

Polar research in the Kingdom of Denmark 2013

A mapping survey

Dag W. Aksnes
Karen Skytte Larsen
Liselotte Nielsen
Kristoffer Rørstad

Report 18/2014

NIFU

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Preface

This report presents the results of a mapping survey of polar research in the Kingdom of Denmark. The report contains a broad range of indicators and statistics on the volume and profile of the polar research carried out by institutions in Denmark, Greenland and the Faroe Islands. The project was funded by the Danish Agency for Science, Technology and Innovation.

The report contains the results of two separate surveys. The first is a survey on R&D resources devoted to polar research within the Kingdom in 2013, the other is an analysis of the publication output of polar research, both internationally and within the Kingdom. The first part was carried out by Dag W. Aksnes (project leader) and Kristoffer Rørstad at the Nordic Institute for Studies in Innovation, Research and Education (NIFU). Trude Røsdal also contributed to this part of the project. The second part of the project was carried out in-house at the Danish Agency for Science, Technology and Innovation by Karen Skytte Larsen and Liselotte Nielsen. There are separate chapters presenting the results of the two surveys. Karen Skytte Larsen and Liselotte Nielsen wrote the chapters presenting the publication analysis (Chapter 3 and Chapter 5.3), while Dag W. Aksnes wrote the other parts of the report.

The project team would like to thank the many departments and institutes that responded to the questionnaire survey.

Oslo, 20.05.14

Kyrre Lekve
Deputy director

Susanne L. Sundnes
Head of research

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Summary

Polar research has a long tradition within the Kingdom of Denmark, and in this report a quantitative overview of the current status is presented.

In total 723 million kroner was spent on polar research in 2013 by institutions and institutes located in Denmark, Greenland and the Faroe Islands. In terms of work effort, a total of 611 polar research work-years (full time equivalents) were carried out. Institutions located in Denmark carried out 490 work-years (80% of the total), while institutions located in Greenland and the Faroe Islands contributed 83 and 38 work-years respectively (14% and 6% of the total).

Polar research is carried out at a large number of departments and institutes within the Kingdom. In total, 91 departments/ institutes/units reported that they carried out polar research in 2013. Aarhus University and University of Copenhagen are by the far the largest contributors to polar research. Together the two institutions account for 42 per cent of the polar research within the Kingdom. The Geological Survey of Denmark and Greenland (GEUS) is the third largest institutional contributor to polar research followed by the Greenland Institute of Natural Resources.

The majority of the polar research is carried out at the universities. By sector of performance, 60 per cent of the research work efforts were carried out by institutions in the higher education sector, and 40 per cent by institutions in the government sector.

Polar research encompasses both marine and terrestrial disciplines. Approximately 70 per cent of the research is land-based, and 30 per cent relates to sea areas. Polar research is carried out within all fields of science, but natural sciences account for the largest proportion. A total of 449 work-years were carried out within the natural sciences, which amounted to 74 per cent of all polar research within the Kingdom. At the level of disciplines, geosciences and biology are by far the largest. The geosciences account for 45 per cent of all polar research within the Kingdom while the corresponding figure for biology is 28 per cent. The four other fields of science; technology, medicine/health, social sciences and humanities, are quite similar in research volume and account for 5 to 8 per cent of the total research.

Naturally, Greenland is the most important land area for the polar research within the Kingdom. In total more than half of the research relates to Greenland. In addition, the Greenland Sea and sea areas surrounding Greenland account for 24 per cent of the research. Thus, in total 76 per cent of the polar research relates to Greenland and the sea areas surrounding the island.

In addition there are research activities relating to many other geographical areas in the Arctic. As the survey also includes sub-Arctic areas, the Faroe Islands and the northern part of other Nordic countries are included. Of the total polar research within the Kingdom, 7 per cent related to The Faroe

Islands, and 4 per cent to other Nordic countries. Svalbard is an international centre for polar research, but there is relatively limited activity related to this archipelago (2% of the total). Only a very small proportion of the polar research within the Kingdom of Denmark relates to Antarctica (1.5%). The marine research is mainly located at the Greenland Sea and sea areas surrounding Greenland, and there is limited research related to other Arctic waters. The Arctic Ocean accounts for 4 per cent of the total polar research, and The Norwegian Sea for 2.2 per cent.

The survey shows that there are a substantial number of PhD students within the field of polar research. Departments in the higher education sector reported that in 2013 there were in total 150 people working on a PhD within the field, and that 72 people have been awarded a doctoral degree during the period 2011-2013. The corresponding numbers of people for units in the government sector were 52 and 22.

The publication analysis carried out encompasses the 5-year period 2008-2012. During the period almost 1800 polar research articles were published by researchers in Denmark, Greenland and the Faroe Islands. The survey shows that the Kingdom of Denmark is the 8th largest contributor to international Arctic polar research with a proportion of 3 per cent of the world production. The USA, Canada and the United Kingdom are the largest polar research nations in terms of publication output. Among the Nordic countries, Norway is by far the largest research country with a production almost 75 per cent higher than that of the Kingdom of Denmark.

The scientific impact of research is commonly measured through citation indicators. The survey shows that the Arctic polar research articles from the Kingdom of Denmark are cited 26 per cent above the world average. This gives an intermediate position among the countries included in the analysis, but above the citation rates of the two major polar research nations, the USA and Canada.

The extent of international research collaboration is significant both generally and within the Kingdom of Denmark. The USA is the nation most frequently involved in collaboration with researchers from the Kingdom and almost one quarter of the Kingdom's polar publications also include US co-authors.

1 Introduction

The polar regions are increasingly important in international research. One reason for this is the awareness that the polar regions are particularly important in understanding global climate changes. Moreover, factors such as prospects for mineral and petroleum resources, new shipping routes and exploitation of biological resources contribute to increased research focus on the polar regions. In addition, the regions are the basis for many types of basic research.

Polar research has a long tradition within the Kingdom of Denmark, and the Kingdom is today an important contributor to international polar research generally, and to Arctic polar research in particular. Naturally, Greenland has been the major area of the research activities, but the efforts span most of the Arctic and even the Antarctic. The research covers a broad range of topics and disciplines, spanning from natural sciences, medicine and engineering to social and cultural studies of indigenous Arctic populations.

Despite these facts, there have not been available data and information on the extent of the research within the Kingdom that actually is devoted to the polar regions.¹ Against this background the Danish Agency for Science, Technology and Innovation took the initiative to carry out a mapping survey of polar research within the Kingdom. This report presents the results of the survey. The main purpose is to provide a quantitative overview of the polar research within the Kingdom of Denmark, in terms of volume, profile and funding. In addition, the report presents a bibliometric analysis of Arctic polar research in an international context. Polar research is delimited using a geographical definition and encompasses all the research that takes place within a limited geographical area. Thus polar research spans many different disciplines. The focus of the survey is the current status: the research activities in 2013. The data presented in the report are based on a questionnaire survey that was sent to a broad range of departments and institutes in Denmark, Greenland and the Faroe Islands. In addition, a publication analysis of the polar research both internationally and within the Kingdom has been carried out. This survey covers the 5-year period 2008-2012. The results of the two surveys are presented in separate chapters.

It should be noted that the report has a strictly descriptive focus. No attempt has been made to discuss normative implications of the findings, to evaluate the status of polar research or to suggest policy-related actions. We leave it to others to discuss these aspects and implications.

The target group of the report is administrators and policy makers at various levels within the research system, as well as researchers and the general public interested in polar research. We hope that the

¹ However, a descriptive overview was provided in a report published in 1993: *Polarforskning. Status 1992*. Kommissionen for Videnskabelige Undersøgelser i Grønland. Dansk Polarcenter, København.

results of the report will be useful as basis for strategic planning and research policy advice related to polar research within the Kingdom of Denmark.

2 Polar research within the Kingdom of Denmark - resources

In this chapter we present the results of the survey on polar research in the Kingdom of Denmark in 2013. Various indicators of research activity are presented, such as human resources, economic resources and funding, geographical profile, institutional profile and discipline structure.

The survey encompasses polar research carried out by institutions and institutes in Denmark, Greenland and the Faroe Islands. In total, 91 departments/institutes/units reported that they carried out polar research in 2013. Polar research is defined as *research carried out on the basis of material from the polar areas (Arctic and Antarctic), on phenomena located in the polar areas or aiming at direct application in polar areas*. We have applied the definition of Arctic developed by the Arctic Monitoring and Assessment Programme (AMAP), which also includes some sub-Arctic areas such as the Faroe Islands, Iceland and the Northern part of Scandinavia. In addition Antarctica and the sea areas surrounding the continent are included. Chapter 5 gives a detailed description of the data and method underlying the survey.

2.1 Total resources

The survey shows that in total 723 million Danish kroner (DKK) was spent on polar research in the Kingdom of Denmark in 2013. In terms of work effort, a total of 611 work-years (full time equivalents) was spent on polar research in 2013.

How large proportion of the public sector's R&D is spent on polar research? In 2011, the total R&D expenditure in the public sector in Denmark (excluding Greenland and the Faroe Islands) amounted to 18 189 million kroner and 20 976 work-years R&D were carried out.² Data for 2013 are currently not available. From 2011 to 2013 the grants allocated for R&D purposes via the Danish Appropriation Act ("offentligt forskningsbudget") have increased by approximately 3.7 per cent (fixed 2013 prices). Using the latter figure as proxy for the 2013 total, 3.8 per cent of the public sector's R&D expenditure was spent on polar research in 2013. In terms of work-years, the proportion is 2.8 per cent.³ The difference is due to the fact that polar research is much more expensive than "average" research, as it

² Source: Innovation og forskning 2013, Danmarks Statistik.

³ Please note, development work is not included in the survey (however, the extent of development work related to the polar regions presumably is rather limited). Limiting the calculation to the research part only, the proportion would be even higher. According to Danmarks Statistik, 14 per cent of the work-years in the public sector are development work (2011). If this development work is excluded, the polar research proportion measured in work-years would be 3.3 per cent and not 2.8 per cent.

often depends on costly research infrastructure, field stations and research vessels (cf. Subchapter 2.5 below). However, it should be noted that the total national R&D expenditure is for Denmark only, as figures are not available for Greenland and the Faroe Islands. If the calculations include only institutions located in Denmark, the proportion in terms of work-years is 2.3 per cent.

In total 91 departments/units within the Kingdom reported that they carried out polar research in 2013 of which 62 are university departments, and 29 units in the government sector.

Table 2.1 shows how the polar research efforts in terms of work-years were distributed according to sector and institutional location⁴. Institutions located in Denmark carried out 490 work-years (80 % of the total), while institutions located in Greenland and the Faroe Islands contributed 83 and 38 work-years, respectively (14 and 6 % of the total).

The majority of the polar research is carried out at the universities. By sector of performance, 60 per cent of the research efforts were carried out by institutions in the higher education sector and 40 per cent by institutions in the government sector.⁵

Table 2.1. Number of polar research work-years in 2013 by geographical area and sector.

Sector	Geographical area (institutional location)			Total
	Denmark	Greenland	The Faroe Islands	
Higher education sector	345	19		364
Government sector*	145	64	38	247
Total	490	83	38	611

* Independent research institutes, museums, hospital sections.

2.2 Institutional distributions

Polar research is carried out at a large number of departments and institutes. Aarhus University and University of Copenhagen are by the far the largest contributors to polar research within the Kingdom. The two institutions have 134 and 122 work-years polar research, respectively (cf. Figure 2.1). Together the two institutions account for 42 per cent of the polar research within the Kingdom.

Aarhus University has established a centre for polar research (Arctic Research Centre) which coordinates much of this activity at the university, and there is a separate centre for Arctic health located at the Department of Public Health. Twelve departments at the university have reported polar research activities, of which the Department of Bioscience, the Department of Physics and Astronomy and the Department of Chemistry are the largest in terms of volume (each with more than 20 work-years).

At the University of Copenhagen, 17 departments reported polar research activities. The largest contributors are the Department of Geosciences and Natural Resource Management (Centre for Permafrost), the Niels Bohr Institute (Centre for Ice and Climate), and the Natural History Museum of Denmark (each with more than 20 work-years).

The Geological Survey of Denmark and Greenland (GEUS) is the third largest institutional contributor to polar research within the Kingdom with 84 work-years, followed by the Greenland Institute of Natural Resources (61 work-years). The two are the largest non-university institutions active in polar

⁴ The institutions are classified according to the address of their headquarters. Institutions/institutes such as GEUS which also have offices in Greenland are therefore included under Denmark in these statistics.

⁵ In this survey, the government sector includes independent research institutes, museums, hospital sections, etc.

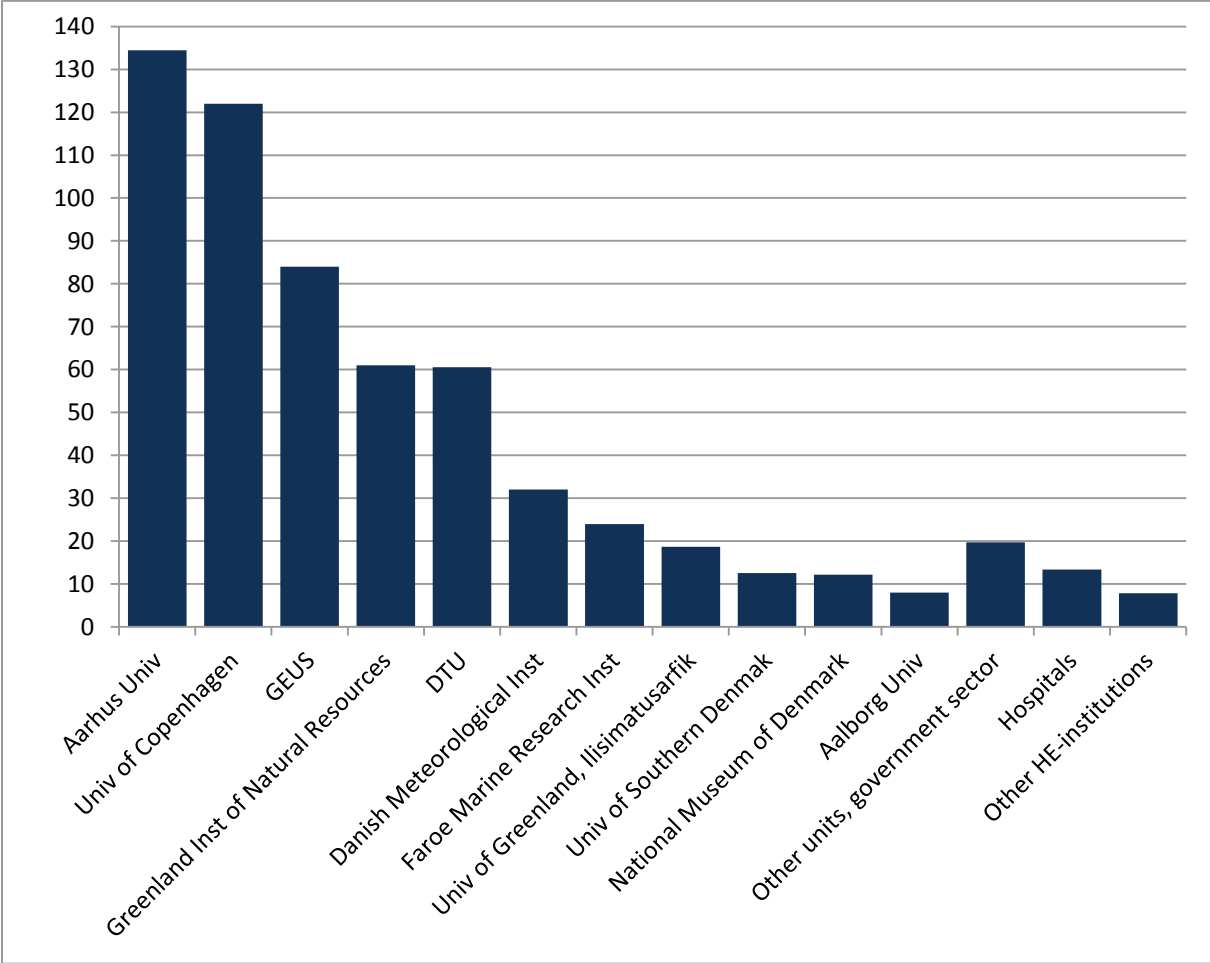
research within the Kingdom. The Greenland Institute of Natural Resources is the largest institution located in Greenland in terms of volume of polar research.

The Technical University of Denmark (DTU) is the fifth largest institutional contributor and the third largest in the higher education sector (61 work-years). DTU has established a centre for polar research (Polar DTU). Six departments at the university have reported polar research activities of which DTU Aqua, DTU Civil Engineering (Arctic Technology Centre) and DTU Space are the largest (each with more than 15 work-years).

The Danish Meteorological Institute also has substantial polar research activity (33 work-years), in particular at the Centre for Ocean and Ice. Next follows The Faroe Marine Research Institute with a volume of 24 work-years, the largest research institution in terms of contribution to polar research located on the Faroe Islands. The University of Greenland (Ilisimatusarfik) has research activity amounting to 19 work-years in 2013, and the Institute of Ilimmarfik is the largest contributor to the research activities.

In Figure 2.1 only institutions/institutes with more than 7 work-years on polar research are shown separately. The National Museum of Denmark, The University of Southern Denmark and Aalborg University have research activities in the range of 8-13 work-years. At the University of Southern Denmark, the National Institute of Public Health and Department of Biology are the main contributors. At Aalborg University there are polar research activities at five departments.

Figure 2.1. Number of polar research work-years 2013 by institutions/institutes*.



* Only institutions/institutes with more than 7 man-years polar research are shown separately in the figure.

In the figure there is a separate category for hospitals. Altogether 13 work-years of polar research were carried out at the hospitals. The activity is located at several different hospitals, for example the Arctic Health Research Centre at Aalborg University Hospital. There are usually strong links between the university hospitals and the medical faculties at the universities, and it should be noted that some of the research activities may have been reported by the universities and not the hospitals. It should also be noted that we have not applied a full scale mapping of the hospitals. Rather, the questionnaire was sent to sections within the hospitals that previously have published articles within medical polar research. Thus, there is a potential risk that the survey has not captured all the polar research at the hospitals. Statens Serum Institut is an important contributor to medical polar research, but this institute is included in the “Other units, government sector” category.

The latter category consists of several units within the government sector. In addition to Statens Serum Institut, institutions such as Asiaq, Greenland Survey are included in this category. In the category for other units in the higher education sector (Other HE institutions) we find for example Roskilde University and Copenhagen Business School.

Polar research within the Kingdom is characterised by a strongly skewed distribution. This is shown in Table 2.2 where the departments/institutes are grouped into size intervals according to the number of polar researches carried out. There are 11 units with a polar research effort of more than 20 work-years. These units performed 2/3 of all polar research within the Kingdom. On the other hand there is a large number of units with minor polar research activities, in total 47 units with 0-2 work-years. These units together contributed a total of 4.6 per cent of the polar research within the Kingdom.

Table 2.2. Distribution of departments/institutes by the number of polar research work-years in 2013 by sector.

Work-years interval	Higher education sector			Government sector		
	Number of departments	Total number of work-years	Proportion of total number of work-years	Number of institutes/units	Total number of work-years	Proportion of total number of work-years
0-2 work-years	32	21	5.8%	15	7	2.9%
2-5 work-years	11	36	9.8%	6	17	7.0%
5-10 work-years	9	50	13.8%	3	18	7.3%
10-15 work-years	1	14	3.7%	1	12	4.9%
15-20 work-years	2	32	8.7%			
>20 work-years	7	212	58.3%	4	192	77.9%
Total	62	364	100.0 %	29	247	100.0 %

2.3 Geographical distributions

Polar research encompasses both marine and terrestrial disciplines. The survey included questions about which geographical area the research was concentrated on (i.e. according to which area data were collected/area the research was dealing with). Based on these data, an overview of the geographical distribution of the polar research is given in Table 2.3. Approximately 70 per cent of the research is land-based, and 30 per cent relates to sea areas. Thus, marine polar research has a significantly smaller volume than terrestrial polar research.

As expected, Greenland is the most important land area for the polar research within the Kingdom. In total more than half of the research relates to Greenland (321 work-years). In addition, the Greenland Sea and sea areas surrounding Greenland account for 24 per cent of the research. Thus, in total 76

per cent of the polar research relates to Greenland and the sea areas surrounding the island. The large majority of this research is carried out by institutions located in Denmark.

The Faroe Islands has a proportion of 7 per cent of the total (45 work-years), of which the majority is carried out by institutions located on the archipelago. The survey also includes sub-Arctic areas in the other Nordic countries. Slightly more than 4 per cent of the research within the Kingdom was related to these areas. Svalbard is an international centre for polar research, but there is relatively limited activity related to this archipelago (11 work-years; 2 %).

Internationally, Antarctica is of equal importance for polar research as the Arctic. Some polar research nations have the bulk of their research activities in Antarctica. However, only a very small proportion of the polar research within the Kingdom of Denmark relates to this continent (1.5 %). Several institutions have nevertheless reported some research activities related to Antarctica, of which Aarhus University is the largest.

The marine research is mainly located at the Greenland Sea and sea areas surrounding Greenland and there is limited research related to other Arctic waters. The Arctic Ocean accounts for 4 per cent of the total polar research, and The Norwegian Sea for 2.2 per cent.

Table 2.3 also shows the geographical distribution by sectors. Overall, there are not very large differences in profile between the sectors, but it should be noted that marine research plays a more important role in the government sector than in the higher education sector (overall proportions of 37 and 25 per cent of the total, respectively). Institutions in the government sector are the main contributors to Faroe Islands research, while the opposite is the case for the Svalbard and Antarctic research.

Table 2.3. Number of polar research work-years by geographical area and sector of performance in 2013.

	Geographical area	Higher education sector	Government sector	Total	Total, proportion
Land areas	Land areas - total	247	178	425	69.8%
	Greenland	185	136	321	52.7%
	The Faroe Islands	9	37	45	7.4%
	Svalbard	11	2	13	2.2%
	Nordic countries, Arctic mainland areas and Iceland	25	2	27	4.4%
	Arctic land areas not specified above	9	1	10	1.6%
	Antarctica	8	1	9	1.5%
Sea areas	Sea areas* - total	81	103	184	30.2%
	Greenland Sea and sea areas surrounding Greenland**	61	82	144	23.6%
	Barents Sea	0.4	1	1	0.2%
	Arctic Ocean	11	11	23	3.7%
	The Norwegian Sea	6	7	14	2.2%
	Other polar seas in the Arctic	1	1	1	0.2%
	Polar seas near Antarctica	1	0.4	2	0.2%
	TOTAL	328	281	609	100%

* As a rough guide the sea areas can be delimited as follows: the Kara Sea extends to the east of Novaya Zemlya. The Barents Sea extends to the west of Novaya Zemlya and the east/south of Svalbard. The Greenland Sea extends from the east coast of Greenland to the north/south of Svalbard. The Arctic Ocean is the waters surrounding the North Pole.

** Fram Strait, Denmark Strait, Baffin Bay, Davis Strait.

Figure 2.2 shows the overall figures presented in Table 2.3 as shares of the total (%).

Figure 2.2. Total number of polar research work-years by geographical area in 2013, per cent.

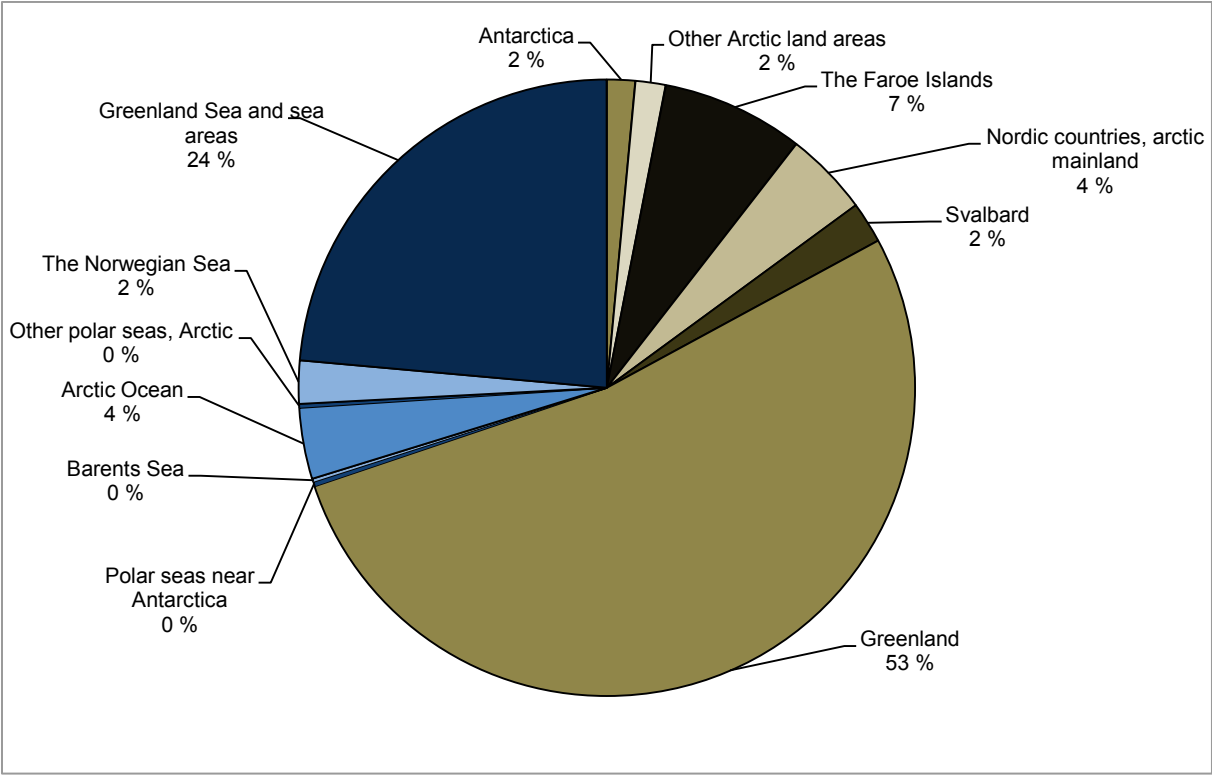
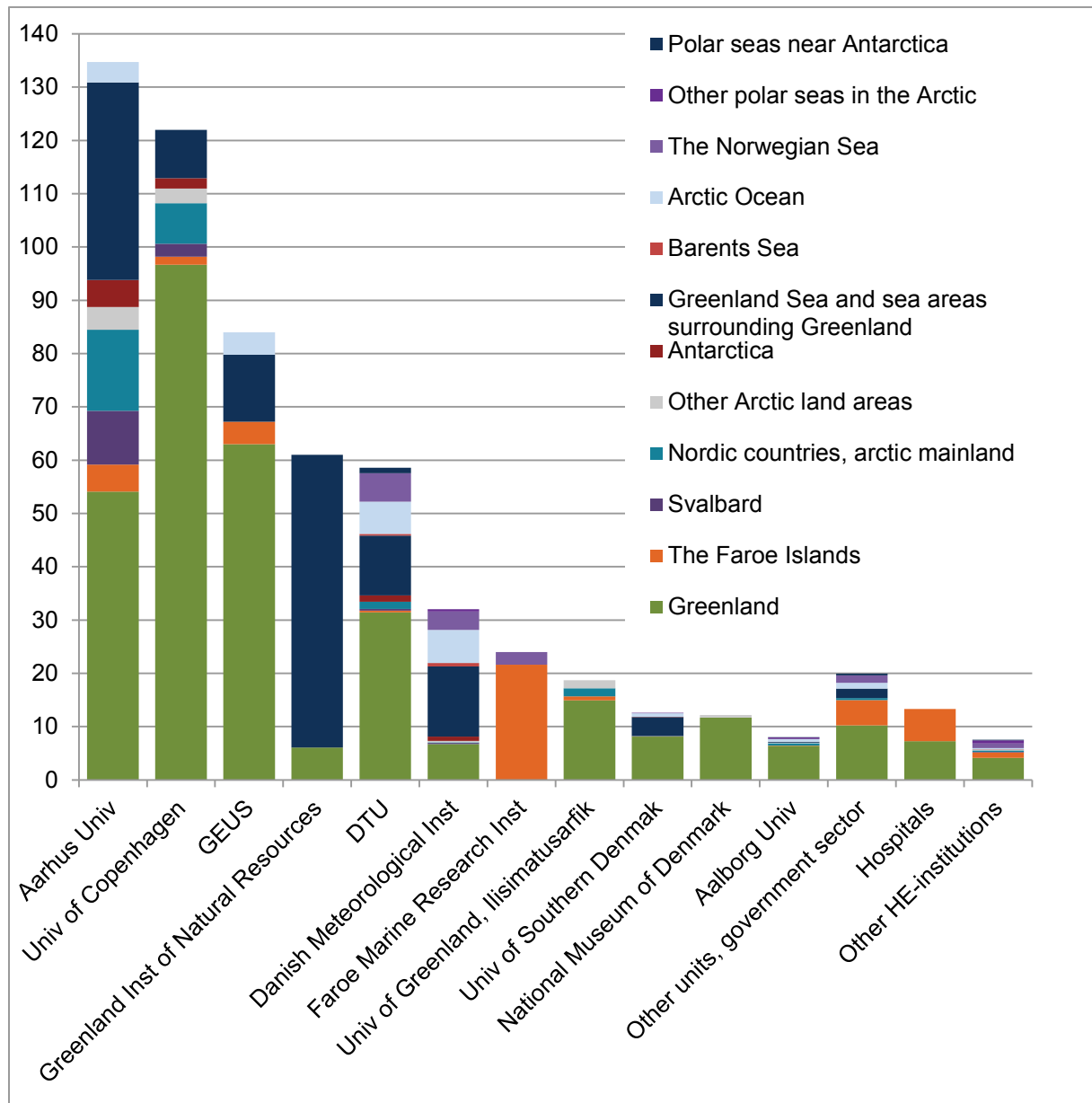


Figure 2.3 shows the geographical profile for the largest institutions. As can be seen, Greenland accounts for the largest proportion of the polar research activities at most of the institutions. The exceptions are institutes with a predominantly marine/sea based research profile such as the Greenland Institute of Natural Resources (Greenland Sea and sea areas surrounding Greenland), the Faroe Marine Research Institute (The Faroe Islands and the Norwegian Sea), and the Danish Meteorological Institute (Arctic Ocean and Greenland Sea and sea areas surrounding Greenland). Interestingly, the two largest institutions; Aarhus University and University of Copenhagen, have a rather different profile. Aarhus University has a more heterogeneous geographical profile than the University of Copenhagen, which is dominated by Greenland.

Figure 2.3. Number of polar research work-years by geographical area for individual institutions/institutes* in 2013.



* Only institutions/institutes with more than 7 work-years polar research are shown separately in the figure.

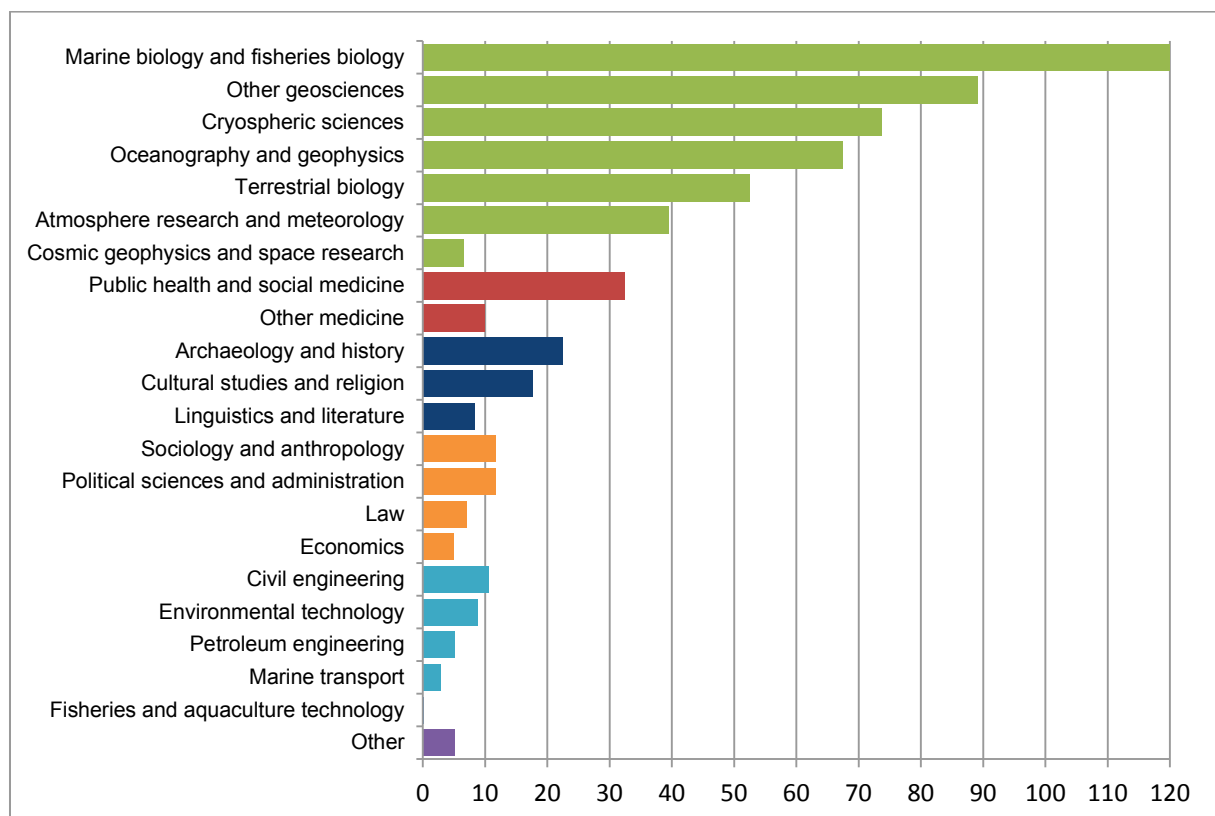
2.4 Scientific profile

Polar research is carried out within all fields of science, but natural sciences account for the largest proportion by far. In 2013, a total of 449 work-years were carried out within the natural sciences, which amounted to 74 per cent of all polar research within the Kingdom. The four other fields of science: technology, medicine/health, social sciences and humanities, are quite similar in research volume and account for 5 to 8 per cent of the total research.

Figure 2.4 shows the total number of polar work-years classified by fields of science and discipline/research field (see Chapter 5 for definitions of the various categories). *Marine biology and fisheries biology* is the largest category in terms of volume (120 work-years). Here the Greenland Institute of Natural Resources and Aarhus University are major contributors (cf. Figure 2.5a). The other biology category, *Terrestrial biology*, is significantly smaller (53 work-years). The University of Copenhagen and Aarhus University are the institutions with the largest volume of terrestrial biology. In total, biology accounts for 28 per cent of the polar research within the Kingdom.

The geosciences have been distributed in four subfields and one “other” category. *Cryospheric sciences* have 74 work-years with University of Copenhagen as the largest contributor. Then follows *Oceanography and geophysics* (67 work-years) and *Atmosphere research and meteorology* (40 work-years). The majority of the latter research is carried out by Aarhus University and the Danish Meteorological Institute. *Cosmic geophysics and space research* is the smallest (7 work-years). There is also a large “*Other geosciences*” category (89 work-years) containing additional research such as geology with GEUS as a main contributor. In total, the geosciences account for 45 per cent of the polar research within the Kingdom.

Figure 2.4. Number of polar research work-years in 2013 by discipline/field, sorted by fields of science in colour.



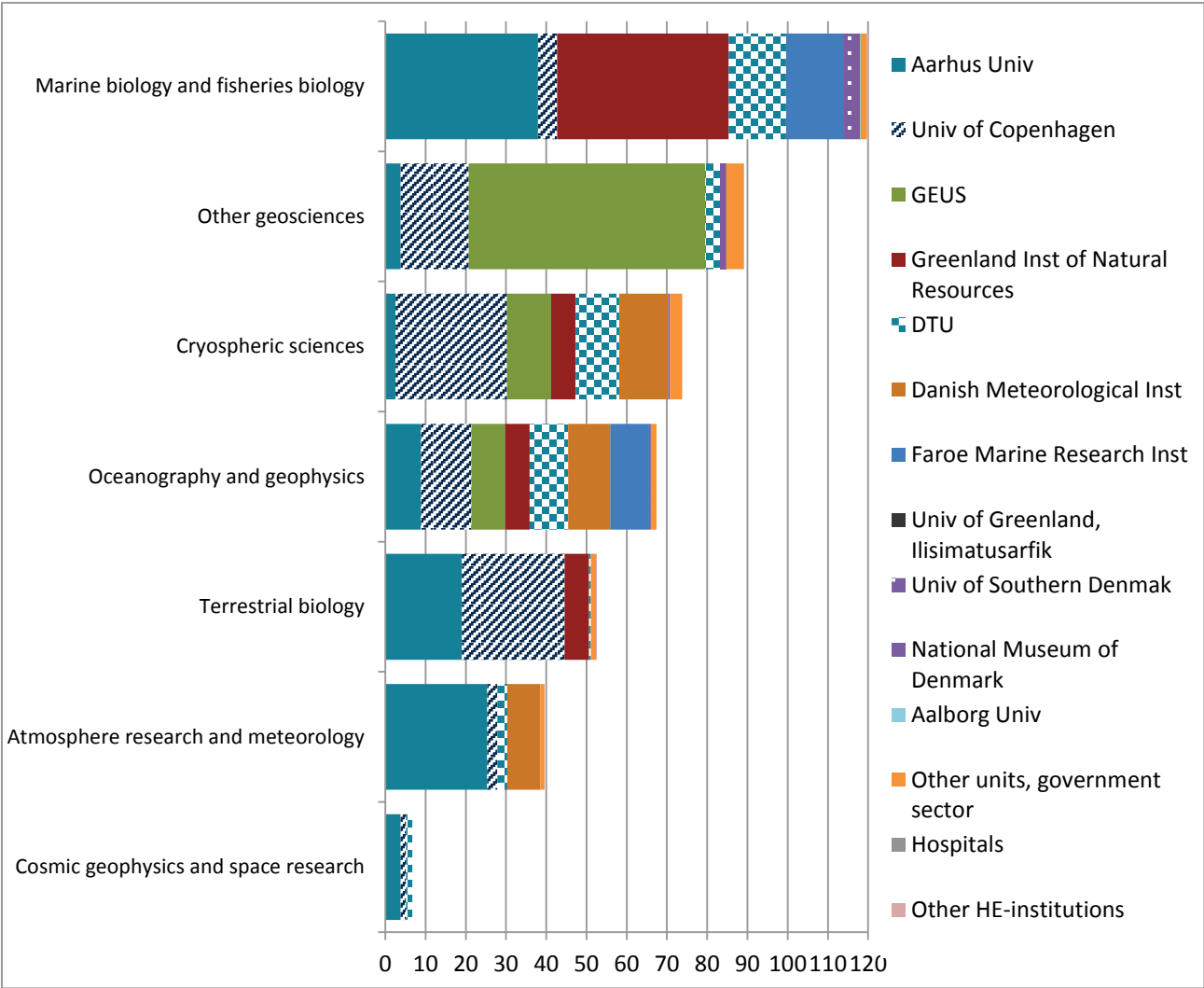
For the health sciences there is only one category, *Public health and social medicine*, in addition to one category for “*Other medicine*”. Most of this research is within *Public health and social medicine* (32 work-years), with Aarhus University, Statens Serum Institute, University of Southern Denmark and various hospitals as major contributors (cf. Figure 2.5b). In the questionnaire a separate category was included for *Psychology and psychiatry*. However, no research was reported within this category, and it has therefore been excluded from the analysis.

Of the technological fields, *Civil engineering* and *Environmental technology* are the largest with 11 and 9 work years, respectively. DTU is a major contributor within both categories in addition to Aarhus University in *Civil engineering*. *Petroleum engineering* has 5 work-years with GEUS as the main actor. There are limited research efforts within the other technology field, *Marine transport*, and *Fisheries and aquaculture technology* (0-3 work-years).

When it comes to the social sciences, *Political sciences and administration* and *Sociology and anthropology* are the largest categories, both with 12 work-years, followed by *Law* (6 work-years) and *Economics* (5 work-years). Many different institutions contribute to social science polar research.

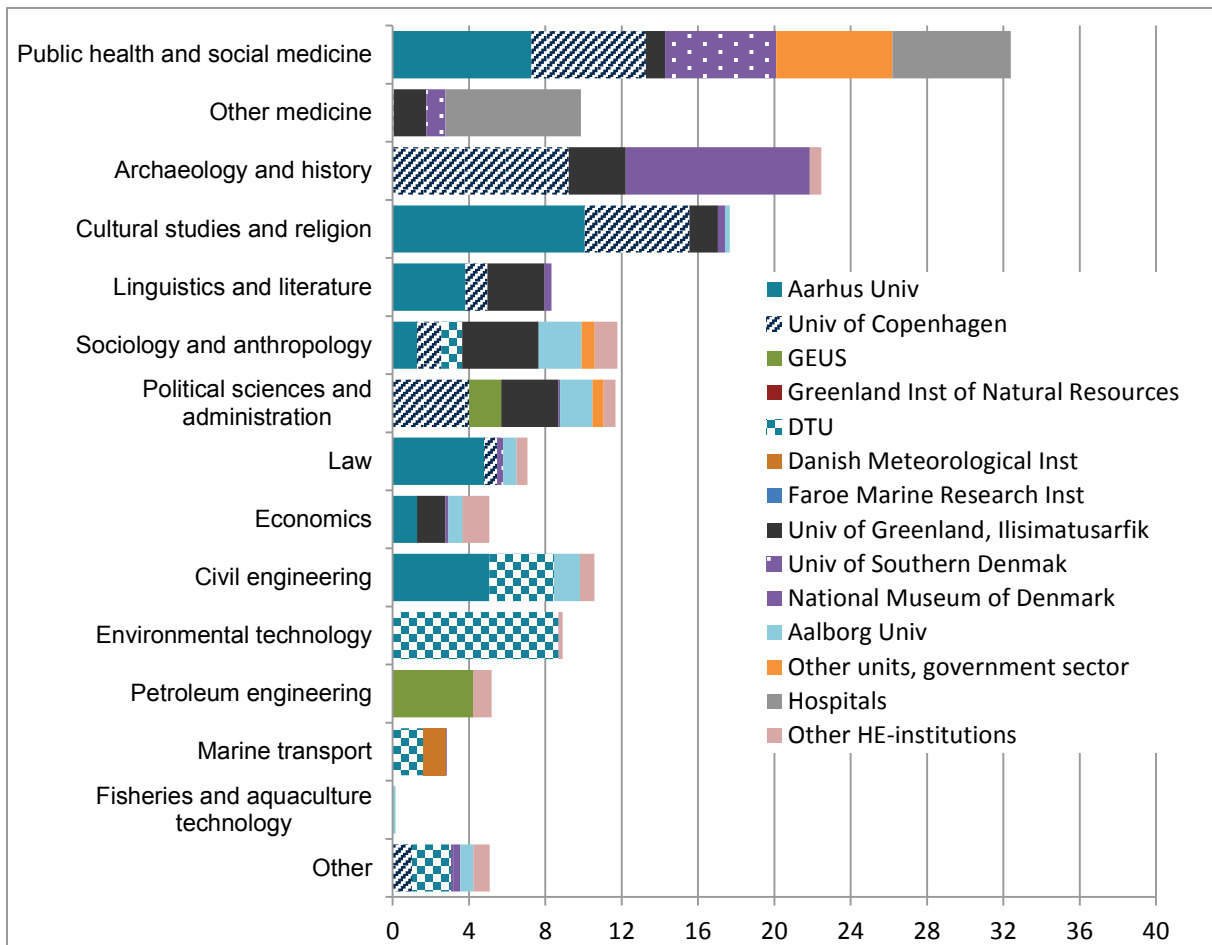
Within the humanities, *Archaeology and history* is the largest field (22 work-years). The National Museum of Denmark and University of Copenhagen are the main contributors to this research in addition to Ilisimatusarfik. *Cultural studies and religion* and *Linguistics and literature* have 18 and 8 work-years, respectively. The majority of the latter research is carried out by Aarhus University, University of Copenhagen and Ilisimatusarfik.

Figure 2.5a. Number of polar research work-years by discipline/field and individual institutions/institutes* in 2013. Natural sciences.



* Only institutions/institutes with more than 7 work-years polar research are shown separately in the figure.

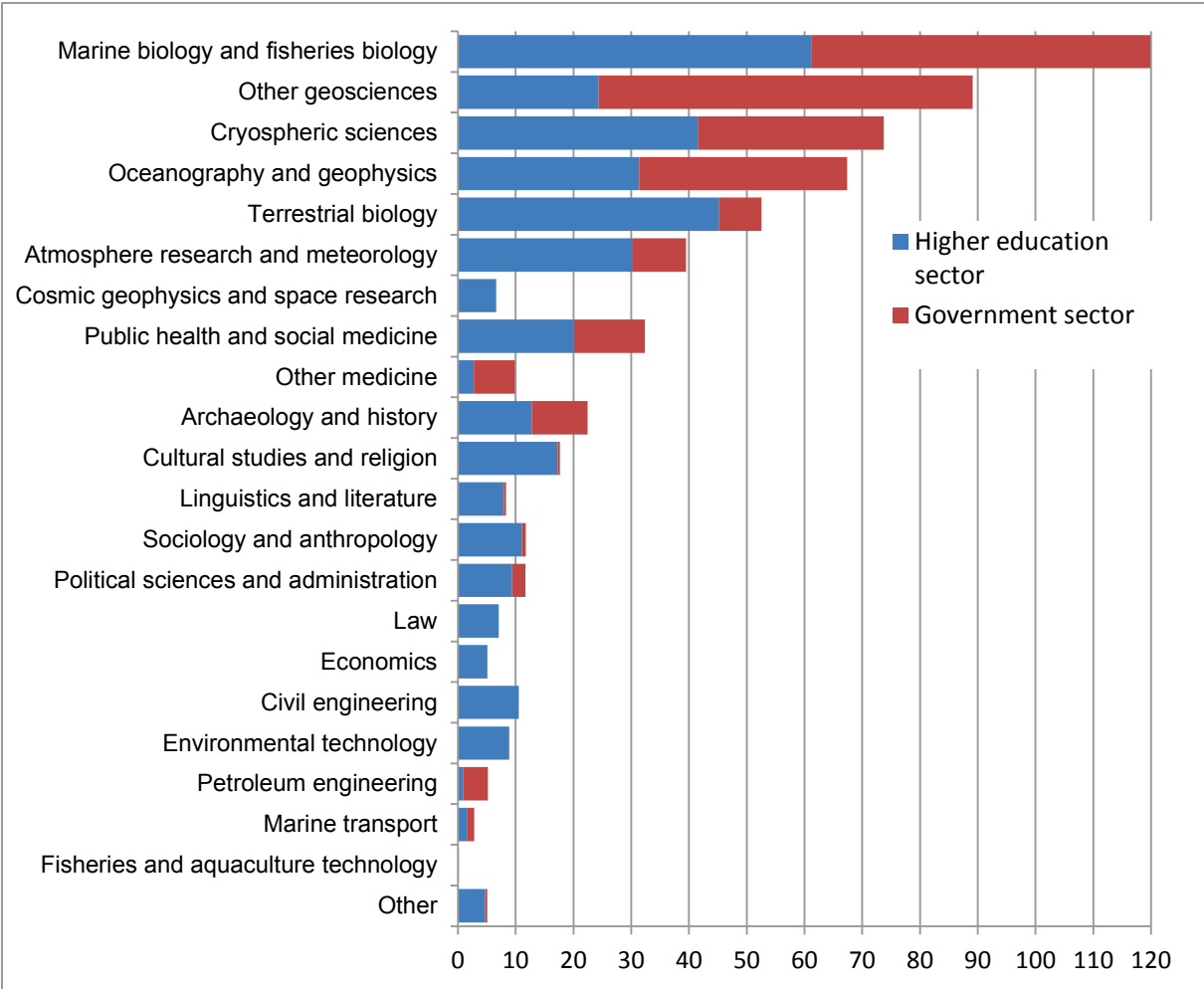
Figure 2.5b. Number of polar research work-years by discipline/field and individual institutions/institutes* in 2013. Other fields.



* Only institutions/institutes with more than 7 work-years polar research are shown separately in the figure.

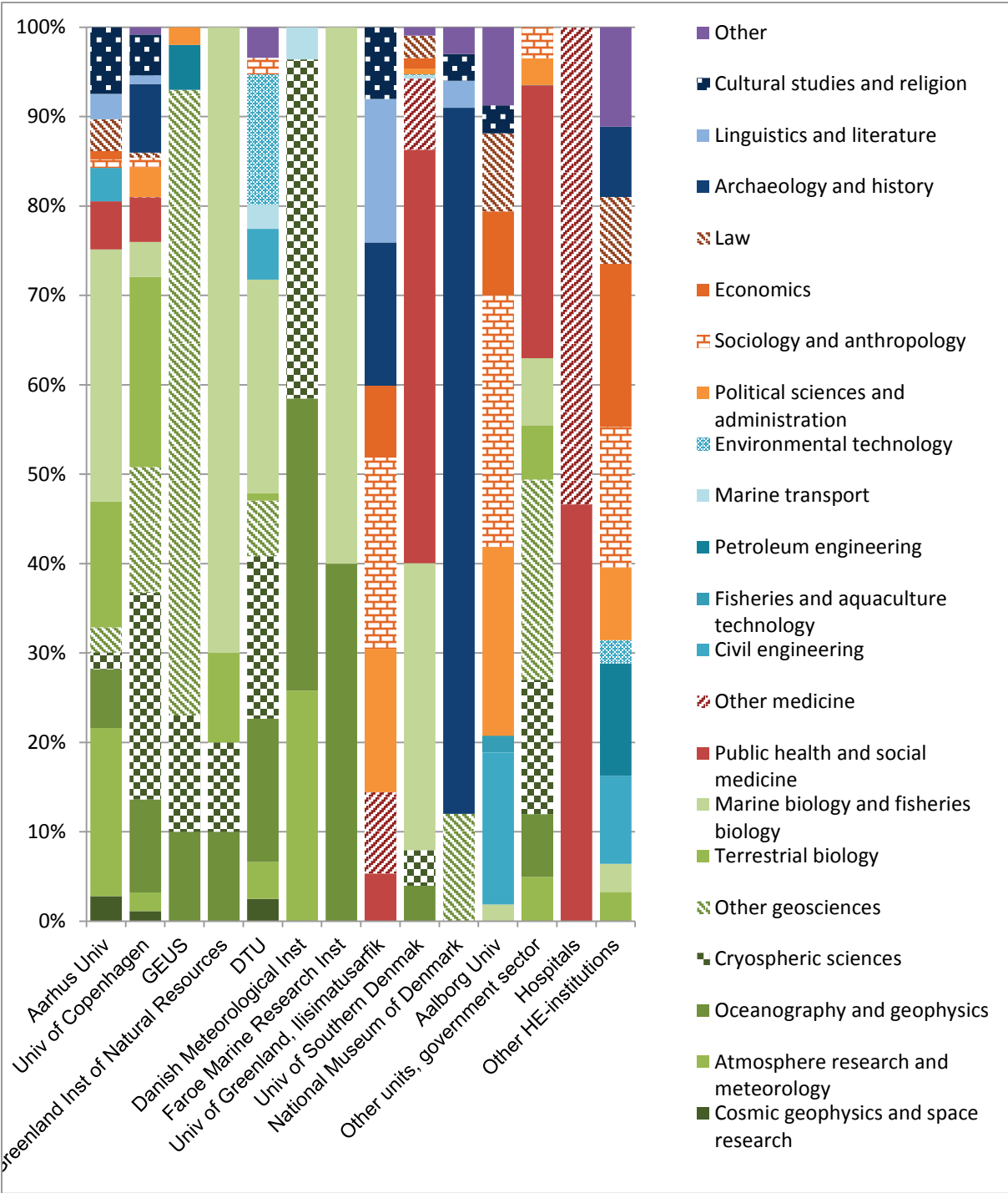
Figure 2.6 shows how polar research is divided by discipline/field and sector of performance. As can be seen, there are large differences between the fields. Institutions within the government sector contribute significantly to the research within the geosciences and marine biology and fisheries biology and much less within most other fields. The research within some fields is almost exclusively carried out by institutions within the higher education sector.

Figure 2.6. Number of polar research work-years in 2013 by discipline/field and sector of performance.



In Figure 2.7 we have shown the polar scientific profile of individual institutions/institutes. The largest universities generally have a broad profile with contributions within most of the fields, while the research institutes in the government sector have a more specialised profile.

Figure 2.7. The polar scientific profile of individual institutions/institutes. Relative contribution in number of work-years 2013 by discipline/field.



In Table 2.4 we present an overview of the departments' polar research efforts for the higher education sector and the government sector. Here, the departments are classified according to the fields of science where they have the majority of their polar research efforts.

Table 2.4. Number of departments/institutes and polar research work-years in 2013 by field of science.

Higher education sector			Government sector		
Field of science	Number of departments*	Work-years	Field of science	Number of institutes/units*	Work-years
Natural sciences	22	251	Natural sciences	14	208
Health sciences	9	18	Health sciences	9	19
Social sciences	26	32	Social sciences	4	3
Humanities	15	38	Humanities	1	10
Technology	9	17	Technology	3	5
Total	62	361	Total	29	247

* Units with research within more than one scientific domain are multiply counted.

2.5 Funding

The polar research survey shows that in total 723 million Danish kroner (DKK) was spent on polar research within the Kingdom of Denmark in 2013. Data on the funding of polar research are based on information obtained through the questionnaire and on estimated figures (cf. Chapter 5). The 723 million kroner are partly financed by the institutions themselves through institutional budgets (basic funding), partly through external sources such as research councils. Overall, 38 per cent of the total, about 275 million kroner, was expenditure paid by institutional budgets. In comparison the corresponding overall figure for the public sector in Denmark is 56 per cent basic funding (2011 figures).⁶ However, in the natural sciences, accounting for the majority of the polar research, the share is lower (47%). Altogether, these figures indicate that polar research depends more heavily on external funding than is the case for the average Danish public research.

Research councils funded a total of approx. 177 million kroner, which accounted for 16 per cent of the total amount spent on polar research in the Kingdom. Ministries funded a total of 120 million, or 17 per cent of the total expenditure (excluding appropriations allocated to the institutions as basic funding). Together, 79 per cent of the polar research was funded through public sources within the Kingdom.

Private funds (e.g. Carlsbergfondet) funded 28 million kroner (4 %). Business/industry contributed 51 million kroner (7 %). Almost 10 per cent of the expenditure was financed through foreign funding sources, of which 40 million kroner were funding from the EU (FP7 and other programmes).

Table 2.5 gives an overview of the total funding of polar research with separate figures for the higher education sector and the government sector. For many of the funding sources the relative proportions are quite similar. We note, however, that the proportion of basic funding is higher in the government sector than in the higher education sector. The latter sector receives significantly more funding from the research councils than the government sector, while the opposite is the case for business/industry funding.

It should also be noted that the government sector accounts for 51 per cent of the expenditure, but only 40 per cent of the work-years. In other words, polar research within the government sector is more costly than the research in the higher education sector. This is mainly due to the different scientific profile of the sectors, where units in the government sector are more heavily engaged in fields where the costs are higher, e.g. by requiring expensive research infrastructure.

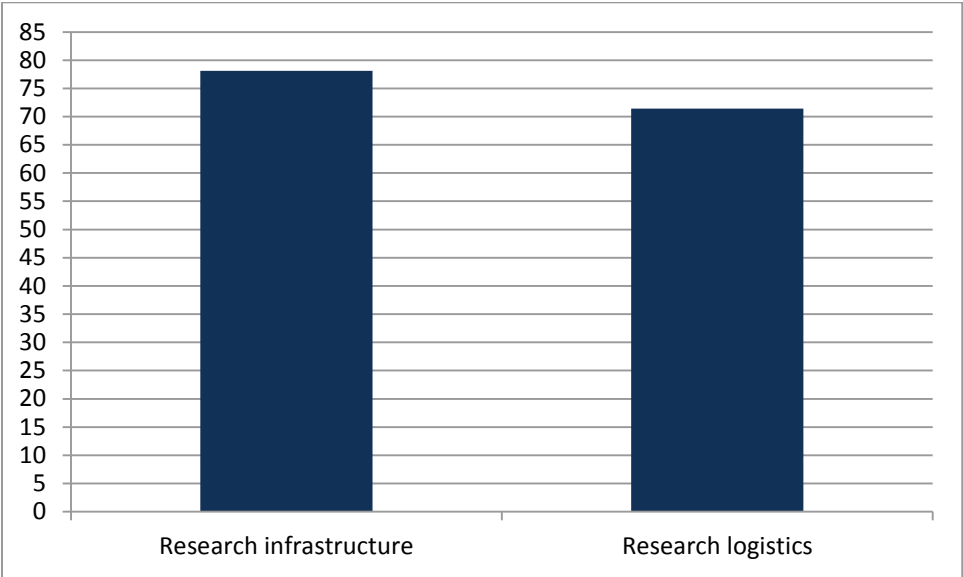
⁶ Source: Innovation og forskning 2013, Danmarks Statistik.

Table 2.5. Funding of polar research 2013 by sectors and sources, amount and proportions.

Funding sources		Higher education sector		Government sector		Total	
		Mill. DKK	Proportion	Mill. DKK	Proportion	Mill. DKK	Proportion
Internal	Basic funding	111	31%	164	44%	275	38%
External funding sources	Research councils	92	26%	25	7%	117	16%
	Ministries	44	12%	75	20%	120	17%
	Other public funding	41	12%	22	6%	63	9%
	Business/industry	5	2%	45	12%	51	7%
	Private funds	18	5%	10	3%	28	4%
	EU (FP7 and other programs)	26	7%	14	4%	40	6%
	Other foreign funding sources	11	3%	11	3%	22	3%
	Sources not specified above	6	2%	2	1%	8	1%
TOTAL		355	100%	368	100%	723	100%

The figures above include all costs associated with carrying out the research: staffing costs (including social security costs and pensions), cost of equipment and material and overhead costs such as rents of buildings, administrative costs, electricity, and so forth. Polar research is, however, often very expensive. First, the research may depend on costly research infrastructure such as research/field stations, observatories, laboratories, and research vessels. Second, the logistics may involve the use of helicopters, planes and ships. Primarily, these extra costs apply to the natural scientific polar research, but also other types of polar research may be more expensive than ordinary research. In order to quantify this expenditure we included two questions in the questionnaire. In Figure 2.8 we have shown the amount spent on research infrastructure and logistics. In total 78 million kroner was spent on research infrastructure, and this amounts to 11 per cent of the total cost of polar research within the Kingdom. The similar figure for logistics is 71 million kroner or 10 per cent. Thus, the survey confirms that there are considerable costs associated with these aspects of polar research.

Figure 2.8. Expenditure for polar research infrastructure* and logistics. mill DKK.**



* Construction and operation of research stations, observatories, laboratories, and research vessels, etc.

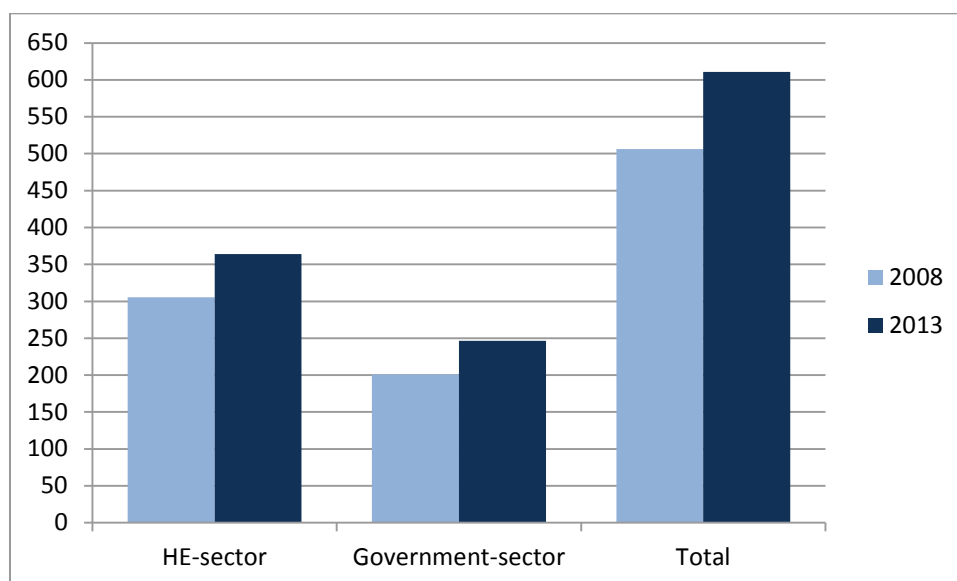
** Transportation and research travels (excluding travels for conferences, administrative meetings etc.).

2.6 Polar research 2008-2013

This is the first time a mapping survey of polar research within the Kingdom of Denmark has been carried out. There are therefore no figures available for the research volume in previous years. We have, however, included a question about the research volume in 2008 compared with the one in 2013. Obviously, it is very difficult for the respondents to provide exact figures on the research that took place many years ago. We, therefore, only asked about a rough estimate of changes in the total research volume in 2008 compared to 2013. The results are shown in Figure 2.9, and the figures for 2008 should be considered as estimates.

There has been a significant increase in the polar research efforts within the Kingdom. In 2008 an estimated 506 work-years were spent on polar research compared with 611 in 2013. The increase of 105 work-years amounts to a relative increase of 21 per cent. In the period 2008-2011, the total volume of work-years R&D in the public sector in Denmark increased by 21 per cent. As noted in Chapter 2.1, figures for 2012 and 2013 are not available, but we have used an estimate of 3.7 per cent increase for the period. This means that the volume of polar research has increased slightly less than the general growth of Danish public research, 21 per cent compared with 25 per cent.

Figure 2.9. Number of polar research work-years in 2008* and 2013.



* Estimates.

It should be noted that during the period, the International Polar Year (IPY) was held in 2007-2008. IPY was an extraordinary initiative that would provide polar research with a significant boost. Extra funding was provided from the government in Denmark with the amount of 70 mill. kr., equally distributed over the two years. Greenland's Home Rule Government did not provide extra funding for IPY, but funded Greenland IPY-projects with 1.75 mill kr. The extraordinary funding for polar research in 2008 is probably also reflected in the number of work-years this year. In other words, the volume of polar research work-years was significantly greater in 2008 (and 2007) than in previous years. Despite the termination of the IPY, the volume of polar research has continued to grow and is significantly higher in 2013 than in 2008. However, the relative increase (2008-2013) is slightly lower for polar research than for the total volume of Danish research, and this can probably be explained by the extra IPY-funding provided in 2008.

2.7 PhD students and doctoral degrees

In order to ensure future human resources for polar research, PhD education is essential. In the survey, respondents were asked about the current situation concerning doctoral education. Two questions were included: one about the number of current PhD students (2013) working on a PhD project with a main theme which may be classified as polar research, and one about the number of doctoral degrees awarded in polar research in the three-year period 2011-2013.

The results are shown in Table 2.6. Departments in the higher education sector reported that there are in total 150 people working on a PhD within the field in 2013, and that 72 people have been awarded a doctoral degree during the period 2011-2013. The corresponding numbers of people for units in the government sector are 52 and 22.

It should be noted, that we have not summarised the figures presented in Table 2.6. In the questionnaire we have only asked respondents to give the numbers and not to provide a list of people. There might be some double counting. For example, awarded doctoral degrees reported by units in the government sector may also have been reported by units in the higher education sector, as the degrees are awarded at an educational institution.

Despite this limitation, we conclude that there is a substantial number of PhD students within the field of polar research. We do not have adequate data on the total number of researchers within polar research (see below) but compared with the total number of work-years, the number of PhD students and doctoral degrees seems quite high. The situation may of course vary between fields, but overall we regard the recruitment situation in respect of polar research as very good.

Table 2.6. Number of PhD students (2013) and number of awarded doctoral degrees (2011-2013) related to polar research by sector.

	Number of current PhD students (2013)	Number of awarded doctoral degrees, 2011-2013
Higher education sector	150	72
Government sector	52	22

3 Polar research within the Kingdom of Denmark – publication analysis

This chapter presents a publication analysis on polar research, regarding the Kingdom of Denmark (Denmark, Greenland and the Faroe Islands) and globally. The method behind the publication analysis is described in the method chapter (Chapter 4).

As there is no clear and concise definition of polar research, a definition has been developed for this specific publication analysis, in order to find the right match of scientific articles within the field of polar research. This definition is based on different elements: geographical land and watermarks, keywords within polar research, and central journal sources within polar research.

We examine performance within research production (publication count), research impact (citations) and international collaboration. In most cases the results are presented at country level or at an institutional level, both within the Arctic and some within Antarctica. It should be noted that the share of polar research publications from the Kingdom of Denmark concerning Antarctica is considerably lower than that of the Arctic.

3.1 Polar research - a global comparison

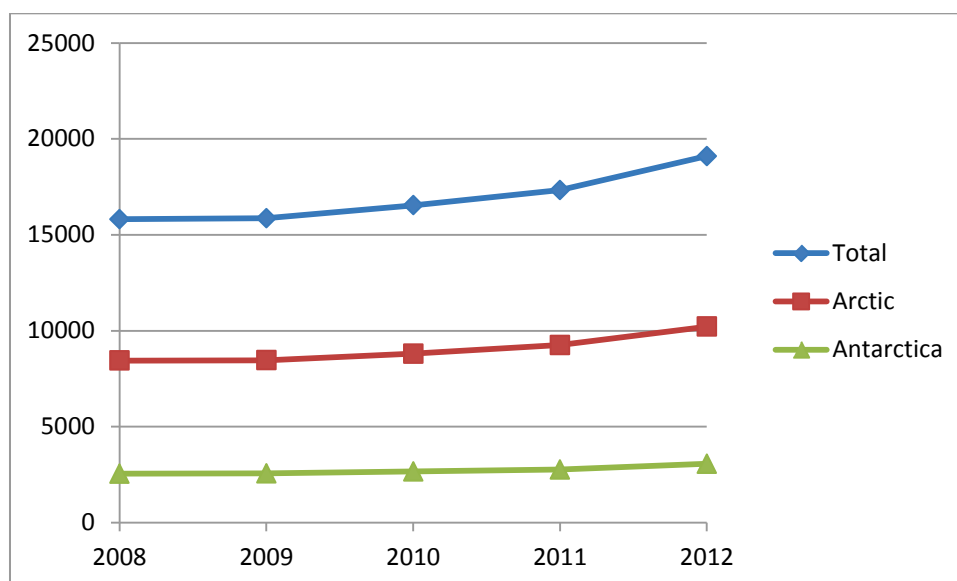
This first part of the publication analysis consists of a global comparison on polar research. This is done in order to compare the results of the analysis (on polar research) within the Kingdom of Denmark. The global comparison has a specific focus on 15 countries.⁷ The reason for this is explained in the method chapter.

Development in the global article production on polar research

Initially we look at the research production. The total number of articles from the Arctic and Antarctica on a global level adds up to almost 39,450 from 2008-2012. It is clear from figure 3.1 that articles on the Arctic present the highest share. The main reason is probably due to the fact that the geographical area of the Arctic consists of more populated land areas compared with Antarctica. In Antarctica there is no “permanent” population, just about two dozen research stations with a total “population” ranging from 1000-4000 researchers depending on the time of year. The total number of articles concerning the Arctic is almost 31,600 and for Antarctica it is 13,600.

⁷ The Kingdom of Denmark (Denmark, Greenland and Faroe Islands), USA, Canada, Russia, Norway, Sweden, Iceland, Finland, The United Kingdom, France, Germany, China, Japan, Australia and The Netherlands.

Figure 3.1. Polar research - development in the global article production 2008-2012.



Data from Web of Science – Thompson Reuters.

Some articles might be counted twice, as they deal with both the Arctic and Antarctica.

With 7,360 articles in 2008 and 8,882 in 2012 the number of articles in polar research has increased by 20.7 per cent. In comparison the increase in science generally was 14.2 per cent in the same time period. This means that article production within polar research has increased more than the world average of science.

National shares in polar research

Table 3.1 displays an overview of the research production by whole count, fractionalised count, share (based on the fractional count) and trend.

The countries are presented in the order of the amount of the fractionalised count. Fractionalised count considers the fact that many scientific articles are co-authored. It divides the shares of an article by the number of authors. This gives a more accurate picture of the actual research production rather than using whole counts, where each author gets one full share of the publication.

Table 3.1 shows the main contributors to articles on polar research in the Arctic and Antarctica. The result is quite clear. The United States (USA) distinguishes itself by producing 28 per cent of the entire polar research production. Canada (10.2 %) and the United Kingdom (8.1 %) respectively represent a large share of the research production, but even when adding the two they remain a distinct second to the USA. The Kingdom of Denmark represents 2.5 per cent. The largest contributor to polar research (from the Arctic and Antarctica) among the Nordic countries is Norway with 1,773 articles (4.6 %).

Table 3.1. Number of articles from 2008-2012 by country: Arctic & Antarctic.

Country	Whole count	Fractionalised	Share	Trend
USA	14,693	10,955	28.1%	■ ■ ■ ■ ■
Canada	5,716	3,958	10.2%	■ ■ ■ ■ ■
The United Kingdom *	5,543	3,167	8.1%	■ ■ ■ ■ ■
Germany	3,921	2,155	5.5%	■ ■ ■ ■ ■
Norway	3,052	1,773	4.6%	■ ■ ■ ■ ■
China	2,291	1,764	4.5%	■ ■ ■ ■ ■
Russia	2,203	1,558	4.0%	■ ■ ■ ■ ■
France	2,606	1,363	3.5%	■ ■ ■ ■ ■
Japan	1,718	1,123	2.9%	■ ■ ■ ■ ■
Australia	2,018	1,120	2.9%	■ ■ ■ ■ ■
The Kingdom of Denmark*	1,761	960	2.5%	■ ■ ■ ■ ■
Sweden	1,778	819	2.1%	■ ■ ■ ■ ■
Iceland	1,285	791	2.0%	■ ■ ■ ■ ■
Netherlands	1,095	511	1.3%	■ ■ ■ ■ ■
Finland	844	446	1.1%	■ ■ ■ ■ ■
Other countries	11,846	6,500	17%	■ ■ ■ ■ ■
Total		38,963	100%	■ ■ ■ ■ ■

Data from Web of Science – Thompson Reuters.

* The United Kingdom (England, Scotland, Wales & Northern Ireland); the Kingdom of Denmark (Denmark & Greenland).

Trend = yearly number of articles (fractionalised).

Table 3.2 shows the number of articles on polar research only within the Arctic area. It is clear that the Nordic countries present a considerable part within the Arctic compared with Antarctica. All the shares of the Nordic countries have increased in comparison with the previous table. The Kingdom of Denmark's share of articles has increased from 2.5 to 3 per cent.

Table 3.2. Number of articles from 2008-2012 by country: Arctic.

Country	Whole count	Fractionalised	Share	Trend
USA	11,984	9,032	29.0%	■ ■ ■ ■ ■
Canada	5,269	3,770	12.1%	■ ■ ■ ■ ■
The United Kingdom*	4,286	2,479	8.0%	■ ■ ■ ■ ■
Norway	2,885	1,704	5.5%	■ ■ ■ ■ ■
Germany	3,038	1,669	5.4%	■ ■ ■ ■ ■
Russia	1,937	1,380	4.4%	■ ■ ■ ■ ■
China	1,784	1,351	4.3%	■ ■ ■ ■ ■
The Kingdom of Denmark*	1,685	935	3.0%	■ ■ ■ ■ ■
France	1,826	926	3.0%	■ ■ ■ ■ ■
Japan	1,286	838	2.7%	■ ■ ■ ■ ■
Iceland	1,282	790	2.5%	■ ■ ■ ■ ■
Sweden	1,589	749	2.4%	■ ■ ■ ■ ■
Australia	1,141	547	1.8%	■ ■ ■ ■ ■
Netherlands	903	428	1.4%	■ ■ ■ ■ ■
Finland	787	425	1.4%	■ ■ ■ ■ ■
Other countries	8,285	4,122	13%	■ ■ ■ ■ ■
Total		31,145	100%	■ ■ ■ ■ ■

Data from Web of Science – Thompson Reuters.

* The United Kingdom (England, Scotland, Wales & Northern Ireland); the Kingdom of Denmark (Denmark & Greenland).

Trend = yearly number of articles (fractionalised).

Table 3.3 shows the number of articles on polar research only within the Antarctica. Globally a change is detected in the shares of publications, except for the USA and the United Kingdom which remain the top contributors. Canada has dropped from 12 per cent of the total share on Arctic research to only 4.8 per cent on Antarctic research. Not surprisingly the Nordic countries all represents a low share of polar research related to Antarctica compared with the Arctic, primarily due to the close historical ties and easier access to the Arctic. The Kingdom of Denmark only reaches a total share of 0.9 per cent.

Table 3.3 Number of articles from 2008-2012 by geographical area: Antarctica.

Country	Whole count	Fractionalised	Share	Trend
USA	4.751	3.359	24.9%	■ ■ ■ ■ ■
The United Kingdom*	2.299	1.313	9.7%	■ ■ ■ ■ ■
Germany	1.576	849	6.3%	■ ■ ■ ■ ■
Australia	1.334	824	6.1%	■ ■ ■ ■ ■
France	1.228	660	4.9%	■ ■ ■ ■ ■
Canada	1.134	647	4.8%	■ ■ ■ ■ ■
China	771	612	4.5%	■ ■ ■ ■ ■
Japan	681	452	3.3%	■ ■ ■ ■ ■
Norway	566	297	2.2%	■ ■ ■ ■ ■
Russia	456	296	2.2%	■ ■ ■ ■ ■
The Netherlands	386	178	1.3%	■ ■ ■ ■ ■
Sweden	353	143	1.1%	■ ■ ■ ■ ■
The Kingdom of Denmark*	276	116	0.9%	■ ■ ■ ■ ■
Finland	172	83	0.6%	■ ■ ■ ■ ■
Iceland	33	14	0.1%	■ ■ ■ ■ ■
Other countries	2.710	3.676	27%	■ ■ ■ ■ ■
Total		13.517	100%	■ ■ ■ ■ ■

Data from Web of Science – Thompson Reuters.

* Great Britain (England, Scotland, Wales & Northern Ireland); the Kingdom of Denmark (Denmark & Greenland)

Trend = yearly number of articles (fractionalised).

Global comparison on research impact

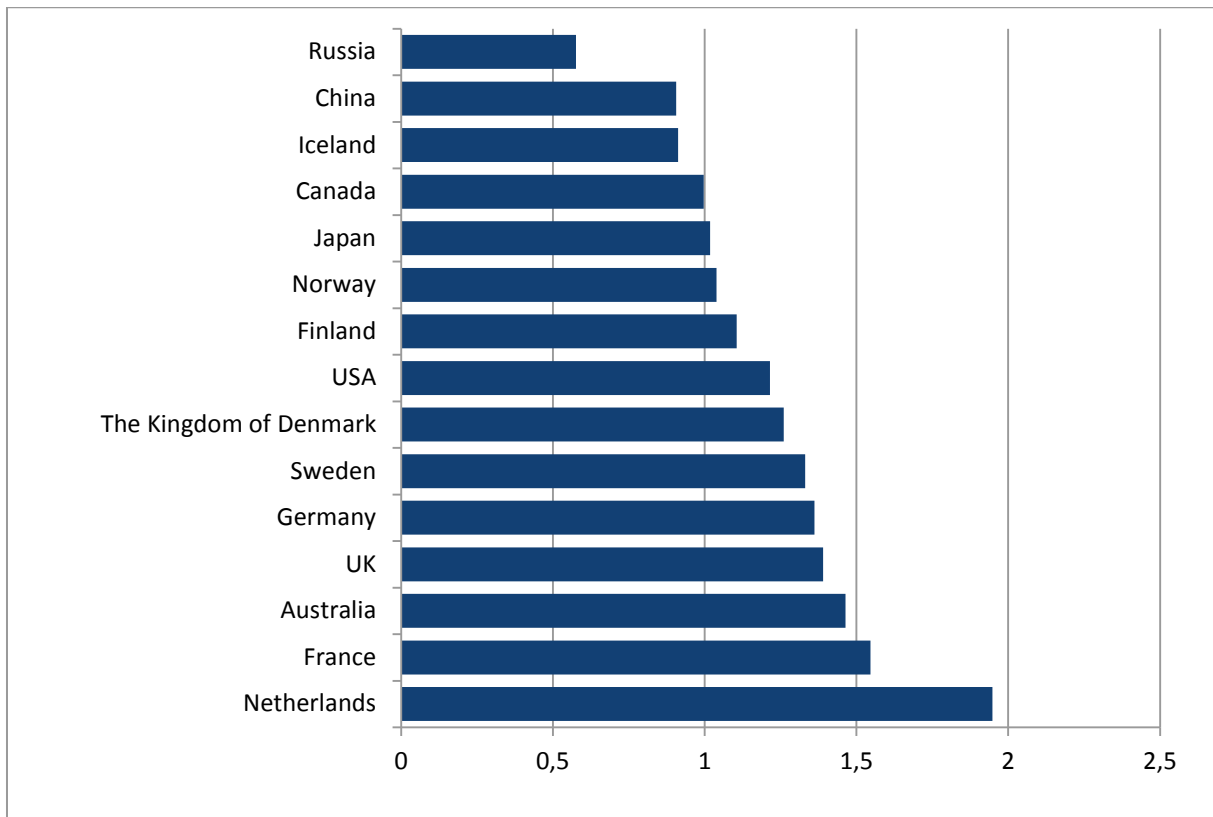
Figure 3.2 is a so-called relative citation index⁸. It shows a comparison of the countries' research impact. The citation impact is based on citations from articles within polar research concerning the Arctic. The horizontal axis 1 represents the world average. Everything below 1 is cited as less than the world average, and everything above 1 is cited as more than the world average.

Articles from the Netherlands are cited almost twice as often as the world average. The USA and Canada, the main contributors in terms of production, both perform above world average but at a much lower level than the Netherlands. It is important to be aware that the calculation is carried out on the basis of fewer articles from the Netherlands than from the US and Canada. However, the index indicates a difference, when comparing performance on research production and performance of research impact. Articles from the Kingdom of Denmark are cited at 26 per cent above world average, which also applies to the other Nordic countries, with the exception of Iceland.⁹

⁸ The method behind relative citation index is described in the method chapter.

⁹ Iceland has a very small research production, which means that index is based on very few articles and citations. Results like these can fluctuate over time, when based on small amounts.

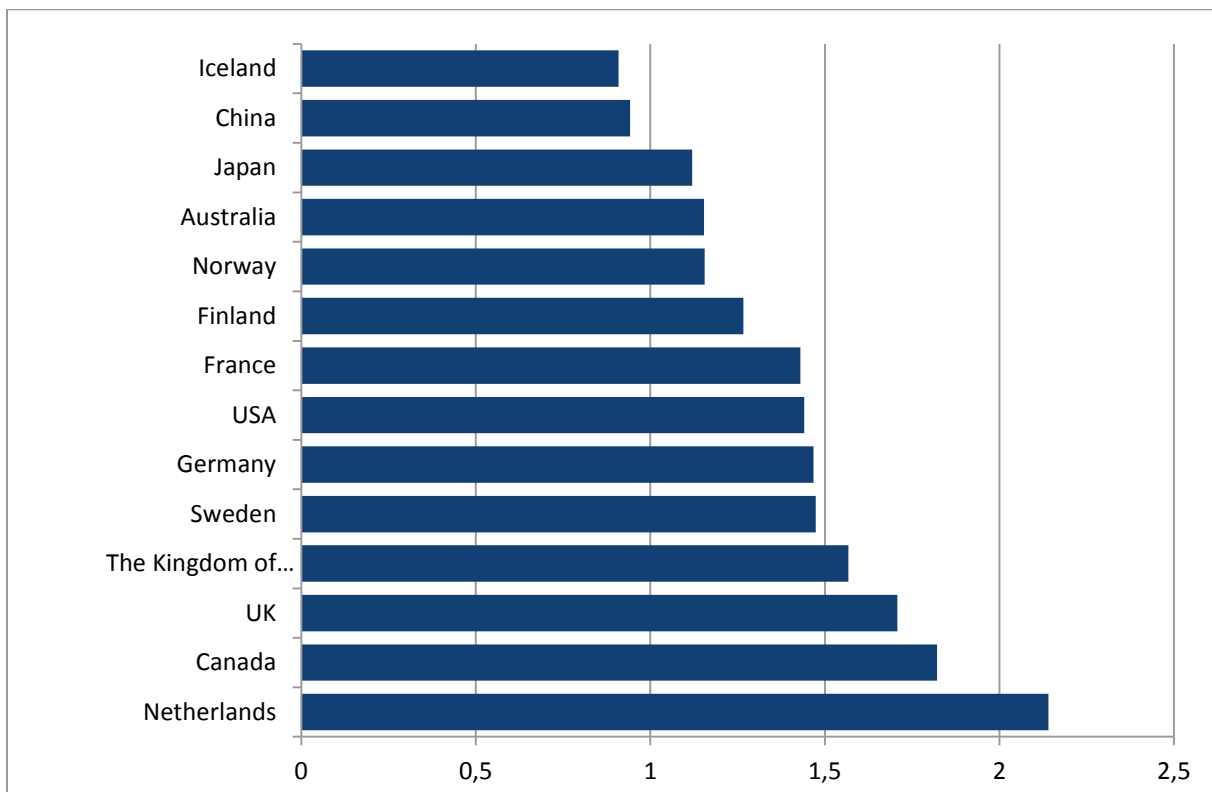
Figure 3.2. Relative Citation Index 2008-2011: Arctic.



Data from Web of Science – Thompson Reuters.

Figure 3.3 shows the impact on polar research in Antarctica. The Netherlands still stands out. The Kingdom of Denmark performs well above world average at 56 per cent. Even though the Kingdom of Denmark produces more articles on Arctic polar research than on Antarctic polar research, it seems that articles on Antarctic polar research from the Kingdom of Denmark have a much higher impact than articles on Arctic polar research, although the national focus is on Arctic polar research (56 % vs. 26 %). Again it should be taken into consideration that the study on Antarctica is carried out on a smaller article count and a few highly cited articles, which can have great impact on the index.

Figure 3.3. Relative Citation Index 2008-2011: Antarctica.



Data from Web of Science – Thompson Reuters.

International collaboration

Most studies show that international collaboration in scientific publishing is increasing. The rate of international collaboration is interesting as it indicates the level of global knowledge transfer. Furthermore, international collaborated articles are more likely to be highly cited.

Table 3.4. International collaboration 2008-2012 in %. Arctic and Antarctica.

Geographical area	2008	2009	2010	2011	2012
Arctic	34%	35%	37%	38%	39%
Antarctica	36%	36%	40%	41%	43%
Total	35%	36%	39%	40%	42%

Data from Web of Science – Thompson Reuters.

Table 3.4 confirms the same trend within polar research. Polar research related to the Arctic and to Antarctica shows that the volume of international collaboration has increased from 2008 to 2012. In 2008, 35 per cent of all scientific articles were produced in collaboration between researchers with affiliations from more than one country. In 2012 the number had increased to 42 per cent, thus almost half of the scientific articles within polar research are the product of international collaboration.

Table 3.5. Share of international co-authored articles 2008-2012: Arctic.

	USA	Canada	United Kingdom	Norway	Germany	Sweden	Kingdom of Denmark
US		12.4%	9.1%	4.2%	6.2%	3.2%	3.2%
Canada	28.2%		8.4%	5.7%	5.6%	2.9%	4.7%
United Kingdom	25.5%	10.3%		11.1%	12.9%	7.8%	7.4%
Norway	17.6%	10.4%	16.4%		11.4%	10.7%	11.4%
Germany	24.5%	9.6%	18.3%	10.8%		7.5%	5.9%
Sweden	24.1%	9.6%	21.2%	19.4%	14.4%		17.8%
Kingdom of Denmark	22.5%	14.6%	18.8%	19.5%	10.6%	16.7%	

Data from Web of Science – Thompson Reuters.

Table 3.5 presents an overview of the share of international co-authored articles in 7 countries. Generally it seems that most countries carry out their research with the USA as the main collaborator. Between 17-28 per cent of the polar research is carried out with an American collaboration partner. Norway has the fewest articles in collaboration with the USA with just 17.6 per cent, while Canada has the most with 28.2 per cent of their research done with American collaborators.

The table only presents a small selection of countries and those represented are the main collaboration partners with the Kingdom of Denmark. The Kingdom of Denmark's largest collaboration partner is the USA followed by Norway and the UK, but the table also shows that Sweden and Canada are important partners. Researchers from the Nordic countries generally collaborate quite often with researchers from the other Nordic countries.

When it comes to the proportion of international collaboration within subject areas, table 3.6 below clearly shows that Geochemistry and Geophysics have the largest share of international collaboration among those subject areas with the highest number of articles.

Table 3.6. Share of international collaborations by subject area 2008-2012. Arctic and Antarctica.

Subject area*	Share**	Articles
Astronomy & Astrophysics	46%	1,449
Biodiversity Conservation	38%	1,388
Ecology	38%	4,035
Environmental Sciences	35%	3,960
Geochemistry & Geophysics	47%	2,827
Geography, Physical	45%	3,998
Geosciences, Multidisciplinary	43%	9,007
Marine & Freshwater Biology	34%	2,660
Meteorology & Atmospheric Sciences	40%	4,200
Oceanography	39%	3,951
Others	29%	27,250

Data from Web of Science – Thompson Reuters.

* Based on ISI subject categories.

** Papers with more than 1 country.

When looking only at the subject areas within the Arctic the major change is that the share of articles within Astronomy and Astrophysics has changed significantly and is no longer represented in the group of the subject areas with the highest number of articles. The reason here could be the large capacity of telescopes in the Antarctic.

Table 3.7. Share of international collaborations by subject area 2008-2012: Arctic.

Subject area*	Share**	Articles
Biodiversity Conservation	37%	1,277
Ecology	37%	3,486
Environmental Sciences	35%	3,586
Geochemistry & Geophysics	47%	2,209
Geography, Physical	44%	3,621
Geology	33%	983
Geosciences, Multidisciplinary	43%	7,702
Marine & Freshwater Biology	33%	1,901
Meteorology & Atmospheric Sciences	40%	3,491
Oceanography	39%	3,012
Others	33%	21,149

Data from Web of Science – Thompson Reuters.

* Based on ISI subject categories.

** Papers with more than 1 country.

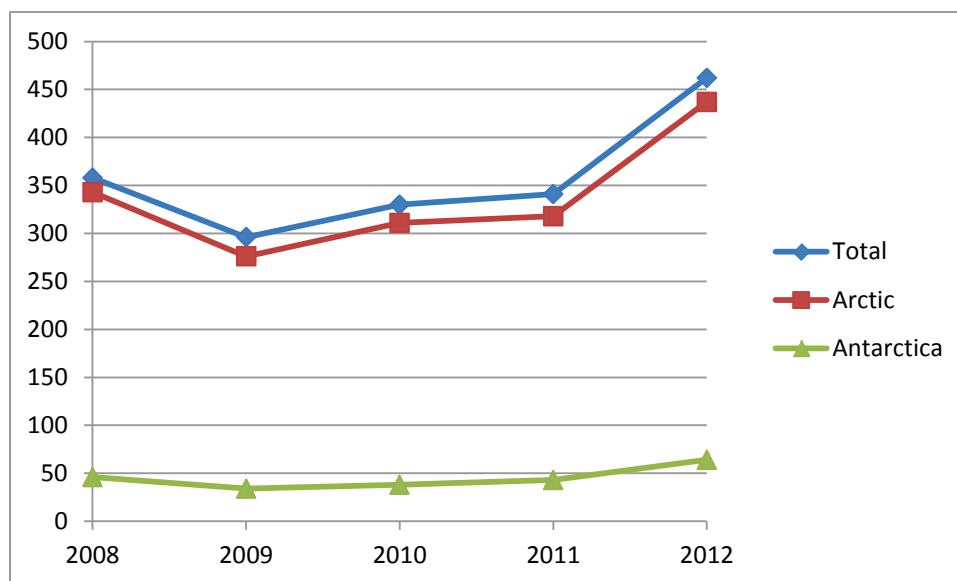
3.2 Polar research in the Kingdom of Denmark

Here we present a publication analysis based on polar research at an institutional level within the Kingdom of Denmark: Denmark, Greenland and The Faroe Islands. Basically all research done in Greenland and The Faroe Islands is regarded in this analysis as polar, due to their geographical position.

Development in research production on polar research within the Kingdom of Denmark

Development in research article production within polar research in the Kingdom of Denmark is shown in figure 3.4. When we compare with the same figure on the global development from the previous paragraph, the difference is that Antarctica plays a much smaller part in polar research in Denmark and seems to continue doing so. There is a significant increase in the number of articles on polar research connected to the Arctic, especially in the period from 2011 to 2012.

Figure 3.4 Polar research - development in article production from the Kingdom of Denmark 2008-2012.



Data from Web of Science – Thompson Reuters.

Some articles might be counted twice, as they deal with both the Arctic and Antarctica.

Share within research areas

The subject categories within the Web of Science database are used in order to identify the main research areas of polar research in the Kingdom of Denmark. The subject categories are not linked to actual articles, but to the source (journal). Table 3.8 displays the top 10 subject categories in polar research. The table presents the number of articles within the subject categories and their share of total article production. Some journals are classified in more than one subject category, which means that articles might be counted twice or more in this table. The result is that Geosciences is the dominant research area, followed by Ecology and Environmental Sciences.

Table 3.8. Share of subject areas within polar research in the Kingdom of Denmark 2008-2012: Arctic.

Subject Areas*	Share**	Articles
Geosciences Multidisciplinary	24%	401
Ecology	13%	216
Environmental Sciences	13%	214
Geography Physical	12%	203
Oceanography	7%	124
Geochemistry Geophysics	7%	123
Marine Freshwater Biology	7%	117
Meteorology atmospheric Sciences	6%	95
Geology	5%	84
Public Environmental Occupational Health	5%	80

Data from Web of Science – Thompson Reuters.

* Based on ISI-subject category.

** Papers with more than 1 country.

Institutions that produce polar research in the Kingdom of Denmark

In order to identify the research institutions involved in polar research in the Kingdom of Denmark, author addresses (also known as affiliations) linked to the articles are used. All author addresses are

used in this indicator, but only the most significant institutions are presented. Articles with collaboration between institutions within the Kingdom will count more than once. The article will count according to the number of affiliations.

Table 3.9 shows the largest research institutions within the Kingdom of Denmark. Only institutions with more than 45 articles are included (not including the university hospitals).

Table 3.9. Institutional level - Articles on polar research 2008-2012: Arctic.

Institutions	Articles
Danish Meteorol Inst.	47
Greenland Inst. Nat. Res.	107
Aarhus University	393
University of Copenhagen	501
University of Southern Denmark	54
Technical University of Denmark	100
Geol. Survey	192
Niels Bohr Institute	87

Data from Web of Science – Thompson Reuters.

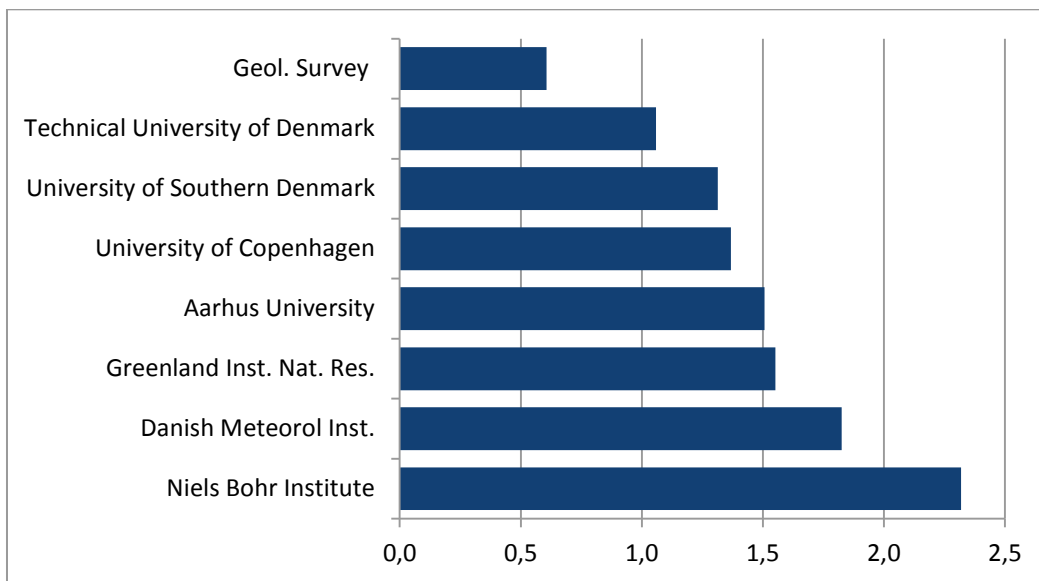
As shown in table 3.9, the University of Copenhagen has the largest production of articles within polar research. We have chosen not to include the Niels Bohr Institute in the University of Copenhagen, as we found that their results are one of a kind, and including the Institute within University of Copenhagen would hide this fact.

Aarhus University is the second largest contributor. Other important contributors are GEUS (The geological survey of Denmark and Greenland) and DMI (The Danish Meteorological Institute), which are institutions under the Danish Ministry of Climate, Energy and Building.

Citation and research impact

When focusing on the impact of polar research from institutions within the Kingdom of Denmark we find that the Niels Bohr Institute is not only a main contributor to the research production but its articles also have great impact. Together with the Danish Meteorological Institute (DMI) their articles are cited more than twice as much as the average article. Figure 3.5 show the impact results compared with the world average.

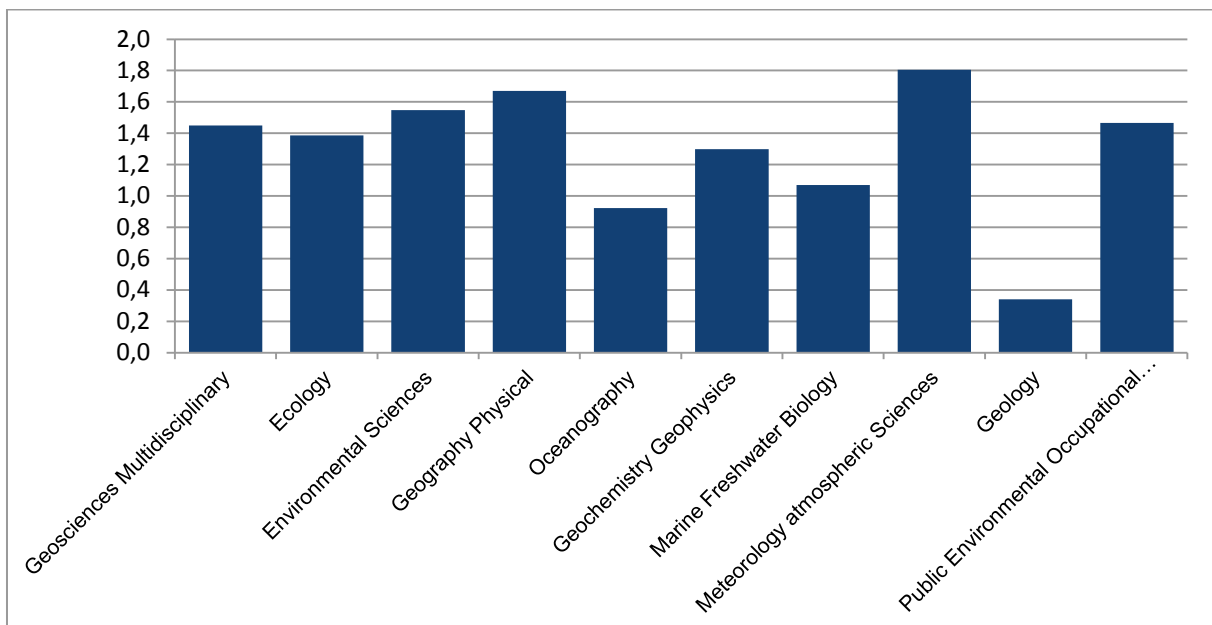
Figure 3.5. Institutions - Relative Citation Index compared to world average 2008-2011: Arctic.



Data from Web of Science – Thompson Reuters.

When looking at the areas of polar research in the Kingdom of Denmark having the greatest impact, figure 3.6 shows that the greatest impact is within Meteorology atmospheric Sciences. The general picture is that the Kingdom of Denmark is cited well above average in almost all the areas. Only Geology and Oceanography stand out with quite a low impact (below world average) compared with the other areas.

Figure 3.6. Subject categories - Relative Citation Index 2008-2011: Arctic and Antarctica.



Data from Web of Science – Thompson Reuters.

4 Conclusions – a comparative perspective

This report is based on two data sources: a questionnaire survey of resources devoted to polar research and a bibliometric survey of the scientific journal publishing. Together they give complementary views on the status of polar research within the Kingdom. While the first survey provides data on the financial and human resources engaged in polar research in 2013, the latter survey analyses the results and output of this research, including issues such as the international position and impact of the Kingdom's polar research and its development over time.

We would, however, emphasise that the results of the two surveys are not directly comparable. The bibliometric analysis is based on a data source (Web of Science) which only covers a part of the scientific and scholarly publications (cf. Chapter 5). In other words, only a subset of the polar research will result in scientific publications indexed in the database. The database has a very good coverage of the research literature in the natural sciences and medicine – where the large majority of the publications appear in international journals. Social sciences and the humanities, on the other hand, are not well represented in the database. As the latter fields are rather small in the context of polar research (accounting for 15% of the total resources devoted to polar research in terms of work-years), this limitation does not have major importance overall. At the level of institutions (and departments), however, this might be different. Institutions with relatively more research relating to the social sciences and humanities will have a comparative disadvantage in terms of publication output. Similarly, units in the government sector generally have a more applied focus and a publication pattern with lower frequencies of scientific journal publishing than units within the higher education sector. Here, other publication types such as reports, which are not covered by the bibliometric analysis, are also important channels for the dissemination of research results.

At the same time there are also limitations with the survey mapping of resources. First, there might be some polar research activities which have not been captured by the survey (cf. Chapter 5). Second, in surveys like this there will always be some uncertainty in the reliability of the figures reported by individual units, as these are based on discretionary estimates. Similar methodological shortcomings are not involved in the bibliometric analysis but in both surveys the issue of delineating polar research involves uncertainties.

Finally, it should be noted there is a time lag between the conduct of the research and the appearance of the results as published articles (usually one or two years or more). Thus, the publications of the polar research carried out in 2013, which is mapped in the survey, will not appear published until 2014 or 2015. The most recent publication numbers presented in the report (2012) are not a result of research carried out in 2013.

These factors obviously have to be taken into consideration when comparing the results of the two surveys. Moreover, many indicators presented in the two chapters are not relevant to compare. One indicator which provides interesting potential in this respect is the institutional volume profiles (Figure 2.1 and Table 3.2.2). Overall, the two surveys provide fairly consistent results. In both surveys the University of Copenhagen and Aarhus University are the largest contributors, followed by The Geological Survey of Denmark and Greenland, Greenland Institute of Natural Resources and the Technical University of Denmark.

A notable difference, however, is that the University of Copenhagen is significantly larger than Aarhus University when it comes to publication output (588 articles in the period 2008-12 (including the Niels Bohr centre) versus 393), while there are only minor differences between the two institutions when it comes to resources. In other words, compared with resource spending the University of Copenhagen is apparently significantly more productive than Aarhus University. It is however, likely that methodological issues may explain part of this difference. The departments at Aarhus University have overall reported a much stronger growth in the polar research volume, during the period 2008-2013, than the departments at the University of Copenhagen. In 2008 the number of polar research work-years was clearly lower at Aarhus University than at the University of Copenhagen. As the publication numbers are the totals for the 2008-2012 period, this obviously explains some of the deviations. Moreover, one cannot rule out the possibility that there has been under-reporting of resources at University of Copenhagen.

5 Data and methods

In this chapter we describe the data and methods applied in the project. The method applied has many similarities to the one applied in NIFU's previous mapping survey of Norwegian polar research.¹⁰

5.1 Definition of polar research

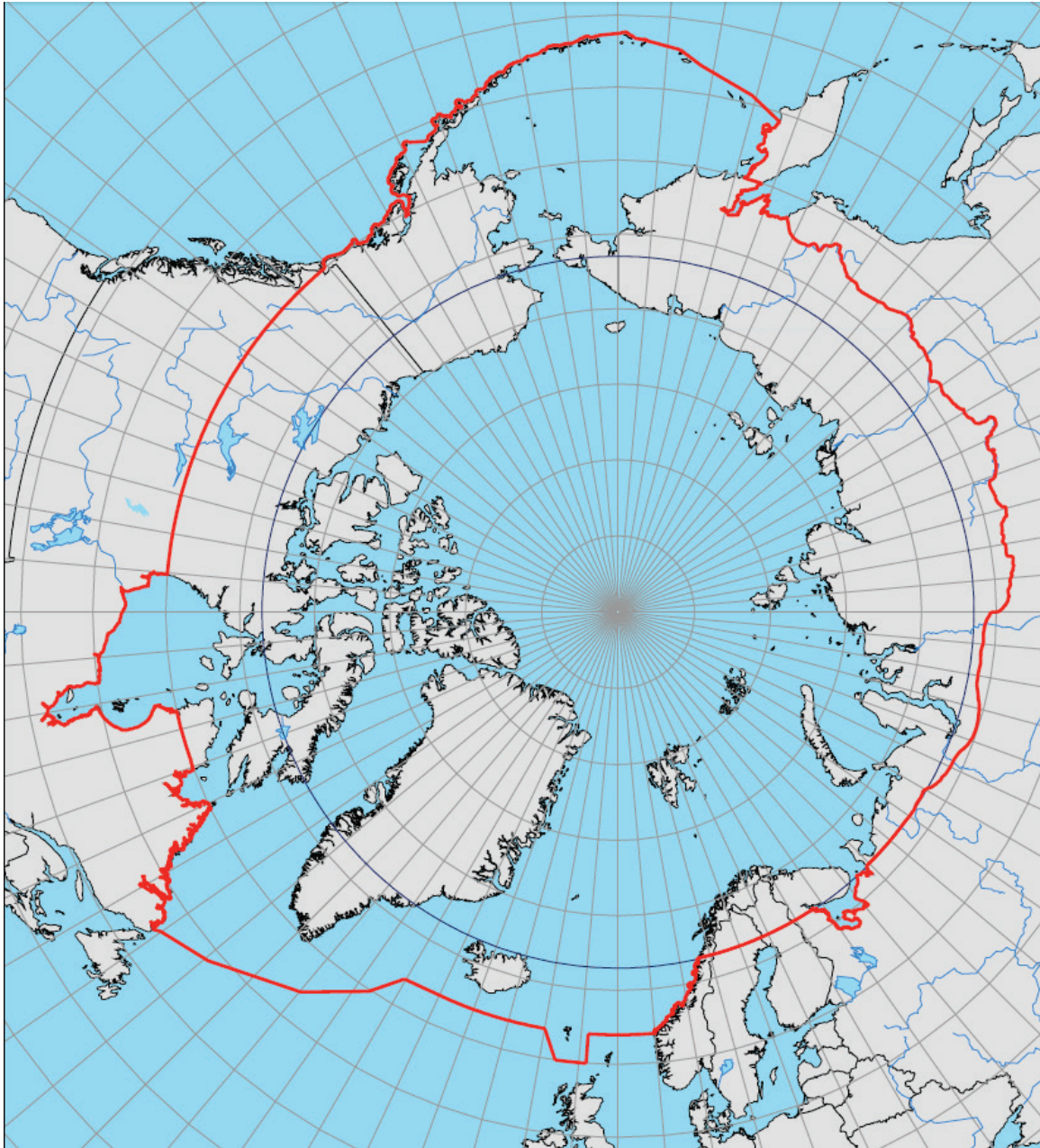
Polar research can be defined in various ways. A crucial question in relation to the survey has therefore been how polar research should be delineated. For example, a broad definition would naturally imply a larger volume of polar research than a more narrow definition. Among polar researchers there will be different opinions on how polar research should be defined. In a report by The Arctic Monitoring and Assessment Programme (AMAP) this issue is discussed.¹¹ Here, various possibilities for delimiting polar, or more specifically the Arctic, are examined, for example using the Arctic Circle (66°32'N) or the 10°C July isotherm as boundaries. Based on this examination, AMAP ends up with a definition based on a combination of different criteria: "This incorporates elements of the Arctic Circle, political boundaries, vegetation boundaries, permafrost limits, and major oceanographic features. The region covered by AMAP is, therefore, essentially the terrestrial and marine areas north of the Arctic Circle (66°32'N), and north of 62°N in Asia and 60°N in North America, modified to include the marine areas north of the Aleutian chain, Hudson Bay, and parts of the North Atlantic Ocean including the Labrador Sea."

In this project we have applied the definition of Arctic developed by AMAP (see the map below). We regard this definition as authoritative, and for the purpose of this survey, it is also an advantage that it includes both the affiliated countries of Denmark, Greenland and the Faroe Islands. However, it should be noted that the definition is somewhat broad and also includes sub-Arctic areas such as Iceland and the Northern part of Scandinavia. In a similar mapping survey of polar research in Norway a more restricted definition of Arctic was used (limited to high Arctic and low Arctic areas).

¹⁰ Aksnes, Dag W., Kristoffer Rørstad & Trude Røsdal (2012) *Norsk polarforskning - forskning på Svalbard. Ressursinnsats og vitenskapelig publisering - indikatorer 2010*. NIFU, Rapport 3 / 2012.

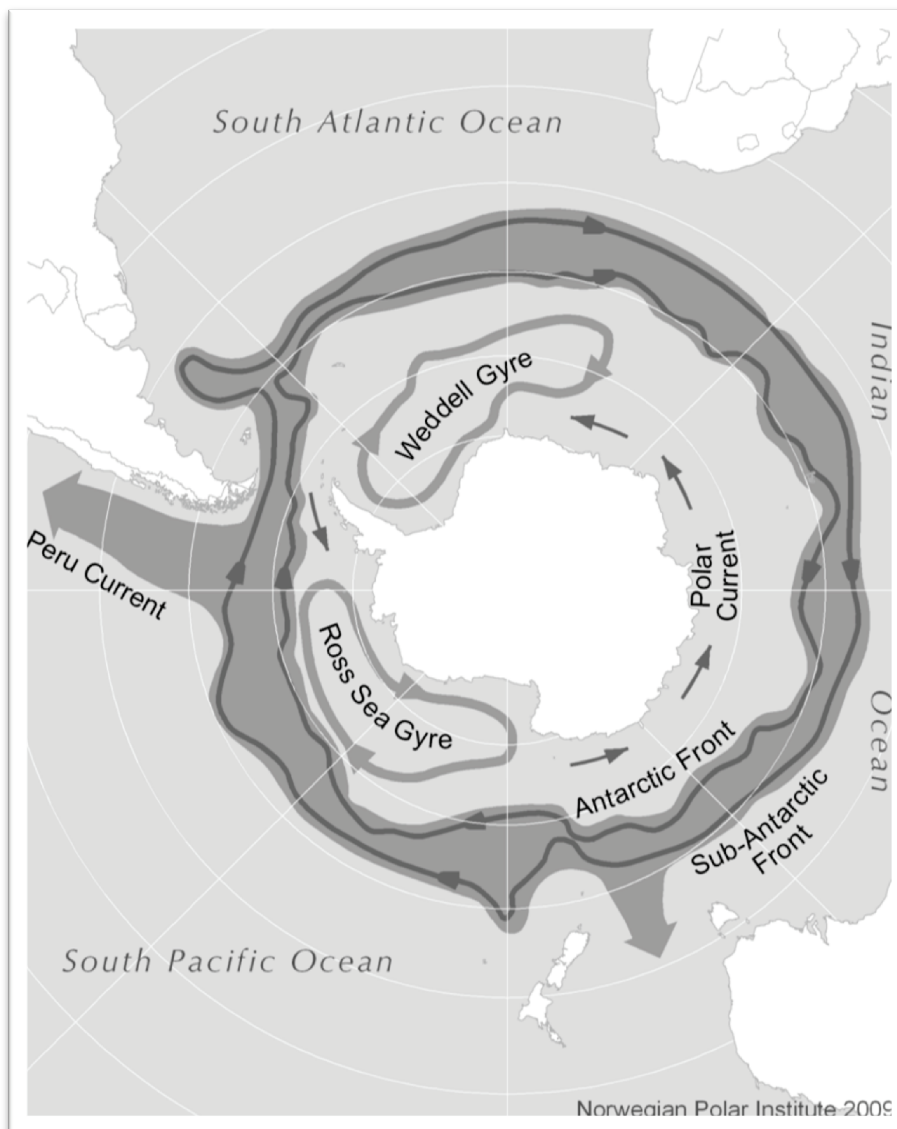
¹¹ AMAP: Physical/Geographical Characteristics of the Arctic, www.amap.no/documents/download/88

Figure 5.1. Map of the Arctic with boundaries defined as polar areas. The area within the red line in the map indicates the boundary of the Arctic as defined in the survey. Source: AMAP.



The survey is however, not limited to research carried out in the Arctic: Antarctica and the sea areas surrounding the continent are also included. Here we have used the definition applied in the similar mapping survey of Norwegian polar research (Aksnes et al. 2012). Antarctica covers areas south of the Antarctic convergence where the warm waters from the north meet the cold waters of the Southern Ocean (polar front). Polar Frontal position varies, but is normally between 50 and 60 degrees south. The survey, however, also includes the sub-Antarctic islands, such as Bouvet Island and South Georgia, which at times may lie north of convergence.

Figure 5.2. Map of the Antarctic with boundaries defined as polar areas. The shaded area indicates the boundary of the Antarctic as defined in the survey. Source: Norwegian Polar Institute.



Based on these geographical delimitations, the following definition of polar research is applied in the project:

Polar research

Research carried out on the basis of material from the polar areas (Arctic and Antarctic), on phenomena located in the polar areas or aiming at direct application in polar areas.

Examples of types of research defined as polar research include:

- Studies involving fieldwork or data collection in polar areas.
- Astrophysics and geophysics studies of the outer space or inner planet based on installations in the polar areas.
- Studies based on data by means of remote sensing and monitoring (by satellite or aircraft) of areas, ecosystems or species in the polar areas.

- Modelling of parameters (e.g. climate, hydrology, sea ice) in the polar areas (although not requiring field work).
- Studies of equipment and technologies intended for applications in polar areas.
- Studies of the human biology, health, socio economic conditions and culture of people and communities in the Arctic.
- Studies of foreign policy and security policy related to the polar regions and resource aspects.

It should be stressed that the survey also includes research carried out on the mainland of Denmark, when this research concerns, or is based on, material/observations from the polar regions. The requirement is that the topic of the research falls under the definition. Often, a polar research project involves a period of field work or other types of observations in polar regions, and the researchers then go to their respective home institutions to work on the material collected.

The survey covers all activities that fall under the research concept in accordance with the OECD definition, ie. experimental or theoretical work undertaken primarily to acquire new knowledge without any particular application or use in view (basic research), as well as original investigation to acquire new knowledge, directed primarily towards a specific practical aim or objective (applied research).

In some cases, it may be difficult to distinguish between research and research-related activities. Routine monitoring (e.g. routine topographical mapping; routine geological, biological hydrological, oceanographic and meteorological surveying) is excluded, except when conducted solely or primarily for the purpose of research. Development work directed at producing new materials, products or devices is not included. Thus, the survey does not include the *D* part of the R&D concept. However, the extent of development work related to the polar regions is presumably very limited.

Another factor is that it can be difficult in practice to determine what falls under the definition of polar research. In particular, this will apply to marine research – there is no physical boundary marking the borderline of Arctic sea areas – and a research cruise may operate on both sides of the geographical borderline. This uncertainty must be taken into account when interpreting the results.

Table 5.1 gives an overview of definitions of polar research disciplines and fields applied in the survey.

Table 5.1. Definitions of polar research disciplines and fields.

Natural sciences	Cosmic geophysics and space research	Includes studies of physical and chemical processes in the part of the atmosphere and near space located outside 50 kilometers above the earth (the upper atmosphere) (e.g. aurora research)
	Atmosphere research and meteorology	Includes meteorology and studies of climate, as well as the composition, chemistry and pollution and of the atmosphere.
	Oceanography and geophysics	Includes studies of the dynamics (transport of water masses) and structure (temperature and salinity) of the ocean (the polar regions) as well as other geophysics
	Cryospheric sciences	Includes studies of all frozen water and land on the surface of the earth, including sea ice, freshwater ice, snow, glaciers, frozen ground and permafrost
	Other geosciences	Includes all arctic geosciences not included in the categories above. Physical geography is also included in this category.
	Terrestrial biology	Includes the study of plant and animal life on land (in polar areas)
	Marine biology and fisheries biology	Includes the study of sea life (in polar areas)
Medicine & health	Public health and social medicine	Includes studies of how social and economic conditions impact the health and disease of humans living in polar areas (indigenous people and others) as well as epidemiology
	Psychology and psychiatry	Includes studies of the mental health of humans living in polar areas (indigenous people and others)
	Other medicine	Includes biomedical and clinical studies related to humans living in polar areas (indigenous people and others)
Engineering	Civil engineering	Includes studies of the design of buildings and constructions in the polar areas, specifically in respect to problems caused by permafrost and extreme cold
	Fisheries and aquaculture technology	Includes studies and development of equipment and techniques for fisheries and aquaculture in polar waters
	Petroleum engineering	Includes Arctic related petroleum technology research
	Marine transport	Includes research related to transportation in polar waters
	Environmental technology	Includes research related to environmental technologies in polar regions
Social sciences	Political sciences and administration	Includes political sciences and studies of public administration related to the polar regions and societies. International politics and security policy is also included in the category.
	Sociology and anthropology	Includes sociological and anthropological studies of humans living in the polar areas, including human geography
	Economics	Includes studies of socio-economic conditions concerning the polar regions and societies as well as business and management sciences
	Law	Includes law studies of matters relating to the polar regions and societies as well as criminology
Humanities	Archaeology and history	Includes studies of material traces of human activity in the polar regions, and history
	Linguistic and literature	includes studies of language, linguistics and literary related to humans living in polar areas
	Cultural studies and religion	includes humanistic studies of the culture and religion of humans living in polar areas
	Other	Other research, not included in the categories listed above.

5.2 Methods – questionnaire survey

The collection of data was based on a questionnaire survey. A questionnaire with guidance and definitions was sent to approximately 270 departments and institutes in Denmark, Greenland and the Faroe Islands. This includes research units within the higher education sector and government sector, but not the business enterprise sector. All departments at the main universities have been included. In addition a selection of other units such as university colleges, independent research institutes, museums and hospital sections are included. The latter are units with a research profile potentially involving polar research or with scientific or scholarly publications within the field.¹²

The questionnaire was sent out at the end of January by regular mail, with a deadline of 15 February. The questionnaires were addressed to the institute leaders/research directors, and the units were asked to report for the entire department/institutes. On 17 February a reminder by e-mail was sent to the institutes that had not responded. A new round with reminders was carried out in the end of February by e-mail and by telephone to the presumably most important departments in terms of activities within polar research. In the process of collecting answers we got assistance from the central administration/ Arctic centres at some of the universities (Aarhus University, Aalborg University, and Copenhagen Business School). The survey was web-based, applying unique login links.

In total 91 units reported that they had carried out polar research in 2013. 111 units reported that they did not carry out polar research, while 68 units did not respond to the survey. An overview of the units reporting polar research can be found in an appendix of the report. Table 5.2 shows how the units are distributed by sector and geographical area.

Table 5.1. Number of departments/institutes reporting polar research in 2013 by geographical area and sector.

Sector of R&D performance	Geographical area (institutional location)		
	Denmark	Greenland	The Faroe Islands
Higher education sector	60	2	0
Government sector*	20	4	5
Total	80	6	5

* Independent research institutes, museums, hospital sections.

The survey included questions about the following activities in 2013 (the questionnaire is included in appendix of the report):

- Number of polar research work-years (full time equivalents, FTE), total and by source of funding.
- Funding of direct expenditure related to polar research, by source of funding, and proportions spent on research infrastructure and research logistics.
- Number of polar research work-years (FTE) by geographical area.
- Number of polar research work-years (FTE) by discipline.
- Overall change in the volume of polar research compared with 2008.
- Doctoral students in 2013 and doctoral degrees in 2011-2013.
- Overview of polar researchers and their collaborative links.

¹² Based on literature searches in the bibliographic databases Web of Science and Forskningsdatabasen using keywords such as Greenland, Grønland and Inuit.

In the survey, we have used work-years as the key input indicator. This is because it is often easier for the respondents to estimate the activities in terms of work-years than to calculate the costs. Work-year is also a well-suited indicator because the numbers are comparable across disciplinary and institutional boundaries. The number of polar research work-years is reported as full time equivalents (FTEs). Administration/management related to this research is also included in the reporting. As an example, a person who spends 40 per cent of his or her time on polar research, 10 per cent on administration of this activity, and 50 per cent on other activities (e.g. teaching), has 0.5 FTE polar research. In addition to researchers, technical and administrative personnel may be included, as far as they have been involved in research projects. In the calculation of work-years, both time spent on field-work and on analysing the results, writing the papers etc. at the home institutions (in Denmark or other places) are included.

When it comes to the expenditure and funding of polar research, this information was partly obtained through the questionnaire, partially estimated. The units were only asked to provide data on direct costs, i.e. cost for equipment, instruments, travel, logistics, operation of research stations and research vessels. Other cost such as salaries for staff as well as indirect costs such as social security contributions, pension insurances, and other social costs should be excluded. The total expenditure was then calculated by NIFU from the data on work-years. This method was chosen because research units, according to NIFU's experiences with similar surveys, often do not include sufficient overhead costs when they report their research spending. More specifically, this means that salaries and operating costs have been calculated based on the FTEs specified and average work-year cost for 2013. The average work-year cost for 2013 is based on figures for expenditure on R&D from the previous R&D statistics in Denmark in 2011 by field of science. These figures have been adjusted by inflation rates for 2012 and 2013 (rates for salaries and consumer prices, in total 3.7 per cent). This gives an average work-year cost of 651 000 to 767 000 DKK in 2013 (depending on research field). At the aggregate level, we consider this method as suitable and reliable for calculating the costs.

In the survey, the respondents were asked to distribute the polar research activities by disciplines. An overview with definitions of these disciplines can be found in the appendix of the report. The classification scheme applied is a modified version of the one previously used in the mapping of Norwegian polar research.

Based on the survey, we are able to provide an overview of the volume and profile of polar research within the Kingdom of Denmark. One important methodological question concerns the completeness of the survey, in other words, if there are units carrying out polar research that not have been identified and included in the survey. We believe that all the relevant departments and institutes in the Kingdom have been included. We carried out investigations of the publication output in the actual field in order to identify relevant units and attain a complete coverage. A more urgent question is the status of the 68 units that did not respond to the survey, despite several rounds of reminders. Some of these units have previously published papers within the field of polar research. However, a web-based examination of the research profile of the non-responding units, indicate that they generally have no or very few activities within polar research. There will be some additional activities that have not been captured by the survey, but the volume of this activity is presumably rather limited compared to the large volume that actually has been included. It should be noted, however, that no departments at the University of the Faroe Islands responded to the survey. We conclude that the survey gives very good coverage of the polar research in the Kingdom of Denmark.

Another methodological issue concerns the reliability of the answers. Generally this will be most critical for the departments that have a large volume of polar research and therefore weigh heavily in the totals. For the respondents there may be a challenge to delineate polar research from other research activities and give precise answers on several of the questions. The numbers should therefore be considered as discretionary estimates. We have, however, critically examined the respondents' answers. If some numbers have seemed unreasonable, the respondents have been contacted and

asked to provide additional information. In any case, due to the various sources of error, a survey like this should be regarded as a rough rather than precise quantification of the research volume.

The questionnaire included a final question where the respondents were asked to provide a list of people involved in polar research, their position and polar research area, as well as their collaborative relationships. Unfortunately, the responses to this question were rather unsatisfactory. Some institutions did not deliver a list, and many departments found it impossible to provide an overview of their collaborative links. The latter fact was justified by referring to the very extensive collaboration pattern often involved in polar research.

The incomplete data on this question have no implications for the statistics and analyses presented above, as these do not depend on data at the level of individuals. The main intention of including this question in the questionnaire was to provide the Danish Agency for Science, Technology and Innovation with an overview of polar researchers in the Kingdom and their collaborative links. This would be the basis for creating a database at the level of individuals that could be useful in future analyses and would at the same time be beneficial for researchers in the area of polar research.¹³ Future actions will, however, be taken by the Danish Agency for Science, Technology and Innovation in order to obtain better coverage and data quality for this database.

The data we have received so far include a total of 500 different individuals. This figure is however, a substantial underestimate of the number of people involved in polar research in the Kingdom, as major institutes such as GEUS have not delivered data.

In this report, we have not used the data for analysing collaboration. National and international collaboration are topics very suitable for a bibliometric analyses, and we refer to Chapter 3 for an overview of this aspect of polar research.

5.3 Methods – bibliometric analysis

What is bibliometrics?

Bibliometrics was originally defined as “book counting”. In research bibliometrics is used to examine publication behaviour and could be described as quantitative studies of research performance and research impact. Bibliometric methods comprise a set of indicators that can be used to draw a picture of the evolution of the performance of various entities (i.e. institutions, countries) in diverse scientific areas.¹⁴

The bibliometric indicators used in this analysis provide information on the level of scientific output, growth and impact of the Kingdom of Denmark and other leading countries in polar research. We examine research activity (publications), research impact (citations) and research collaboration (national/international). To examine the research activity we use metadata from the publications: country, institutions, author addresses. To examine the impact we use information on the citations given to a publication; and how many times other authors have cited the publication.

Datasets

The bibliometric analysis is based on Thomson Reuters Web of Science, which is the most commonly used database for bibliometric studies. The Web of Science Core Collection currently includes about 12,000 international scientific journals covering more than 250 disciplines. Although its coverage is not

¹³ It should be noted that many polar research projects have already been registered in the online database for arctic research: <https://creator.zoho.com/arcticstatus/research-2012-2013#>. However, this database does not contain all the data required.

¹⁴ Cf. King, Jean (1987). A review of bibliometric and other science indicators and their role in research evaluation. *Journal of Information Science archive*, 13 (5), 261 – 276.

complete, the database covers all major journals within the sciences, medicine and technology and is generally considered as a satisfactory representation of international scientific research.

Web of Science, like other citation indexes, has the disadvantage that its coverage of main research areas such as the Social Sciences and Humanities (SSH) is poor, and this should be taken in to consideration when reading the results of the publication analysis.

Methods and indicators

In summary:

- Data from the Thomson Reuters Web of Science Core Collection indices: Science Citation Index Expanded, Social Sciences Citation Index and Arts & Humanities Citation Index.
- Data from the time period 2008-2012.
- Covering publications defined by Thomson Reuters as research articles, letters, reviews and proceeding papers.
- Covering polar research globally and within the Kingdom of Denmark (Denmark, Greenland and Faroe Islands). The definition of polar research was made particularly for this report since there is no specific Thompson Reuters category covering this field.
- Specific focus on 15 countries including the Kingdom of Denmark.
- Measures of research activities based on whole and fractionalised publication counts and impact measures based on fractionalised citation indicators. Self-citations excluded.

Search

Polar research is not a traditional scientific discipline and can be defined in various ways. The bibliometric analysis uses the same AMAP definition as explained in Chapter 5.1 – Definition of polar research.

The use of the AMAP definition of the Arctic entails a broader view of the geographic area than more commonly used definitions on the Arctic Circle. This means that this analysis includes areas such as Alaska, Iceland, Faroe Islands and the northern states of Canada, and therefore we find more publications related to the Arctic than other similar publication analysis.

In March the final search in the Web of Science (WoS) database was done and consisted of the following elements: timeframe, document types, geographical areas, keywords and names of central journals within polar research. Separate searches were made for the Arctic and the Antarctic area. The above mentioned elements apply to the Arctic search, whereas the Antarctica search was based on: timeframe, document type, geographical areas and central journal sources.

The Arctic dataset was built by conducting searches using three different principles. First we included all publications from journals that entirely or mainly cover polar research.¹⁵ Second, we added specific geographical land and watermarks search terms following the AMAP definition.¹⁶ Third, Arctic specific keywords were identified via publications from the above mentioned search set and from consulting various internet resources. The searches were done through titles and abstracts from all publications

¹⁵ Antarctic science, Arctic, Arctic Antarctic and Alpine Research, Arctic Anthropology, Permafrost and Periglacial Processes, Polar Biology, Polar Record, Polar Research, Polish Polar Research.

¹⁶ Amund Ringnes Island, Amundsen Basin, Amundsen Gulf, Arctic, Axel Heiberg Island, Baffin Island, Banks Island, Barents Sea, Barentsburg, Bathurst Island, Beaufort Gyre, Beaufort Sea, Bering Strait, Bjornoya, Bear Island, Brooks Range, Bylot Island, Cambridge Bay, Canada Basin, Chukchi, Chukchi Sea, Cumberland Sound, Davis Strait, Denmark Strait, Devon Island, Ellef Ringnes Island, Ellesmere Island, Eskimo, Eurasian Basin, Fram Strait, Greenland, Greenland Sea, Greenlander, Hopen, Hornsund, Hudson Bay, Hudson Strait, Inuit, Inupiat, Jan Mayen, Kara Sea, Karskoje Sea, King William Island, Kongsfjord, Northwest Territories, East Siberian Sea, Lancaster Sound, Laptev Sea, Lomonosov Ridge, Longyearbyen, Mendeleev Ridge, Mendeleev Rise, Nares Strait, North Magnetic Pole, North Pole, North Pole, Northwest Passage, Novaya Zemlya, Novosibirskije Ostrova, Nunavik, Nunavut, Nunivak Island, Ny Alesund, Polynya, Prince Charles Island, Prince of Wales Island, Prince Patrick Island, Queen Elizabeth Island, Qaanaaq, Repulse Bay, Resolute Bay, Severnaya Zemlya, Seward Peninsula, Siberian Sea, Somerset Island, Southampton Island, Spitsbergen, St Lawrence Island, St Matthew Island, Storfjorden, Svalbard, Taymyr Peninsula, Tiksi, Ungava, Victoria Island, Wrangel Island, Gulf of Alaska, Alaska, Iceland, Faroe Island, Nansen Basin, Franz Josef Land, Gakkel Ridge, Bristol Bay, Arctic Bay, Labrador Sea, Thule

in WoS. The assumption was that the geographical location in which the research had been performed would be mentioned in either the title or the abstract.

The Antarctic dataset was built by including all publications from the same journals as included in the Arctic search. Also, the name of the entire continent was used in addition to names of the surrounding oceans. We did not use field-specific search terms for the Antarctic search.

All bibliographic details of all publications (from both the Arctic and Antarctic search sets) were downloaded and further analysed using Bibexcel.¹⁷

Timeframe

The timeframe was 2008-2012 (5 years). 2007-2008 was the international polar year – a research programme organised by the International Council for Science (ICSU) and the World Meteorological Organization (WMO). Since it takes time to index all publications for a given year in Web of Science, 2012 was chosen as the last year since most publications must be considered to be registered by now, which is probably not the case for all 2013 publications.

Document types

The publication analysis is based on only scientific peer-reviewed articles. Web of Science indexes all journals cover to cover and therefore consists of a wide selection of document types, which is why it was necessary to choose only a few document types. The chosen document types were research articles, letters, reviews and proceeding papers. Hence editorials, books, book chapters etc. are not included.

Focus on 15 countries

The publication analysis has a special focus on the Kingdom of Denmark in a global context. The global comparison pays special attention to 15 countries. This is based on two facts. The first is that we wanted to include the eight members of the Arctic Council, since they all have a special interest in the Arctic area and they are also considered potential collaboration partners. The members of the Arctic Council are: The Kingdom of Denmark (Denmark, Greenland and Faroe Islands), USA, Canada, Russia, Norway, Sweden, Iceland and Finland.

The second is the inclusion of seven countries which came up in the publication analysis as the countries with the highest shares of publications within polar research. These countries are: the United Kingdom, France, Germany, China, Japan, Australia and The Netherlands.

The country members of the Arctic Council are also influential when it comes to research production and also have high shares of publications within polar research.

Merged countries

In Web of Science the United Kingdom is divided into four countries: England, Scotland, Wales and Northern Ireland. In this analysis we have chosen to merge them into one entity; this was done while searching in the database to avoid double counting. Likewise the Kingdom of Denmark is divided into two separate countries: Denmark and Greenland. These were also merged into one entity.

Publications from the Faroe Island are registered with Danish addresses in the database, so it has not been necessary to take certain precautions to ensure that they are included in the Kingdom of Denmark.

Whole counting/fractional counting

Many publications are written by more than one author with either collaboration between institutions from the same country or with international collaboration between institutions from different countries (co-authored), and are therefore a result of collaborative efforts involving more than one country/institution. Different counting methods can be applied in bibliometric studies to deal with this. The most common method is whole counting, that is with no fractional attribution of credit.

¹⁷ Bibexcel can be found at: <http://www8.umu.se/inforsk/Bibexcel/>

Each country/institution gets full credit for the publication, and the publication is counted as one for each. Another method is using fractional counting, where the credit is divided equally between all the contributing authors addresses. The result being that a publication is only counted once and the institutions/countries each get their part. For example, if an article has one author from Denmark and one from Norway each country will receive a value of 0.5 publications. In this analysis we use a fractionalised counting scheme where all addresses in a publication share one credit. For example if a publication has 3 Danish addresses, one from Norway and one from USA, Denmark receives three-fifths, Norway one-fifth and USA one-fifth.

Citations

Evaluative bibliometrics is a subfield of quantitative science and technology studies, aimed at constructing indicators of research performance from a quantitative analysis of scholarly documents; here citation analysis is one of its key methodologies.¹⁸ Where the publication analysis tells us about how productive a country is on research output, the citation analysis tells us how much impact the research has had in the scientific communities.

To see if the Kingdom of Denmark and the institutions within the Kingdom is cited more than average we use a relative citation index (given citations/world citations) / (number of articles/all articles).

Here an index value of 1.00 is the "world average". An index value of 1.10 rates 10 percent above average and an index value of 0.80 rates 20 percent below average.

We use two types of citation index, one showing citation rates per country and institution and one showing citation rates per discipline/field.

The citation index per country/institution is normalised for neither field nor publication. Since polar research consists of various numbers of different field areas, this would be an impossible task. This means that the index does not take into consideration that different fields have different citation patterns. It also means that countries/institutions which publish many articles in highly-cited fields will be favoured over countries/institution which publish in lower-cited fields. The citation index should only be seen as an indicator of how the countries are cited within polar research as one field.

The citations count is based on the timeframe 2008-2011. Publications from 2012 are not included, since making citation analysis demands data (publications) which have had at least 2 years in which to be cited. Citations are counted within the timeframe, meaning that each year has a different citation window: 2008 publications have a 5 year window; 2009, 4 years etc.

Self-citations: a citation in which the author cites himself/herself in a former publication. To give a more accurate picture of the number of citations, self-citations are subtracted.

¹⁸ Cf. Moed, Henk (2005). *Citation Analysis in Research Evaluation*, Springer.

Appendix 1. Units* reporting polar research

Institution	Department	Location
Aalborg University	Department of Culture and Global Studies	Denmark
	Department of Development and Planning	
	Department of Electronic Systems	
	Department of Law	
	Danish Building Research Institute	
Aalborg University Hospital	Arctic Health Research Centre	Denmark
Aarhus School of Architecture		Denmark
Aarhus University	AU Herning	Denmark
	DCE - Danish Centre for Environment and Energy	
	Department of Aesthetics and Communication	
	Department of Bioscience	
	Department of Chemistry	
	Department of Culture and Society	
	Department of Economics and Business	
	Department of Education	
	Department of Environmental Science	
	Department of Geoscience	
	Department of Law	
	Department of Physics and Astronomy	
	Department of Public Health	
Aarhus University Hospital	Department of Occupational Medicine	Denmark
Asiaq, Greenland Survey	Hydrology and Climate	Greenland
Bispebjerg University Hospital	Occupational and Environmental Medicine	Denmark
	Department of respiratory medicine	
Copenhagen Business school	Department of Business and Politics	Denmark
	Department of Economics	
	Department of Intercultural Communication and Management (ICM)	
	Department of International Economics and Management	
	Department of Marketing	
	Department of Operations Management	
Danish Institute for International Studies		Denmark
Danish Meteorological Institute	Centre for Ocean and Ice	Denmark
	Centre for Meteorological Models	
	Danish Climate Centre	
	Research and Development	
Danish national Centre for Social Research		Denmark
Danish National Metrology Institute		Denmark
Department of Occupational Medicine and Public Health		Faroe Islands
DHI	Ports and Offshore Technology	Denmark
Environment Agency	Research	Faroe Islands
Faroe Islands National Heritage, Archives, Library and Museums	Søvn Landsins	Faroe Islands
Faroe Marine Research Institute		Faroe Islands
Geological Survey of Denmark and Greenland (GEUS)		Denmark
Greenland Climate Research Centre		Greenland
Greenland Institute of Natural Resources		Greenland

Jardfeingi, Faroese Earth and Energy Directorate	Geoinformation Department	Faroe Islands
National Museum of Denmark		Denmark
Odense University Hospital	Department of Infectious Diseases	Denmark
Queen Ingrid's Hospital	Department of Health	Greenland
Rigshospitalet	Department of Infectious Diseases	Denmark
	Pathology	
Roskilde University	Department of Environmental, Social and Spatial Change	Denmark
	Department of Science, Systems and Models	
	Roskilde University Library	
Royal Danish Academy of Fine Arts, Schools of Architecture, Design and Conservation		Denmark
Royal Danish Defence College		Denmark
Statens Serum Institut (SSI)	Department of Epidemiology Research	Denmark
	Diagnostics & Infection Control	
Technical University of Denmark	DTU Space	Denmark
	DTU Systems Biology	
	DTU Civil Engineering, Arctic Technology Centre (Artek)	
	DTU National Institute of Aquatic Resources	
	DTU National Veterinary Institute	
	DTU Space	
	DTU Systems Biology	
	DTU Wind Energy	
University of Copenhagen	Department of Anthropology	Denmark
	Department of Arts and Cultural Studies	
	Department of Biology	
	Department of Clinical Medicine	
	Department of Cross-Cultural and Regional Studies	
	Department of English Germanic and Romance Studies	
	Department of Forensic Medicine	
	Department of Geosciences and Natural Resource Management, Centre for Permafrost	
	Department of Pharmacy	
	Department of Plant and Environmental Sciences	
	Department of Political Science	
	Department of Public Health, Centre for Epidemiology and Screening	
	Faculty of Law	
	Natural History Museum of Denmark	
	Saxo Institute	
Section for Church History		
The Niels Bohr Institute, Centre for Ice and Climate		
University of Greenland, Ilimmarfik	Institute of Ilimmarfik	Greenland
	Institute of Nursing and Health Science	
University of Southern Denmark	Department of Biology	Denmark
	Department of Environmental and Business Economics	
	Department of Law	
	Institute of Clinical Research	
	Institute of Public Health	
	National Institute of Public Health	

* Some Arctic research centres are administratively organised within a department. Therefore, these units do not appear on the list.

Appendix 2. Questionnaire

NIFU

Nordisk institutt for studier av
innovasjon, forskning og utdanning



Danish Ministry of Science, Innovation and Higher Education

Mapping of polar research in the Kingdom of Denmark

POLAR RESEARCH 2013

The information you enter will be saved when you scroll back and forth within the questionnaire. It is possible to exit the form and then come back at a later time without previously entered data disappearing. Once the form has been delivered and you have received the message "Thank you for answering the mapping of polar research in 2013", it is no longer possible to log on and make changes, unless the form is being reopened by NIFU (please contact NIFU if you need to make changes in the submitted form).

Before answering the questionnaire, please read the letter containing guidance and definitions.

In the form, total figures for your department should be given.

Any inquiries can be directed to Kristoffer Rørstad, tel + 47 22 59 51 79, e-mail: kristoffer.rorstad@nifu.no or Dag W. Aksnes, tel + 47 99 47 43 38, email: dag.w.aksnes@nifu.no

Please return the questionnaire by February 15th 2014

Declaration of Consent

The institution hereby declare, that all information conveyed in this questionnaire, is done so in accordance with the institutions rules and regulations and that no confidential nor personal sensitive information is provided herein.

The institution hereby grants the Danish Ministry of Science, Innovation and Higher Education the right to use the submitted data for the mapping of polar research in the Kingdom of Denmark and publish the final report on www.fivu.dk. Consent is given when the questionnaire is submitted to NIFU.

Start

1. Please provide contact information

Department	<input type="text"/>
Institution	<input type="text"/>
Contact person	<input type="text"/>
Telephone	<input type="text"/>
E-mail	<input type="text"/>

2. Did the department/institute carry out polar research in 2013?

Cf. the definition of polar research. Research carried on the basis of material from the polar areas (Arctic and Antarctic), on phenomena localized in the polar areas or aiming at direct application in polar areas (confer the enclosed letter for further details on the definition).

Yes No

3. Total volume of polar research - number of work-years

Enter an estimate of the total number of work-years (FTEs) polar research carried out by the staff at your department/institute in 2013 (permanent and non-permanent staff, including technical/administrative staff and PhD students).

Total number of work-years (FTEs) in 2013	<input type="text"/>
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4. Funding sources

Please enter an estimate of how the work-years (FTEs) polar research in 2013 were distributed according to funding sources (percentage)

(The proportions should sum up to 100 %)

Funding sources	Proportion (%)
Basic funding (applicable for permanent staff, postdocs, PhD fellows and others paid by institutional budgets)	<input type="text"/>
Research councils (including the Danish National Research Foundation)	<input type="text"/>
Ministries	<input type="text"/>
Other public funding	<input type="text"/>
Business/industry	<input type="text"/>
Private funds (Carlsbergfondet and others)	<input type="text"/>
EU (FP7 and other programs)	<input type="text"/>
Other foreign funding sources	<input type="text"/>
Sources not specified above	<input type="text"/>
Total	0

5. Funding of direct expenditures

Please enter how direct expenditures related to polar research in 2013 has been funded. Direct costs refer to e.g. equipment, instruments travel, logistics, operation of research stations and research vessels). NB! Expenditures related to hiring of personnel should not be included here (e.g. salaries for staff as well as indirectly associated costs such as social security contributions, pension insurances, and social costs)

Funding sources	Amount in 1000 DKK
Basic funding (expenditures paid by institutional budgets)	<input type="text"/>
Research councils (including the Danish National Research Foundation)	<input type="text"/>
Ministries	<input type="text"/>
Other public funding	<input type="text"/>
Business/industry	<input type="text"/>
Private funds (Carlsbergfondet and others)	<input type="text"/>
EU (FP7 and other programs)	<input type="text"/>
Other foreign funding sources	<input type="text"/>
Sources not specified above	<input type="text"/>
Total	0 <input type="text"/>

6. How large proportion of the direct expenditures in question 5 was spent on research infrastructure

(i.e. construction and operation of research stations, observatories, laboratories, and research vessels)?

Proportion spent on research infrastructure in per cent

7. How large a proportion of the direct expenditures in question 5 was spent on research logistics?

(i.e. transportation and research travels (excluding travels for conferences, administrative meetings etc.))

Proportion spent on logistics in per cent

8. Geographical areas

Please give an estimate of how the work-years (FTEs) polar research in 2013 were distributed according to geographical area (i.e. according to which area data were collected/area the research was dealing with), percentage.

(The proportions should sum up to 100 %)

Area	Proportion (%)
Land areas	0
Greenland	
The Faroe Islands	
Svalbard	
Nordic countries, arctic mainland areas and Iceland	
Arctic land areas not specifies above	
Antarctica	
Sea areas*	0
Greenland Sea and sea areas surrounding Greenland**	
Barents Sea	
Arctic Ocean	
The Norwegian Sea	
Other polar seas in the Arctic	
Polar seas near Antarctica	
Total	0

* As a rough guide the sea areas can be delimited as follows: Kara Sea extends to the east of Novaya Zemlya. Barents Sea extends to the west of Novaya Zemlya and the east/south of Svalbard. Greenland Sea extends from the eastcoast of Greenland to the north/south of Svalbard. The Arctic Ocean is the waters surrounding the North Pole. See also the enclosed map.

** Fram Strait, Denmark Strait, Baffin Bay, Davis Strait.

9. Polar research by discipline

Please give an estimate of how the work-years (FTEs) polar research in 2013 were distributed according to field of study. See the enclosed letter for definitions of the various fields.

(The proportions should sum up to 100%).

Domain	Dicipline/field	Proportion (%)
Natural sciences	Cosmic geophysics and space research	<input type="text"/>
	Atmosphere research and meteorology	<input type="text"/>
	Oceanography and geophysics	<input type="text"/>
	Cryospheric sciences	<input type="text"/>
	Other geosciences	<input type="text"/>
	Terrestrial biology	<input type="text"/>
	Marine and fisheries biology	<input type="text"/>
Medicine	Public healt and social medicine	<input type="text"/>
	Psycology and psychiatry	<input type="text"/>
	Other medicine	<input type="text"/>
Engineering	Civil engineering	<input type="text"/>
	Fisheries and aquaculture technology	<input type="text"/>
	Petroleum engineering	<input type="text"/>
	Marine transport	<input type="text"/>
	Environmental technology	<input type="text"/>
Social Sciences*	Political sciences and administration	<input type="text"/>
	Sociology and anthropology	<input type="text"/>
	Economics	<input type="text"/>
	Law	<input type="text"/>
Humanities	Archaeology and history	<input type="text"/>
	Linguistics and literary	<input type="text"/>
	Cultural studies and religion	<input type="text"/>
Other	<input type="text"/>	<input type="text"/>
	TOTAL	0

* Psychology has been included under medicine

10. Polar research 2008-2013

We are interested in data to assess the overall trend in the volume of polar research since 2008: increase, decrease or status quo. Compared to 2008 was the total volume of the polar research (based on number of work-years) carried out at your department/institute in 2013 higher or lower? Use percentage to indicate the change (e.g. 10 per cent increase). Please note, we acknowledge that it will only be possible to give a very rough estimate of the change of the volume.

Change in volume of polar research compared to 2008, per cent

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