Evaluation of Marine Environmental Research in Sweden

January 2010

Preface

The marine environment is a highly prioritized research area in Sweden. Due to several societal activities in the whole watershed, e.g. land-use, waste-water disposal, industry, transportation, fisheries and tourism, the pressure on the marine environment is substantial. For a sustainable use of the sea, it is of outmost importance to invest in sound research, creating the basis for effective management practices.

An important step in the continuous improvement of research funding is to evaluate the research already made and to analyse if and how the scientific knowledge is transferred to and used in society. The Swedish Research Council for Environment, Agricultural Sciences and Spatial Planning (Formas) received in its government approval document for 2009 the assignment to evaluate marine environmental research in Sweden in consultation with the Swedish Environmental Protection Agency (Swedish EPA). The evaluation should address the scientific quality of the research, as well as its societal relevance and importance for the management of the marine environment.

The evaluation comprised projects and programs that had funding from Formas and Swedish EPA between 2003 and 2008 and were finalised during this time-period. A part of the research performed within the Swedish Board of Fisheries was also included in the evaluation. Nearly 60 projects and two larger programs, in total amounting to a little more than 140 MSEK, were included in the evaluation.

The evaluation was performed by an international board made up by 11 active researchers and stakeholders/end-users. The board evaluated the individual projects and programs with reference to scientific and societal values and then summarized conclusions and recommendations for broader, thematic areas. The funding organisations are grateful to the evaluation board for its important and excellent work. Especially, the funders would like to thank Professor Laurence Mee from the Scottish Association of Marine Science, UK for his excellent work as chairman of the board.

The recommendations given by the evaluation board are highly appreciated by the funding organisations, and hopefully also by scientists and universities and university colleges. They will have a decisive influence of future research funding and performance. Most of the research was considered to be of very good quality in an international comparison, and there are a number of excellent and outstanding Swedish researchers within the field. However, the board also identified some areas with a challenging need for improvements, e.g. the transfer of relevant knowledge from scientists to stakeholders, interdisciplinary research and collaborations between researchers. The board concluded that there is a clear role for the funding organisations to facilitate the communication between the scientific and the societal worlds.

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Contents

Summary

The Swedish Research Council for Environment, Agricultural Sciences and Spatial Planning (Formas) was in the government approval document[1] for 2009 given an assignment to evaluate Marine Environmental Research in Sweden. The evaluation was to be undertaken in consultation with the Swedish Environmental Protection Agency (Swedish EPA) and include an evaluation of scientific quality as well as the societal relevance of the research. The evaluation included research projects and programs funded by Formas and the Swedish EPA, as well as a part of the research performed within the Swedish Board of Fisheries' operation. The evaluated projects and programs have been running between 2003 and 2008 in Sweden and have been finalised and reported within this time frame.

Formas and the Swedish EPA appointed an evaluation board of 11 active researchers and end-users from Sweden and other European countries during spring and summer of 2009. The board worked with the evaluation from August 2009 until January 2010 and had two meetings in Sweden during this period. In order to facilitate the work with the evaluation, the board decided to divide the individual research projects and[1] programs into five thematic areas; Biodiversity, Ecosystem structure and processes, Eutrophication, Toxicology, and Fish and Fisheries. The research performed by the Swedish Board of Fisheries (SBF) was evaluated separately by the Fish and Fisheries group. A group of 2 – 3 board members were made responsible for each thematic area.

The board agreed on a set of evaluation criteria and grades for the evaluation of single projects/ programs. An individual assessment of each project was made independently by 2 – 3 members of the board. At the second board meeting, each thematic group summarized its area and identified strengths and weaknesses of the area as a whole.

The board concluded that the scientific quality of the evaluated research is generally very high, at least comparable with any other country with a strong interest in marine science. On the other hand, the range of values between individual projects was quite large in some thematic areas, ranging from "satisfactory" to "outstanding". Projects within the thematic areas Biodiversity, Eutrophication and Toxicology were particularly highly rated for their scientific excellence.

The board noted that there was a clear positive relationship between the quality of the research and the amount of international and national collaborations. This reflects an international trend that high profile publications increasingly involve major inter-institutional collaborations. The board also noted that interdisciplinary research was seriously undervalued, which is interpreted as a result of funding schemes that tend to encourage single discipline work.

Regarding the societal aspects of the research, the board concluded that the research generally address important environmental problems with a high relevance for the society. However, the communication of results to relevant stakeholders and the involvement of stakeholders in planning of the research are in general poor. There is also a problem in itself that many of the scientists reported theses aspects of their research very poorly. The scientists must be encouraged and motivated to think about their research also in terms of usability and

[1] In Swedish: Regleringsbrev

beneficiaries, since this is not a strong driving force within the academic world. The research bodies can influence the development by actively engaging in these issues.

Sammanfattning

Forskningsrådet för miljö, areella näringar och samhällsbyggande (Formas) fick i regleringsbrevet för 2009 uppdraget att utvärdera marin miljöforskning i Sverige. Utvärderingen skulle genomföras i samråd med Naturvårdsverket och omfatta såväl forskningens vetenskapliga kvalitet som relevans, samt dess betydelse för åtgärdsarbetet i havsmiljön. Utvärderingen inkluderade forskningsprojekt och –program som finansierats av Formas och Naturvårdsverket, samt en del av den forskning som bedrivs av Fiskeriverket. De utvärderade forskningsprojekten och –programmen är sådana som pågått mellan 2003 och 2008 i Sverige och som blivit slutförda och slutrapporterade inom denna tidsperiod.

Formas och Naturvårdsverket utnämnde en utvärderingspanel bestående av 11 aktiva forskare och användare från Sverige och andra europeiska länder, under våren och sommaren 2009. Panelen arbetade med utvärderingen från augusti 2009 till januari 2010 och hade två möten under denna tidsperiod. För att underlätta arbetet med utvärderingen delades de individuella projekten och programmen in i fem olika teman; biodiversitet, ekosystemens struktur och funktion, eutrofiering, toxikologi och fisk och fiske. Fiskeriverkets forskningsprojekt utvärderades separat av fisk och fiskerigruppen. Ansvaret för varje tema delades av 2 – 3 personer i panelen.

Utvärderingspanelen tog med hjälp av forskningssekreterare vid Formas och Naturvårdsverket fram de utvärderingskriterier och betygssteg som användes vid utvärdering av enskilda projekt/ program. En oberoende utvärdering av varje projekt genomfördes av 2 – 3 personer i panelen. Vid det andra panelmötet summerades varje temaområde och generella styrkor och svagheter identifierades.

Utvärderingspanelen konkluderade att den vetenskapliga kvaliteten på forskningen generellt sett är mycket hög, åtminstone jämförbar med andra länder med ett starkt intresse i marin miljöforskning. Emellertid varierade kvaliteten på de enskilda projekten mycket i vissa temaområden – från ”tillfredställande” till ”enastående”. Projekt inom temaområdena biodiversitet, eutrofiering och toxikologi var särskilt uppmärksammade för sin vetenskapliga excellens.

Panelen noterade att det fanns ett tydligt positivt samband mellan forskningens kvalitet och i vilken mån nationellt och internationellt samarbete bedrevs. Detta reflekterar en internationell trend där publiceringar med hög profil allt oftare inkluderar samarbeten mellan olika institut och länder. Panelen noterade också att interdisciplinär forskning fortfarande är allvarligt undervärderad, vilket tolkas som ett resultat av att forskningsfinansieringens genomförande tenderar att uppmuntra disciplinär forskning.

När det gäller forskningens samhälleliga relevans och användarvärde, konkluderade panelen att forskningen generellt sett adresserar viktiga miljöproblem som har hög relevans för samhället. Emellertid är kommunikationen av forskningsresultat till relevanta användare och problemägare generellt sett undermålig. Panelen ansåg det också vara ett problem i sig själv att många forskare rapporterade denna aspekt av sin forskning mycket dåligt. Forskare bör därför uppmuntras och motiveras att tänka på sin forskning i termer av användbarhet och

mottagare, då detta idag inte är en uttalad drivkraft inom den akademiska sfären. Här kan forskningsråden utöva stort inflytande genom att aktivt arbeta med dessa frågor.

Background

The assignment of evaluating Marine Environmental Research in Sweden was given to the Swedish Research Council for Environment, Agricultural Sciences and Spatial Planning (Formas) by the Ministry of the Environment in the government approval document for 2009. The government approval document states that the evaluation shall be made in consultation with the Swedish Environmental Protection Agency (Swedish EPA) and include an evaluation of scientific quality as well as the societal relevance of the research.

The purpose of the evaluation is not explicitly stated in the government approval document. It is Formas' and Swedish EPA's interpretation that the aim of the evaluation is to assess if the governmental investments in research are used in a proper manner and if the research contributes to better management of the marine ecosystems. The evaluation will broadly answer the following questions:

1. Does the marine environmental research in Sweden have high enough quality?
2. Does the research match the environmental problems?
3. Is the research adapted to the needs of societal users?
4. Are there existing mechanisms for transfer of knowledge between researchers and users?

From the funding bodies' perspective, the outcome of the evaluation can be valuable for authorities with responsibility for marine environmental issues and for the Ministry of the Environment, who will get a better picture of the use of research funds and if the research contributes to a sound management of the marine environment. The outcome can also be valuable for universities and university colleges that prosecute research within the marine area. The evaluation may also have a strategic impact on future investments within the research area.

Marine environmental research is a wide concept. Formas and Swedish EPA have chosen to only include projects and programs that have a direct connection to marine environmental issues, management of the marine environment and research relevant for the Swedish marine environmental goals. Thus, research about physiology, ethology, systematics and more basic research-issues, yet in the marine environment, have been excluded. We have also chosen to exclude research about marine monitoring, as well as more technical research. Some parts of the fisheries research performed by the Swedish Board of Fisheries (SBF) are included in the evaluation. These SBF projects have direct bearing on marine environmental issues. SBF projects that deal with fishing gear development, data collection or monitoring issues are thus not included in the evaluation.

The evaluation includes research projects and programs that have been running between 2003 and 2008 in Sweden and have been finalised and reported within this time frame. The total funding for the evaluated projects amounts to 140.5 MSEK, of which 66.1 MSEK is Swedish EPA's funding of the marine programs "Marbipp" and "AquAliens", 39.1 MSEK is Formas' funding of marine environmental projects and 35.3 MSEK is the SBF's projects on fisheries research connected to marine environmental issues.

To collect data from the researchers, Formas and Swedish EPA sent out a questionnaire to project leaders in May 2009. The questionnaire can be found in Annex II of this report. Besides reporting on their main activities, methods and principal results, the researchers were also asked to send in an up to date CV and reprints of the two most important publications from the project at hand.

The questionnaire was sent to the project leaders of the Swedish EPA-funded programs Marbipp and AquAliens, and to 54 project leaders of Formas-funded projects. Questionnaires for the SBF projects were administrated by the head of the research and development unit at the SBF.

Of the 54 Formas-funded projects, only 40 project leaders responded to the questionnaire despite three reminders. This corresponds to a percentage of answers of 74 %. The number of replies and no replies from the different universities and university colleges can be found in table 1.

Table 1. Number of replies per university.

University/ University college	Number of questionnaires sent	Number of replies (i.e. number of projects in evaluation)	Number of no replies
Göteborg University	21	17	4
Stockholm University	17	11	6
Lund University	3	3	-
Umeå University	2	2	-
Uppsala University	2	2	-
Linköping University	1	-	1
Kalmar University college	4	2	2
Gotland University college	1	1	-
Swedish Museum of Natural History	1	1	-
Södertörn University college	1	1	-
Luleå University of Technology	1	-	1

Marine Research in Sweden – an overview of main funding organisations and research areas

During the first years of the 21st century, marine research in Sweden has been funded by about 135 MSEK yearly (Table 2). This funding includes all kinds of research that is related to the marine environment and includes basic, as well as applied science. Apart from this funding, research is also supported by governmental grants directly to universities and university colleges. Primarily, the governmental grants fund positions at the universities and university colleges.

Table 2. Funding of marine research by public funds (numbers from the Final report from the Marine Environment Commission. In Swedish: En utvecklad havsmiljöförvaltning. Slutbetänkande av havsmiljöutredningen, SOU 2008:48).

Funding Organisation	**Million SEK per year (mean of 2002 – 2006)**
Formas	34
The Swedish Research Council (VR)	34 (mean of 2004-2006)
Mistra	30
Sida/SAREC	20
Swedish EPA	11
Swedish Energy Agency	2.4
Swedish Space Agency	2.1
Swedish Species Information Centre	1.4
SUM	**134.9**

Formas is one of the main financers of marine research in Sweden, and supports basic and applied science within the areas environment, agricultural sciences and spatial planning. The main part of Formas' funding is distributed yearly in open calls and a smaller part is distributed in special calls on more focussed topics. Formas had specific calls for marine environmental research during 2003 – 2007, amounting to about 10 MSEK annually. Formas has also launched special calls within the areas of social sciences' environmental research, ecotoxicology, biodiversity and climate change, all which in some way are connected to the marine environment.

The Swedish Research Council (VR) is the other main financer of marine research in Sweden. VR has a focus on basic science and distributes the main part of its funding in open calls.

The Swedish EPA finance research that brings forward data to support the work with the national environmental goals, environmental legislation and international negotiations. In addition, Swedish EPA funds specific projects that can find solutions for the internal environmental work at Swedish EPA. The Swedish EPA has, together with Mistra, co-financed several cross-disciplinary marine projects during the last 10-15 years.

The Foundation for Strategic Environmental Research (Mistra) work for sustainable development by supporting collaborations between researchers and stakeholders/practitioners,

with the aim is to solve environmental problems. Mistra has been a main financer in the marine area during the last 10 – 15 years, with programs like Sucozoma (Coastal Zone Management) and MARE (Marine Research on Eutrophication). Presently (2010), there is only one Mistra-financed program running, with the goal to bring forward an ecologically sound anti-fouling product (Marine Paint).

New initiatives for the marine environment

The European ERA-net BONUS lunched a call in 2007 (BONUS Plus Call) with the aim to finance research dealing with the Baltic Sea environment, its environmental problems and management. In each research project within BONUS Plus, researchers from at least two countries participate. The overarching aim is to strengthen the link between science and society, and that the management of the marine environment should be based on the ecosystem approach. The BONUS projects started up during 2008 and the total budget is about € 23 million over three years. Formas fund the BONUS projects by 10 MSEK and the Swedish EPA by 5 MSEK per year. About one third of the total funding of the BONUS Plus projects comes from the European Commission.

During 2008, the Swedish EPA in cooperation with Formas, VINNOVA and Baltic Sea 2020, launched a call for pilot studies for oxygenation of anoxic bottoms and precipitation of phosphorus. Two projects received totally about 15 MSEK each for three years of studies, and the activities has started during 2009.

Marine research at universities, university colleges and authorities

Research relevant for the marine environment is carried out at Stockholm University, Göteborg University and Umeå University – here the national marine centres are also located. Marine environment research is also carried out at e.g. Lund University, Kalmar University College, Gotland University College, Uppsala University, Södertörn University College, The Royal Institute of Technology (KTH), Chalmers University of Technology, Luleå University of Technology, the Natural History Museum and Swedish University of Agricultural Sciences (SLU).

An extensive part of the **Swedish Board of Fisheries' (SBF)** operation is research and development activities, aiming at increased knowledge about fish stocks, fishing gear and the environmental effects of fishing. The goal for the knowledge-based activities is to increase and distribute knowledge for the benefit of a long-term sustainable fishery, leisure fishing, fishing tourism and aquaculture.

At the **Swedish meteorological and hydrological institute's (SMHI)** research division, research about weather, water, climate and environment is carried out. At the oceanographic division physical oceanography, biogeochemistry and ice conditions are studied.

The **Geological Survey of Sweden (SGU)** carries out applied research and development activities, also in the marine environment. These activities are mainly focussed on GIS (Geological Information Systems) applications and marine geological mapping.

The **Swedish Defence Research Agency (FOI)** carries out research about acoustic and electromagnetic signal's propagation in submarine environments. At the agency new methods

for calculations and simulations, as well as for sensors and monitoring of the aquatic environments, are developed.

Other research institutes that carry out marine research

Stockholm Resilience Centre (SRC)
SRC was founded in 2007 and is a collaboration between Stockholm University, The Beijer Institute of Ecological Economics and the Stockholm Environmental Institute. The Centre is financed by Mistra by in total 105 MSEK during the starting period (2007 – 2013). After this period, the Centre can be supported by an additional 20 MSEK per year for 5 years. At the Centre, the research is focussed on how human welfare and ecosystem health can co-develop to secure sustainable development for the whole planet. SRC also constitutes a platform for dialogue among politicians, authorities and other stakeholders at local, regional and global levels. Much emphasis is put on communication and spreading of information. The centre will have about a hundred researchers representing natural sciences, social sciences and humanities bound to it.

Baltic Nest Institute (BNI)
The BNI was founded in 2007 and is situated next to SRC in Stockholm and at the National Environmental Research Institute at Aarhus University in Denmark. The BNI originates from the Mistra-program MARE (MArine Research on Eutrophication). Within the MARE program, a user-friendly decision-support system was developed and is supposed to be used by decision makers around the Baltic Sea. The system (called NEST) visualises the most cost-effective measures needed to attain one or several environmental quality goals (e.g. a reduction in nitrogen concentration by a certain percentage) in the Baltic Sea. The user can, by changing the prerequisites for the system, create different scenarios for a range of measures in different parts of the Baltic Sea area. The decision support system is used in HELCOM's work and has been the basis for the agreements on emission limits within the Baltic Sea Action Plan. The development of the NEST system is a continuous process at BNI.

The Marine Environment Institute
The Commission for the Marine Environment (Havsmiljöutredningen) suggested in its interim report (SOU 2006:112) that a new Swedish Marine Environmental Institute shall be established. The institutes' duties will be e.g. to give scientific support to monitoring, make syntheses in support of different authorities' work with the marine environment, to improve communication between researchers and people involved in monitoring and remedial measures, and inform the public and stakeholders / politicians of the state of the marine environment. The institute will consist of four parts, where the marine centres in Stockholm, Umeå and Göteborg are three and a fourth will be established at Kalmar University College. The Marine Environment Institute was formally opened in July 2008 and its main office is located in Göteborg. The activities have to date (January 2010) not yet fully started.

The Evaluation Board and its mode of operation

The Evaluation board comprised:

Professor Laurence Mee (Chair), Director and Professor of Marine and Coastal Policy, Scottish Association for Marine Science (SAMS), UK

Mr. Mats Abrahamsson, Environmental Consultant, Sweden

Professor Valery E Forbes, Professor of Ecotoxicology, Roskilde University, Denmark

Dr. Gerd Hubold, Secterary General, ICES (International Council for the Exploration of the Sea)

Professor Michel J Kaiser, Professor of Coastal Resource Ecology, University of Wales-Bangor, UK

Professor Johanna Mattila, Professor of Coastal Ecology, Åbo Akademi, Finland

Professor Victor Smetacek, Professor of Biological Oceanography, Alfred Wegener Institute, Germany

Dr. Karin Pettersson, Assistant director, Water District Authority and Water protection Section, County Administrative Board of Västra Götaland, Sweden

Dr. Eeva-Liisa Poutanen, Environment Counsellor, Ministry of the Environment, Finland

Professor Isabel Sousa Pinto, Professor of Coastal Biodiversity, University of Porto, Portugal

Dr. Petra Wallberg, Marine Environment Unit, Swedish Environmental Protection Agency

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The evaluation board met in Stockholm on 9 – 10 September and in Sigtuna on 2 – 4 December 2009. At the first meeting, the funding bodies presented their approach to the evaluation and the board discussed and determined the procedures to be followed. The board decided to divide the individual research projects/ programs into five thematic areas; Biodiversity, Ecosystem structure and processes, Eutrophication, Toxic Chemicals and Fish and Fisheries, in order to facilitate the evaluation. A group of 2 – 3 board members were made responsible for each thematic area. The research funded and performed by the Swedish Board of Fisheries (SBF) was evaluated separately by the Fish and Fisheries group.

The data available for the evaluation board was a questionnaire (Appendix II) that was sent out to the researchers / principal investigators in May 2009. In addition to the questionnaire, the researchers were requested to provide a current CV and the two most important peer-reviewed publications from the project at hand.

In between the two meetings, all members of the board reviewed and evaluated the individual research projects in their respective thematic areas (the evaluation form is found in Appendix III). Each board member also summarised all projects in a written thematic area report that was circulated to the other board members prior to the second meeting.

At the second board meeting in December, the focus was to discuss and summarise the thematic areas, as well as the overall conclusions and recommendations. In addition, a presentation of the citation analysis (Appendix I) was given by Magnus Gunnarsson, Swedish Research Council at the meeting.

In total, the board has evaluated 40 Formas-funded projects, 2 research programs funded by the Swedish EPA and 17 projects performed by the Swedish Board of Fisheries.

Overall conclusions and recommendations

It is essential for research councils to conduct periodic evaluations of the effectiveness of their investments. Marine environmental science is strategically important for Sweden and scientific research is increasingly necessary to answer key questions related to the development and implementation of environmental legislation, to identify emerging issues and solutions and to help the country undertake its international commitments, particularly within the context of the EU Water Framework Directive and the Marine Strategy Framework Directive.

In this context, four questions were posed for the evaluation to answer at a comprehensive level:

- Does the marine environmental research in Sweden have high enough quality?
- Does the research match the environmental problems?
- Is the research adapted to the needs of societal users?
- Are there existing mechanisms for transfer of knowledge between researchers and users?

The study brought together three techniques for measuring the performance of marine research projects:

1. External peer review of project summary sheets prepared by the scientist responsible for each project and the key open literature publications generated
2. Numerical scoring of the projects using agreed common criteria
3. Metrics of the overall scientific output by the sector that enabled benchmarking against marine science in other countries (Appendix I)

The peer review team included experienced national and international specialists and representatives of science user groups. The reviewers had the opportunity to work individually and collectively. Although all projects were carefully examined, the objective was not to report on individual projects but to produce thematic evaluations, noting strengths and weaknesses and selecting a few exemplary case studies to illustrate what the reviewers jointly regard as good practice. Thematic areas selected were eutrophication, toxicology, ecosystems, fisheries (projects undertaken by the Swedish Board of Fisheries were considered separately) and biodiversity (with Swedish EPA and Formas projects considered separately). Individual projects were allocated to these themes by the review team, understanding that there were overlaps between them.

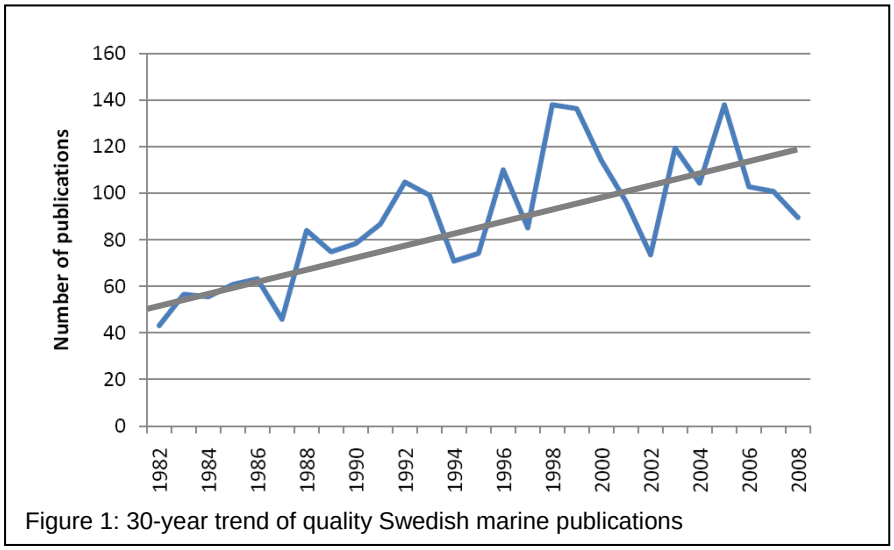

Figure 1: 30-year trend of quality Swedish marine publications

The overall analysis of metrics was conducted independently (Appendix I) and clearly demonstrates that, measured by scientific output, Swedish marine science is on a par with other countries in Europe. Swedish

scientific publications in this area have shown an almost three fold growth over the past 30 years as illustrated in Figure 1 (fluctuations around the trend line are not unusual). Production has increased by some 50% since the previous review in 1993. High quality marine research is clearly important in Sweden.

A full analysis of the scores for each thematic area is provided in the chapters for each area and the meaning of the scores used can be found in Appendix III. The criterions used are explained in Table 3. As would be expected, the range of values between individual projects was quite large in some cases. Table 4 illustrates the mean scores per thematic area. The review group was satisfied that the criteria were applied in an objective and even-handed manner between the various thematic areas. A more detailed analysis of the scientific and social implications is given below.

Table 3. Criterions used for evaluation of projects.

A. The scientific quality of the project	**B. The relevance and use of the research in society**
1. Used methods (appropriate and up to date?)	1. Production of useful and accessible knowledge for relevant stakeholders
2. Innovation and new ideas	2. Communication with appropriate stakeholders
3. International and national collaboration	3. Has the research led to measurable or foreseeable changes in policy or practice
4. Production of peer-reviewed articles and other scientific publications	4. Summary – overall societal relevance and importance
5. Capacity building (i.e. to what extent the project has contributed to MSc, Lic, Dr)	
6. Summary – overall scientific quality	

Table 4. The mean scores per thematic area.

Criterion	**Eutrophi-cation**	**Toxicology**	**Ecosystems**	**Fisheries**	**SBF**	**Biodiversity Formas**	**Biodiversity SEPA**
Scientific quality							
A1	*7.3*	*5.4 (range 0-7)*	*5.3*	*6.6*	*5.5*	*7.3*	*6*
A2	*7*	*5.7*	*4.9*	*6.3*	*5.3*	*6.3*	*6*
A3	*5.1*	*5.3*	*4.9*	*5.9*	*5.1*	*4.8*	*5*
A4	*6.7*	*5.4*	*4.4*	*6.3*	*6.2*	*6.3*	*6*
A5	*6.4*	*5.2*	*4.4*	*5.1*	*2.9*	*4.3*	*6*
Summary	**6.7**	**5.6**	**5.2**	**5.8**	**4.9**	**6.8**	**6**
Societal relevance							
B1	*5.3*	*6.0*	*4.6*	*5.4*	*4.7*	*5.0*	*6*
B2	*3.2*	*4.7*	*3.5 (range 2-7)*	*5.4*	*4.2*	*2.5*	*6*
B3	*2.3*	-	*3.2*	*5.5*	*3.8*	*2.5*	*5*
Summary	**4.6**	**-**	**3.9**	**5.2**	**4.3**	**4.0**	**6**

A more statistically rigorous analysis of the summary scores is shown in Figure 2. This illustrates the clear difference between scores for scientific aspects (A) of the projects and for their societal impacts (B). It is worth bearing in mind that scores of over 6 place projects in the 'Very Good' and 7 or over as 'Excellent'. Projects in biodiversity, eutrophication and toxicology were particularly highly rated for their scientific excellence. Conversely, almost no projects were rated above 7 (research addressing an important challenge for sustainable development and project outcome which may be highly beneficial for society) for their societal aspects.

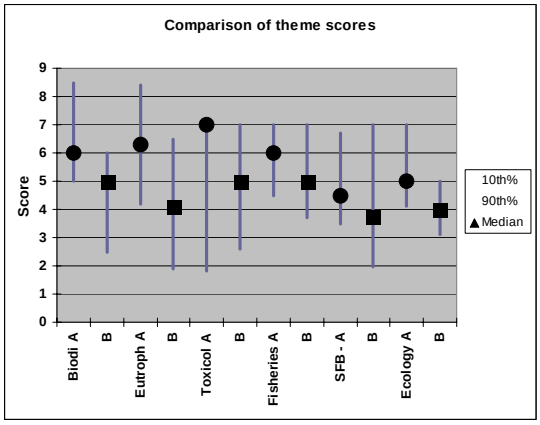

Figure 2. Median and 10-90 percentile range of the theme scores. Filled circles refers to scientific value and filled squares refers to societal value.

Some output results broken down by funding body

The evaluation board recognises the differences in scope and types of funding schemes that characterise the three funding bodies. Nevertheless, a comparison can still be of use for future strategies of the funding bodies. Table 5 summarises the total amount of funding, and the output in terms of publications, PhD theses and Master theses per MSEK.

Table 5. Funding and output per funding body.

Funding body	Total funding (MSEK)	Publications per MSEK	PhD theses per MSEK	Master theses per MSEK
Formas	39.11	3.98	0.84	1.63
Swedish EPA	66.10	1.41	0.24	0.51
Swedish Board of Fisheries	35.25	0.20	0.06	0.26

Scientific aspects of the projects reviewed

The overall scientific quality and development of science capacity can be summarised as follows:

- The quality of science is generally very high, at least comparable with any other country with strong interest in marine science.
- There is no clear positive relationship between quantity of money and quality of research and there is a clear role also for small research projects. Some scientists made clever use of small amounts of funding to attract additional support or complete work that had been partly supported elsewhere.
- There was a clear positive relationship between quality of research and national and international collaborations. This reflects an international trend; high profile publications increasingly involve major inter-institutional collaborations.
- Interdisciplinary science is still seriously undervalued (i.e. both within natural sciences and between natural sciences and e.g. social sciences). This is largely a consequence of the funding schemes that still tend to encourage single discipline work.

- Capacity building should be important in all areas. We note that the SBF was much poorer in this respect compared to the universities. We appreciate that the SBF has a different primary purpose but still consider that it should be more actively involved in forming new capacity.

Societal implications of the research

Evaluation of the societal implications of the research proved quite difficult because many of the researchers provided poor information on this aspect of their work. Reporting on the potential impacts of research often takes natural scientists out of their 'comfort zone'. This is not a problem unique to Sweden and is a matter being addressed by research councils in many countries. The inclusion of research-policy specialists and users of research in the evaluation helped to make a more objective assessment of these aspects of the work. We concluded that:

- Generally speaking, most of the research addresses important environmental problems with high relevance for the society.
- In the call texts and instructions to applicants (applies to Formas special calls on marine environment research) no explicit requirements that stakeholders should be involved in the projects were stated and this may have led to some confusion by scientists asked to report on this aspect of their research.
- There is clearly a mismatch/barrier between scientists and policy makers/ stakeholders. From the evaluation it seems almost random which projects or subject areas that succeeded in communicating their results with relevant stakeholders. There are examples of excellent science that would fit perfectly into the policy area but the scientists didn't appear to bother to make the link. There are also examples of where the scientists really tried to communicate but did it in the wrong way.
- There is a great gap between policymaking and science. Often technical reports and implementation schemes are not using up-to-date research results and therefore "blocking" a sound communication between science and policy.

Recommendations

Our overall recommendations are aimed at maintaining the excellent quality and competitiveness of Swedish marine science whilst making optimal use of it to address issues of societal concern. In doing so, we also recognise that some research will not have immediate use for policymaking but will produce benefits well downstream, perhaps when applied by other scientists who base their work on the building blocks constructed by others. The development of these building blocks should continue to receive support but there needs to be a balance between this work and work that addresses pressing societal needs. We consider that:

- Funding agencies should take active part in facilitating interdisciplinary research, e.g. by launching problem-focused calls. This approach has proven to be very effective in other countries.
- In order to encourage scientists to engage with stakeholders, the instructions to applicants must be really clear. There are good examples, e.g. from the UK – the NERC implementation plan, from which Swedish research councils can learn. The

NERC implementation plan is a scheme which aims at helping the researchers to focus on how they will deliver policy relevant science and maximise its impact.

- Support can be given to the development and application of decision support tools. To be effective, these must involve an active collaboration between scientists and the relevant stakeholder from the outset.
- The reward system within universities needs to be changed so that communication with stakeholders and making science more accessible to a broader audience is more highly valued. Funding organisations can make a change here by allocating a proportion of their funding to support researchers that genuinely engage in stakeholder communication, and by bringing scientists and stakeholders together. There are many innovative schemes for funding science for policy programs including bursaries for scientists to work with policy makers, the media and other stakeholders and also to fund politicians to spend short periods of time in a scientific institute. None of this will happen however unless such activities are given a higher value in academic or political circles.

Thematic area – Biodiversity

Conclusions / Recommendations

The assessed research in biodiversity was considered of very high quality as a whole, with projects ranging from good to excellent in scientific quality. The body of knowledge produced is of high societal importance and can be of great assistance to conservation policy makers and managers. However, in some cases this knowledge was not properly disseminated to the relevant stakeholders or to the general public and was presented only to a scientific audience: *some of the best results in terms of their potential to have an important impact to society demonstrated the least evidence of active dissemination.*

To improve the dissemination research findings of relevance to society, it is suggested that researchers should be rewarded if they are successful in seeking collaboration with external relevant bodies (other researchers and/or stakeholders) in their research. Engagement with science users from the beginning of the project (proposal writing stage) should be encouraged to maximize downstream impact and uptake at the policy level. The Marbipp and AquAliens programs are good examples of an attempt to achieve this.

For the dissemination to the general public it is suggested that Formas takes this role centrally to allow for a more professional and coordinated approach that might not be possible with smaller projects that are likely to achieve a disparate and inconsistent output of public dissemination.

Description of the thematic area, incl. statistics

Research on biodiversity addressed several important issues including the patterns and processes in different marine ecosystems, mainly in shallow-water but including important work on deep water coral reefs, genetic biodiversity and speciation, biodiversity indicators and alien species. Other important areas as the role of biodiversity on ecosystem functioning and on ecosystem services, and the valuation of these services was also well represented, resulting in some very high impact publications. This research has high societal relevance because it provides knowledge and a robust evidence-base for the need to protect biodiversity. Accordingly, this research has high policy relevance in relation to EU and international conventions. The knowledge produced also provides valuable inputs for management of species and habitats, and assists in the identification of important threats to the quality of the marine environment.

This research produced excellent scientific results that are important for policy and e.g. it demonstrated that maintenance of a high biodiversity of consumers will significantly increase overall consumption of primary producers and that a loss of consumer diversity may lead to excessive biomass accumulation of producers, e.g. blooms of plankton or benthic filamentous algae.

Table 6. An overview of expenditure and outputs

Project No	Total funding	Senior scientists	PhD students	Publi-cations	Submit. Ms	PhD thesis	Lic thesis	Master thesis
AquAliens	30 400 000	17	10	35	8	5	3	16
Marbipp	35 700 000	19	11	58	7	11	2	18
F-Bio 1	585 000	1	1	3		1		1
F-Bio 2	1 026 000	1	1	8		1		3
F-Bio 3	2 042 000	2	1	1	1		1	2
F-Bio 4	805 000	1		5				
Total Swedish EPA	*66 100 000*	*36*	*21*	*93*	*15*	*16*	*5*	*34*
Total Formas	*4 458 000*	*5*	*3*	*17*	*1*	*2*	*1*	*6*
Total:	**70 558 000**	**41**	**24**	**110**	**16**	**18**	**6**	**40**

Scientific quality

Table 7

Question	Score	Comment
1. Used methods (appropriate and up to date?)	7	Most of the methods used were appropriate and up to date
2. Innovation and new ideas	7	The themes selected and the publications that resulted from the projects were within the current discussions and important research issues. The projects ranged from good to excellent in innovation and new ideas
3. International and national collaboration	5	There was some international collaboration but this could be enhanced, especially collaborations outside the Nordic countries. This aspect was uneven throughout the Biodiversity area
4. Production of peer-reviewed articles and other scientific publications	7	In average the publications produced by the projects reviewed were very good with evidence of excellence.
5. Capacity building (i.e. to what extent the project has contributed to MSc, Lic, Dr)	7	The programs produced a good number of PhDs and master students and were a very good capacity building instrument

6. Summary – overall scientific quality

Score	Comment
7	The overall scientific quality of the research in this field is very good and at high international level

Strengths and weaknesses

The research produced some top level scientific publications, with new and some paradigm shifting scientific results and good number of publications as a whole. The Swedish EPA programs were multidisciplinary and included researchers from genetics to economic valuation. The latter was a considerable strength and may have led to the high impact of the

resulting outputs. The research undertaken dealt with most of the current important issues in biodiversity research.

International cooperation in the projects occurred mostly with Nordic countries. Some important issues like climate change (and acidification) and their interaction with biodiversity and with the introduction and dynamics of alien species where not dealt with adequately within the assessed projects. This topic is addressed in other areas but in programs such as *Marbipp* and *AquAliens* it is surprising not to see this issue properly addressed.

Relevance and use of the research in society

Table 8

Question	Score	Comment
1. Production of useful and accessible knowledge for relevant stakeholders	7	All the projects produced results that are in principle relevant for stakeholders, mostly for conservation managers and could also be useful for other sectors (e.g fisheries, transport)
2. Communication with appropriate stakeholders	5	Most of the projects showed an attempt to communicate their results to stakeholders and to produce publications or other deliverables appropriate for non-scientists. Some of the knowledge that is communicated through the Marbipp website and included in the AquAliens report seems to be very well adapted to their "users". However, for some of the other projects, the quality of communication with stakeholders was low and was identified as a main weakness of this program
3. Has the research led to measurable or foreseeable changes in policy or practice	-	Very hard to judge with the information provided. The measurability could be improved through a survey among policy makers and other 'science user groups'.

4. Summary – overall societal relevance and importance

Score	Comment
5	As a whole the results produced by this research improved the knowledge and robust evidence-base especially for improving the justification for the conservation of biodiversity. It also produced knowledge that can be useful for management e.g. mapping of genetic diversity, indicators and knowledge on alien species. There were some successful efforts to communicate with stakeholders but more could have been done and *an integration of the relevant stakeholders in the planning of the research can better shape the results to the needs of these stakeholders*. With the current practice there is the potential for missed opportunities of dissemination of findings of great societal importance

Strengths and weaknesses

The research on biodiversity produced knowledge and a robust evidence-base that can be used especially for policy and management related to conservation of the main marine habitats and species. There was also production of knowledge that is relevant for some sectors as fisheries and transport and for the management of alien species. The Marbipp website is a useful and well used tool for conservation and resource managers (see “best practice” communication example below).

There is still a lack of appreciation of science users’ needs and how to deliver usable outputs and tools to these stakeholders. Some of the research doesn’t seem tailored to respond to urgent societal demands, but more to the scientific interest of the researchers. Often, there seems to be too much of a disconnect between the producers and the users of this science.

Important issues not addressed within the area

It was difficult to determine the lack of research in some areas, since aspects of biodiversity were also addressed within other thematic areas. A major area that was apparently not addressed in depth was the interaction between climate change and biodiversity.

Project highlighted as ‘best practice’

The Marbipp program produced excellent research results with high societal relevance. In addition they also built a website (www.marbipp.se) that is a good example of how a research project can communicate sections of its results to a specific user group. The Marbipp project contacted controlling and managing authorities to get a better picture of their needs. The project then created a website with a box of tools for these specific needs. The toolbox contains some of the knowledge produced by the program and very hands-on advice for conservation and resource managers.

Thematic area – Ecosystem structure and processes

Conclusions/Recommendations

Most of the projects were located on the fringes of proper ecosystem research, whereas a few were of high quality and did justice to this theme area. This disparity had an effect on the overall rating which has to be pointed out at the onset. Our major recommendation is to encourage more ecosystem-oriented research, as this will enhance interdisciplinary cooperation, pool talents and produce results which are more likely to be communicated to stakeholders. The ongoing effects of climate change are an added incentive to intensify research effort based on the ecosystem approach. Guidelines for applicants will need to be complemented with examples of good practice (exemplary projects).

The Baltic has a long history of ecosystem research carried out with the intention of elucidating basic processes but also of ascertaining the effects of human impact in order to apply mitigation measures. Further, it is now widely agreed that the ecosystem approach is the most appropriate way to understand the effects of human impacts on the marine environment: from fisheries and eutrophication to coastal development. Public awareness of environmental issues is particularly well developed in Sweden, implying that there is a large body of potential stakeholders interested in the outcome of this research and the efficacy of the measures undertaken. Against this background one would expect more vigorous ecosystem-oriented research than represented by many of the projects we had to review.

There were some excellent projects that could serve as role models. High-lighting such successful projects would help scientists applying for research funding to organise their research in a relevant manner and demonstrate to them how to interact directly with stakeholders. Generally, scientists concentrate on writing papers read by their community and are able to judge the quality of their research from the literature. However, they are often not aware of the criteria that make up a successful project, from capacity building to interacting with stakeholders. Guidelines written as rules are often too abstract to be followed. Making selected reports of successful projects accessible to applicants would help them understand what is required of a research project funded by an environmental agency.

Description of the thematic area, including statistics

The projects included in the thematic area “Ecosystems” are scattered over a broad range of topics and were hence difficult to judge as a whole. Many of the projects were concerned with only a small part of the ecosystem. A proper understanding of the structure and functioning of ecosystems is a prerequisite to assessing the effects of human impacts, both direct effects due to over-fishing and pollution, or indirect ones by shifts in nutrient loading or climate. This topic was in the forefront of research from the 1970s onward but, like many other themes in the broader field of marine environmental research, has lost some of its appeal without central questions, such as factors controlling ecosystem structure and functioning, being adequately answered. The projects included in this thematic area ranged from development of methods to the investigation of properties of key organisms, with actual studies of ecosystem structure and processes in the minority. The lack of cohesion between the projects could be due to fragmentation of the field, or to researchers being attracted to other fields such as biodiversity. Certainly, it is not due to the problems dealt with in the past having been resolved. Because of this diversity it is difficult to make an overall assessment of the research being carried out in

this thematic area that would do justice to the individual projects. Many of the topics are interesting in their own right but the overarching, interdisciplinary spirit of the 1990s seems to have faded a bit and would require active encouragement. Many ecologists have been attracted to new topics such as biodiversity and impact of introduced species, or are digging deeper into issues such as ongoing eutrophication and there are some projects within the thematic areas "Biodiversity" and "Eutrophication" with an ecosystem approach. So our assessment has to be viewed in this light.

Table 9. An overview of expenditure and outputs

Project number	Total funding	Senior scientists	PhD students	Publica-tions	Submit-ted ms	PhD thesis	Lic thesis	master thesis
Eco 1	208 000	1		3	1		1	
Eco 2	1 350 000	1			1			1
Eco 3	429 000	1						
Eco 4	1 525 000	1	2		7	1		1
Eco 5	1 498 500	4			3		1	1
Eco 6	648 000	1	1	4				1
Eco 7	1 034 000	1	1	6		1		
Eco 8	1 633 000	1		7				3
Eco 9	247 000	2						
Eco 10	2 040 000	1	1	2	2	1		1
Eco 11	2 900 000	2	2	4		2		
Eco 12	700 000	1	1	3	1	1		
total	*14 212 500*	*17*	*8*	*29*	*15*	*6*	*2*	*8*
mean	*1 184 375*	*1.4*	*1.3*	*4.1*	*2.5*	*1.2*	*1.0*	*1.3*

Scientific quality

The average score on each question in the evaluation form are presented in table 10.

Table 10. Average score per evaluation criteria

Question	Average
1. Used methods (appropriate and up to date?)	5.3
2. Innovation and new ideas	4.9
3. International and national collaboration	4.9
4. Production of peer-reviewed articles and other scientific publications	4.4
5. Capacity building (i.e. to what extent the project has contributed to MSc, Lic, Dr)	4.4
6. Summary – overall scientific quality	5.2

Strengths and weaknesses

In most of the projects the scientific methods are at a strongly competitive international level and otherwise competitive on a national level. One of the projects is still not finished in the part that could bring something new to the area and therefore lowered the points. Most of the projects are not as strong concerning innovation and new ideas but most of them are still very

good. Nearly all the projects have collaboration with others on a national level and some of them are excellent also in their international collaboration. Not all of the projects have published their results so far and some of them have lists of papers in preparation which made it impossible to judge their quality. The projects with published papers are generally very good or excellent. Half of the projects only reach the satisfactory or lower level concerning capacity building and this is the area with the largest difference between the project since the other six projects are very good or excellent.

The relevance and use of research in society

Realisation has been growing since the past decade that ecosystem services that go far beyond providing harvestable goods are of immense importance in regulating climate and can be actually valued. The Baltic and its connection to the ocean are amongst the water bodies most severely impacted by humans but they are also amongst the best studied. They hence serve as a model of how scientific research can be put to use to mitigate the effects of anthropogenic impacts.

Table 11. Average score for each evaluation criteria

Question	Average score
1. Production of useful and accessible knowledge for relevant stakeholders	4.6
2. Communication with appropriate stakeholders	3.5
3. Has the research led to measureable or foreseeable changes in policy or practice	3.2
4. Summary – overall societal relevance	3.9

Strengths and weaknesses

All the projects deal with important problems and should produce useful knowledge for different stakeholders, but in some cases the relevance of the project in a larger context was not adequately appreciated, whereas others have described it very well. It is important to stress this question already in the application since some researchers need more thinking about the societal value of their research. A very important matter in many projects is both to identify the appropriate stakeholders and to communicate with them. Not all of the principal investigators have provided information on these questions and therefore there have been difficulties in judging them. Many projects have produced important results but in many cases the results were not communicated with relevant stakeholders. Some of the scientists have contacts with stakeholders at different levels and are taking part in seminars and discussions and also write popular science articles. These kinds of activity need to be encouraged.

Important issues not addressed within the area

Long-term changes in the annual cycles of human-impacted coastal ecosystems is currently a major concern as there are few cases where the application of measures to reduce nutrient loading has resulted in restoration of the original “pristine” ecosystem. The Baltic, with its long history of research, lends itself ideally to the study of this important issue but only one project on zooplankton is dealing with it. There is a need to use and evaluate results from national and regional marine monitoring programmes to a greater extent. It should be possible

to do some good research on the long-term series of monitoring data and also to combine research and monitoring results.

Project highlighted as "best practice"

The exemplary project chosen in this area is about "the sensitivity and resilience in shallow water sediments" led by Professor Kristina Sundbäck in Göteborg University which has combined funding from several sources. The experimental approach applied here addresses a range of questions such as physical disturbance, toxicant exposure and nutrient load in shallow water sediments with the aim to learn more about the capacity of these important areas to recover from perturbations. More knowledge of these processes is crucial since these areas are being more and more exploited by, e.g. building of harbours for pleasure boats causing spread of sediment during dredging and leakage of toxic substances from anti-fouling paints. The perturbations chosen in the experiments are highly relevant and occurring regularly in shallow water environments along the Swedish coast.
The results have been discussed with stakeholders and the findings have also been used in a report suggesting measures to restore small, shallow areas from the effects of long-term loading of nutrients.

Thematic area – Eutrophication

Conclusions / Recommendations

This is an area of great importance to policymakers in the Baltic region and one in which Sweden has a strong track record internationally. Our independent project-by-project assessment showed remarkable consistency between evaluators. The projects we reviewed are generally at a high international level of scientific quality. The smallest grants were reported quite poorly but could perhaps be excluded from this type of evaluations. The degree of national and international collaboration was quite variable but there was evidence that the projects with the greatest degree of collaboration produced the highest quality outputs. This also makes assessment quite difficult though, as it is not easy to work out the relative contribution of Formas-funded research to the outputs. Nevertheless we feel that collaboration should be further encouraged in order to raise the scientific quality of the research in cases where this is below international quality.

Dissemination of results and information to stakeholders should be a requirement in all projects. This was clearly deficient in most of the projects evaluated. In most cases the research was generating results that had a huge potential for helping Sweden to achieve its policy commitments at a national and international scale (e.g. to the Water Framework Directive or the Marine Strategy Framework Directive). However, there was little evidence of how this potential would be realized and much greater attention will be needed to this in the future. There should be rewards to the researchers for engaging in the work of translating their research into policy-relevant information; these publications and communications should also result in (scientific) credits in evaluations of science projects. The problem is larger than this though because (particularly younger) academics may not be rewarded for such activities in connection with hiring, promotion, awards, etc. The financing bodies should engage actively in changing this culture otherwise the researchers will not work towards these goals.

Formas or another Swedish body may consider funding one or more additional projects that explore the science/policy interface and help to translate the latest science into useful policy-relevant products.

Description of the thematic area, incl. statistics

Eutrophication is often caused by an excessive supply of plant nutrients resulting in an excessive production of marine algae. This, in turn, has major ecosystem effects and in the worst circumstance may cause hypoxia and a marine ‘dead zone’. Other factors contributing to this phenomenon include the ‘trophic cascade’ effect, resulting from the removal of top predators from the food web, and the discharge of terrestrial organic matter. There are major uncertainties in our knowledge of the causes, effects and management of eutrophication and these can be addressed through scientific research.

<u>Research and environmental issues addressed</u>

Six out of ten evaluated projects deal with effects of eutrophication on different type of algae and vegetation (toxic plankton algae, macroalgae, seagrass). Three projects deal with potential changes in nutrient and organic material supplies for food chains. The last project compares

effects of physical and biological disturbance on hard bottoms. Questions regarding effects of climate change are studied in several projects.

Table 12. An overview of expenditure and outputs

Project number	Total funding	University	Senior scientists	PhD students	Publica-tions	Submitted ms	PhD thesis	Lic thesis	Master thesis
Eutroph 1	325 000	GU	1		1				
Eutroph 2	675 000	UmU	2	2	5	5	1		4
Eutroph 3	916 500	GU	2	1	2	2			
Eutroph 4	1 482 000	GU	1		7	2			2
Eutroph 5	140 000	HIK	1	1	1				
Eutroph 6	1 175 000	LU	1	1	1	1			2
Eutroph 7	1 310 000	GU	1	1	2	2	1		
Eutroph 8	1 150 000	SU	1	3	3		2	2	4
Eutroph 9	450 000	GU	1		1				6
Eutroph 10	700 000	HIK	1	3	15		1		
Total	*8 323 500*		*12*	*12*	*38*	*12*	*5*	*2*	*18*

The average output per 1 MSEK for this theme is 1.4 PhD students (in progress or completed), 2.2 completed Masters theses. In terms of capacity building, this is comparatively good value for money.

Scientific quality

Table 13. Average score for each evaluation criteria.

Question	Average
1. Used methods (appropriate and up to date?)	7.3
2. Innovation and new ideas	7.0
3. International and national collaboration	5.1
4. Production of peer-reviewed articles and other scientific publications	6.7
5. Capacity building (i.e. to what extent the project has contributed to MSc, Lic, Dr)	6.4
A6. Overall Score	6.7

Strengths and weaknesses

The scientific methods used are mainly at state of the art level, and the scientific expertise of project leaders is at a high level. Level of innovation and creation of new ideas is good, but no really revolutionary projects were included in this evaluation. This may be due to the rather small grants approved. Some of the projects have a very good level of international and national collaboration, while others lack almost totally collaborative aspects. Production of scientific publications is most often very good. However, the method of collecting this information may not have resulted in 100% correct reports, since some project leaders seem to have reported a very large selection of publication in relation to project duration and financing. Most projects had included students either or both at master's and postgraduate level, but a few were totally lacking this capacity building aspect.

Relevance and use of the research in society

Table 14. Average score for each evaluation criteria.

Question	Average
1. Production of useful and accessible knowledge for relevant stakeholders	5.3
2. Communication with appropriate stakeholders	3.2
3. Has the research led to measurable or foreseeable changes in policy or practice	2.3
B4. Overall Score	4.6

Strengths and weaknesses

Most projects had a clear *potential* to produce relevant information for the use by society. However, three projects were more or less totally lacking descriptions of societal relevance, and we felt that they were driven exclusively by scientific curiosity. This would be perfectly acceptable in another context but does not fit with the objectives of Formas research funding. Some project leaders had, however succeeded in identifying the societal relevance aspects rather clearly. The overall weakness in most projects was, however, the total lack of communication with and dissemination of scientific results to stakeholders. This severely hinders the application of the new scientific results for policy making and practical applications in management. This is unfortunate because the research is mostly of a very high quality.

Important issues not addressed within the area

There are clear connections with other research themes that need to be identified, and we note that no studies on zooplankton, benthic fauna or fish were reported here. Studies comparing the consequences and synergies of eutrophication with over-fishing, toxic chemicals and habitat deterioration would be of great value. Similarly, there are no studies of the social and economic implications of eutrophication and projections for the future.

Project highlighted as 'best practice'

We are unanimous in our choice of top scoring project. This was the study titled "Effekt av ökat inflöde av organiskt material på marina födovävar" (project Eutroph 2) led by Professor Agneta Andersson in Umeå University. The study used available resources very wisely and, partly through well chosen cooperation, built a team that was able to deploy a wide range of tools to examine the central hypothesis that marine food chains in the Bothnian Bay are moving from plankton-dominated systems to those dominated by the bacterial decomposition of land-derived organic material. Climate change, according to the research, will exacerbate this shift due to increased river flow and average temperatures. The consequence may be a major decrease in productivity of the system at all levels. This work has already generated excellent publications in highly ranked scientific journals. The researchers understood the societal relevance of their conclusions and made considerable effort to engage with stakeholders at the local, national and international level. The work is important for Sweden and Finland in setting objectives for the Water Framework Directive and Marine Strategy Framework Directive and has major implications for similar systems around the world. We congratulate Professor Andersson and her team for the overall quality of this study and consider that it is a valuable example to other researchers.

Thematic area – Toxic Chemicals

Conclusions / Recommendations

In total seven Formas projects were evaluated under this thematic area, which varied widely in size and in types of items funded, which made a comparative analysis somewhat difficult.

Most of the projects produced results of a high scientific quality that were publishable in international peer-reviewed journals. However, only one project led to measurable change in policy or practice.

In general, the level of collaboration (and in particular international collaboration) was rather limited, and consideration should be given to if and which initiatives should be taken to improve this situation.

Most of the projects evaluated were less than three years in duration, and thus opportunities for capacity building would have been limited. If capacity building is a priority, specific instruments designed to enhance capacity building should be considered.

The questions raised are in general of high value for stakeholders, such as environmental policy makers. The stakeholders where not specified in the evaluation form, which sometimes made it difficult to evaluate if the communication has been sufficient. One suggestion is that this should be clarified already in the application, and a communication plan should be included.

Suggestions for future priority areas for funding include research directly related to new EU legislation and the challenges posed by the new Directives. For instance, development of alternatives to animal testing (encouraged by REACH), and the development of more robust and transparent approaches to Weight of Evidence methods for identifying causation in complex environmental situations. The Marine Strategy Framework Directive and the Water Framework Directive are pressing issues. In order to achieve preventative action to reduce the use of hazardous substances collaboration between different disciplines (e.g. natural and social sciences) has to be encouraged.

Description of the thematic area, incl. statistics

There was a total of 7 Formas projects evaluated under this theme. They addressed the following topics: development of a behavioural-based system for rapid evaluation of antifouling substances; examination of the causes of gut wounds in Baltic Grey Seals; the role of bioturbation in the environmental fate of radionuclides in Baltic Sea sediments; environmental causes of variations of sex ratios in fish; the role of science, politics and the media in EU chemicals regulation; mechanisms of toxicity for dioxin and PCB toxicity in fish; identification of the sources of dioxins to the Baltic Sea. The projects varied widely in size (level of funding and duration), and the types of items funded was also variable (e.g., a piece of equipment, organisation of a conference and publication of its proceedings, laboratory/field work). This made a comparative analysis somewhat difficult.

Table 15. An overview of expenditure and outputs.

Project No	Total Funding	Publications	Submitted Ms.	PhD Theses	Lic. Theses	MSc. Theses
Tox 1	416 000	0	0	0	0	0
Tox 2	520 000	0	0	0	0	0
Tox 3	182 000	2	0	1	0	1
Tox 4	1 201 500	1	0	2	0	2
Tox 5	910 000	0	5	0	1	1
Tox 6	927 000	4	0	2	0	0
Tox 7	1 350 000	1	1	1	0	2
Total	*5 506 500*	*8*	*6*	*6*	*1*	*6*
Mean	*786 643*	*1*	*1*	*1*	*0*	*1*

The above statistics should be treated with care given the very small sample size on which they are based. The total funding for the evaluated projects was 5 506 500 SEK and they resulted in a total of 8 peer-reviewed publications.

Scientific quality

Table 16. The mean scores for each evaluation criteria.

Question	Average
1. Used methods (appropriate and up to date?)	5.4
2. Innovation and new ideas	5.7
3. International and national collaboration	5.3
4. Production of peer-reviewed articles and other scientific publications	5.4
5. Capacity building (i.e. to what extent the project has contributed to MSc, Lic, Dr)	5.2
A6. Overall Score	5.6

The scientific quality of the projects evaluated varied widely. One project completely failed to get any results due to problems during sampling and therefore scored 0. If that project is excluded the mean score increases with 0.9 – 1.0 units.

Strengths and weaknesses

Most of the projects produced results of a high scientific quality that were publishable in international peer-reviewed journals. Overall the research in the area of toxic chemicals is fragmented. There is greatest focus on persistent organic pollutants. In the case of dioxin this is understandable given the ban of selling herring from the Baltic sea within EU (except in Finland and Sweden) and given that dioxin levels in fatty fish have not continued to decline with time (as have PCBs), but rather have levelled off. This remains a topic of high importance for Sweden.

In general, the level of collaboration (and in particular international collaboration) was rather limited. Whereas it should not be assumed that bigger projects necessarily lead to better science, there are opportunities for gaining added value by encouraging researchers to interact and coordinate their efforts.

Five of the seven projects resulted in the publication of articles in international peer-reviewed journals. One of the projects did not produce any publishable results, and one of the projects listed two articles in preparation that have (several years later) still not been published. It was difficult to use the information provided in the category 'other relevant peer-reviewed articles in the subject area'. These could simply be an indication that the researcher had funding from other sources, that they were part of a larger group of collaborators, or possibly something else.

Most of the projects evaluated were less than three years in duration, and thus opportunities for capacity building (particularly contribution to Ph.D. degrees with $\geq$ 50%) would have been limited. If capacity building is a priority, specific instruments designed to enhance capacity building should be considered. For example, it might be possible to offer a scheme of co-financing in which Formas would fund 50% of a PhD fellowship provided that matching funds could be contributed by the applicant (e.g., via funding from a university, government agency or the private sector).

Relevance and use of the research in society

The relevance for the questions raised had an average score of 6.0 – most of the questions raised are of high relevance for society. Communication has an average of 4.7. With one exception the projects with high scientific scores got relatively lower scores for the relevance of the question raised and for communication to a wider (non-scientific) audience. Only one project could report that the research led to measurable or foreseeable changes in policy or practice.

Strengths and weaknesses

Most of the questions raised within the research theme on toxic chemicals may be beneficial for society. However, with one exception the communication could have been improved. Specific stakeholders were in some cases not identified in the questionnaires submitted by the scientists, which, in some cases, made it difficult to determine the extent to which communication was addressed to the right stakeholders and in the best way. It is probable that Formas could improve the quality in the reporting by demanding a plan for communication in the call (e.g. in the instructions for the research program). Such a communication plan should specify the key stakeholders and a detailed plan for communicating with them. It could also be considered that appropriate stakeholders are involved at the application stage and that mechanisms are put in place to ensure that the results of the research are actually used. In addition, it may be helpful to involve stakeholders in defining the best instruments for dissemination from the start, to ensure that appropriate time and funds are set aside and to ensure that the intended audience is reached effectively.

We were uncertain about the extent to which stakeholder involvement and societal relevance were explicitly stated as criteria for funding in the calls under which these projects were funded. In a couple of cases, we were able to identify societal relevance even though the scientists filling out the questionnaires did not appear to have given this much attention. The

current Formas handbook does seem to spell out this aspect of the application evaluation criteria much better than previously, but consideration should be given to whether expectations for applicants could be made even more explicit.

Important issues not addressed within the area

The evaluated projects focused largely on selected persistent organic toxicants (e.g. dioxins) and there was a bias towards measurement of presence of chemicals (rather than their effects), as well as correlative analyses among investigated variables, as opposed to mechanistic modelling or manipulative experiments.

There should be more research directly related to new EU legislation and the challenges posed by the new Directives. In particular, REACH is encouraging the development of alternatives to animal testing, and it needs to be ensured that such methods provide relevant measures of ecological effects. Effective implementation of the Water Framework Directive (WFD) and the Marine Strategic Framework Directive (MSFD) will require the development of more robust and transparent approaches to Weight of Evidence methods for identifying causation in complex environmental situations. The issue of mixture toxicity remains an important challenge and has recently come to the European Commission's attention with regard to human exposure. Also, it would be beneficial to see more projects integrating different types of environmental stressors, e.g. eutrophication and toxic chemicals, toxic stressors and biodiversity, the impact of climate change, etc.

Most environmental problems are complex and involve a range of disciplines. But there remain major challenges in getting natural scientists from different disciplines to collaborate and even larger challenges in getting natural scientists and social scientists to work together. Truly achieving sustainable development will therefore require more attention to identifying the most promising areas of inter-disciplinary or multidisciplinary research and to putting instruments in place that facilitate such collaborations.

Additional priority areas that should be considered include how the use of hazardous substances by society can be reduced. This is relevant for REACH in which substitution is encouraged. Additional research into the main sources of priority contaminants into the marine environment is needed, for example, the importance of national sources (e.g. from shipping) in relation to long-range transport.

Project highlighted as 'best practice'

Dioxiner i Östersjön - källspårning med hjälp av sedimentanalys och receptormodellering, Project leader Mats Tysklind, Umeå University.

Despite actions to reduce emissions of polychlorinated dibenzo-*p*-dioxins (PCDDs) and polychlorinated dibenzofurans (PCDFs) the levels in Baltic biota have still, after 20-25 years, not declined to satisfactory levels. The aims of the present study were to *i*) investigate the levels and profiles in surface sediment along the Swedish coast, *ii*) investigate the relative impact of various sources by applying multivariate statistical tools, *iii*) investigate time trends and *iv*) relate the sediment data to levels in Baltic herring sampled in the same areas as the sediments.

This project addressed the above issues using state-of-the-art methods and included development of innovative statistical methods for source identification. The project has so far resulted in one peer-reviewed article plus two more are in the pipeline. A total of 16 'other'

publications, including oral conference presentations were produced as well as four additional relevant publications within the subject area. The project involved both national and international collaborators and contributed to two MSc. students and a PhD student.

The findings have been published in popular science articles and in Swedish reports. During the project there was a continuous dialogue with all the relevant stakeholders; the industry, Swedish EPA and the county administrative board. The Swedish EPA has launched a new call based on the results from this project. New collaboration projects with the county administrative boards have been started. In meetings with industry, advice concerning remediation and sampling has been given.

Thematic area – Fish and fisheries

Conclusions / Recommendations

The amount of Formas funding for the eight projects in the area "Fish" is small and fragmented, and a significant impact of the funded projects can only be seen where they have been used as add-ons to larger projects. Without such links, the research themes are locally restricted and of limited general applicability. Despite of this, the majority of projects have produced excellent results in terms of publication and capacity building. The small amount of funding was best used where they covered starting or coordination cost as national shares for EU framework programme projects. Swedish researchers have been creative in the manner in which they have deployed the limited funds available. The quality of the majority of research undertaken would indicate that there is strength in fish biology and ecology in Swedish academic institutions.

In order to make Swedish fish research more competitive and visible in the European research community an injection of strategic funding for genuine Swedish research projects is required. Greater impact would be achieved through the organization of clusters of projects with a significant financial volume. Investment in infrastructure such as research vessels and large research facilities and equipment is necessary if Swedish fish research is to maintain or improve its impact.

Description of the thematic area, incl. statistics

The projects funded under the "fish" heading covered mainly aspects of the interactions of abiotic factors and fish ecology. Other areas were gear technology (1184) and the effects of the introduction of alien species, genetics of salmon (1288) and population structure of cod (1090). All projects addressed relevant societal and environmental questions in relation to the sustainable use of living resources and protection of the environment from unintended human impacts.

Table 17. An overview of expenditure and outputs

Project No	Total funding	yrs	Publications	Ph D theses	Master theses
Fish 1	860 000	2			
Fish 2	396 756	3	3		
Fish 3	1 030 824	2	9	1	4
Fish 4	864 000	5	6	2	1
Fish 5	535 000	4	4		2
Fish 6	259 000	2	4	1	1
Fish 7	710 000	4	3	1	
Fish 8	3 998 000	6	16	6	15
Total	*8 653 580*		*45*	*11*	*23*
Mean	*1 081 698*	*3*	*6*	*1*	*3*

Total Formas funding of the 8 projects under thematic area fish and fisheries was 8.7 MSEK. The average amount per project was 1 MSEK, but excluding the one big project (Fish 8), the average was only 670 000 SEK. Mean project duration was 3 years and the resulting funding was less than 300 000 SEK (247 000 excluding project Fish 8) per project and year. This level of funding of marine environmental projects under "Fish" can be considered as poor or

insignificant, given the normally high demand on infrastructure (ship time, equipment, labour cost) for experimental marine research. However the reviewers recognise that FORMAS is not the only source of funding for this research and it would have been useful to have had metrics that demonstrated the full level of funding for fish related research in Sweden.

Despite of the low funding level, the average output in terms of capacity building and publications was high with 1.3 PhD theses, 2.7 Master theses and 5.2 publications for each 1 MSEK spent on "Fish".

Fragmented funding of 200 000 – 500 000 SEK per year over 2 – 4 years cannot be expected to create significant international impact unless it is used to top up larger projects funded by other sources, which makes it difficult to identify the direct contribution by FORMAS for the scientific output of the projects. Nevertheless, these projects demonstrate the advantage of being able to contribute small amounts of funds that may have a much larger impact when added to other larger research efforts. Therefore the reviewers consider that such funding is extremely valuable, but on its own would not address the science need.

Add-on funding was explicitly mentioned in two of the projects which were related to or part of larger EU funded cooperation (projects STORE and AQUAWILD): co-funding of 396 756 and 1 030 824 SEK, respectively, covered the project starting and task coordination cost. Both projects have competed internationally and their standards and results can be considered excellent. In both cases, the Formas funding can be considered as efficient, although the project results are difficult to attribute to Formas funding. Nevertheless such funding may have been critical to enable the project to function in an efficient manner.

One project (Fish 8) was funded with four times the mean amount (4 Million SEK). The project was an *ad personam* grant and was used by the coordinator for science development as well as for capacity building. The evaluation form does not specify relevant outcomes or societal application of products from this project except for the statement that the project contributed to make the coordinator a "known expert in the field". In terms of publications and capacity building the result is excellent (although not 4 x average). The lack of engagement by the recipient of the grant was disappointing in relation to addressing the societal outputs of the project. This project was interesting in that it differed considerably from other forms of funding and yet it appears to have been highly beneficial. The successful scientific outcome of the project perhaps highlights the need for a programme specifically designed to release academics to enable them to undertake a focus period of research with clearly defined outcomes.

Scientific quality

The quality of the projects was from satisfactory to more than excellent.

Table 18. Average score for each evaluation criteria

Question	Average
1. Used methods (appropriate and up to date?)	6
2. Innovation and new ideas	6
3. International and national collaboration	6
4. Production of peer-reviewed articles and other	6

scientific publications	
5. Capacity building (i.e. to what extent the project has contributed to MSc, Lic, Dr)	5
A6. Overall Score	6

In terms of addressing the five questions on scientific quality, the "Fish" projects were between "very good" and "excellent" and this provides evidence of strength in this area of research in Sweden. However this may represent a skewed view of fish research overall (i.e. there may be a body of fish researchers that do not receive this funding that are not generating such high quality outputs).

Strengths and weaknesses

Most projects had an interdisciplinary and ecosystem approach from the beginning and were aimed at producing useful results for society and stakeholders. A high degree of international cooperation and stakeholder involvement was visible. It was not always possible, however, to identify the ways in which project results were communicated, and in some cases the responses were not sufficiently elaborate to assess the impact of the project results. Due to the restricted funding, some projects were of very small scale and only relevant for a very local stakeholder community, nevertheless, the quality of the science produced remained high.

Relevance and use of the research in society

Total scores for the societal value of the projects were from "limited applicability" to "highly beneficial" and of "general applicability". As a mean, the projects under thematic area fish and fisheries represented "research with high value for sustainable development and project outcome which may be beneficial for society". Due to the often regional approach, they are considered as "applicable in some areas".

Table 19. Average score for each evaluation criteria.

Question	Average
1. Production of useful and accessible knowledge for relevant stakeholders	5
2. Communication with appropriate stakeholders	5
3. Has the research led to measurable or foreseeable changes in policy or practice	5
B4. Overall Score	5

The mean scores for the individual criteria indicated "high value for sustainable development and project outcome which may be beneficial for society and applicable in some areas."

Strengths and weaknesses

The response to the request form often did not state the project outcome in respect to societal benefits. In reality there were probably more presentations and stakeholder interaction than stated, and often scientific results have a long lag time until they reach and impact society and management. Given the high relevance of most of the funded themes, the value for sustainable development on the long run will be most probably higher than indicated by the

average score 5 in this evaluation. There was a clear problem in assessing the third criterion that related to impact of research on policy and regulation and changes in practices.

Important issues not addressed within the area

Due to the very small funding volume, large scale ecological interactions in the Baltic or beyond were not addressed, and trans-boundary research was mainly linked to participation in EU projects only. Some of the best research was undertaken within the large collaborative EU projects and the impact of this research was undoubtedly maximised at a national and EU and international level as a result. Strategic funding to encourage the development of international networks would ensure the production of science with the greatest global societal impact. The limited amount of funding means that some key issues such as climate change impacts and cross-disciplinary research (e.g. integration with socio-economics) may be missed. However the latter may have been covered by other areas of funding of which the board were not aware.

Project highlighted as 'best practice'- Fish 3

This project (led by Dr Jörgen Johnsson, Gothenburg University) was designed to understand the impact of stocking salmonids into natural river systems using a combination of approaches including: animal behaviour, physiology, ecology and quantitative genetics. The experiments were performed both in laboratories (i.e. stream tanks and experimental streams) and in nature (natural and semi-natural rivers). Wild and domesticated populations of two salmonid species were used. The project was well conceived from the outset given the multidisciplinary approach, the quality and quantity of outputs was high and thus provides a strong evidence base for scientific advice. The output of capacity building was strong with 3 MSc and a PhD completed. The science led to clearly defined management and husbandry changes and also provided clear unambiguous advice that was adopted at the national and international level. The latter was clearly addressed in the report.

Thematic area – Swedish Board of Fisheries

Conclusions / Recommendations

The format of the evaluation was shaped in a way that it had a strong focus on academic research, i.e. production of peer-reviewed articles and other scientific publications and capacity building (i.e. to what extent the project has contributed to MSc, Lic, Dr). Obviously, these priorities do not match fully with the tasks of a governmental institute such as the SBF, which to a high degree has to deliver standard data sets and routine tasks to the Ministry of Fisheries. Probably related to this mismatch, there was a worrying lack of engagement from some of the project leaders that provided either inadequate supporting text, no text, or were not explicit enough in their reporting to enable accurate evaluation.

Based on the available information, there was evidence of excellence and high impact research, but some evidence of insufficient consideration given to the wider dissemination and impact of some of the science undertaken. There has been involvement in some important EU programmes, but a concern is the minor role undertaken by the Swedish researchers in some of these programmes. This has implications for future participation as there is a danger that non-contributing countries/organisations are ignored in future bids. The researchers in SBF have a lot to offer and therefore should attempt to play a more prominent role in the international programmes. The small focussed projects were useful and addressed locally or nationally important issues. There are few (no) links to projects with a climate change focus, or that integrate issues related to climate change. Given the linkage between land-discharges and the health of Baltic ecosystems, there is no evidence of any of the projects taking a much broader cross-disciplinary approach that might also include socio-economic considerations.

Table 20. An overview of expenditure and outputs.

Project number	Total funding	Senior scien-tists	PhD students	Publi-cations	Subm. ms	Ph D thesis	Master thesis
SBF 1	2 827 000	1	1	1	1	1	1
SBF 2	1 456 000	4		(17)	(8)		(2)
SBF 3	2 276 000	3					
SBF 4	3 905 000	1	1	4	1		
SBF 5	962 000	2	1		2		2
SBF 6	1 827 650	1	2		1		3
SBF 7	3 854 000	5	1				2
SBF 8	3 765 000	4	1	1	3	1	
SBF 9	2 087 000	2	1				
SBF 10	3 079 000	2					
SBF 11	1 368 000						
SBF 12	613 000	2	1				1
SBF 13	688 000	4					
SBF 14	1 774 000	2		1			
SBF 15	2 384 000	3					
SBF 16	2 100 000	3					
SBF 17	280 000	3	1				
Total	*35 250 000*			*7*	*8*	*2*	*9*

Description of the thematic area, incl. statistics

The reviewers were asked to evaluate 17 projects that were written in English. Projects written in Swedish (11 projects) were not evaluated. Of the projects reviewed, three provided insufficient information for any form of evaluation by the reviewers.

The overall level of funding was relatively high, but was spread among a large number of projects. Despite the relatively high investment (compared with other themes), the outputs per 1 MSEK was low relative to the other thematic areas addressed within this review. The average output in terms of capacity building and publications was 0.06 PhD theses, 0.26 Master theses and 0.2 publications for each 1 MSEK spent on these projects, compared to an average of 3.98 publications per 1 MSEK for the Formas-funded research projects and 1.41 publications for the two Swedish EPA programs.

Scientific quality

Table 21. Average score for each evaluation criteria

Question	Average
1. Used methods (appropriate and up to date?)	5.5
2. Innovation and new ideas	5.3
3. International and national collaboration	5.1
4. Production of peer-reviewed articles and other scientific publications	6.2
5. Capacity building (i.e. to what extent the project has contributed to MSc, Lic, Dr)	2.9
A6. Summary – overall scientific quality	4.9

Strengths and weaknesses

This was the largest group of projects examined by the evaluators. The level of scientific excellence and delivery was highly variable (grades from 2 – 7) and there were four projects in which the evaluators differed significantly in their assessment. There was a worrying lack of engagement from some of the project leaders that provided either inadequate supporting text, no text, or were not explicit enough in their reporting to enable accurate evaluation. There was a dichotomy between the characteristics of the projects that dealt with high level paradigms (e.g. causes of regime shifts) compared with smaller more focussed problems (e.g. predation by cormorants). The research with the greatest societal impact generally occurred when the SBF researchers were involved in larger EU level research programmes, however often it was not possible to ascertain precisely what input SBF researchers had contributed to these programmes. The smaller projects tended to be highly focussed on a specific problem. Often these delivered useful findings that provided the appropriate evidence-base. Given the discrepancies in the scores given by the evaluators for four of the projects, each of these will be discussed in turn.

SBF 9: This project deals with the impact of trawling on the resuspension of sediment and the consequences of this activity. While this is an important project, it is not clear that the experimental protocols have sufficient statistical power to determine effects; there is a possibility of pseudoreplication based on the information provided by the PI. If the methodology is in doubt, the value of the project is questionable.

SBF 14: This project falls within a wider EU programme called NECESSITY. The EU programme is well considered, however the contribution of SBF researchers to this programme is not clear from the evaluation form. Indeed the PI has simply copied and pasted the proposal text without identifying precisely what SBF has contributed to this project. Based solely on the information provided in the form it appears that SBF has made little contribution to this important project. The papers listed under this project do not feature any Swedish authors, which hints to a significant lack of involvement.

SBF 7: This project is still in progress and given the information supplied one of the evaluators was not content to assess the quality of this project at this stage.

SBF 2: This is an important project that deals with the utility of Marine Protected Areas. However, the comments made in relation to project SBF 14 equally apply to SBF 2. However, although the effort made by the PI is much better, it is impossible to ascertain the role of SBF in this project and there is little evidence to suggest innovation on behalf of the Swedish researchers.

Relevance and use of the research in society

Table 22. Average score for each evaluation criteria

Question	Average
1. Production of useful and accessible knowledge for relevant stakeholders	4.7
2. Communication with appropriate stakeholders	4.2
3. Has the research led to measurable or foreseeable changes in policy or practice	3.8
B4. Summary – overall societal relevance and importance	4.3

Strengths and weaknesses

There was better concordance between the reviewers in regard of the societal importance of the projects in which SBF were involved. There is evidence of excellent practice in some projects but there is also evidence of poor performance. Due to the nature of many of the projects there tends to be strong dialogue with key stakeholders such as fishers. However without such dialogue it would be impossible to execute some of the programmes. Therefore information exchange occurs by default. SBF researchers would be expected to gain high scores for communication with key science users but the evidence provided to support this indicated a lack of direct linkages. However, this is the assessment made on the basis of the reports provided and it may be that communication with policy makers and science users is in fact much stronger.

Important issues not addressed within the area

There are few (no) links to projects with a climate change focus, or that integrate issues related to climate change. Given the linkage between land-discharges and the health of Baltic ecosystems there is no evidence of any of the projects taking a much broader cross-disciplinary approach that might also include socio-economic considerations. It is recognised however that FORMAS has stimulated such multi-disciplinary initiatives over the last 12 months.

Project highlighted as 'best practice'- SBF 4/ FishACE

This project was an EU funded Marie-Curie action and resulted in one PhD student. The project addressed a fundamentally important issue examining the importance of fishery induced genetic changes. The project delivered clear findings that showed a rapid decrease in size-at-maturation in Eastern Baltic cod which increases the urgency to reduce fishing mortality on this stock. The genetic changes are rapid and occurred within decades and varied between stocks.

There were a high number and quality in terms of the scientific outputs and extensive stakeholder engagement at all levels (high level scientific meetings, science users and policy makers and engagement with the general public through newspaper articles). More importantly the project had influence on a European Commission change in policy in relation to fisheries management and this was clearly documented by the scientists.

Can research undertaken by SBF be undertaken by Universities?

In addition to the questions addressed under all thematic areas, the reviewers were requested to consider if it was possible for the projects undertaken by SBF could be undertaken by Universities instead.

In order to answer the question more information regarding the projects is required than was provided in the current review process. Those projects that would seem to be most suitable to be undertaken by universities as an alternative to SBF are those that do not rely on other data resources or infra-structure that exists at SBF. So called 'task and end' projects that are self contained are probably suitable. However it is impossible for the reviewers to ascertain the extent to which such projects were achieved with a low budget because of the long-term relationships developed with stakeholders by SBF. If a review of the SBF research is to be undertaken in an evidence based manner it would be prudent for a more thorough review of SBF activity. As such we were exposed only to a small proportion of the activities of the organisation and therefore they were seen out of context. A review panel comprising at least three reviewers with different backgrounds would be required with the opportunity to have presentations of major projects and the opportunity to talk directly to SBF staff.

Appendix I

Research on Marine Environments

A bibliometric survey focusing Swedish research

Magnus Gunnarsson & Ulf Kronman, Swedish Research Council

13 november 2009

To be used in the evaluation of research on marine environments performed by the Swedish Research Council for Environment, Agricultural Sciences and Spatial Planning in cooperation with the Swedish Environment Protection Agency.

Introduction

On behalf of Formas (the Swedish Research Council for Environment, Agricultural Sciences and Spatial Planning) Vetenskapsrådet (the Swedish Research Council) has made a bibliometric study over research on marine environments. The study will be used as one part of a larger evaluation of research on marine environments. The study is based on data from the citation database at Vetenskapsrådet, containing data from Thomson Reuters[1,2]. Research on marine environments has been defined by letting domain experts list scientific journals that primarily contain research on marine environments.

An Overview of the Subject Area

Organised by Formas, domain experts listed 22 scientific journals that primarily contain research on marine environments. The journals are listed below.

- Ambio
- Aquatic Biology
- Aquatic Microbial Ecology
- Aquatic Toxicology
- Canadian Journal of Fisheries and Marine Science
- Ecotoxicology
- Estaurine and Coastal Shelf Science
- Fisheries Research
- Harmful algae
- Hydrobiologia
- ICES Journal of Marine Science
- Journal of Experimental Marine Biology and Ecology
- Journal of Fish Biology
- Journal of Plankton Research
- Journal of Sea Research
- Limnology and Oceanography
- Marine Biology
- Marine Ecology Progress Series
- Marine Environmental Research
- Marine Policy
- Marine Pollution Bulletin
- Ocean and Coastal Management

In this study these journals define the subject area of research on marine environment: publications in these journals are considered research publications on marine environment, publications in other journals are not considered such. This is clearly an imperfect definition,

[1] The database is described in greater detail in the appendix.

[2] Certain data included herein are derived from the Science Citation Index Expanded, Social Science Citation Index and Arts & Humanities Citation Index, prepared by Thomson Reuters®, Philadelphia, Pennsylvania, USA.

and its deviation from a more general understanding of the concept "research on marine environments" must be remembered throughout the entire report.

From these journals, only publications of the type Articles and Reviews published between 1999 and 2008 have been investigated, forming a total of 38 880 publications.

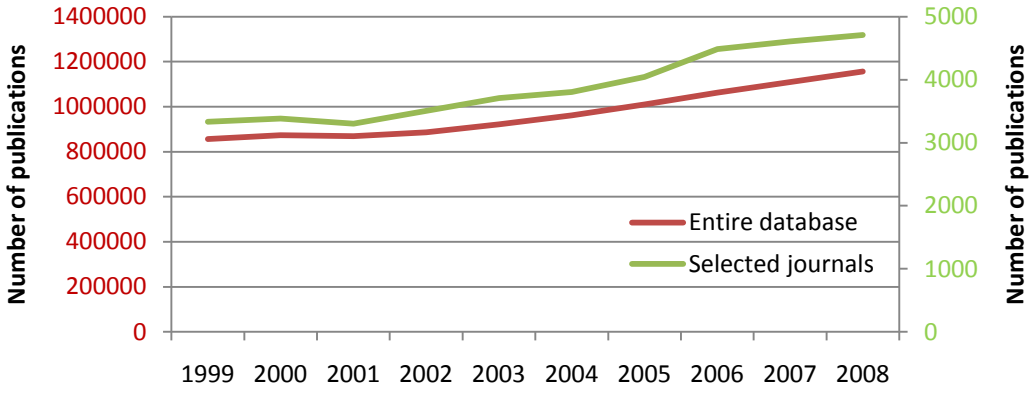

Figure 1: Publication growth in the studied journals and in the entire database.

Figure 1 shows the development in the selected journals and in the database as a whole during the period 1999-2008. The number of publications in the selected journals has increased steadily, in approximately the same rate as the database as a whole has increased (i.e. all journals). The studied journals provide circa 0.4 % of the publications in the database.

The countries that are most frequently represented among the research addresses of the studied publications are shown in the diagram below.

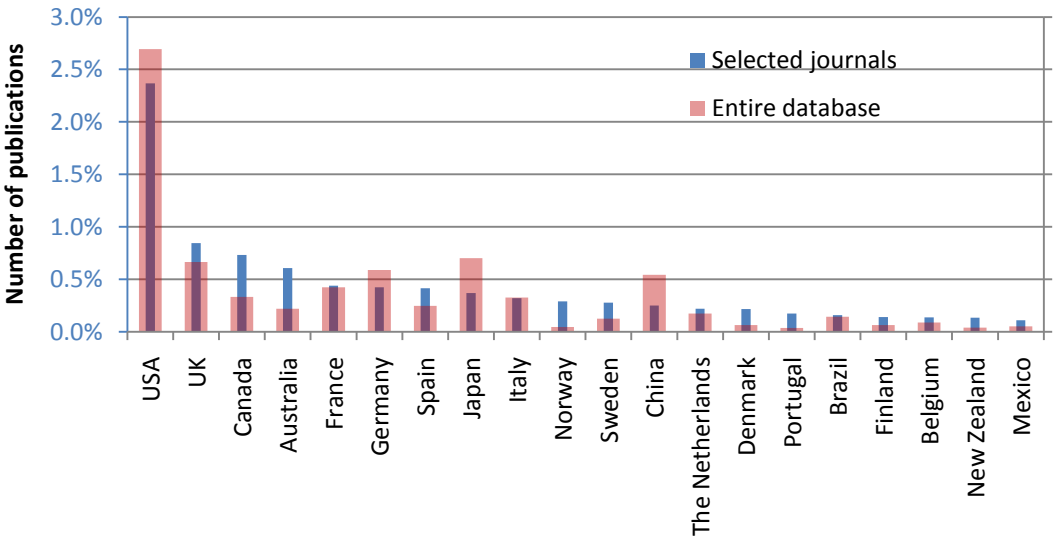

Figure 2: The largest countries in the selected journals, in terms of number of publications. The period 1999-2008, fractionalised numbers[1].

The diagram above shows that USA is the dominating country in the research published in the selected journals, as in research in general. The mainland Nordic countries, together with

[1] See the appendix for an explanation of fractionalisation.

Canada, Australia and New Zealand, are considerably larger in these journals than in the database as a whole, relatively speaking. China and Japan have a small share of their research in these journals, compared to their share in the database as a whole.

Thomson Reuters has set up a subject classification system consisting of 255 fields, and assigned one or more of these fields to each of the journals. Figure 3 shows the distribution of subject fields for the studied publications.

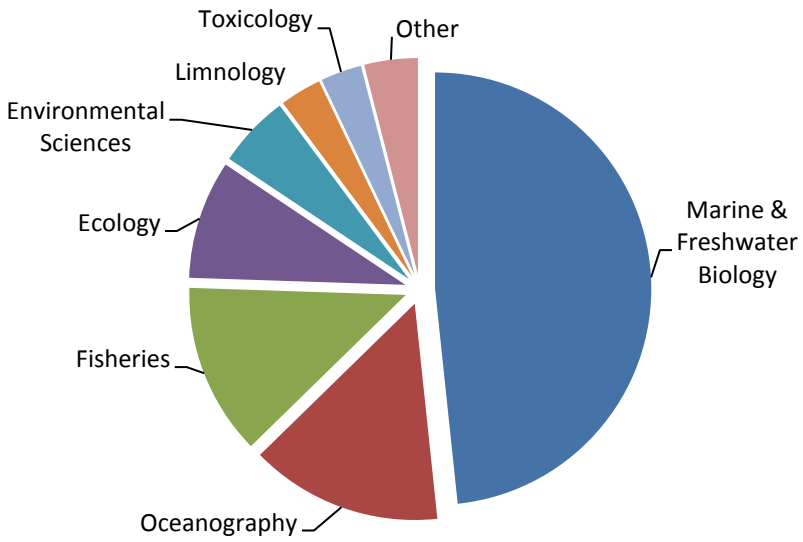

Figure 3: Subject distribution for the selected journals. Fractionalised numbers[1], the period 1999-2008. 'Other' = Engineering, Environmental; Environmental Studies; International Relations; Microbiology and Water Resources.

The subject field *Marine & Freshwater Biology* stands for almost half of the publication volume in the studied journals. The reason for this could be that one or two of the selected journals classified as *Marine & Freshwater Biology* have a large number of publications per year, and thus dominates the selection. Another possible reason is that most of the journals could have *Marine & Freshwater Biology* as one of their subject tags. There is unfortunately not enough time available in this project to make further investigations into this.

The diagram below shows how large part of each field that the selected journals cover.

[1] See the appendix for an explanation of fractionalisation.

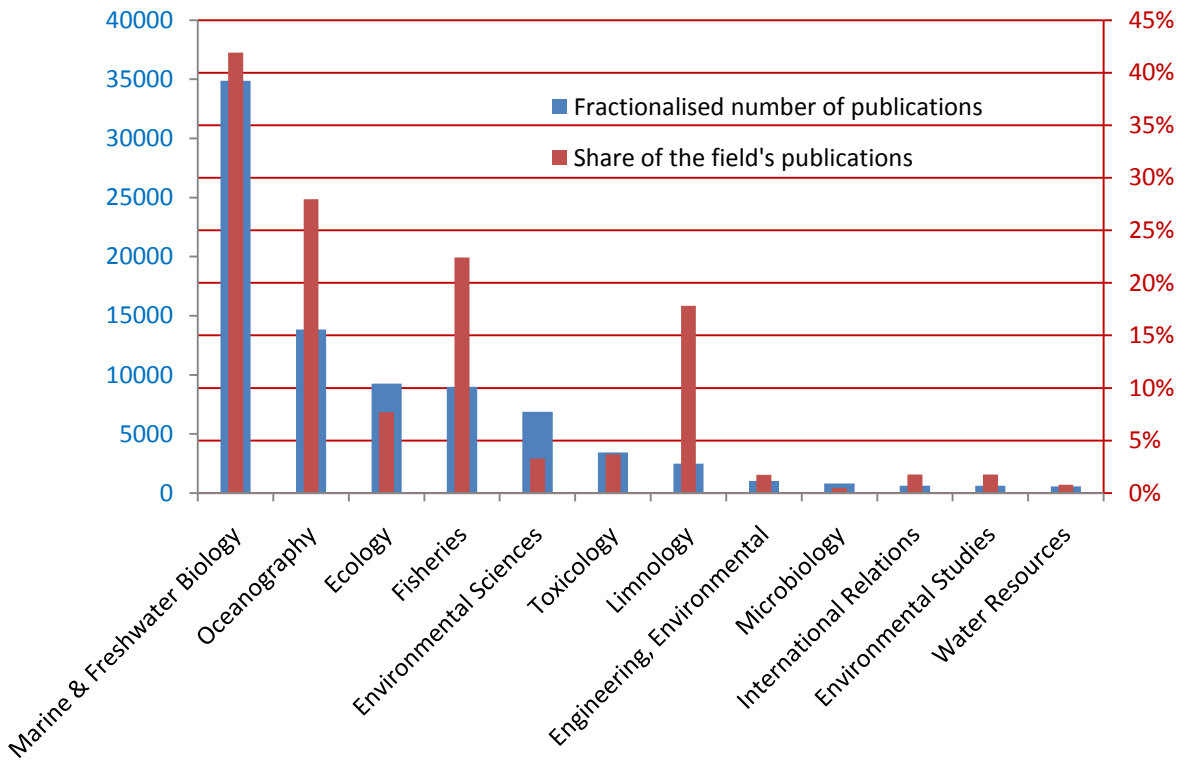

Figure 4: The coverage of the selected journals for each subject field.

Figure 4 shows that the selected journals cover more than 40 % of the field *Marine & Freshwater Biology*, and that substantial parts of the fields *Oceanography*, *Fisheries* and *Limnology* are covered by these journals.

One measure of the attention a publication receives is to count the number of citations from other publications. Since the traditions for how other works are referenced varies between different fields, these citation counts are usually *field normalised*, i.e. the number of citations for each publication is related to the average number of citations per publication for that field (for a given year and document type). This translates the citation count into an index where 1 means 'as many citations as the world average' and 2 means 'twice as many citations as the world average'.

In our case the 255 Thomson Reuters fields are used for field normalisation and it is therefore interesting to see what the field normalised citation rate is for the selected journals.

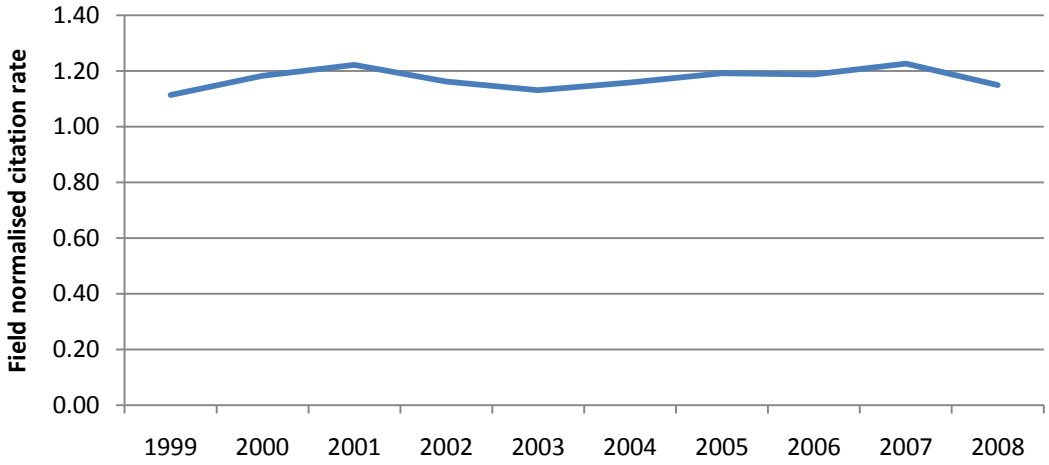

Figure 5: Field normalised citation rate for the selected journals. Self-citations excluded, 3-year citation window[1].

The citation rate for the studied publications is above 1 throughout the period, which means that they are cited more than average for the publications in the respective fields. This may be because research in these journals is of greater interest for other research areas than vice versa, but it can also be because the research published in these journals has a slightly different citation tradition than other research in the respective fields.

Swedish Research on Marine Environments

Figure 2 above showed that Sweden stands for a comparatively large share of the research in the selected journals. The diagram below shows this share in greater detail.

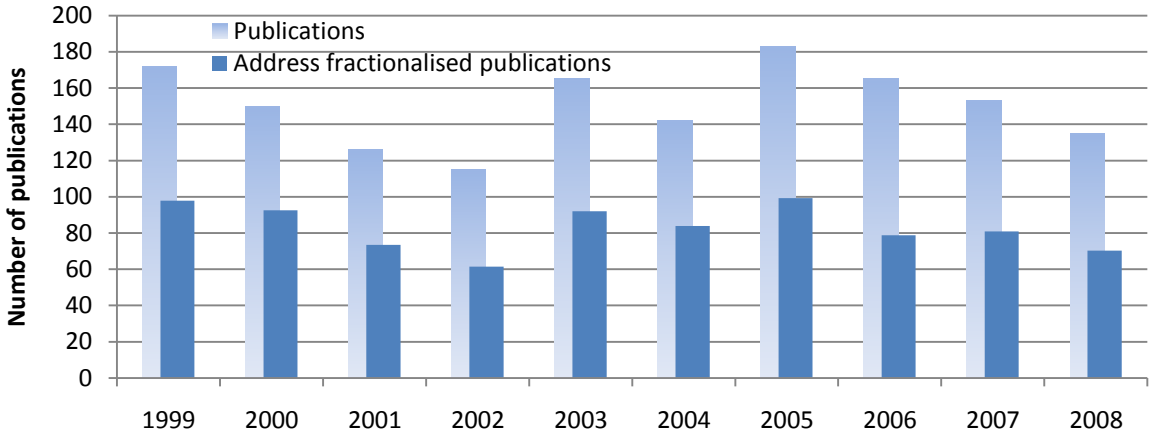

Figure 6: Number of Swedish publications in the selected journals.

During the studied period, the Swedish publication volume has been around 140 publications (100 fractionalised) per year. Since the area as a whole has grown during the same period the Swedish share has gone down, as illustrated in figure 6.

[1] See the appendix for an explanation of citation window.

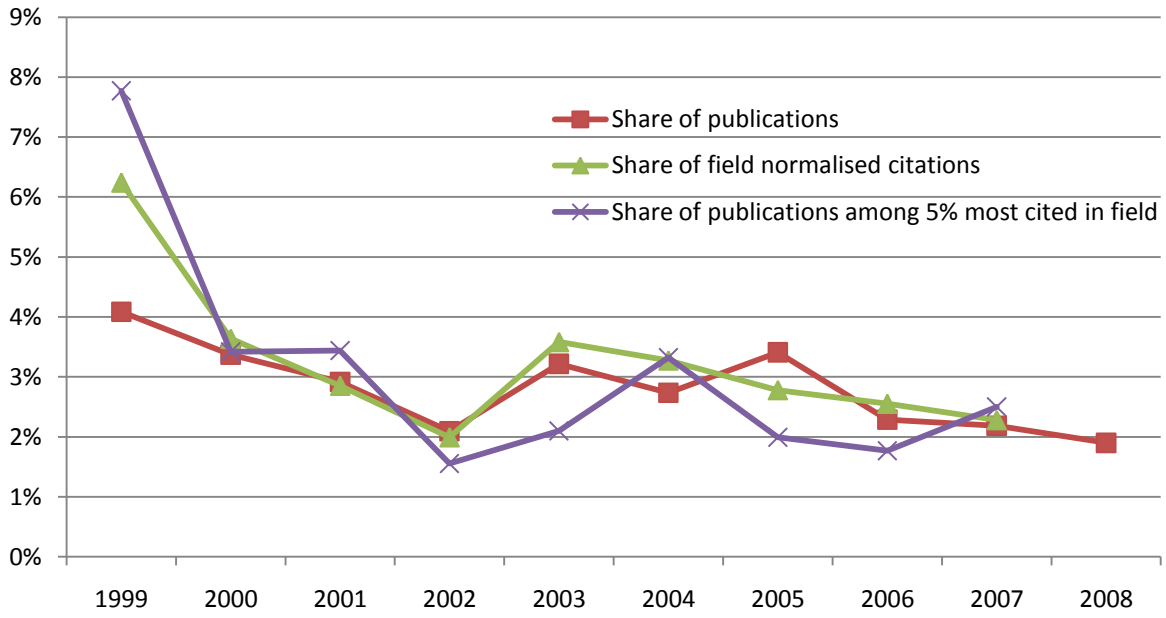

Figure 7: Sweden's share of publications, field normalised citations and highly cited publications, in the selected journals. The period 1999-2008, fractionalised numbers, 3-year citation window[1]. For the top5 category it holds that a publication must have strictly more citations than the limit for the 95th percentile.

The Swedish share of publications, as well as that of citations, has decreased during the period.

Since the distribution of citations over publications is very skewed – typically very few publications stand for the majority of the citations – the average citation rate can be somewhat misleading. One way to complement the average citation rate is to look at highly cited papers. In this case we have defined *highly cited* as belonging to the 5% most cited in the field. The purple (crossed) line in the diagram above shows the share of Swedish publications that are highly cited.

The development for field normalised citations and highly cited papers roughly follows that of publications, and the differences that are there should not be given much weight, since the absolute number of publications is small.

If the first year of the period is ignored, the decrease is much less obvious. For that reason we look at the publication volume for period 1982-2008.

[1] See the appendix for an explanation of fractionalisation and of citation window.

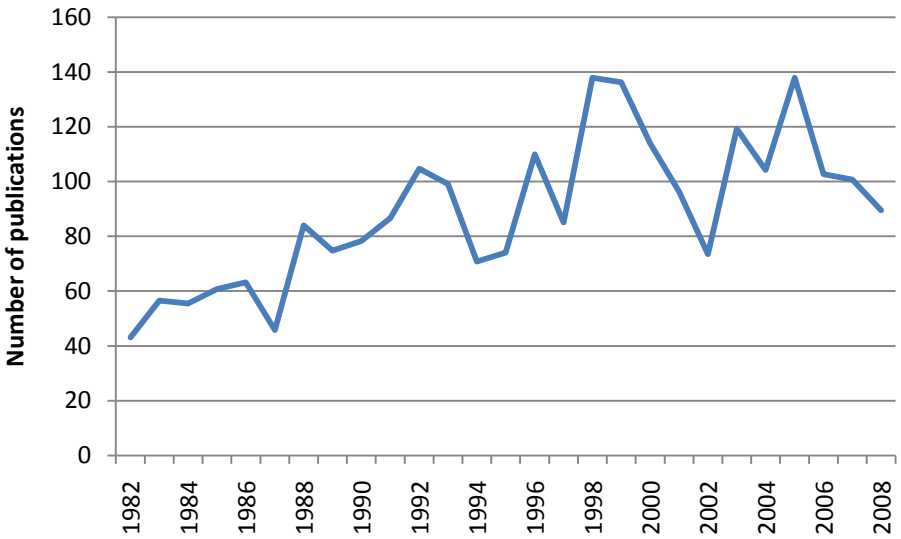

Figure 8: Publication volume for Sweden in the selected journals. Fractionalised numbers[1].

The diagram above shows that 1999 and 1998 were rather exceptional years in terms of Swedish publication volume in the selected journals.

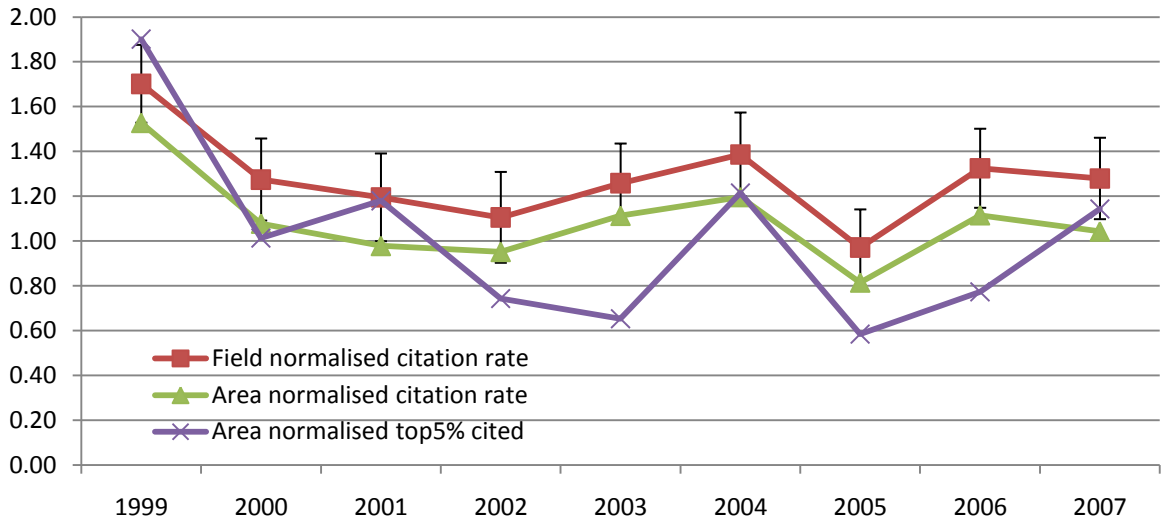

Figure 9: Field normalised citation rate, area normalised citation rate and area normalised top5 for Sweden. Fractionalised numbers[2]. The black bars show the margin for 'normal variation'[3] .

The diagram above shows the development for citations to Swedish publications in the selected journals. Field normalised citation rate was explained above (p. 4). Since the field normalised citation rate for the area as a whole is above 1 (see Figure 5), the ratio between

[1] See the appendix for an explanation of fractionalisation.

[2] See the appendix for an explanation of fractionalisation.

[3] Kronman, Ulf & Karlsson, Staffan (forthcoming). *Error margins for the field normalised citation rate*. Vetenskapsrådet.

the Swedish average field normalised citation rate and the total average field normalised citation rate is shown too, with the label *area normalised citation rate*. The term *area normalised top5* denotes the share of Swedish publications belonging to the 5 % most cited, related to the corresponding share for all countries[1].

The Swedish citation rate has, with the exception of a very high value 1999, been around 1.0 both as regards the area normalised citation rate and the area normalised top5. The top5 measure is based on very small absolute numbers, and should be interpreted with great caution.

The subject profile for the studied journals is shown in figure 6.

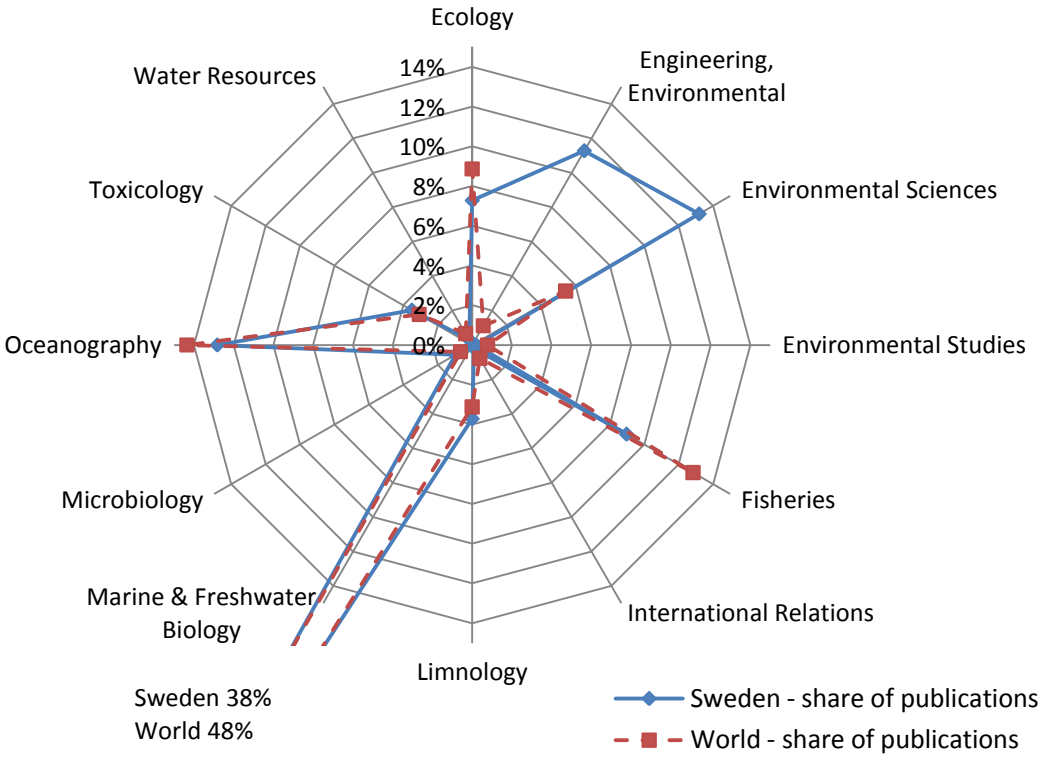

Figure 10: Subject distribution for the selected journals. 1999-2008, fractionalised numbers[2].

The diagram above shows that compared to the database as a whole, Sweden has a higher share of its marine environment research within the subject fields *Environmental Engineering* and *Environmental Sciences*. At the same time it has a smaller share within *Marine & Freshwater Biology*.

[1] Since only publications with *more* citations than the 95th percentile is included in the top5 category, *less* than 5% of the publications are among the top 5% highly cited papers. Relating the Swedish share to the world share, for the selected journals, translates the percentage number to a ratio of the same kind as the field normalised citation rate: 1 means "as large share as the world average", and 2 means "twice as large share as the world average".

[2] See the appendix for an explanation of fractionalisation.

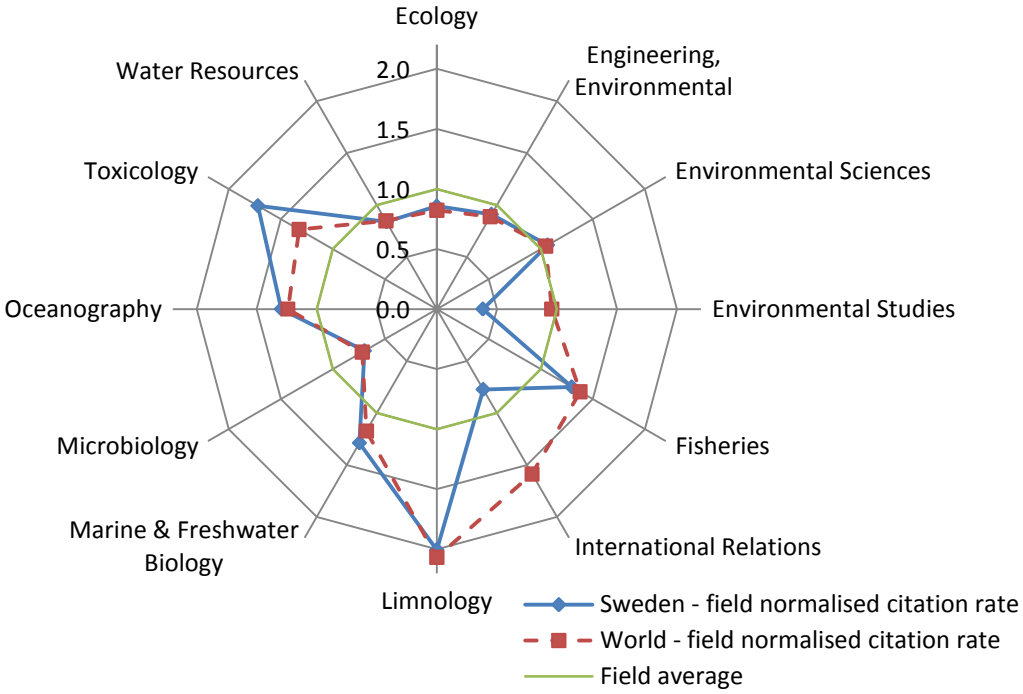

Figure 11: Field normalised citation rate per subject for the selected journals. 1999-2008, fractionalised numbers[1].

Figure 11 shows that the citation rate for the large (in terms of publication volume) Swedish fields *Oceanography, Ecology, Environmental Engineering, Environmental Sciences, Fisheries* and *Marine & Freshwater Biology* are on the same level as the world average for the area. The fields where the Swedish citation rate differs considerable from the area as a whole are all very small and the citation rates are thus unstable.

[1] See the appendix for an explanation of fractionalisation.

Swedish Organisations

Looking at the period 1999-2008 the selected journals contain many enough Swedish publications to make it meaningful to investigate the distribution of publications between the Swedish organisations. This distribution is shown in the diagram below.

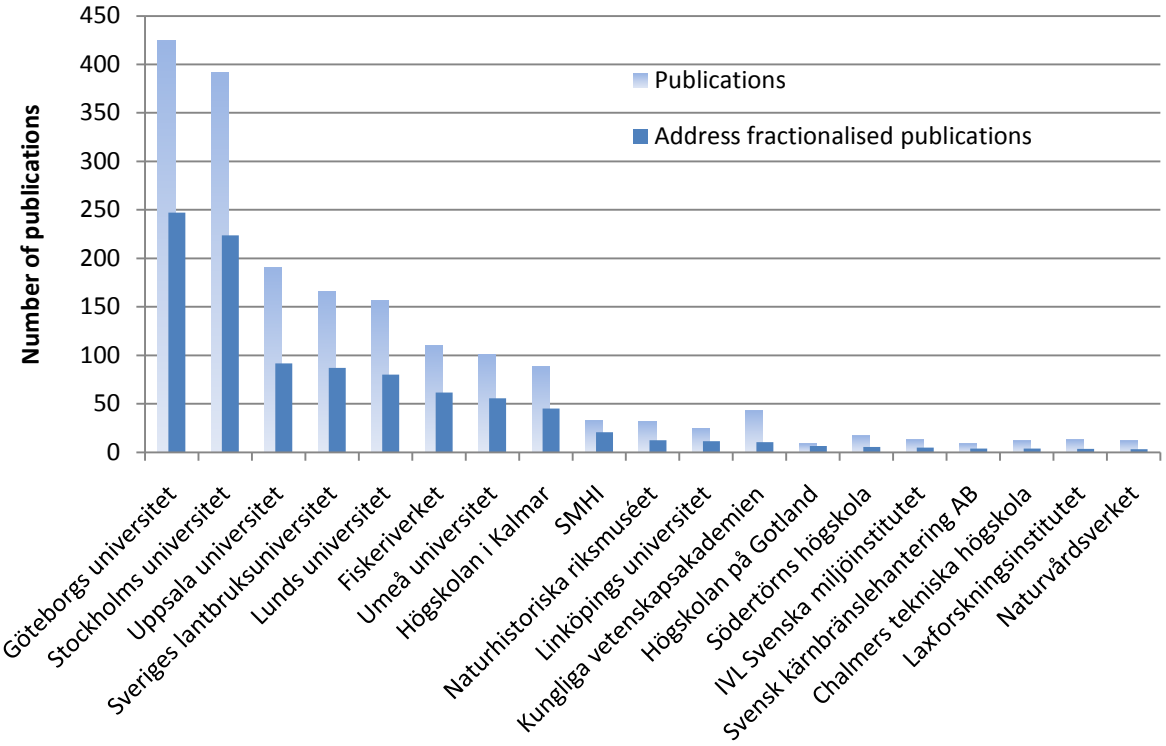

Figure 12: Publication volume per Swedish organisation for the selected journals. 1999-2008. Only organisations with at least 9 publications (whole counts) during the period are included.

University of Gothenburg and Stockholm University are clearly the dominating organisations in Sweden for the selected journals, and together they stand for more than one third of the Swedish publication volume (817 of 2284, whole counts). Uppsala University, Swedish University of Agricultural Sciences, Lund University, Swedish Board of Fisheries, Umeå University and Kalmar University constitute a group with 90-190 publications (whole counts) during the period. Remaining organisations are marginal in this context.

The citation rates for Swedish organisations are shown in the diagram below.

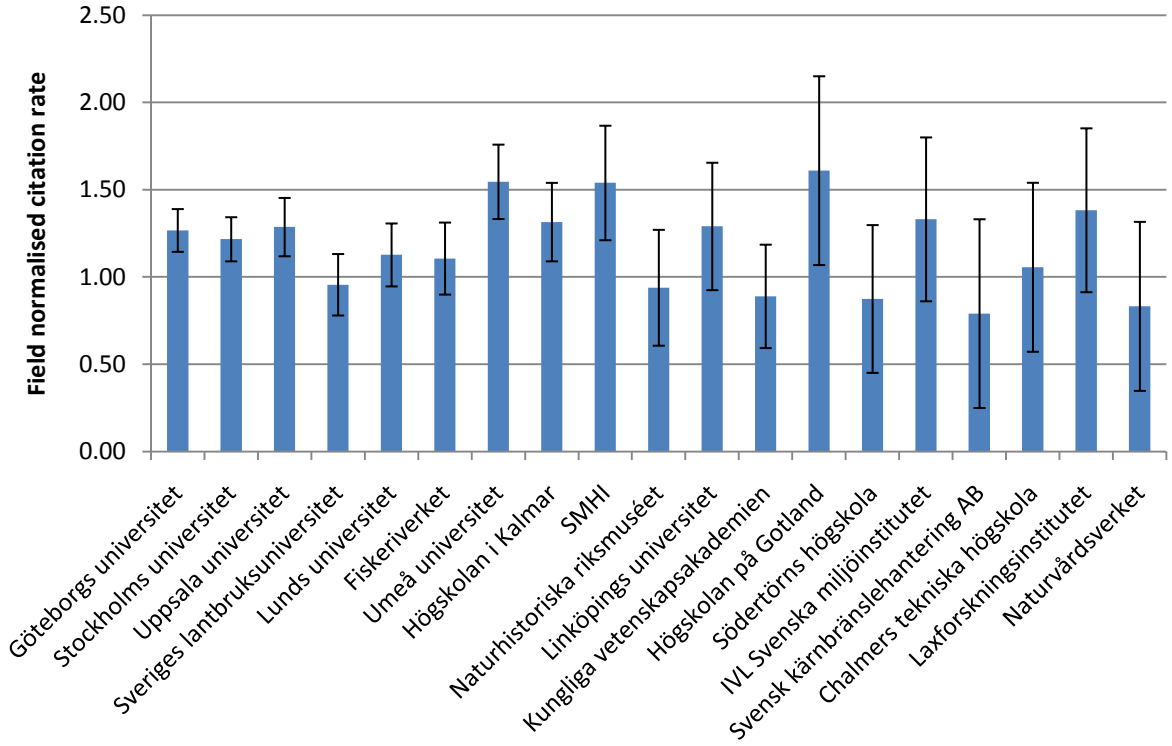

Figure 13: Field normalised citation rate for Swedish organisations with at least 9 publications (whole counts) during the period. 1999-2008, fractionalised numbers[1].

The black bars in the diagram are not traditional error margins, but show a cautious estimation of how much the citation rate can be expected to vary between years as "normal variation"[2].

[1] See the appendix for an explanation of fractionalisation.

[2] Kronman, Ulf & Karlsson, Staffan (forthcoming). *Error margins for the field normalised citation rate*. Vetenskapsrådet.

Appendix: Methods

Scope of the Thomson Reuters citation database

The ISI database attempts to include all publications from the best international, scientific journals for every field. This attempt is reasonably successful, but for a number of scientific fields journal articles are not the only or even the most important type of publication. Monographs, book chapters, conference proceedings, scientific editions and other kinds may contain large or even major shares of the scientific output of a field. Furthermore, some scientific fields are not internationalised to the degree that the best journals are international but rather regional or national.

All this boils down to the following: the ISI database covers scientific publications in Medicine and the Natural Sciences very well, and publications in Technological Sciences are covered reasonably well. For Arts, Humanities and Social Sciences the coverage is, with few exceptions, incomplete and unsatisfactory.

Publication

A publication in the ISI database means, in this document, an item of type Article, Review, Letter, Note or Chronology. The three latter ones are comparably very few and are included in the type Article.

Fractionalisation

It is common that researchers from different countries cooperate in writing scientific papers. Still, in this report we provide publication counts for individual countries. Such counts can be calculated either by counting all publications where the country in question is represented in the address list (*whole counts*) or *address fractionalised*. Address fractionalisation means that publications with authors from more than one country are split between the countries in proportion to the number of addresses from each country.

For example, when one Swedish researcher and one Japanese researcher have written an article together, that counts as 0.5 articles for Sweden and 0.5 for Japan. If an article has been written by 5 Swedes, 2 Japanese and 3 Danes, then it counts as 0.5 articles for Sweden, 0.2 articles for Japan, and 0.3 articles for Denmark.

This fractionalisation makes it possible to compare the number of publications for a single country with the number of publications for the entire world. (The sum of the number of publications for each country in the world will be equal to the number of publications for the world.)

Citations and field normalisation

From a statistical viewpoint, the number of citations for a publication is likely to reflect the scientific quality of that publication. This means that for a reasonably large number of publications, the total citation count will reflect the overall scientific quality. There are a number of pitfalls in this assumption; please see “Hur mycket citeras svenska publikationer? “Bibliometrisk översikt över Sveriges vetenskapliga publicering mellan 1982 och 2004”, Vetenskapsrådets rapportserie 13:2006 for details.

One difficulty when comparing citations is that different scientific fields have different citation traditions. In field A, an average article may have 10 citations, while in field B the average is 3 citations. An article in field B with 10 citations must thus be seen as having made considerably more impact than an article in field A with the same number of citations. Another similar difficulty is that different types of publications attract different attention and are therefore cited to different extent. Review articles describing the frontiers within a scientific area usually get more citations than original publication.

In order to handle this variation in citing traditions, field normalised citations are used. For each field, publication type and year, the average number of citations per article is calculated (field reference value, FRV). The citation count for each article, C, is then related to this average: C/FRV. An example: in 2002, the average number of citations per article in field A is 10.0. For field B, the average is 3.0. Article X, which belongs to field B and was published in 2003, has 10 citations. The field normalised citation count for article X is then 10/3= 3.33. Article Y, which belongs to field A and was published in 2003, also has 10 citations, but the field normalised citation count is 10/10=1.0.

This way, articles from different scientific fields and of different types can be compared as regards citation counts. In this context 1.0 always means that the publication, or publications, attracts attention corresponding to a "world average" publication.

Citation Window

For practical reasons, we only count citations from articles not more than two years younger than the cited article. That is, an article from 1990 only gathers citations from articles published in 1990, 1991 and 1992.

Appendix II

Evaluation of Marine Environment Research in Sweden

1. Project formalities

Funding organisation	
Title of the original application	
Registration number at the funding organisation	
Duration (start and end – month, year)	
Granted funding (SEK)	
Principal investigator (or investigators if changed during project)	
Academic title	
Affiliation	
E-mail address	
Other researchers (PhD or PhD-student) working within the project more than 3 months (name, academic exam, department, university, number of months employed)	

2. Project content and principal results

Rationale and subject matter

Principal method(s) and activities

Main scientific findings

Relevance for the marine environment and use of marine resources, the most important conclusions of practical relevance (for policy makers and other stakeholders)

3. List of scientific publications

The scientific publications should be presented under the following three categories:
a/ Published peer-reviewed articles mainly (> 50%) being a product of the project in question, b/ submitted or accepted manuscripts mainly (> 50%) being a product of the project in question, c/ other scientific publications belonging to the project in question (reports, conference proceedings, etc), and d/ other relevant peer-reviewed articles within the subject area that was published during 2000 – 2009.

a/ Published peer-reviewed articles from project in question

	Scientific publication (Author/s, publication year, title of article, full journal name, volume, issue, pages)
1.	
2.	
…..	

Mark the two most important peer-reviewed articles, and please submit one reprint/copy/pdf to Formas together with this questionnaire.

b/ Submitted / accepted manuscripts

	Manuscript title, author/s, full journal name	Status of manuscript (submitted / accepted)
1.		
2.		
…		

c/ Other important scientific publications (including proceedings)

1.	
2.	
…	

d/ Other relevant peer-reviewed articles within the subject area

	Scientific publication (Author/s, publication year, title of article, full journal name, volume, issue, pages)
1.	
2.	
…..	

4. Oral presentations at international scientific conferences

For the two most prominent presentations, mainly (> 50%) being a result of the project in question, please describe:

	Title of conference	Place, date and main organizer	Approx. number of participants	Title of own oral presentation
1.				
2.				

5. International and national cooperation

Please list the three most important ***international*** scientific collaborations for the project

	Aim	Nature	Partner	Duration
1.				
2.				
3.				

Please list the three most important ***national*** scientific collaborations for the project

	Aim	Nature	Partner	Duration
1.				
2.				
3.				

6. Capacity building

Master theses (year of exam, thesis title)	
Lic/PhD-exams obtained with a substantial (≥ 50%) contribution from the actual project (name of Lic/PhD-student, year of exam, thesis title and present employment if known)	

7. Dissemination of results outside the scientific community

a/ Did you have a continuous dialogue with stakeholders (policy makers, managers or practitioners) during the project?

Form of dialogue	With whom	How often	Effect (on your project or on policy makers / stakeholders)

b/ Have results from the project been communicated to stakeholders (policy makers, managers or practitioners)?

To whom	In what arena / context?	Main message	Outcome (if known, e.g. change in policy)

c/ Publications / publicity outside the scientific community about the project

Form of publication / publicity	When	Main message

Thank you for your participation!

Appendix III

Project evaluation form

General instructions

Every question is marked with a score (0 – 10) and a short comment. If no judgement can be made, due to lack of information, question is not relevant, etc., put a "-" in the field and an explanation in the comments field.

The general quality of project is also given a score and summarized in a somewhat longer comment on the general strengths and weaknesses.

Remember to take the following into consideration when judging the projects:

- When the project was completed (can have implications on e.g. the number of papers published)
- The amount of funding
- The type of project (e.g. large SEPA program / small Formas project)

Scores and definition of scores:

	Scientific Value	**Societal Value**
10	**Outstanding**, at the forefront of international research	Research addressing a major challenge for sustainable development and project outcome which may be highly beneficial for society. Prospects of general applicability
7	**Excellent**, strongly competitive at an international level	Research addressing an important challenge for sustainable development and project outcome which may be highly beneficial for society.
5	**Very good**, strongly competitive at a national level	Research with high value for sustainable development and project outcome which may be beneficial for society. Applicable in some areas.
4	**Satisfactory** – competitive at a national level	Research with moderate value for sustainable development and project outcome which may be beneficial for society. Limited applicability.
3	**Fair** – achieves some of its aims but makes limited progress to advance this area of work	Research with limited value for sustainable development. Project outcome may be beneficial for society. Limited applicability.
2	**Barely acceptable** – the work is reported but not publishable	Limited benefit for society but not applicable in its current form.
0	**Poor** – Insufficient quality	No benefit for society.

Evaluators' name:

Project information:

Number	
Principal investigator	

A. The scientific quality of the research project

Question	Score	Comment
1. Used methods (appropriate and up to date?)		
2. Innovation and new ideas		
3. International and national collaboration		
4. Production of peer-reviewed articles and other scientific publications		
5. Capacity building (i.e. to what extent the project has contributed to MSc, Lic, Dr)		

A6. Summary – overall scientific quality

Score	Comment

B. The relevance and use of the research in society

Question	Score	Comment
1. Production of useful and accessible knowledge for relevant stakeholders		
2. Communication with appropriate stakeholders		
3. Has the research led to measurable or foreseeable changes in policy or practice		

B4. Summary – overall societal relevance and importance

Score	Comment