, but these results should be taken with caution as the value corresponds to the use of the area, which can be independent from the existence of the MPA. Furthermore this can plead for increasing the touristic activities, which then generates more pressures. In the Valmer project the ecosystem accounting enabled to link the management efforts to the benefits in terms of human activities and it was also useful to promote an integrated approach in the management. In both cases, an important lesson learnt was that the monetary assessment entails several pitfalls and should be used very cautiously.

Strategic area – Contribute to the management of fishing resources

In general, the management of fishing resources is not targeted directly by MPAs. Natural reserves, National Parks and Marine Natural Parks can contribute to the conservation of exploited resources but also the ecological functions. For instance, the functional interest of a submarine dune was taken into account when considering the extension of a sand extraction project in the Iroise Marine Natural Park (the project did not occur finally). In the Port-Cros National Park, based on fishermen advice, a ”resource area” was created to enhance the fishing resources. Otherwise, National Parks and Marine Natural Parks can support the development of fishing activity, as long as it meets the MPA objectives, in different ways: scientific studies (ursin fishing in the Golfe du Lion MNP), scallop seeding in Iroise or improvements of fishing gears.

To a lesser extent Natura 2000 sites can contribute to the management of fishery resources through the conservation of habitats functions, very few examples exist, but we can mention the Baie de Seine occidentale Special Area of Conservation which protect flat fishes' nurseries in the sandbanks habitat.

The creation of a new MPA category, Fisheries Conservation Areas, is still pending the adoption of the new Biodiversity law. This type of MPA should enable to prevent damages from all activities to functional areas.

Strategic area – control

MNPs, NPs and NRs generally have their own means of control (boats and sworn in staff) but the situation varies mainly due to the size of the MPA. In NRs, it does not exceed 4 people in most cases, whereas in NPs there can be up to 50 sworn in employees (with half of them dedicated to the marine part) and in MNPs, the operational functioning relies on a field team of 10 to 15 people. Only a small part of the infringements are billed (around one tenth in the NPs for instance), and field officers favour information and awareness-raising.

Apart from the internal resources, the coordination of external means is a key aspect in terms of control (for instance Natura 2000 sites does not have their own means, except very few cases). To that respect, progress has been made in 2015 with the implementation of a ministerial coordination system for the control of the marine environment. It is now concentrated on the means of the Ministry of Ecology and in the mainland waters; but it should be widened in the near future. It has already led to a pilot control plan for the MPAs and the marine environment in the western Channel and north Atlantic part of the French waters. This plan has been realised in close cooperation with MPAs managers so that the control effort targets the main ecological stakes.

Last, new technologies, like remote-sensing detection, are being tested to improve the control capacity.

3.4. A network included in the integrated policies for marine environmental management and which contributes to the land-sea coherence of public policy

The MPA network is now addressed by the various environmental policies as well as the different sector-based policies. However it cannot be considered as fully integrated and several areas of progress are possible.

At the European level:

- The new Common Fisheries Policy and the Maritime and Fisheries Fund provides a better legal and financial framework to enhance the compatibility between the fishing activity and the ecological stakes within Natura 2000 sites and MPAs in general. The transposition into the French law is in line with this evolution, although the operational programme has not been implemented yet.
- The French programme of measures under the Marine Strategy Framework Directive foresees some developments of the MPA network such as new offshore Natura 2000 sites and highly protected areas and the monitoring programme is partly managed by the French Agency for MPAs (the marine mammals, seabirds and benthic habitats sections). However the implementation is also under way and some aspects remain challenging such as the funding of the monitoring and the necessary developments to assess the environmental status.
- The water development plans that are elaborated to meet the requirements of the Water Framework Directives still lack taking into account all types of MPAs, beyond Natura 2000 sites. Some progresses are made enabled through large MPAs, like Marine Natural Parks which enable discussions between the marine and water governance boards.

The assessment pointed out that **sector-based frameworks**, either at national or local levels, now identify MPAs more frequently. For instance MPAs are mentioned in the planning of offshore windfarms, dredging or sand extraction, even if some improvements are still possible. Indeed the ideal planning does not consists only in avoiding MPAs which could be the simplified approach in terms of planning, but rather to strike the best balance between the economic development and the impacts on the marine environment, within and outside MPAs.

In terms of **integrated management** and **planning** of marine activities, the large MPAs can act as a laboratory. The approach of the “vocations’ map” in the Marine Natural Parks follows this objective. This tool is embodied in the management plan and draws the collective vision for the next 15 years regarding the levels of protection that are expected for the different areas of the MPAs: protection, reasoned use or sustainable development.

Last but not least, **the land-sea dimension** entails several shortcomings. Besides the issue of water quality mentioned previously, the examples of coherent management of the land-sea interface are quite rare: some contiguous protected areas (marine and terrestrial) have implemented specific actions of cooperation and means of governance; and the National Parks which have important terrestrial part represent the best context to reach this coherence. Similarly, the involvement of local authorities in the management of MPAs, either financially or through the governance system, can help in driving the policies at land to integrate the marine issues; but the situations remains widely heterogeneous among those authorities.

Strategic area – Make use of and pool the existing tools

The French MPA network is composed by fifteen MPA categories and twelve of them apply to the metropolitan waters. This leads to frequent overlaps between MPAs from distinct categories and around 30 % of the protected waters are covered by at least two MPAs. The “melting” of MPAs is nonetheless very unusual, even when they have similar protection levels. Since 2015, the *Réserve nationale naturelle de l’archipel de Riou* which have been absorbed by the *Parc national des Calanques* is the only case. The regulation of the reserve has been transposed into core zones of the National Park (and the staff integrated in the new structure).

Retrospectively, it appears that overlap should be considered more carefully at the designation stage even for MPAs that do not provide additional protection (such as most of the MPAs designated under the Regional Seas Conventions). Indeed these situations do not help the stakeholders in identifying the usefulness of the various devices and some overlaps create difficulties in terms of governance.

Significant efforts are made to make it work and to coordinate the national policy at various levels. Among MPAs managers, a project carried out in 2012 led to a background document “Protecting the sea together, how does it work?” (Luneau, 2014). In the north of France, within and around the territory of the *parc naturel marin des estuaire picards et de la mer d’Opale*, a pilot exercise of “common management document” is implemented. Through a single document produced collaboratively, this aims at enhancing the coherence and pooling the resources of the various protected areas in terms of conservation objectives, monitoring, actions plans strategies and governance.

Strategic area – Encourage adaptive management

The idea of evolving measures, spatially and temporally, is not realistic to date in the French MPAs and the MPAs do not really have the means to implement adaptive management. The main driver for adaptive management is the existence of an assessment device to know whether the MPA is moving towards its conservation objective or not. This is one of the objectives of the dashboard which is implemented in few MPAs and shall help the manager to prioritize and drive its actions plan. However this has yet to developed in those MPAs and spread out at the network level.

3.5. A network that meets multi-scale objectives

In terms of coverage and to some extent in terms of ecological coherence, the French MPA network in metropolitan waters is in the way of meeting those various objectives: exceeding Aïchi targets, fulfilling the requirements of the European directives and Regional Seas Conventions commitments but also national objectives (20 % MPA coverage is the goal of the French strategy). However the question of effectiveness, which is not the least challenge, remains. As described previously, knowledge lacks to have a clear idea about the conservation status of the protected features, but in the few cases where features were assessed, the results point out significant gaps with the conservation objectives. Indeed among the Natura 2000 features, it results from the last assessment (2013) that the conservation status is unfavourable (bad or inadequate) for 13 out of the 15 assessed marine habitats and for 14 out of the 16 assessed marine species (plus unknown for 28 features).

Furthermore, within Regional Seas Conventions, beyond the achievements in terms of coverage, the usefulness of those designations is limited. Most of them represent overlays of existing MPAs, designated under national or European legislation without addressing more particularly the species or habitats listed under those conventions. The marine mammals Pelagos sanctuary is the main exception.

Strategic area – Estimate financial costs

The total budget allocated to the MPA network (including overseas territories here) represents around 60 million euros, born in majority by the State (40 million euros). But there is an important gap between the current and the foreseen situation which plans a budget of 170 million for an MPA network covering 20 % of the French waters (around 16.5 % to date). The discrepancy impacts severely the Marine Natural Parks and to a lesser extent National Parks, Natural Reserves and Natura 2000 sites and some projects are still standing by such as the areas for the conservation of fishing resources.

In parallel of the development of the MPA network, financing options to complement the State budget have been considered but none of them have been concretized: taxes or fees on anchoring, the occupation of the maritime domain, the extraction of mineral resources or touristic activities for instance.

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Canyon heads in the French Mediterranean Sea - Conservation issues

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Abstract

The numerous submarine canyons cutting across the Mediterranean continental shelf represent key habitats for understanding and managing the biodiversity of coastal areas and the continental shelf. The canyons are extremely frequent in the Mediterranean Sea. They are a pathway of transferring matter between the coast and the deep sea. They can represent biodiversity hotspots and recruit areas for many species.

Knowledge of these poorly studied habitats is crucial for the implementation of the Barcelona convention, to extend Natura 2000 offshore network, to define new marine protected areas and to build their management plans.

The MEDSEACAN and CORSEACAN data acquisition campaigns were organized from 2008 to 2010 between Spain and Monaco, and off the western coast of Corsica. These cruises aimed to obtain a reference state of the ecosystems between a depth of 100 and 700 metres, including specific information about the presence and distribution of deep-sea corals and specific biological species (fish, crustaceans, cnidarians), and data about these ecosystems and the impact of human activities in these particularly vulnerable areas.

These campaigns are conducted by the French Marine Protected Areas Agency in partnership with various scientific and were the very first attempt to systematically explore the French Mediterranean deep sea canyons.

The surveying effort was distributed as equally as possible among canyons in order to allow comparisons. The canyon slopes were explored using the same methodology. The description of the environment is based mainly on the acquisition of image data (photos, video) obtained from manned or unmanned submarines. Megafauna species were visually identified based on samples taken during the campaign where possible. The same scientific treated team the data (568 hours of diving video records including 18 hours of HD video, 17600 HD photos, dozens of samples).

We can do general remarks:

a. There is a great heterogeneity between the canyons as regards their shape, geology and distance from the coast,
b. A brief review of the biodiversity shows some significant differences between the rocky canyons: the canyons in the eastern part show that the presence of hard substrates does not necessarily mean that there is any significant fixed fauna. Many vagile, or even fixed species, were observed in some silted canyons,
c. Certain species observed are very rare in the Mediterranean and descriptions were brief. Several of these species are considered to be endangered by the IUCN,
d. New occurrences of cold corals were observed.

The anthropogenic impact is easily visible with a clear accumulation of waste (mainly plastic) where the continental shelf is narrow and the canyons are close to large cities such as Marseille and Nice. On the silted canyons in the Gulf of Lion, fishing activity is visible (traces of trawl nets). In canyons with rocky slopes, there are many lost nets and longlines. On the Corsican canyons, the communities are in a good state of preservation instead of continental canyons.

The acquisition of data from these campaigns contributes to scientific research in various disciplines (biology, zoology, ecology, geology, oceanography, etc.). Data compiled in a Geographic Information System is available to scientists and has already been used for several publications.

Data have clarified the boundaries and issues of two marine protected areas. The Lacaze-Duthiers and Cassidaigne canyons are exceptional biodiversity hotspots. In the Lacaze-Duthiers canyon, exuberant colonies of *Madrepora oculata* and *Lophelia pertusa* were observed, together with numerous vagile and sessile species. The colonies of *Lophelia* are the largest ever observed in the Mediterranean to date. Biodiversity in the Cassidaigne canyon is heterogeneous, although a highly varied fauna was found in one localized sector - with a diversity of anthozoans observed nowhere else in a single site. These observations fully justify that these sites were specifically protected through new marine protected areas:

a. The canyon heads of Lacaze-Duthiers and the two canyons further east have thus beenincorporated into the Gulf of Lion marine nature park boundaries,
b. A part of the Cassidaigne canyon is included within the Calanques national park.

The results of MEDSEACAN-CORSECAN campains are currently being used by French Museum of Natural History to improve the current typology of deep marine habitats in Mediterranean. The main changes concern bathyal rocky habitats.

Data have contributed to the establishment of the initial assessment of the bathyal benthic ecosystems in French submarine canyons of the Mediterranean for Marine Strategy Framework Directive.

Marine Conservation in Portugal - Recent Progress and Perspectives

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1. Introduction

Portugal in world history is acknowledged as a maritime nation which set new routes across the Ocean. Nature conservation in a modern form came in 1971 with a marine Reserve designated around the Salvages, a small volcanic archipelago, 160 nautical miles south of Madeira Island. This protected area marked an early start for marine conservation as we understand it today and introduced some new concepts (Santos Júnior, 1971). Strict protection measures based on the "nature sanctuary" concept were considered and these were in line with classic views from the Naturschutzgesetz of 1935 (RNG). But they did come out mixed up with state of the art views on the governance and management of marine resources. This piece of legislation (Decreto nº 458/71, publ. 29 October 1971) was contemporary to international debate on the developing concept of Exclusive Economic Zone (EEZ) and the United Nations Convention on the Law of the Sea (UNCLOS).

Following abrupt change in its home politics in 1974, Portugal set up a network of protected areas under national legislation. A few international agreements were instrumental to support this effort and the Ramsar Convention was especially noteworthy by that time. Nature Reserves were declared in wetlands, either on the big estuaries or in coastal lagoons. This brought a positive contribution to the conservation of marine ecosystems in adjacent coastal areas.

Portugal joined the EU in 1986 and a subsequent build-up of Natura 2000 sites contributed to expand further the network of pre-existing protected areas. Outstanding progress was achieved in Madeira and in the Azores at this stage. Some prime marine sites there eventually became OSPAR MPAs.
These marine sites were set up mainly in coastal areas, around important features ashore. They often included important seabird breeding sites.

2. New facts and changing perspectives

In 2009 Portugal submitted to the Commission on the Limits of the Continental Shelf a claim to the seabed and subsoil beyond 200 nautical miles, based on a series of recent geological surveys. According to UNCLOS this brought under Portuguese jurisdiction a substantial marine area on the seafloor of the NE Atlantic, that currently stretches over 3,800,000 km^2.

Portugal therefore has the opportunity (and the international duty according to UNCLOS) to bring sound conservation principles to the management of these new areas. This makes an excellent case to develop a coherent network of MPAs across the whole marine area under Portuguese jurisdiction.

There are still many gaps in our global understanding of the deep sea ecosystems and a precautionary approach is often required. To avoid costly mistakes and to ensure wise use of any living and mineral resources we need a coordinated effort and cooperation with relevant partners worldwide.

Portugal has taken important steps to fulfill the purpose of keeping environmental sustainability in the areas within its national jurisdiction, and is promoting solutions for enhanced marine governance.

Deep-sea fisheries are often blamed for their negative impact on biodiversity of vulnerable marine ecosystems and could be a threat to the species and habitats on the seabed (Gianni 2004; FAO 2009). PT legislation was passed in 2014 to ban the use of fishing trawls and other bottom contacting gear (except for longlines) in most seabed areas under Portuguese jurisdiction. These measures aim to protect seabed integrity but so far they apply only to those fishing vessels flying the Portuguese flag. There is now a formal request by the PT authorities to the EU Commission, in order to make the same rules applicable to all fleets under the Common Fisheries Policy (CFP). The new seabed protection area is a little bit over 2,277,800 km^2 and it is illustrated in Figure 1.

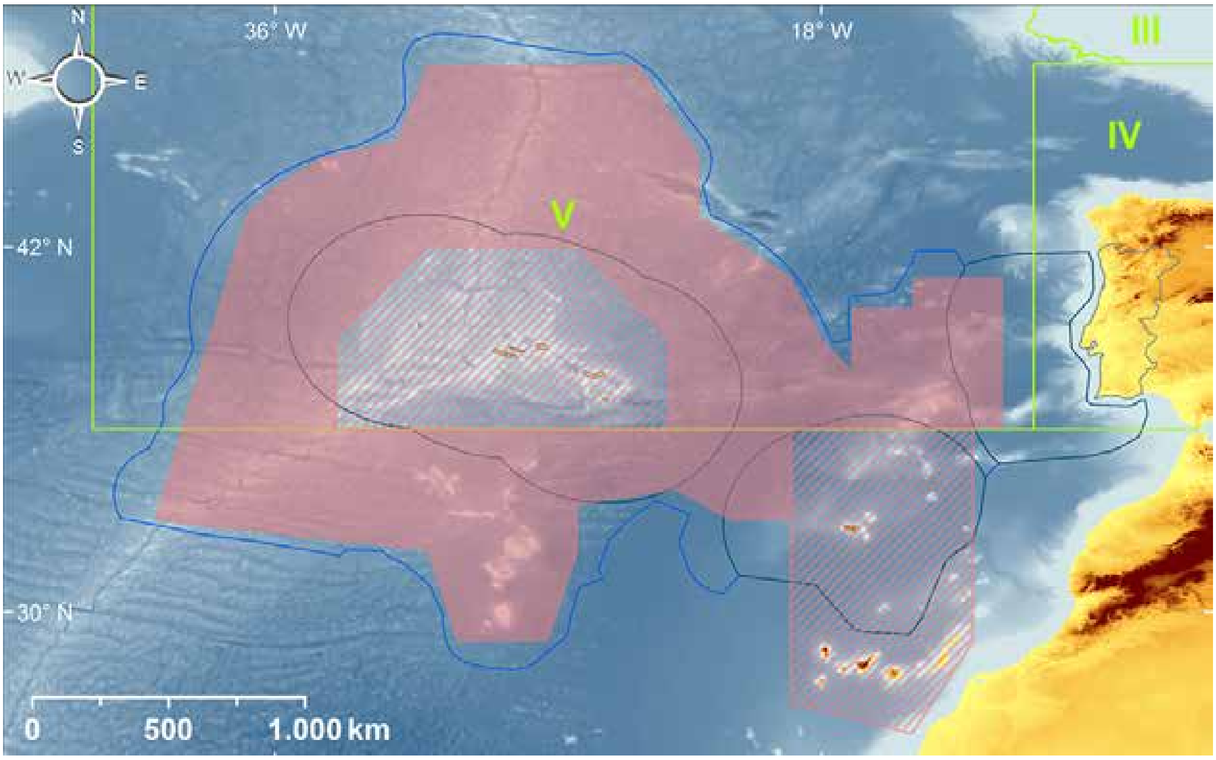

Figure 1: The huge area declared by PT in 2014 to exclude bottom contacting gear (except longlines) from operating in deep water habitats throughout most of its marine jurisdiction. This measure was established in Portuguese legislation (Portaria 114/2014 from 28th May) and includes most of the new seabed territories in the PT claim to the extended continental shelf under UNCLOS. Purple hatched areas refer to Council Regulation No. 1568/2005, adopted in 2005, which prohibited the use of bottom trawl and bottom gillnets below 200 m in EU waters around Madeira, the Azores and the Canary Islands. The new protection area decided by PT is complementary in shape and size to the protection areas already considered in article 34d of Council Regulation (EC) No. 850/98, from 30 March 1998, where measures were defined to protect vulnerable deep-sea habitats in the NEAFC Regulatory Area, including the Azores, the seas around Madeira Island, and in the Canaries. Blue lines in the map show the geographic limits of PT jurisdiction. The boundaries of OSPAR regions are marked in light green: III (Celtic Seas), IV (Bay of Biscay and Iberian Cost) and V (Wider Atlantic).

Figure 2: The new OSPAR MPAs declared by Portugal in February 2015. They contain representative samples of the species and habitats occurring in PT territorial waters on the western coast of Iberia.

3. The new Portuguese OSPAR MPAs

3.1 Territorial waters on the Portuguese mainland

In February 2015 Portugal has contributed five new sites within its territorial waters off western Iberia to the OSPAR network of MPAs. Formal designation was forwarded to the Secretariat, together with technical information in standard forms as required to complete the designation process. Combined area of the new OPAR sites is 536.27 km^2 overall and they are illustrated in Figure 2.

3.2 OSPAR MPAs on the seabed of PT extended shelf

In addition to the coastal waters on its mainland territory Portugal is taking measures to protect also important areas offshore. These include the seabed of seamounts Altair and Antialtair, plus a large area of the seafloor on both sides of the Mid Atlantic Ridge North of the Azores (MARNA):

- Altair Seamount - total area of 4,408.71 km^2 – the seabed and subsoil below the water column of the corresponding OSPAR High Seas MPA;
- Antialtair Seamount - total area of 2,207.68 km^2 - the seabed and subsoil below the water column of the corresponding OSPAR High Seas MPA;
- MARNA - total area of 93,568 km^2 – same as for the two previous MPAs.

These deepwater MPAs are illustrated in Figure 3 and their seabed areas are part of the Portuguese claim to the extended continental shelf. It should be noted that the superjacent water columns are Areas Beyond National Jurisdiction (ABNJ) and they are not in the EEZ of PT. They were declared High Seas MPAs following a collective arrangement by all OSPAR

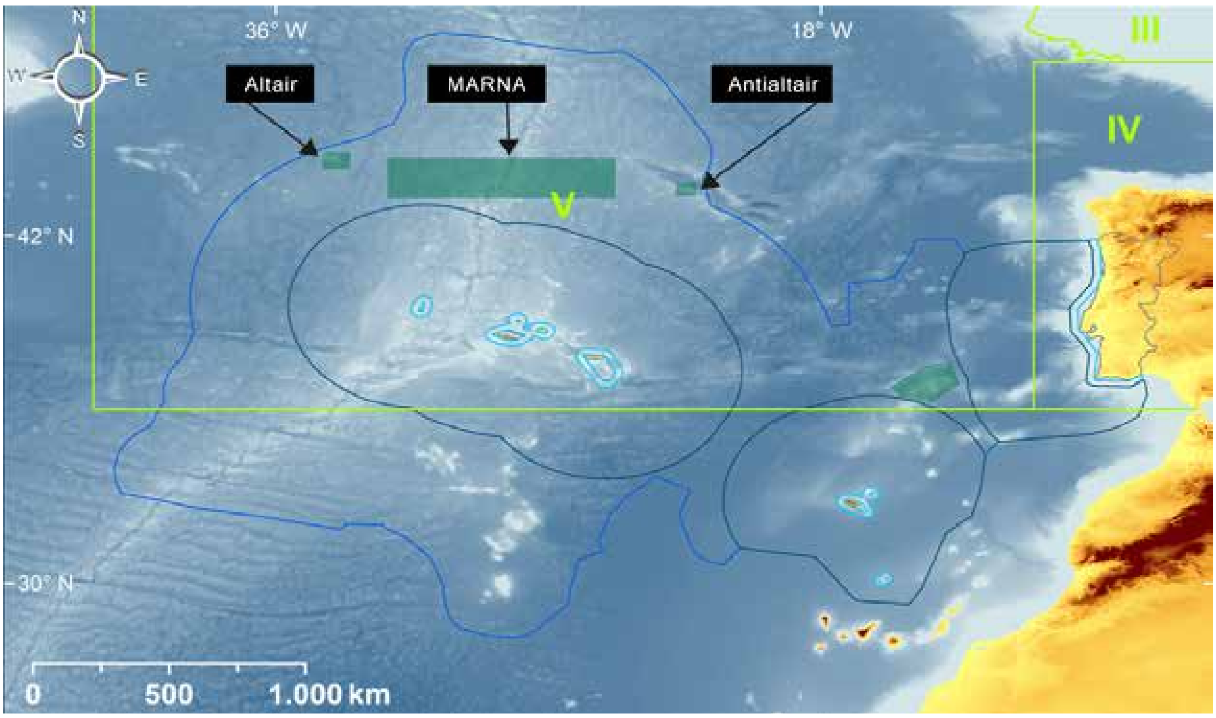

Figure 3: The new oceanic MPAs on the seabed of Altair and Antialtair seamounts, and on both sides of the Mid Atlantic Ridge North of the Azores (MARNA). PT now affords protection to the seabed and subsoil within its jurisdiction (UNCLOS) to complement protection of the water column in existing OSPAR High Seas MPAs.

Contracting Parties, pursuant of a decision invited by Portugal at the OSPAR Ministerial Meeting 2010 in Bergen / Norway (OSPAR 2013).

3.3 The new large Oceanic MPAs

To help with building up a coherent global network of Oceanic MPAs in the NE Atlantic, Portugal has decided to designate also one pair of very large marine protection areas offshore. These were delineated around large seamount complexes within limits of PT national jurisdiction. Where necessary, the protection of complementary marine areas in the High Seas adjacent to the MPAs will be addressed in OSPAR.

The Madeira-Tore MPA covers a total area of 139,406.53 km^2 on the seafloor of a very complex geological region stretching between Madeira Island and Cape St. Vincent (on the SW tip of the PT mainland). Water columns in the MPA that fit in the PT EEZ are also included (with 103,006.17 km^2). The MPA comprises seamounts Seine, Unicorn, Lion, Dragon, Horseshoe, Josephine, Gago Coutinho, Hirondelle, Ashton, and Tore, plus many smaller features. The Gorringe Bank is also part of the MPA, with its slopes that rise steeply from abyssal depths in excess of 5 000 m to just a few metres below the ocean surface and reaching well into the photic zone (Figure 4). In fact the Gorringe Bank rises up to peak Ormonde (33-46 m) and culminates at peak Gettysburg (28 m). In days of calm weather its summit may be visible from the surface.

The Gorringe Bank is comparatively well-studied in the context of all PT offshore and deep sea areas (Albuquerque 2013; Oceana 2014, Vieira et al. 2015). In July 2015 it was included in a national list of Sites of Scientific Interest (SSI) to the EU habitats directive and became therefore a candidate site to Natura 2000.

PT jurisdiction in the Madeira-Tore applies to a wide range of areas of the seabed and in the subsoil; two thirds of the water column above the MPA are included in the PT EEZ; another part (above Josephine Seamount) is in the High Seas. The northern part of the MPA is included in Regions IV and V while the southern part is outside the OSPAR Area.

It should be noted that the OSPAR Commission has published, in its Biodiversity Series, important reference documents where the conservation values of these areas are discussed in some detail (OSPAR 2011a - d). All these publications make a case for declaring MPAs.

The limits of the Great Meteor MPA are delineated around a huge underwater archipelago south of the Azores. There is a complex pattern of jurisdictions much like in the Madeira-Tore MPA. The protected area will cover a total area of 123,238 km^2 on the seabed and subsoil (with only 13,788 km^2 below water columns in the PT EEZ). The Great Meteor underwater archipelago stands to the south of Region V, which makes it not eligible for the OSPAR network. The MPA includes seamounts Great Meteor, Small Meteor, Plateau, Hyères, Irving, Plato, Atlantis, Tyro, and also Cruiser underwater plateau (Figure 5).

4. Portuguese EBSAs and OSPAR

As part of the ongoing process of marine surveys there are now a few areas identified on a broad scale that shall meet the scientific criteria to be part of the EBSA network under the UN

Figure 4: Shape and size of the proposed Madeira-Tore MPA. Portugal is making up a new large oceanic MPA and parts of it are in OSPAR regions IV and V. These parts will be added up to the OSPAR MPA network. The dark green areas are in OSPAR waters while areas painted in light green are outside OSPAR waters.

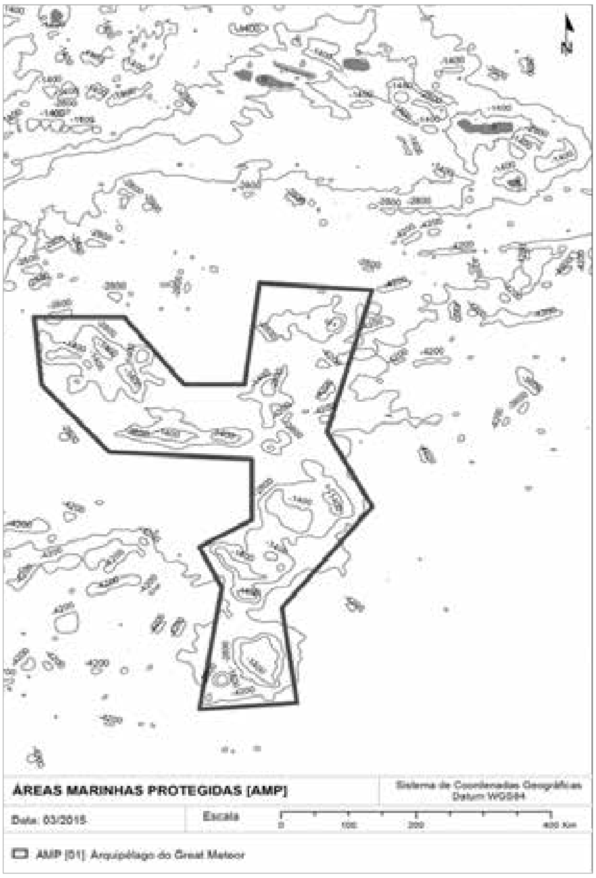

Figure 5: The shape and size of another large PT oceanic MPA, delineated around the Great Meteor seamount complex south of the Azores. This MPA fits entirely to the south of the OSPAR Area. Therefore, it is not eligible to become part of the OSPAR network.

Convention on Biological Diversity (CBD).

In addition to the new large oceanic MPAs of Madeira-Tore and Great Meteor, the Portuguese authorities are willing to submit also other areas in the NE Atlantic to be part of the CBD EBSA network. These areas are illustrated in Figure 6 and will include:

- One large stretch of seafloor along the Mid-Atlantic Ridge to the North of the Azores (MARNA), shaped in the form of a wide longitudinal band that spans from the outer limit of the territorial sea (12 nautical miles) around the Azorean shoreline to the outer limit of the PT expanded shelf in that area;
- Another large stretch of seafloor along the Mid-Atlantic Ridge South of the Azores (MARSA), also in a wide longitudinal band that starts at the outer limits of the territorial sea there (12 nautical miles), and runs down to a line (not yet defined) that would be close to the southern limit of the PT extended shelf.

It should be noted here that the geographic limits of the candidate PT EBSAs are not fully decided yet. The issue is by no means closed, either on a scientific perspective or simply based on policy grounds. Further discussion will happen in 2016, involving different levels of the PT Administration.

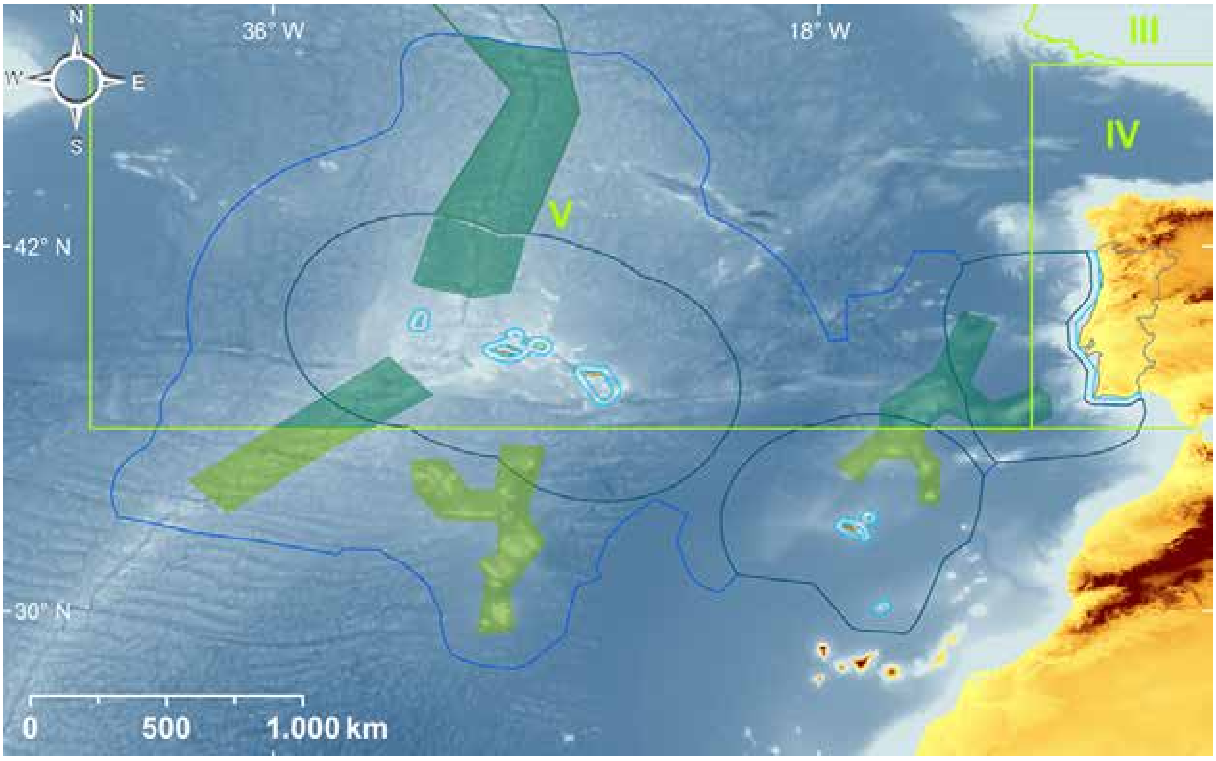

Figure 6: Marine areas under Portuguese jurisdiction in the North-East Atlantic that meet the EBSA criteria and may therefore qualify for submission to the CBD. The boundary lines of the two very large areas running alongside the Mid-Atlantic Ridge still need clarification and limits are not closed yet. Color codes in the figure are: Dark green – areas included in OSPAR waters; light green – areas that are not in OSPAR waters. Straight lines painted in a bright green color show the limits of OSPAR Regions III, IV and V. The blue lines in the map refer to areas with different types of PT jurisdiction (territorial waters, EEZ, extended shelf).

The geographic limits of the two large areas running alongside the Mid-Atlantic Ridge also still need clarification and the delineation of these areas is not closed yet.

5. Problems encountered in the nomination process

Various problems had to be tackled in the nomination process, including:

- The huge size of the offshore areas, their remoteness in the wide ocean and the high financial costs to working there. Scientific data is often scarce and there is a lack of reliable background information for many of the species and habitats in some areas. Eventually it may not be possible to obtain all information that would be required to make reliable historical assessments reaching back over extended periods of time. Some of these drawbacks may be partially overcome through intensive data mining and by collating information obtained from many different sources, available in Portugal and abroad.
- Complexity of the legal framework about jurisdiction in the oceans and management of human activities in marine areas is a real problem. Time-consuming arrangements were required in the national context and the job is not finished yet. There is an obvious need to reach a common perspective for the MPAs, and to ensure that the jurisdictions of managing bodies are respected. Constitutional rights must also be shared adequately among the national Government (PT mainland) and the Regional Governments in the Azores and Madeira. The importance of these issues shall not be underestimated. Things must be addressed properly and this kind of work is pretty much time-consuming. Complex negotiations are

often required and wise decisions shall be made before any real progress is achieved.

- Different interpretation of legal issues among the relevant persons and institutions involved which caused a need for clarification about the responsibility and sovereign rights of the Coastal States, as compared to the role of supranational bodies.

6. Methodological approach for area delineation

An easy straightforward approach was used to delineate these areas whenever possible. The large oceanic MPAs were shaped like rather simple geometric polygons defined by geographic coordinates. These were picked up to include seamounts and chains of underwater physical features that are associated with rich wildlife assemblages and boast high conservation value. Our efforts are based on the best scientific data available combined to expert judgement. Key points in our analysis include the following: a) the presence of large seamount areas associated to known aggregation of priority species and habitats; b) well-documented occurrence of active hydrothermal vents on the seafloor.

In the case of EBSAs, we took large areas of the seafloor with important biological or ecological features associated to the Mid-Atlantic Ridge. These areas were then encased in a polygon made up of straight lines drawn between points marked around them. Our approach is highly precautionary and allows for a subsequent fine-tuning of high priority conservation areas and buffer zones inside the MPA, as necessary.

Further studies will be required in the future, but essential values in the MPA shall be secured at an early stage. This approach is in accordance to the sound principle to "err on the side of caution and protect the widest-possible areas of ecologically important deep sea" as suggested by experts in the field (Weaver & Johnson, 2012).

7. Concluding remarks

Extensive as it may seem, the current survey on Portuguese MPAs still leaves room for further development. Just to prove the point, three large MPAs are planned at major underwater canyon systems off western Iberia (Nazaré; Espichel / Comporta; and Cape St. Vincent) to help preserve Vulnerable Marine Ecosystems (VME) and to highlight the need for cetacean protection in deep water close to the Portuguese mainland.

Coming closer inshore, there are still quite a few very important small areas left with an amazingly diverse collection of species and habitats of high conservation value. These sites must be preserved from damage, and sustainable management practices by local stakeholders should be encouraged there.

Once designated, the new MPAs will be submitted to OSPAR to be part of the OSPAR MPA network. Attention shall be paid also to the possibility of including parts of them in the Natura 2000 network. Quite obviously, when the task is completed there will be no shortage of MPAs in Portuguese waters.

The challenge ahead is how to ensure adequate management of all these MPAs.

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Progress in marine coastal conservation in the Azores

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1. Introduction

Global efforts to implement Marine Protected Areas (MPAs) as a tool for both biodiversity conservation and fisheries management have increased significantly over the last decades (Gell & Roberts 2003, Higgins et al. 2008, Green et al. 2014). Government agencies responsible for the management of marine resources are now obligated to define clear MPA objectives and provide a framework for measuring MPA effectiveness. Much progress has been made since the first MPAs were designated in the 1980's in the Azores (Abecasis et al. 2015). Natura2000 sites, Island Nature Parks (INPs), and the Azores Marine Park (AMP) that includes several offshore MPAs were designated. The AMP and INPs integrate all marine Natura2000 areas and other MPAs and were re-classified according to IUCN categories and objectives. Some of these MPAs are also integrated in the OSPAR MPA network. The Marine Strategy Framework Directive (MSFD) requires assessment and monitoring of the environmental status of marine ecosystems, and the new legal framework of the Azorean network of MPAs calls for monitoring programmes in support of marine management (MAM et al. 2014, SRMCT 2014). However, fifteen years after the first designation of Natura2000 marine sites and the subsequent establishment of the INPs and the AMP, often focusing on areas of great ecological and socio-economic interest, all of these sites still lack effective management plans, adequate enforcement and monitoring programmes (Abecasis et al. 2015). In this context, the coastal network of MPAs was critically assessed and its effectiveness evaluated for supporting future spatial management actions and potentially improving marine conservation in the Azores.

2. Priority habitats for conservation in the Azores

As result of its volcanic origin and location at a tectonic triple junction, the Azores archipelago harbours a variety of marine habitats. Many of these habitats have been listed as critical or priority habitats for protection by international bodies, such as the EU Habitats Directive (Council Directive 92/43/EEC) and the OSPAR list of threatened and/or declining species and habitats (OSPAR Commission 2008). These habitats range from shallow coastal areas to the deep sea.

Island shelves and coastal habitats, together with their associated marine populations (fauna and flora), are spatially restricted and isolated from other habitats/populations. Nevertheless, these areas are essential habitats for certain species and life stages (e.g. nursery grounds for fishes, Santos & Nash 1995). Reefs, marine caves, shallow inlets and bays, which are listed under the EU Habitats Directive, are common features. The coastal areas are extensively used by local fisheries and the leisure industry and thus require adequate conservation and management strategies (Schmiing et al. 2015). The open ocean in the Azores region is a feeding and resting ground for migrating species, such as cetaceans (SILVA et al. 2013) and juvenile marine turtles, including *Caretta caretta* that is protected under the EU Habitats Directive. Furthermore, it is a nursery area and potential pupping ground for juvenile blue sharks (VANDEPERRE et al. 2014). Coastal shores are important breeding grounds for Cory's Shearwater that use the open ocean as feeding area (BIRDLIFE INTERNATIONAL 2004).

Offshore banks and shallow reefs have a high ecological value and often function as (seasonal) aggregation sites for different fish species (e.g. spawning/feeding ground). Only few of such sites are georeferenced and described in the Azores, including aggregations of

iii. mobulid rays that display a certain site fidelity during summer aggregations (SOBRAL & AFONSO 2014);
iv. hammerhead sharks, *Sphyrna zygaena*, with a potential nursery ground at the north coast of Faial (AFONSO et al., unpubl. data);
v. eagle rays, *Myliobatis aquila* (AFONSO & VASCO-RODRIGUES 2015); and
vi. island groupers, *Mycteroperca fusca* (AFONSO et al., unpubl. data), that are endemic to the Macaronesian region.

All of these species are listed as vulnerable or endangered species on the IUCN Red List.

More than 60 large and about 400 small seamount-like features are described in the Azores (MORATO et al. 2008). These habitats are known for their increased biomass, as important feeding and spawning grounds (PROBERT et al. 2007), but also for an increased vulnerability to fishing (MORATO et al. 2006). Together with hydrothermal vent fields they are listed as priorities for protection by to the OSPAR commission and as potential indicators of Vulnerable Marine Ecosystems (VMEs) by ICES (ICES 2013). Hydrothermal vents support a high biomass of an often specialised fauna, including chemoautotrophic bacteria that are the core of the communities (VAN DOVER 2000). Several fields have been discovered in the Azores but only few are protected against human threats. VMEs are groups of species, communities or habitats that are potentially vulnerable to impacts from fishing and are easily disturbed and very slow (or never) to recover (FAO 2009). In 2006 the United Nations General Assembly Resolution 61/105 (UNGA 2006) called "upon States to take action immediately, individually and through regional fisheries management organizations and arrangements, […], to sustainably manage fish stocks and protect vulnerable marine ecosystems …". Although first sites, such as cold-water coral reefs, have been described more research is needed to get a realistic picture of the occurrence and distribution of these critical habitats on an archipelago-wide scale.

3. Regional network of protected areas

Coastal network

The first Azorean MPAs were established in the 1980's. Until 2000, the initial coastal network consisted of nine regional 'reserves', one voluntary reserve and 34 no-take reserves for limpets. These MPAs, however, were rather small, not very representative, dispersed, and often not respected by the community (ABECASIS et al. 2015), and consequently mostly inefficient.

From 2001 onwards, the Natura2000 network was implemented in the region, integrating until today 41 areas: a) 3 Sites of Community Importance (SCIs) and 23 Special Areas of Conservation (SACs), most of them marine (2 SCIs, 17 SACs), and b) 15 Special Protection Areas for marine birds, all of them terrestrial. Management plans, however, have not been yet established for these sites. Between 2008 and 2011 Island Nature Parks (INPs) were implemented that integrate all previously established MPAs, including the Natura2000 sites. One INP exists per island, encompassing several terrestrial and marine areas inside the territorial sea (12 nautical miles). All protected areas were classified according to IUCN categories. Of the 34 MPAs, five are nature reserves (category I) and 29 protected areas for the sustainable use of natural resources (category VI) (GAMPA 2015). Three of the marine sites of the INPs are also classified under the OSPAR Convention (Faial-Pico Channel, Formigas, Corvo). The OSPAR Convention obliges all member states to establish measures for preventing and eliminating pollution, and for protecting the marine environment against negative impacts from human activities to safeguard human health and conserve or restore the marine ecosystem. In addition to the INPs, some small archaeological reserves have been established in several islands (Terceira, São Miguel, Pico, Flores, and Santa Maria) that generally prohibit fishing, except at Terceira, and anchoring. The INP concept offers a good opportunity for progress towards achieving an effective spatial management with multiple objectives (e.g. reduction of conflicts between different users, sustainable management of marine resources, and conservation of biodiversity). However, the design and regulations in practice are sometimes inadequate. Furthermore, management plans, the centrepiece for the operationalisation of this concept, are still missing.

Offshore network

The Azores Marine Park (AMP) includes 11 MPAs outside territorial waters but within the boundaries of the Azorean EEZ and the submitted extension of the continental shelf. The AMP was implemented in 2011 and similar to the INPs integrates Natura 2000, OSPAR, and Important Bird Areas. All MPAs are reclassified according to IUCN categories. Some specific restrictions exist for the AMP but otherwise the legislation is rather general. In four MPAs fishing is only permitted for epipelagic migratory species. Management plans are still in preparation.

In general, bottom trawling and similar gears are banned by EU regulations (Council Regulation (EC) no. 1811/2004) in addition to “the prohibited use of any demersal fishing gear gillnet, entangling net or trammel net at depths greater than 200m and any bottom trawl or similar towed nets operating in contact with the bottom of the sea” (Council Regulation (EC) no. 1568/2005) in almost the entire Azorean EEZ.

Bottom-up approaches

A bottom-up approach resulted in the implementation of the small voluntary reserve ‘Caneiro dos Meros’ in Corvo in 1999. In agreement between fishermen and local Marine Tourism Operators fishing was banned from the area to protect the local biodiversity and support non-extractive activities, namely SCUBA diving. Similarly, four special protected areas were established in Santa Maria (‘dive reserves’) in 2012 with the objective to reduce stakeholder conflicts. These small areas prohibit fishing and regulate the access of vessels and maritime touristic activities (revised every 2 years, GAMPA 2015). A temporary ‘scientific reserve’ was established in 2010 at Condor Seamount, close to Faial Island. All fishing, except for pelagic predators (tuna and billfish), is forbidden at this seamount, which was once an important fishing ground. Such stakeholder initiatives generally generate the best functioning reserves (Abecasis et al. 2015, Afonso et al., unpubl. data). Similar processes and requests are ongoing in other islands (e.g. Graciosa, São Miguel).

4. MPA assessment

To evaluate the existing coastal MPA network in the Azores, to assess its strengths and weaknesses, and to propose general guidelines for its re-design we analysed

i. the objectives,
ii. design characteristics,
iii. protected habitats,
iv. ecological coherence,
v. the legal framework of INPs in relation to international conservation criteria and targets, and
vi. potential reserve effects of selected MPAs.

Analyses of the ecological coherence of the coastal MPA network were based on the OSPAR criteria (i.e. adequacy, representativeness, replication and connectivity; Ardron 2008). International recommendations typically refer to the protection of 10 - 30 % of a given habitat type (e.g. IUCN, Aichi target; WPC 2003, CBD 2010). For most of the islands the coastal habitat (< 50 m) was well represented (8 - 53 %) and corresponded to these recommendations. If only rocky substrate of the coastal habitat was considered, that support a high amount of habitats and biodiversity, representativeness was still reasonably high, except for the INP of Terceira. Overall, 32 % (218 km^2) of the coastal habitat was integrated in INPs, meeting recommended targets. However, protected areas

1. are not distributed evenly between the islands, and
2. do not always have sufficient measures to ensure the sustainable use of marine resources (i.e. fisheries restrictions are missing).

Furthermore, other recommendations advise to protect 20 - 40 % (Green et al. 2014) or 30 - 50 % of the available habitat (Airame et al. 2003). INPs of Terceira and São Jorge clearly do not meet these recommendations. In addition, protection of the island shelves (50 - 200 m) is clearly under-represented (< 10 %) in six of nine islands (Santa Maria, São Miguel, Terceira, Graciosa, São Jorge, Flores). Only the INP of Corvo and Formigas Islets (included in the INP of Santa Maria) potentially protect all habitats (coast, shelf, and slope). On an archipelago-wide scale, only 13 % (194 km^2) of the shelf habitat is integrated in the INPs, although these habitats are very important and encompass, for example, VMEs. No coastal MPA, however, explicitly considers the protection of VMEs although these exist in proximity to the island coasts, such as cold-water coral gardens described south of the Faial-Pico Channel (Matos et al. 2014; Tempera et al. 2014). The AMP, on the contrary, integrates MPAs that were designated with the objective of conserving VMEs.

However, all international recommendations of protection targets refer to full (not partial) protection, i.e. without any disruption and extraction of marine resources (e.g. IUCN category I). In the Azores, INPs mainly integrate partial MPAs (IUCN category VI) that often do not regulate extractive activities of living resources or only regulate a certain method or extraction of a particular species. MPAs of IUCN category I are under-represented and mostly of minimal size. Only five sites correspond to this category, yet four have exceptions for the extraction of living resources and only one is a true no-take area (i.e. no fishing and other extractive activities allowed).

Many of the coastal MPA units are relatively small (ca. 1 km^2). Only ten of 34 MPAs are larger than 10 km^2 and only seven have a length of more than 10 km, which is substantially smaller than a recommended size of 5 - 20 km (Shanks et al. 2003, reviewed in McLeod et al. 2009). INPs of Terceira, Graciosa and São Jorge are the smallest. On the contrary, distances between individual marine sites of an INP are on average between 8 and 35 km, which probably is adequate to allow replenishment via larval dispersal on an island-scale (Fontes et al. 2009), considering the generally short larval dispersal of reef fishes (Jones et al. 2009) and spacing recommendations of 10 - 20 km (Shanks et al. 2003). In some islands, however, greater gaps exist between individual sites (e.g. north coast of Pico, south coast of São Jorge/São Miguel).

A comparison of the different legislations in place (i.e. INP and other spatial measures) revealed several incongruities, heterogeneities and legal conflicts. A certain activity may be prohibited inside the INP but is allowed or conditioned according to another legislation. Similarly, a review of the INP legislation revealed errors, such as prohibiting and conditioning a certain activity at the same time or regulating activities that do not apply to the marine realm. In some cases, rules were rather unclear or of difficult interpretation, and a spatial overlap of (contrasting) regulations existed, impeding comprehension by stakeholders (GAMPA 2015).

The response of commercially interesting coastal fishes with different ecological traits to protection was analysed for three marine reserves of contrasting habitats (coastal vs. offshore reefs), regime (legal vs. voluntary, partial vs. total protection), and age (8, 15 and 22 years after designation) (Afonso et al., unpubl. data). Overall, no indications for MPA efficiency were detected (i.e. only limited positive effects of protection on the abundance or size of fishes). Instead, abundances of more than half of the studied ecological traits were significantly influenced by ‘year since protection’ and decreased over time or showed no clear signal. Some positive effects were detected for commercial fishes of larger size and lower mobility (e.g. groupers, moray eels, and large wrasses) and in reserves exhibiting stronger compliance and less poaching (i.e. in the voluntary reserve ‘Caneiro dos Meros’). There was also an influence of depth on fish abundance (species-specific patterns) and a common preference for substrates of higher rugosity across ecological traits, highlighting the need to include complex reef structures and a wide variety of coastal habitats when designing multispecies marine reserves. Findings indicate that small reserves may not provide adequate protection to the entire fish community. Instead their effects are localized and restricted to highly sedentary species, reducing their contribution to manage fisheries and conserve biodiversity. Underperforming MPAs may be caused by missing enforcement and miss-management, as observed elsewhere (e.g. Guidetti et al. 2008, Edgar et al. 2014).

In conclusion, the MPA assessment shows that

1. many MPAs are far too small and may not effectively protect multiple species and species with a higher mobility;
2. too few offer an adequate protection level, i.e. hardly any no-take zones exist;
3. INPs do not include recently identified critical habitats, such as VMEs and aggregations sites;
4. habitat representativeness varies substantially between MPAs of different islands;
5. there are no official monitoring programmes (even if mandatory);
6. there are substantial incongruences, heterogeneities and legal conflicts between different legislations;
7. rules are often unclear and difficult to interpret; and
8. insufficient enforcement of the regulations may be responsible for the absence of reserve effects.

5. Future perspectives

Findings indicate

i. that existing measures of Azorean INPs are considered insufficient to provide an effective and inclusive protection of habitats and species and to promote undisturbed coastal biotopes, and
ii. that the existing MPA network would benefit from a critical revision (including the regulation) and re-zoning to achieve conservation objectives set for the Azores and internationally, including within the EU MSFD.

The fact that INP management plans are in preparation and that novel, important information is now becoming available from research (e.g. maps of VME, essential fish habitats and critical biodiversity hotspots) offers the good opportunity to achieve this goal.
General guidelines for such a review should consider:

3. An increase in size and number of no-take areas (IUCN I) (e.g. larger reserves with the potential for protecting multiple species).
4. A zonation scheme with core and buffer areas for each INP.
5. The prohibition of activities with high impact (e.g. fishing, extraction of inert materials, dredging deposits).
6. A more representative set of habitat types in MPAs. The increased protection of the island shelf, for example, may support the potential use of INPs to manage the commercially important bottom fisheries.
7. Protecting critical habitats/species under a precautionary approach, such as VMEs (e.g. cold-water coral banks) and fish aggregations.
8. Establishing regular monitoring programmes with clear objectives and measures.
9. Simplifying the legislation and regulations and realisation of awareness-raising actions to facilitate comprehension and promote compliance by stakeholders and the public.
10. Improving surveillance and enforcement of rules.

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Managing Fishing in MPAs: Making a Start

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Background - In England for many years, commercial fisheries had not been subject to formal assessment under the EC Habitats and Birds Directives. In 2013 the Department for Environment & Rural Affairs (Defra) issued a policy paper setting out a "Revised Approach" to commercial fisheries in European marine sites (Ems = Marine SACs and SPAs). The aim of the Revised Approach is to ensure that fisheries management within Ems's achieves compliance with Article 6 of the Habitats Directive.

Natural England (NE) is a statutory nature conservation body (SNCB) and part of Defra. We provide statutory conservation advice on fisheries (and other sectors) in Marine Protected Areas within the 0-12nm area to ten Inshore Fisheries & Conservation Authorities (IFCAs), the Marine Management Organisation (MMO) and the Environment Agency (EA). We also advise the MMO and Joint Nature Conservation Committee (JNCC) on sites straddling the 12nm boundary. Fisheries in sites beyond the 12nm limit are managed by Defra under the auspices of the Common Fisheries Policy and the European Commission. A Project Board for the Revised Approach has been convened, comprising Defra, NE, MMO, JNCC, IFCAs and the EA. Also, an Implementation Group has also been set up with members drawn more widely from the fishing industry and NGOs thus ensuring effective input from a range of stakeholders.

The Revised Approach - The Approach has been implemented on a risk-prioritised phased basis including UK and non-UK vessels. Assessment of fishing activity has been carried out in a manner that is consistent with Article 6.3 of the Habitats Directive. In 2009, a new piece of domestic marine legislation was enacted in the UK: The Marine & Coastal Access Act 2009. This act provided for the designation of Marine Conservation Zones (MCZ). In the light of this development, in late 2013 the "Revised Approach" became the "Fisheries in MPA Project" as MCZs were brought within scope.

An initial prioritisation process was implemented using a matrix-based decision making tool (see Figure 1). This classified gear-feature interactions into Red, Amber, Green or Blue categories according to the degree of actual or potential impact the gear might have upon site features. Generic gear-feature interactions were assessed using best available peer reviewed and grey literature evidence and expert judgement. Red interactions were assessed as those gears considered incompatible at any intensity with certain site features and were to be subject to appropriate management immediately. Aside from Reds (and Blues), the matrix gives no indication of potential management requirements. Most management measures for fisheries affecting red risk Ems gear-feature interactions were put in place by May 2014. Assessment of green and amber risk gear-feature interactions is underway presently with all remaining management measures to be put in place by December 2016.

Evidence - During the assessment process, consideration was given to the following:

- Conservation objectives of the site;
- Feature condition, sensitivity and extent;
- Characteristics of the fishery and gear impacts;
- Experience from other cases;
- Expert judgement from NE and other agencies.

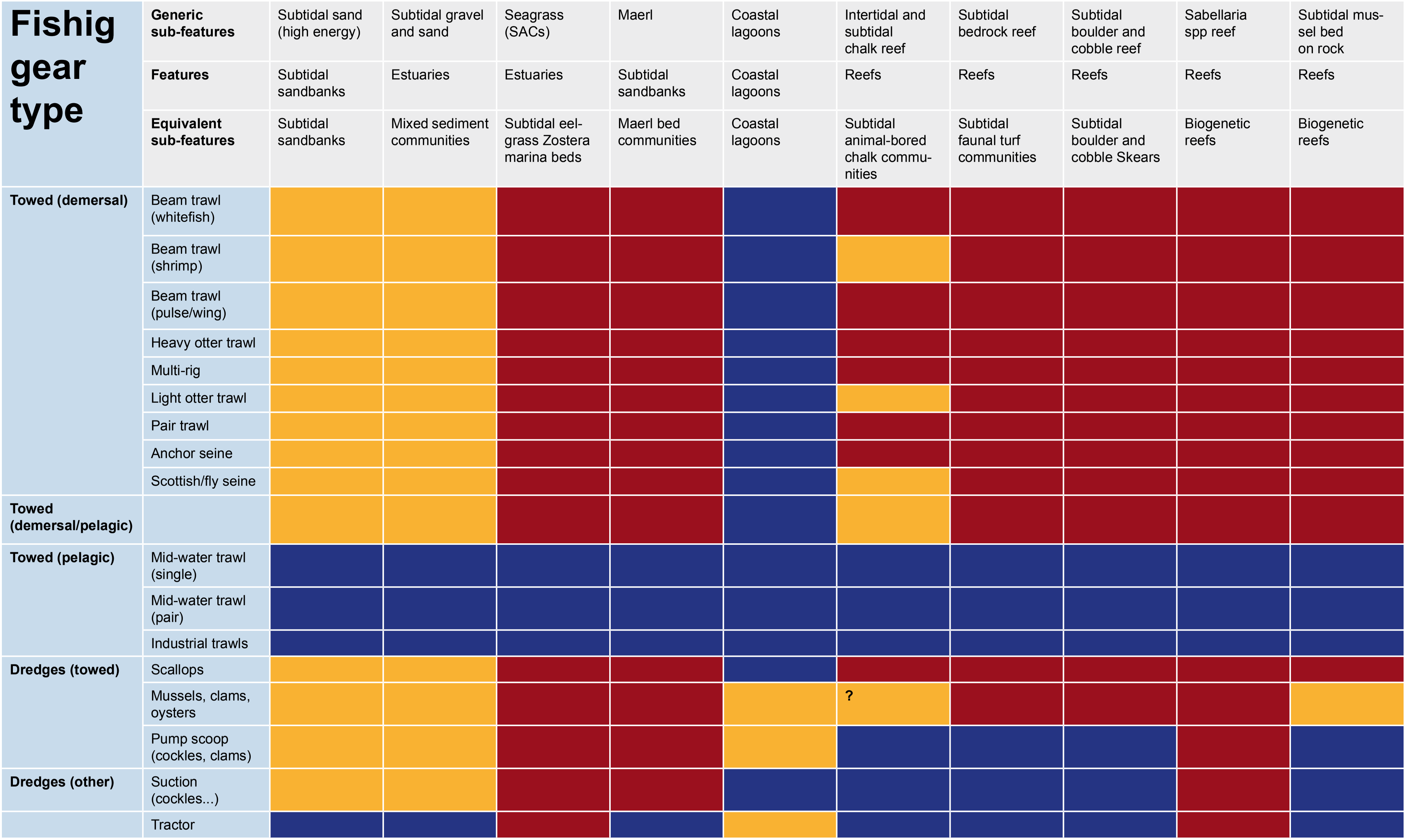

Figure 1: An example section of the gear-feature interaction matrix.

high risk medium risk no risk

Operation	Activity	Pressure	Justification	Annex I habitat: Estuaries									Annex I habitat: Mudflats and sandflats not covered by seawater at low tide				Annex II species	
				Infralittoral rock	Intertidal coarse sediment	Intertidal mixed sediments	Intertidal mud	Intertidal rock	Intertidal sand and muddy sand	Subtidal coarse sediment	Subtidal mixed sediments	Subtidal sand	Intertidal coarse sediment	Intertidal mixed sediments	Intertidal mud	Intertidal sand and muddy sand	River lamprey (Lampetra fluviatilis)	Sea lamprey (Petromyzon marinus)
		Synthetic compound contamination (incl. pesticides, antifoulants, pharmaceuticals). Includes those priority substances listed in Annex II of Directive 2008/105/EC.	166	NS	IE	NS	NS	IE	NS	NS	NS	NS	IE	NS	NS	NS	IE	IE
		Transition elements & organo-metal (e.g. TBT) contamination. Includes those priority substances listed in Annex II of Directive 2008/105/EC.	166	NS	IE	NS	NS	IE	NS	NS	NS	NS	IE	NS	NS	NS	IE	IE
		Underwater noise changes	536														S	S
		Visual disturbance	362															
	Demersal seines	Above water noise	708															
		Abrasion/disturbance of the substrate on the surface of the seabed	553	S	NS	S	S	S	S	S	S	S	NS	S	S	S		
		Changes in suspended solids (water clarity)	132	S	NS	S	NS	S	NS	S	S	S	NS	S	NS	NS		
		Collision ABOVE water with static or moving objects not naturally found in the marine environment (e.g., boats, machinery, and structures)	150															
		Collision BELOW water with static or moving objects not naturally found in the marine environment (e.g., boats, machinery, and structures)	150														S	S
		Deoxygenation	234	IE	NS	NS	NS	IE	NS	NS	NS	NS	NS	NS	NS	NS	S	S

Figure 2: Advice on Operations Table - activities, pressures and associated sensivities. The table compares pressures with different features and establishes a sensitivity rating for the interaction - NS = Not sensitive, S = Sensitive and IE = Insufficient Evidence

The evidence base was peer reviewed independently and evidence tools and workshops were then developed to assist regulators in their assessments and management decisions. These included the following:

- SPA Toolkit;
- Fishing Impacts Evidence Database;
- Case history workshops with fisheries managers;
- Conservation Advice Workshops.

For some more recently designated sites, evidence for feature extent/condition was poor. In the light of this process, project partners have had to collect new primary data in order to help inform this process. The IFCAs have significantly increased their capacity to collect data through acquiring new survey equipment and skills. NE has also committed significant resources to monitoring projects on existing sites and to keep pace with the designation of new sites.

Conservation Advice - Prior to the advent of the Fishing in MPA Project, Natural England had embarked upon a process to update its formal conservation advice. Advice for some early SACs and SPAs was becoming dated. In the intervening period, demands upon the marine environment have changed significantly. Furthermore, many new sites have also been designated. A new approach has been taken to our statutory conservation advice to assist developers and fishers in understanding the implications of their activities and to inform future management. This includes the provision of detailed Site Attribute Tables and Advice on Operations Tables which look at activity-pressure combinations and assign a sensitivity category to them (see figure 2). Ensuring that the evidence and conservation advice processes keep pace with fisheries assessments remains challenging.

Fisheries Assessment Process - All Red gear-feature interactions were assessed first and management was put in place by March 2014 through the introduction of IFCA and MMO byelaws. Gears that are assessed as having "no interaction" with the feature are filtered out (Blue). Amber and Green interactions are currently being assessed by the IFCAs and MMO using an Article 6.3 process. NE has provided both informal support and dialogue leading up to the provision of our statutory advice. Assessments will largely be concluded by the end of 2015 to allow for the introduction of relevant management including statutory measures during 2016.

Assessments are undertaken in light of the site's conservation objectives and comprise tests for "likely significant effects" and if required an Appropriate Assessment of "adverse effects on site integrity". The task undertaken by all the agencies involved has been considerable. By the time the work is complete, the IFCAs will have assessed fishing activities in **110** designated sites including SPAs, SACs and MCZs comprising **12,460** gear-feature interactions. The MMO will have considered gear-feature interactions in **12 sites** in the 6nm to 12nm and **11 offshore sites**. Natural England will provide support and formal statutory advice on all these assessments, comprising evidence for site feature condition and extent and where available a revised formal conservation advice package.

The Results So Far - Seventeen new statutory IFCA byelaws managing red risk interactions came into place between the end of 2013 and May 2014. The MMO have so far introduced 4 new byelaws in European marine sites since 2013. A further sixteen IFCA byelaws and 2 MMO byelaws are anticipated by the end of 2016. As of July 2015 the IFCAs have undertaken 4123 tests of likely significant effects and 260 appropriate assessments. To date the MMO have undertaken tests of likely significant effect in 8 sites in the 6-12nm and are currently undertaking appropriate assessments of fishing activities in 6 sites. Upon completion Fisheries in MPA Project will have significantly enhanced effective management of fishing activities in English MPAs. Furthermore, the Project will have enhanced the relationship between fisheries managers and nature conservation agencies.

Adaptive Risk Management - For many gear-feature interactions, the relationship between fishing pressure and feature condition is uncertain. This is particularly true for habitats that are subject to high levels of natural disturbance (e.g., sediments in shallow water) and for fishing gears that have low unit impact but may have a significant effect at very high effort levels. Additionally, our knowledge of baseline conditions for some habitats may be poor leading to low certainty over the definition of favourable condition and consequently, the setting of specific conservation objectives. In the face of uncertainty, doing nothing is not an option and a blanket fishing ban may be over-precautionary. An alternative approach that is under consideration for many sites is the application of "adaptive risk management" which allows us to augment our evidence base and amend management accordingly.

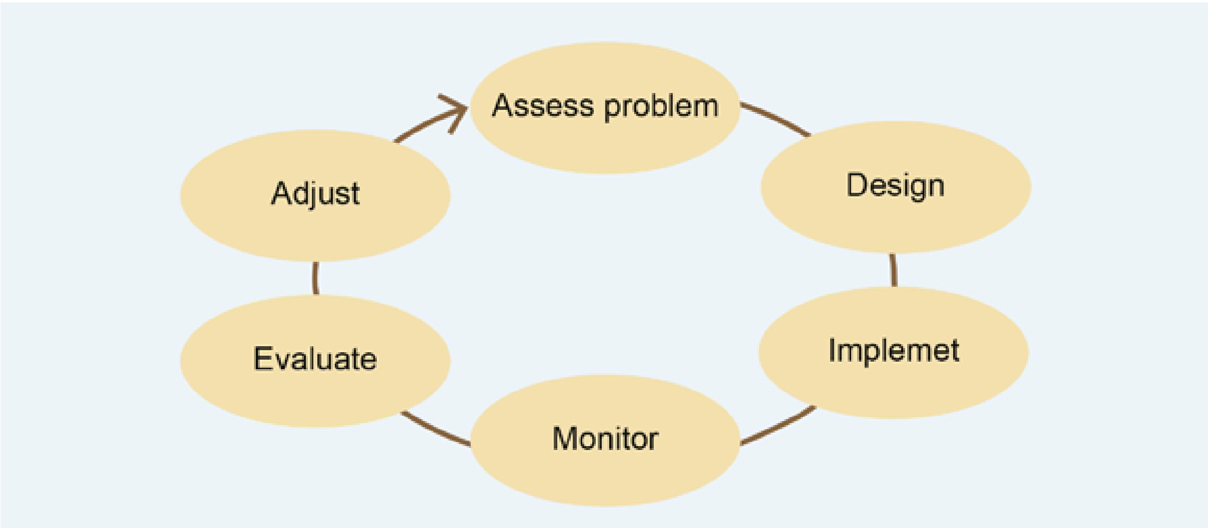

Figure 3. Adaptive Risk management schematic

The above schematic is from the United States Department for the Interior, who have described adaptive management as:

"Exploring alternative ways to meet management objectives, predicting the outcomes of alternatives based on the current state of knowledge, implementing one or more of these alternatives, monitoring to learn about the impacts of management actions, and then using the results to update knowledge and adjust management actions. Adaptive management focuses on learning and adapting, through partnerships of managers, scientists, and other stakeholders who learn together how to create and maintain sustainable resource systems".

Challenges

- The need for new evidence on MPA features will continue into the future;
- Continued research on gear impacts is needed and we need to share experiences across Europe;
- Managing adaptively in the face of uncertainty and deciding who will pay for monitoring;
- The effects of fishing effort displacement have yet to be quantified and assessed.

Benefits

- The relationship and dialogue between fishers, fisheries managers and conservation agencies has improved significantly, particularly on MPAs;
- A significant proportion of fisheries in MPAs are now actively managed and more will follow before the end of 2016;
- Currently approximately 25 % of English waters are in an MPA. This will increase to about 33 % when designation of new sites is complete.

Impacts of bottom-set gillnet anchors on the seafloor and associated flora – potential implications for fisheries management in protected areas

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1. Introduction

In recent years the process of developing and implementing measures to manage fisheries in marine protected areas such as those designated by EU member countries under the Habitats Directive has accelerated. While emphasis in national processes such as the German EMPAS project (Pusch & Pedersen 2010) and the Dutch FIMPAS (ICES 2011) has traditionally been placed on mobile, bottom contacting fishing gears, little attention has been given to the potential impacts of static, passive fishing gears such as bottom-set gillnets. This may be attributed to a substantial lack of scientific literature describing the physical impacts of gillnets on seafloor features and associated flora and fauna.

In the following, a concise review of existing literature describing physical impacts of gillnets is provided. In addition, observations from an initial investigation of gillnet impacts in Danish waters will be presented.

2. Physical impacts of gillnet fishing

Bottom-set gillnets (Figure 1) usually consist of a netting wall of varying height which is usually set on the bottom in a straight line across the seafloor. The net stands vertically in the water due to a float line and a weighted lead line. Gillnets are weighted on both ends, usually with anchors. Most commercial fishermen use hydraulic net haulers to retrieve nets during fishing (FAO 2015). The vast majority of the literature describing environmental impacts of bottom-set gillnets focuses solely on the incidental bycatch of birds (e.g. Zydelis et al. 2013) and marine mammals (e.g. Vinther & Larsen 2004). In contrast, the scientific literature documenting the physical impacts of gillnets on marine habitats and associated flora and fauna is very sparse.

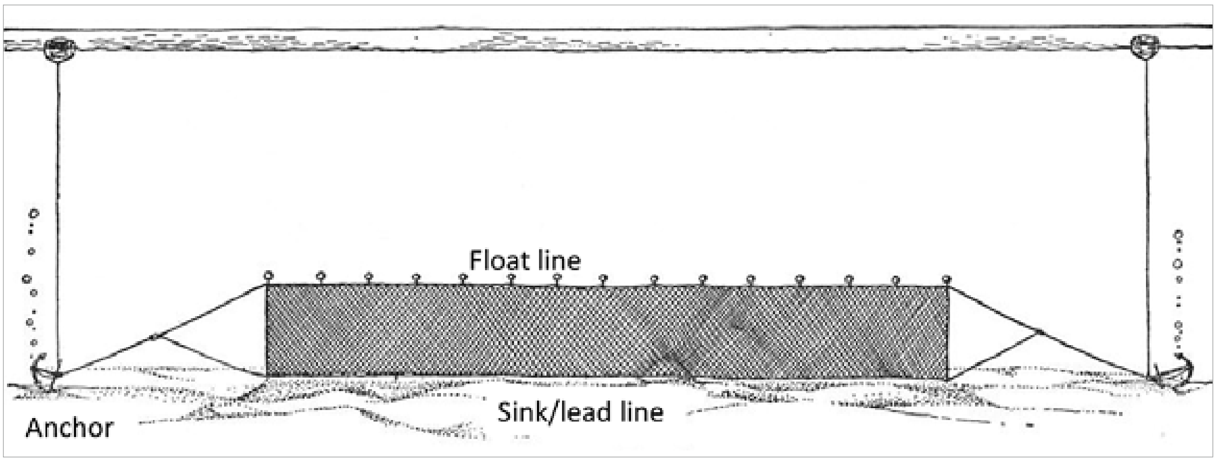

Figure 1: Bottom-set gillnet (Modified from Umali 1950).

The physical impact of any fishing gear is dependent on among other things the nature of the impact, the rigging and deployment of the fishing gear and the location and scale of the fishery (DFO 2010). Impacts of fishing gears are also highly dependent on the fragility and sensitivity of prevailing species and habitats (ICES 2006). In the case of the gillnet fishery, the location and scale of the fishery is dependent on presence of target species but is additionally limited by intra-sectoral competition with active gears such as bottom trawlers. As a result, impacts may not be evenly distributed and may often be concentrated (DFO 2010) within favourable fishing grounds that are relatively free of bottom trawling activity.

Most studies conclude that physical impacts of gillnets on the seafloor and its habitats and species are limited. Many of such studies have focused on abandoned or lost gillnets (e.g. Kaiser et al. 1996) that physically affect the surrounding substrate in a lighter, more smothering and abrasive fashion (Brown & Macfadyen 2007). There are three components of gillnets that have physical contact with, and therefore also potential impact on, benthic habitats and species: the anchors, the bottom leadlines and the net itself (DFO 2010). When fishing in areas with strong currents, gillnets may cause impacts to habitats and species when leadlines and the net itself is pushed downwards towards the substrate or when currents cause nets to sway back and forth in a sweeping motion across the seafloor (High 1998; Shester & Micheli 2011). Shester and Micheli (2011) conducted a study of the impacts of gillnets on temperate to sub-tropical kelp forests and rocky reefs. They observed that gillnets damaged or removed, on average, 19.2 % of all kelp and 16.8 % of all gorgonians within 1 m of the net path. It must, however, be noted that gillnets were in contact with the seafloor only 43 % of the time, where it may be assumed that net movements would have been more limited and therefore less damaging to surrounding flora and fauna.

The largest impacts occur during hauling of gears, where the individual components of the fishing gear such as anchors can cause severe impacts to marine organisms (ICES 2006; Eno et al. 2001; DFO 2010). In structurally complex habitats, impacts can be substantial (ICES 2006). Several studies have documented the impacts of gillnets on fragile habitats such as coral reefs, where gillnets caused breakage during fishing and hauling (e.g. Gomez et al. 1987; Fosså et al. 2002; Hourigan 2014). Munro et al. (1987) conclude that this impact is amplified through the use of mechanical net haulers. The weight of the anchors employed influences the risk of habitat impacts due to dragging during hauling of nets. In addition, the length of nets and the depths of fishing grounds influence the likely degree of impact. Gillnets that are of length equal to or less than the depth may have a lower impact, as they are more likely to be lifted nearly vertically from the seafloor, thereby limiting dragging of anchors and nets (DFO 2010).

3. Observations of physical impacts of bottom-set gillnets

In order to study the physical impacts of bottom-set gillnets on reef habitats and associated flora and fauna, field experiments were conducted in 2014 and 2015 in Øresund, Denmark.

3.1 Methods

The focus was on stony areas and mixed seabed at depths between 3-6 meters. Once a suitable spot was located, a 300 meter bottom-set cod gillnet was laid out from a chartered fishing vessel. Two anchors were used for each gillnet; each anchor weighing 6 kg, with a length of 61 cm and 4 prongs, each of a length of 30 cm. Hexagonal concrete tiles (10 kg) with a wooden stand were used to mount GoPro cameras (Figure 2), two of which were placed on the seafloor facing each of the two anchors to record impacts occurring during the retrieval/hauling of gillnets by the fishing vessel. Once gillnets were hauled in, the mounted cameras were retrieved and video data was transferred to a pc.

Figure 2: GoPro camera on customized mount.

A total of 25 successful anchor observations were recorded, which were later analysed visually in relation to substrate type, the nature of the haul, i.e. the presence/absence of anchor drag across the seafloor, and the position of the anchor's prongs. The length of the drag, if present, was estimated based on the total length of the anchor stem. The removal of algae and stones and the presence of scavengers close to the anchor site after the haul were also recorded.

3.2 Results

Anchor impacts observed during some of the experimental hauls included the snagging and subsequent uprooting/removal of macroalgae and direct physical impacts on seafloor substrates and blue mussel beds.

3.2.1 Dragging of anchors along seafloor

Tables 1 & 2 summarize the observed distances over which anchors were observed to drag along the seafloor during retrieval of gillnets. Distances were estimated in relation to anchor length (e.g. 1½ x anchor length, 3 x anchor length etc) and subsequently translated to centimeters.

Table 1: Observed distance of drag when anchors were hauled (August 2014).

OBSERVED ANCHOR DRAG (cm) 2014 **Depth approx. 5-7 m**															**Total Drag (cm)**	**Average cm drag per anchor**	**Average cm drag per trip (7½) trips, 2 anchors per trip)**
122	122	244	30	30	488	20	61	122	122	90	183	0	122	0	1757,5	117,16	234,3

Table 2: Observed distance of drag when anchors were hauled (June 2015).

OBSERVED ANCHOR DRAG (cm) 2015 **Depth approx. 4-5 m**										**Total Drag (cm)**	**Average cm drag per anchor**	**Average cm drag per trip using 2 anchors (5 trips, 2 anchors per trip)**
244	61	488	793	122	305	152	488	183	0	2836	283,6	567,2

There were very large differences between the individual drag distances observed at individual locations (i.e. from 0 - approx. 8 meters) and the average anchor drag per trip in the two field surveys. It is not possible here to attribute the large variation in anchor drag distances to specific factors, as they may range from the behaviour and attention of the fisherman at the given time of hauling to differences in the depths of the fished sites.

As can be seen from the results, approximately half of the anchors removed little or no benthic flora, while the other half removed intermediate to large amounts of algae (most of which was filamentous, “spaghetti” algae) or eelgrass. The exact position of the anchor is beyond the control of the fisherman, but it is inherent that risks of impacting vegetation is highest where densities of vegetation are highest, i.e. in sunlit areas with hard bottom substrates (macroalgae) and in relatively shallow, sandy areas (eelgrass).

3.2.2 Uprooting/removal of benthic flora

Estimates were made of the removal of macroalgae and seagrasses during hauling of anchors (Tables 3 & 4). Examples from field studies are provided in Figure 3.

Table 3: Observed removal of vegetation by gillnet anchors (August 2014)

VEGETATION REMOVED 2014 **Mixed bottom with eelgrass, stones, mussel beds, frequent macroalgae**	**No. of observations**
MINOR (e.g. small tufts/few strands of algae, few blades of eelgrass)	6
INTERMEDIATE (e.g. ½ kg algae, many blades of eelgrass)	4
MAJOR (e.g. > ½ kg algae, many strands of filamentous algae)	4
NO REMOVAL	1

Table 4: Observed removal of vegetation by gillnet anchors (June 2015)

VEGETATION REMOVED 2015 **Sandy, mixed bottom, eelgrass, interspersed macroalgae**	**No. of observations**
MINOR (e.g. small tufts/few strands of algae, few blades of eelgrass)	4
INTERMEDIATE (e.g. ½ kg algae, many blades of eelgrass)	4
MAJOR (e.g. > ½ kg algae, many strands of filamentous algae)	1
NO REMOVAL	1

Figure 3: As anchors are dragged across the seafloor, algae and seagrasses become snagged and removed.

3.2.3 Impacts to substrates (incl. blue mussels)

In the majority of the experiments it was not possible to quantify impacts on substrates or benthic organisms. In the June field campaign a scuba diver was employed to document furrows in the seafloor and/or mortality to organisms caused by dragged anchors. However, strong currents made any detailed work extremely difficult and as a result, the original aim of using diver observations was abandoned for the remainder of the study.

It can be assumed that effects of physical disturbance could be visually observed in sandy areas. The depth with which prongs penetrate the sediment determines the magnitude of this impact. In our experiments in June 2015, where sediments were mostly sandy, anchor prongs rested on the seabed, most often only penetrating the sand to a small degree. In the August 2014 study, however, it was often seen that 1-2 anchor prongs were more than half submerged in either the sediment or blue mussel beds, i.e. causing a greater degree of impact (see Figure 4 for examples). On a single occasion the anchor was observed to be stuck behind a boulder, only becoming free once it completely displaced the boulder (Figure 5).

Figure 4: Anchors dragged through blue mussel beds can cause mortality to organisms.

Figure 5: The anchor was stuck behind a boulder, which was subsequently displaced.

Figure 6: Impacts are to a large degree eliminated if hauling is carried out with the vessel positioned directly above the anchor. Anchor prongs point upwards and removal of algae and disturbance to sediments is usually avoided.

On a few occasions scavengers such as crabs and opportunistic feeders such as cod were observed approaching the path of the anchor.

The angle of approach was observed to be an important factor in reducing drag of anchors during hauling. When anchors are hauled from a sharper angle (i.e. with a greater distance between the fishing vessel and the anchor), the prongs of the anchor are tilted forward or downward, i.e. resulting in a “ploughing” effect. The further away the fishing vessel was positioned when beginning hauling operations, the greater the degree and distance of drag. When the angle between the rope and the seafloor exceeded approximately 50-60 degrees before hauling the anchor, dragging was either eliminated completely or reduced to “skidding” of the top parts of the anchor along the seafloor (Figure 6).

4. Discussion

Bottom-set gillnets are employed in almost all parts of the sea, from recreational nets set very near the coastline to commercial gillnetting in offshore, deep-water grounds. Gillnets are employed near wrecks, on reefs as well as the on the smooth, soft bottom.

It is generally accepted that gillnet fishing has much smaller physical impacts on benthic habitats and associated species than mobile, bottom-contacting gears such as bottom trawling, beamtrawling and seine fisheries and has in a fisheries management context often been deemed insignificant due to comparisons with such fisheries. However, gillnet fishing can frequently be carried out in areas where mobile fisheries cannot and may therefore have a tendency to become concentrated in such areas. These areas may include reefs within sites that have been designated as protected areas under the Habitats Directive (Natura 2000). Considering the relative sensitivity of reefs habitats and species that are considered characteristic for reefs, it is prudent to consider the impacts of gillnet fishing in isolation, rather than omitting the evaluation of physical impacts of gillnets in the management process altogether (e.g. Pusch & Pedersen 2010) or evaluating them in comparison with active, mobile gears. If considered at all, physical impacts of gillnets have usually been based on anecdotal evidence or expert judgement (e.g. ICES 2011).

Fishing vessels with lengths over 12 m are obliged to send information on their positions by satellite every hour (Vessel monitoring system or VMS data). Due to low costs, relative ease of handling and their versatility, gillnets are the favoured fishing gear of small scale fishermen. As a result, much gillnetting that takes place is carried out with vessels below 12 m, i.e. vessels that do not employ VMS data systems on board. These smaller vessels thereby become invisible to managers when assessing fishing effort in areas with sensitive habitats.

5. Conclusion

Although this study is based on a limited number of observations documented under circumstances unique to the natural conditions and the fishing carried out in the experiments, it does add some needed documentation of some of the physical impacts that bottom-set gillnets and gillnet anchors may inflict on benthic habitats and associated species. The isolated observed impacts of individual gillnets and/or gillnet anchors on e.g. a boulder reef are negligible, in particular when compared with mobile, bottom contacting fishing gears. However, the accumulated impacts of a gillnet fishery in a given area or reef complex may be considered substantial from a conservation perspective if fishing intensity is high, chronic and concentrated within areas containing particularly sensitive habitats and species. Such considerations are especially relevant in relation to management of fisheries in Natura 2000 sites designated to protect reefs, where the overall conservation objective is to achieve a favourable conservation status for reef structures and characteristic species.

The project was supported by the Ministry of Environment and Food of Denmark and the European Fisheries Fund.

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Fisheries management on the international Dogger Bank: a primer for nature conservation in the North Sea

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Abstract

Since 2006 North Sea states have attempted to coordinate their efforts in respect of fisheries management in the marine protected areas (ref. EMPAS, Fimpas). These coordination efforts were mainly geared towards achieving fisheries measures for the Member States' own Natura 2000 sites situated within the national jurisdiction. In 2011 the Dogger Bank Steering Group was formed. Its task is to coordinate fisheries measures proposed by Germany, UK, and the Netherlands with the collaboration of Denmark for the Natura 2000 sites on the Dogger Bank. Scientific Advice was sought and provided for by ICES. ICES also provided for support in the process of drawing up the submission to the EU. This contribution describes the successive steps Dogger Bank states have taken to get to an agreement and the mutually coordinated and holistic approach they have undertaken in order to reach agreement on a fisheries regime for the international Dogger Bank that safeguards the conservation targets as agreed by these states. It is shown what are the factors for success and which factors have been decisive in relationship to the support that Dogger Bank states sought from the Stakeholders. The role and contributions of stakeholders have been inventoried. Special attention is given to the role of the European Commission which attended the meetings of the steering group as an observer. This question is relevant since during the Dogger Bank negotiations the Common Fisheries Policy was revised and a whole new set of rules and procedures entered into force during the work of the Dogger Bank Steering Group. Furthermore the fact that these states intended to submit a joint request to the EU Commission for coordinated fisheries measures also raised the question as to whether states were individually acquitted for their legal obligations under the EU regulations and directives if they submit a collective request.

Special attention is also given to the role of Denmark, which although being a Dogger Bank state does not have a Natura 2000 site on the Dogger Bank. Why did Denmark participate?

By showing maps of the Dogger Bank as these were conceived at different stages of the negotiations, the positions of states are illustrated.

The Dogger Bank process shows how states and the EC have got on grips with an entirely new situation viz. multilateral cooperation between states to comply with EU obligations in the field of fisheries which fall under the exclusive jurisdiction of the EU.

Influence of a discard ban on the transition towards more selective fishing gear

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Abstract

A large part of demersal fisheries catches constitute of undersized target species. Minimum landing size (MLS) regulations require a fisher to discard this part of the catch, causing additional mortality and hence reducing future yield of a fishery that is already in a fragile economic situation. Discard reduction is high on the agenda of EU fisheries managers wherein modifying current fishing technologies (pulse trawling) are among the possible adaptive strategies of fishers to cope with the changes in management (e.g. discard ban). Given the current situation in which a discard ban and technical modifications are gradually being introduced, this study explores the economic and environmental implications of a discard ban for mixed fisheries with two gear types that differ in their selectivity for the target species. Our hypothesis is that the economic returns resulting from the discard ban are not equal among different fisheries and thus may enhance the transition towards a more selective gear. We will use a Dynamic State Variable Model (DSVM) for testing this hypothesis for a bottom trawl fleet targeting several flatfish species in the North Sea.

A scientific paper on this topic has been published in Fisheries Research, Volume 174, February 2016, Pages 118-128.

See: http://www.sciencedirect.com/science/article/pii/S0165783615300825

Can automatic longlines and jigging machines replace gillnets in bycatch conflict areas? Results of a Baltic Sea research project

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1. Introduction

The incidental bycatch of sea birds and marine mammals in gillnet fisheries is a global conservation issue and is recognized as a severe conflict within and outside Baltic Sea Natura 2000 sites. Science and policy are suffering from a fundamental lack of reliable and quantitative data, in particular from small-scale fisheries preventing the implementation of effective mitigation and management measures. A review of about 30 studies estimated that at least 76,000 birds are killed by gillnets in the Baltic Sea each year concluding that this is almost certainly a substantial underestimate (Zydelis et al. 2009). More than 148 bird species seem to be affected (Zydelis et al. 2013). Bycatch data on marine mammals, particularly harbour porpoises is even harder to collect due to monitoring obligations not focused on the problematic fishing gears (EU Regulation 812/2004). A distinct increase in numbers of porpoise strandings showing lesions (net marks) along the Dutch and Belgian coastline and a mean proportion of suspected by-catches of 47 % in fresh and moderate carcasses stranded along the German coast are an indication that bycatch is a major anthropogenic cause of death (Haelters & Camphuysen 2008, Herr et al. 2009).

To analyze the impacts of fisheries on habitats and species in Natura 2000 sites and to develop site specific management actions, the German Federal Agency for Nature Conservation (BfN) initiated a research project called "Environmentally Sound Fisheries Management in Marine Protected Areas" (EMPAS) in 2006. The project was accomplished by the International Council for the Exploration of the Seas (ICES). EMPAS benefited from the participation of different scientists from marine and fisheries biology and stakeholders from the fishing industry and nature conservation (Pusch et al. 2010). The project was completed in 2008. It proposed concrete management actions for fisheries with gillnets in the German waters of the Baltic and North Sea to protect wintering sea birds and harbor porpoises including spatio-temporal closures and research on the development of ecologically-sound gear. Based on EMPAS recommendations and some smaller national research projects, NABU, the Nature and Biodiversity Conservation Union coordinated a three-year project commissioned by BfN from 2012 to 2015. The project aimed at testing fisheries with an automatic longline system and a number of jigging machines and to investigate their application in German waters in order to replace gillnets in marine protected areas in the future.

2. Fisheries and bycatch numbers in German Baltic waters

The German Baltic Sea fishing fleet is dominated by small vessels usually less than twelve metres in length. The fleet register of the European Union listed up to 1,460 vessels in December 2015 and more than 70 % are licensed to operate gillnets. Vessels up to 12 meters in length are allowed to set up to nine kilometres of gill nets a day while larger ones can even set up to 21 kilometres (Art. 8, EU Regulation 2187/2005). Thus, the operation of bottom-set gillnets accounts for about 60 % of total German fishing effort (Schulz 2011). There are only a few quantitative studies on sea bird bycatch in German waters. Bellebaum et al. (2011) estimated an annual bycatch of 17,550 birds solely in the German gillnet fleet in Mecklenburg Western Pomerania. This annual mortality is thought to have decreased in recent years caused by the severe decline in sea duck populations (Skov et al. 2011) and decreasing number of fishing vessels. The bycatch risk results from the fact that diving and foraging sea birds come into contact with the almost invisible nets, where they become entangled and drown. Therefore, overlaps between important fishing areas and the feeding grounds and seasons of the different sea bird species concerned are particularly problematical from a conservational point of view (SRU 2013). Such overlap has been shown for the German Baltic by Sonntag et al. (2012).

Figure 1: Long-tailed duck bycatch Germany (Rainer Borcherding).

The harbour porpoise population of the Baltic Proper is threatened by extinction (IUCN Red List 2014). For many years, the lack of data on the distribution and abundance of this population has been the key obstacle to take targeted action for their protection. In 2014 the SAMBAH project (Static Acoustic Monitoring of the Baltic Sea Harbour Porpoise) estimated that this population only consists of approximately 450 animals. These results are based on a study, in which static acoustic monitoring data were collected at 300 stations for two years. This means that each individual bycatch victim prevents this population from recovery (ASCOBANS 2010, HELCOM 2015).

3. Natura 2000 and alternative fishing gear

In recent years, a considerable proportion of marine waters in Germany, both, within the 12 nautical mile zone (coastal seas) and in the EEZ has been designated as Natura 2000 sites (more than 45 % of Germany's entire marine waters). These areas are primarily designated to protect marine biodiversity and restore favourable conservation status for species and habitats in accordance with the EU Birds and Habitats Directives. Sites have mainly been selected according to the presence and distribution of specific species of sea birds, marine mammals and of sandbank and reef habitat types. Although, there are clear signs of conflicts between the interests of the fishing industry and the conservation objectives of marine Natura 2000 sites, no respective fisheries management measures or even restrictions have been implemented so far.

To replace gillnets in "bycatch conflict areas", a range of different alternative fishing techniques could be applied such as baited pots, fish traps (pound nets), jigging-reels or automatic longline systems. Many of these are already in practice in various fisheries across the world, i.e. in Scandinavian countries or Canada.

4. The alternative gear project

The project was commissioned by BfN in 2012 in the framework of the EEZ research project. One overall goal was to support sustainable fisheries management in marine protected areas by improving the collaboration between fishermen, scientists and nature conservation. Further, it aimed to provide a basis for replacing gill nets by alternative and ecological sustainable fishing gear. Test fisheries with new gear types should be prepared and implemented and those gear types selected should be adapted to specific conditions and needs in German Baltic waters as well as modified if necessary.

The collaboration with commercial fishermen was of fundamental importance. Potential project partners were contacted from the beginning, and they were also involved in gear type selection and in the development of the overall project strategy. Test fisheries took place in the federal state of Schleswig-Holstein, in Kiel Bight and around the island of Fehmarn. The scientific advice and an accompanying observer scheme were covered by fisheries biologists supported by the a CCTV camera monitoring system of the Department of Fisheries and Survey Technology of the Thünen Institute for Baltic Sea Fisheries (TI).

In November and December 2013 one fishing vessel was equipped with an Oilwind automatic longline system and another one with four DNG jigging machines. The Oilwind system is constructed for vessels from five meters in length and it consists of different components: the bait cutter and the automatic baiter, the hauler and the line preparer. The system is able to set up to 4,000 hooks per hour and haul up to 1,400 hooks per hour. The DNG jigging-reels are running with up to six hooks with different artificial bait, one fisherman can operate four machines (Figure 2 and 3, next page).

5. Results of test fisheries

Whereas the jigging-reels were applied sporadically with a focus on winter months, the longline system was applied for an entire fishing season from June 2014 to May 2015 after a first experimental fishery was conducted until spring 2014.

Figure 2 and 3: Alternative fishing gear in field studies : Oilwind longline system (baiter) and DNG jigging machines (NABU/K.Detloff).

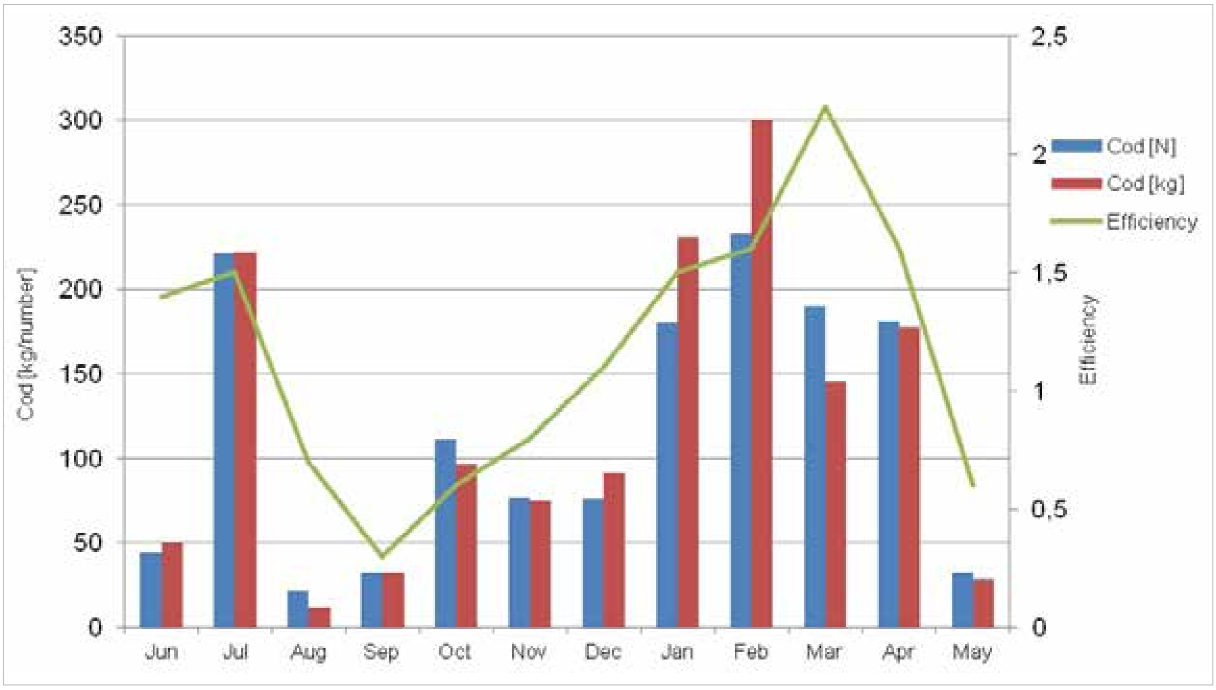

Figure 4: Cod landings and catch efficiency (cod/100 hooks) from June 2014 to May 2015.

<u>Longline</u>

In total, 90 fishing days with two vessels operating the longline system were evaluated and approximately one third was covered by the accompanying observer scheme. About 135,000 hooks of different sizes were set and two tons of fish were caught, dominated by 1.7 tons of cod. Figure 4 shows the catch rates and catch efficiency from June 2014 to May 2015. The highest catch rates have been observed in winter months (Jan.-Mar.). However there was a second peak in catch efficiency in July.

In the course of the research project various longline configurations were tested: two different hook sizes (Mustad 10 and 12), using floats lifting the main line from the sea floor allowing suprabenthic fishing and testing of different bait types, particularly sprat and herring.

No significant differences between these configurations were observed; however, an accompanying test fishery with a hand-set traditional longline operating with hook size 4 indicated that smaller hooks may increase catch efficiency. Over the entire project period sporadic sea bird bycatch was observed. But after a significant increase of gull bycatch during setting in March 2015, a technical mitigation experiment was established. No further bycatch occurred after the installation of the acoustic BirdGard mitigation system and a kite in shape of a raptor during line setting.

<u>Jigging-machines</u>

Ten scientific surveys using the method of jigging-reels were conducted between June 2014 and July 2015. Further sporadic testing was conducted by fishermen themselves between their trawling operations. Best results were observed in deeper waters between 20 and 40 meters with up to 46 cods per hour operating with four machines. Fishing in shallow near shore waters was less efficient.

6. Conclusions

Two new alternative fishing techniques were tested in German Baltic Sea during the project period. Technical manufacturer instructions were achieved and systems were modified for operations in the Baltic Sea, which is characterized by shallow water depth and seasonally high macrophyte biomass. Therefore, inter alia an additional rotating cleaning brush had to be installed. Longlines and jigging-reels are usually applied in deeper waters and rocky substrate e.g. in Scandinavia or Canada.Catch rates over the entire season were too low to replace bottom-set gillnets from an economic perspective, today. Future projects should investigate the influence of the hook size using floats and different bait species such as sand eels to increase catch rates. Additionally, large fish traps (e.g. pound nets, pontoon traps with excluder grids or cod traps) and baited fish pots should be tested as well. Most likely, there is no universal alternative fishing technique, which can be used to replace all gillnets in the Baltic Sea in all seasons. Thus, different techniques must be tested and modified according to local conditions. Furthermore, technical measures must go hand in hand with operational measures such as spatio-temporal closures in marine protected areas to reach existing conservation targets. Limited exclusive access to marine protected areas using alternative gear types can be an important incentive for fishermen's gear switching. A major success of the project was the improvement of collaboration between fishermen, fisheries science and nature conservation providing a basis for future research projects. A successful way to sustainable and ecosystem-friendly fishing practices and an economic viable fishing sector needs encouragement of all different stakeholders.

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Spatial distribution and temporal development in the use of the Wadden Sea and the adjacent North Sea by the German brown shrimp fishery, 2007-2013

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WWF Germany, Wadden Sea Office

The brown shrimp *(Crangon crangon)* fishery has relatively high economic importance within the German fishing industry. It is operated mainly in the southern North Sea, and within the Wadden Sea and the surrounding seas it also uses important protected areas. However, detailed quantitative information on the spatial and temporal activities of the brown shrimp fishery for the whole area has so far been lacking. This fact makes it difficult to discuss and implement appropriate conservation objectives for fisheries management in the protected areas. The satellite-based monitoring and reporting system for European fisheries („Vessel Monitoring System", VMS) offers the possibility to analyze the spatial and temporal distribution of the fishery, thus creating a basis for discussion.

Figure 1: Shrimp fishery vessel in the Wadden Sea (H.-U. Rösner / WWF)

Figure 2: The brown shrimp fishery generates a lot of bycatch, consisting of small brown shrimp, other crustaceans and invertebrates, young fish and small fish. (H.-U. Rösner / WWF)

Using VMS data for the years 2007 to 2013, this study describes the spatial and temporal use of the German Wadden Sea and the adjacent North Sea areas by the brown shrimp fishery. The analysis is limited to shrimp vessels registered in Germany, which are longer than 12 or 15 metres (since the VMS obligation only applies to fishing vessels > 12 m, and formerly > 15 m; Regulation (EC) No 1224/2009 — EU fisheries control system), and on fishing trips where the shrimps were landed in German ports. The study had to ignore the brown shrimp fishery with smaller vessels and by foreign boats as data were not yet available. Since the transmitted VMS data also includes a speed signal, there is a high probability of deducing whether a cutter was fishing at this time. Mainly data from vessels that were actually fishing were used for analysis, giving a total of 971,149 data points, which are shown in an overview map in Figure 3. Since a signal only has to be sent every two hours, it is impossible to calculate the actual fishing area used. However, areas can be compared well with each other by the number of VMS points accumulated in them in terms of the „fishing events" there, or the „fishing intensity" related to the area size (as a measure of the density.

In the **Exclusive Economic Zone** (EEZ, seaward of the 12 nautical mile line) German fishers caught comparatively few shrimps. Altogether 5.6 % of the brown shrimp fishery took place there (Table 1). However, it must be considered that the total fishing intensity for the target shrimp species in the EEZ is significantly higher than described here because foreign shrimp vessels also operate there.

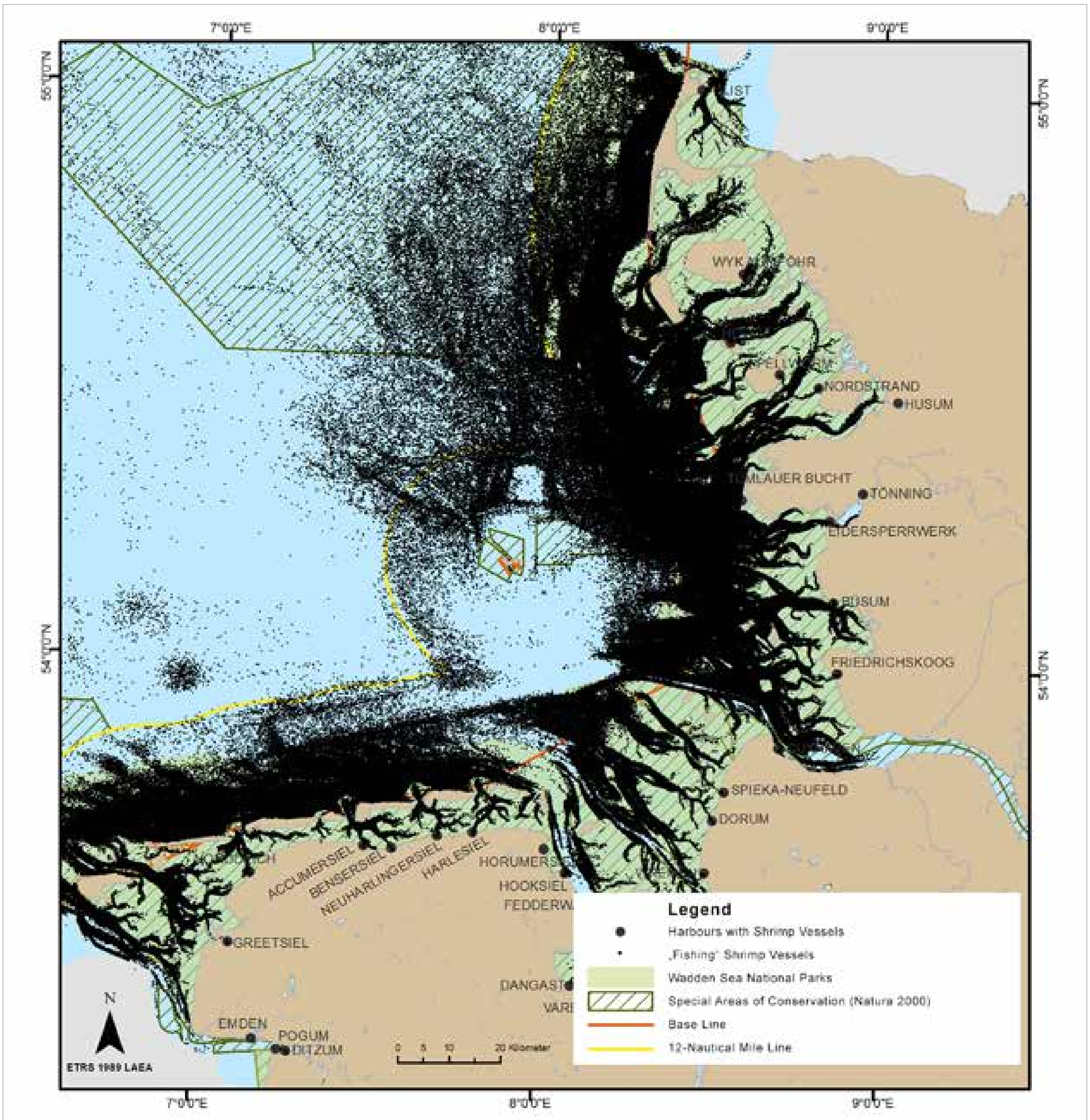

Figure 3: Spatial distribution of the brown shrimp fishery in the German North Sea. Shown are all VMS points labelled as „fishing" from German vessels landing shrimps in German harbours from 2007 to 2013.

The German brown shrimp fishery focused closer to the coast in **internal waters** (landward of the base line) as well as in **territorial waters** (between the base line and the 12-nautical mile line) and more in the area of Schleswig-Holstein than of Lower Saxony. Fishing intensity was comparatively high in both the internal waters and the territorial waters. However, this is only at first glance: if one differentiates the territorial waters into a near-coast (baseline to 3-nautical mile line) and a more distant coast area (3- to 12-nautical mile line), the more distant coast area was significantly less fished (Table 1). However, in the more distant coastal part of the territorial waters, as in the EEZ, foreign brown shrimp fishery is permitted, so the actual fishing is higher there than identified by the data. Considering only the near-coast part of territorial waters, which are directly adjacent to the seaward islands, shrimps were fished on average about 2.5 as intensively as in the internal waters (Table 1).

Table 1: Overview on the use of the different spatial units (Maritime Zones as well as Marine Protected Areas and Tidal Basins) by German brown shrimp fishery within German waters from 2007 to 2013. n = 971,149 VMS points labelled as „fishing“. Ares sizes are based on the GIS-calculation.

		Size (km2)	% of German shrimp fishery in German waters	Intensity (= effort) (VMS points/km2 * year)
Spatial use as based on Maritime Zones				
Exclusive Economic Zone (EEZ, seaward of the 12 nautical mile line)		28,640	5.6	0.3
Territorial Waters (base line to 12-nautical mile line)		7,020	53.5	8.9
	…more distant coast area (3- to 12-nautical mile line)	5,503	25.7	6.5
	… near-coast area (base line to 3-nautical mile line)	1,517	27.8	25.4
Internal Waters		5,392	40.9	10.5
Spatial use as based on Marine Protected Areas and Tidal Basins				
European Habitats Directive areas outside the Wadden Sea		7,872	3.1	0.5
Wadden Sea National Parks		7,703	69.1	12.4
	… Schleswig-Holstein	4,305	40.9	13.1
	… Hamburg	128	0.3	3.3
	… Niedersachsen (Lower Saxony)	3,270	27.9	11.8
Tidal Basins		4,517	25.8	7.9

In the internal waters the spatial differentiation also shows a more accurate picture. Large areas are very flat there and twice a day they are exposed by the tide. In practice these areas are often not fishable by shrimp cutters or fishing is not worth it because of the low density of shrimps. Based on the actual fishable areas, the fishing intensity is high in the deeper sublittoral as well as the deeper creeks and channels (see Figure 4 for an example). If the internal waters are divided into states (the German “Länder”), then fishing intensity is similar in Schleswig-Holstein, Hamburg and Lower Saxony.

With individual examination of the 27 **tidal basins** of the internal waters, great differences become apparent. The most intensive fishing is in the area of the Eider and Elbe estuaries, in the tidal basin off Büsum and in the Meldorf Bay, as well as in the Osterems. There are comparatively significantly lower levels of exploitation in large parts of North Frisia and in the area of the Jade tidal basin. However, this comparison is only partly possible because the delimitation of the tidal basins used in the study usually does not include the ebb deltas which actually belong to them, and in whose channels fishing is sometimes very intense. Overall, 25.8 % of the brown shrimp fishery was carried out in the tidal basins (Table 1).

When looking at the important protected areas regarding the brown shrimp fishery, the **Wadden Sea National Parks** shows a picture of an intense exploitation, with an average of 13.1 and 11.8 VMS points per km² and per year in the Schleswig-Holstein and Lower Saxony Wadden Sea National Parks, and a lower value of 3.3 in the Hamburg Wadden Sea National Park (Table 1).

The National Parks include the vast majority of the internal waters as well as parts of the territorial waters. A total 69.1 % of the brown shrimp fishery took place there. Even a very small no-take-zone within the Schleswig-Holstein National Park, which is closed to fishing by law, is apparently fished just like the surroundings (Figure 4). By comparison, the closure of some channels for fishing in the Hamburg National Park works better, though the closure is apparently not fully respected. Also in some of the restricted areas of the Danish Wadden Sea and in the neighbouring territory of the Netherlands, activities of the German brown shrimp fishery can be observed.

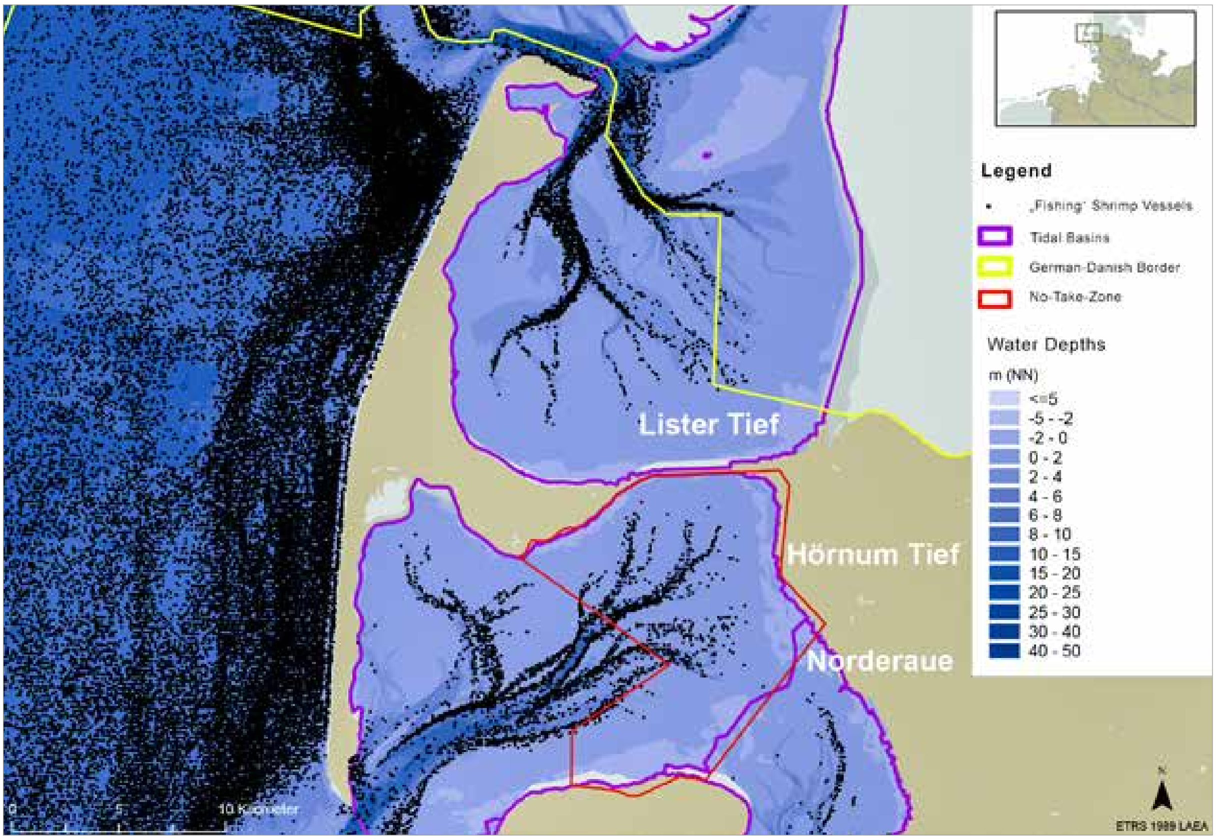

Figure 4: Spatial distribution of the brown shrimp fishery in the tidal basins „Lister Tief" (northeast of the island of Sylt) and „Hörnumtief" (southeast of the island of Sylt). Shown are all VMS points labelled as „fishing" from 2007 to 2013. The Wadden Sea and the marine area south of the yellow line (the German-Danish border) belongs to the National Park Schleswig-Holstein Wadden Sea. While shrimp fishery is in general still allowed within the National Park, it is by law not allowed within the no-take-zone delimited by the red line.

Among the **European Habitats Directive areas** (Special Areas of Conservation) outside the Wadden Sea (partly belonging to the EEZ and partly to Schleswig-Holstein's territorial waters) the „Steingrund“ stands out, as the north-eastern part is fished to a similar extent as the adjacent areas outside the protected area. This also applies to the south-eastern region of the Habitats Directive area „Sylter Außenriff“. However, the western parts of these two protected areas are only rarely used by the German brown shrimp fishery, so that the mean intensity of brown shrimp fishery is comparatively low in the two areas. In contrast, the Habitats Directive areas „Doggerbank“, „Helgoland mit Helgoländer Felssockel“ and „Borkum-Riffgrund“ are hardly used by the German brown shrimp fishery. Overall, 3.1 % of the German brown shrimp fishery took place in the Habitats Directive areas outside the Wadden Sea (Table 1).

Over the seven-year study period a slight decrease in fishing can be seen for the EEZ and territorial waters. Such a trend is not apparent in the internal waters. No trend is evident for both large national parks. In the Hamburg National Park, the brown shrimp fishery declined. In almost all areas, the year 2011 showed relatively low fishing intensities. The shrimp fishermen were on strike for a long time that year.

Analysis of the seasonal development of fishing intensity shows that by far the most fishing in the EEZ was in the months of January to April. In the near-coast areas, there are very low exploitation rates by the German brown shrimp fishery in January and February, medium in March and in December, with a high from April to November.

The study describes the distribution of the German brown shrimp fishery in sufficient detail to act as a **basis for discussions on the management of the protected areas and appropriate decisions**. Nevertheless, it would be advisable to also include data on foreign shrimp vessels in future work and to look at the distribution of small boats less than 15 and 12 m long which may preferably use the internal waters. In addition, fishing in special protection zones such as national park core zones, the moulting ground of shelducks *(Tadorna tadorna)*, as well as the officially un-fished areas in the three national parks should be investigated in more detail.

This paper is an abridged version of Kuechly et al. (2016).

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Supported by the Federal Agency for Nature Conservation (BfN) with funding from the Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety (BMUB) as part of an R&D project on environmentally compatible shrimp fishing (FKZ 3512 85 0400).

The manuscript reflects the opinion of the authors and does not necessarily represent the position of BfN. The WWF is supported in the project by EDEKA ZENTRALE AG & Co. KG.

Gear technology concepts to support sustainable fishery (“Tool + tool + tool = toolbox”)

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Most fisheries use highly productive fish stocks. Therefore, fishery can significantly contribute to world food-supply in long-term. However, the basis is an environmental and economic sustainable fishery, which uses natural resources and marine environment in a responsible way. Consequently, there is a rethinking process in the society, fisheries management and – last but not least – in fisheries itself. Additionally, the influence of sustainability and ecological imprint of food production on consumer’s decisions will increase. Such developments support a change in fishery and an increasing demand for sustainable, ecosystem adapted and energy-saving fishing gear. The change in European fisheries management – including a stepwise introduction of a landing obligation – will produce further need for action.

Consequently, gear technology research has fundamentally changed over the past 20 years. Historically, the target was to improve fishing efficiency. Nowadays, the research questions include how to develop the fishing process towards improved ecological and economic sustainability (incl. improved energy efficiency, reduced gear impact on the marine environment, reduction of unwanted bycatches).

In addition to an altered scope of gear technology research, the challenges have changed over the past years: Whereas, many fisheries around the world are mixed fisheries, fisheries management (and gear technology research) mostly focused on the improvement of selectivity for a given target species and mostly focused on the selective properties of codends (the final collecting bags in trawls). This “single-species approach” is often not suitable, especially in the light of the new fisheries policy in Europe, including a landing obligation and under increased ecological/ethical demands from costumers.

A good example is the mixed bottom trawl fishery in the Baltic Sea. The fisheries management in the Baltic Sea introduced a variety of different codends for this fishery over the past 15 years. The mesh size and mesh geometry of the codend meshes were solely optimized for cod (Figure 1), whereas other species than cod are also caught. Especially flatfish species, such as flounder *(Plathychtes flesus)*, plaice *(Pleuronectes platessa)* and turbot *(Psetta maxima)* have a morphology (body shape) which does not fit to the codend meshes, optimized for cod. This resulted in high discard rates of flatfish species in this fishery.

Since different species often have different selective properties (e.g. flatfish vs. roundfish), it is difficult to optimize selectivity for both types of fish solely within the codend. Consequently, new concepts for multispecies selectivity have to be developed and tested, whereas different fisheries can have different challenges to cope with /problems to solve and even the challenges in one fleet might change between areas and seasons.
Therefore the aim of the gear-technology working group of the Thuenen Institute of Baltic Sea Fisheries is to establish a toolbox containing several tools to obtain multi-species selectivity in mixed fisheries and hence to give opportunities to fishery and fishery management to cope with the current challenges in fisheries.

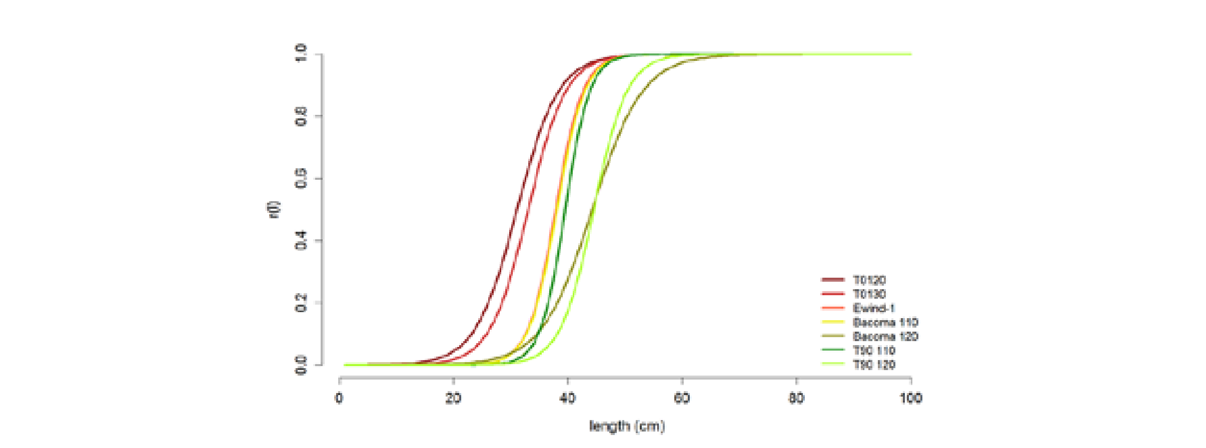

Figure 1: Example for selectivity curves of different codends for cod (*Gadus morhua*) which were legal during the past two decades. Y-axis: Likelood that a fish of a given length is retained in the codend. Description of codends (including period when legal): a) T0120=T0 120mm (1999-2001); b) T0130=T0 130mm (2002-2003); c) Ewind-1= Exit Window Model 1 (1999-2001); d) Bacoma 110=Bacoma Window 110mm (2003-2009); e) Bacoma 120=Bacoma Window 120mm (2001-2003, 2010-recent); f) T90 110=T90 110mm (2006-2009); g) T90 120=T90 120mm (2010-recent)

Current examples for new gear technology concepts, which were developed and/or tested in this working group, were given in the presentation (not for all concepts the same level detail was given). Aside from a presentation of these tools, special attention was paid on the process of the development of the different solutions, especially to demonstrate the potential risk of fall-backs and what we can learn from it (e.g. fishermen participation, intensive behavior studies).

a) **FRESWIND** (**F**latfish **R**igid **ES**cape **WIND**ows): A flatfish by-catch reduction device for demersal roundfish fisheries

FRESWIND is an innovative and simple selection device for trawl gears, designed to reduce flatfish by-catches in demersal roundfish fisheries by supplementing the codend selectivity. The concept is based on a sequential selection process for flatfish and roundfish species, an improved selection device and the alteration of the flatfish behavior.

The FRESWIND is a species selection device, which uses differences in the morphology between flatfish and roundfish species to improve the selectivity of trawl gears. In mixed demersal fisheries, the codend selectivity is often optimized for roundfish species, such as for cod in the Baltic demersal trawl fishery. Based on differences in the morphology of flatfish and roundfish, flatfish usually have a poor selectivity in these codends, resulting in high and often unwanted by-catches. The retained flatfish then often influences the roundfish selectivity negatively because it clogs the net. The basic concept of the FRESWIND approach is:

a. to establish a sequential selectivity process by mounting the selective devices for different species in different parts of the trawl;
b. to design an escapement device optimized for flatfish species and
c. to alter the behavior of flatfish within the trawl to improve the probability of contacts between fish and escapement device.

Good selective properties for flatfish species are achieved by a specific design based on two lateral escape windows mounted in front of the codend. The windows are constructed as rigid, grid-like sections made of steel to keep the distance between bars stable and well-defined.

The dimensions of the windows are relatively small (480 x 900 mm). The inner bars (and consequently the bar spacing) are horizontally oriented to match the flatfish body shape in natural swimming orientation. Regional catch profile preferences must be considered to specify the optimal bar spacing of the windows. For the specific case of Baltic Sea cod-directed trawl fishery (where the device was tested for the first time), the bar spacing was set to 38 mm. Based on prior experiments, this spacing was considered sufficient to allow escapements of a wide range of flatfish size classes, while only undersized cod would have any chance to escape through these windows. The rigid windows are fitted to the sides of a 4 panel extension piece, designed to provide geometrical stability to ensure the optimal position of the windows during the fishing process. In addition, the design of the extension piece enabled us to mount the windows with an angle of attack of 45° in relation to the towing direction. Such angle of attack creates a tapering effect, which enhances the fish contacts with the escape windows while swimming towards the codend.

To further increase the contact probability between fish and escape windows, a guiding device made of canvas was attached ahead of the windows in the center of the extension piece to alter the flatfish swimming direction sideways towards the windows. For the Baltic case study, the FRESWIND was used in connection with the BACOMA codend, one of the mandatory codends used in the Baltic Sea, specifically designed to improve cod size selection.

The FRESWIND was already tested under commercial and research conditions, in both cases using twin trawl rigging for optimal experimental setup. The reference gear used had a BACOMA codend (one of the two mandatory codends in the Baltic demersal trawl fishery) as selection system, while the test gear used the sequential selection system composed by the FRESWIND in conjunction with the BACOMA codend. By using this experimental design, both fishers and fishing technologist were able to assess the practical implementation of the FRESWIND. The results obtained from the commercial sea trials demonstrate a significant flatfish catch reduction due to the effect of FRESWIND. By species, the usage of FRESWIND resulted in more than 60 % and 55 % reduction in flounder and plaice catches, respectively. In addition, the new device supplemented cod size selection in the codend by reducing the catch of undersized cod by more than 30 %, while only minor losses of marketable cod (above minimum landing size) were reported. By adjusting the bar spacing, the performance of the selection device can be easily adjusted to specific needs, e.g. to reduce the loss of marketable cod or to implement the device in other fisheries. More information to be found in Santos (in press)

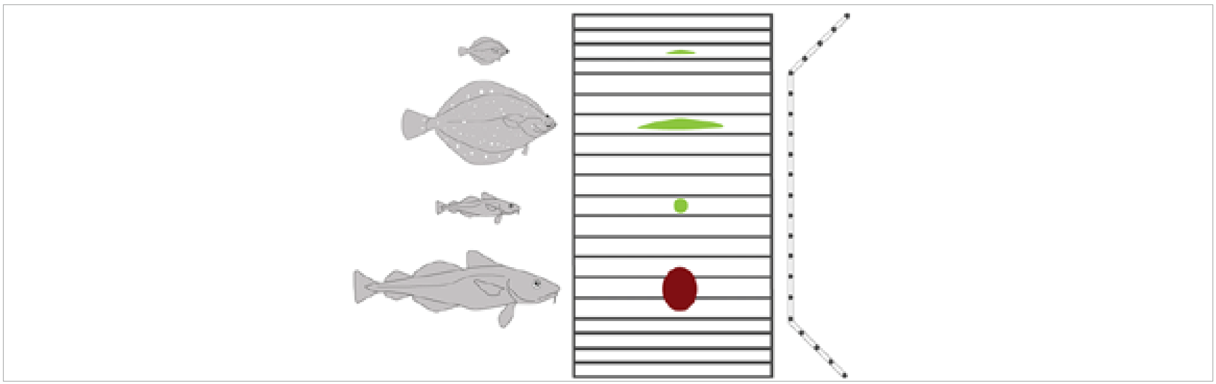

Figure 2: Schematic presentation of the flatfish escapement window used in FRESWIND. Left: different demersal fish species and sizes (from top: plaice below current minimum landing size (MLS); plaice above MLS; cod below MLS; cod above MLS); Mid: window with bar spacing and cross section of fish, green color of the cross section indicates successful penetration of the selection device; Right: cross section of window.

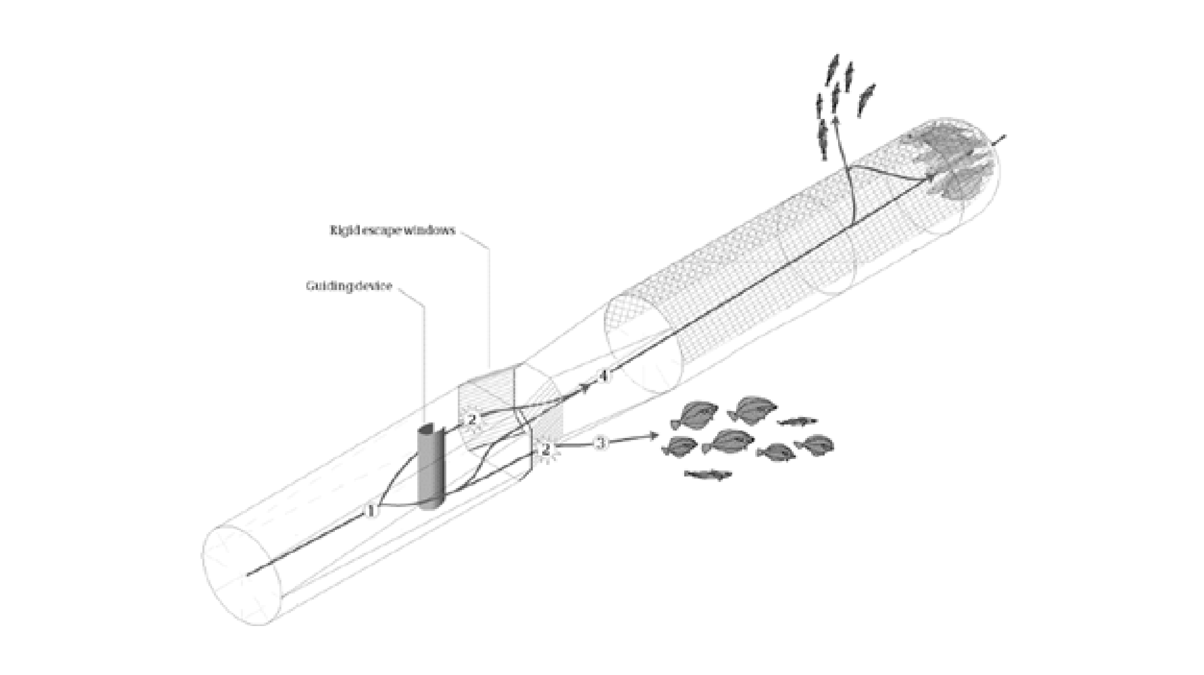

Figure 3: Sequential selection system with FRESWIND mounted in front of a BACOMA codend. The numbers represent the expected events occurring when fish swim into the FRESWIND area. (1) Fish entering the extension piece are guided sideways by the canvas device and (2) will contact the escapement window. (3) Fish escapement depending on the size selection in the FRESWIND escapement window. This size selection is defined by the bar spacing (38 mm for the Baltic Sea case study). (4) Fish which did not efficiently contact, or were not able to escape through the rigid windows (because they were too large) follow the path towards the codend (4) where a successive, roundfish-directed selection process takes place.

b) **FLEX** (**FL**atfish **EX**luder): Another flatfish by-catch reduction device for demersal roundfish fisheries**.**

When working on the FRESWIND-concept (see above), intensive behavior observations were carried out to understand the behavior of the fish in the trawl and to be able to use natural behavior and stimulate a behavior change, where needed. During these video observations, it became clear that there is a pronounced difference in the orientation of different species in relation to the cross section of the trawl. Whereas cod try to stay clear of netting, flatfish drift back into the codend mostly directly on the lower panel of the net tunnel.

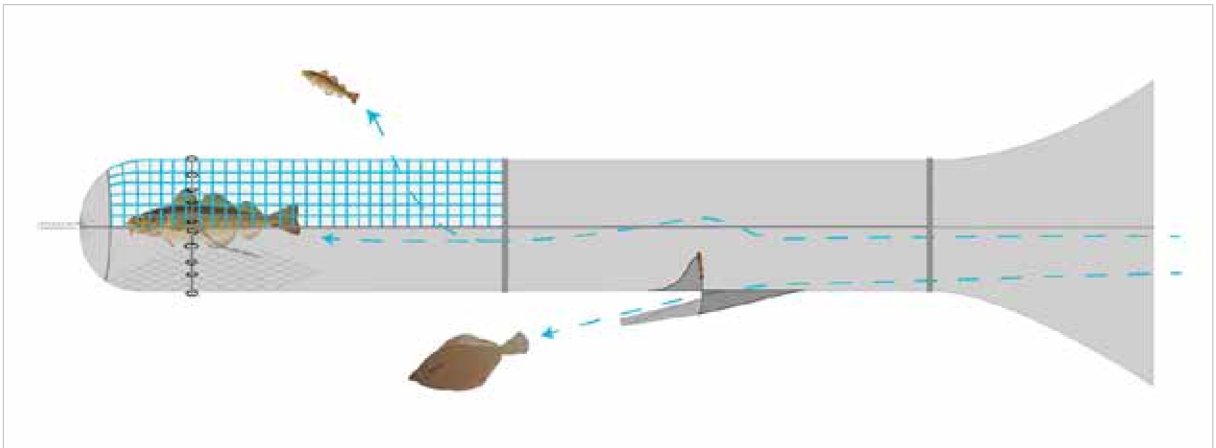

Figure 4: Sequential selection system with FLEX mounted in front of a BACOMA codend, schematic drawing.

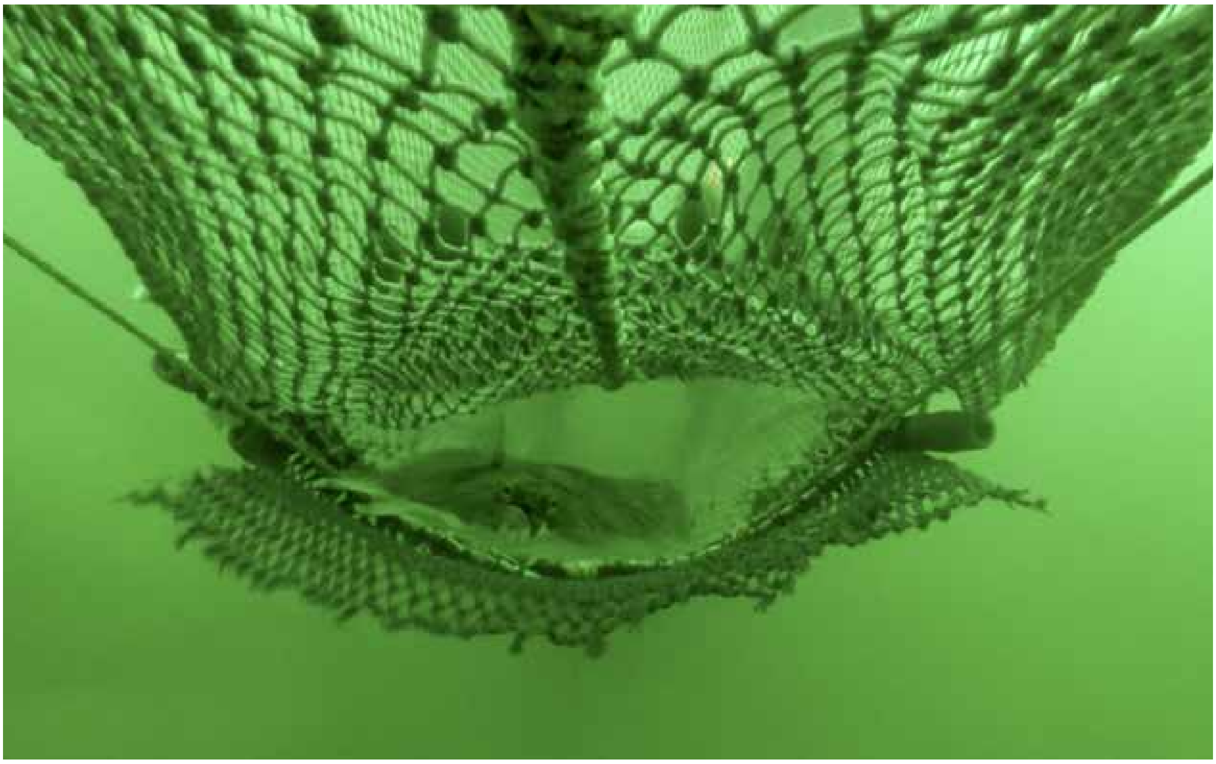

Figure 5: FLEX underwater picture: a flatfish escaping from the FLEX-opening; camera mounted outside the trawl, looking forward

Therefore, the next logical step to reduce the bycatches of flatfish in roundfish fisheries is to use this difference in behavior and open an escapement opportunity in the lower part of the net. As with FRESWIND, a dual selection process was established, were Flatfish can escape through the FLEX-opening in the tunnel section of the trawl (ahead of the codend) and the roundfish (e.g. cod) can be size selected in the codend (Figure 4). During the presentation, the process of development was described with focus on the problems that can occur when using behavior to select species. Several changes to the original layout were necessary for an optimal performance. The results obtained from sea trials with the optimal design demonstrate a significant flatfish catch reduction (80 %) due to the effect of FLEX. In addition, the FLEX device supplemented cod size selection in the codend by reducing the catch of undersized cod by 14 %, while only minor losses of marketable cod (above minimum landing size) were reported.

Whereas FRESWIND and FLEX aim to reduce the unwanted bycatch of flatfish in roundfish fisheries, both devices have their justification and can be used as two separate tools to adjust the fishing activity to the different needs (Table 1).

Table 1: Comparison of FRESWIND and FLEX

	FRESWIND	**FLEX**
Construction	rather simple and cheap to (be built by the fishermen), but rigid grid needs more attention during handling on deck	Simple and cheap (to be built by the fishermen)

	FRESWIND	FLEX
Reduction of flatfish by-catches	Flatfish reduction significant. By adjusting the bar spacing of the grid, the size of wanted (marktable) flatfish to be kept in the trawl can be adjusted, if needed	Flatfish reduction significant. Since there is no size selection device (such as a grid) mounted in the FLEX-desig, flatfish escape independent on size. Nevertheless, if the fishermen is able to land/sell a given amount of flatfish per trip, it is easy to close FLEX. E.g. it is possible to fish with closed FLEX some hauls during a fishing trip until the desired amount of flatfish is caught and then to open the device to avoid catches of flatfish.
Reduction of roundfish catches	Escapement of roundfish through the grid can be easily be adjusted by bar spacing	Escapement of roundfish through the FLEX is possible (no barrier), when no additional adaptations of the device are used. Further improvements of the device already tested.

c) STIPED: A by-catch reduction concept for mixed fisheries.

Fisheries targeting small sized target species, such as the *Nephrops* fishery in the North Sea, require rather small meshes in the codend to avoid losses of target species. This often results in unwanted bycatches of larger individuals of other species (such as cod in the *Nephrops* fishery). To solve this problem, square mesh panel windows ahead of the codend are mandatory in some fisheries. Unfortunately, catch comparison experiments have shown very limited efficiency of these escapement devices. Underwater video observations have shown that cod try to stay clear of netting and mostly don't use such escape panels – even when the meshes are very large. Therefore, we developed a simple device to stimulate roundfish to use such escapement panels and tested its efficiency compared to other devices.

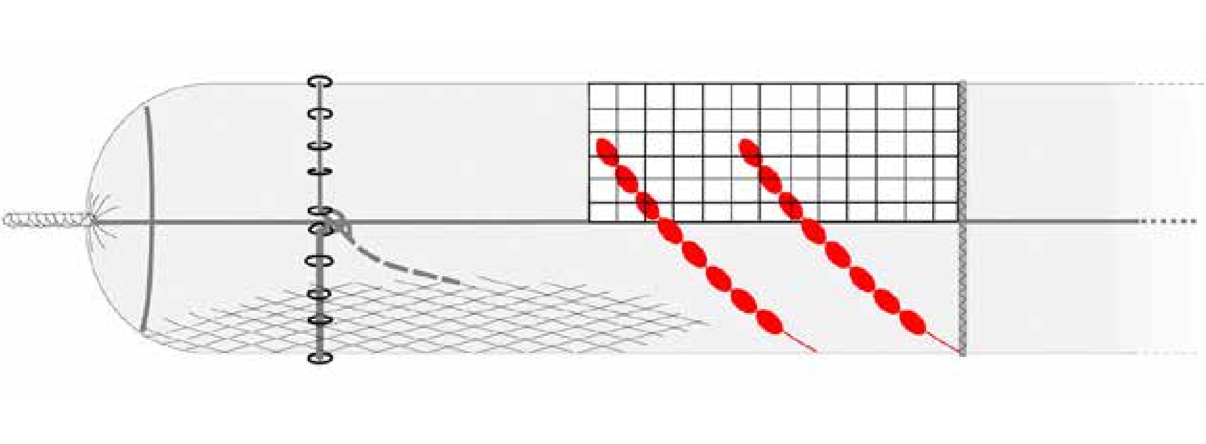

Figure 6: Schematic drawing of STIPED devices. STIPED is mounted below a square mesh panel and consists of roped, which are fixed in the lower panel, and floating devices (red color).

Additional information can be found in Herrmann et al. 2015.

d) Other ways to improve the selectivity and hence the sustainability of fisheries

Two additional projects were mentioned during the presentation. Both are focusing on the improvement of sustainability of North Sea brown shrimp (*Crangon*) fishery.

- CRANNET: a project to investigate the optimal mesh size and shape for this fishery, taking into account the influence on population dynamics.
- Shrimp-Pulsetrawl: A device to reduce the bycatch in *Crangon* fishery and significantly reduce the bottom contact.

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Satellite Tracking to Create Transparency in Fishing

Alfred Schumm

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The facts are frightening, to say the least. In 2014, the United Nations Food and Agricultural Organization (FAO) declared that 28 % of world fisheries are overfished and over 60 % fished to their limits. Still, the demand for seafood is expected to increase, wild capture and farmed seafood remaining one of the most traded food commodities worldwide with over 200 countries exporting fish and seafood products. By 2030 the FAO estimates we will need additional 45 million tons to meet demand. It has never been more important to make a global shift towards well-managed, sustainable and ecologicall sound fisheries.

Overfishing has pushed oceans to the limits of their productivity, and is threatening the world's fisheries, and consequently, the human populations that depend on the sea. Unsustainable management and illegal, unreported and unregulated (IUU) fishing damage ecosystems, undermine livelihoods, and are often associated with other serious problems such as drug trafficking, human slavery, organized crime and maritime security. Every year, millions of tons of fish are stolen from our oceans and brought to market disguised as legal catch. Pirate fishing is a multi-billion dollar industry that endangers marine ecosystems. It continues because it is profitable: pirate fishers find it easy to bring their tainted goods into ports, across borders, and onto our store shelves and restaurant menus. The global seafood supply chain is complex and often poorly regulated, enabling the origin and movements of illegal products to be concealed, making it more difficult for the fishing industry and consumers to ensure products are legally caught. A crucial step against illegal, unreported and unregulated fishing and sustainable resource use is transparency.

The Smart Fishing Initiative (SFI), the global fisheries programme of WWF, is meeting the challenge of global overfishing head-on and working to mitigate the potential "ecological disaster" of worldwide overfishing by advocating good governance, supporting sustainable markets, and encouraging responsible investment. To create transparency at sea and stop illegal fishing we need good systems to monitor global fishing activities and track fish.

Satellite technology is offering a way to help combat overfishing by monitoring fisheries and tracking catches and asking commercial fishing companies to be transparent. Technologies such as the Automatic Identification System (AIS), Vessel Monitoring System (VMS) and other tracking systems can be of great help to create transparency. AIS is an open communication tool widely used in commercial shipping to help ships avoid collisions. It can be captured by satellite and provides information about GPS location, speed, direction of travel and ship identity. VMS is a fishery management system which allows selected groups to track and monitor the activities of fishing vessels. Other tracking systems entail systems based on mobile network technology and GPS location. However, VMS obligation only applies to fishing vessels >12m (Regulation (EC) No 1224/2009 - EU fisheries control system). They are developed to track small scale fishery vessels and have a low power consumption and low operating costs.

WWF and its partner navama, the Munich based technology company, have been developing and actively promoting the use of the Automatic Identification System, which is an affordable way to use satellite data to monitor fishing operations.

AIS was introduced by the International Maritime Organization (IMO) in December 2000 for safety reasons but outside the European Union Exclusive Economic Zone (EEZ) and several other state EEZs the installation of the AIS system is mandatory only for ships over 300 metric tonnes, but not for fishing vessels.

Beginning in December 2004, the IMO, has required all vessels over 299 GRT to carry an AIS transponder on board; the EU is now requiring the entire EU fishing fleet over 15 meters to install Class A AIS transmitters (In comparison to Class-B-transmitters, Class-A-transmitters use stronger VHF-signals and a higher signal repetition rate which is automatically adjusted e.g. to the speed and status of the vessel.) and Member States may use AIS data for Monitoring, Control and Surveillance (MCS) purposes. Additionally, a number of other countries, including China, India, the U.S., Argentina and Singapore, have started AIS mandate programmes which require large numbers of vessels to fit an approved AIS device for safety and national security purposes.

WWF initiated several projects to prove that the use of satellite technology in the surveillance of fishing activities can be an efficient and simple method to increase safety on fishing vessels and promote legal and transparent fishing operations. WWF and navama for example cooperate with Sea Quest, a fishing company in Fiji in the South Pacific that agreed to install Automatic Identification System (AIS) transmitters on its tuna fishing vessels to demonstrate full transparency of the company´s fishing operations (Figure 1).

Since June 2013, AIS transmitters have been activated round-the-clock on the long-line MSC certified tuna fishing vessels of Sea Quest. The AIS, a reliable supplier of data is constantly sending VHF (Very High Frequency) radio signals (Class A: 161.957 MHz) from the vessels where it has been installed to the WWF/navama database to monitor and evaluate fishing and vessel operations on the water. WWF/navama can retrace the routes and activities of Sea Quest's fishing vessels and ensure that boundaries of sensitive areas and no take zones are respected. Similar projects exist in Mozambique, Senegal, and Pakistan.

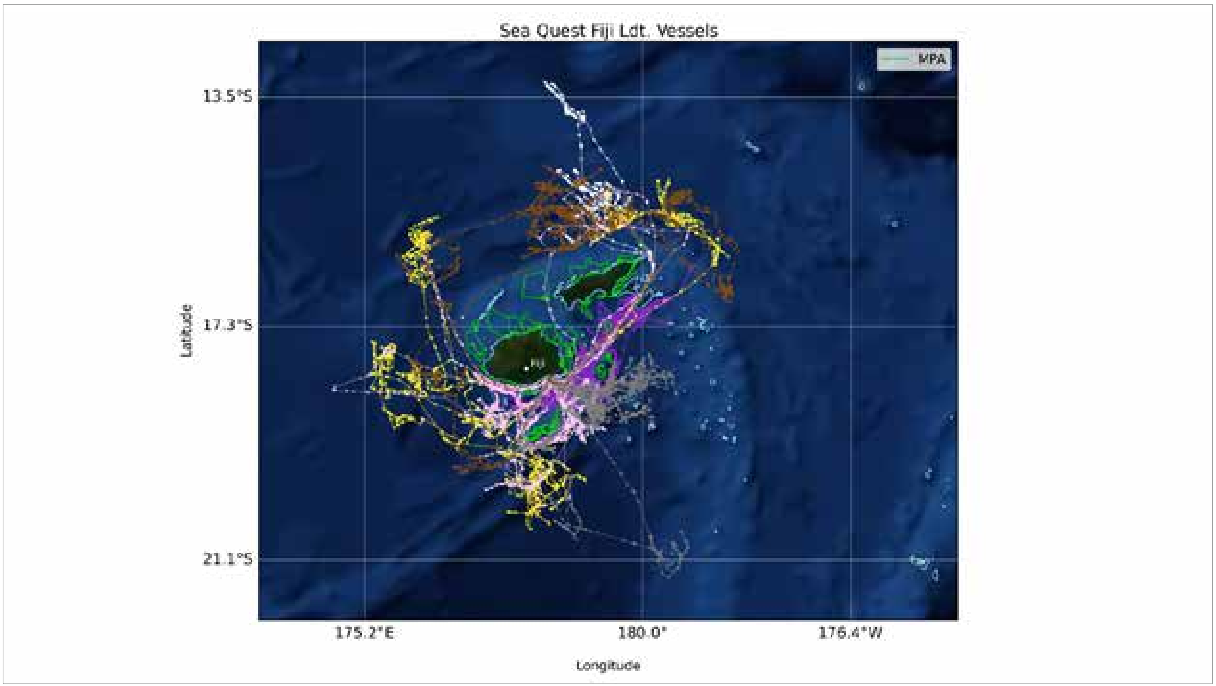

Figure 1: Sea Quest Tuna Vessels (2013-06-25 bis 2014-07-31). Copyright WWF & navama

WWF and navama, the environmental technology innovators, gained a lot of experiences working for more than 4 years with AIS data (example see Figure 2) and now we have developed some sophisticated analytical tools and crosschecks to enable a good understanding of the satellite-data. Our aim is to make fishing operations transparent and to ensure that the seafood reaching markets is fully traceable to legal sources.

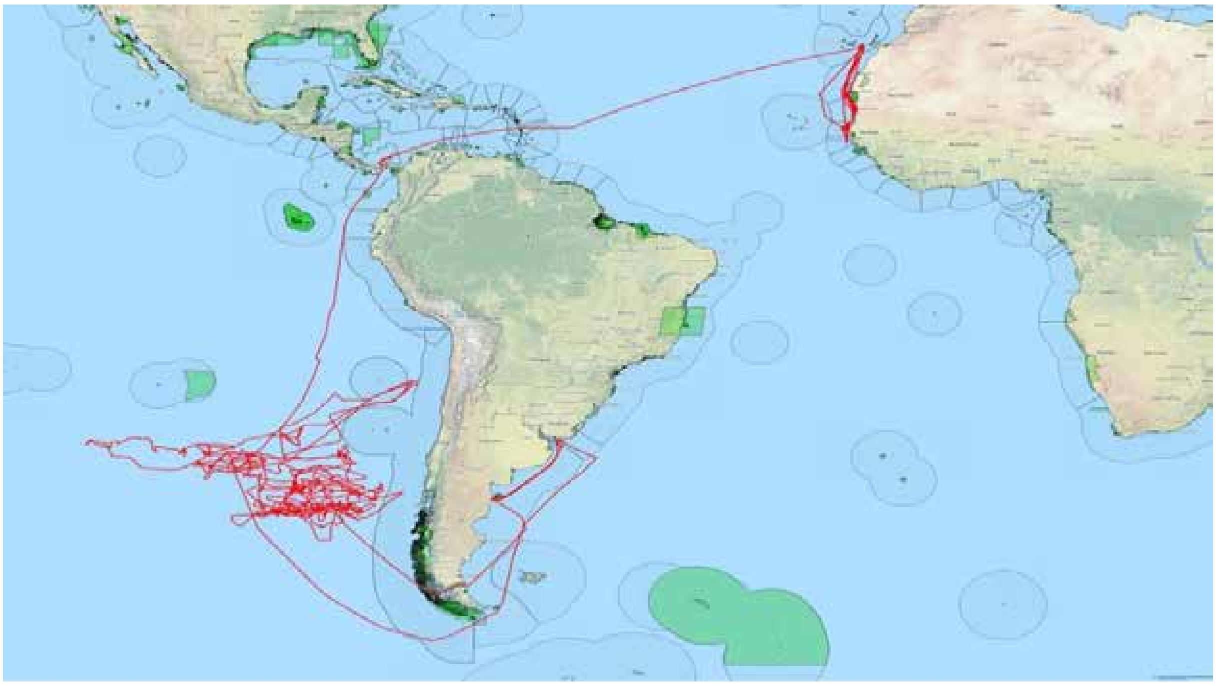

Figure 2: AIS Track of a fishing vessel, showing international movement.

Transparency in fishing operations means that you have full disclosure and traceability of fish harvested in a fishery, so that you can properly manage the removals from that fishery. Full traceability means you can trace the catch, from a particular vessel or fisherman all the way to its final destination. When there is no full transparency, catches often go unaccounted for, leading to overfishing and, ultimately, fisheries collapse.

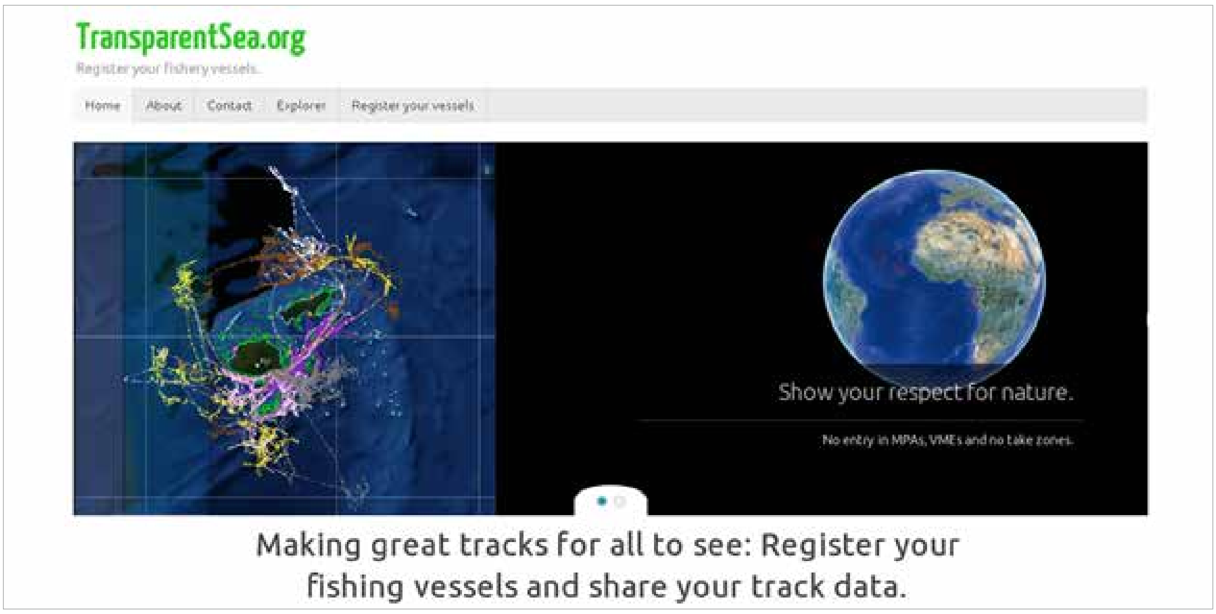

Figure 3: Homepage: www.transparentsea.org

WWF and navama have developed four tools based on Vessel Monitoring technologies, to create more transparency at sea, which I am going to describe below.

First: Together with navama, we introduced **TransparentSea.org**, a tracking tool and data sharing platform that allows fisheries all over the world to voluntarily register with the system, and make their fishing activities "transparent." We visualize routes of fishing vessels, and co-operate with fisheries who want to make their operations transparent and register on our new website www.transparentsea.org (see Figure 3).
With their registration fisheries agree to share 24/7, either satellite AIS data, VMS data or other location based information data of their vessels with independent experts from WWF, navama, other NGOs, governments and science. With the fishing company's approval, the data from their experience can even be published. Fisheries which cooperate with us can thus show their customers that they are committed to legal and responsible fishing and demonstrate that they respect boundaries of sensitive areas and no take zones and use responsible fishing practices.

Second: seeFish builds on modern technology to establish a consumer friendly traceability system from catch to supermarket shelf. Consumers will be able to trace products back to the catch location with smartphones and tablet PCs. Satellite technologies (GPS, satellite AIS and VMS), modern database management and automated analysis procedures play a vital role in tracking fish products. It is a joined project of Luxspace, WWF and navama, funded by the European Space Agency (ESA) and German Aerospace (DLR).

Third: We also developed a new fishery track data analysis platform for fisheries experts called **seeOcean** - a web based analysis tool for marine geographic information and AIS/VMS/GSM tracks. It enables access to a big AIS satellite database with data about global AIS coverage, individual shared fishery tracks, marine protected areas, wind and waves, track patterns, ports, and economic data which can be combined and visualized to provide a holistic view of fishing operations. It can be used by governments, supply chain representatives, fishermen and scientists to monitor and visualize fishing activities worldwide (see Figure 4 next page).

Fourth: smartTrack is a vessel tracking system for artisanal fisheries based on vendor independent hardware solutions. smartTrack supports small scale and artisanal fisheries who seek better access to efficient and affordable sustainability certification processes. It is a project in which WWF and navama test and install various position tracking systems on artisanal vessels, supplied with solar power where necessary.

All these tools contribute to improve collaboration on transparency between fisheries, NGOs, administration, the seafood industry and science.

We want to create transparency and understanding and show that the fisheries management, monitoring and control measures are essential to make fishing sustainable. Governments over the world should make AIS installation mandatory for every commercial fishing vessel to increase safety and transparency.

WWF urges national governments, Regional Fisheries Management Organisations as well as states flagging fishing vessels operating on the high seas to promote transparency at sea and adopt mandatory installation of the AIS system on all commercial fishing vessels under their flag or fishing in their national waters in addition to monitoring, control and surveillance (MCS) measures currently used such as VMS systems.

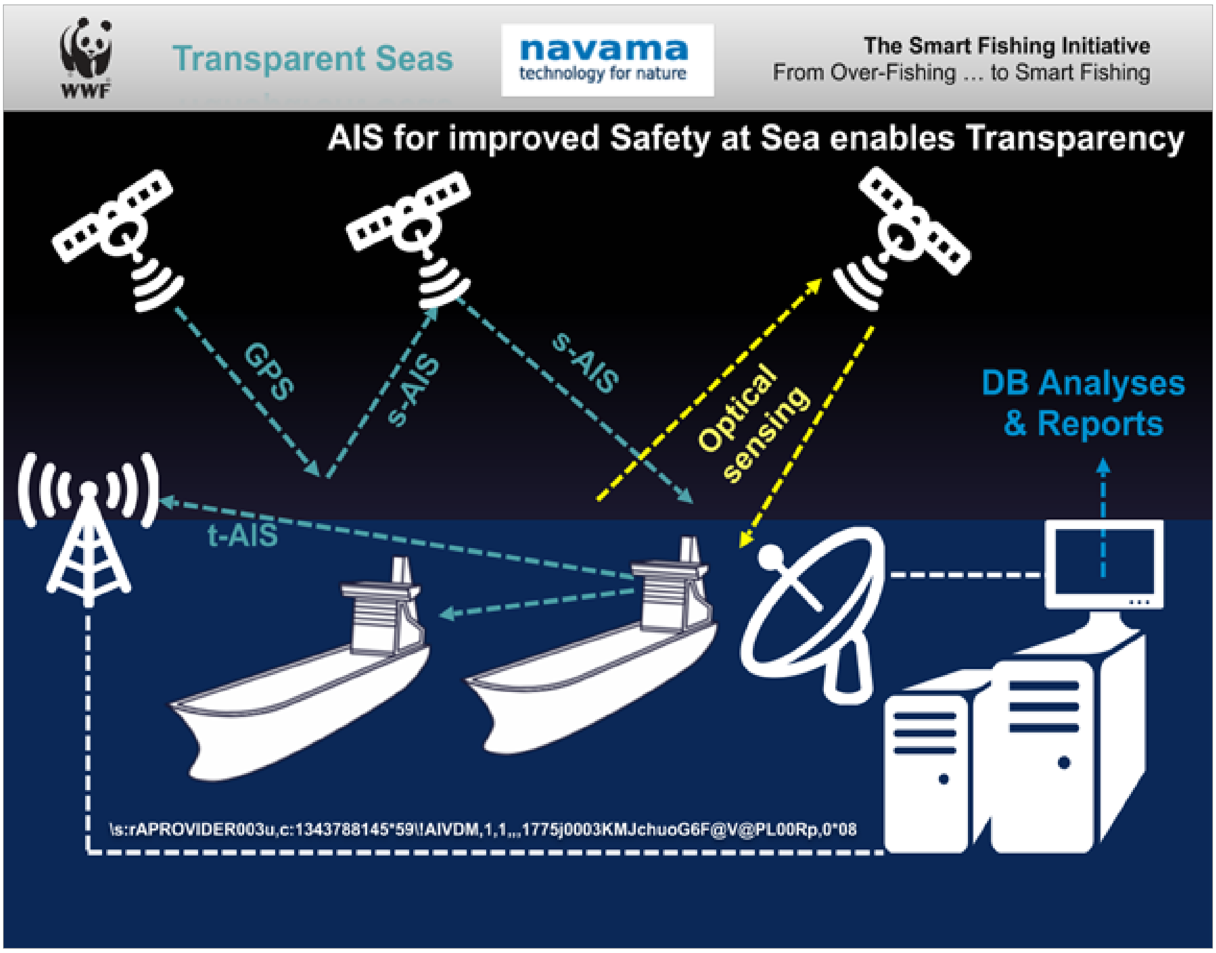

Figure 4: The **seeOcean** explorer enables global access to AIS- and complementary marine-data for all project-partners.

We support the critical steps to implement sustainable fishing methods, to create transparency at sea, to preserve fish stocks, secure and improve coastal communities' livelihoods. Only through joint efforts to make fisheries and the whole global seafood industry fully transparent and sustainable, can we stop the over-exploitation of the seas.

Figure 5: Indian Ocean tuna: Tuna is a vital source of food, a source of income and an essential link in the marine food web (Photo: Wetjens Dimmlich, WWF-SFI).

Progress in marine biotope mapping in Germany

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1 Background and Goal

In European marine waters sound biotope maps are needed to meet the requirements arising from different directives of the European Union and national laws, e.g. the Habitats Directive (HD), the Marine Strategy Framework Directive (MSFD) and the Federal German Nature Conservation Act (BNatSchG). In Germany's Exclusive Economic Zone (EEZ) these maps are currently developed by two consortia in projects funded by the Federal Agency for Nature Conservation (Pesch et al. 2014; Propp et al. 2014). The approach of the biotope mapping projects is based on the combination of existing and newly collected macrobenthos and sediment data, the latter including both high-resolution full-coverage mosaics received from by acoustic backscatter techniques and broad-scale sediment maps obtained by point sampling. Additionally, further relevant geodata on e.g. hydrography and topography were used to assess the spatial heterogeneity of the abiotic and biotic conditions and to fulfill the requirements of available classification systems for the North- and Baltic Sea EEZ.

The actual manuscript summarizes the major outcomes of the initial project phase (2011-2014). This phase focused both on the development of broad-scale resolution maps of soft bottom biotopes and the promotion of the coverage of high-resolution sediment maps in the Baltic as well as in the North Sea EEZ.

2 Biotope Classification Systems

Whereas for the Baltic Sea, the *HELCOM Underwater Biotope and habitat classification* (*HUB* - HELCOM 2013), an internationally agreed upon hierarchical classification system, was available, the classification of biotopes in the North Sea EEZ relied on a first draft of a national biotope classification system. Both classification systems have meanwhile been overworked thoroughly and adjusted to the present conditions in Germany's marine areas in a separate project. Future biotope mapping for hard and soft-bottom biotopes will rely on these updated classification systems.

As mentioned, the full-coverage soft-bottom biotope mapping in the *Baltic Sea EEZ* relied on the classification rules of *HELCOM HUB* developed to form a framework for classifying biotopes in the Baltic Sea (HELCOM 2013). Regarding its hierarchical structure, HUB was constructed to be compatible with the European Nature Information System (EUNIS - Davies et al. 2004) which does not cover all known habitats and biotopes in the Baltic Sea (HELCOM 2013). HUB was developed in a five year period under the by HELCOM Red List Biotope Expert Group including national experts from the Baltic Sea bordering countries. As a result, the classifications system consists of six hierarchical levels defining 328 underwater biotopes and ten biotope complexes. Regarding the benthic environment, HUB defines the Baltic Sea as a unique biogeographical region in Level 1. Level 2 structures the ocean floor into either photic or aphotic zones followed by the delineation of substrate classes in level 3. Levels 4 to 6 then address biotic classification aspects covering community structures in level 4, characteristic communities in level 5 and dominant taxa in level 6. The hierarchical system relies on defined splitting rules enabling to connect the six hierarchies provided.

Regarding the German EEZ of the North Sea, a first biotope classification draft was developed strongly resembling the hierarchical structure given by EUNIS and HUB. Furthermore, the state of the art regarding benthic ecological conditions in the North Sea area was accounted for (Pesch et al. 2014). Consequently, the classification system also relied on six hierarchical levels consisting of the biogeographical region (level 1), photic/aphotic conditions or biological zones (level 2), substrate classes (level 3), biotope structures (level 4), biotope types (level 5) and subbiotope types (level 6). Classification criteria were defined for the abiotic classification levels by expert opinion and classification criteria given by EUNIS. Level 5 soft-bottom biotope types were defined by application of data analytical investigations. The corresponding statistical design thereby relied on cluster analytical analysis of the benthic abundance data available (Fiorentino et al. in prep.). The derived benthic groups thereby mostly reflect scientific knowledge on the occurrence of soft bottom communities in the German North Sea since five of the six groups have already been documented in the scientific literature (Rachor & Nehmer 2003; Salzwedel et al. 1985). Regarding level 6, potential classification criteria were suggested with help of an extensive feasibility study in terms of relevant infauna species for nature conservation issues.

3 Empirical Investigations

3.1 Sedimentological Investigations

Whereas full-coverage broad-scale sediment maps (Laurer et al. 2013; Tauber et al. 2012) and a large amount of grain-size sampling data could already be used for the biotope classification at the beginning of the project, high-resolution and full-coverage sediment data derived from backscatter data were only available for few and very small areas within the German EEZ of the North Sea. In the Baltic Sea, extensive data is pre-existing, but not yet processed and thereby not available for data interpretation. Hence, one of the major goals of the project was to compile as well as process existing data and obtain corresponding acoustic backscatter data for the eight Natura2000 sites according to the Habitats Directive within the German EEZ of the North Sea (*Sylter Outer Reef, Borkum Reefground* and *Doggerbank*) and Baltic Sea (*Fehmarnbelt, Kadetrinne, Adlergrund, Westliche Rönnebank* and *Oderbank*). Therefore, full-coverage mapping surveys using sidescan-sonar systems were performed and ground truthing was carried out using grab samplers and video devices.

Concurrently, a standardized, national guideline for seafloor mapping and classification was developed that includes specifications on data collection, processing, and data interpretation.

Emphasis was put on the latter, and standardized strategies for the classification and discrimination for different seafloor sediment types were defined. With the completion of the standardized mapping procedure, reproducible criteria were specified for consistent data interpretation, and first detailed sediment distribution maps based on sidescan mosaic with a resolution of 1m were created. Due to the considerable time required for this development process, high resolution maps were not available for biotope classification and modelling within the first phase of the project, but will play a dominant role for the works to come.

3.2 Benthic Sampling

For both the Baltic and the North Sea area, a large amount of benthic abundance data were already available at the beginning of the project coming from environmental impact assessments and research projects. Nevertheless, these data were not sufficient to enable a representative mapping of species and communities within both marine regions as they were not sufficiently distributed along spatial and environmental gradients. Hence, additional benthic data were needed in areas with low sampling densities. The empirical design thereby followed the recommendations put down in the German version of the *Standard for Environmental Impact Assessment BSH* (2013). Accordingly, at each sampling station three parallels and one separate sediment sample were taken to assess the infauna and sedimentology by use of Van Veen grabs. Dredge or 2 m beam trawl respectively and video investigations were furthermore carried out to investigate the epifauna and habitat characteristics. Additional relevant abiotic parameters were measured using CTDs (Conductivity, Temperature, and Density) sensors.

Until autumn of 2014 overall 244 stations were sampled, thereof 130 stations in the North Sea within and near the *Sylter Outer Reef, Borkum Reefground* und *Doggerbank*. and 114 sites in the Baltic Sea area concentrating on the five Natura 2000 sites *Fehmarnbelt, Kadetrinne, Adlergrund, Westliche Rönnebank* and *Oderbank*. Additional samples were taken outside protected areas to map potential special biotopes as put down in German national law (§ 30 of the Federal Nature Conservation Act/BNatSChG) and to close further spatial gaps. In both marine regions the spatial sampling design relied on a standardised 10 km reference grid provided by the European Environmental Agency (EEA).

3.3 Data Compilation and Management

All available biotic and sediment data were compiled in a Geographical Information System *GIS Biotope Mapping* relying on ArcGIS Version 10.0 and additional geodata layers on protected areas and administrative borders. Furthermore, geo data layers from other projects and databases were integrated into the GIS environment. These include e.g. geodata layers on biological zones from the European Marine Observation and Data Network (EMODnet), biotope data layers produced by Schuchardt et al. (2011), polygon raster data on chosen benthic infauna species for the North Sea made available by the Alfred-Wegener-Institute (Dannheim et al. 2013) and broad-scale sediment maps for the Germany's EEZ and coastal areas of the North and the Baltic Sea made available by the Federal Maritime and Hydrographic Agency of Germany and the Leibniz Institute for Baltic Sea Research (Laurer et al. 2013; Tauber 2012).

3.4 Predictive Modeling of Benthic Species and Communities

For both the Baltic and the North Sea stations specific information on benthic species and/or communities were intersected with full-coverage geodata on e.g. photic conditions, topography, sediments and physical / chemical properties of the water column to predictively model biological classification criteria as required by the biotope classification systems applied. In both marine areas the statistical associations between communities and species occurrence or dominance were quantified in terms of *Random Forest* models (Breiman 2001). The tree models were applied on the full-coverage information on abiotic variables to map the variables of interest for the EEZ and coastal areas. Next to the prediction of communities and species the application of statistical models like Random Forests enable to assess the uncertainty of the prediction in terms of misclassification and confusion index maps. These should be taken into account when using corresponding species and communities maps for environmental monitoring and planning within the scope of marine nature conservation issues.

4 Biotope Mapping Results and Outlook

Making use of acquired and sampled data and the chosen biotope classification systems soft bottom biotopes and biotope types could be mapped for both the Baltic and the North Sea areas. Regarding the Baltic Sea the mapping was done according to the classification rules of HELCOM HUB. Accordingly, six levels could be mapped for the entire German Baltic Sea depending on the data available. Down to level 3, corresponding maps could be produced by use of data on photic conditions at the sea floor and on the sediment conditions. Regarding the biological levels selected species put down for HUB level 6 were predictively modeled and queried in terms of dominating species to produce a level 6 map covering 78 % of the German Baltic Sea (Schiele et al. 2015). In the North Sea biotope mapping was carried out according to the draft biotope classification system (Pesch et al. 2014). Next to maps on biological zones (level 2) and substrate types (level 3) full-coverage maps of biotope types (level 5) could be mapped in terms of the spatial distribution of six benthic communities for soft substrates using predictive modelling techniques. The same methodology was applied on chosen benthic species relevant for nature conservation issues (level 6).

As a conclusion the overall design to produce broad-scale biotope maps for soft bottom sediments has proven well. The modelled maps meet scientific quality criteria and the underlying statistical methods furthermore enable to assess the accuracy of prediction. Nevertheless, the validity of the results depends on spatiotemporal representativeness and quality aspects of the used data. Regarding both the North and the Baltic Sea area new benthic sampling data will be available in the future. This data will be used to fill spatial gaps and to update the benthos databases for both EEZ areas. The actual species and community maps will be validated and, if necessary, be recalculated accounting for the updated information.

Besides the validation of the broad-scale soft-bottom biotope maps, future works will concentrate on high-resolution mapping of biotope and subbiotope types for both hard and soft-sediment habitats by linking biological data with high-resolution substrate and stone field maps created on the basis of side scan-sonar data. First pilot studies have been started in both the North and the Baltic Sea EEZ. In the North Sea, a detailed sediment distribution map of the southwestern part of the Natura 2000 site *Sylter Outer Reef* was the basis for an extensive sampling campaign with 176 benthos stations taken in this area. The results of these benthos samples will be used to analyze the linkage between the spatial distribution of species / communities and small-scale spatial pattern of sediment classes derived from the sediment distribution maps based on side scan mosaics. The same will be done in the Baltic Sea where similar empirical investigations were started in the Natura 2000 site *Fehmarn Belt*. Here, additional focus is put on the spatial distribution of macrophytes and sessile epifauna.

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Investigation and classification of reefs in the German Baltic Sea

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Abstract (extended version)

Due to increasing pressures on the oceans by human activities, effective conservation measures for marine habitats and biotopes are urgently needed. In order to address requirements such as the protection of ecologically important areas and setting legislations to safeguard the oceans, knowledge of the extent, geographical range and ecological functioning of benthic ecosystems is essential (Brown et al. 2011). However, spatial data on the distribution of seafloor habitats and biotopes is still extremely poor especially due to limitations of traditional seabed survey methods, and it is estimated that only up to 10 % of seabed habitats are mapped with a resolution of comparable terrestrial investigations (Wright and Heyman 2008; Brown et al. 2011).

This lack of knowledge is even more pronounced regarding small-sized, special or rare habitats like marine hard substrata which often show a patchy distribution within vast sand and mud flats. As solid surfaces presenting anomalies in the marine realm, hard bottom biotopes vary in size from tens to hundreds of square meters. If these structures are topographically distinct from the surrounding seafloor and host a specific community that depends on the hard substrate rather than on the nearby sediment, they can be classified as reefs according to the Habitats Directive (92/43/EEC, Annex I European Council 1992). Reefs can either be biogenic concretions (e.g. mussel beds) or of geogenic origin (e.g. boulder fields). Hosting a diverse, primarily epibenthic community with motile and attached, colonial and individual species, they generally make a significant contribution to benthic production and play an important role for marine food webs (Wahl 2009). Erect biota (e.g. foliose red algae, sponges and bryozoans) additionally enhances the three-dimensional habitat complexity, alters the physical and biogeochemical micro-scale environment and thus affects the distribution of smaller-sized bottom fauna as well as mobile megafauna (Wahl 2009; Bergmann et al. 2011). Despite the brackish environment, also Baltic reefs provide a habitat for many invertebrates and serve as nursery ground for fish and as feeding grounds for marine mammals and birds. Isolated hard structures such as glacial boulders provide refuges and act as stepping stones for sessile organisms with planktonic larval stages. However, little is known about the community structure and functionality of Baltic reefs, especially in offshore areas, and a coherent classification is lacking.

Beside the development of large-scale maps focusing on predominant soft sediment biotopes (Schiele et al. 2015; Pesch et al. 2016, this issue), the development of high resolution maps of hard-substrate biotopes is one goal of the project *Monitoring, assessment and mapping of benthic species and habitats in the German EEZ* funded by the Federal Agency for Nature Conservation. As standard operating procedures exist neither for the investigation of offshore hard substratum assemblages nor for the merging of biological and geological data, the principal objective of the present study is to develop adequate mapping techniques for reef biotopes in the exclusive economic zone of the German Baltic Sea. Based on high resolution sediment maps, providing more detailed information on the heterogeneity of the seafloor sediments and

features and the location of hard substrata, a case study was initiated within the NATURA2000 site “Fehmarn Belt”.

An area of 53 square kilometers was selected, covering a depth gradient from 12 to 42 m and including various substrate types. The complex surficial geology creates a huge heterogeneity in benthic habitats, thought to influence distribution patterns of sessile invertebrates and macroalgae, their total hard surface coverage and the reef-associated mobile fauna. Digital images of the seafloor were collected in June 2015, using an underwater platform equipped with video and still cameras, towed by a research vessel in drift mode near the seafloor. High-resolution color images (24 megapixels) were collected with a downward-facing camera. A transect was overlaid each station and pictures were taken alongside every minute and additionally when features of particular interest occurred in the field of view. Covered seafloor area was calculated based on lasers 62 mm apart. Ten minutes per transect resulted in ten pictures per station which were cropped to 0.4 square meter of seabed area in post-processing. A matrix of 50 random point was overlaid on each image and the species and substrate type beneath each point was visually identified using the open-source software Coral Point Count with Excel extensions (CPCe, Kohler and Gill 2006). For the validation of identified species (biological ground truthing) and exact calculation of biomass ratios, quantitative investigations by scuba diving were carried out at selected stations. Three samples a 0.1 square meter were collected at each station, using a modified “Kautsky frame” and scratching off organisms from the substrate into a mesh bag. Samples were sieved (1 mm) and preserved in formaldehyde. In the lab, organisms were identified to the lowest possible taxonomic level and biomass was measured as wet weight. At PMCE, the preliminary results of four selected stations were presented.

After calculating the mean percentage coverage of substrate types and epibenthic species per image, the predominant taxa and substratum per station were identified. For each station, a biotope type was assigned, following the splitting rules of the HELCOM Underwater Biotope and Habitat Classification System (HELCOM HUB, HELCOM 2013). Schiele et al. (2013) demonstrated that HELCOM HUB is applicable and feasible for soft substrate communities in the south-western Baltic Sea and therefore should also be practical for hard-bottom assemblages. Down to level 5 (characteristic community), an assignment was achievable solely by mean percentage coverage analysis of underwater still images. To reach level 6 (dominant taxa), biomass data from the frame sample have to be consulted.

The results portend that

1. seafloor imaging techniques are a potent method to identify and characterize hard-bottom communities on small- to mesoscale;
2. additional biological destructive ground truthing can complement imaging techniques and precise the classification;
3. HELCOM HUB system seem to be an appropriate tool for classifying reef assemblages in the NATURA2000 site “Fehmarn Belt”.

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Conceptual ecological models in benthic habitats monitoring

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1 Introduction

In order to manage the marine environment effectively it is necessary for decision makers to have access to suitable tools for identifying the state of marine biodiversity and habitats. When a change in state occurs, these tools allow users to identify possible manageable causes. Conceptual ecological models (CEMs) are visual representations of a target system (e.g. ecosystem, habitat, protected site) which summarise complex ecological interactions.

Although CEMs are recognised as an important step in terrestrial monitoring programmes, they are rarely used in the marine environment due to greater ecosystem complexity and a lack of information for many habitat types. However, with increased legislative demands to monitor and assess benthic habitat condition, the need to develop CEMs has never been greater. As part of the UK Marine Biodiversity Monitoring R&D Programme, the Joint Nature Conservation Committee (JNCC) has developed a methodology for creating habitat CEMs. This is based on a thorough literature review and incorporates knowledge gap analysis, confidence assessment and peer-review stages.

CEMs are diagrammatic representations of the influences and processes which occur within an ecosystem. They can be used to identify critical aspects of an ecosystem which may be taken forward for further study, or serve as the basis for the selection of indicators for environmental monitoring purposes. The models produced using these methods are control diagrams, representing the unimpacted state of the habitat of interest free from anthropogenic pressures.

CEMs have been developed for five MSFD predominant habitats:

- Shallow sublittoral coarse sediment[1] (Alexander et al. 2014)
- Sublittoral rock[2] (Alexander et al. 2015)
- Shallow sublittoral mud[3] (Coates et al. 2015)
- Shallow sublittoral mixed sediment (Alexander et al. In Prep)
- Shallow sublittoral sand (Coates et al. In Prep)

Each project had the aims of reviewing the information available for the habitat type, creating a hierarchical set of models for the habitat and identifying which components of the habitat are most useful for monitoring habitat status and change due to natural variation. Specific details of the methods and the models themselves can be found in each of the habitat specific reports.

1 JNCC report number 520: http://jncc.defra.gov.uk/pdf/Report%20520_web.pdf

2 JNCC report number 560: http://jncc.defra.gov.uk/pdf/Report_560_web.pdf

3 JNCC report number 557: http://jncc.defra.gov.uk/pdf/Report%20557_web.pdf

2 Literature Review

The process for producing the CEMs begins with an initial literature review to provide necessary information to inform the model building. Information on the following topics was gathered:

- Environmental drivers of the habitat/biotopes
- Species composition within the biotopes
- Biological traits of the key species
- Ecosystem functions provided by the habitat and its associated species

2.1 Species Selection

An initial review of all taxa associated with the project biotopes yielded long lists of species species (Connor et al. 2004). For each project the list of species was refined to the key characterising taxa representative of all the project biotopes. Fauna were selected for inclusion based on the biotope description criteria below:

i. Title species: Fauna named in biotope title
ii. Title group species: Example taxa identified from the full species list to represent those groups named in the biotope titles
iii. Description species: Species identified as particularly characterising in the biotope descriptive text but not included within the biotope title.
iv. Description example taxa: Example taxa identified from the full species list to represent those groups named in the biotope descriptive text. Representative species were chosen as those that typically represented the group, based on expert judgement.

2.2 Species Traits

Species traits are an essential consideration within the model, impacting on the ecosystem functions and feedback influences within the habitat. A comprehensive list of species traits were collated from the MarLIN Biological Traits Information Catalogue (BIOTIC) database (MarLIN 2006) and further supplemented with other traits considered to be important by the project team for informing the models.

2.3 Magnitude and direction of influence

It is necessary to describe the direction and magnitude of influence between components. A direction of the interaction (Positive or Negative) as well as a magnitude (Low to High) was assigned to each linkage in the model.

2.4 Confidence Assessment

Confidence in the data gathered and in the models produced is a key consideration. Confidence has been assessed based on the quality of the evidence (Peer reviewed paper to expert judgement) and the applicability of the evidence (Study based on UK data to proxies used for the component of interest).

3 Model Development

3.1 Model Design

The CEMs developed for each predominant habitat are designed to represent both an overarching general model for each habitat, as well as more detailed sub-models which cover specific sub-components of the habitat. To aid easy understanding of the models a standard format was developed based on a model hierarchy to facilitate consistent presentation of components, interactions and temporal / spatial scales.

3.1.1 Model Hierarchy

An overarching general model is produced for each habitat to indicate the general processes which occur within the ecosystem across all relevant biotopes. Sub-models are then produced to show a greater level of detail around specific ecological aspects of the habitat and aim to inform the selection of monitoring aspects at a meaningful ecological scale.

Functional groups of each habitat are identified for the key characterising species selected for each habitat type. The identification of these groups draws heavily upon the ecological groups described by TILLIN AND TYLER-WALTERS, (2014). The ecological groups were distinguished by using both biological traits and habitat preferences, supported by ordination and clustering analyses.

3.1.2 Model Levels

Each model is broken down into several component levels which address differing spatial scales of input and output processes. The models and sub-models are defined as a series of seven levels as shown below.

Driving Influences:

1. *Regional to Global Drivers* – high level influencing inputs to the habitat which drive processes and shape the habitat at a large-scale.

2. *Water Column Processes* – processes and inputs within the water column which feed into local sea-bed inputs and processes.

3. *Local Processes/Inputs at the Seabed* – localised inputs and processes to the ecosystem which di-rectly influence the characterising fauna of the habitat.

Defining Habitat:

4. *Habitat and Biological Assemblage* – the characterising fauna and sediment type(s) which typifies the habitat. For the sub-models, fauna are broken down into functional groups

Outputs:

5. *Output Processes* – the specific environmental, chemical and physical processes performed by the biological components of the habitat.

6. *Local Ecosystem Functions* – the functions resulting from the output processes of the habitat which are applicable on a local scale, whether close to the seabed or within the water column.

7. *Regional to Global Ecosystem Functions* – ecosystem functions which occur as a result of the local processes and functions performed by the biota of the habitat at a regional to global scale.

3.1.3 Model Components

Each model level is populated with various components of the ecosystem. Model components are informed by the literature review and in some cases, expert judgement.

3.1.4 Natural Variability

Natural variability of the main environmental drivers is indicated on the models by graduated circles. The degree of natural variability is based on the following three factors: Potential for intra-annual (e.g. seasonal) variability; Potential for inter-annual disturbances and variability; and the Frequency of extreme disturbances e.g. storm events.

3.2 Model Confidence

A confidence score for each individual source of evidence for interactions between model components was assigned based on the number of sources related to one particular link within the model and the level of agreement between them. Wherever possible, the links in each of the models are informed by evidence gathered as part of the literature review. However some links are informed by expert judgement in cases where no references could be identified. In these cases, confidence can only be medium (for those relationships certain to exist), or low (for those relationships which possibly exist but are not evidenced).

4 Model Results

As results, two conceptual ecological models (CEMs) are presented in the figures on the following pages. Figure 1 on page 129 shows an example of a general model for the shallow sublittoral mud habitat. Figure 2 on page 130 shows an example of a sub-model for the shallow sublittoral mud habitat identifying the magnitude of interactions.

5 Monitoring Habitat Status Change with Natural Variability

Using the information gathered during the literature review and presented in the models, the CEM components which are most useful for monitoring habitat status in the context of natural variation in the environment can be identified. Identification of these components will allow monitoring programmes to take account of how the habitat is varying naturally, so that any changes detected can be put within this context.

These components are identified through an assessment of interactions within the models.

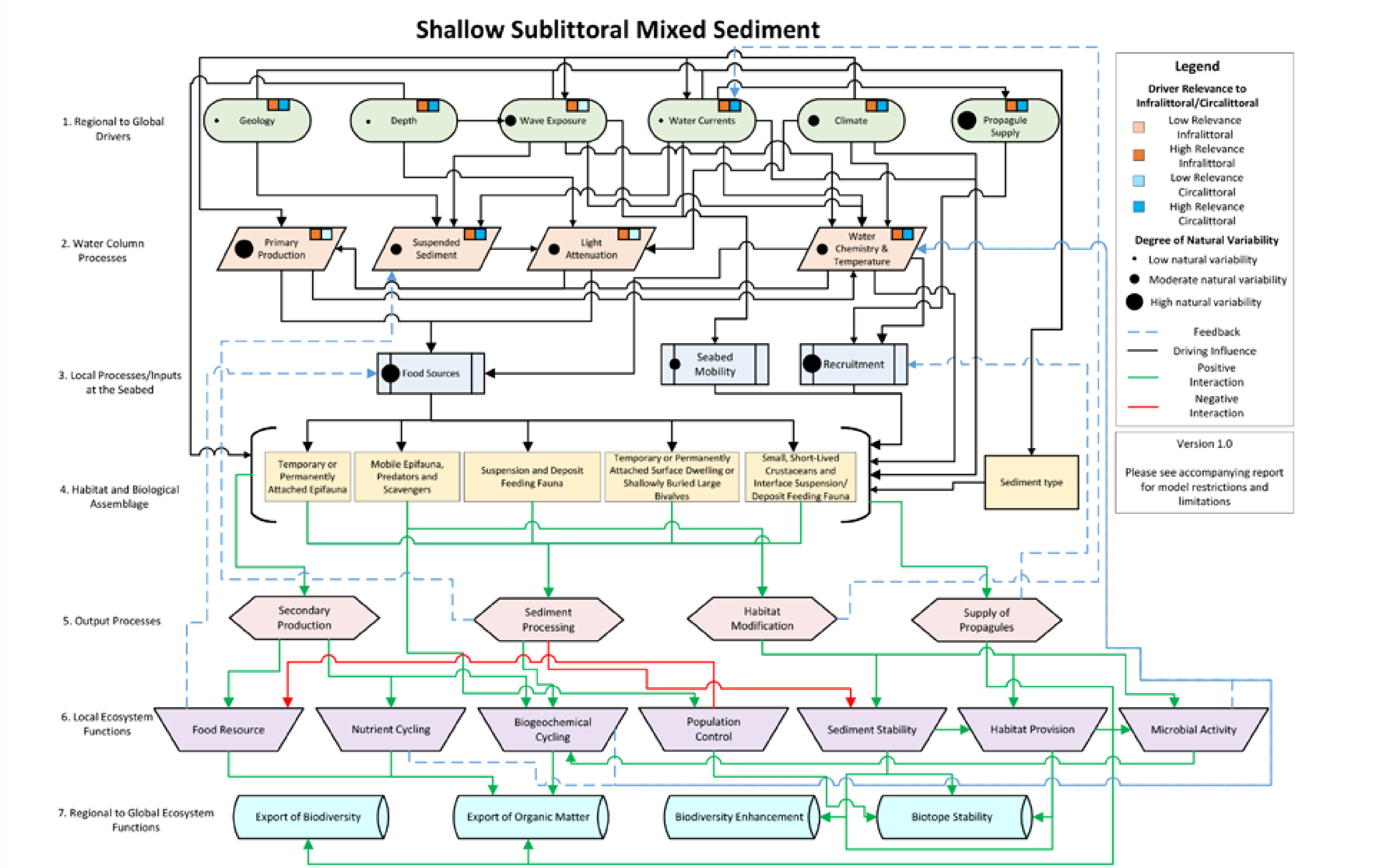

Figure 1: Example general model for the shallow sublittoral mud habitat (COATES et al. 2015)

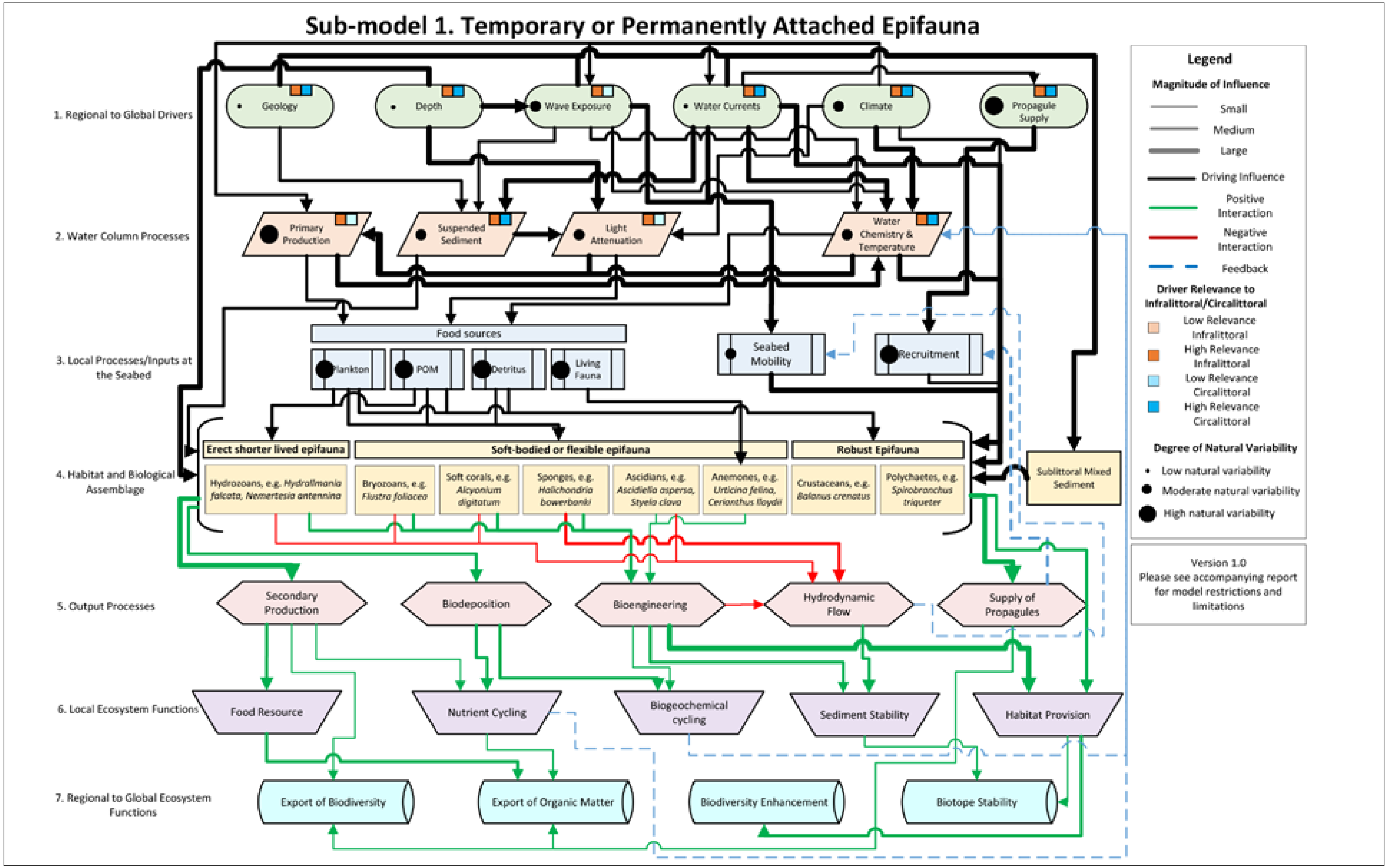

Figure 2: Example sub-model for the shallow sublittoral mud habitat identifying the magnitude of interactions (COATES et al. 2015)

Selected habitat components will have a large magnitude of effect on the structure and functioning of the habitat, a generally low level of natural variability and operate at relevant spatial and temporal scales to reflect change in the habitat. The components highlighted for each habitat are detailed in each of the specific habitat reports.

6 Conclusions

The models describe environmental drivers at global, regional and local scales and how these drivers influence the biological assemblage groups. Faunal interactions, ecosystem functions and feedback systems are also expressed. Ecosystem complexity is captured by displaying the impact and magnitude of each interaction and the degree of natural variability for each model component. The species and ecological groups included within the models relate to sensitivity assessments, highlighting aspects of the habitat important for monitoring both natural variation and human-induced change. The models can be used as a qualitative tool to identify potential relevant indicators and inform recommendations for future research. The greater understanding of habitat ecology provided by the models will aid subsequent data interpretation and models may be used as a communication tool among partners when developing management options.

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Managing long-term & large-scale data on marine biodiversity

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1 Marine Monitoring of Species and Habitats

The Federal Agency for Nature Conservation (BfN) has implemented long-term and large-scale monitoring schemes to document the state of marine biodiversity in the German Exclusive Economic Zone (EEZ) of the North and Baltic Seas.

Visual ship- and aircraft-based transect surveys are routinely carried out to map seabirds and marine mammals, as well as benthic organisms and their habitats.

In addition, the frequency distribution of harbor porpoises is passively tracked via networks of acoustic porpoise detectors.

Within the monitoring framework, large amounts of data corresponding to different validation and aggregation levels are stored and processed by BfN and its research partners.

Besides new technological developments at the detection level (e.g., the use of digital aerial imagery for surveying seabirds and marine mammals), the design and optimization of complex database applications is becoming increasingly important as data volumes become continuously larger.

2 Reporting and Data Availability

Usually, the gathered data will be published in the form of reports after intensive technical evaluation and handed over at the same time to the BfN in various digital formats.

Data in report form are not granular enough to be merged with other similar data and to be provided for comprehensive evaluations and representations.

Going beyond classic scientific reporting, BfN's overall aim is to make marine environmental data comprehensive, transparent and accessible to a broad public, including governmental authorities and non-governmental organizations (see Figure 1).

On behalf of BfN, GICON Großmann Ingenieur Consult GmbH – Niederlassung Leipzig worked in cooperation with the Institut für Angewandte Ökosystemforschung GmbH (IfAÖ) and con terra Gesellschaft für Angewandte Informationstechnologie mbH (con terra) on tasks in support of data management and quality assurance with regard to marine biodiversity in the German EEZ of the North and Baltic Seas.

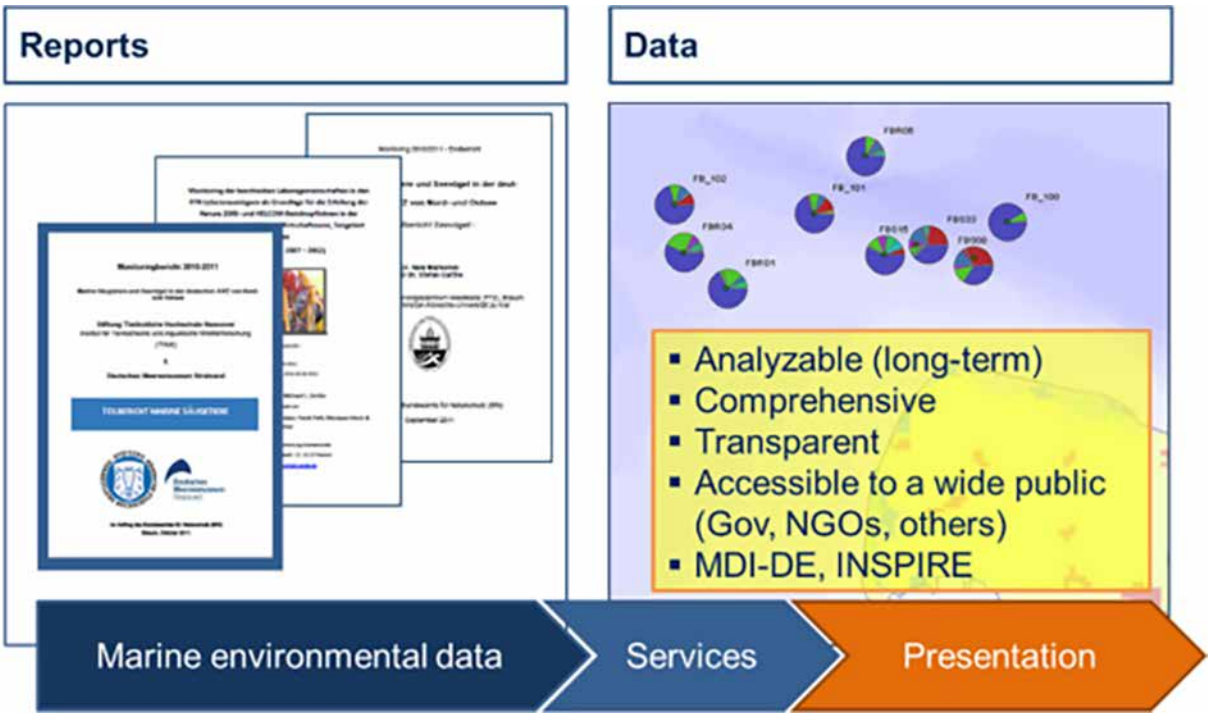

Figure 1: Making marine environmental data comprehensive, transparent and accessible

The project partners set out to provide technical and electronic support tools for data management and analysis of the data. The goal was to develop new and improve existing workflows for storage and processing of monitoring data / processed raw data, thereby taking into account quality assurance measures.

The approach jointly pursued by the project partners was as follows:

- Analysis of current datasets and workflows at BfN's Island of Vilm/Rügen Field Office
- Identification of further requirements and development of varied information-technology-based implementation variants
- Processing of marine environmental data by means of Geographic Information Systems (GIS)
- Introduction of appropriate metadata management, taking into account national and international requirements and standards

As a result of these activities, existing data sets can now be jointly visualized in their spatial as well as temporal context and provided to data interfaces and services within the Marine Data Infrastructure Germany (MDI-DE) as well as the European Geodata Infrastructure (INSPIRE). This improved data management at BfN will eventually make marine environmental data accessible to a broad public.

3 Data Management and Quality Assurance

As part of the project, a detailed concept was initially developed, which comprised the latest information about the technical environment of implementation, the proposed approach, the overall workflow, as well as the GIS-related workflow and the deployment design.

Efforts were focused on the most relevant and important steps within the analyzed workflows to ultimately provide tool support in priority areas.

3.1 Workflow analysis

In particular, the analysis and presentation of the overall workflow are well suited to provide technical coordination within the project (processing of “field data”, “processed raw data”, “aggregated raw data” and “result data” as well as integration of quality assurance steps) and with other included data-providing research institutions (vertebrate monitoring, benthos monitoring, biotope monitoring).

Thus, the workflow embraces the generation and storage of raw and processed data, taking quality assurance (QA) measures at all levels into account.

Figure 2 gives a simplified scheme of the revised workflow from data gathering to data usage.

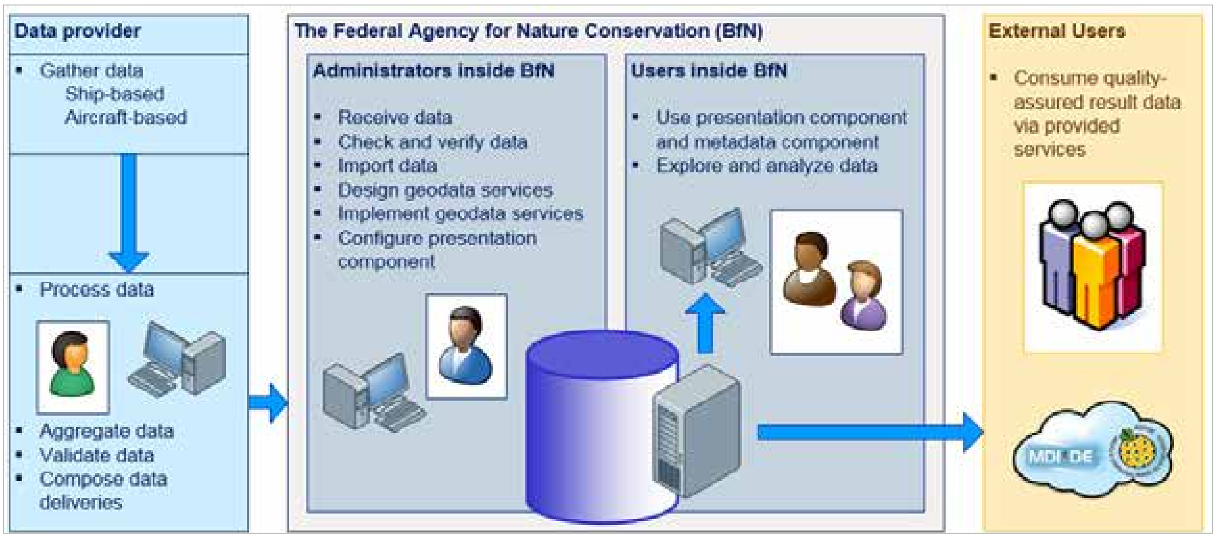

Figure 2: Simplified presentation of the data-processing workflow at BfN

3.2 System architecture and implementation

One of the concept phase objectives was the design, testing and evaluation of an adequate information technology platform and its components.

This platform takes BfN’s technical-environment conditions into account and was based on standard software products, as well as customized software extensions.

To evaluate individual components of the overall system, a test system based on Oracle, ESRI and Microsoft technology was implemented. The test system was initially used to develop the central database and to examine the operation of Windows client components (e.g. ESRI ArcGIS, FME Desktop) with Citrix-based terminal server technology. All customized software extensions developed by the project partners were transferred step-by-step to the test system in a realistic operational context.

The technical solutions include a variety of modern standard software components, as well as purpose-designed software components and tools (which will be described later) to match the data-processing environment at BfN.

3.2.1 Data modelling and database structure

The analysis of data management started with the examination and cataloging of BfN's existing data pool. Data structures can be described by data models. In our case, initial structures were derived and documented using the software SparxSystems Enterprise Architect (EA) for database reverse engineering.

Aim of the modelling process was the development of adequate data models for BfN's marine-ecological data.

The data sets were classified into raw data, processed data and result data. It was examined, whether these data sets are suited to reporting and for further publication by geodata services.

In the course of the project, the initial structures were widened with particular emphasis on the following aspects:

- Generalization, adaptation and refining to integrate benthos monitoring data
- Definition of grouping and classification
- Chance sightings of harbor porpoises
- Survey-related single sightings
- Indexing

A system of consecutive database schemes for factual as well as for geographic data was developed, providing the possibility to administrate user rights at different levels of aggregation.

The multi-layer approach and essential features of the data-management solution implemented in BfN's network are outlined in Figure 3.

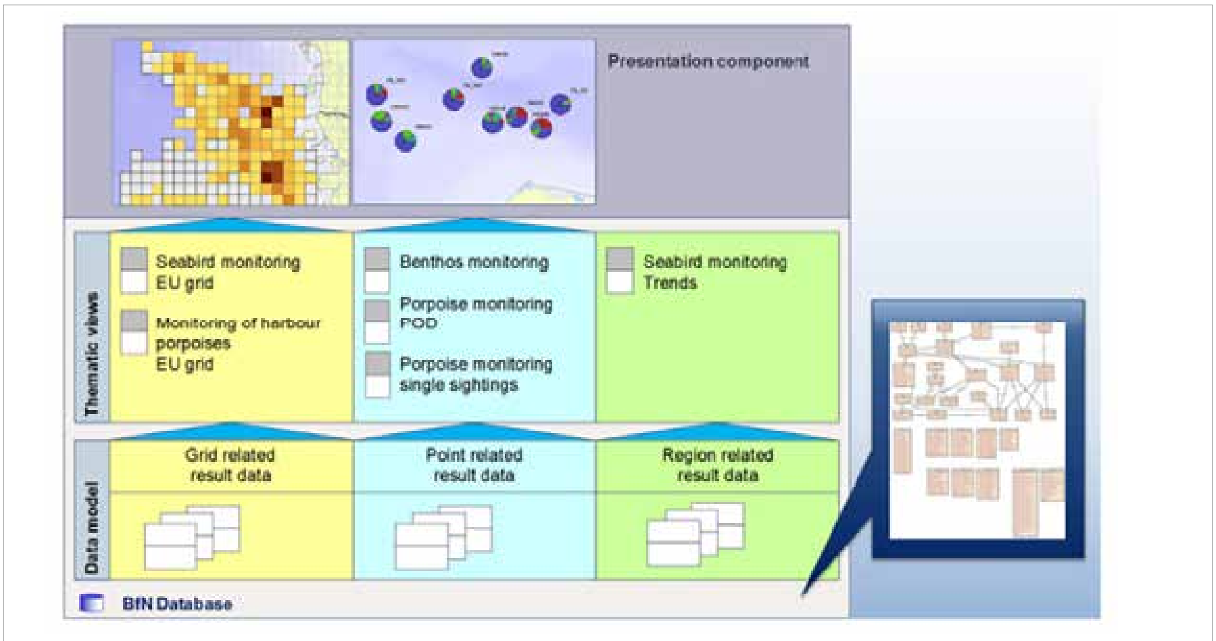

Figure 3: Data management scheme at BfN

Its core is the data structure, comprising database tables arranged in different schemes and storing point-, grid- and region-specific monitoring data.

The implemented data model supports data take-over and import processes over various levels of aggregation. Object descriptions and attribution were harmonized as far as possible.

The geodata base is designed to enable efficient export of data for further analyses by interested parties as well as the import of data from providers outside BfN.

Thematic views facilitate the access to the structured and approved data and form the basis of geodata services.

Con terra's functionally-enlarged map.apps geodata viewer software was used in the project as presentation component.

3.2.2 Spatial data services

Data modelling was optimized to provide marine data for spatial data services implemented in the project.

Storing the data to be published in an ESRI Enterprise Geodatabase managed by the Oracle database management system allows the implementation of purpose-adapted database views. These views aggregate data from different tables and define alias names for single table fields (attributes). Thus, the system performance can be improved by executing database-sided joins. The definition of joins in the basic ArcMap project is no longer necessary.

An operating procedure to build suited spatial data services was developed as part of the project. The data sets to be published will be prepared by setting up ArcMap project files (MXD files) and map-service-definition files, including layer structuring and symbolization.

Parallel to the development process, a security concept was elaborated to strengthen BfN's system architecture as it relates to spatial data services, for which administrative, spatial, temporal and content-related criteria are relevant. The security concept also covers map applications (geo-apps) inside the map.apps presentation component. Consequently, unauthorized access to BfN's data processing environment will be prevented and licensing conditions of third-party providers are accounted for.

As early as 2011, BfN had defined its overall concept for implementing INSPIRE requirements and requirements according to the German Geodata Access Act (GeoZG). Based on this concept, consequences were drawn with respect to data model structures for seabird monitoring and for protected sites. Data providing mechanisms, viewing and download services, as well as mapping procedures were designed.

3.2.3 Metadata and thesauri

Metadata is used to facilitate finding and accessing information within large amounts of data.

Standard software products are available to gather, store and analyze metadata at different levels of complexity.

A part of the project was therefore the development of a preliminary concept to clarify the system-related requirements, to develop a metadata profile based on ISO 19115 and ISO 19119 with respect to INSPIRE and MDI-DE, and to determine an appropriate product.

Finally, con terra's software terra.catalog was used as a metadata component in a tailored and integrated version. BfN's metadata sets already stored in ArcGIS were extracted and imported.

Furthermore, finding and accessing are facilitated by integrating thesauri.

During the project term, no specifically-designed thesaurus was available for the needs of biodiversity monitoring. Therefore, the marine-ecological thesaurus MeerThes was developed based on BfN's vocabulary and integrated as an Oracle-based iQvoc instance. The tool iQvoc is well-suited to manage SKOS-based (Simple Knowledge Organization System) thesauri. The MeerThes content is maintained by BfN, who is responsible for data sovereignty.

In a more complex data processing environment, MeerThes thesaurus cooperates with other thesauri (e.g. UBA's UMTHES) as part of a thesauri federation.

3.2.4 Web-based presentation component

One of the key-components of BfN's geodata infrastructure is the web-based presentation component.

A part of BfN's data-processing environment concerning storage, analysis, processing and presentation of geographic data is client- and server-based products from ESRI (ArcGIS product family).

The presentation component is based con terra's product map.apps. It is attached to the ArcGIS Server API and is well-integrated in the overall environment of already available GDI components (e.g. metadata component).

User-specific requirements are covered by standard functionality and configuration.

In addition, project-specific extension and refinements were carried out to improve data selection, diagram generation, geo-visualization of time series and data export. A geo-thesaurus was integrated as well.

The project partners have proposed and intensively discussed various approaches for improving the visualization of spatial and temporal trends to document the state of marine species. For this, a time-slider function was integrated in the presentation component map.apps. A specially-designed time-slider control can be used to configure and apply cumulative and accumulative presentations of layer data arising from ArcGIS Server geodata services. The functions includes stop / start of automatic replay, manual operation, time-interval definition and configuration of scenarios.

The presentation component with integrated time-slider has been evaluated using chance sightings of harbour porpoises from 2012 (data was kindly provided by Anja Gallus and Anne Herrmann from Deutsches Meeresmuseum Stralsund, Germany).

Figure 4 provides an impression of selected data visualizations related to ship- and aircraft-based observations of seabirds, marine mammals and benthic organisms.

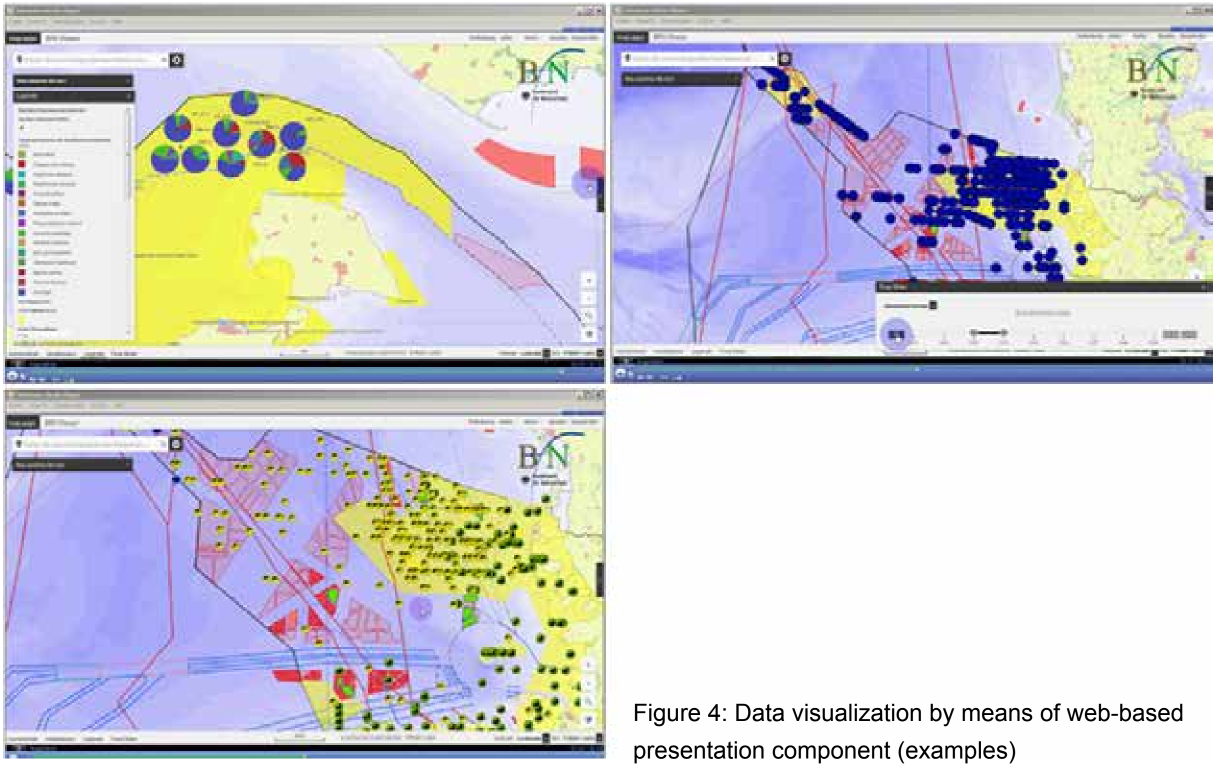

Figure 4: Data visualization by means of web-based presentation component (examples)

3.2.5 Tool-supported data transfer

Workflow steps related to data take-over from data suppliers, to data import and to the treatment of the incoming data are decisive when considering the manual effort of BfN staff and all participating research partners.

To minimize this effort, a tool-based approach was followed.

During the project period, two specific software components were designed and implemented (see Figure 5), which facilitate data delivery by the data supplier (research partner), stabilize the transfer process and the data import on BfN's side and improve quality assurance:

- Tool used by BfN for managing data reception, quality assurance support and data import (Tool DeV in Figure 5, next page)
- Tool used by data suppliers for data packaging, generation of accompanying supply form and for data delivery according to agreed-upon requirements (Tool ZDI in Figure 5)

The data transfer process was refined with the help of BfN's framework research partners and tested with survey-based seabird monitoring data.

A multi-part framework application (simple windows forms application) integrates extension components (plug-ins) with specific functions for every type of defined data package (e.g. aggregated benthos monitoring raw data, aggregated seabird monitoring raw data, aggregated harbour porpoise monitoring raw data).

Quality assurance measures, as part of the overall workflow addresses two aspects: First,

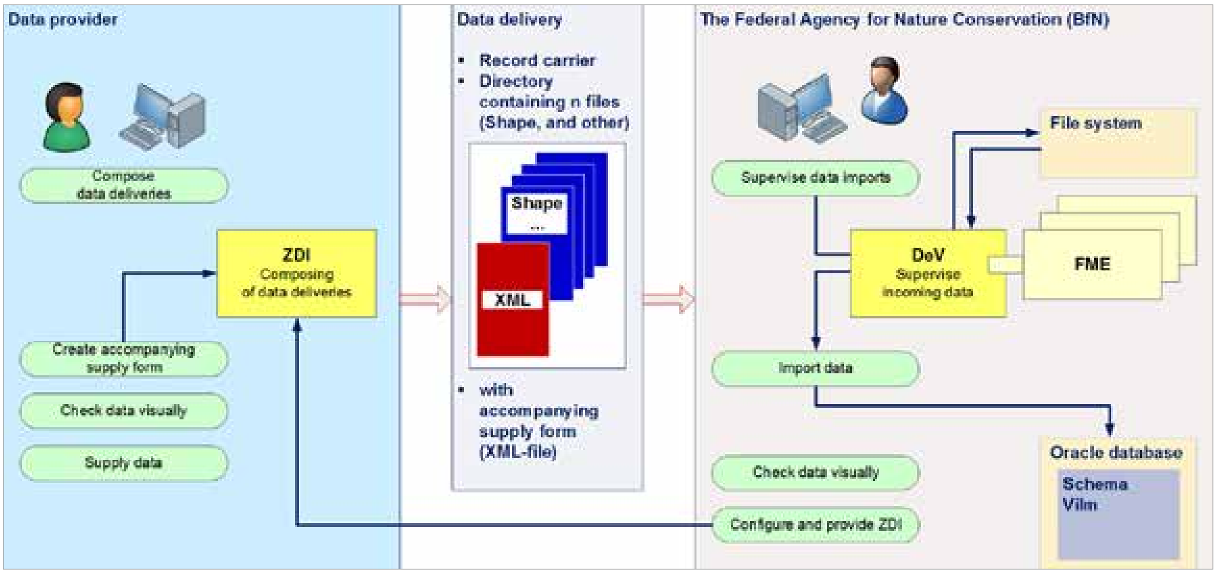

Figure 5: Tool-supported data transfer to BfN

the methods for collecting data should be standardized (as described in so-called Standard Operating Procedures, or SOP's). Second, stages in the overall workflow where formalized quality assurance takes place should be defined. This approach is related to the ETL concept (Extract, Transform, and Load), meaning automated software-supported processes manage and influence data workflow in accordance with specific purposes.

SafeSoftware's FME software (Feature Manipulation Engine, www.safe.com) was used in the project to process spatial-related data received from BfN's research partners. The software was applied to implement so-called FME Workbenches for data transformation and quality assurance. FME reads source formats and transforms them into a system-neutral feature format.

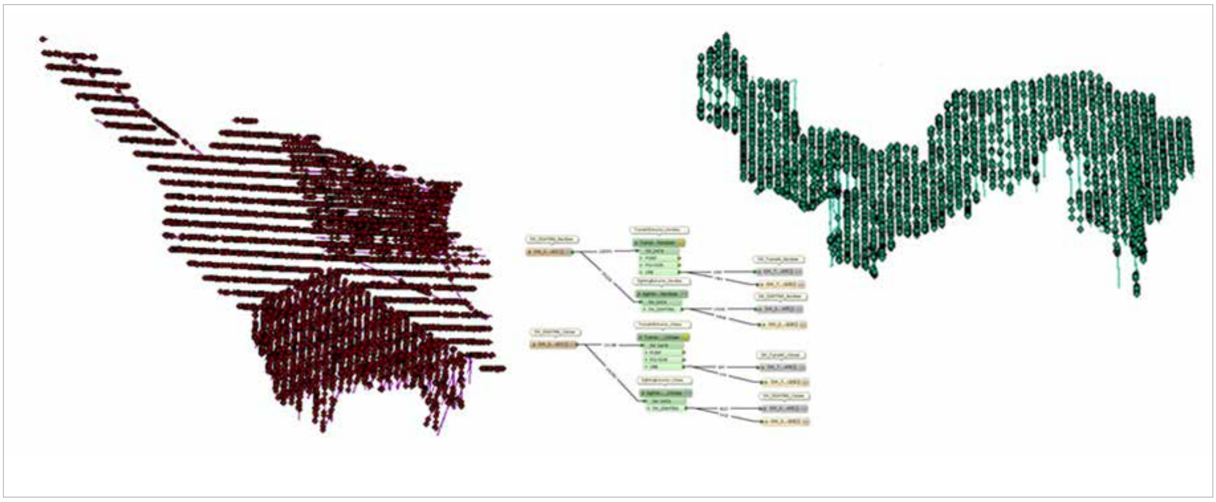

Figure 6: ETL-tool based extraction of survey transects and single sightings of marine mammals and other objects of interest in the German Exclusive Economic Zone (EEZ) of the North and Baltic Seas

These features can be deployed with a variety of functions, so-called transformers. Subsequently, the resulting data can be exported in arbitrarily-specified target formats. FME Workbench describes an assembly of data processing steps to manipulate any kind of data (but especially geodata), defined via the graphical FME Desktop interface and using, configuring and linking various data processing tools from a preformed gallery.

DataReader (source) and DataWriter (target) are defined per Workbench. The DataReader cares for source data capture, whereas the DataWriter transfers the data to a defined target. So-called transformers can be placed between both components to acquire the data from the DataReader, perform a more or less complex transformation and to ultimately deliver it to the DataWriter. To carry out data checks and validation processes, appropriate quality assurance transformers can be configured, related to the DataReader and stacked one after the other.

FME Workbench will be run under FME Desktop. Above and beyond this client-based application, FME Workbench can be established as a service on the FME Server.

3.3 Standard Operating Procedures

At the raw data level, data quality depends strongly on the consistency of the applied survey methods, for which standard operating procedures (SOP's) provide the formal framework. The revision of these guidelines is carried out on a regular basis by research partners from all relevant disciplines and by independent auditors from the Federal Environment Agency (UBA). Within the scope of the project, first drafts of SOP were issued for ship-based and aerial visual seabird and marine mammal surveys. These documents await up-dating as new methods based on digital imagery are being adapted.

4 Summary

BfN has recently implemented a state-of-the-art data management system to increase the efficiency of the reporting process and to keep up-to-date with the increasing demand to archive large data sets. Its geodata infrastructure was extended by integrating standard software and purpose-designed software components and tools to support the overall workflow from data gathering to service providing.

Central database structures were designed and optimized to support data transfer, data storage and data provisioning in an adequate manner. For data provisioning, spatial data services based on database views were established and can be used by standard viewer components.

An implemented marine-ecological thesaurus (MeerThes) facilitates finding and accessing data.

This improved information processing provides fertile ground for further development and strengthening of BfN's capability to make marine environmental data comprehensive, transparent and accessible to a broad public.

„UFOs“ in the North Sea: High-tech for a Modern & Innovative Monitoring of Fish and Other Marine Organisms…

Joachim Gröger

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1. Abstract

Based on an idea and concept of Joachim Gröger of the Thünen Institute of Sea Fisheries (TI-SF, Hamburg), research on an innovative, intelligent Underwater Fish Observatory (UFO) for the North Sea has been initiated and subsequently undertaken as part of an innovation support project. The UFO idea arose when he was working as a Professor of Fisheries Oceanography at the University of Massachusetts (USA), where he also began to practically explore the feasibilities. An UFO pre-prototype is currently being developed under his guidance in Kiel, in cooperation with a consortium of two other project partners from industry and research. UFO is designed not only to automatically detect fish stocks in an intelligent and non-invasive manner, but at the same time also to extensively and continuously monitor the ambient environmental conditions, being aimed at early-detecting environmental changes and sustainably managing fish stocks as well as entire marine ecosystems.

In the first stage, UFO is conceptualized as a stationary system. It is innovative in the sense that for the first time highly sensitive opto-acoustical system components are combined, calibrated and synchronized with other sensors, collectively providing a continuous and synoptical stream of blended acoustico-stereo-optical fish images plus synchronically taken environmental information. When contrasting this with the conventional situation, unlike research vessels the integrated UFO approach is similar to generating highly resolved video sequences instead of only snapshots. Hence, the UFO data stream allows quantitative statements, for instance, about the density (abundance, biomass) of fish populations (indexed by species and size in terms of numbers and/or weight) as well as of the state of ecosystems which is completely in line with the Marine Strategy Framework Directive of the EU. Continuously monitoring UFO arrays may be installed, for instance, in sensitive key areas such as Marine Protected Areas (MPAs) – e.g. the German Wadden Sea – or wind parks and other areas where research vessels have no access to. In a later stage, also a mobile version in terms of an autonomous underwater vehicle (AUV) being based on the same concept (again an idea of Gröger) is to be developed to complement the static systems in areas where fishing is not prohibited and thus collisions of fishing gear with a static UFO are likely.

It should be noted that – because of its open design – UFO does not only allow to detect fish, but may be adapted, to also or selectively detect other organisms such as whales, seals, squid, jelly fish, allowing to continuously monitor all of these species. In cases where individual identification is essential and possible a real micro-census based on meristic and/or morphometric properties may be performed using intelligent algorithms of pattern recognition.

2. Background

An increasing number of competing human pressures affect marine systems in addition to global changes induced by natural or man-made changes of the climate. Such competing human pressures are for instance the foreseen construction of several thousand wind mills in off-shore windfarms, oil exploitation, gravel mining, fisheries, transportation, shipyard and power station activities, bathing and other leisure or touristic activities, land reclamation, establishing marine protected areas, etc. Other influences may be sea level rise, saline or freshwater inflows, and the introduction of invasive species. Due to the complexity and the interactions between organisms and their environment on the one hand, and the non-linear environmental dynamics on the other hand most of the underlying interacting processes and mechanisms are rarely understood. In relation to wild fish stocks this complexity is illustrated by Figure 1. This clearly affects sustainability in an unidentified manner and hampers the implementation of the "Ecosystem Approach to Management (EAM)" as being politically demanded. Apart from this, the EU Marine Strategy Framework Directive (MSFD), the European Water Framework Directive (WFD), and the recently revised EU Common Fisheries Policy (CFP) require the development of sustainable ecosystem-based management strategies to reach the goal of Good Environmental Status (GES).

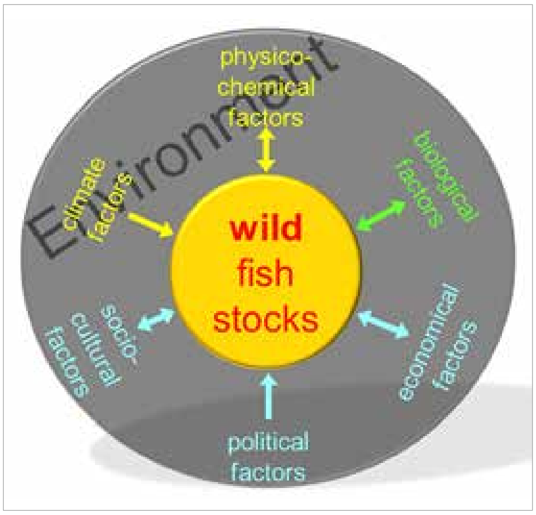

Figure 1: High complexity of the fishery system with manifold interactions between wild fish stocks and their environment.

One major reason for the principle deficiency in marine ecosystem knowledge is the snapshot-like, i.e. discrete and insufficiently low, discontinuous and asynchronous scanning and sampling rate by which we study continuous processes and their interactions based on traditional data collection methods. In contrast, we would need video-like screening and scanning operations that are able to detect important signals relevant to the indicators in question on an appropriate highly resolved time scale. This requires non-manual operation modes functioning at least semi-automatically, if not autonomously: the functioning may then be either continuous, based on some sampling design or modulated in an event-triggered mode. The resulting data need to allow quantification in accordance with rules as agreed by international communities and organisations such as the Helsinki Commission (HELCOM) or the International Council for the Exploration of the Sea (ICES). Moreover, as the translation process from science into national or international law and subsequent regulations lacks an efficient communication between national authorities on the one side and research institutions such as universities or federal research institutes on the other side, this needs to be improved.

Apart from this, the existing restrictions are long known, but just recently gain increasing political attention with the establishment of the MSFD. Because of this, the paramount goal for the next decade has been formulated as not only improving the scientific foundation of the EAM but also its subsequent implementation in accordance with regulation frameworks including the MSFD and the WFD, among others through a better communication between the different parties involved in this process. By 2020 member states have to exhaustively maintain and document a good environmental status of their marine coastal habitats; even under the perspective of future increased anthropogenic offshore activities. MSFD defines a set of top level descriptors, that relate to a wide range of topics, like biological diversity (D1), non-indigenous species (D2), fisheries (D3), food webs (D4), eutrophication and planktonic biota & particles

(D5), hydrography (D7), garbage (D10) or energy input (D11). A common task is to identify and surveil major threats for the marine environment. It is obvious that several parameters are barely recordable with fundamental physical principles. Although the date for MSFD implementation approaches rapidly, several descriptors still require basic research how to deduce cardinal proxies in the field. This urges the deployment of multi sensor systems, as pivotal key components.

3. Scientific Problem

It is key to understand that there is a clear relationship between data quality and/or scale on the one hand, and sustainability on the other hand, as illustrated by Figure 2. If the quality ofthe data is poor, reaching sustainability is at risk. Data poorness is mainly driven by temporal and/or spatial gaps in observations, reflecting missing knowledge and understanding. Those gaps may arise from filtering real world's information and translating this into data with a reduced content of information, for instance through arbitrary variable selection, inappropriate sampling rates or scaling, inadequate bundling procedures leading to biasedness. As an example, consider the term "climate": we usually interpret this, for instance as mean values of annual temperature, atmospheric pressure, CO^2, oxygen, humidity, etc. In reality, this does not only comprise an arbitrary and too small subset of all climate features being possible to observe, but is usually also measured at an inappropriate, discontinuous, low sampling rate (see Figure 3). Given this, climate may be inadequately interpreted based on too few characteristics arbitrarily chosen, on an inadequate definition of discreteness (time stamps and increments) as well as their level (daily, weekly, monthly, seasonally, yearly, etc.) and type (means, sums, extremes, etc.) of aggregation.

Figure 2: The relationship between data quality and sustainability is determined via uncertainty and risk by the degree of explanation.

In traditional fish monitoring, state variables embedding the catches in the abiotic environment and processes which drive the distribution and abundance of food are not observed or available. Existing procedures rely on highly invasive, costly, time and labour consuming ship-survey methodology, as a consequence being performed only "sporadically". Given the fact of sub-optimal sampling, they fail to observe reality on an appropriate time scale as demanded for deriving unbiased descriptors and indicators of good environmental health.

Suppose we fish at three different catch positions, for instance, in the Baltic Sea over a period of five years and keep thee three positions fix over the years. As we do not understand the true underlying processes we might get three contradicting wrong linear trends as given in Figure 4: Here the three oscillating curves (red, blue, pink) represent the true underlying processes that generate the abundance (amount, density) of fish on the three catch positions. It is obvious, that the three slopes of the linear trend lines vary significantly between the three catch positions, although all three oscillations are of the same type, except that the amplitude on catch position 3 is a little larger and that the oscillation on catch position 2 is slightly shifted. This means, the average abundance of fish is constant over the five years and the observed trends are

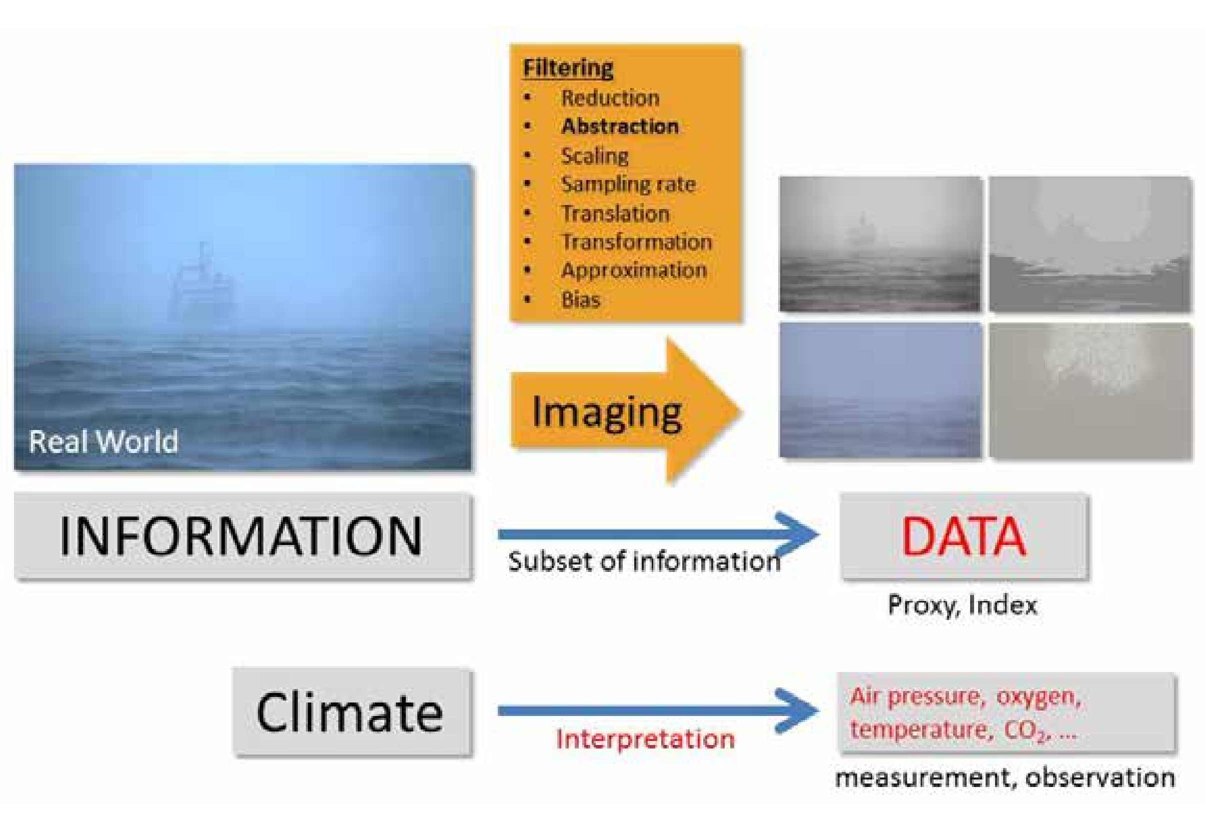

Figure 3: From real world information to observed data: the process of losing information through filtering and interpretation. On the left the “real world” is represented by a “foggy” photograph of the German research vessel “Walther Herwig III” taken at sea, which became transformed into four less highly resolved and/or greyed images on the right. This reflects, for instance the loss of information when interpreting climate through a subset of climate features (proxies), such as atmospheric pressure, oxygen, temperature, CO2, etc.

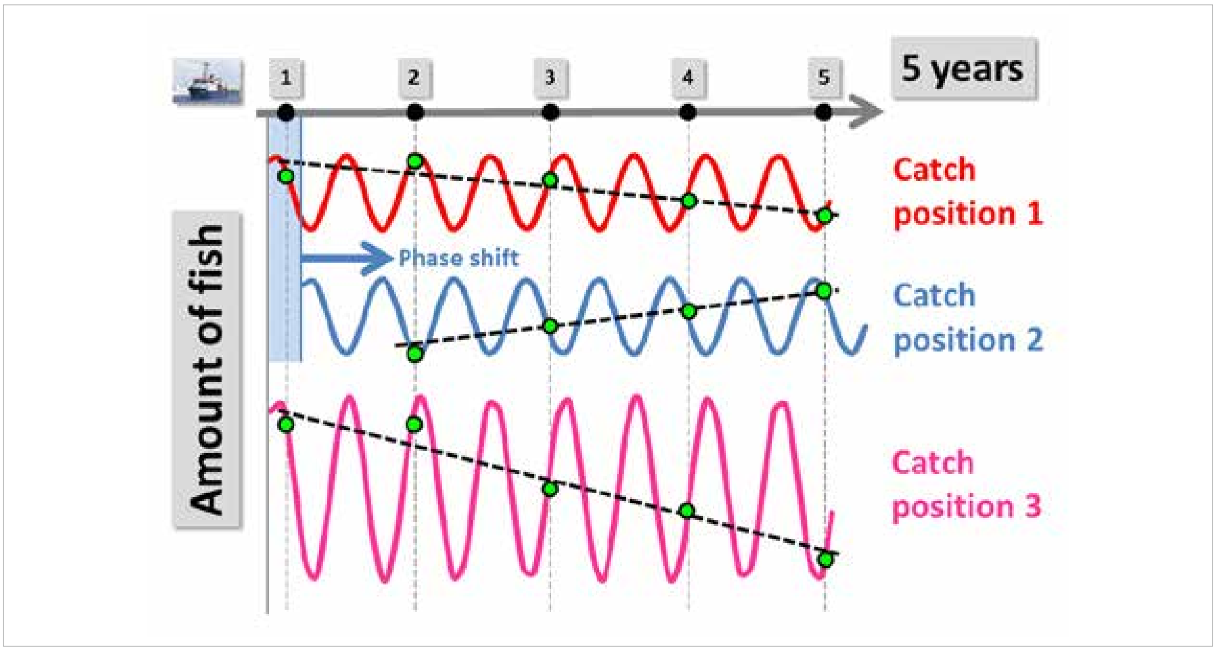

Figure 4: The panel plot (x-axis: time, y-axis: fish abundance) illustrates insufficient understanding of the underlying processes that generate fish abundance for 3 different catch positions over a period of 5 years with contradicting wrong trends including differing amplitudes between stations. The primary reason responsible for this issue is a sub-optimal sampling rate (sporadic or undersampling).

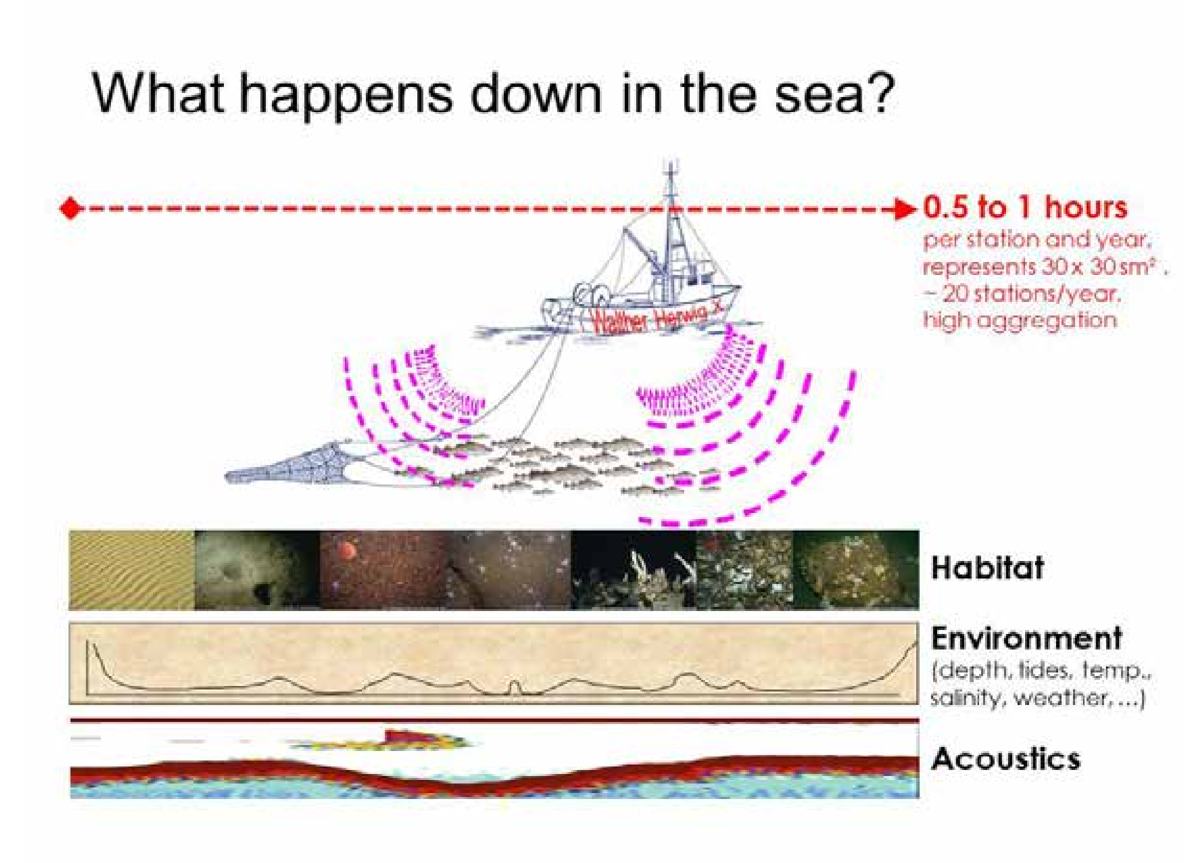

Figure 5: The Sea is a 3D space, a natural black box. Even when using hull-mounted acoustic devices and/or catching fish by fishing gear of research vessels, for different reasons we cannot representatively determine the amount of fish through counting them like trees or birds.

wrong. However, due to sub-optimal or under-sampling, the trend lines is only what we see, we do not see the oscillating curves. The biological reason is that fish is more or less continuously moving horizontally as well vertically (daily and annual migrations) over various habitats passing different environmental conditions and national borders. And, because the sea is a 3D space for us, i.e. a natural black box with a different physical density than air, we are not able to count fish and to correctly identify the true underlying abundances and migration patterns (see Figure 5) – even not, with the current implementation of hull-mounted hydro-acoustic sensors, due to many acoustical restrictions and deficiencies (erroneous reflections, wrong resolutions, large sensor-to-object distances, etc.). Collectively,

- we cannot see and count fish (like trees in a forest or birds in the air)
- unlike a video, the sampling technique is punctual, sporadic („snapshot"-like), non-synoptic/asynchronous, highly aggregating, and not highly resolved
- research surveys are invasive, expensive, and not always and everywhere realisable (wind farms, marine protected areas, shallow waters, weather conditions, etc.).

4. Objective, Idea & Concept, Lander Design, and First Results

In the light of this and to be in accordance with EU directives, future decision support requires a network of in situ observatories, focussing on higher trophic levels. To illustrate this, an automatic non-invasive and continuous Underwater Fish Observatory (UFO) will be introduced here. Its overarching design allows monitoring the dynamics and biodiversity of fish and other marine organisms (including marine mammals) plus that of further MSFD indicators in key areas such as wind parks, protected, spawning and nursery areas to aid in supporting a good environmental status and keeping intact the ecosystem services of these waters. Given this, the objective has been the construction and first deployment of an integrated UFO as a surveillance system to automatically, continuously and non-invasively monitor fish in its ambient environment. To achieve the ambitious goals, our conceptual approach was to use innovative modern technology being paired with intelligent data collection designs and new non-invasive and continuous sampling strategies, respectively. In the light of this, the UFO project has been decomposed into following steps and phases, respectively, to:

- find and integrate high-performance hardware into a modularly expandable lander, newly to be developed
- develop stereo-optical pattern recognition algorithms addressing various optical aspects, among others to allow detecting individual fish sizes, volumes, distances, orientations, and swimming trajectories, being blended and calibrated with findings from the sonar system
- develop acoustic pattern recognition algorithms to allow triggering all other UFO devices as well as detecting distances, counts, densities, swimming trajectories being related to fish individuals and schools, respectively, and blended (calibrated) with findings from the optical system
- develop species, size, volume, and weight based classification keys including area-to-weight relationships etc.
- perform explorative off-shore at-sea testing while deployed at FINO3 in the North Sea
- perform ground truthing as part of a project accompanying programme, based on research vessels.

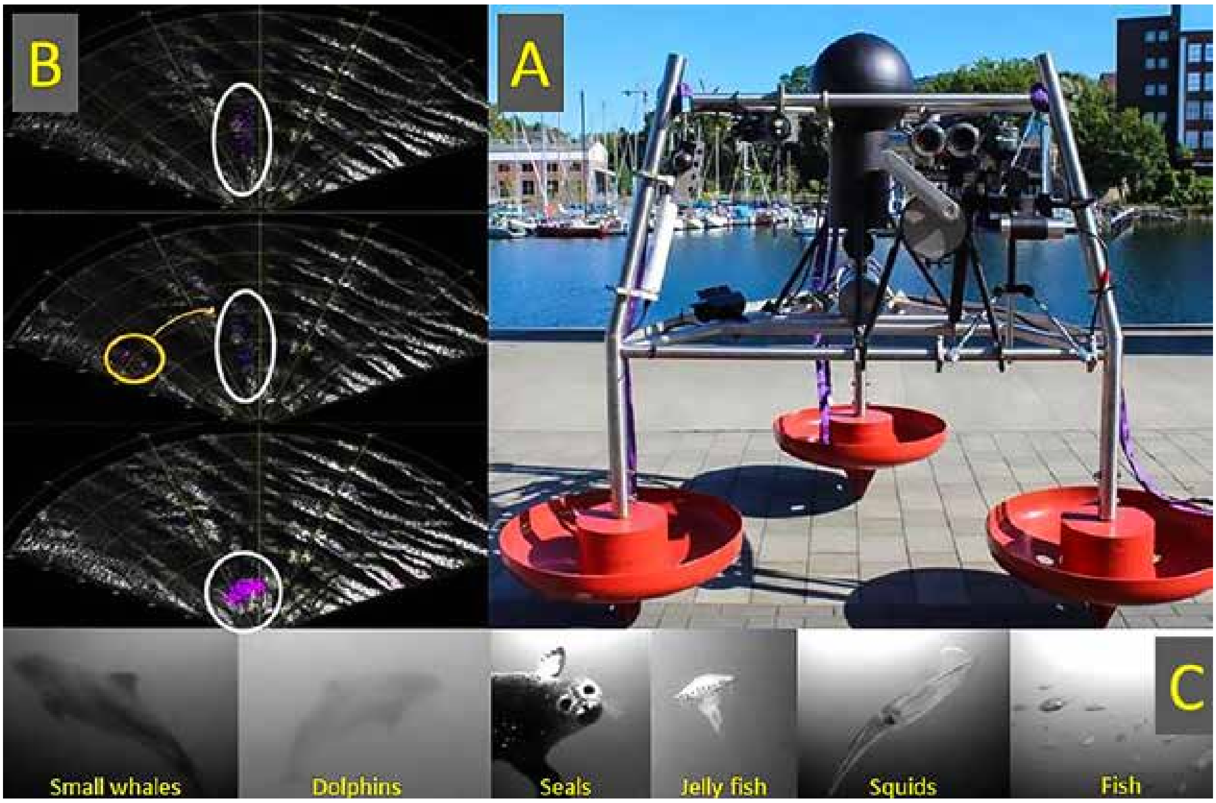

Figure 6: The panel photos illustrate (A) the UFO design including its current equipment, (B) a 3-subpanel echogram taken by the 900 kHz sonar to demonstrate prey-predator behaviour, and (C) an arbitrary collection of snapshots of organisms taken with the low light cameras during the off-shore test of UFO in a North Sea wind park in 22 m depth under dark conditions in November 2014.

Hence, given this and to allow monitoring a broad range of environmental parameters being relevant to study many aspects of potential causal impacts on fish, UFO features highly sensitive low-light stereo cameras (Nocturn Stereo High-Performance Camera System), a high-frequency sonar system (Teledyne BlueView Sonar), a wiper unit to keep the cameras free, a unit to adjust the opto-acoustical component, an "Acoustic Doppler Current Profiler" (ADCP), a turbidity sensor, a "Conductivity, Temperature, Depth" probe (CTD) with oxygen sensor, a multiplexer, a slope sensor, an electronic tag signal receiver, and a recovery unit with buoy. Because of its modular and open design UFO can be easily expanded by extra sensor units. The current UFO setup is illustrated in Figure 6(A) above, the three following links to movies of two German TV channels demonstrate the UFO "in action":

1. http://www.hamburg.sat1regional.de/aktuell-hh/article/kiel-unterwasserstation-zur-ueberwachung-von-fischbestaenden-vorgestellt-153594.html
2. http://rtlnord.de/nachrichten/ufo.html
3. http://rtlnord.de/nachrichten/faszinierende-bilder-aus-der-unterwasserwelt.html

UFO is the worldwide first opto-acoustical in-situ quantification device for marine fish, which follows international standards of stock assessment as it delivers abundances (observations of densities and/or biomass) by species and size class (and/or age), thus meeting the requirements of current size or age based stock assessment models. To illustrate the high quality of the acoustic images (echograms) taken by the 900 kHz sonar, a compound echogram is displayed in Figure 6(B) with two cetaceans hunting a school of fish, providing some insight into the foraging strategy of cetaceans on the one hand, and the predator-avoidance behaviour of fish on the other hand (see also life in the TV reportage under 3. above). To illustrate the high quality of the optical images, a collection of some rather clear snapshots of a broader spectrum of organisms detected by UFO are displayed in Figure 6(C) that were taken under dark conditions in 22 m depth in November 2014 during an off-shore test while glass-fibre connected to FINO3, a North Sea wind farm research platform 70 km north-western of Sylt Island.

The quantitative concept of fish stock assessment is illustrated in Figure 7: Acoustical and optical information are mutually blended to enumerate species and size (age-) specific fish abundances (biomass) as required by ICES standards. Environmental information being relevant for HELCOM and for implementing the EAM is gained by extra sensors mounted on UFO. The idea is running the system automatically by at the same time saving energy: all devices and sensors are triggered by the continuously pinging sonar system, where the pinging rate is pre-set in accordance with a pre-defined sampling strategy. If fish or other relevant organisms will be detected by the pings then all other devices will be switched on and a "compound video sequence" of specific length (again a matter of the sampling strategy) will be produced and intermediately stored, containing the synchronously taken results. Synchronicity is ensured based on time stamps. In case of a LAN or wireless connection the compound signal will be transmitted (for instance via satellite or internet) into our labs using a compressed data format. This data set will thus contain acoustic echograms and stereo-images along with species-specific information, such as observed individual fish sizes, individual sensor-to-fish distances, individual 3D orientation, individual fish footages, volumes and trajectories, plus observations of abiotic habitat conditions including temperature, oxygen, salinity, turbidity, etc.. Opto-acoustical blending allows to calibrate and hence correctly estimate the density and biomass of fish for the surrounding area UFO will be representative for. In an interplay between the integrated electronic tag signal receiver and (tagging) experiments with tagged fish, information about the "reef" effect will be delivered to correct for a potential attraction error. This is cross-validated with information from fish tracing using echograms.

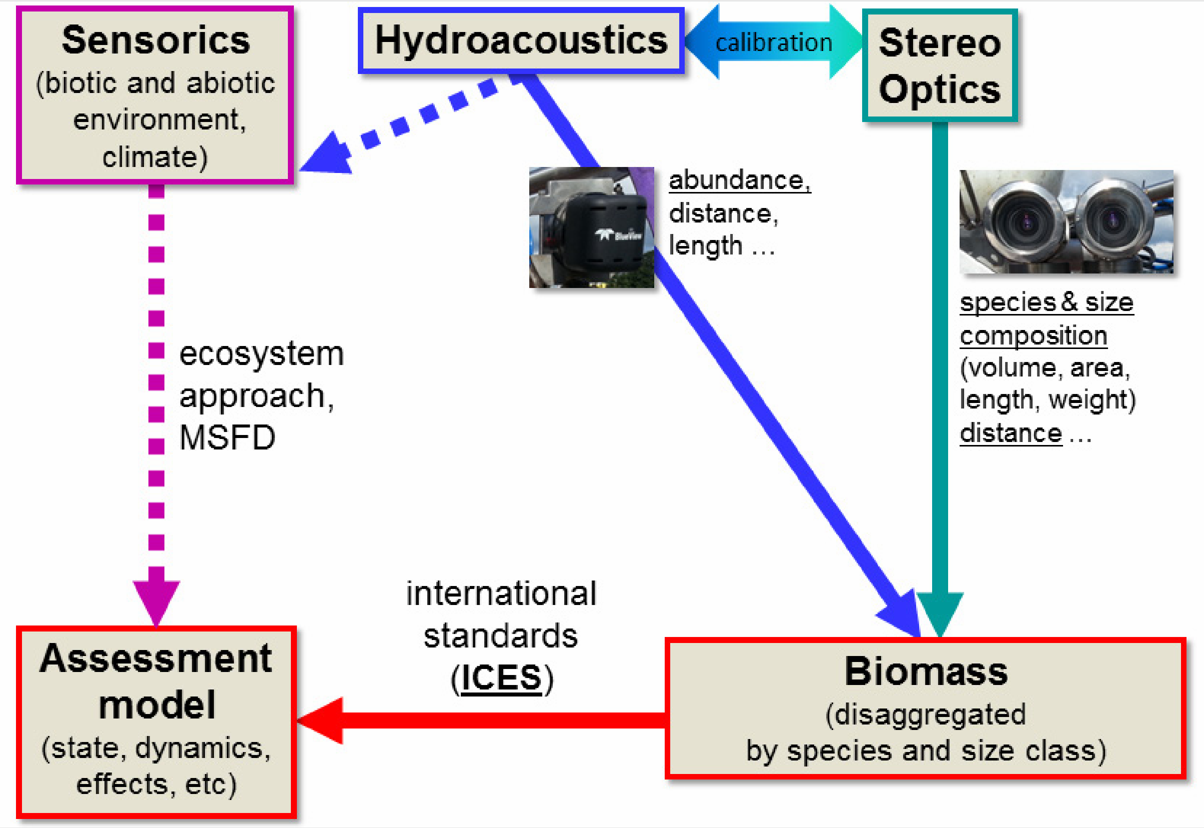

Figure 7: Stock assessment algorithm: acoustical and stereo-optical information is blended to allow quantification of fish stock biomass by species and size given ICES standards, along with further information relevant for HELCOM and to foster implementation of the EAM..

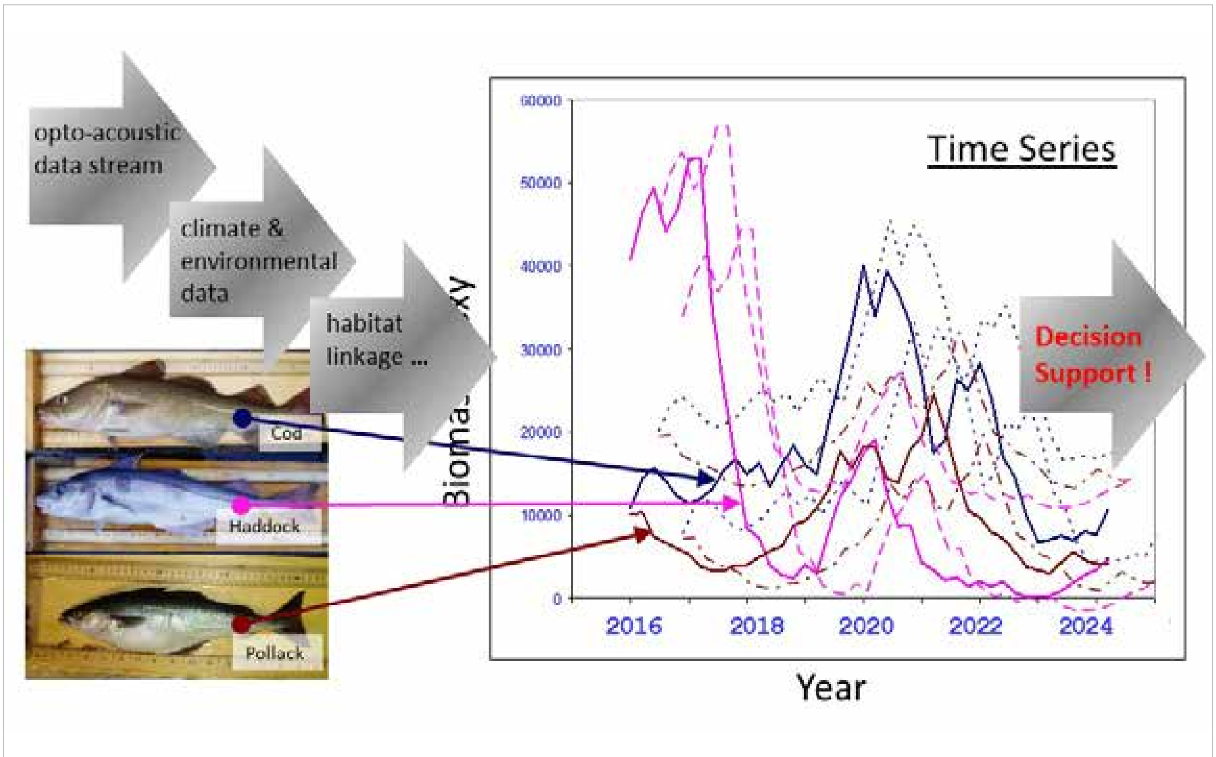

Figure 8: In the long-run an expected output of the UFO detection process while deployed at-sea will be a continuous stream of data (time series) synchronously collecting biotic and abiotic information that can subsequently serve as input for any kind of decision support to foster EAM and improve GES.

Modelling is performed on different levels and scales, which includes developing opto-acoustical pattern recognition algorithms, analyzing and modelling biological and physico-oceanogra

phic data, among others to perform:

- effect analyses
- causal pathway analyses
- calibrations
- conversions
- projections including predictions, forecasts, simulations and scenarios.

Fish pattern recognition (optically and acoustically) functions via learning techniques using numerical algorithms of artificial intelligence (artificial neural networks).

Collectively, the resulting UFO output will consist of a multitude of time series of species related attributes (including abundances, sizes, etc.) plus that of other relevant environmental observations (see Figure 8). Accordingly, using UFO and investigating the conditions in its neighbourhood will shed light on the temporal dynamics of all relevant biotic and abiotic signals, processes and mechanisms as well as their interactions in this area. The analysis of UFO data will thus characterize site specific ecosystem variability, helps to develop UFO-based MSFD indicators, can be used as input for any kind of decision support if required (see Gröger et al. 2004, 2007), and supports marine conservation in principle.

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Acknowledgements

My first acknowledgements go to the entire UFO consortium consisting of the three project partners Thünen-Institute of Sea Fisheries (project coordination; Boris Ciseweski, Sven Hamann, Florian Krau), the University of Applied Sciences Kiel (Hauke Schramm, Sabah-Badri Höher, Gordon Böer, Lars Wolf, Björn Lehmann-Matthaei), and our industry partner MBT GmbH (Torsten Turla, Katharina Grummt, Alexander Davidov). I would also like to thank the Federal Office for Agriculture and Food (PT-BLE, project executing organisation) for its administrational support and the German Federal Ministry of Food and Agriculture (BMEL) for funding the project by about 4 Mio EUR via its federal innovation support programme.

Porpoise Alerting Device (PAL): synthetic harbour porpoise *(Phocoena phocoena)* communication signals influence behaviour and reduce by-catch

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1. Introduction

Our research is focussed on using specific acoustic porpoise communication signals to a) mitigate by-catch in fisheries (Figure 1) and b) increase their detectability.

In a recent study, Reeves et al. (2013) show that over the past 20 years the vast majority of odontocete, mysticete, and pinniped species, as well as sirenians and marine mustelids were recorded as gillnet by-catch. Between 2000 and 2009, the number of harbour porpoise carcasses found annually along the German Baltic Sea coast ranged between 25 to 152 y-1 (Herr et al. 2009; Koschinski and Pfander 2009), decreasing to around 70 in 2012 (Wehrmeister et al. 2012). In 47 % - 86 % of the carcasses, by-catch was identified as the mortality cause.

Figure 1: Porpoises near acoustic buoy during field experiments in Little Belt, Denmark.

To reduce fishery by-catch, currently employed pingers produce aversive noise. Culik et al. (2001) showed that porpoises maintain a safety distance of several 100 m to pinger-equipped nets. This may lead to exclusion from parts of the habitat. However, the animals simultaneously reduce echolocation intensity (Cox et al. 2001, Culik et al. 2001, Carlström et al. 2009, Hardy et al. 2012) and therefore may become entangled between too widely spaced (Berggren et al. 2002) or defective pingers (Palka et al. 2008, Carretta & Barlow 2011).

Because of the large safety distance, it might be possible that porpoises fail to establish a connection between the aversive noise of pingers and the threatening nets. Their sensory capabilities as well as their ability to learn are thus not put to their full use: Monofilament gillnets become only discernible for their biosonar if the animals are actively echolocating and at very close range (estimates range from 8-25 m, Koschinski et al. 2006).

For echolocation as well as for communication, members of the *Phocoenidae* produce narrowband, high frequency clicks (NBHF) arranged in specific click trains (Clausen et al. 2010). NBHF clicks have durations of approx. 100 µs, high directionality, centre frequencies around

130 kHz, and source levels of up to 205 dB pp re 1 µPa, 1 m (Villadsgaard et al. 2007).

Click trains recorded during aggressive interactions between harbour porpoises observed in captivity (Clausen et al. 2010) served as a template to program and generate de novo life-like communication sounds. We used our new patented, self-contained synthetic porpoise click train generator PAL (Porpoise ALarm; Culik et al. 2013) to play back these signals in the field during a) behavioural experiments and b) normal operations of commercial gill-net fisheries.

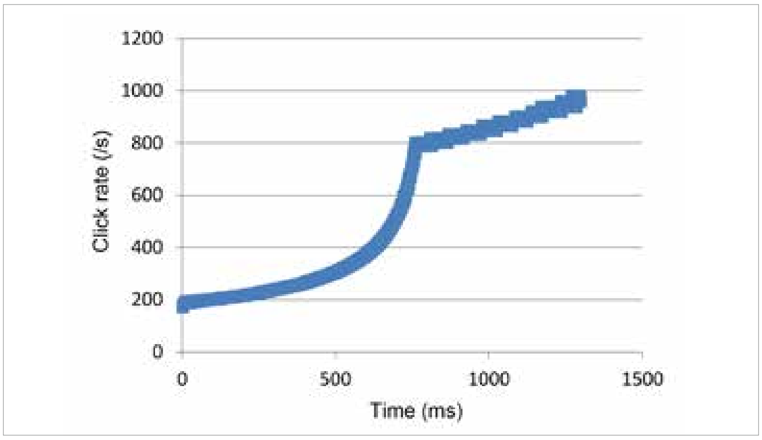

Figure 2: Synthetic porpoise signal „F3“ generated by PALfi

2. Behavioural experiments

In the Little Belt, Denmark, we employed PAL (SL 158 db ± 1 dB p-p re 1 µPa @ 1 m; centroid frequency 133 kHz ± 8,5 kHz) to synthesize three aggressive click train types termed „A“, „F3“ (Figure 2) and „M1“ to naive, free-living harbour porpoises. Via theodolite tracking (372 h of total visual effort spread over 10 expeditions) we found that depending on signal type, porpoises either avoid or become attracted to PAL (Culik et al. 2015).

Signal type „A“ and „F3“ are slight deterrents, porpoises increasing their mean minimum range of 144 m to the PAL by 23 to 32 m, respectively, whereas „M1“ attracts porpoises, reducing range by - 29 m. As determined via archival acoustic detectors (AAD), signal „A“ led to a significant reduction of echolocation (click rate - 59 %) whereas both signals „F3“ and „M1“ led to an increase (by + 10 and 68 %, respectively).

Detection probability and -radius of PAL/AAD tandems could be improved by emitting signal „M1“ (one upsweep chirp, 0.47s duration, 130-911 clicks/s, repeated 3 times per minute) to focus porpoise echolocation signals on the AAD. We calculated that in fair weather, PAL would be heard by porpoises within a radius of 460 m (head on) to 240 m (tail on). The signal may also be useful in luring animals away from hazards. This effect could be helpful for conservation measures prior to the onset of harmful acoustic activities such as pile-driving, seismic exploration or ammunition clearance.


Figure 3: PALfi attached to gillnet floatline.

Koschinski et al. (2006) showed that harbour porpoises could be stimulated to increase echolocation activity by exposing free-living animals to synthesized low-frequency offshore windmill noise. Pleskunas & Tregenza (2005) found an increase in porpoise click activity after the emission of a very brief synthetic click train. Culik et al. (2015) propose that equipping fishing gear with PAL emitting signal „F3“ can potentially reduce porpoise by-catch by increasing a) awareness through enhanced echolocation and b) distance to the nets.

Many previous studies (see review by Coram et al. 2014) report a reduction in responsiveness to acoustic deterrents over time, often referred to as “habituation“. However, Dawson et al. (2013) found that there was no diminution of the response of cetaceans (as measured by by-catch rates) to long-term exposure to pingers. Because PAL produces biologically significant signals, with potential reinforcement occurring during interspecific interactions, we do not expect habituation over time.

3. PAL deployment in commercial gill-net fisheries

To test the effectiveness of the PAL signal during deployment in commercial gill-net fisheries, we developed a fisheries version of PAL. PALfi (Figure 3) produces 3 synthetic porpoise-likealerting signals per Minute. Each upsweep chirp corresponds to signal „F3“ described above, has a duration of 1.3 s and consists of 700 clicks (SL 151db ± 2dB p-p re 1µPa at 1 m; centre frequency 133 kHz ± 0,5 kHz). PALfi are attached to the headrope of gillnets and spaced 200 m apart. Like most pinger types, PALfi are directional and all have to be attached facing the same direction to avoid acoustic „holes“.

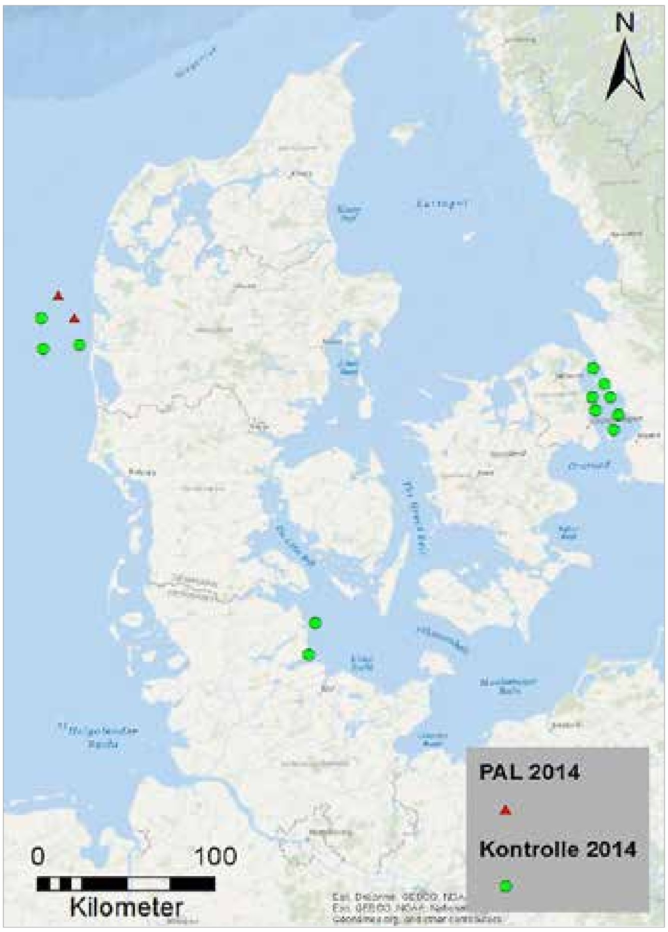

Figure 4: Porpoise by-catch in 2014 gillnet fisheries. Green: control. Red: PALfi-equipped nets.

Between Sept. 10, 2013 and Nov. 6, 2014 we deployed and re-deployed a total of 524 PALfi in German and Danish gillnet fisheries in the Baltic and North Sea. Deployment duration for each batch of 30-50 PALfi was approximately 45 days (corresponding to the safe battery autonomy of the experimental prototype). Fishermen had PALfi attached to gillnets and soaked for approximately 900 Net Kilometer Days.

Simultaneously to deployed nets equipped with PALfi, approx. the same number and net types were set as controls. Details of fishing operations were reported by the fishermen via protocols and for many trips additionally monitored by on-board video-equipment or scientific observers.

A total of 14 porpoises were by-caught during the 14 month field test: 12 in control and 2 in PAL nets (p= 0.006, binomial test). In detail, 3 porpoises were reported in the North Sea from control and 2 from PAL-equipped nets (p=0.5, binomial test). This difference is not significant and needs to be confirmed during ongoing research. It may be that the separate North Sea stock (Tiedemann 2015, see also abstract in this issue) uses different communication signals to alert conspecifics. Further research will have to confirm this.

In the western Baltic Sea, however, zero porpoises were reported from PAL-equipped gill nets as opposed to 9 from control nets (p=0.002, binomial test). This difference is significant and needs to be confirmed by applying more rigorous statistics such as e.g. Fisher's Exact Test. To avoid pseudo-replication, we will analyse all data with respect to bycatch events (as opposed to individuals) and filter it to ensure that the difference of net fleet length between control and PAL nets is within 15 %. Results of statistical tests on part of the trials carried out in 2015, where these conditions are fulfilled, look very promising. Therefore, we are looking forward to confirm the preliminary conclusion that PAL seems to be a very effective by-catch mitigation device for harbour porpoises in the western Baltic Sea.

Our research project is ongoing and we are currently improving PAL hard- and software, battery autonomy as well as attachment and monitoring techniques.

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Acknowledgements

We are grateful for support by Loro Parque Foundation, Tenerife, Spain. PALfi housings were developed and co-financed by Plastimat, Oranienburg, Germany. Funded by the German Fed. Min. of Food, Agriculture and Consumer Protection (BMELV), Grant Nr. 2819100612 to F³, Boris Culik and Grant Nr. 2819100512 to Thünen Institute, Christian von Dorrien.

Using high-resolution aerial imagery to assess populations of wintering waterbirds

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1 Introduction

Birds inhabit heterogeneous environments across a wide range of temporal and spatial scales. Migratory waterbirds in particular are highly reactive to changes in climate, food availability and anthropogenic influences, and thus represent important indicators for assessing the status of the marine environment.

The Baltic Sea with its many protected areas holds large numbers of moulting and wintering waterbirds. While some of the species are listed as "vulnerable" under Annex I of the EU Birds Directive, e.g. Red-throated Diver *(Gavia stellata)*, most of the waterfowl species listed under Annex II are currently among those species showing the strongest overall population declines (European Commission 2015). The Long-tailed Duck *(Clangula hyemalis)* has recently been uplisted to "vulnerable" because of an apparent rapid decline detected in the wintering population in the Baltic Sea since the 1990s (BirdLife International 2015, see also Bellebaum et al. 2014).

The Natura 2000 network, comprising Special Protection Areas (SPAs) under the EU Birds Directive and Special Areas of Conservation (SACs) under the EU Habitats Directive, now covers over 4 % of Europe's seas (European Commission 2015). SPAs are designated according to criteria such as "1 % of the population of listed vulnerable species" or "wetlands of international importance for migratory waterfowl". These criteria are currently based on observational census data collected during ship-based and aerial transect surveys (e.g. Markones et al. 2015).

Seasonal or monthly surveys of seabirds and waterbirds represent snapshots (random samples) of local populations that form part of unknown meta-populations. The robustness of site-specific population estimates depends largely on the accuracy of the applied survey technique, the design and level of spatial coverage, and on the timing of the surveying effort relative to the phenology of a given species. Observational methods introduce further uncertainty to the resulting population estimates. Ships (Schwemmer et al. 2011) and low-flying aircraft (Kulemeyer et al. 2011) disturb sensitive bird species and thus negatively affect detection rates. Furthermore, theoretical models correcting for distance-related observer-bias generally assume random distribution of individuals. This is evidently not the case in benthivorous sea ducks that aggregate in response to the accessibility of their invertebrate food. A biased detection in combination with simplified spatial assumptions can potentially generate inaccurate population estimates with far-reaching consequences for conservation policy.

Recent developments in digital aerial imagery allow a less invasive and safer census of marine wildlife, thereby solving major problems with previous survey methods (Buckland et al. 2012, Taylor et al. 2014, Coppack et al. 2015). Survey data resulting from orthogonal digital images no longer need to be corrected for distance-related detection bias. The recent switch from analogue to digital methods, however, has led to a significant rise in survey costs, because image acquisition, data processing and archiving require expensive equipment and experienced staff, which currently sets limits to the affordable number of surveys per annual cycle. Thus, there is an urgent need to consider trade-offs between image quality (resolution, signal-to-noise ratio) and quantity (coverage) in order to propose cost-efficient survey designs that generate significant, interpretable data.

In this pilot study, we carried out experimental trials based on gapless, vertical imagery of a species-rich area in the German Baltic Sea (Bay of Wismar), followed by a stepwise, post-flight sub-sampling to determine the minimum coverage required for quantifying aggregations of waterbird species relevant to marine conservation and spatial planning, i.e. Common Scoter *(Melanitta nigra)*, Common Eider *(Somateria mollissima)*, and Long-tailed Duck.

2 Methods

The study area of 46.75 km² was situated in the Bay of Wismar, western Baltic Sea (SPA, UM M-V 2006), and covered a water-depth gradient ranging from 3 m in the south to about 20 m in the north. On March 12 2014, a complete survey of the area was performed in 4 h with a Partenavia P68C flying at 180 km/h at an altitude of about 420 m. The GIS-based flight plan included 33 parallel transects of 8.5 km length each oriented in north to south direction and covering the entire study area. Digital images were collected and stored with a PhaseOne iXA 180 (80 Mpx) equipped with a 110 mm lens (Schneider-Kreuznach LS) mounted perpendicularly into the hatch of the aircraft. The aircraft's position was continuously logged by GPS (Leica GPS1200), which automatically synchronized the release mechanism of the camera. Each photo contained 10328 by 7760 pixels and covered an image footprint of 200 x 150 m at 2 cm ground sample distance (GSD), i.e. each pixel represents an area of 2 cm × 2 cm at ground level. Images were oversampled in flight direction leading to an overlap of 30 % between consecutive photos. Image overlap between neighbouring transects lay at around 20 %. The survey took place under suitable weather conditions (wind speed < 5 m/s, sea state < 3, visibility > 5 km).

After the survey, the digital image files were georectified, georeferenced and transferred to a GIS environment for further editing, taking the overlapping areas and areas affected by glare into account (cf. Steffen 2014, Coppack et al. 2015). The remaining image strips were visually screened with a purpose-programmed viewer software by a single trained person. Each detected bird signal was identified to species level and its geographical position was logged in GIS.

The region of interest was grouped into cells with 38 rows and 49 columns in an east-to-west transect configuration, and 29 rows and 59 columns in a north-to-south transect configuration. Each cell had a footprint of 200 × 150 m and corresponded to the PhaseOne iXA180 sampling design. For the experiment, we used a jack knife approach to calculate the fluctuation of basic statistical parameters over the variation of sampling experiments with a given effort (for example 50 %, 33 %, 25 %, 12 %, etc.). An effort of 25 % (1/4), for example, provides 4 variants for sampling the region of interest and yields 4 average density values, an effort of 12,5 % (1/8) yields 8 values, and so forth. These spectra of densities over effort were compared with the accurate density values determined at 100 % coverage (i.e. for Common Scoter 93 indiv./km², for Common Eider 80 indiv./km², for Long-tailed Duck 43 indiv./km², cf. Figure 1).

In this experiment, we only varied coverage and did not test the outcomes of different sampling configurations, such as transect- and grid-based designs (analysis in prep.).

3 Results

Figure 1 shows the relationship between simulated survey effort and estimated densities for the three duck species Common Scoter, Common Eider, and Long-tailed Duck. A stepwise reduction of sampling effort (spatial coverage) led to an increase of the variation of calculated densities. The increase of variation was evident in all species below 50 % (1/2) of total coverage. This effect of sampling effort on the survey outcome was independent of the orientation of the simulated flight (sampling) trajectories (north-to-south or east-to-west).

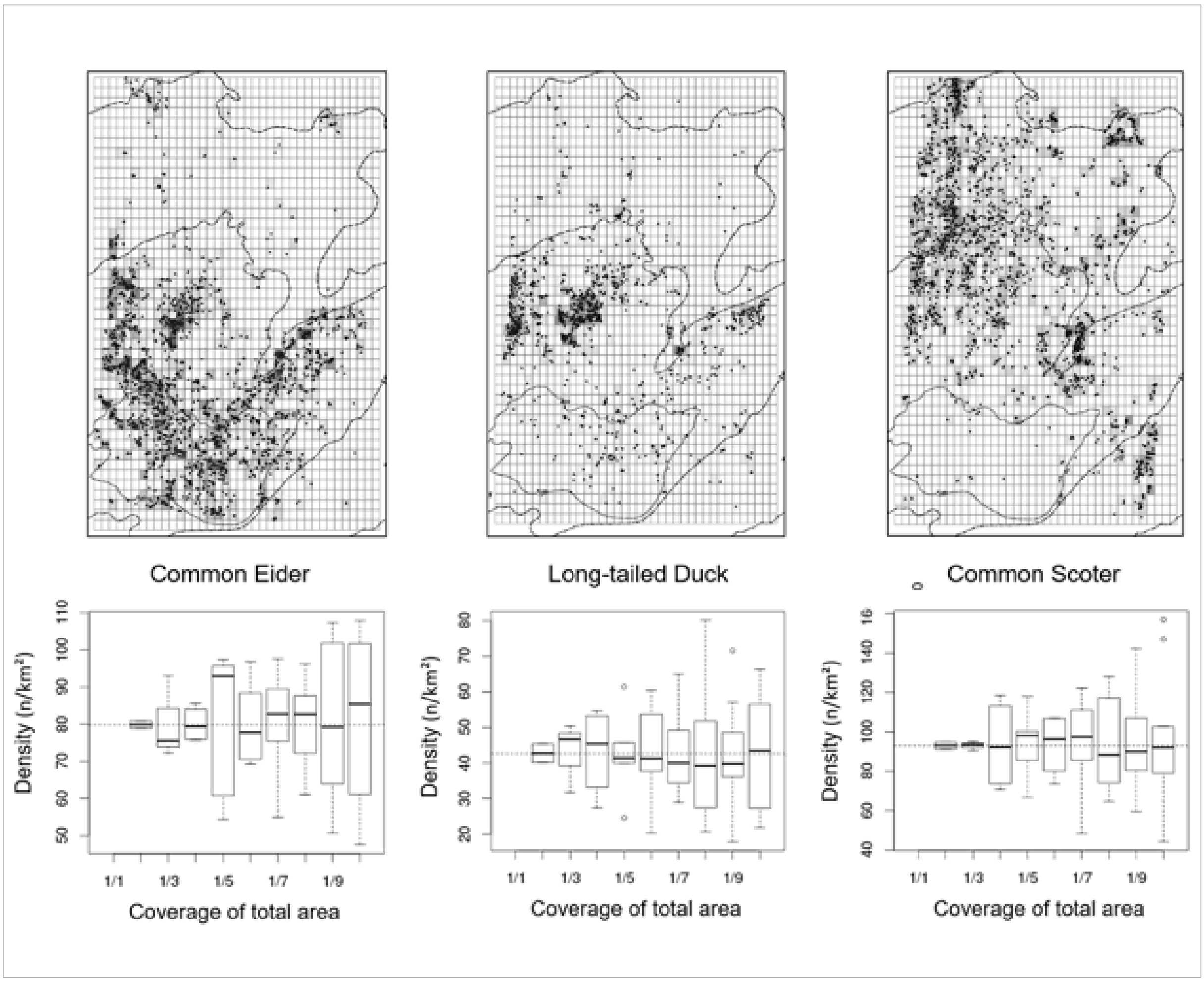

Figure 1:

Top: Grid maps of three sea duck species (Common Eider, Long-tailed Duck, Common Scoter) based on gapless aerial photos taken on March 12 2014 in the German Baltic Sea (Bay of Wismar).

Below: Box plots of population densities following a stepwise sub-sampling of imagery (north-to-south configuration), which simulated different proportions of spatial coverage from 100 % (1/1) to 10 % (1/10). The dotted horizontal lines show the average densities found at 100 % coverage. The graphs show that sampling efforts below 25 % may result in systematic under- and over-estimations of population density by factors > 2.

4 Discussion

Here, for the first time, we simulated various aerial survey efforts on the basis of an empirically determined and spatially distinct population of wintering waterbirds. A simulated reduction of aerial coverage by 50 % did not significantly affect estimates of mean population density for the three selected sea duck species. However, values varied significantly beneath this threshold such that population densities were either overestimated or underestimated with decreasing survey effort. This result emphasises the importance of adjusting areal coverage to the expected frequency distribution of birds before commissioning dedicated aerial surveys. The effect of areal coverage on the quantitative outcome of a survey is predicted to be especially strong when the species of interest is non-randomly distributed, like in our case.

Our study has major implications for the future design and implementation of aerial digital surveys for assessing populations of wintering waterbirds in protected areas. Reducing spatial coverage for economic reasons and following a traditional transect design (continuous series of images collected along widely spaced trajectories) increases the chance that a SPA or aggregation of birds is chronically undersampled. Through concentrating and equally spacing digital sampling effort to predefined areas of interest and by taking area-specific expectation values and overall probability densities into account, the relative quantity of images, survey time and costs could be reduced, while the statistical power and biological meaning of the surveys would increase.

The minimum technical and methodological requirements for carrying out digital aerial surveys are subject to ongoing basic research. A sound conceptual framework based on further empirical trials, e.g. by comparing simultaneous ship-based and aerial observations, will be decisive for the calibration of observational and camera-based survey techniques in order to evaluate the backlog of existing data and population estimations.

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Marine Ecosystem Services Assessment to Support Marine Management, from Theory to Practice

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While economic valuation of ecosystem services (ES) is widely acknowledged as a tool to support decision-making processes, studies have also shown that there exists a literature blindspot on the effective use of economic valuation (Laurans et al. 2013; Marcone and Mongruel 2014). The VALMER project seeks to bridge this gap between theory and practice by looking at how ecosystem services assessment (ESA) can support marine management and planning. Natural scientists, economists and marine environment managers from various institutions undertook ESAs in six pilot sites over the two sides of the Channel. The objectives of this paper are to share some results of two French ESAs, and to discuss issues and perspectives of ESAs from a marine management perspective. This paper is based on an oral communication given at the 4th conference on *Progress in Marine Conservation in Europe 2015*, organised by the German Federal Agency for Nature Conservation (BfN), in cooperation with the German Oceanographic Museum.

1 The VALMER Project

VALMER was an INTERREG IV-A France (Channel) – England project. It gathered eleven partners from September 2012 to March 2015, and aimed at trying to answer the following question: “To what extent can the marine ESA inform and contribute to a more efficient management and governance of the marine environment?” At the science-management interface, the results and lessons learnt from the VALMER project are significant. This paper does not pretend to be exhaustive; it will merely share and compare the experience of two French pilot sites, and will emphasise the importance of starting from the management context and features.

2 Marine Ecosystem Services

Ecosystem services are the benefits people derive from ecosystems. If the origins of the ES approach are to be found in the 1970s, with then important milestones in the 1990s – particularly with the Costanza et al. (1997) paper on the value of the world’s natural capital, it is the Millennium Ecosystem Assessment (MA 2005), which popularised it (Mongruel et al. 2015).

A major output of the MA is the classification of ES into four categories, namely the provisioning services, the regulating services, the cultural services and the supporting services (that allow the delivery of all others). With some adaptation and after Liquete et al. (2013), the VALMER project's team established the following list (table 1):

Table 1: Classification of Marine and Coastal ES (Source: Mongruel et al. 2015)

	Marine ES	**Specific components**
Provisioning services	Food provision	Fishing activities (either commercial or subsistence fishing) and aquaculture
	Water storage and provision	Water use for desalination plants, industrial cooling processes or coastal aquaculture
	Biotic materials and biofuels	Medicinal, ornamental and other industrial resources (oil and fishmeal); biomass to produce energy
Regulation and maintenance services	Water purification	Treatment of human wastes through dilution, sedimentation, trapping or sequestration, etc.
	Air quality regulation	Absorption by vegetal or water bodies of air pollutants like particulate matter, ozone or sulphur dioxide
	Coastal protection	Natural defense of the coastal zone against inundation and erosion from waves, storms or sea level rise
	Climate regulation	Sequestration by the ocean of greenhouse and climate active gases
	Weather regulation	Influence of coastal vegetation and wetlands on air moisture or the formation of clouds
	Ocean nourishment	Natural cycling processes leading to the availability of nutrients in the seawater for the production of organic matter
	Life cycle maintenance	The maintenance of key habitats that act as nurseries, spawning areas or migratory routes
	Biological regulation	Control of fish pathogens, biological control on the spread of vector borne human diseases
Cultural services	Symbolic and aesthetic values	Contribution to local identity, value of charismatic habitats and species such as coral reefs or marine mammals
	Recreation and tourism	Coastal activities (bathing, snorkeling, scuba diving) and offshore activities (sailing, recreational fishing, whale watching)
	Cognitive effects	Inspiration for arts and applications, material for research and education, information and awareness

Given the diversity of marine ES, it appears necessary to select some of them to be further studied: on which criteria could this be done?

3 Tailoring the Ecosystem Services Assessment to the Needs of Managers: Implementing the Triage Approach

Pendleton et al. (2015) explain how a triage process can support the definition of the goal of an ESA and its scope, as well as the identification of the tools and methods which would appear the most suitable to carry out the assessment. The main aim is to improve the uptake and usefulness of ESAs, through a transparent, collective, and step-wise approach.

Step 1 (see Figure 1, Pendleton et al. (2015)) guides discussions about the aim of the ESA, the main issues to be considered and the scope of the assessment. Once the general aim is agreed upon, step 2 allows refining the scope of the ESA, by selecting some ES that are perceived as particularly relevant, due to their potential change in value, their sensitivity to management measures and their potential to react to wider drivers of change on which local management would have little influence. Only then the reflection on methods and tools is undertaken, with step 3. Again, a series of questions supports the selection of methods, starting from the identification of meaningful metrics and taking into consideration available means and resources to ensure the feasibility of the suggested methods and tools.

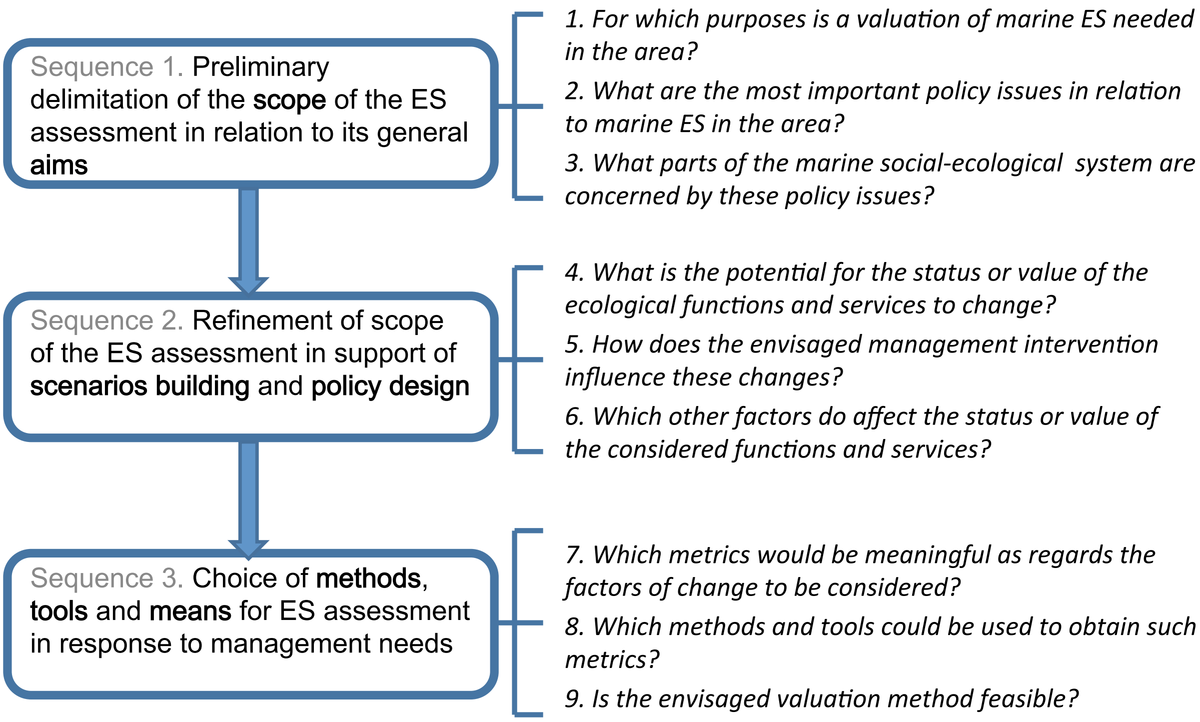

Figure 1: Triage process (Source: Pendleton et al., 2015)

As a result, the ESAs of the six VALMER pilot sites were very different from one another, with aims on improving knowledge, designing or comparing management options, raising awareness, and methods ranging from Bayesian belief networks, travel costs, choice experiment, to multi-criteria analyses and others. Nevertheless, a common feature was that almost all sites studied a bundle of ES.

Two contrasting French experiences are presented and discussed in the next part, the Parc naturel marin d'Iroise (PNMI) and the Golfe normand-breton (GNB), through the lenses of what the triage highlighted: the need to tailor the ESAs to the users' needs.

4 Two Contrasting Marine Ecosystem Services Assessments

4.1 ESA in the Parc naturel marin d'Iroise

This part mostly relies on Vanhoutte-Brunier et al. (2016).

4.1.1 Background

The PNMI was created in 2007. The management plan of the Park was adopted in 2010. This means the MPA is relatively well established, with defined long-term goals and means to reach them. A marine nature park is a multi-objectives type of marine protected area (MPA), with conservation goals as well as sustainable development ones.

In the PNMI, the Molène's archipelago hosts the widest field of brown macroalgae species (also called kelps) of the French coastal waters. This productive habitat is an essential shelter to many marine mammals, birds, fish, and algae species. Alongside this rich biodiversity, the *Laminaria digitata* and *Laminaria hyperborea* are exploited by about fifteen boats. This harvest represents up to 60 % of the national production. Moreover, there is a growing demand from the industrial sector, looking for alginates used in agribusiness and cosmetics. Thus, this *Laminaria* field embodies the tradeoffs that conservation and sustainable development trigger.

The rules regarding kelp harvesting are defined by the 'Algae Committee' which gathers representatives from kelp harvesters, State services, processing industries and a scientist. The decisions enter into force after having been validated by the regional Prefect. The PNMI has a responsibility on producing knowledge on the state of ecosystems and trying to conciliate development and conservation (Frangoudes & Garineaud 2015).

4.1.2 Objective of the ESA

Through the VALMER project, and implementing the triage approach, the PNMI team seized the opportunity to compare management options of kelp fields.

4.1.3 Methods

Through step 2 of the triage, the following ES delivered by kelp fields were scored as priorities:
i. provisioning services from kelp for industrial sectors (food, medicine, cosmetics) and commercial fisheries (abalone, fishes, crustaceans),
ii. support and regulation services linked to the maintenance of habitat for many commercial and emblematic species and
iii. cultural services for ecotourism and symbolic value of emblematic species and traditional activities.

The assessment was undertaken through a dynamic spatialised simulation model that encompasses
i. a kelp population model sensitive to environmental conditions,
ii. a bio-economic model describing kelp harvesting and
iii. a module assessing ecological functions and providing ES indicators.

In combination with a multicriteria grid to assess the effects of management on ES and scenarios to be implemented in the model, the ESA should enable the MPA managers to compare contrasting scenarios on the level of ES provided by kelp forests.

Stakeholders participated to the elaboration of the conceptual model, which describes how the socio-ecosystem works, what the interlinkages between the ‘institutional framework’, ‘activities’ and ‘kelp ecosystem’ are, as well as relationships within the three ‘boxes’. They were then consulted along the development of the dynamic simulation model at critical stages, to validate some data or choices.

4.1.4 Some Results

Table 2 shows some results of the kelp fields’ ESA: for each ES, the goal was to have state, supply and demand indicators. These results come from collected data and produced ones by the model.

Table 2: Results of the Initial Assessment of Kelp Ecosystem Services (Source: VANHOUTTE-BRUNIER et al. 2016)

		State	**Potential supply**	**Actual supply**	**Demand**
Support & Regu- lation Service	Key habitat supporting: - strong biociversity - commercial species - emblematic species grey seal, bottle-nose dolphin, European shag	Total biomass: 510‘000 tons MSFD & WFD	Life cycle maintenance capacity	No. of individuals: 130 35 531	MSFD & WFD
Provi- sioning Services	Kelp harvesting and alginates	Total biomass: 510‘000 tons	Maximum sustainable harvest: 180‘000 tons	Production: 52‘000 tons CPUE: ~ 4.6 tons/hour	No. of kelp harvesters: 25 No. of months of activity: 23 Wage/min. wage: 2.7 Net return: 42‘500€
	Commercial fisheries abalone, European lobster, seabass, pollock				
Cultural Services	Ecotourism (sealife watching) grey seal, bottle-nose dolphin, European shag	No. of individuals: 130 35 531		No. of individuals: 130 35 531	
	Ecotourism (sealife watching) grey seal, bottle-nose dolphin, European shag	Presence of sp. with recreational value: yes yes yes		No. of tourists: up to 3‘000 per mesh	No. of tourists: up to 3‘000 per mesh
	Local identity trough traditional activity (kelb harvesting)	Presence of kelb harvesting activity: yes		No. of cultural activities: 2 museums, 1 fest	No. of visitors in cultural events: 20‘000

4.1.5 Challenges and Prospects

Main challenges have to do with daily management issues, such as relationships with the stakeholders on sensitive topics – 2014 had been a difficult year for the kelp harvesters due to several exceptional storms. Timing was a major constraint, and did not allow supporting the decision-making process for the 2015 harvesting rules: instead, it enables specifying some rules which have been already agreed upon, or testing effects of some of them (e.g.: quotas). Eventually, the construction of the model was as inclusive as possible but stays a very technical process, developed by actors not totally endowed with powers on the definition of rules. Confidence in the model had to be sought and built to make the model legitimate. Beyond the dynamic simulation model, the VALMER project has provided through the ES approach a framework for discussion, allowing stakeholders to enlarge their view of the system functioning and related issues. Testing scenarios showed the interest in implementing conservation measures, even strong ones: this is very useful to the management team. Finally, the ESA has the potential to support a mid-term evaluation and/or a revision of the PNMI's management plan, which lasts until 2025.

4.2 ESA in the Golfe Normand-Breton

This part is mostly based on Dedieu & Morisseau (2015); Morisseau et al. (2015a), Morisseau et al. (2015b).

4.2.1 Background

The GNB covers 6,300 km², with bays, vast shores, harbours, numerous islands, rocky, muddy and sandy bottoms. Marine habitats are very diverse, and uses too. Indeed, there are fishing activities, shellfish culture, recreational activities, tourism and extraction of aggregates, as well as new developments such as aquaculture and offshore windfarms. Conflicts over the use of the marine environment exist and might become more important in the future. There are different MPAs in the GNB, but the whole zone is a proposed marine nature park, which would have the means to consider environmental protection in relation to the diversity and trends of maritime activities, at a relevant scale. Being a proposed MPA implies that there is a team in charge of improving knowledge about ecosystems, uses and cultural elements, and of constructing a collective – with all stakeholders – strategic vision for this area, while waiting for a governmental decision to create the marine nature park. Currently, the GNB does not have a management plan, or governance bodies, in contrast with the PNMI situation described in 4.1.

4.2.2 Objective of the ESA

The goals of the ESA in the GNB were to i/ draw an initial diagnosis of ES delivered by all benthic habitats and ii/ anticipate future changes, while maintaining a common culture with stakeholders about the issues and prospects for the area. They result from the management features of the GNB: the need to improve global knowledge before targeting specific stakes, and the need to continue developing a collective dynamic to prepare the future discussions and decisions involving the stakeholders.

4.2.3 Methods

In order to draw an initial diagnosis of ES produced by benthic habitats, four approaches were undertaken.

Substantial work was carried out in order to analyse the links between the benthic habitats and ecological functions on one side, and benthic habitats and ES on the other side. Methods included literature review, cartographic information and expert judgment. Various tools and methodologies were then developed in order to characterise the current state of some of the marine ES.

Through historic and economic analysis, a diagnosis about the ecosystems and stocks that support the fishing activity in the GNB was made. Firstly, through 'depletion corrected average catch' models, sustainable levels of fishing were calculated for 9 species of the GNB. Secondly, the dependence of fleets to the GNB area and to species was studied, in order to define which ones were the most vulnerable to ecological and economic changes.

An ecosystem-based activity accounting was undertaken, so as to link the efforts made by society to protect ecological processes that allow the production of ES, and the benefits society derive from these ES, with accounting indicators. Looking at these accounting indicators together with biophysical ones related to the state of the ES should enable to know if the monetary value of production is sustainable (Martin et al. 2015).

To improve knowledge on the effects of cumulative pressures and their potential impacts on the level of ES, modules of the InVest model (see www.naturalcapitalproject.org/invest/) have been used. Three steps were pursued to quantify and map cumulative risks:

i. mapping pressures coming from human activities;
ii. mapping habitats and
iii. through expert judgment, moving from a level of pressure to a risk of impact (Cabral et al. 2014).

In parallel to these 4 approaches, a participative scenario-building exercise was undertaken so as to co-construct possible futures about the level of two ES (fish provisioning from open-seas and recreational activities at the foreshore) in relation with general economic trends and the state of marine waters. Workshops gathering the VALMER team project and stakeholders were carried out over a year to this effect.

4.2.4 Some Results

The ecological approach produced matrices on habitats-functions and on habitat-services in the GNB, as well as the most recent and exhaustive habitats mapping of the area (Figure 2).

Among the findings of the focus on fishing, are the levels of sustainable fishing for 9 species, and the evidence that while some were able to recover after a collapse due to overexploitation (e.g.: scallops), others are still not recovering, such as clams. Of the 617 boats registered within the GNB area in 2012, 408 spent more than 50 % of their time in the GNB. Dependencies on species are available in Morisseau et al. (2015b).

The ecosystem-based activity accounting showed that the means society devotes to maintaining ES in the GNB are up to 125,000 EUR, with a major part of this budget (112,000) dedicated to sewage water treatment. This finding questions allocation of efforts. Results are shown in Morisseau et al. (2015b).

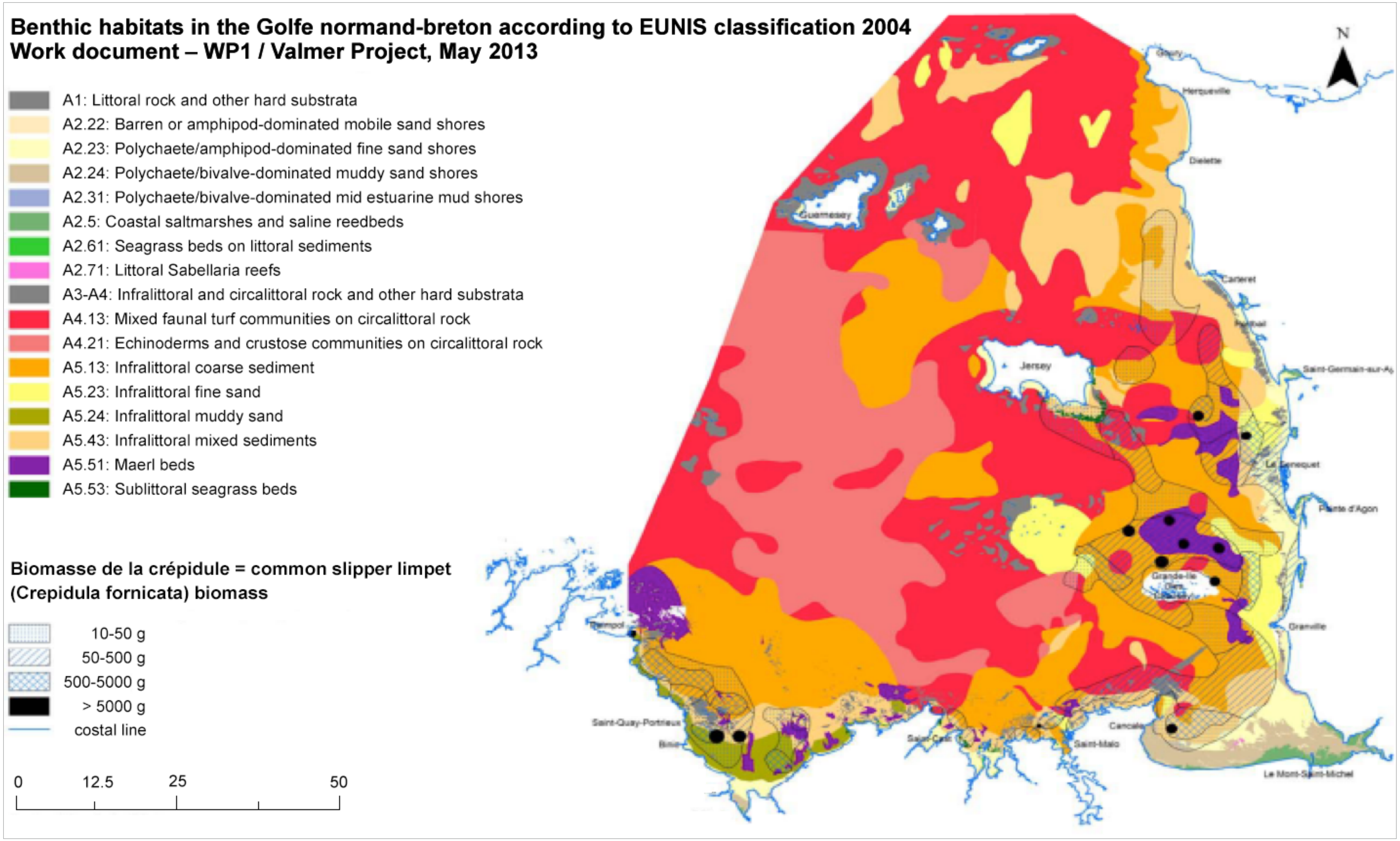

Figure 2: Benthic Habitats of the GNB (Source: SCHOENN, 2013)

A map of the risks of cumulative impacts for benthic habitats of the GNB was produced andtells us that risks are more important next to ports and by the coast – where most activities are concentrated. Also, maps representing the potential capacities of habitats to deliver ES were realised, showing for example that cultural services are more intense by the coast – related to the number of visitors (Morisseau et al. 2015b).

Results from the scenario-building exercise are described in Dedieu & Morisseau, (2015b), and the relationships between the scenarios and the ESA are analysed in Morisseau et al. (2016). Basically, although the two processes were led separately and simultaneously, bridges were built towards the end of the project, by focusing on specific ES (e.g.: on the provisioning of shellfish).

4.2.5 Challenges and Prospects

The diversity of methods and tools deployed caused certain difficulties in the GNB, which makes this case study particularly interesting. There was indeed a challenge to develop or strengthen the links between the four approaches and the scenarios, so as to make a coherent story useful to managers.

VALMER gathered, produced and organised lots of information about ecosystems and ecosystems services in the GNB, a broad overview that should be very helpful to the elaboration of a management plan once a marine nature park would be created.

5. Conclusion

If challenges regarding these two ESAs lie in scientific and technical developments (e.g.: dealing with uncertainties, with lack of knowledge on the links between marine ecological functions and services), the choice has been made here to deliver feedback from a marine management point of view. In both cases, the necessity and relevance of involving the stakeholders was highlighted, knowing that this requires significant time and educational effort. The two ESAs followed very different paths, accordingly to their respective contexts. However, they both improved knowledge on ES and shaped a framework for discussions, beyond their first goals. This is also very important from a management standpoint.

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Assessing the maintenance costs of marine ecosystems in the context of the MSFD: the French experience

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Abstract

This short paper presents the approach which has been implemented in France for estimating the costs of ecosystem degradation in the context of the Marine Strategy Framework Directive (MSFD). Among the possible approaches, forgone benefits assessment or maintenance costs assessment, France decided to use the latter. The paper contains an introduction, a section which explains how to choose an economic approach coherent with the MSFD rationale, a section which exposes the methodology developed for implementing the approach, and a section on the main results.

1. Introduction

The Marine Strategy Framework Directive (MSFD) represents the environmental component of the European integrated marine approach and establishes a legislative framework for community action in the area of marine environmental policy. The aim is in the end to design a program of environmental measures to achieve a good environmental status (GES) by 2020. The MSFD is founded on an initial assessment of the current environmental status of national marine waters and a socio-economic analysis of human activities in these waters, which had to be completed by 2012 (MSFD, 2008/56/EC). As stated by the MSFD article 8, the initial assessment includes a socio-economic analysis of the costs of degradation of the marine environment.

However, no indication is provided as regards the method to be used for implementing such an assessment. There are two possible ways for assessing the costs of environmental degradation: as the costs associated with the loss of benefits resulting from the degradation of natural capital (Barbier et al. 2009, EPA 2009), and as the maintenance costs required to compensate for the actual or potential degradation of natural capital (Bartelmus 2009, SEEA 2003). The first of these methods is based on the Total Economic Value (TEV) of benefits forgone because of the depletion of ecosystem services delivered by marine biodiversity. The second method is based on the costs required to maintain a good state of marine biodiversity which makes it possible to deliver ecosystem services. This short paper gives an illustration of the second approach.

2. Why not calculate the loss of benefits due to marine ecosystem degradation[1]

Economics are not a unified science: economists may propose different approaches and methods which are more or less adapted to the issue at stake and the context. When it is proposed to estimate the “economic” value of Nature, different purposes may be pursued. This economic value may be used for convincing people that environmental damages lead to welfare losses for society: in that case “economic value” means monetary value of the benefits provided by ecosystems, and this economic value is expected to raise awareness and therefore strengthen demand for Nature conservation. But this economic value may also be used for implementing an environmental policy: in such a situation, the society is already convinced that Nature conservation is a goal to be achieved, and the question to be addressed by economist is to estimate the means which are required in order to improve Nature conservation. In that case, economic analysis may in particular be used to estimate what the cost of existing ecosystem preservation measures is, in the prospect of improving the cost-efficiency ratio of future environmental policies adopting higher targets.

This perspective provides a first argument for choosing the maintenance costs approach when assessing the “cost of the degradation of marine waters”, as required by MSFD Article 8. Suppose that the cost of the degradation of marine waters would be estimated by the loss of benefits approach: this would be useful for demonstrating the impact of marine ecosystem degradation on social welfare and would attract peoples‘ attention to the need of a marine conservation policy… Yet, would such benefit loss estimates be worth in the MSFD context? The MSFD is the environmental pillar of the European maritime integrated policy; it sets strong nature conservation targets through the GES concept, provides a schedule with strict time constraints and requires each Member State to start implementing a Programme of Measures for marine ecosystem preservation in 2016. Thus, is it now the time to raise awareness and strengthen demand for an ambitious marine preservation policy, or should we consider that this policy will be *de facto* the MSFD, which thus calls now for the assessment of the actual costs of current marine preservation measures in order to prepare for future additional and more efficient measures?

The second argument concerns the feasibility of the loss of benefits approach. Basically, this approach searches for changes in the Total Economic Value (TEV) of environmental assets. The TEV encompasses benefits from direct consumptive uses, direct non-consumptive uses, indirect uses, but also option values, associated with benefits individuals expect from possible future uses, and non-use values (Pearce & Turner 1990). Non-use values include bequest value, ethical value and existence value, which depend on the satisfaction obtained from respectively the fact that future generations will have access to ecosystem benefits, the fact that other people have access to ecosystem benefits and the fact that ecosystems exist. It has to be emphasized that the TEV approach for Nature valuation is valid only for measuring the change in people’s preferences under small or marginal changes in ecosystems and the goods and services they provide (Pascual & Muradian 2010).

1 This title refers to the article written by Michael Toman (1998) as an introduction to a special issue of the journal *Ecological Economics*, whose intent was to criticize the famous paper by Costanza et al. (1997) previously published in *Nature*; Toman reveals in his paper that the journal *Nature* refused at that time to print any follow-up correspondence to Costanza’s controversial essay.

Since the first attempt to estimate the TEV of natural capital and ecosystem services at very broad scales (Costanza et al. 1997), the pitfalls, internal discrepancies and lack of usefulness of this approach have been demonstrated by environmental and ecological economists (Toman 1998). Indeed, estimating a TEV for all natural assets is really difficult and questionable for the following reasons: the lack of data on interactions between changes in ecological functions or ecosystem services production and changes in well-being; the high level of uncertainty regarding some of the values based on support services or cultural services; the controversies around the benefit-transfer method for extrapolating local values to a regional or national scale; the controversies around the stated preferences analysis for capturing non-use, indirect use, and non-market use values; ethical issues regarding the commensurability and monetisation of nature (Levrel et al. 2014).

The third and last argument deals with the vision of the sustainability of the relationships between nature and human societies that each economic paradigm assumes. Neoclassical ("standard") economics uses the maximum of welfare criterion because it assumes that all natural assets are substitutable and all damage to the environment is reversible; putting a monetary value on each ecosystem is possible and can be used in a cost-benefit analysis to decide whether it has to be preserved or not. Ecological economics emphasizes that in a situation where those assumptions are no longer valid, the changes of an ecosystem which would result from the decision to protect it or not are no longer small or marginal, and the consecutive changes in social preferences can no longer be estimated by monetary values. This is the reason why, when natural capital become scarce and produces decreasing ecosystem services, the value that society grants to nature is sky-rocketing: the closer ecosystems are to the critical resilience thresholds, the higher the values attributed to the benefits of healthy ecosystems, especially non market benefits which are the less tangible (Figure 1). And when ecosystems are closed to resilience thresholds, the issue at stake is no longer to estimate their value, which may tend toward infinity, but to analyze the costs and efficiency of the measures required for improving ecosystem status. Considering the MSFD rationale, it is doubtful that TEV could give relevant information for implementing a policy which targets strong sustainability goals.

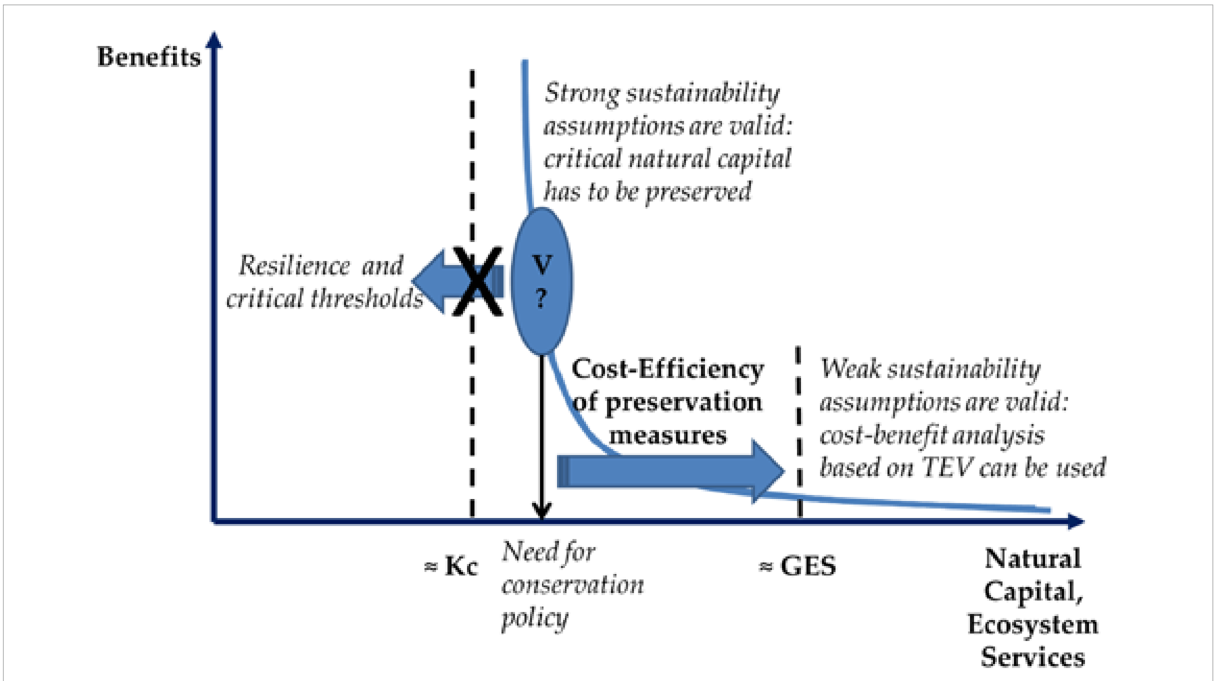

Figure 1: Marginal benefits of ecosystem preservation (after Pearce 2007).

Finally, in the context of the MSFD, it seems inappropriate to provide a judgment on marine ecosystems based on forgone benefits due to changes in their TEV. TEV is obtained from aggregated individual preferences, and the consecutive decisions use should target the maximum of welfare, a normative principle which is different from the one adopted within the MSFD, namely the ‚good environmental status' (GES). In addition, the assumptions of the TEV approach do not stand when ecosystems are closer to critical sustainability thresholds than to GES; thus, estimating a TEV would mean assuming that marine ecosystems are close to the GES, an implicit statement which dismisses the very rationale of the MSFD. On the other hand, it might seem meaningful to know the current maintenance costs devoted to marine environmental ecosystem management, considering the gap between the present situation and the GES goal. Indeed, achieving GES will require improving and complementing existing marine environmental management measures, which will generate additional costs. From this perspective, the maintenance cost approach will also provide the basis for a future cost-effectiveness analysis of the complex management system which will result from the Programme of Measures recommended by the MSFD[1] (Levrel et al. 2014).

3. Materials and method

Recognising the limits of the TEV approach, Pearce (2007) has proposed paying attention to the real costs borne by society to provision and maintain ecosystem services – that is, the costs of conservation policies. Bartelmus (2009) also suggests paying attention to the maintenance costs of a given environmental state: "Maintenance cost is applied to environmental degradation. The SEEA reviews maintenance costing critically as the hypothetical cost of avoiding pollution or restoring the polluted environment (SEEA 2003). Maintenance cost can be seen, however, as the weights for actual environmental impacts 'according to society's obligation and capacity for dealing with environmental concerns'". In contrast to the TEV, "such costing is indeed more practical than the assessment of elusive damage effects from environmental impacts" (Bartelmus 2009).

The maintenance costs which have been calculated in the initial assessment of the Marine Strategy Framework Directive (MSFD) in France are divided into three categories (Figure 2): 1) Costs of monitoring and information, which aim at improving information and coordination levels relative to conservation of the marine environment; 2) Costs of preventing or avoiding environmental degradation, which represent the costs of specific investment in preventing and avoiding environmental impact. 3) Costs of environmental restoration and remediation, which represent the costs of restoration and remediation after an environmental damage or an ecological accident. Despite the implementation of the above mentioned measures, residual impacts are still observed: providing a description of these impacts will give a proxy of the efficiency of current marine ecosystem preservation policies. The estimation adopts a problem-oriented approach and addresses nine problem areas corresponding to nine sources of environmental degradation.

Each source of environmental degradation is linked to either a GES descriptor of the MSFD or to a component of the "pressures-impacts" analysis. The nine problems for which degradation costs have been estimated are described hereafter. "Marine litter" refers to descriptor 10 of

1 On the opposite, the forgone benefits approach would prepare for cost-benefit analyses of marine ecosystem preservation measures, which in turn could lead to demonstrate that no additional preservation is needed.

the MSFD, and also to the related components of OSPAR and Barcelona Conventions and the EU Waste Water Treatment Regulation and the Water Frameword Directive. “Chemical compounds” refers to descriptors 8 “contaminants and pollution, ecological effects” and 9 “contaminants in food” of the MSFD, as well as the corresponding aspects of the REACH Directive and of the EU Waste Water Treatment Regulation, the Water Framework Directive and the Bathing Water Regulation. “Microbial pathogens” refers to the pressure-impact topic “introduction of microbial pathogens”, as well as the EU Waste Water Treatment Regulation, the Water Framework Directive, the Bathing Water Regulation and the Regulation on Animal Products for Human Consumption (Food Legislation). “Oil spills and illegal discharges” refers to the MSFD descriptors 8 “contaminants and pollution, ecological effects” and 9 “contaminants in food”, as well as the related aspects of the International Convention for the Prevention of Pollution from Ships (MARPOL), the International Convention on the Establishment of an International Fund for Compensation for Oil Pollution (FIPOL), the Convention for the Protection of the Marine Environment of the North-East Atlantic (OSPAR) and the Barcelona Convention. “Eutrophication” refers to the descriptor 5 “eutrophication” of the MSFD as well as the EU Nitrate Directive. “Non-native invasive species” refers to the descriptor 2 “non-native species” of the MSFD as well as the Ramsar, CITES, Berne, Bonn, Biodiversity, Barcelona, OMI Conventions. “Biological degradation of exploited natural resources”, which is split into 2 sub-problems, aquaculture and fisheries, refers to the MSFD descriptor 3 “status of species exploited” as well as the European common fisheries policy. “Loss of biodiversity” refers to the MSFD descriptors 6 and 1 regarding “biodiversity and integrity of the marine substrates” and descriptor 4 “Foodwebs”, as well as the Convention on Biological Diversity, the European Strategy on Biodiversity, and the French Strategy on Biodiversity. “Introduction of energy into the environment and changes in water regime” refers to the MSFD descriptors 11 “energy” and 7 “hydrography”, as well as the EU Environmental Impact Assessment Directive.

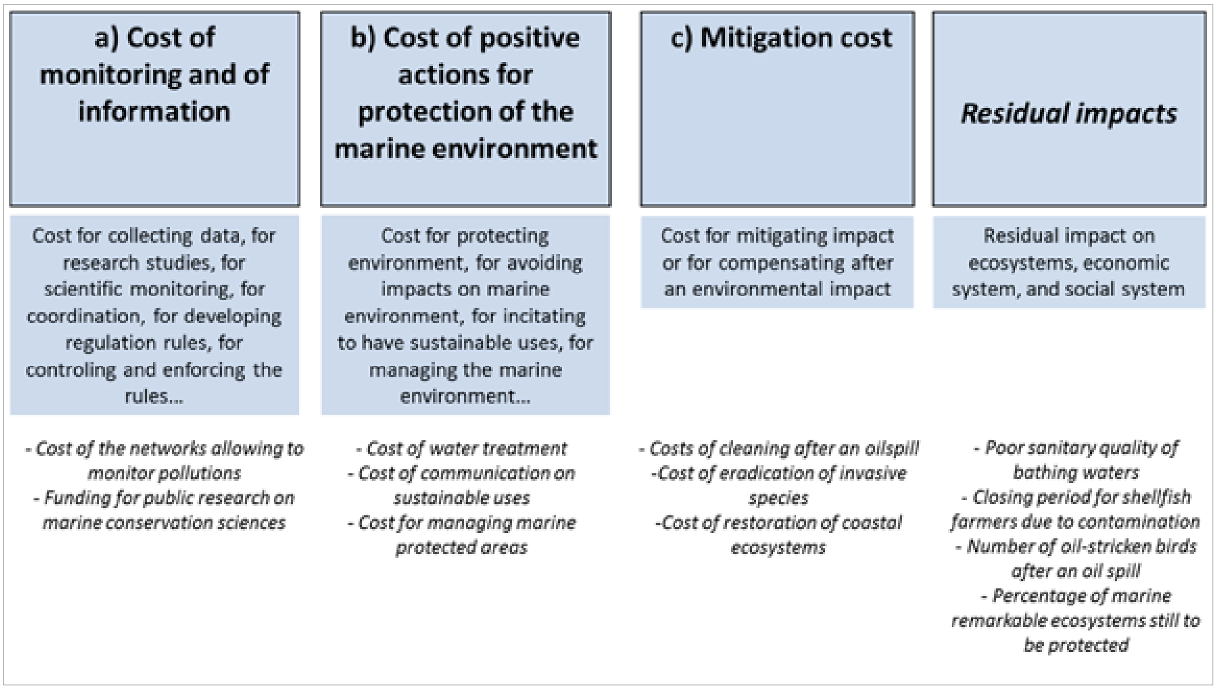

Figure 2: Typology of maintenance costs for marine ecosystems.

For each thematic, a researcher was in charge of reviewing the literature, contacting experts and identifying data sources. Data were collected during the first semester 2011, the reference year being 2010 for the initial assessment (time-series were also used when available).

Depending on the thematic, between 5 (introduction of energy) to 130 organisations (loss of biodiversity) were contacted; the response rate was between 60 % (eutrophication) and 100 % (degradation of aquaculture resources, microbiological pathogens). Data were not significant regarding two themes, “marine litter” and “introduction of non-native invasive species”, which were removed from the analysis. In addition to the response rate, we encountered some difficulties regarding the format or even the interpretation of the data, for instance as regards the degradation of fishery resources: in particular, it was sometimes complicated to allocate public expenses to specific measures, and some expenses raised the problem of ‘damaging subsidies’.

4. Results

The results give a total figure for these degradation costs (around 2 billion EUR). A significant proportion of these costs (1,247 million EUR) was related to preventing marine water degradation by microbial pathogens, and took the form of enforcement of water quality standards. The second highest was the chemical compounds category, with costs associated with prevention of chemical pollution amounting to 347 million EUR. In both cases, the main goal is protection of human health, which explains the size of this expenditure. The following two positions are associated with loss of biodiversity and decrease of fish stocks, 148 and 133 million EUR respectively. The high costs associated with fishing are due to the increasing erosion of fish stocks and the need for more sustainable management of these stocks (67 % of costs). The costs linked to biodiversity loss are mainly related to monitoring and reporting (52 % of costs), which indicate substantial interest in these issues and a serious lack of scientific data. There are three problems for which the costs of environmental degradation are much lower: eutrophication (47.4 million EUR), oil pollution (47.3 million EUR), and degradation of exploited resources related to aquaculture (30 million EUR).

The results for France could be compared with those of other Member States who have taken similar approaches in the context of the MSFD. Nevertheless, it is not really possible yet to make meaningful comparisons at this stage, since the methods of data collection and the nature of the costs are very different. This situation highlights the heterogeneity of methods based on cost assessments, in contrast to conventional monetary economic valuations which have been discussed for a long time and are more stabilized. However, the “cost-based approach” could easily be improved if common criteria are adopted for the expenditures to be taken into account, for the standardization of the scope and target of policy measures, and for the calibration of accounting costs (salaries, investments, etc.). This emphasizes the need to develop such assessments in a standardized way. Such improvements of the approach could be targeted during the implementation of the second cycle of the MSFD, whose preparatory phase should start in 2018.

Finally, this French experience in implementing the maintenance cost approach reminds that economic valuation methods are not neutral: some of them are typical of the ‘weak sustainability’ approach, which is not necessarily coherent with the rationale of an environment preservation policy such as the MSFD. The arguments for not applying the forgone benefits approach in the initial assessment are still valid when considering the further steps of the MSFD. Cost-benefit analysis, which uses the TEV and is based on the ‘welfare maximization’ paradigm, assumes substitutability and reversibility: these assumptions are not in line with the general objective of reaching the GES. This is the reason why, when assessing the Programme of Measures, it should be recommended to first define priority and non-priority targets: then, the choice of measures for priority targets should be based on cost-effectiveness analyses, while measures for non-priority targets only could be submitted to cost-benefit analyses, which could demonstrate that the measure is not beneficial. In conclusion, considering the internal rationale of the MSFD, we argue that a marine protection policy which targets strong conservation goals should prefer the maintenance costs approach for the initial diagnosis and the cost-effectiveness analysis for selecting operational measures.

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Developing regional indicators to assess the status of marine biodiversity

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1. Introduction

For the first time all European Member states have developed holistic marine strategies under obligation by union legislation with the ultimate aim of maintaining biodiversity and providing diverse and dynamic oceans and seas which are clean, healthy and productive. To determine the state of the European marine environment, indicator-driven assessments can be used to inform reporting requirements under multiple policy instruments. At the European marine level, these policy instruments include the Marine Strategy Framework Directive (MSFD, 2008/56/EC), the Habitats Directive (HD, 92/43/EEC) and the Birds Directive (BD, 2009/147/EC) as well as the Water Framework Directive (WFD, 2000/60/EC) in coastal waters. Obligations stemming from these instruments are implemented nationally per EU Member State as well as through regional cooperation conducted within the frameworks of Regional Seas Conventions (RSCs). Since 1972 the "OSPAR Convention" has worked on a regional level encompassing the North East Atlantic Ocean in a cooperation of 16 contracting parties[1] and therefore has provided a platform to support the regional coordination aspects of the MSFD. Under this convention a suite of MSFD indicators is developed by scientific workings groups for assessing and monitoring the status of the marine environment for each of the five OSPAR regions, including the North Sea. As an example a seafloor indicator will be explained in detail below. Although biodiversity indicators have been developed under the MSFD banner they can also e.g. be used to support and progress work of the OSPAR North East Atlantic Environment Strategy. The development work is currently a main task of working groups and committees within the OSPAR framework.

Why marine indicators?

Obligations under European legislation require every Member State to analyse the state of marine ecosystems and their components, and to implement measures necessary to avoid deterioration of marine ecosystems and to improve their state. Particularly for this assessment round the MSFD Article 9 requires the development of criteria and methodological standards to allow for a consistent assessment of marine regions which are specified for all MSFD descriptors so far by the EU Commission Decision 2010/477/EU[2] (COM DEC). The indicator described below will be developed for COM DEC criterion 6.1 "physical damage having regard to substrate characteristics" for the Northeast Atlantic, in particular for the OSPAR subregions: Greater North Sea, Celtic Seas and Bay of Biscay and the Iberian Coast.

1 Belgium, Denmark, European Union, Finland, France, Germany, Iceland, Ireland, Luxembourg, The Netherlands, Norway, Portugal, Spain, Sweden, Switzerland and United Kingdom.

2 http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2010:232:0014:0024:EN:PDF

Who is developing marine indicators?

For Northeast Atlantic marine ecosystems under the OSPAR convention biodiversity indicators are being developed by the Intersessional Correspondence Group on Biodiversity Assessment and Monitoring (ICG COBAM), and a first round of assessments utilising approximately 15 indicators is going to be delivered as part of the OSPAR Intermediate Assessment in 2017. The outcomes of these assessments are intended to be used as a roof report for some Member States, which can be further specified by national assessments and is subsequently going to support ongoing development and the implementation of regional and national management measures to protect marine biodiversity. One of these biodiversity indicators focussing on the state of the sea floor – a benthic indicator jointly developed between the Nature Conservation Agencies of the United Kingdom (JNCC) and of Germany (BfN) – is presented here as a case study to illustrate the overarching MSFD assessment structure and to inform on the development progress of this indicator, respectively.

2. OSPAR Biodiversity indicator BH3 – 'Extent of physical damage to seafloor habitats'

The indicator "Benthic habitats - Extent of physical damage to seafloor habitats" (OSPAR Code: BH 3) has been developed and preliminarily tested within the OSPAR framework by the UK and Germany and it has made considerable progress in the last year. This is an OSPAR "common indicator" for the Greater North Sea (OSPAR Region II), Celtic Seas (OSPAR Region III), and Bay of Biscay/Iberian peninsula (OSPAR Region IV), which implies that all contracting parties within these OSPAR regions have signed up to the delivery of data to support indicator development and promote indicator assessments based on this information. It has further been proposed as a "candidate indicator", subject to further testing, for the Arctic region (Region I) and Wider Atlantic (Region V), which means that it might deliver partial assessments for those regions, if data is available for the testing.

Benthic communities formed by marine organisms living on or within the seafloor sediments undertake essential ecological processes and functions to support healthy ecosystems. They are a key component of the food web, providing a major food source for predators, including food for human consumption, and therefore they are a key component for the provision of ecosystem services. The diversity of sea floor habitats is mainly shaped by depth, light penetration, exposure, substrate type and their specific flora and fauna communities.

The overall aspiration of the indicator is to evaluate to what extent the integrity of the seafloor and its associated ecology is being damaged by anthropogenic activities. It is designed as a tool to target larger sea areas with no additional sampling effort, *i.e.* utilising existing information on the sea floor. In particular, it is being designed to assess predominant as well as special marine habitat types as defined by the MSFD Annex III by using a combination of data on seafloor sensitivity assessments and the intensity with which the seafloor is being exposed to anthropogenic pressures. At present and as a first development step the indicator is exclusively addressing abrasion caused by fishing activities for vessels > 12 m. Impacts from smaller vessels and information from other human activities causing physical damage will be added at a later stage, if available.

In general, physical disturbance of the seabed by human activities such as fishing,

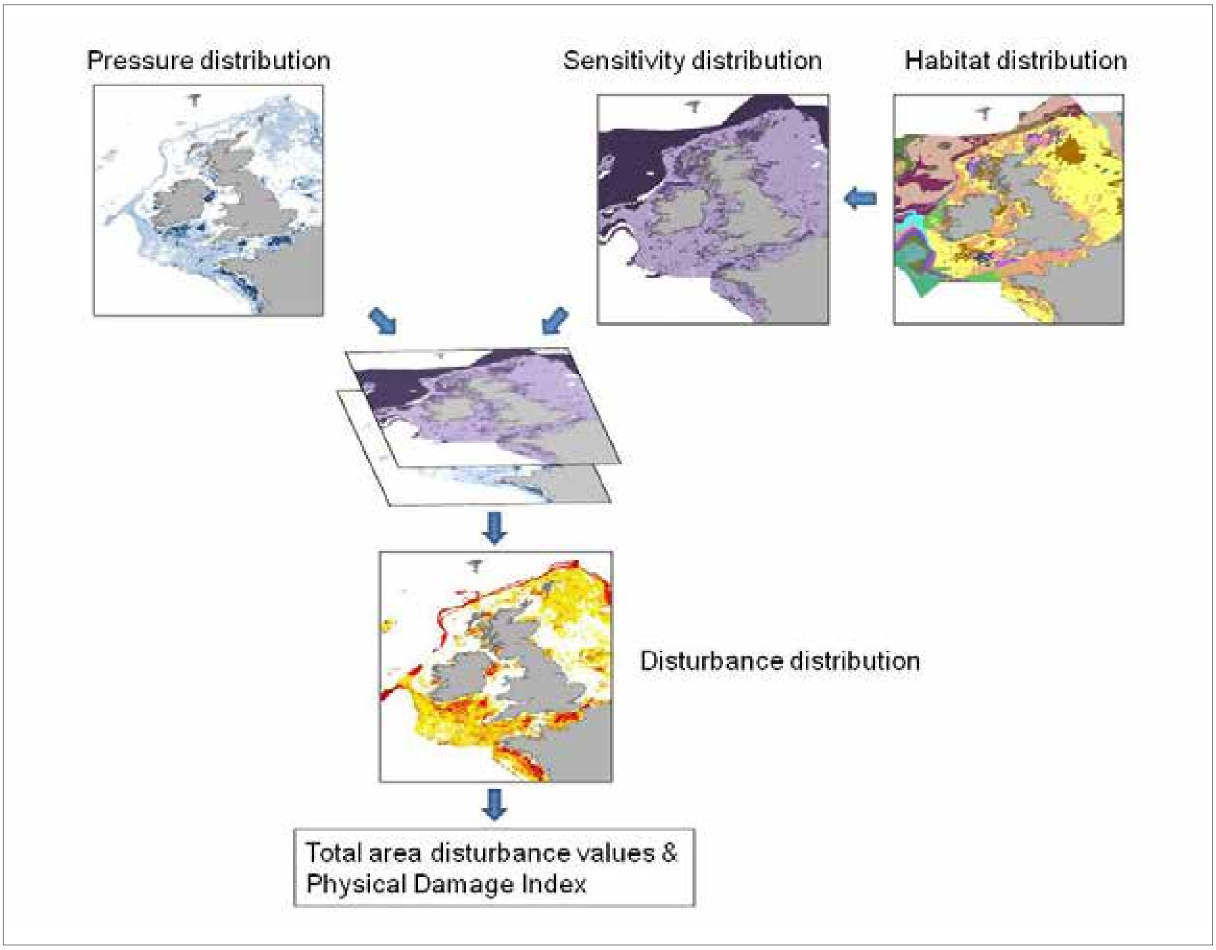

Figure 1: Broad overview of the assessment method used to calculate a Physical Damage Index from information on the distribution of physical pressures, distribution of benthic habitats and their associated sensitivities to aforementioned pressures.

sandextraction or offshore construction especially endangers habitats with larger and fragile species and species attached to the sea floor. In many regions of the OSPAR marine area, a shift in community composition has been reported where large and long-lived species have been replaced by small and fast-growing opportunistic species and scavengers that profit from disturbance and the availability of dead organisms. The impact of fishing with bottom contacting gear is considered to be the main driver of these seafloor community changes. The 'physical damage' indicator aims to assess the level of current disturbance at a regional scale by matching spatial information in a geographic information system. The indicator method combines data on the spatial distribution and intensity of physical damage pressures with the distribution and range of habitat sensitivities using a GIS spatial analysis model (see Figure 1). The final output of this model is a 'Physical Damage Index' for each benthic habitat or geographical area. However, the indicator in its current modification is limited in its ability to assess historical damages, which had caused the deterioration and modification of seafloor habitats in the past.

The components of the analysis are (cf. Figure 1):

- Combined habitat maps showing the extent and distribution of habitats (based on observational and modelled data e.g. as published by Rachor & Nehmer 2003), including the mapped extent of any relevant features (e.g. records and distribution of particular species and biotopes like EUNIS Level 5 habitats or other biological characteristics) grouped at EUNIS level 3 (spatial assessment has been done at EUNIS level 3, combining the sensitivity and exposure data from habitats, biotopes and species within the EUNIS level 3 habitat polygons)

- Distribution of habitat sensitivity based on the resistance and resilience (recoverability) of benthic habitats
- Distribution and intensity of physical damage pressures: at present surface and sub-surface abrasion
- Levels of disturbance per habitat type based on exposure matrices combining pressure intensity and habitat sensitivity per pressure type.

Components data are analysed to calculate the total area of disturbance categories per habitat type across the region per habitat type, and the Physical Damage Index (PDI) value for each benthic habitat or geographical area (see Figure 1).

3. Indicator Components

1) Components: Assessment of the extent and distribution of physical damage pressures

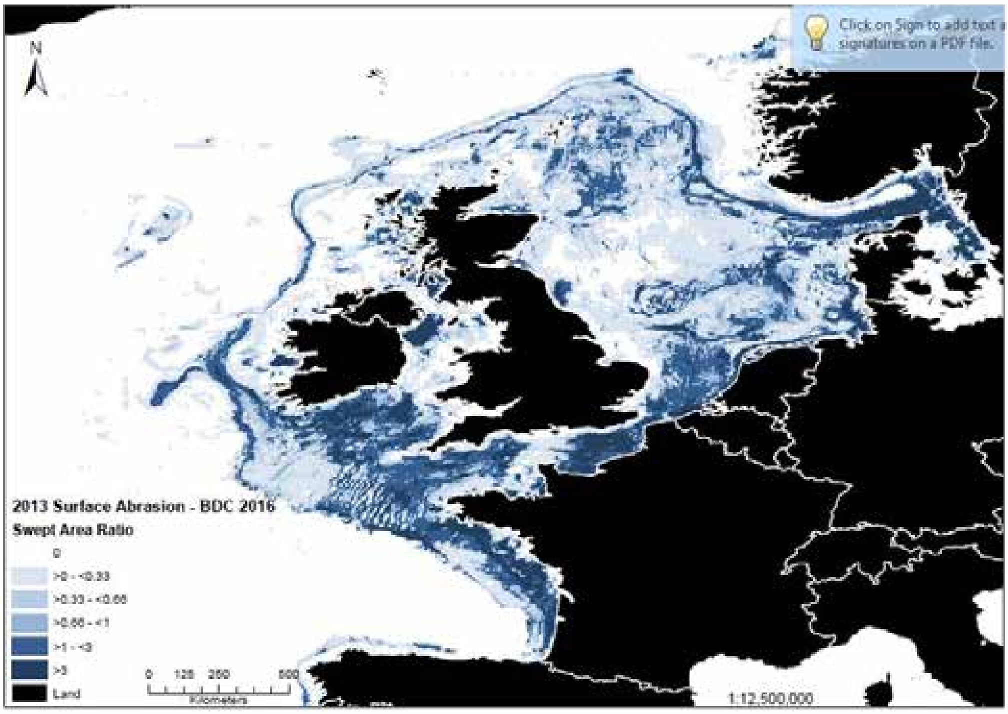

Figure 2: Surface abrasion pressure in 2013 from VMS data showing swept area ratio (SAR) for each 0.05x0.05 grid cell.

The first step is to determine relevant human activities causing physical pressures and their spatial and temporal extent. A data call on VMS and Log-book data was coordinated by ICES to collect and aggregate fishing effort for bottom contact gears. As fishing with bottom contacting gear generates pressures with the widest distribution and extent on seabed habitats, the methodology currently focuses on the assessment of the corresponding pressures surface abrasion (damage to seabed surface features) and subsurface abrasion (penetration and/or disturbance of the substrate below the surface of the seabed) due to fisheries (method based on recommendations outlined in JNCC 2011; ICES 2015, Eigaard et al. 2015). Pre-processed

VMS fishing data are used to calculate the ‘swept area’ of a specific group of fishing metiers (or gear-type if metier data is not available), which is the width of fishing gear multiplied by the average vessel speed and the time fished. This calculation is done on a cell-by-cell basis per gear and year with data covering the relevant reporting period of six years. Only the proportion of the gear in contact with the sea floor is used for the analysis, therefore all the gears have been classified according to type and/or metier group. The swept area ratio (proportion of cell area swept per year) is then calculated by dividing the swept area by the grid cell area. The trawling effort is classified with an intensity scale ranging from ‘none’ (no overlap between habitat and abrasion pressure or habitat is not sensitive to the pressure) to ‘very high’ (cell area swept more than 300 % or 3 times per year). Separate GIS layers are produced for surface abrasion (see Figure 2) and subsurface abrasion.

The map with the distribution of fishing pressure by vessels > 12 m causing surface abrasion in 2013 is presented in Figure 2. It distinguishes areas at low fishing intensity or where no fishing occurs, from those highly fished e.g. southern areas of the North Sea and Celtic Sea, Western parts of the Bay of Biscay, and the Skagerrak.

An important component of this indicator is the provision of habitat maps showing the extent and distribution of habitats and their associated sensitivities. These maps can be produced with a combination of benthic survey data (observations) and modelled habitat maps. As a basis for the assessment, a combined map of EUNIS level 3 habitats for the OSPAR region is produced.

2) Matching: The assessment of habitat sensitivity

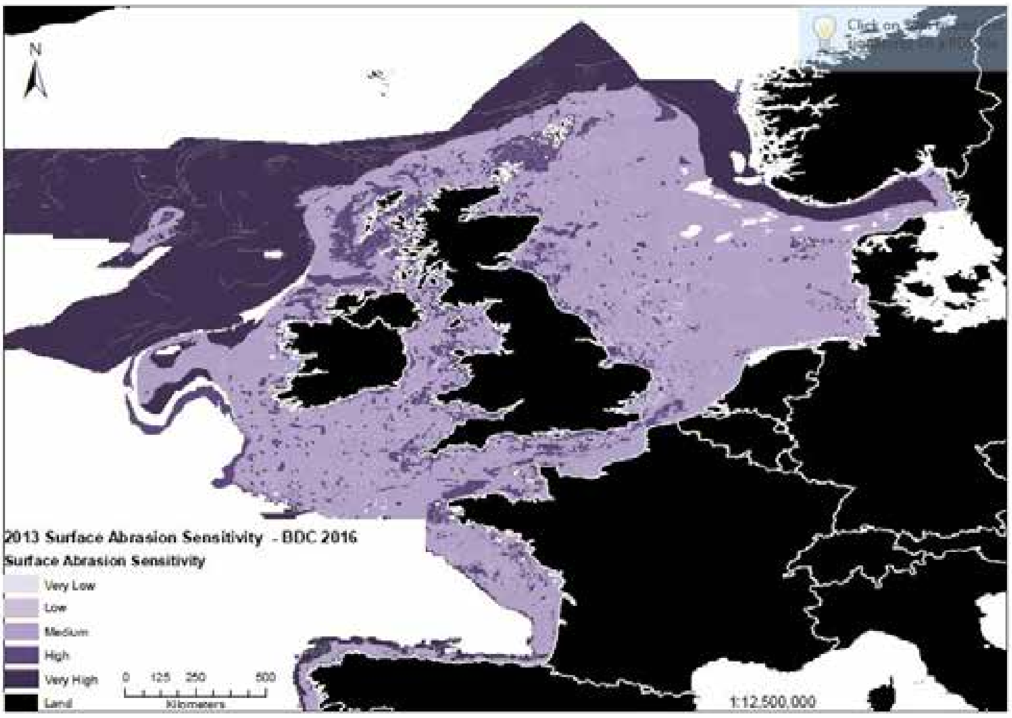

Figure 3: Extent and distribution of sensitivity categories to surface abrasion aggregated at EUNIS Level 3 habitat types.

As a next step sensitivities of characteristic species (as defined e.g. in Rachor et al. 2007) are determined based on available information on resistance (tolerance) and resilience (recoverability) of the species in relation to the intensity of each pressure (Bildstein et al. 2014, Tillin & Tyler-Walters 2014a-c). A sensitivity matrix combines both aspects and determines the sensitivity rank of each species.

This results in spatial information, which can be illustrated by a sensitivity map composed of three layers:

1. The map with the best available evidence is the survey map, where species records from survey data that match the list of characterising species are mapped with their associated sensitivities. The point data are then converted to a grid showing the maximum sensitivity values per cell. This approach reduces the risk of missing any highly sensitive species because of the scale of the grid.
2. In a second step a 'survey + modelled map' is produced which extrapolates the survey data to the habitat polygon where the point is embedded in. For each habitat polygon, the information of the survey records is extrapolated using the modal sensitivity.
3. Finally, in order to act as a background map and to fill in areas not covered by the survey and the extrapolated map, the combined habitat map is used to assign EUNIS level 3 sensitivities to the whole area (Tillin et al. 2010). The maps are combined showing the best available information (see Figure 3).

Confidence layers will also be produced to distinguish between areas with high confidence (survey data), areas with medium confidence (extrapolated data) and areas with low confidence (modelled habitat map).

3) Calculation: The combination of pressure intensity and habitat sensitivity

The degree of disturbance of a habitat is a product of its sensitivity and the exposure to a specific pressure. In order to assess the level of disturbance the linkage of sensitivity information with pressure data is required.

A matrix combining pressure intensity and habitat sensitivity supports the classification in nine categories of disturbance (very low to very high). A degree of disturbance is assigned to each rank which should provide an approximation of the relative impact on the habitat with regard to e.g. habitat structure, species richness, abundance or biomass. Due to the different nature of the pressures 'selective extraction', 'abrasion' and 'changes in siltation', for each of these physical damage pressures a separate disturbance matrix is required in order to include a weighting factor in the assessment.

4) Final index calculation: Calculation of the disturbance categories and the Physical Damage Index

In order to determine the cumulative physical disturbance of a particular predominant or special habitat across the region the total area of a habitat under each level of disturbance is calculated using information on a pressure-impact study (Schröder et al. 2008). This can be plotted spatially to show the distribution of disturbance across the region (see Figure 4).

The indicator will use an additive approach for future inclusion of multiple pressures, as the physical pressures considered are assumed to affect habitat structure and suitability in a similar mode.

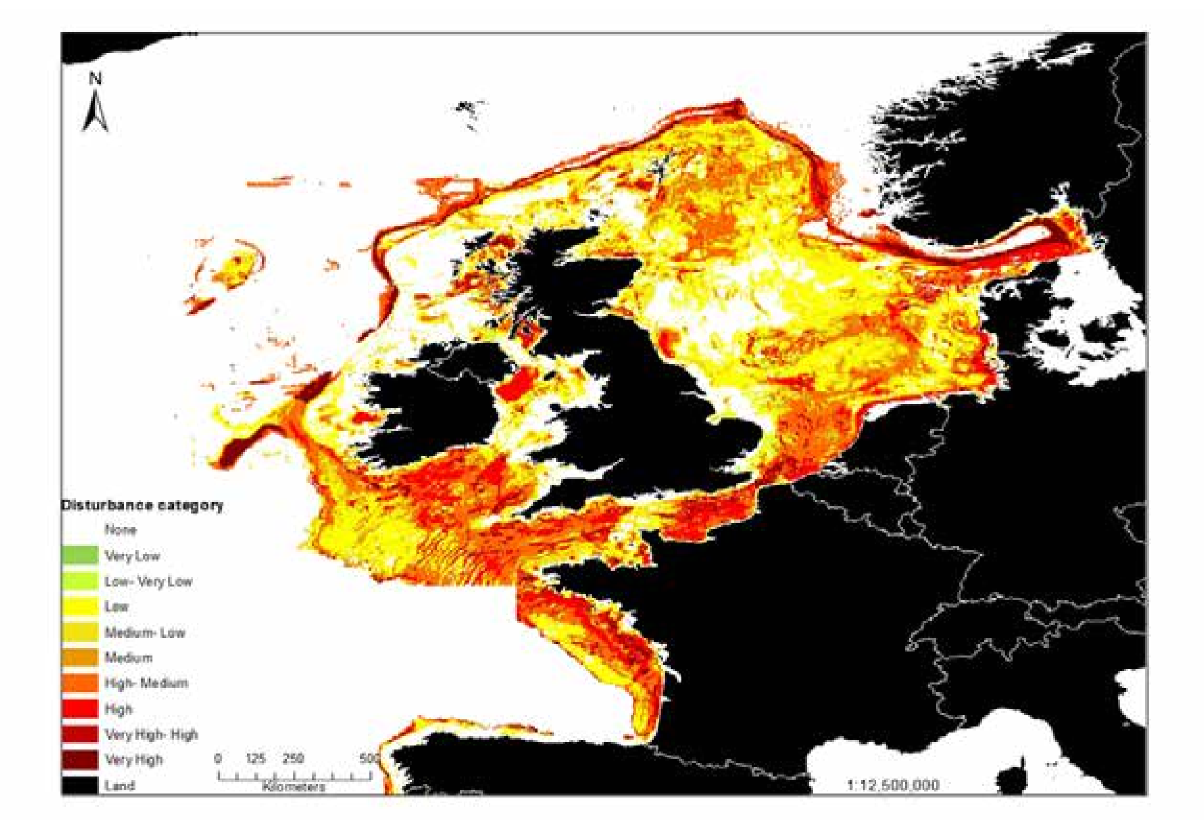

Figure 4: Distribution of categories of disturbance caused by Surface Abrasion across OSPAR regions based on 2013 VMS fishing data.

To summarise the combined disturbance the ‘Physical Damage Index (PDI)’ is calculated as follows:

$$PDI = 1 - \left(\frac{\sum_{i=1}^{10} d_i a_i}{100 \times A}\right)$$

Where d is the degree of disturbance, a is the habitat area subject to disturbance, i, 1-10 represents the disturbance categories calculated for a specific habitat and A is the total habitat area.

Low PDI values indicate either pressures with considerable temporal and spatial extent or habitats with high sensitivity towards the occurring pressures. The index values may range from 0 indicating habitat is highly disturbed to 1 which would be a habitat without impacts. This method provides the advantage of easily comparing different impacts of physical damage pressures and results in a single value of physical degradation for each habitat.

The results presented here are only preliminary and subjected to modification as new habitat and fisheries data are going to be made available in the next few months. It is also expected that during the next cycle disturbance matrices and the final algorithm will be modified accordingly and calibrated using the outputs from site-scale condition indicators. This is the first time that an assessment of this type at the regional scale has been undertaken, and it will still be required to include additional data during the next MSFD cycle to fully understand the extent of damage across the regions.

Cooperation with other indicator assessments and other RSCs

The development and testing of the BH3 indicator is being done alongside benthic condition indicators, in particular the Condition of Habitat Community indicator (Multimetric index) (BH2) and the Condition of Typical Species (BH1). It is envisaged these two indicators will be used twofold:

1. to ground-truth BH3 spatial outputs, and improve the evidence on areas that have low confidence due to gaps; and
2. to calibrate the metrics and analytical steps underpinning BH3, and in particular the pressure/impacts matrices being used within the models.

In addition, for all EU Member States regional coherency and coordination when measuring the state of the marine environment is obligatory to achieve under Article 12 MSFD. Therefore, the RSCs responsible for the protection of the NE-Atlantic and the Baltic Sea intend to develop these indicators as similarly as possible. Thus, in parallel to the process detailed above for developing this biodiversity indicator within the OSPAR framework, a very similar indicator has been developed under the HELCOM CORESET II project, the so called the "Cumulative Impact" Indicator (CumI). The ambition of Germany and the UK is to utilise the same or very similar indicators for both RSCs and therefore meet requirements for regional coordination under the MSFD. The overall aspirations of the OSPAR and HELCOM benthic expert groups are to develop complementary benthic indicators which can be integrated to obtain a holistic assessment of seabed habitats, if scientifically sound.

4. Conclusion

The OSPAR Indicator to assess the extent of physical damage to seafloor habitats (BH 3) detailed in this article show the state of development of a modelled assessment of the pressures exerted by bottom fishing gears on seabed habitats in parts of the OSPAR area. Preliminary results show evidence on the distribution and extent of habitat sensitivity, the overlapping fishing pressures and the resulting disturbance, and it allows the identification of habitats or geographical areas which are, according to its specific sensitivity, under pressure from fishing activities and therefore showing high levels of disturbance.

An important limitation of the indicator seems to be that due historical and/or chronical anthropogenic impacts some areas have already lost sensitive species/biotopes to an unknown extend. As historic data of benthic communities are often missing this indicator may result in disturbance scores significantly lower, than analyses capable to reflect deterioration of the original habitat thoroughly would suggest and therefore might underestimate existing damage. Additionally, this indicator is only showing part of the picture in terms of benthic habitat deterioration at regional scales, due to gaps in data and knowledge on habitat and pressure distribution which affect outcomes. The current indicator outputs reflect current knowledge, and confidence maps will be provided in August 2016 to show areas where these gaps exist and further investigations are needed.

It is thus expected that during the next MSFD implementation cycle disturbance matrices and the final algorithm will be modified, calibrated and validated using the outputs from site-scale condition indicators. These adaptations will allow refining the values underpinning the disturbance matrices and the approach used to categorise abrasion fishing pressures.

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Healthy oceans by 2020 in the context of the MSFD – an NGO perspective

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1 Introduction

Healthy oceans are rich and diverse ecosystems with a wide range of connected biological communities. However, human activities have altered this biome considerably for decades e.g. by exploiting marine living and non living resources and discharging large amounts of toxic substances and nutrients into the seas. Some of the main pressures in the European Seas are eutrophication, destruction of habitats, overfishing, contaminants and marine litter. The cumulative effect of all these pressures on marine ecosystems is still largely unknown yet climate change is another threat which has the potential to add negative effects to already stressed marine environments.

With the Marine Strategy Framework Directive (MSFD) the EU has implemented a legally binding framework aiming to protect of the marine environment. The MSFD is the first all-encompassing European legislation specifically aimed at the protection of the marine environment. Its ultimate objective is to achieve a Good Environmental Status (GES) in all European waters by 2020 at the latest.

The Directive foresees the implementation of an ecosystem-based approach to the management of activities having an impact on the marine environment. The key deliverable stemming from the implementation of the Directive is a set of "Marine Strategies" which every EU Member State has to develop in coordination with their neighbouring coastal states in three steps:

- In 2012 (and then every 6 years), the countries had to report on the environmental status of their marine waters, descriptions of what GES means for their marine waters and an associated set of environmental targets and indicators.
- 2014 saw the adoption of national monitoring programmes.
- By the end of 2015 (NB: Germany has handed in its national framework programme of measures in March 2016), the countries had to develop programmes of measures (PoMs) designed to achieve or maintain GES. The PoMs should entry into operation by 2016.

Thus the MSFD has now entered a crucial phase: this year (2015) Member States are developing their programmes of measures (PoMs). Environmental NGOs started at an early phase to develop their own views on essential measures that should be undertaken to obtain GES in our seas and published these as national (www.bund.net/fileadmin/bundnet/pdfs/meere/141010_bund_meeresschutz_schattenliste_umweltverbaende.pdf) and international (www.seas-at-risk.org/images/pdf/archive/2014/NGO_priorities_for_PoM_-__with_additional_chapters_-_FINAL_17_October_2014.pdf) shadow lists.

Unfortunately the EU is still far from enforcing their instruments to reach healthy oceans and seas. In 2014 a report by the EU Commission claimed that "Meeting this objective by 2020, in less than seven years, implies renewed and intensified efforts and rapid and important change in the way Member States, the European Commission, Regional Seas Conventions and other relevant organisations work together" (Article 12 report of the EU Commission, Feb 2014). Based on a joint NGO paper at EU level, German NGOs compiled a document introducing a detailed analysis of the threats to the marine environment and the crucial measures necessary to be implemented without delay.

2 Urgent measures

2.1 Eutrophication

2.1.1 Background

As a long-lasting, widely accepted and scientifically thoroughly analysed problem, eutrophication still affects the majority of European water bodies. In the marine environment levels of nutrients are overall still above acceptable limits. The agriculture sector has been identified as currently being the main contributor to nutrient enrichment. Oxygen depletion, as a result of nutrient pollution, is particularly serious in the Baltic and Black seas (see Article 12 report of the EU Commission, Feb 2014), but is also a problem in the Adriatic Sea and the North Sea.

The assessment of the European Commission reveals that despite the imminent threat to our seas, most Member States do not show any ambitions to reach a Good Environmental Status by 2020. For eutrophication most Member States failed to make the (crucial) link between the MSFD work and the work, knowledge and targets set under the Water Framework Directive (WFD) – an omission that shows the lack of ambition and national coherence.

The lack of coherence is also clearly visible at regional and international level. Eutrophication is a threat to our ecosystems that inherently has to be tackled at regional level. Joint indicators and targets must be set up and included in the PoMs, and those that are already used must be streamlined to work jointly towards healthy European seas.

2.1.2 Priority measures (examples of the NGO list)

- Reduce agriculture nutrient run-off by e.g. cutting harmful subsidies of intensive farming and industrial animal farming, ensuring financial support for low nutrient-surplus agriculture and nutrient-balanced fertilization practices, introducing mandatory annual nutrient accounting/bookkeeping at farm level and binding legislation that makes over-fertilization illegal, drastically reducing intensive livestock production.
- Implement the Clean Ship concept by introducing stronger restriction for NOx-emissions in sea areas sensitive for eutrophication and introduce No-Special-Fee systems in ports to support and motivate ships to dispose of waste water, garbage etc. in harbour reception facilities.
- Do not allow open aquaculture systems in or near protected areas or in areas affected by eutrophication.
- Inform consumers about the impact of agriculture on the marine environment.

2.2 Marine Litter

2.2.1 Background

Marine litter is a growing problem worldwide, with millions of tonnes of litter ending up in the marine environment every year. Plastic makes up the major part of marine litter, with items eventually breaking up into ever smaller particles. Large scale, cost effective removal of marine litter is currently not possible, the only way to reduce the problem is the reduction and final stop of flooding our seas with litter.

The MSFD is currently the only piece of EU legislation which addresses the issue, meaning that strong and ambitious measures under this directive are vital. The sources and pathways of marine litter are complex, and touch upon many different areas including waste management on land, fisheries, shipping, sewage treatment and tourism. Therefore efforts to tackle the problem will necessarily stretch beyond the traditional sectors of marine policy. Marine litter is a transboundary problem, so measures will have the greatest success when coordinated at a regional or sub-regional level.

2.2.2 Priority measures (examples of the NGO list)

- Reduce input of marine litter by 50 % by 2020 and to 0 by 2050 by e.g. promoting economic instruments that support the full implementation of the waste hierarchy, such as extended producer responsibility, pay-as-you-throw schemes and the taxation of resources where appropriate.
- End of the use of single-use products, in particular plastic items such as carrier bags, disposable cutlery, coffee-to-go cups and bottles wherever possible.
- Charge higher fines for litter offences on land and at sea.
- Implement compulsory marking for fishing gear to end gear dumping and minimise the presence of ghost nets in European seas.

2.3 Noise

2.3.1 Background

Many marine mammals and fish rely on sound for orientation, navigation and communication, to locate food, find mates and protect themselves. Thus sound is of vital importance for marine biodiversity and increasing noise can be dangerous for many species. A growing body of scientific research shows clear evidence that anthropogenic noise can induce various adverse effects in fish, marine mammals and other marine life (including crustaceans and cephalopods), ranging from disturbance or displacement to body abnormalities, physical injury and death.

Within the MSFD, Member States must ensure that any introduction of underwater noise is at levels that do not adversely affect the marine environment.

Noting the increasing concerns about both short- and long-term negative consequences of underwater noise activities for marine biodiversity, there is an imperative need for Member States to apply the precautionary principle in any case of scientific uncertainty.

2.3.2 Some examples for measures proposed by NGOs

- Develop specific measures to properly address underwater noise already at source. The identified sources to date are shipping, seismic surveys, industrial construction activities (e.g. pile driving) and military activities. Alternative technologies have to be encouraged to develop proper solutions in ongoing planning and licensing procedures.
- Identify and designate exclusion zones where intense sound production is prohibited.

- Implement precautionary and practical targets within the MSFD to reduce underwater noise pollution.

2.4 Fisheries

2.4.1 Background

Existing for centuries overfishing is still a severe threat in all European seas; currently 41 % of the assessed fish stocks in the North East Atlantic are overfished, and 91 % of assessed stocks in the Mediterranean (COM (2014) 388 final). Overfishing not only dramatically reduces fish stocks but many of the fishing gears used also have devastating impacts on seafloor habitats and on non-target species such as whales and turtles; bottom trawling and by-catch are of particular concern.

The recent reform of the Common Fisheries Policy (CFP) resulted in some important changes, which should contribute to achieving good environmental status (GES). As an example Member States are now committed to restore and maintain fish stocks above biomass levels capable of producing maximum sustainable yield (BMSY). In order to reach that they must set fishing limits according to the exploitation rate consistent with this aim (FMSY) by 2015 where possible, and at the latest by 2020 for all stocks. In addition, there is a possibility for Member States to reward operators that fish sustainably and in an environmentally friendly way with extra quota, while keeping the total amount of quota within the limits advised by scientists. The wasteful practice of discarding perfectly edible fish overboard will gradually be banned, with the aim to encourage fishers to fish more selectively and avoid unwanted catches.

Even though industrial fishing has been identified as one of the main impacts on the European marine environment, fishing measures in national PoMs are still scarce and mostly inefficient. As for many other pressures, fishery is a topic where fundamental issues such as the amount of fish consumed need to be tackled not just with the fishing industry but with the consumers. Fish needs to be treated as a delicacy and not an every-day dish.

2.4.2 Priority measures (examples of the NGO list)

- Set fishing limits for all commercially exploited species below FMSY. This should be a limit rather than a target reference point – and in order to ensure that the limit is not exceeded, Member States should aim at a fishing mortality below FMSY.
- Within Marine Protected Areas (MPAs) close at least 50 % of the area fully for fisheries and any other destructive impacts.
- Reduce impacts of fisheries on habitats and fish stocks also outside marine protected areas by temporal area closures and by developing and promoting more selective and environmentally sound fishing gears.
- Ensure sufficient control capacities to enforce binding legislation.
- Inform consumers about the impact of fish consumption on the marine environment.

3 Outlook

The cumulative effect of all to date already existing anthropogenic pressures is largely unknown. Many impacts overlap spatially and/or temporally and cumulative impacts can be greater than the sum of stresses. MSFD should take this effect into account when assessing pressures on the marine environment and developing strategies to reduce these pressures.

A broad range of cross-cutting and sectoral conservation measures already exists and is ready for implementation, e.g. increasing selectivity of fishing gear, closed areas etc., that will need to be implemented to achieve the biodiversity elements of GES. Creation of MPAs is one of the most efficient tools to reach MSFD goals. Member states urgently need to develop an ecologically coherent network of well managed MPAs, which must meet international principles on coherence and protect the full range of species present in the area. The network must be properly managed and protected from all damaging activities to ensure an effective protection of habitats and species.

If implemented as expressed in the ambitious preambles of the directive the MSFD is the opportunity for our oceans that should be seized!

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HELCOM Red List of Species and Habitats

Dieter Boedeker[1] & Ulla Li Zweifel[2]

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1 HELCOM Red Lists

In 2007 the Contracting Parties to the Helsinki Convention agreed through the HELCOM Baltic Sea Action Plan (BSAP) on the updating of the HELCOM Red list of Baltic marine habitats/ biotopes and biotope complexes, and on the elaboration of a comprehensive HELCOM Red list of Baltic Sea species by 2013.

In order to carry out this task, HELCOM established a comprehensive Red List Project that started in 2008 and that was based on specialist teams for fish, birds, mammals, benthic invertebrate species and macrophytes, respectively as well as for biotopes. Altogether more than 100 experts participated in the work that was supervised by a steering group.

Two lists were prepared, the 'Red List of Baltic Sea species in danger of becoming extinct' and the 'Red List of Baltic Sea underwater biotopes, habitats and biotope complexes'. Both were published in 2013 (HELCOM 2013 a, b).

The Red Lists are an important support to HELCOM's efforts to protect the Baltic Sea environment and biodiversity as they can serve as indicators in the assessment of progress towards reaching the goals of the Baltic Sea Action Plan.

1.1 Red List of Baltic Sea Species

The HELCOM Red List of Baltic Sea Species is the first regional threat assessment for the Baltic Sea that classifies macroscopic species according to different threat categories. This assessment was carried out using internationally agreed and globally applied criteria of the International Union for Conservation of Nature (IUCN Standards and Petitions Subcommittee 2014).

In the Red List assessment of species almost 2,800 species were considered and about 1,750 were evaluated according to the IUCN Red List criteria. Figure 1 shows the frequency of evaluated species of different taxonomic groups compared to those which could not be evaluated or were not applicable, respectively.

In the preparatory work of the Red list, check-lists of all macro-species in the Baltic Sea were prepared (HELCOM 2012). The check-lists indicated a total of about 2,000 benthic invertebrate species, about 500 macrophytes, a little above 200 fish and lamprey species, in total 100 wintering and breeding birds, and 6 mammal species.

In general 60 % or more of these species were assessed (Figure 1). The exception is fish where many species on the check-list were categorized as introduced or vagrants and therefore not included in the assessment. Not to evaluate a species was mainly decided when species or groups had high taxonomical uncertainties.

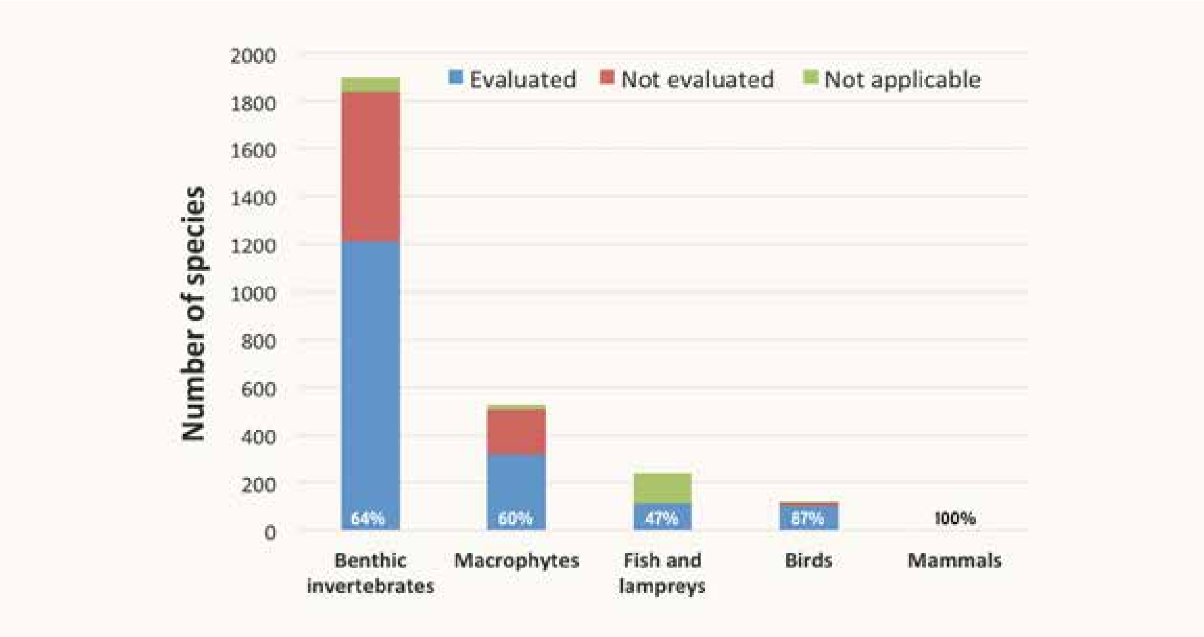

Figure 1: Frequency of evaluated species

The figure 2 illustrates the IUCN category system applied by HELCOM for the red listing of Baltic Sea species.

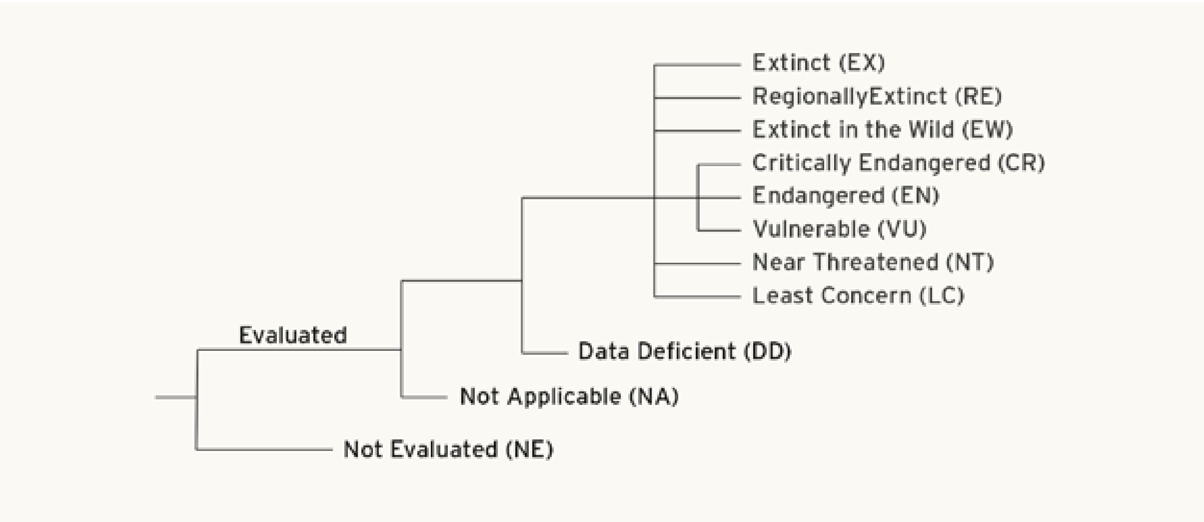

Figure 2: Structure of the IUCN Red List categories at the regional level (HELCOM 2013 a)

Five criteria are used in the assessment resulting in the threat categorization as depicted in figure 2:

- Criterion A: Reduction in population size
- Criterion B: 1. Extent of occurrence, 2. Area of occupancy
- Criterion C: Small and continuously declining population
- Criterion D: Very small and restricted population
- Criterion E: Probability of extinction on the basis of quantitative analysis.

All criteria supported by sufficient data were applied. In the HELCOM assessment of species, typically only one or two criteria have been used. Criterion A that is related to decline in population size was used mainly for fish, birds, mammals and some benthic invertebrate species, while criterion B related to extent and area was mainly used for macrophytes and also for some benthic invertebrates. Criterion E that is based on modelling, was not used at all. For the final assessment it is the criteria that gives the highest risk of extinction that determines the threat category. The categories critically endangered (CR), endangered (EN), and vulnerable (VU) are jointly labelled as representing species threatened by extinction.

The figures 3 to 6 show the threatened species broken down into different taxonomic groups.

Benthic invertebrates

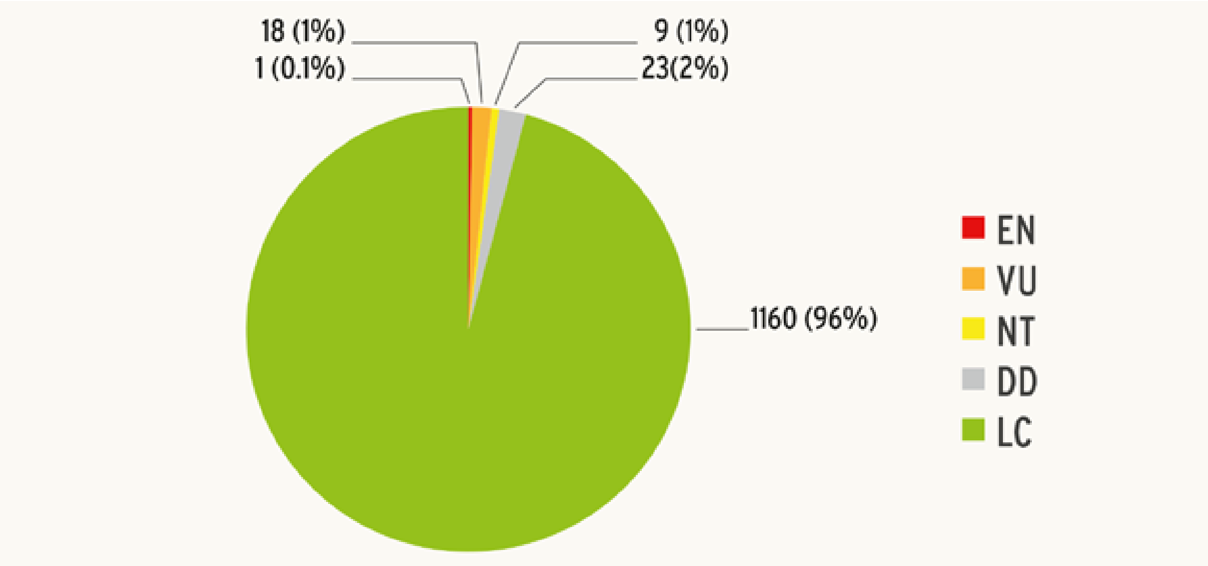

Figure 3: Threatened benthic invertebrates: 19 (1.1%) of evaluated species

Nineteen benthic invertebrate species or about 1 % of those assessed were categorized as threatened (EN, VU) while a majority of species assessed were considered of least concern (LC). This category is used for widespread and abundant species where there is no evidence of population decline.

The assessment was mainly driven by data from monitoring or mapping programmes. Long-term data series exist for some benthic invertebrate species in the Baltic Sea, in particular in coastal areas, but there are also many groups not covered by monitoring programmes.

Most of the threatened species are restricted to the western part of the HELCOM area, mainly the Kattegat area, where many species are living on the limit of their distribution area. Those species were only red listed when a combination of continuing decline in the population, range, or quantity and quality of their habitats could be detected for the HELCOM area.

Macrophytes

Seven macrophyte species were considered as threatened (EN, VU). However, it should be noted that this assessment focused on the risk of extinction at the regional level and so locally or nationally there may be additional species that are assessed as threatened.

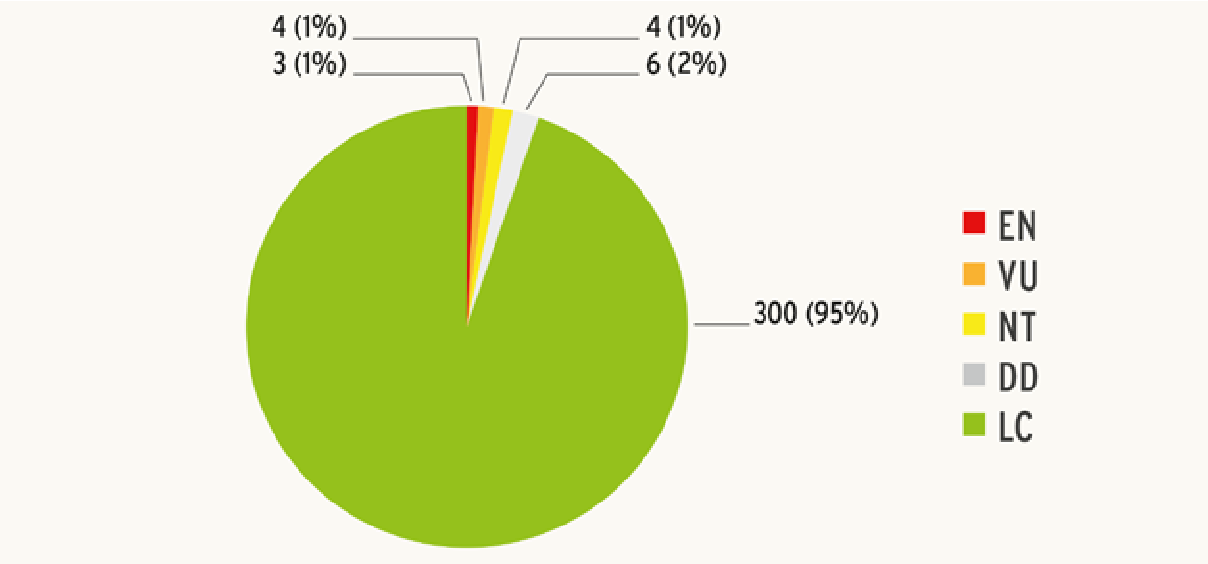

Figure 4: Threatened macrophyres: 7 (2 %) of evaluated species

When it comes to data and information used in the assessment, information on distribution of macrophytes in the Baltic Sea is relatively good, but long-term data on trends is poor.

Fish and lamprey species

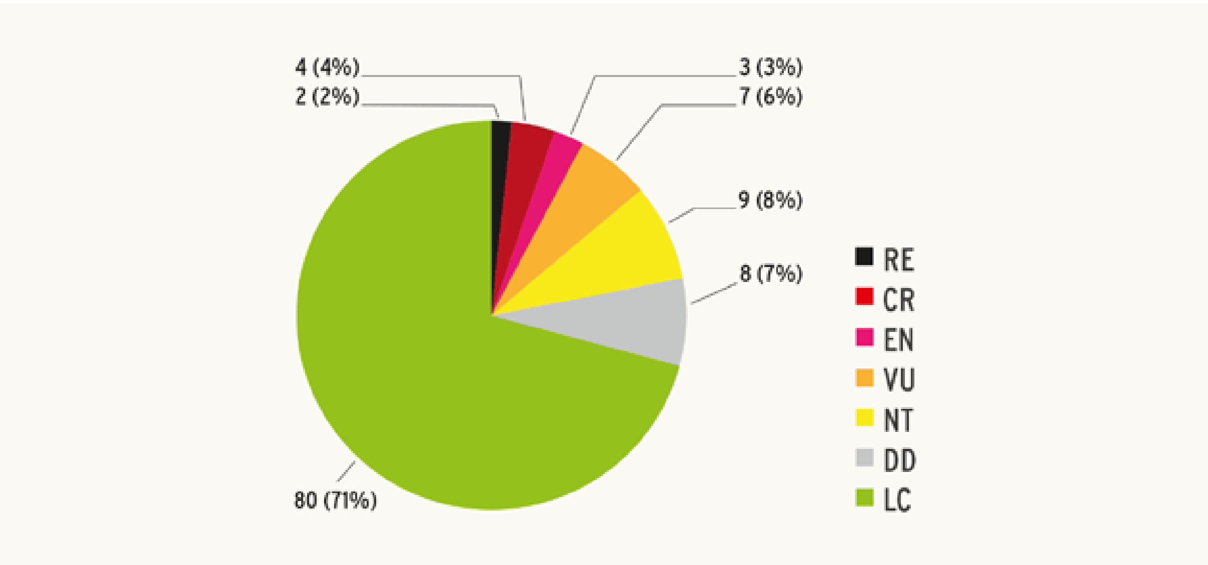

Figure 5: Threatened fish and lamprey species: 14 (13%) of those evaluated

Fourteen fish or lamprey species were categorized as threatened (CR, EN, VU) and nine as near threatened (NT).

Data availability is generally good since many species in this group are commercially exploited and therefore monitored as part of mandatory surveys. HELCOM also has a programme for monitoring of coastal fish.

Two species are already considered as Regionally Extinct (RE) in the HELCOM area; the American Atlantic sturgeon *(Acipenser oxyrinchus)* and the common skate *(Dipturus batis)*. European eel is one of the species assessed as critically endangered.

Wintering Birds and Breeding Birds

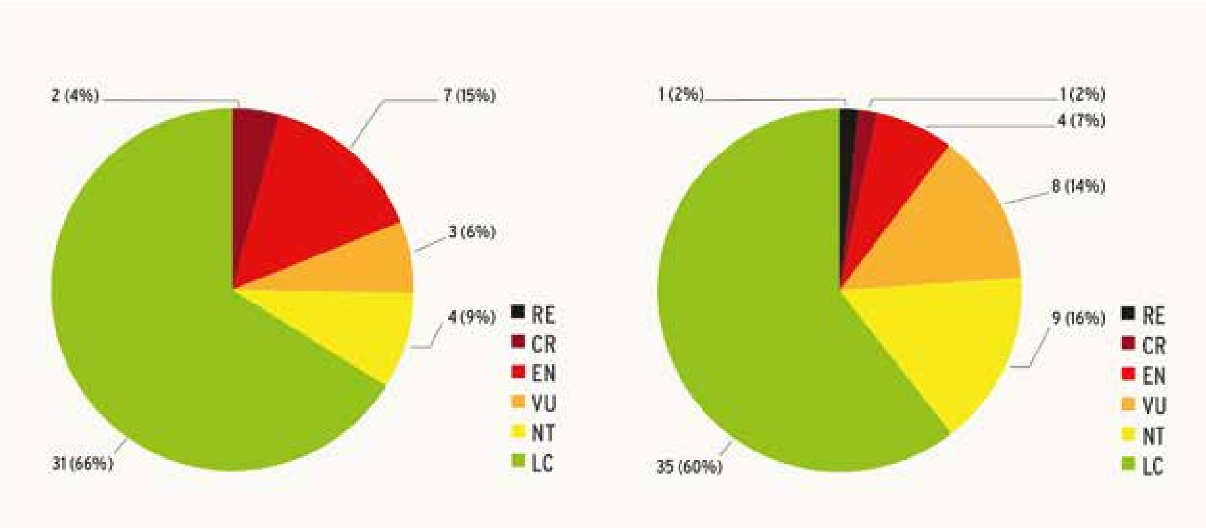

Figure 6: Threatened wintering birds (left): 12 (25%) of evaluated species; threatened breeding birds (right): 13 (23%) of evaluated species

Both for breeding and wintering birds, about 25 % of the assessed species were assessed as threatened (CR, EN, VU). The Gull-billed tern *(Gelochelidon nilotica)* is regarded regionally extinct (RE) in the Baltic Sea area. Data availability is relatively good when it comes to coastal areas, but there is limited offshore monitoring of birds in the Baltic Sea.

Mammals

Table 1: Threatened mammals: 4 of the 6 evaluated species

Species and taxonomic group		**Red List category**
Cetartiodactyla		
Porpoises (Phocoenidae)		
Harbour Porpoise Western Baltic subpopulation	*Phocoena phocoena*	**VU**
Harbour Porpoise Baltic Sea subpopulation	*Phocoena phocoena*	**CR**
Carnivora		
True seals (Phocidae)		
Harbour seal Kalmarsund population	*Phoca vitulina*	**VU**
Baltic Ringed seal	*Phoca hispida botnica*	**VU**
Grey seal	*Halichoerus grypus*	**LC**
Mustelidae		
Eurasian Otter	*Lutra lutra*	**NT**

Six mammals were included in the assessment and four of those considered as being threatened (CR, VU):

- The two Harbour porpoise populations with the Baltic sea population considered as critically endangered
- ringed seal that dependent on ice for breeding
- and the harbor seal Kalmarsund population which is a genetically distinct sub-population on the Swedish east-coast.

The grey seal population in the Baltic Sea has recovered from previously low abundance and was considered of Least Concern (LC) while the Otter was assessed as near threatened (NT).

For seals, data is good in the Baltic Sea and the HELCOM Seal expert group regularly follows up the status of the seal populations and the HELCOM recommendation on seals.

<u>Results assessment of species</u>

Overall the assessment resulted in 4 % (69) of assessed species being categorized as threatened and 2 % (36) of assessed species being categorized as near threatened. The low proportion of threatened species has most likely two major reasons:
1. the IUCN Red List criteria were especially designed to find species with a high risk of (regional) extinction
2. due to the lack of data it was impossible to estimate how many threatened species have been left unevaluated. Some 800 (of 2,730) species that were included in the Baltic Sea checklist (HELCOM 2012) could not be evaluated (HELCOM 2013 a).

However, those species which were regarded as threatened (Critically Endangered (CR), Endangered (EN) or Vulnerable (VU)) are in danger of becoming extinct in the Baltic Sea area.

The assessment results also indicated that all the threatened species are under pressure from human activities and that none of them seem to be under pressure from a single specific human activity; each species rather faces a multitude of pressures. Most often stated pressures were:
- Eutrophication (macrophytes, benthic invertebrates)
- fishing and fisheries (benthic invertebrates, birds)
- construction activities.

1.2 Red List of Baltic Sea underwater biotopes, habitats and biotope complexes

HELCOM (2013 c) developed a comprehensive hierarchical classification system for underwater habitats and biotopes in the Baltic Sea area (HELCOM HUB) which includes six levels. The term *habitat* defines the abiotic environment (levels 1-3 in HUB), whereas the term *biotope* defines the environment together with the associated biotic community (levels 4-6). This new classification which is compatible to the EUNIS[1] classification served as scientific basis for the threat assessment of biotopes. HELCOM HUB further lists 10 biotope complexes in the Baltic Sea area, which comply with marine NATURA2000 natural habitats as in Annex I of the Habitats Directive. They were assessed as such, but were excluded from the biotope classification (HUB), because they don't fit into a classification, they rather form a complex of different biotopes.

1 European nature information system (http://eunis.eea.europa.eu/habitats.jsp)

HELCOM used the following criteria for its assessment:

- Declining distribution (Criterion A)
- Restricted distribution (Criterion B)
- Qualitative degradation (Criterion C).

All of these three criteria had been applied, when they were supported by sufficient data. The criteria that gave the highest risk of extinction determined the threat category

The Red List assessment criteria and threat categories applied in the HELCOM Red List and shown in figure 7 based on the methodology used in an earlier HELCOM Red List (HELCOM 1998) and on risk assessment criteria which were developed by IUCN (Rodríguez et al. 2011, Keith et al. 2013).

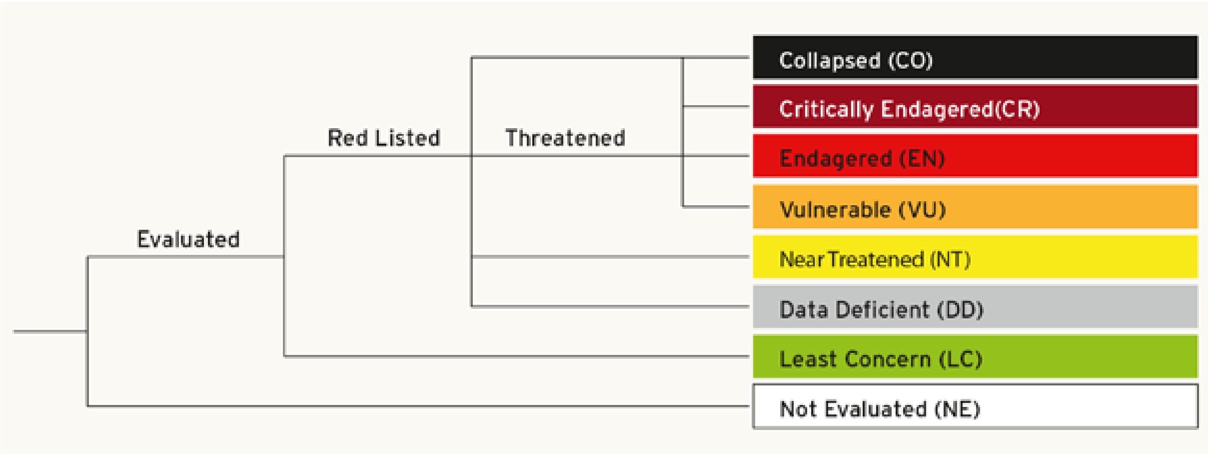

Figure 7: Red List assessment criteria and threat categories

The HELCOM Red List includes only assessments for biotopes (mostly on level 6) and biotope complexes.

Biotopes

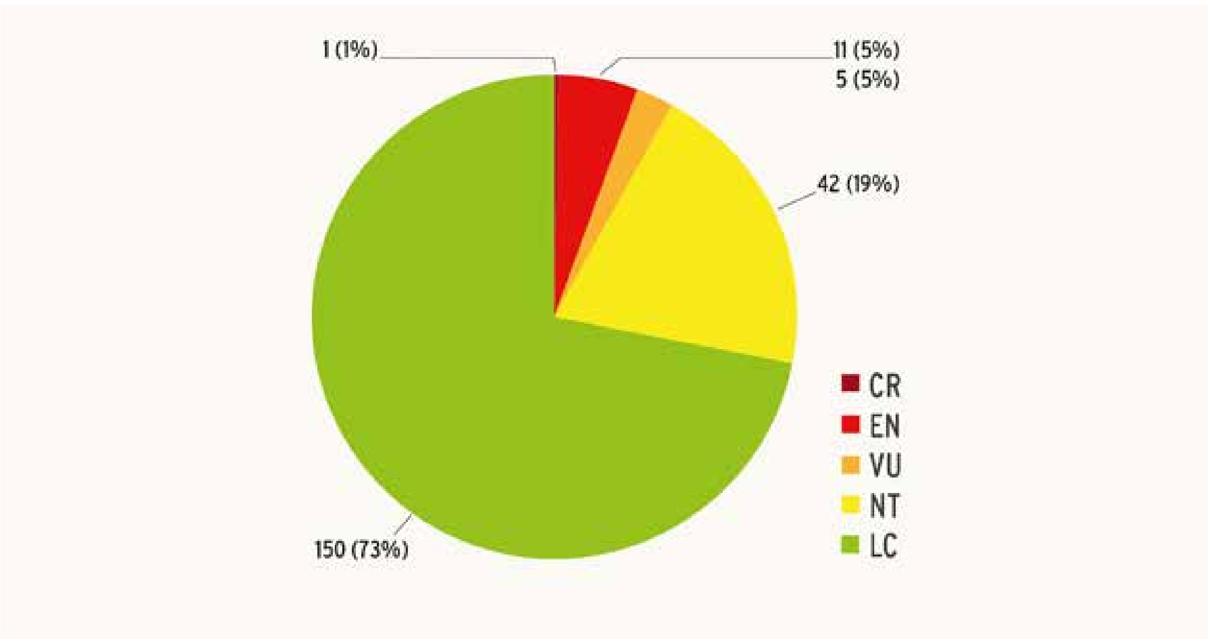

Figure 8: Threatened biotopes and habitats: 17 (8%) of evaluated are threatened

Out of 209 biotopes are 59 (27 %) red-listed (CR, EN, VU, NT) and 17 (8 %) are regarded as threatened (CR, EN, VU), while 150 (73 %) are classified as Least Concern (LC) and were not seen to be at actual risk of collapse (Figure 8).

Biotope complexes

Table 2: Threatened: 8 of the 10 evaluated biotope complexes

Code	Biotope complex (HD Annex 1 description, EUR 27)	Threat category
1130	Estuaries	CR
1180	Submarine structures made by leaking gases	EN
1150	Coastel lagoons	EN
1110	Sandbanks which are slightly covered by sea water all the time	VU
1140	Mudflats ansd sandflats not covered by seawater at low tide	VU
1160	Large shallow inlets and bays	VU
1170	Reefs	VU
1650	Boreal baltic narrow inlets	VU
1610	Baltic esker islands with sandy, rocky and shingle beach vegetation and sublittoral vegetation	NT
1620	Boreal baltic islets and small islands	NT

All the 10 biotope complexes in the Baltic Sea area were assessed and eight of them are according to different threat classes in danger of collapsing (Table 2).

Data availability was relatively poor for many biotopes, and long time series were generally not available. Therefore the threat assessment was largely based on expert judgement. However, the results of the Red List assessment for underwater biotopes indicate that many of the threatened biotopes occur in the deep areas of the Baltic Sea. The most important pressure is eutrophication, indirectly causing oxygen depletion in the deeper areas. Many of the deep biotopes occurring on soft sediments had also declined due to destructive fishing methods such as bottom trawling. Furthermore, many of the red-listed biotopes occur in the southwestern Baltic Sea due to the salinity restricted distribution of the species that are characteristic of the biotope.

2 Implications of the Red Lists

The results of the Red List assessments naturally give cause for major concern among HELCOM Contracting Parties.

In fact, the goal of the Baltic Sea Action Plan to “achieve a favourable conservation status of all species by 2021” cannot be achieved with species being red listed and threatened. The same is due for biotopes and biotope complexes. As a consequence, the 2013 HELCOM Copenhagen Ministerial Declaration stated that conservation plans for species at risk of extinction should be established. Therefore HELCOM is currently developing a HELCOM Recommendation for the conservation of such species as a response of the Contracting Parties. This recommendation will include specific protection and conservation advises such as:

- actions needed to mitigate identified threats (pressures and/or impacts) as specified in the red list
- consideration whether any sites justify selection as new or expanded MPAs
- regular reviews of the progress the conservation plan.

A complementary HELCOM Recommendation on biotopes, habitats and biotope complexes is also planned.

HELCOM has agreed to make the Red List assessments of Baltic Sea species, habitats and biotopes a regular activity with the next planned assessment in 2019 which will enable the tracking of long-term trends and the effectiveness of the implementation of recommendations to protect and conserve Baltic Sea biodiversity.

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What do population trends of seabirds tell us about the ecological conditions in the North Sea?

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Abstract

Among marine organisms seabirds are comparatively easy to census both on land and at sea. While counts in breeding colonies often go back in time to the early 20th century, systematic counts of birds at sea commenced many decades later. In the North Sea, ship-based census data from monitoring and research programmes are stored in the European Seabirds at Sea (ESAS) Database, managed by the Joint Nature Conservation Committee (JNCC).

For this talk, data from the ESAS Database, covering the period 1980 to 2010, were analysed. The focus was particularly on the common pelagic (offshore) species. Because survey effort was not homogeneous over space and time, analyses are based on seabird abundances in ten discrete spatial units, covering major parts of the North Sea. Data were aggregated over 3-year-periods and analysed with the widely used software TRIM (Pannekoek & van Strien 2005).

Significant increases of numbers at sea during the 30-year-period were found for Northern Gannet (both during the breeding and non-breeding seasons), Great Skua (breeding season), Lesser Black-backed Gull (breeding season), Common Guillemot (breeding season) and Atlantic Puffin (breeding season), significant decreases for Northern Fulmar (breeding season), Herring Gull (season non-breeding) and Great Black-backed Gull (both during the breeding and non-breeding seasons).

The observed trends are striking. Both direct and indirect effects of fisheries appear to have the strongest effects on the trends of the common offshore seabird species. On one side, the availability of discards and offal from fishing vessels has recently decreased, especially in winter and in the central North Sea. On the other hand, overfishing of large predatory fish has led to increases in small pelagic fish that are the preferred prey of various seabird species. Recent increases in water temperature due to climate changes and alterations in the food web do not seem to have negatively affected the investigated species at the temporal scale of this study but may be a strong (negative) force in the future.

Generally, changes in seabird numbers and biology are suitable indicators of changes in the marine environment. Trend analyses are relatively simple but important tools highlighting possible changes at an early stage; they should be established in international conservation targets such as the European Union Marine Strategy Framework Directive (MSFD).

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Population trends and threats from ship traffic to long-tailed ducks in the Baltic Sea

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1. Introduction

The long-tailed duck *Clangula hyemalis* is a small sea duck that breeds in Arctic tundra regions and winter in marine and brackish waters. Surveys indicate substantial declines in numbers in recent decades and the species is now classified by IUCN as globally threatened in the category "vulnerable". The largest of the four recognized long-tailed duck populations is the West Siberian / North European population. Birds belonging to the WS/NE population breed in northern Russia and northern Scandinavia and overwinter mainly in the Baltic Sea. An International Single Species Action Plan for the long-tailed duck has also recently been developed by specialists under the auspices of AEWA (Agreement on the Conservation of African-Eurasian Migratory Waterbirds) (Hearn et al. 2015)

Two Baltic wide surveys have shown that the WS/NE population has decreased very rapidly from approx. 4.3 million birds in 1992-93 to approx. 1.5 million birds in 2007-2009 (Durinck et al. 1994; Skov et al. 2011). Although there is some uncertainty regarding the overall level of the population size estimates it is believed that the difference between the estimates accurately reflects the trend between the mid 1990s and late 2000s. A further decline also after 2009 can be assumed as the mean proportion of juveniles in the wintering population has been low since 2009. The recent decline of the WS/NE population can most likely be explained by a combination of factors affecting both the productivity at the Arctic breeding grounds and the adult mortality in the wintering areas in the Baltic Sea.

Four important anthropogenic threats affecting the wintering birds have been recognised, namely,

1. operational oil spills from ships at core wintering sites,
2. by-catches in fishery,
3. hunting and
4. disturbance at and exploitation of offshore mussel banks.

Mortality due to by-catches has decreased but is still high (Bellebaum et al. 2013). Hunting mortality is fairly well known and can be regulated if agreements are reached. Displacement of wintering long-tailed ducks from good feeding areas might be more important in future if planned large scale wind farms will be established at core wintering sites, i.e. at offshore banks.

In this note one of the four recognised anthropogenic threats, i.e. the threat from intensive shipping activities is elucidated. More specifically, an analysis of ship traffic within and close to two marine Natura 2000 sites is presented. The analysed sites, the Hoburgs bank and the Northern Midsjö bank, are two of the most important wintering sites for long-tailed ducks in the Baltic Sea. Several hundred thousand long-tailed ducks, which is a significant part of the global population, have been observed wintering within these areas in recent years (Skov et al. 2011, Nilsson 2012). Possible methods to reduce the threat from ship traffic are also discussed.

2. Shipping within or close to protected wintering sites

2.1. Effects of intense ship traffic

Shipping is a very important mode of transport in the Baltic Sea region. Approximately 10,000 unique vessels registered in more than 100 countries are visiting the Baltic Sea each year (Grimvall & Larsson 2014). More than 2,000 ships are estimated in transit on the Baltic Sea at any given time. Shipping in the Baltic Sea is also expected to increase in the years to come. Today a large proportion of the ships in the Baltic Sea follow static routes recommended by traffic separation schemes.

Intensive shipping gives rise to negative environmental impacts in the form of emissions to air and water. Sometimes also a disturbance effect of the ships themselves (Schwemmer et al. 2011) or by the underwater noise they produce is detected. The various impacts of shipping can be measured on different spatial and temporal scales. The emissions to air usually have regional or global effects, while other types of emissions and discharges to water, for example operational oil spills, may have more well-defined local effects. Although discharges of oil from cargo or machinery spaces at concentrations above 15 ppm are prohibited in the Baltic Sea, visible oil slicks along the main shipping routes are regularly detected by surveillance flights (HELCOM 2015; Swedish Coast Guard 2015). Studies in different parts of the world have shown that the effect of a given discharge or emission on the marine environment is not only dependent on the size of the discharge or emission, but also to a very great extent on where and when they take place (Camphuysen et al. 2005).

2.2. AIS-data can be used to examine traffic intensity and conflict areas

Automatic Identification System (AIS) is a maritime tracking system intended primarily to increase maritime safety and make it easier for authorities to monitor and manage sea traffic. AIS data on a vessel's identity, position, course and speed are available in real time both to other vessels and to those onshore. The system is based on communication between transponders installed on board ships, onshore base stations and a growing number of satellites. The use of AIS transponders is governed by the SOLAS convention. Under the convention, all vessels in international traffic with a gross tonnage of 300 or more have had to be equipped with AIS since 2005. Vessels not in international traffic must also be fitted with AIS equipment if they have a gross tonnage of 500 or more or if they carry passengers. Shipping in the Baltic Sea is continuously monitored and historical AIS data from base stations in the countries around the Baltic Sea have been stored since 2006. Under an agreement reached through HELCOM, these data are available for environmental research. By analysing historical AIS-data ship traffic intensity can be mapped in detail and provide important input to marine conservation and marine spatial planning.

2.3. Ship traffic intensity at the Natura 2000 sites Hoburgs bank and Northern Midsjö bank

The ship traffic intensity in year 2014 close to or within the Natura 2000 sites Hoburgs bank and Northern Midsjö bank is visualised in Figures 1 and 2. More than 20,000 ship passages were recorded within the Natura 2000 site Hoburgs bank and more than 10,000 ship passages were recorded within the Natura 2000 site Northern Midsjö bank. In connection to the decision by the International Maritime Organization (IMO) in 2005 to classify the Baltic Sea as a Particularly

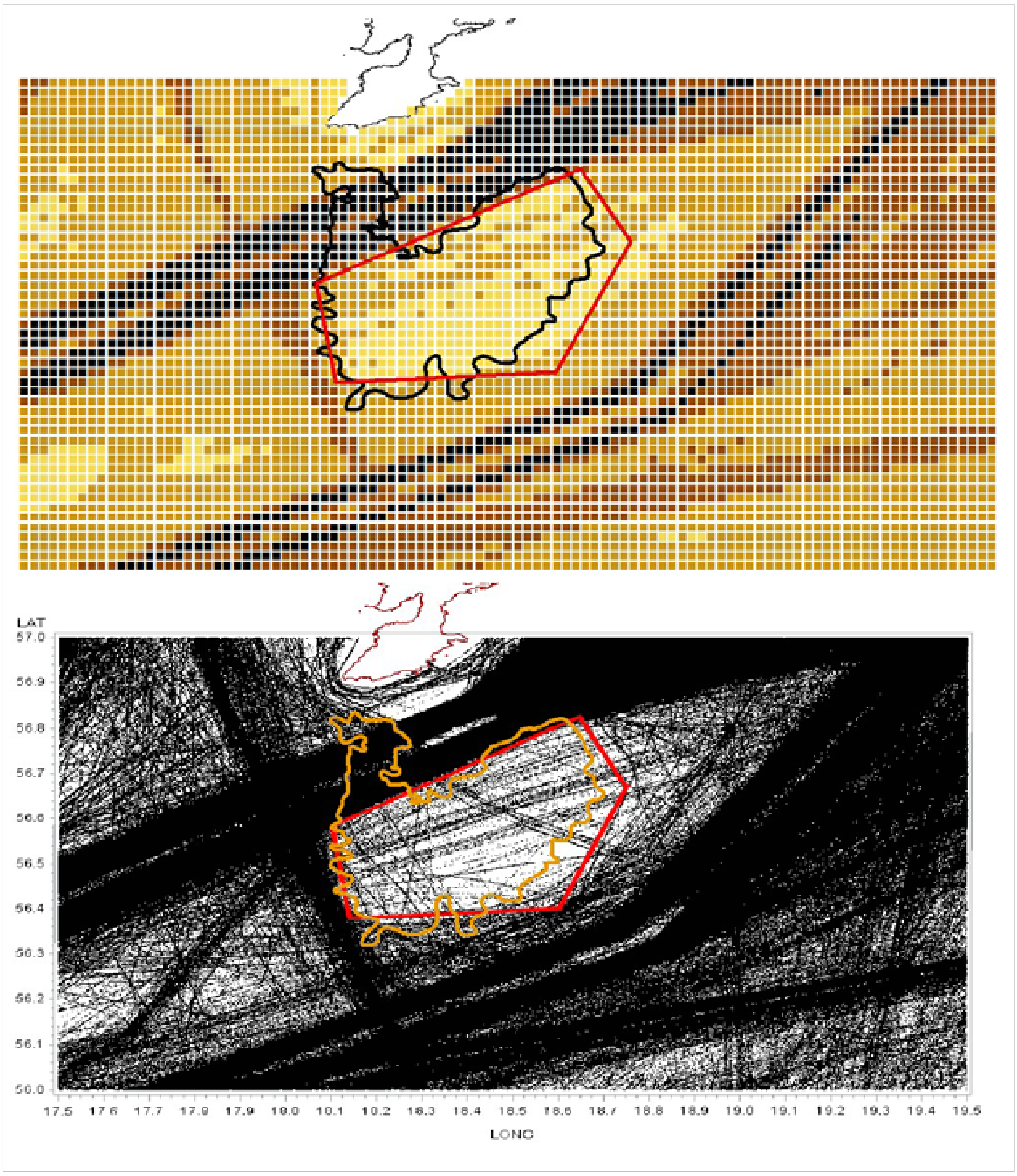

Figure 1: Ship traffic intensity at the marine Natura 2000 site Hoburgs bank south of the island of Gotland in the central Baltic Sea in 2014. The curved line (black in A and orange in B) shows the border of the Natura 2000 site. The red polygon shows the border of the area which ships are recommended to avoid, i.e. an area that the International Maritime Organization, IMO, has classified as an Area to be Avoided (AtbA).

More than 20,000 ship passages were recorded within the northwestern part of the Natura 2000 site between the southern tip of Gotland and the northern border of the AtbA in 2014. More than 100 ship passages were recorded within the AtbA.

In (A), each small square has a height and width of 0.02 degrees.

The colour coding shows the number of vessels that visited each square in 2014: yellow = 1-10 vessels, light brown = 11-100 vessels, dark brown = 100-1,000 vessels and black = 1,000 or more vessels.

In (B) the positions of the AIS signals are plotted as small dots. The route of a single ship may be seen as a very thin line.

Sensitive Sea Area (PSSA) two Associated Protective Measures (APMs), concerning two recommended Areas to be Avoided (AtbA) at Hoburgs bank and Northern Midsjö bank, were also decided. However, the decided borders of the AtbA Hoburgs bank did not follow the border of the Natura 2000 site Hoburgs bank that was established earlier. Likewise, the Natura 2000 site Northern Midsjö bank is larger than the AtbA Northern Midsjö bank.

3. Adjusting shipping routes

Standardised weekly winter surveys of oiled long-tailed ducks at the southern tip of the island of Gotland in the central Baltic Sea have shown that the recurrent operational oil spills from ships at routes within or close to the Natura 2000 site Hoburgs bank have killed tens of thousands of long-tailed ducks each year during the past 20 years (Larsson & Tydén 2005; Larsson unpubl). From 2008, the number of observed oiled long-tailed ducks during the standardized surveys has decreased but the numbers are still significant (Larsson unpubl). Oiled long-tailed ducks have also been regularly observed in recent years along the east coast of the island of Öland. This indicates that long-tailed ducks wintering at the Northern Midsjö banks also are regularly and significantly affected by operational oil spills from ships.

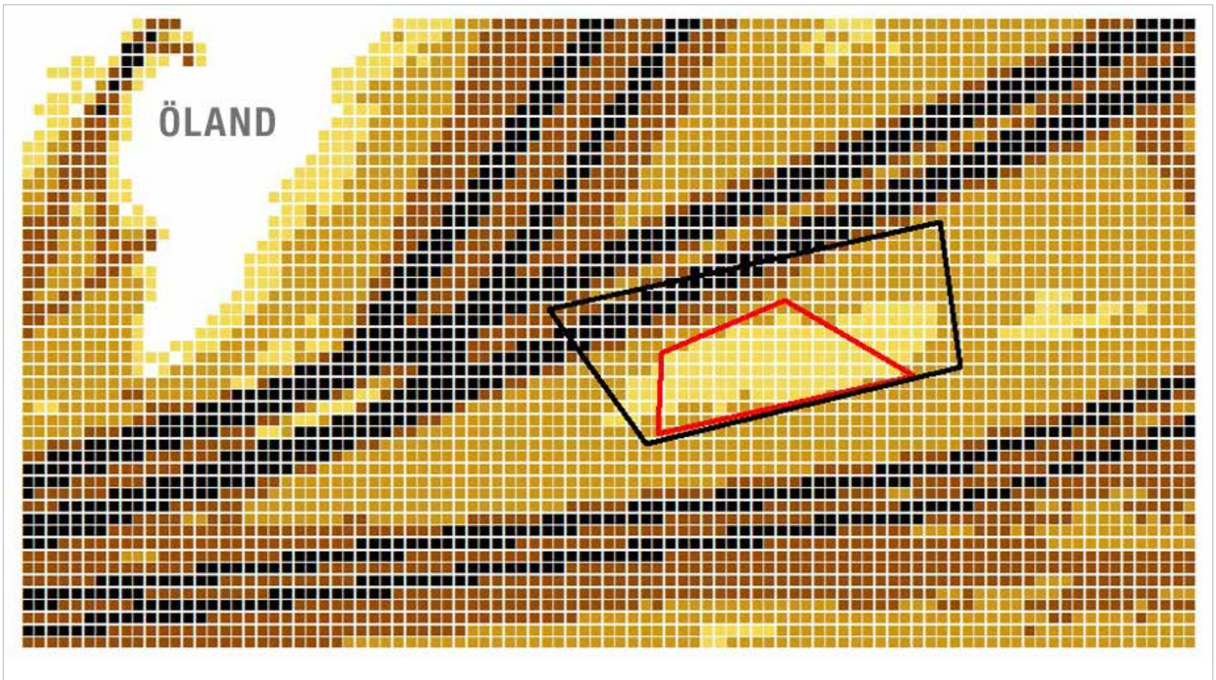

Figure 2: Ship traffic intensity at the marine Natura 2000 site Northern Midsjö bank east of the island of Öland in the central Baltic Sea. The black polygon shows the border of the Natura 2000 site and the red polygon shows the border of the AtbA. More than 10,000 ship passages were recorded within the northwestern part of the Natura 2000 site. More than 100 ship passages were also recorded within the considerably smaller AtbA. For colour coding of squares see Figure 1.

Discharges of oil and oily water from ships are prohibited. However, given the very large number of ships, i.e. tens of thousands ship passages per year, it will in practice not be possible by legal means only to eliminate all accidental and intentional operational oil spills within or close to the protected Natura 2000 sites. Modifications of the present ship routes are therefore necessary if the conservation values within the Natura 2000 sites should be preserved. Modifications of ships routes can be performed in several ways, for example by dynamic route planning where ships to a greater extent than today are assigned individual routes based on the traffic situation, season of the year, and sensitive marine areas. Future modifications of ship routes should also consider the so called squat effects, i.e. meaning that large ships, due to a hydrodynamic phenomenon, consume more fuel and produce more emissions to air when passing over shallow areas, for example over offshore banks.

A marine spatial planning process is urgently needed to resolve conflicts between shipping and the protection of sensitive habitat and threatened species. The shipping industry and the maritime administrations need to be more involved in the marine spatial planning process in the Baltic Sea.

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Feasibility of the restoration of the European flat oyster in the German Bight – opportunities and perspectives

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Abstract

Up to the second half of the 19th century the European flat oyster (*Ostrea edulis*) was once widely distributed in the Wadden Sea and in deeper areas of the German Bight. During long periods of time, oyster beds had developed mainly on sandy sediments. As a result of in particular improved fishing methods and lack of resource saving management, stocks declined dramatically and were practically extinct in the German North Sea in the early 20th century.

The biogenic oyster reefs are habitats with a high biological diversity and play an important role as biological hot spot in marine communities. Because of the important role of *Ostrea edulis* beds in marine ecology, they are included in the OSPAR list of threatened and/or declining species and are in the focus of the Federal Agency for Nature Conservation (BfN).

In the light of this, a study was funded by BfN in order to assess whether a reintroduction of the native oyster in the German North might be feasible. At first the historical distribution of the European flat oyster in the German Bight and the factors that led to the extinction of oyster reefs were investigated. In addition abiotic factors like temperature and substrate, biotic factors like disease and pests as well as genetic aspects were highlighted. Furthermore the condition of present populations of *Ostrea edulis* and efforts for the restoration of stocks were considered.

As a result of the study, it was concluded that a reintroduction of the native oyster in the German Bight might be feasible. The main findings that support this conclusion are the genetic similarity of the European populations of *Ostrea edulis*, the availability of disease free oysters from a Danish and a Swedish hatchery together with oysters from a natural population in the Danish Limfjord. To have a reasonable chance of success, it is crucial to offer suitable substrate (cultch) and to fully protect the restoration site from fishing activity just to name only two preconditions. Before starting a large-scale reintroduction project, it is recommended to perform a pilot-scale transfer of oysters at selected sites in order to examine their performance with respect to growth, reproduction and diseases.

A long-running monitoring will be necessary once a large-scale oyster transplantation would be realized. A reintroduction of *Ostrea edulis* and the restoration of reefs definitely is a long-term commitment.

Download of the feasibility study at: http://www.bfn.de/0314_meeresnaturschutz-berichte.html

Identification of high risk areas for porpoise bycatch by use of data from remote electronic monitoring and satellite telemetry

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Abstract

Incidental catch of harbour porpoises *(Phocoena phocoena)* is an issue of major concern for fisheries management and harbour porpoise conservation. With the aim of identifying areas of potential high risk for porpoise bycatch, we analyzed high resolution spatial and temporal data on porpoise density and fishing effort data from the Danish Skagerrak Sea, including areas designated under the EC Habitats Directive (Natura 2000) for harbour porpoise protection. From May 2010 to April 2011 four commercial gillnet vessels were equipped with Remote Electronic Monitoring (REM). The REM system recorded time, position and CCTV (Closed-circuit television) footage of all net hauls. The REM data were used to identify fishing grounds, quantify fishing effort and document bycatches of harbour porpoises. Movement data from 53 harbour porpoises equipped with satellite transmitters from 1997 - 2012 were used to model porpoise density. A simple model was set up for investigating the relationship between the response (number of porpoises caught) and porpoise density and fishing effort described by net soak time, net length and target species. The results showed that a model including both porpoise density and effort data predicts bycatch better compared to models including only one factor. We therefore conclude that the inclusion of porpoise telemetry data allows for better prediction of areas of high porpoise bycatch than when using the fishing effort data alone. The final model can thus be used as a tool to identity areas of porpoise bycatch risk and hereby support the management of both fisheries and porpoises in accordance with the Habitats Directive.

A paper on this topic has already been published at Inter-Research.

See: http://www.int-res.com/articles/esr_oa/n019p075.pdf

Effects of vessel noise on harbour porpoise *(Phocoena phocoena)* foraging activity

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Abstract

While cetacean auditory systems have evolved to cope with underwater noise from natural sources, there is a growing concern that anthropogenic noise may disrupt the behaviour, impair the hearing or compromise the general health of cetaceans. Little is known about the noise free-ranging animals are exposed to and how individuals react to specific noise sources.

We deployed archival multi-sensor DTAG3 tags on ten wild harbour porpoises to study noise exposure and behaviour in the highly trafficked Danish Straits. The suction-cup attached tags provided continuous recordings for up to 24 hours, while logging stereo sound (500 kHz), triaxial magnetometry, acceleration and depth (250 - 625 Hz).

The movement and noise exposure of the animals in relation to ships were estimated using sensors on the tag and attaepts have been made to relate the noise exposure to the AIS positioning system carried by larger vessels. The porpoises were exposed to low-to-moderate vessel noise for up to 16 - 73 % of the recordings from different animals, with occasional high levels extending for > 1 hour.

Received noise levels were analysed in 1-min segments in the 16 and 50 kHz third-octave-bands and correlated with the occurrence of buzzes indicative of foraging. The animals foraging activity constitute more than 50 % of the dive time for most animals and context-dependent reactions to noise including cessation of foraging and echolocation, logging at the surface, or sustained energetic fluking was observed. No clear general difference in noise level was seen between minutes with and without foraging activity.

The effect on foraging activity from ship noise exposure suggests strong implications for foraging efficiency, energy expenditure and stress impacts.

Genome-wide Single Nucleotide Polymorphism (SNP) analysis of harbour porpoises *(Phocoena phocoena)* improves population resolution in North and Baltic Seas

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Abstract

In a pilot study, we investigated the population differentiation of harbour porpoises from the populations in the Baltic Sea and adjacent waters, in comparison to European Atlantic shelf waters (Iceland, Spain) and the Black Sea. We tested a population genomics approach using 1,801 Single Nucleotide Polymorphisms (SNPs) and compared the population resolution to those using more traditional molecular markers (microsatellites, mitochondrial DNA). We observed a distinct separation of the North Sea/Skagerrak population from the other Baltic Sea populations and identified splits between porpoise populations in the southern Kattegat, the Belt Sea, and the inner Baltic Sea. The improved resolution of harbour porpoise population assignments for the Baltic is important for conservation management of this endangered cetacean in threatened habitats, particularly in the Baltic Sea proper. We also show that genome-wide SNPs outperform microsatellite markers both regarding population delimitation and population assignment of single specimens. We demonstrate the utility of the approach on a relatively small sample set, and suggest an upscaled analysis including a more comprehensive sampling from North and Baltic Seas. Such a comprehensive spatially and seasonally explicit study on porpoises of different age and gender has the ability to provide detailed information on the population status and relatedness among individual porpoises and may hence contribute to the identification of reproduction areas, close kin associations, and seasonal migration.

A paper on this topic will soon be published at PloS ONE.

See: Lah, L., Trense, D., Benke, H., Berggren, P., Gunnlaugsson, Þ., Lockyer, C., Öztürk, A., Öztürk, B., Pawliczka, I., Roos, A., Siebert, U., Skóra, K., Víkingsson, G., Tiedemann, R. (2016). Spatially explicit analysis of genome-wide SNPs detects subtle population structure in a mobile marine mammal, the Harbor porpoise. PLoS ONE, in press.

Distribution of harbour porpoises in the Baltic Sea - SAMBAH Results (Results of the Static Acoustic Monitoring of the Baltic harbour porpoise)

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Abstract

SAMBAH (Static Acoustic Monitoring of the Baltic harbour porpoise, www.sambah.org) aims at contributing to the conservation of the harbour porpoise population in the Baltic Sea. The project started in January 2010 and ends in September 2015. All EU member states around the Baltic Sea are involved in the project. It is funded by the EU LIFE+ program and various national sources; the German part was completely funded by the Federal Agency for Nature Conservation.

The harbour porpoise is one of the smallest toothed whales and it has a wide distribution in temperate waters in the northern hemisphere. In the Baltic region, there are three harbour porpoise sub-populations; (1) in the northern North Sea, Skagerrak and Kattegat, (2) in the southern Kattegat, Belt Seas and Western Baltic, and (3) in the Baltic Proper and north-northeast thereof. The latter is very small and has been drastically reduced during the last half of the 20th century, and is now classified as critically endangered by the IUCN. The species is listed in Annexes 2 and 4 of the EC Habitats Directive as well as in the national red lists of several EU Member States.

Due to the very low population density in the Baltic, traditional survey methods have not yielded enough data for robust abundance estimates. Hence a new survey methodology was called for. SAMBAH built on previous Static Acoustic Monitoring (SAM) studies, and combined their methods with point transect methodology. SAM relies on logging the high frequency click trains produced by harbour porpoises for echolocation and communication. These echolocation click trains were recorded by acoustic data loggers called C-PODs. In total, C-PODs were deployed at 304 locations in waters 5-80 m deep, within the project area stretching from south and east of the Darss and Limhamn ridges in the south-west, to latitude 60° 20’ N in the north. The C-PODs were kept in operation for two years and then followed two years of statistical analyses. The SAMBAH project has so far reached a preliminary population abundance estimate for porpoises in the Baltic Sea Proper which is approximately 500 porpoises. New auxiliary data are now being analyzed in order to confirm this number and to minimize the confidence interval.

Based on spatial modeling, preliminary maps showing the distribution of porpoises in time and space have also been produced. These show a clear spatial separation during May-October between a porpoise concentration on the offshore banks in the Baltic Proper and the relatively high population density in the south-western Baltic. Porpoises give birth, mate and nurse their calves during this period, and thus these offshore banks seem to be an important breeding area for the critically endangered Baltic porpoise sub-population.

The SAMBAH results are expected to contribute to improved conservation status of the Baltic

harbour porpoise, since a population estimate in combination with known distribution in space and time opens up for dedicated conservation actions that will make a difference. Being the largest ever SAM study of any animal, the developed methodologies offer new possibilities for assessing population densities, abundance and distribution using passive acoustics.

Quieting Technologies for Offshore Pile Driving

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Impulsive noise from pile driving in offshore wind farms or at oil and gas installations has the potential to harm marine animals or to deteriorate neighbouring marine protected areas. The ever-increasing diameters of driven monopiles require increasingly effective noise mitigation techniques in order to meet threshold levels or conservation objectives. This becomes evident when analysing the radius for disturbance for harbour porpoises near construction sites which can extend beyond 20 km (Tougaard et al. 2009) when quieting measures are not imposed. A serious conservation problem may arise in the Baltic Sea when plans for the construction of offshore windfarms on the Midsjö offshore banks are realised as intended because this area is a potential breeding area for the critically endangered harbour porpoise population of the Baltic Proper (SAMBAH in prep.).

Noise can be reduced directly at the source (primary noise mitigation) or during radiation through the water (secondary noise mitigation). So far, mostly secondary noise mitigation has been applied on construction sites in the German EEZ by using various setups of bubble curtains or an isolation casing or Hydro Sound Dampers around the driven pile, or various combinations of these systems.

The only primary noise mitigation method currently applied is the reduction of blow energy in order to meet obligations if secondary noise mitigation measures alone are not sufficient to meet the standard (e. g. in Germany where a sound exposure level below 160 dB re 1 μPa²s at 750 m is required by approval authorities). Empirical data suggests that sound energy is proportional to pile-driving energy. For example, a reduction in blow energy by 50 % results in a noise reduction of 3 dB. This also produces less fatigue on equipment and material, but results in an unwanted higher number of pile strikes at a higher rate.

A novel method is BLUE Piling by the Dutch company FISTUCA BV which instead of a hydraulic hammer uses a hammer with a large water column inside to generate the driving force in two steps (OSPAR Commission 2014). Sea water inside a steel tube closed at the bottom is pushed upwards by igniting a gas mixture in a combustion chamber at the bottom. The pressure increase by the flue gases lifts the water column and generates a downward force at the same time. A second downward force pulse is produced when the water falls down again. In a 250 kJ prototype the gradual force build-up increased the pulse duration by a factor of 20 and reduced the amplitude of noise emissions by about 25 dB under inshore conditions. A 1,000 kJ test piler (diameter: 5 m) of this scalable technology will be tested nearshore in 2016. A full scale test with a monopile is scheduled for 2017.

A completely different pile driving method which reduces the noise amplitude at the source is vibropiling. A set of vibropilers attached to the top of the pile transmits flexural oscillations to the pile which allows even very large piles to be driven. The resulting amplitude of underwater noise is about 15 - 20 dB lower compared to impact driven piles. Contrary to impact piling, vibropiling emits continuous sound. The overall impact of continuous noise on marine organisms cannot be directly compared to that of impulsive noise. A disadvantage of vibropiling is that the verification of the load baring capacity is not possible using standard procedures (relating blow count and penetration). As a consequence it is not approved by the German approval authority BSH as stand-alone method where it is currently used in combination with impact pile driving only.

The most tested offshore technology for secondary noise mitigation is the bubble curtain. Big bubble curtains have been used in > 600 piles as per November 2014 (Bellmann 2014, OSPAR Commission 2014). Also various types of small bubble curtains have been tested. The noise reduction is a function of the air volume stream and smaller and more bubbles reduce the piling noise better than less larger bubbles. In a single application a noise reduction of 10 to 15 dB is possible. Doubling or a combination with other secondary noise quieting technologies can further reduce the noise by a few decibels. Seismic waves coupling to the water body limit the overall noise reduction which can be achieved by secondary methods. As a further limitation of bubble curtains, increasing hydrostatic pressure at larger depth reduces the effective air volume.

Isolation casings such as the IHC Noise Mitigation System are based on the principle of decoupling the noise transmission from the pile into the water using air filled double steel walls and a layered confined bubble curtain inside. It has been used in various commercial projects (> 150 piles, Bellmann 2014). The noise reduction is between 10 and 14 dB (SEL) with best attenuation in the frequency range of 150 Hz to 8 kHz. The German standard could be met in most cases, with large monopiles in combination with big bubble curtains. A close-fitting system of inflated air chambers is the HydroNas system. A full scale offshore trial is planned after successful prototype testing.

Cofferdams are another shielding system. These have an air gap between the casing and the pile. Air is the optimum medium to decouple sound transmission from the pile into the water. The seal at the bottom of the cofferdam is a critical part and requires much attention in the engineering process because effective noise reduction can only be reached in a completely dewatered cofferdam. In a test pile with a diameter of 2.13 m a noise reduction of 23 dB (SEL) was reached. So far cofferdams have been applied only at a few offshore foundations such as at the converter platforms BorWin beta and HelWin alpha in the German EEZ. Pile-in-pipe piling is a variation of the cofferdam in which the cofferdam is part of the structure and remains in place after the installation.

An approach under development (prototype tested at the offshore wind farm Amrumbank West) is the use of „Hydro Sound Dampers“ or „encapsulated bubbles“ developed by two different companies. The principle of these gas filled elastic balloons or foam elements which are fixed to nets held around the pile by a frame is scattering and absorption as well as stimulation with the resonance frequency of balloons. Foam elements act as impact absorbers. The attenuation frequencies can be adjusted by the size of balloons or foam pellets. This offers a system to selectively reduce noise at frequencies of biological significance (e. g., within the hearing range of an animal in order to reduce disturbance) or at frequencies of maximum energy in pile strikes to optimise for the amount of noise reduction. So far, the broadband noise mitigation is in the order of 8 to 13 dB (SEL) (Bellmann 2014). It is assumed that the number of Hydro Sound Dampers can enhance the noise reduction.

The use of a combination of both, primary and secondary noise mitigation systems, offers the potential for a more effective noise reduction. In addition to noise mitigation methods, several alternative foundation types exist or are under development. With these, wind turbines can be founded without impact pile driving and therefore much less underwater noise generation is expected.

Progress has been made in bucket foundations which are steel caissons deployed using suction pumps (making use of vacuum inside and hydrostatic pressure outside of the caisson). Being state-of-the-art for offshore platforms already, a demonstration turbine on a three-legged jacket on buckets (3 buckets of 88 t each, jacket design suitable for up to 60 m water depth) has been successfully installed in the offshore wind farm Borkum Riffgrund 1 in summer 2014. The company DONG Energy plans a further demonstration project. Monopods (installations on a single bucket) had been successfully tested before with metmasts (Horns Rev 2, Dogger Bank) and a 3 MW wind turbine „nearshore“ (Frederikshavn / DK). There are concrete plans for the installation of monopod turbines under offshore conditions.

Gravity base foundations are large concrete box girders whose stability is achieved by self-weight of the structure and additional ballast (e.g. sand). They are state-of-the-art for water depths up to 20 m. Innovative cost-efficient gravity base foundations do not need large cranes. A demonstration foundation by the company Seatower has been installed at a depth 28 m at Fécamp offshore wind farm in France. In this foundation, no soil preparation -a potential noise source- was necessary.

Drilled foundations are suitable for larger pile diameters compared to impact piling. Partial-face excavation machines allow drilling underneath the pile which penetrates as drilling progresses. Drilling produces very low noise emissions. Modelling of noise measurements conducted onshore revealed 117 dB at 750 m (Ahrens & Wiegand 2009). The drilling technology by Herrenknecht/Van Oord is fully developed and DNV-GL certified. Nearshore tests would be the next step.

For floating wind turbines three different concepts exist. These are based on deep water oil platform types spar buoy, semi-submersible and tension leg platform (TLP). Existing full scale prototypes of these are HYWIND (installed in Norway 2009) and WindFloat (installed in Portugal 2011). In Germany, the installation of the TLP based turbine GICON SOF off the Baltic Sea coast is scheduled for 2016.

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Measuring pile-driving noise and related potential effects on porpoises with special emphasis on the construction of the OWF Butendiek

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Abstract

The erection of offshore wind farms (OWFs) has moved on from first installations of a few turbines as pilot projects towards the regular use of pile driving procedures throughout the North Sea for building foundations for a multitude of wind farm projects. Porpoises *(Phocoena phocoena)* have been shown to be displaced up to distances of 20 km around ongoing pile driving due to the impulsive noise emissions. Such displacement is one of the strongest behavioral reactions of animals towards sound that are observable in the wild. Others include change of behavior (e.g. interruption of feeding behavior, communication, changes in movement pattern or speed) or increase of respiration and heart rate, stress in general and may lead in their totality to a decreased fitness of the population. Whether this is true for offshore wind farms and porpoises remains unknown and depends on how much pile driving is being conducted, what other (noise) effects contribute and if porpoises are disturbed in high density areas during 'biologically important behaviors´ for a relevant period of time.

A monitoring of harbour porpoise and noise levels was conducted in 2013 for a two months period during the construction of three OWFs in close vicinity of 'Sylt Outer Reef' – an area, amongst others, designated a Natura 2000 site due to high abundance of porpoises in the breeding period. The monitoring was continued in 2014 when the OWF Butendiek - the only one permitted in a Natura 2000 site - was constructed. These building processes were monitored using stationary acoustic monitoring for echolocation clicks with CPODs (Porpoise detectors, www.chelonia.co.uk) as well as noise monitoring with AMARs (Autonomous Multichannel Acoustic Recorders, www.jasco.com) and DSG-Oceans (www.loggerhead.com). Aim was set at quantifying behavioral reactions of harbour porpoises in larger distances in terms of displacement.

Results indicate that noise levels throughout Sylt Outer Reef were highly variable. Depending on geographic location of the measuring device noise levels were elevated in 2013 or 2014, but a contribution of anthropogenic (ship) noise in the 50 to 100 Hz range is likely and increased noise levels in this band by ~15 dB. One conclusion of the found noise levels is that effective noise mitigation already reduced impulsive noise around the OWF Butendiek to a great extent.

Motivation: Effects of noise on harbour porpoises

Max Schuster

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1. Introduction

Underwater noise has been identified as potential threat for marine mammals, e.g. by Lucke (Lucke et al., 2009) who linked threats for harbour porpoises to industrial activity at sea among which piling noise used to be by far the noisiest source in waters of the German Exclusive Economic zone.

Since 2008, licensing of offshore wind farms in the waters of the German Exclusive Economic Zone (EEZ) is only accepted if the potential for injury of protected species is minimized. The current limit values are defined based on scientific findings for the harbour porpoise which is regarded as the acoustically most sensitive creature among those in the relevant area. To avoid injury the dual criterion for a measurement location in 750 m distance from piling location must not be exceeded according to the Concept for protection of harbour porpoises against noise exposure during construction of wind farms in the German North Sea (Bundesministerium für Umwelt, Naturschutz und Reaktorsicherheit, 2013), further denoted as "Concept for protection against noise":

- Sound exposure level (SEL) max. 160 dB re 1 µPa²s
- Peak sound pressure max. 190 dB re 1 µPa²

At present, there are no mandatory limit values defined to avoid disturbance of harbour porpoises. Disturbance is relevant for protected species as soon as unnatural behavior leads to effects on population level. However, current findings such as those by Pehlke (Pehlke et al. 2013) are taken into account for licensing of wind farms in vicinity of protected areas. All investigations of disturbance were based on impulsive noise so far, described by the quantity SEL. In 2013 the findings of recent investigations were implemented in the Concept for protection against noise. Since then, disturbance of harbour porpoises is assumed to occur at values above 140 dB re 1 µPa²s sound exposure level of single events.

All through the years since 2009 technical measures to reduce radiated piling noise have been further developed and progressed. An overview on state of the art technology is presented e.g. by Koschinski (Koschinski et al. 2013). These measures lead to significantly reduced noise emissions during pile driving such that mandatory limits for sound exposure and peak pressure in 750 m distance from site can be achieved by technical means.

2. Wind farm Butendiek

A very challenging wind farm construction was conducted in the North Sea within the Natura 2000 site "Sylter Außenriff".

Installation of the large monopoles piles was scheduled for summertime when many harbour porpoises are present in Sylter Außenriff for breeding and foraging. During this season pairs of mother and calf are particularly sensitive to acoustic disturbance. Hence, the installation was licensed exclusively under the premise that sound exposure level (SEL) of 160 dB re 1 µPa²s in 750 m distance from piling must not be exceeded in any case. This requirement should ensure that disturbance is reduced equivalently.

Noise measurements were conducted in the circumference of the wind farm as shown in Figure 1. These recordings revealed that a sound exposure level of 140 dB re 1 µPa²s was exceeded in approximately 5.6 km or less which corresponds to approximately 100 km² area size. One exception was detected by one particular pile with 140.5 dB re 1 µPa²s in 8.1 km distance. Comparison with other measurement locations shows that this pile radiated high noise levels in only north-east direction. There is no additional information available for further investigation of this issue; one possible explanation is limited attenuation in one segment of the bubble curtain. Observation of noise levels in 750 m distance was conducted by a contractor of the installation company. These results are not publicly available.

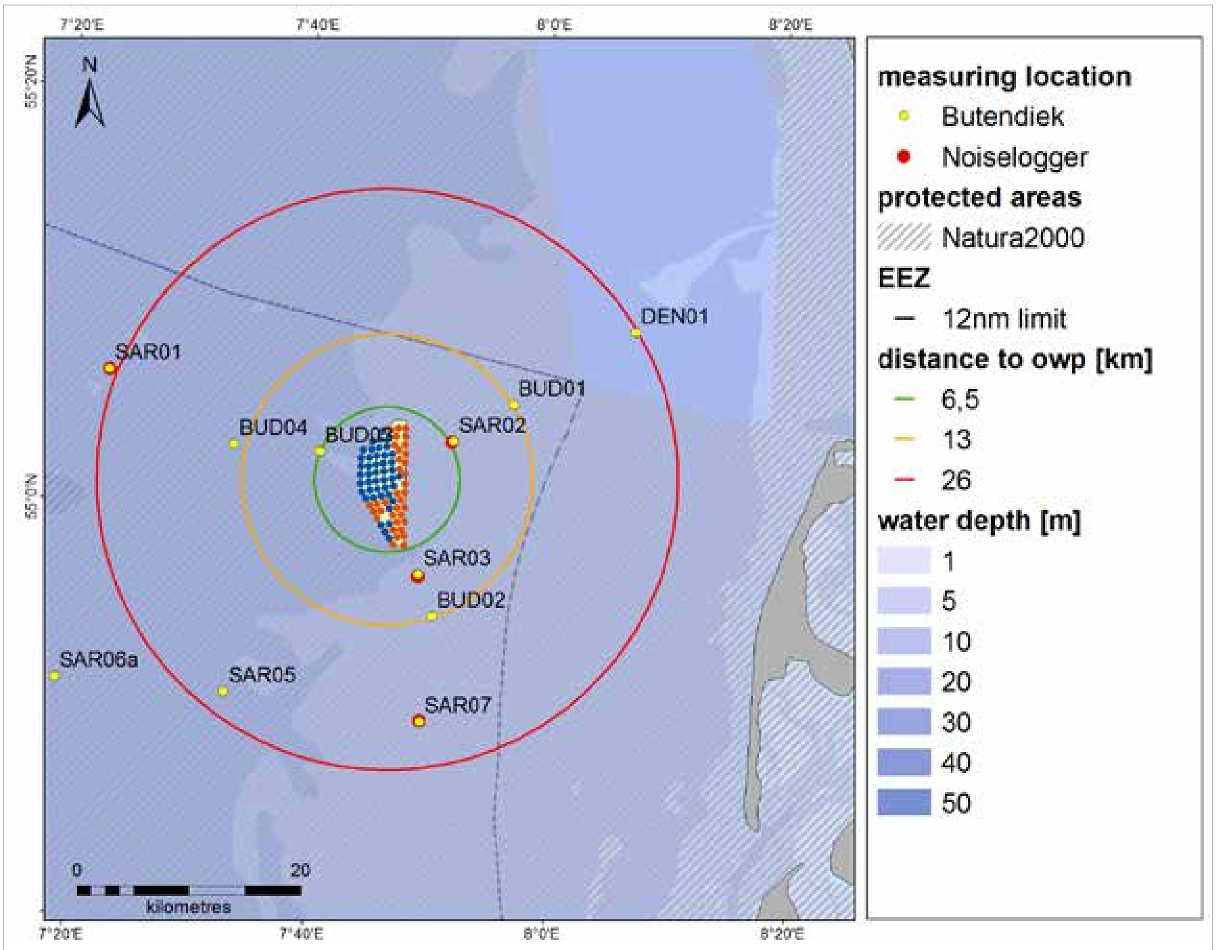

Figure 1: Locations for measurement of underwater noise in the vicinity of wind farm Butendiek. Blue dots within the windfarm show piles that were already installed before start of noise measurements. Red dots show piles that were monitored by noise measurements during the construction phase.

During installation of the wind farm Butendiek a two-stage noise mitigation system was selected to ensure that the limit value for injury would not be exceeded in 750 m distance. This combination of cofferdam (IHC pipe) and large bubble curtain comes along with very high attenuation at frequencies around several hundreds of Hz. The dominant noise transmission through the mitigation system occurs at frequencies below 100 Hz where overall attenuation of the water-borne path is limited due to noise radiation through the seabed (Stokes, et al., 2010). In addition, the use of very large monopoles leads to relatively low peak frequencies around 100 Hz. These very low frequency emissions are most likely the reason for pronounced noise reduction over range as shown in Figure 2. A very rough estimate for transmission loss of piling noise in the North Sea is e.g. provided by Elmer (Elmer et al. 2007). Due to the uncommonly high transmission loss the affected area was relatively small in comparison with other construction sites (Pehlke et al, 2013) where 144 dB re 1 µPa²s were detected in 4.8 km distance, resulting in approximately 50 % more affected area than in Butendiek.

Porpoise densities were monitored both by means of visual observation during flight surveys and by means of stationary C-Pods, moored in vicinity of the noise recorders. The findings from these investigations will be summarized in a publication by Bundesamt für Naturschutz which is currently in preparation. All those investigations are conducted with focus on a relationship between received sound exposure levels and avoidance behavior. In comparison with results from windfarm Borkum West II (Pehlke et al. 2013) it was found that disturbance radii of harbour porpoises are significantly larger in Butendiek even though radii of disturbance (140 re 1 µPa²s) were smaller in Butendiek. Preliminary hypotheses from this work are:

1. Nuisance due to piling noise corresponds rather to signal to noise ratio than to absolute levels
2. Nuisance is linked to anthropogenic noise sources other than piling noise
   a. Therange of piling noise during construction of Butendiek is limited due to noise mitigation close to the source in combination with high transmission loss. Therefore, other noise sources such as ships become dominant in a larger area.
   b. Contribution of continuous noise sources in offshore construction activities has not been quantified so far. Yet, there are no investigations that compare piling noise with continuous underwater noise in construction sites.

Therefore further investigations of ambient noise in the vicinity of wind farm Butendiek were conducted to quantify other anthropogenic contribution than pile driving.

3. Underwater noise in vicinity of wind farm construction site Butendiek

In Butendiek 80 turbines were installed in 113 days between 31.03. and 22.07.. This accounts for roughly one pile per day in average. However, the temporal sequence of individual piles was rather non-homogeneous so that two piles per day were installed occasionally. A typical situation for underwater noise in this period of time is shown in Figure 3 for two measurement locations. During the whole period of time a continuous contribution is detected in the frequency range between 50 Hz and 1000 Hz. The broadband Leq noise level plotted in between the spectrograms of the individual locations shows that pile driving noise is well detected at the position 3.0 km close to the wind farm. Signal to noise ratio of pile driving noise is between 15 and 20 dB, dominated by frequencies below 250 Hz. Pile driving noise in the far recording position is mainly detected at very low frequencies below 50 Hz which most likely propagate through the seabed. In the frequency range above 50 Hz pile driving noise contribution is covered by other continuous sources which are temporarily exceeded by transient events, for example sounds from transiting ships.
In 10.3 km distance fluctuation of the broad band noise level due to pile driving is only very

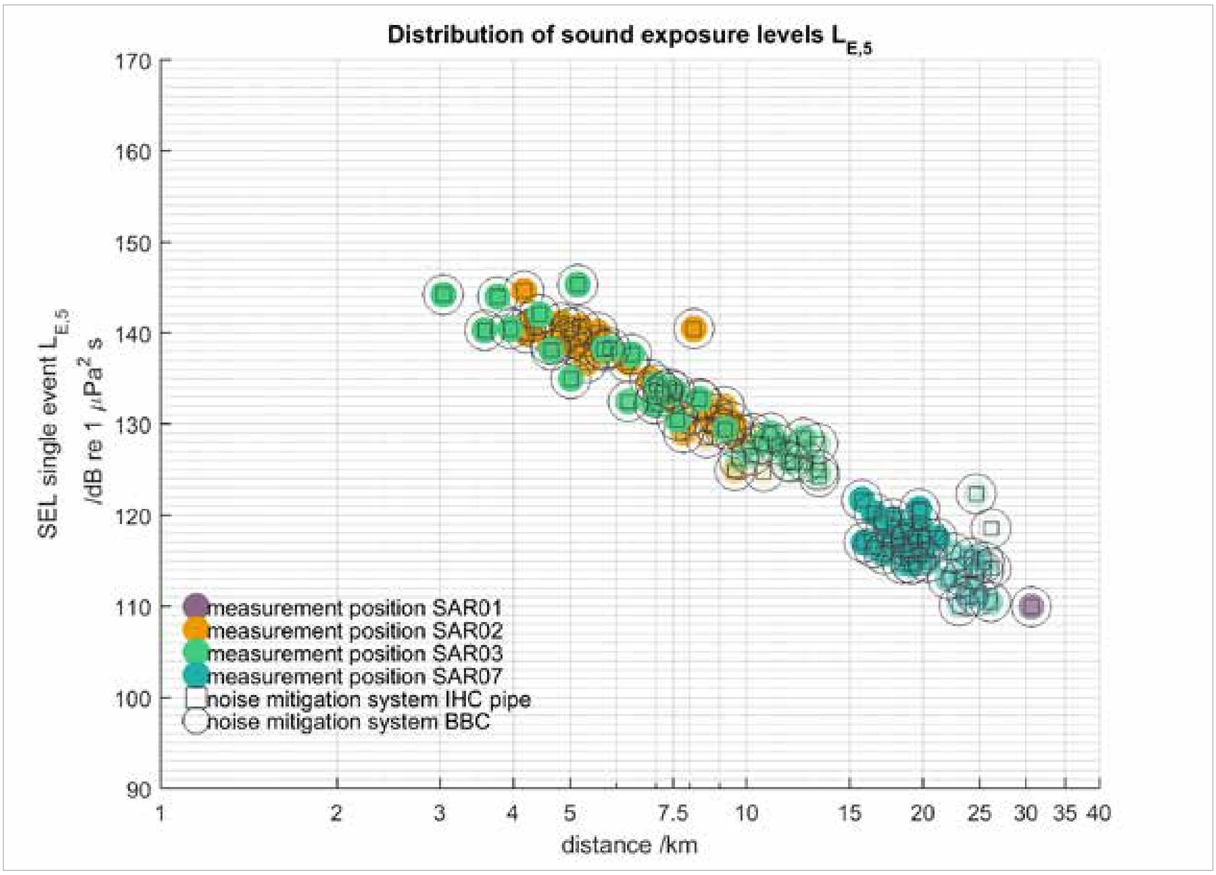

Figure 2: 5 % exceedance level of measured sound exposure levels (L5), plotted over distance

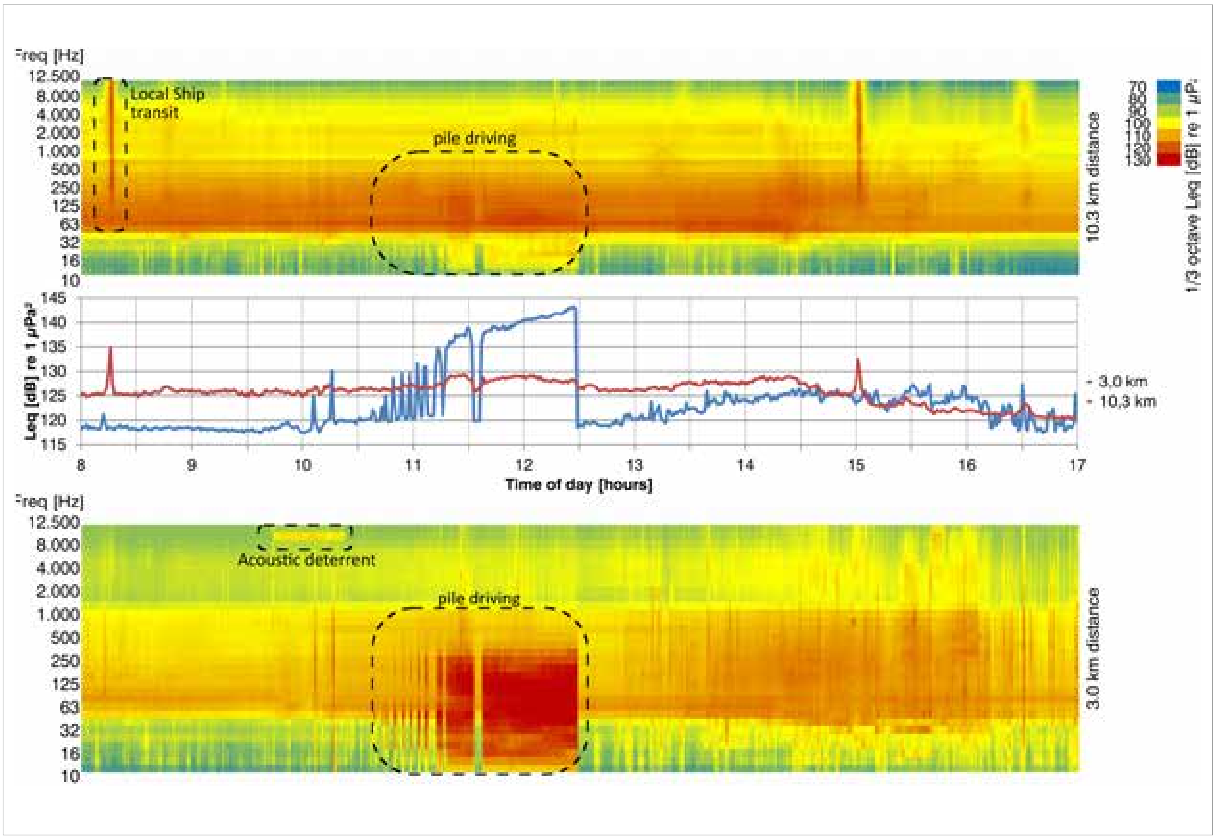

Figure 3: 1/3 octave spectrograms and broadband noise levels at two locations during same period of time. Broadband noise levels in 10.3 km distance are temporarily higher than in 3 km distance due to local noise sources.

few dB. This is shown by the red graph between time 11:00 and 12:30. Fluctuation in 3 km distance is approximately 20 dB. Different levels of fluctuation are not only caused by the distance between source and receiver. Comparison of the red and blue curve also shows that local background noise is 5 dB higher in 10.3 km distance; this reduces fluctuation of signals from distant sources. In both locations the impulsive noise can be well identified by means of a detector algorithm. The detection results for all measurement locations in the vicinity of wind farm Butendiek are compiled in Figure 2, showing the 5 % exceedance level for sound exposure of single pile driving events, further denoted as SEL05. The events in the spectrograms shown in Figure 3 include SEL05 values of 144 dB re 1 µPa²s in 3.0 km distance and 127 dB re 1 µPa²s in 10.3 km distance.

The observations of porpoises showed that porpoises temporarily avoided the constructions site Butendiek in a wide radius, details are to be published soon. However, analysis of continuous noise has not yet been taken into account in this analysis procedure. Therefore no conclusion can be drawn whether noise from other sources than pile driving may also be a trigger for avoidance reactions of porpoises.

An analysis of a time period in the scale of months shows that continuous noise in the frequency range between 50 Hz and 1000 Hz is not continuously present, see Figure 4. In this spectrogram the sequences of piling noise are marked by sharp peaks at frequency below 50 Hz which is also shown in Figure 3. The displayed period of time covers roughly 2 ½ months with large variations especially in the frequency range between 50 Hz and 1000 Hz. Noisy periods of time are denoted by contributions of 1/3 octave Leq up to 120 dB re 1 µPa² which exceeds quiet moments by approximately 20 dB (Figure 4). Most of these patches are marked by abrupt appearance and disappearance which is a clear hint that the sounds originate from anthropogenic sources and are not caused by natural effects such as wind or waves.

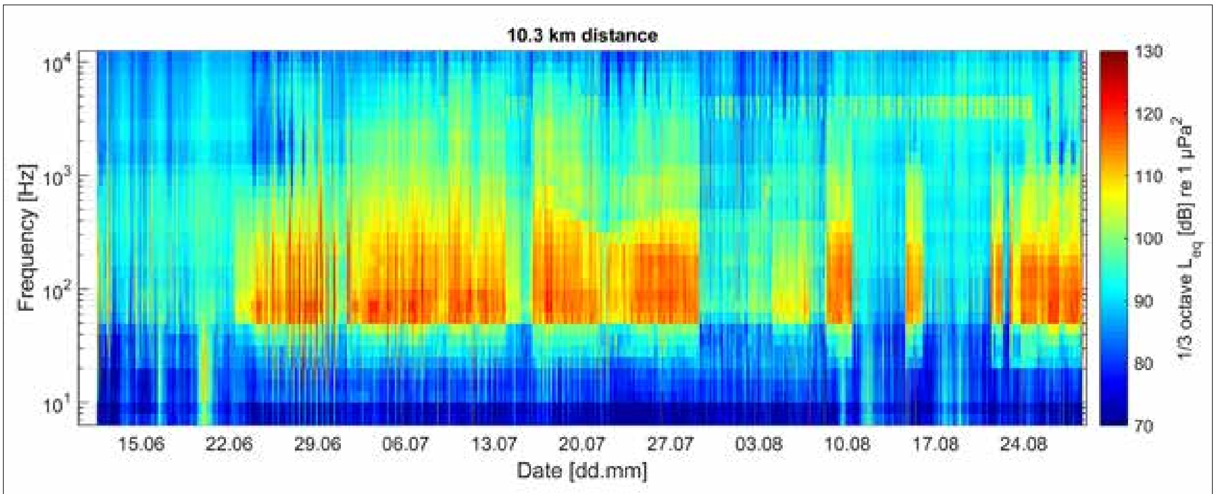

Figure 4: Long-time spectrogram for one measurement location in the vicinity of wind farm Butendiek

Since the contribution of continuous noise is very dominant the recordings were analyzed for continuous noise from anthropogenic sources such as ship engines and ship propellers. Two algorithms were applied for automatic identification of typical characteristics of engine and propeller noise, these are:

- Tonal sounds, indicated by pronounced single frequencies. This is typically radiated by most types of combustion engines (Arveson et al. 2000)

- Modulated broadband noise, typically generated by cavitation on ship propellers (Baiter, 1992)

An example of the results from the modulation detector is shown in the upper graph of Figure 5. Here, a horizontal line is visible at 25 Hz which indicates continuous contribution of a modulated sound over long periods of time. The temporal agreement of this detected modulation and continuous mid-frequency noise in the spectrogram between 50 Hz and 1000 Hz is an additional hint that increased ambient noise levels may be attributed to an anthropogenic source. For the time of this analysis AIS data was not available to analyze the locations of ships in the vicinity of the recorders. Due to the fact that the distance between noise source (ship) and receiver is currently unknown the data set does not contain sufficiently detailed information to derive statements on the spatial extent of increased ambient noise levels. Potential sources are for example guard vessels or support vessels of the piling vessel. Nevertheless, the effect of temporally increased ambient noise is detected in all measurement locations in vicinity of the wind farm. Therefore it is very likely to affect not only the measurement locations but a larger area with support vessels. The analysis of correlation between harbour porpoises' avoidance behavior and presence of ship noise is to be conducted in the BfN project "Effects of noise from offshore windfarms on marine mammals" (FKZ 3515822000).

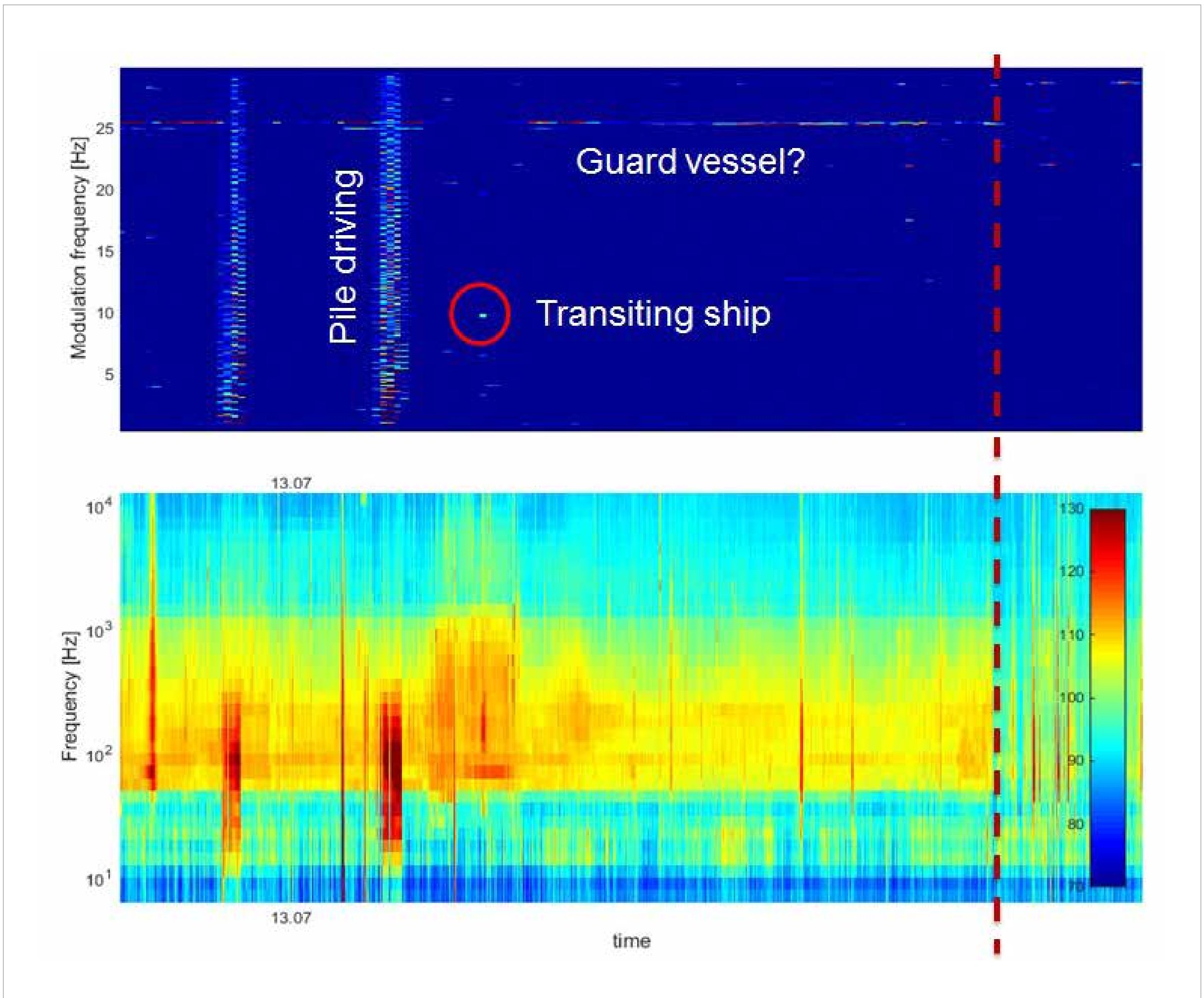

Figure 5: Example for results of the modulation detector (upper graph), red line showing accordance of 25 Hz modulation and presence of continuous noise contribution in spectrogram (lower graph)

4. Conclusion and outlook

Extensive mitigation of pile driving noise during the construction of wind farm Butendiek made possible that mandatory limit values were not exceeded. Radiated frequencies were below 250 Hz with peak components below 100 Hz, therefore limited noise propagation leads to strong decrease of sound exposure levels over distance. Due to the relatively low sound exposure levels in 10 km distance other noise sources related to wind farm construction tend to be more dominant.

The acoustic data set of underwater noise measurements during the construction of wind farm Butendiek gives evidence that continuous anthropogenic noise especially from ships is a dominant noise source over long periods of time. In 10 km distance from the construction site the measured continuous noise levels are comparable to the received noise levels of pile driving.

The biological effects of continuous noise are currently unknown. These shall be further investigated in a project of the BfN: "Auswirkungen des Unterwasserschalls der Offshore-Windenergieanlagen auf marine Säugetiere" (Effects of underwater noise related to offshore wind farms on marine mammals), FKZ 3515822000. In this project special attention is paid to underwater noise from ships because these will be present in wind farms all through the operating time. Daily traffic of crew transfer vessels is expected within the wind farm and for the connection to shore; therefore adjacent habitats will be affected by repeated occurrence of ship noise. The results of the project shall deliver a judgment of the consequences on habitat use.

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Collisions of Vessels with Cetaceans: How to mitigate an issue with many unknowns

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The worldwide number of collisions has significantly increased since the 1950. During the past years, with a steep global increase of shipping traffic and increasing average travel speeds of vessels, the situation became - at least in some areas of the world – a real conservation problem, sometimes even a matter of survival for cetaceans on a population level. Whales may be hit either by the bow or the keel of a vessel, protruding parts of vessels like skegs or stabilizers, or by its propeller, leaving such nasty wounds on a live animal. Sometimes whales will be stuck on the bow of large ships and brought into the harbour. Such cases might only be recognized upon arrival at port.

Figure 1: Vessels and whales not always get out of the way of each other. (Photo: Christiane Loch / MEER e.V.)

Which vessel types are involved?

As cetaceans are animals that have to come to the surface to breathe, quite naturally every type of vessel can hit a whale or dolphin. All of the following have been reported to hit cetaceans: freighters, large ferries, high speed ferries or cruise ship, small boats, hydrofoils, navy vessels, whale watching boats and even sailors, especially those ones traveling at considerable speeds, for example during regattas and ocean races.

Which species are affected?

In principle every cetacean, be it a dolphin or a whale, can be hit. However, we know that certain species are especially vulnerable: namely those ones that are slow swimmers and/or stay for longer periods on the surface: such as right whales. As an example, 35 % of North Atlantic right whales fatalities on the East coast US have been attributed to collisions and 20 % of Sothern right whales in South Africa die due to ship strikes. In the Mediterranean Sea, collisions predominantly occur with fin and sperm whales, while around Hawaii, numbers of collisions with humpbacks are rising - apparently as a result of their increasing abundance in that area. In the Canary Islands sperm whales - another species spending prolonged periods of time on the surface - are threatened, with animals sometimes cut into halves by large high speed ferries. And there is another species affected, that is us humans – as we know of several incidents where humans got injured, including some cases of fatality. A number of sailors have lost their boat as a consequence of running into a whale, and ferry passengers were injured, so we are talking about a safety issue here, too.

Why do collisions occur?

Cetaceans may be in a state of decreased alertness when resting. They might be distracted by hunting or feeding behaviours. Also, there will be interspecies differences or differences between age or sex classes, and even between individuals within a species. This in turn is related to experience & learning by individual animals.

Additionally, high levels of background noise or the fact that animals suffer from hearing damage will make them less likely to detect approaching ships. Phenomena like refraction, bending and absorption of sound, as well as bubbles, sound shadows created in front of a vessel, Lloyd mirror effect or near field effects may all play a role. This will lead to difficulties or even confusion about how to interpret vessel noise, i.e. knowing how far away and how fast a vessel is, which direction it comes from, etc. And of course we thereby already imply that whales know to interpret certain types of noise as a danger, which simply might not be case either.

So there are still many unknowns. We *do* know, however, that fatality and severity of injuries (on the side of the whales) are related to size and speed of vessels. The great majority of accounts when whales were severely hurt or killed occurred at speeds of 14 knots or more. Studies show that from around 10 knots the probability of a lethal outcome for a whale increases sharply. Moreover, large ships cause most lethal and serious injuries.

As an admittedly extreme example think of a fast ferry travelling at 35-40 knots where the crew detects a whale 600 m in front of the bow: The remaining reaction time will be just about 30 seconds before the ship is where that whale was seen. So what do you do? This will be referred to again in a minute.

And we have to keep in mind that larger vessel might not be able to freely navigate due to their size, the presence of other vessels or the fact that they are navigating in shallow or otherwise restricted waters.

How many ship strikes are there?

The honest answer is: We don‘t know! Our knowledge gaps are a result of the fact that collisions may not be recognised at all (as whales hit mostly will not stay on the bow), injured animals may not be identified as such, dead animals often will drift way and sink to the bottom, and in stranded animals the cause of death not always is unambiguously identifiable as you need decent knowledge to tell pre-mortem from post-morten strikes, etc. Hence we can be quite sure that there is a probably quite large *dark number*.

Mitigation measures

There are three categories of mitigation measures: TECHNOLOGICAL, OPERATIONAL and EDUCATIONAL. Here is an overview.

TECHNOLOGICAL: *Sonar* will only be applicable within a very short range, and of course it introduces an additional source of noise into the marine environment. Actually, historically whalers used to use Sonar (Asdic) to bring whales to the surface so such a measure could also cause more hits. The same applies to *Acoustic warning devices* (AWDs), where again nobody knows what type of warning sound would be an alerting signal for cetaceans, and even if that was the case there easily might be effects like habituation. Other systems have been developed include *night vision, infrared or thermal imaging* technologies but again efficacy will largely depend on the general conditions.

As for measures that can be summarized as *alerting tools*, a famous example is the passive acoustic monitoring system off Boston (USA), involving a number of hydrophones where acoustical whale detections are broadcasted in real time to mariners in the area. No need to tell that this system involves large amounts of money which not always will be available elsewhere, e.g. in developing countries. Another system is REPCET developed in the Mediterranean Sea where ship crews can inform each other about whale sightings via an online interface. Recently the first mobile APP was developed which has a similar mode of operation. Placing on-board observers is another option, especially as studies have revealed that observers are an effective means to detect whales in the path of a ship.

It has to be noted that the value of alerting tools may be limited given the unpredictable nature of whale movements, their dependence on favourable (light, weather and sea state) conditions and the fact that they will strongly rely on crews and captains reacting in the right way. Hence, all these systems need proper testing before being considered as „true“ and effective mitigation tools. As a conclusion: there is currently no technology known to effectively avoid collisions.

Possible OPERATIONAL mitigation measures include the relocation of shipping lanes, such as the realignment of the Traffic Separation Schemes (TSS) servicing Boston, and the ones implemented off San Francisco and in Southern Spain off Almeria, where the TSS was moved offshore away from an existing marine mammal protected area. These re-routing measures were implemented through the International Maritime Organisation (IMO). Here we need to consider a multi-species approach, as moving shipping routes offshore may lift the pressure from the more coastal species, but at the same time create problems for others with a more pelagic distribution. So there is always a necessity that such measures are based on sufficient scientific data. And the process to implement such measures through the IMO can sometimes be quite lengthy. Other operational measures include Areas To Be Avoided (ATBAs) off Nova Scotia in Canada, as well as voluntary & mandatory speed reductions introduced in the Strait of Gibraltar or in the Glacier National Park in Alaska. Off the east coast of the US, there are seasonal speed restrictions in place for North Atlantic right whales in accordance to their occurrence when migrating north or south. Here, all ships 65 feet or longer have to slow down to 10 knots in certain areas and during certain seasons.

Generally, mandatory reporting should be implemented wherever possible, ideally through strong legislation. Common sense tells us that there should always to be the possibility to initiate avoidance manoeuvres, but one may become a sceptic as we know of countless cases of near misses even under good conditions, where the whale was seen well in advance and still there was no obvious option to avoid it.

As a skipper or captain, when you detect or are alerted to a whale, you will have to decide
a. where to go so as to steer away from the animal
b. about reducing speed which has consequences for manoeuvrability, or
c. opt for doing nothing relying on the whale to avoid the vessel.

These are no trivial questions and decisions, especially when you only have seconds to react.

The third level of mitigation is EDUCATION. Training vessel personnel & crew is paramount, but knowledge about the issue must also be increased in managers and policy makers. Introduction of the issue into the curricula at navigational schools is equally important, and speed reductions can be noted on nautical maps.

Other tools to make people including the general public aware are given here, they include websites, brochures and a leaflet produced by Belgium as a member state of the IWC in collaboration with IFAW.

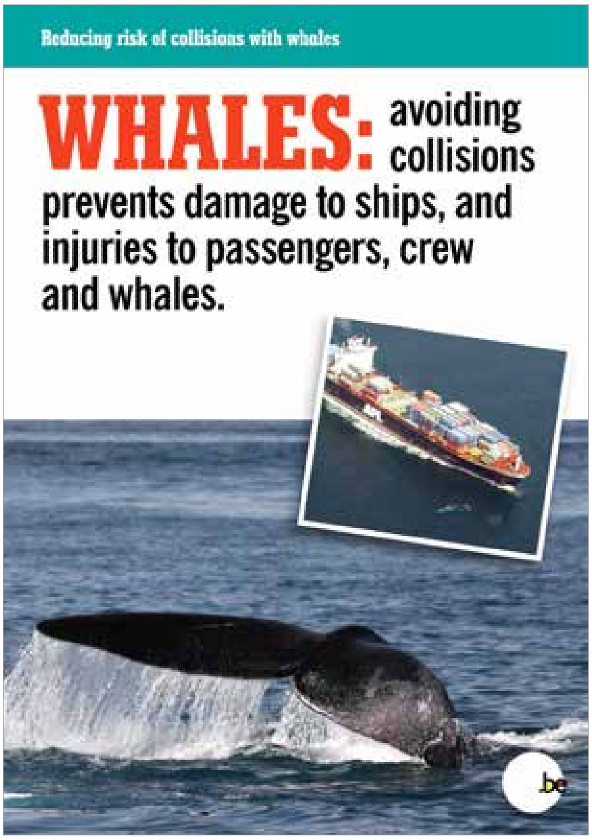

Figure 2: Leaflet on ship strikes, available from IWC in five languages.

The role of the International Whaling Commission (IWC)
IWC has been central in placing the issue high on the international agenda. Already in the 1990s, a dedicated Ship Strike Working Group has been set up and recently two SSDCs have

been appointed. Under the leadership of Belgium the IWC has set up regular documentations of the global situation, as well as international expert workshops. The according reports all can be found on the organisation‘s website.

At the moment, IWC is reaching out to the shipping industry to develop guidance documents, and only in 2015 IWC had a very fruitful collaboration with WWF and the Volvo Ocean Race (VOR), a global regatta that took place 2014/15.

One of the take-home-messages is: *Reporting is essential*. That is why the IWC has developed its global database on ship strikes, which went online in 2009, and which was modernized and re-launched in 2015. The database currently holds a total of about 1,200 incidents, both historical and recent, with numbers of reports increasing steadily. Please visit the IWC Website if you are searching for more information: www.iwc.int/ship-strikes. The database guides you through questions in an interview style with an intuitive and interactive interface. Most importantly: If you have witnessed a strike, if you found a dead animal with suspicious lesions, or if you were unlucky enough to have had a collision, go there and enter all the information you have.

IWC recommendations:

- Wherever possible, separate vessels from whales: A precondition will be the availability of sufficient data about abundance of cetaceans
- The *only* mitigation measures known to date to be effective in reducing numbers of ship strikes are SEPARATING VESSELS FROM WHALES and SPEED REDUCTION
- On-board observers: but note the limitations that have been mentioned
- Report collisions to the IWC data base

Annex

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Programme (2015)

Monday, 14 September 2015

Arrival	17:30	**Arrival & Registration** (17:30h - 20:00h)	**Venue:** German Oceanographic Museum Main Entrance: Mönchstraße/Bielkenhagen 18439 Stralsund
	18:00	**Get-Together-Party** (18:00h - 22:00h) *(on invitation by BfN)*	

Tuesday, 15 September 2015

Late Registration	8:30	**Venue:** OZEANEUM, Hafenstraße 11, 18439 Stralsund
Opening	9:00	**Opening by the Federal Agency for Nature Conservation** Henning von Nordheim, Federal Agency for Nature Conservation (BfN), Germany
	9:10	**Welcome by the German Oceanographic Museum** Harald Benke, Director of German Oceanographic Museum (DMM), Germany
	9:15	**Opening speech** Jochen Flasbarth, State Secretary, Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety (BMUB), Germany
	9:40	**Progress in marine conservation in Europe – a current overview** Beate Jessel, President of the Federal Agency for Nature Conservation (BfN), Germany
Marine Biodiversity and Marine Protected Areas	10:00	**Global Ocean Process of Identifying Ecologically and Biologically Significant Areas (EBSA) – what now, what next** David Johnson, Seascapeconsultant, Coordinator GOBI
	10:20	Discussion
	10:40	Coffee / Tea (30min)

Tuesday, 15 September 2015		
	11:10	**Network of OSPAR and HELCOM MPAs by 2015** Henning von Nordheim, Federal Agecy for Nature Conservation (BfN), Germany
	10:30	Discussion
	11:50	**Evaluating Progress towards meeting MPA commitments – experiences from the UK** Hannah Carr, JNCC, UK
	12:10	Discussion
	12:30	Lunch / Press Conference (1h 30min)
	14:00	**Progress in the implementation of the French strategy for the creation and management of MPAs** Benjamin Ponge & Neil Alloncle, Agence des Aires marines protégées, France
	14:20	**Canyon heads in the French Mediterranean Sea – Conservation issues** Pierre Watremez, Agence des Aires marines protégées, France
	14:40	Discussion of the previous 2 talks
Marine Biodiversity and Marine Protected Areas	15:00	**Marine Conservation in Portugal - Recent Progress and Perspectives** António Teixeira, DGRM, Ministry for the Sea and Marine Affairs, Portugal
	15:20	**Progress in coastal marine conservation in the Azores** Mara Schmiing, IMAR; University of the Azores, Portugal
	15:40	Discussion of the previous 2 talks
	16:00	Coffee / Tea (30min)
Fishery management in MPAs	16:30	**Advice on managing fisheries in MPAs** Mike Quigley, Natural England, UK
	16:50	Discussion

Tuesday, 15 September 2015

	17:10	**Impacts of bottom set gillnet anchors on the seafloor and associated flora – potential implications for fisheries management in protected areas** Thomas Kirk Soerensen, DTU Aqua, Technical University of Denmark, Denmark
	17:30	Discussion
	17:50	End of the Session
	20:00	Conference Buffet (on invitation by BfN) — Venue: OZEANEUM Exhibition Hall "Giants of the Sea"

Wednesday, 16 September 2015

Marine Nature Conservation and Fisheries	9:00	**Fisheries management on the international Dogger Bank: a primer for nature conservation in the North Sea** Ton Ijlstra, Nature Conservation Department, Ministry of Economic Affairs, Netherlands
	9:20	Discussion
	9:40	**Influence of discard ban on transition towards more selective fishing gear** Jurgen Batsleer, IMARES, Netherlands
	10:00	Discussion
	10:20	**Can automatic longlines and jigging-machines replace gillnets in bycatch conflict areas? Results of a Baltic Sea research project** Kim Detloff, NABU e.V., Germany
	10:40	Discussion
	11:00	Coffee / Tea (30min)
	11:30	**Spatial and seasonal pattern of shrimp fisheries in the German Wadden Sea and adjacent North Sea** Hans-Ulrich Rösner, WWF, Germany
	11:50	Discussion
Marine Nature Conservation and Fisheries	12:10	**Gear technology concepts to support sustainable fishery** Daniel Stepputtis, Thünen-Institute, Germany

Wednesday, 16 September 2015		
	12:30	Discussion
Monitoring, Mapping & Methods, Part I	12:50	**Satellite Tracking to Create Transparency in Fishing** Alfred Schumm, WWF Smart Fishing Global Initiative
	13:00	Discussion
	13:30	Lunch (45min for participants of the excursions)
Excursions	14:15	Meeting point: Busses in front of the Ozeaneum.

Thursday, 17 September 2015		
Monitoring, Mapping & Methods, Part II	9:00	**Progress in marine biotope mapping in Germany** Roland Pesch, Bioconsult Schuchardt & Schuchardt, Germany & Dieter Boedeker, BfN, Germany
	9:20	**Investigation and classification of reefs in the German Baltic Sea (biotope mapping)** Alexander Darr & Kolja Beisiegel, IOW, Germany
	9:40	Discussion of the previous 2 talks
	10:00	**Conceptual ecological models in benthic habitats monitoring** Joe Turner, JNCC, UK
	10:10	Discussion
	10:20	**Managing long-term and large-scale data on marine biodiversity** Heiko Kalies, Gicon GmbH, Germany
	10:30	Discussion
	10:40	Coffee / Tea (30min)
	11:10	**UFOs in the North Sea - High tech for a modern and innovative monitoring of fish and other marine organisms** Joachim Gröger, University of Rostock, Germany
	11:20	Discussion

Thursday, 17 September 2015		
	11:30	**Porpoise Alerting Device (PAL): synthetic harbour porpoise (Phocoena phocoena) communication signals influence behaviour and reduce bycatch** Boris Culik, F3: Forschung-Fakten-Fantasie, Germany
	11:40	Discussion
	11:50	**Using high-resolution aerial imagery to assess populations of wintering waterbirds** Timothy Coppack, Institute of Applied Ecology (IFAOE), Germany
	12:00	Discussion
Ecosystem services	12:10	**Marine ecosystem services assessment to support marine management, from theory to practice** Diane Vaschalde, Agence des Aires marines protégées, France
	12:30	Discussion
	12:50	Lunch (1h)
Marine Strategy Framework Directive	13:50	**Assessing maintenance costs of marine ecosystems in the context of the MSFD** Remi Mongruel, IFREMER, France
	14:10	Discussion
	14:30	**Developing regional indicators to assess the status of marine biodiversity** Cristina Herbon, JNCC, UK & Jochen Krause & Nina Schröder, BfN, Germany
	14:50	Discussion
	15:10	**Healthy oceans by 2020 in the context of the MSFD – an NGO perspective** Nadja Ziebarth & Bettina Taylor, BUND e.V., Germany
	15:30	Discussion
	15:50	Coffee / Tea (20min)
Protection of endangered species and habitats, Part I	16:10	**HELCOM Red List of Species and Habitats** Ulla Li Zweifel, HELCOM, Finland & Dieter Boedeker, BfN, Germany
	16:30	Discussion

Thursday, 17 September 2015

	16:50	**What do population trends of seabirds tell us about the ecological conditions in the North Sea?** Stefan Garthe, Research and Technology Centre, University of Kiel, Germany
	17:10	Discussion
	17:30	**Population trends and anthropogenic threats of long-tailed ducks in the Baltic Sea** Kjell Larsson, Kalmar Maritime Academy, University of Linnaeus, Sweden
	17:50	Discussion
	18:10	**Feasibility of the restoration of the European flat oyster in the German Bight – opportunities and perspectives** Andreas Schmidt, Institute for Applied Ecology (IFAOE), Germany
	18:30	Discussion
	18:50	End of the session
	20:00	**Raising public awareness - marine nature conservation issues in films and videos** Meeting at the Conference Room

Friday, 18 September 2015

Protection of endangered species and habitats, Part II	9:00	**Identification of high risk areas for porpoise bycatch by use of data from remote electronic monitoring and satellite telemetry** Lotte Kindt-Larsen, University of Aarhus, Denmark
	9:20	Discussion
	9:40	**Effects of vessel noise on *harbor porpoise (Phocoena phocoena)* foraging activity** Danuta Wisniewska, University of Aarhus, Denmark
	10:00	Discussion
	10:20	**Genome-wide Single Nucleotide Polymorphism (SNP) analysis of *harbor porpoise (Phocoena phocoena)* improves population resolution in North and Baltic Seas** Ralph Tiedemann, University of Potsdam, Germany

Friday, 18 September 2015		
	10:30	Discussion
	10:40	**Distribution of Harbour Porpoises in the Baltic Sea - SAMBAH-Results** Mats Amundin, Project Coordinator SAMBAH, Kolmarden Djurpark, Sweden
	10:50	Discussion
	11:00	Coffee / Tea (30min)
Anthropogenic impacts on marine biodiversity	11:30	**Quieting Technologies for Offshore Pile Driving** Sven Koschinski, Meereszoologie, Germany
	11:50	**Measuring pile-driving noise and related potential effects on porpoises with special emphasis on the construction of the OWF Butendiek** Michael Dähne & Andreas Ruser, Institute for Terrestrial and Aquatic Wildlife Research (ITAW), University of Veterinary Medicine Hannover, Foundation, Germany
	12:10	Discussion of the previous 2 talks
	12:30	**Continuous underwater noise from activity in offshore wind farms: potential for environmental protection** Max Schuster, DW Ship Consult GmbH, Germany
	12:50	Discussion
	13:10	**Whales and ship strikes – how to mitigate a problem with many unknowns** Fabian Ritter, IWC & MEER e.V., Germany
	13:20	Discussion
	13:30	Closing of the Conference

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Can automatic longlines and jigging machines replace gillnets in bycatch conflict areas? Results of a Baltic Sea research project

Spatial distribution and temporal development in the use of the Wadden Sea and the adjacent North Sea by the German brown shrimp fishery, 2007-2013

Gear technology concepts to support sustainable fishery ("Tool + tool + tool = toolbox")

Satellite Tracking to Create Transparency in Fishing

Conceptual ecological models in benthic habitats monitoring

Managing long-term & large-scale data on marine biodiversity

„UFOs“ in the North Sea: High-tech for a Modern & Innovative Monitoring of Fish and Other Marine Organisms...

Using high-resolution aerial imagery to assess populations of wintering waterbirds

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HELCOM Red List of Species and Habitats

Annex

List of abbreviations

AMP	Azores Marine Park
BD	Birds Directive (BD, 2009/147/EC)
BIOTIC	Biological Traits Information Catalogue
CEM	Conceptual Ecological Model
CFP	Common Fisheries Policy
EEZ	Exclusive Economic Zone
GES	Good environmental status
HELCOM	Helsinki Commission
HD	Habitats Directive (HD, 92/43/EEC)
INP	Island Nature Park
IUCN	International Union for Conservation of Nature
JNCC	Joint Nature Conservation Committee
MarLIN	Marine Life Information Network
MPA	Marine Protected Area
MSFD	Marine Strategy Framework Directive
MSY	Maximum Sustainable Yield
OSPAR	Oslo-Paris Convention for the Protection of the Marine Environment of the North-East Atlantic
RSCs	Regional Seas Conventions
SAC	Special Area of Conservation
SCI	Site of Community Importance
VME	Vulnerable Marine Ecosystem
WFD	Water Framework Directive (WFD, 2000/60/EC)