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# *Operational Oceanography: Data Requirements Survey*

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***Cover picture***

***Large image:*** "A water perspective of Europe", courtesy of Swedish Meteorological and Hydrological Institute. The white lines show the watershed boundaries between the different catchment areas flowing into the regional seas of Europe.

***Inset image:*** Height of the sea surface in the north Atlantic and Arctic simulated by the OCCAM global ocean model, courtesy of David Webb, James Rennell Division, Southampton Oceanography Centre.

# *Operational Oceanography: Data Requirements Survey*

by J Fischer and N C Flemming

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# Contents

# Preface

EuroGOOS is the Association of European national agencies for developing operational oceanographic systems and services in European seas, and for promoting European participation in the Global Ocean Observing System (GOOS). EuroGOOS was set up in December 1994. In 1999 it has 31 Members from 16 countries, and Associate Membership from several key European multi-national bodies.

EuroGOOS has published its Strategy (1996) and an outline implementation Plan (1997), as well as special reports on its Science Basis (1998), Atlantic Workshop (1998) and Technology Survey (1998) and Mediterranean Forecasting System (1998).

The design of a permanent operational oceanographic observing system depends upon scientific understanding of marine physical and biological processes, possession of competent technology, and a knowledge of what is required by potential users of the information. During the last decade various expert committees and workshops have defined the measurements which are needed by government and UN Agencies to make marine weather forecasts, climate models and forecasts, and those needed for control of pollution. It is more difficult to determine the full range of marine data forecasts and models needed by the whole variety of governmental services, like resource management and environmental protection, as well as of commercial industries and services which work on the sea and the coast, and the requirements on the coasts and in estuaries at the local level. This is the purpose of this report.

The objective of EuroGOOS is to promote the design and implementation of an observing system which will provide Europe with the most useful and economic array of data products derived from a co-ordinated and minimal pattern of observations. Ideally the maximum number of potential users will be provided with the widest possible variety of products from the simplest possible deployment of instrumentation. This requires assimilation of the observed measurements into numerical models in order to produce gridded data outputs.

There are of course many obstacles to achieving this ideal outcome. It is impossible to obtain all the information needed to give perfect knowledge of the market, and perfect knowledge of the economic and social benefits from using the improved information in each Sector of the market. This report is only one input to aid the design of GOOS and EuroGOOS. Other groups in EuroGOOS are examining ways of improving our knowledge of the actual economic scale of marine activities in Europe, and how they would benefit from improved forecasts.

The present report gives the most complete survey and analysis so far conducted of the full range of potential customers for marine operational data, based on an open-ended survey in which they had the option to chose any Variable which might be useful to them. A survey of this kind is a sociological exercise, not a scientific experiment, and the results need to be interpreted with a careful attention to the context of each piece of information. There is no single dominant customer for marine environmental data, and thus the survey data set is multi-dimensional, with dozens of customers requiring dozens of different Variables in dozens of different combinations and characteristics. Only very few Variables and products identified in this survey are needed by most of the total market and it would be naïve to expect that one could identify the typical or average customer for a particular Variable or product. Used with judgement and care, this survey does show very clearly the range of customers for each product, and the range of characteristics which they require for different applications. The internal consistency of the survey results confirm the reliability of the information.

Readers who wish to have access to the original national survey results should contact their EuroGOOS Member representative at the relevant national agency listed on the cover of this report, and Annexe 4.

Thanks are due to Giuseppe Cutugno, Erik Buch, Gregorio Parrilla, Frans van Dongen, and

Christos Tziavos for running the survey in their respective countries, and to Emanuel Paris for conducting the first stage of the multi-national data analysis. Sally Marine designed the data base on ACCESS and prepared the discs for use by national organisers.

# Executive Summary

A survey questionnaire was distributed in 6 countries giving a balanced north-south sample of operational marine data requirements from 155 organisations. The design of the questionnaire itself, the list of 116 Applications Sectors and 136 measured Variables is checked for bias, and the responses are checked for bias in the selection of respondents, and for carelessness or ignorance in completion of the forms. The results indicate a strong demand for operational data from a well-informed user community which includes research organisations, marine services, environmental management bodies, building, transport, defence, engineering and offshore oil and gas companies and their contractors, aquaculture and fishing industry, and others. The demand for data products is dominated by the physical parameters of the coastal seas and upper ocean, but phytoplankton, chlorophyll, nutrients, and oxygen concentrations all appear as requirements in the top 40 ranking.

We describe the data requirements in terms of the data set (Variables, geographic coverage, accuracy, spatial, vertical and temporal resolution, and forecast period) as it would be delivered to the user. In most cases the delivery would occur after data analysis, processing, modelling, or creation of a gridded high resolution product. Only 20% of users require raw observational data on average, although this varies with the topic. The characteristics of the data requirements therefore describe in general the output from models, not the accuracy or resolution of the observing system which produced the data input to the models. The design of an observing system which can satisfy the requirements expressed in this survey depends upon specifying the model software and data input to that model which will produce the required output.

The user community responding included every Application in the EuroGOOS list, excepting only deep sea mineral mining and extraction of minerals from seawater. The respondents expressed a requirement for every Variable listed in the questionnaire, with a strong gradient from the most frequent requirements (over 50% of respondents) to the least required (2% of respondents).

We identify correlations and trends as between countries, and between Variables, user applications, geographical scales, accuracy requirements, and other characteristics of the data set. In all cases there is a wide spread of choices selected by respondents because they have genuinely different needs. This spread is not an error about a presumed mean for an ideal user, but is a real reflection of the wide range of applications and geographical environments. A data supplier wishing to market data products can therefore see what proportion of the total potential market would be satisfied by a product of given specifications. A more detailed analysis can show what characteristics of the data are required by single industries or Application Sectors.

This report will be useful to operators of data services and value-added companies who wish to assess the present and future demand for different data products. While physical Variables and derived products dominate the ranking, descriptions of the ecosystem, water quality, chemistry, and sediment characteristics are close behind, and evidence from this survey and other studies by EuroGOOS confirm the steady growth in importance of ecosystem and water quality modelling and forecasting.

EuroGOOS Member Agencies with responsibility for the development of observing systems in the different regional seas of Europe can use the results to help in the design of observing networks and models.

There is an implied connection between the results of this survey and the EuroGOOS economic studies which show the importance of different marine industries and services to Europe. At a very simple level this survey demonstrates that every marine activity in Europe has a demand for improved operational marine data, and would therefore benefit economically from the provision of those data. The more complex exercise of connecting individual industries and applications to their data requirements, and hence to the benefit which would be expected to result from investment in different observations and services will be developed cautiously. Since each Variable is required in a different way, with different sensitivity, by many industries and applications, the total benefit from improving the accuracy or resolution of that data set is the aggregate of many economic calculations. Within 5 years it is probable that the demand for operational data will have evolved and changed sufficiently for a re-assessment to be carried out, identifying new priorities and ranking.

We recommend that the results of this survey should be available electronically to organisations wishing to work on the data in more detail, and that the national data sets should be made available in more detail to approved customers where possible. An improved survey should be repeated in 3-5 years time. The data and results of this survey should be used as inputs to the EuroGOOS Products Working Group. The Technology Plan Working Group and the Science Advisory Working Group should consider the implications of data requirements for the design of observation and modelling systems.

# 1 Objective and Analysis of Survey Design

## 1.1 Aim of the EuroGOOS Survey of Data Requirements

The aim of the EuroGOOS Requirements Survey (ERS) is to identify the classes of applications and uses for operational data on the marine environment, to identify what products and Variables are required, and to define the accuracy, resolution, space and time scales, forecast periods, and types of products needed. This information is one input amongst other which help to design the observing system most appropriate to Europe, to develop the products needed, and make economic and social decisions about priorities for marine observations.

The ERS has been carried out in response to a need expressed at EuroGOOS Plenary Meetings in 1995 (Sopot, and Dublin) to quantify the user demand and requirement for operational data products. The importance of the Survey was stressed in the EuroGOOS Strategy (1996) and the EuroGOOS Plan (1997). The results of the survey give a preliminary market analysis of requirements by obtaining the views of 155 data using agencies, institutes, and companies in 6 countries. This should be considered in parallel with the political and social priorities established by consideration of public good, and long term planning to cope with factors like climate change. The end-user market considered in this survey is more diverse and fragmented than the governmental requirements, and the survey design takes account of this.

This survey of operational marine data needs is, by definition, additional to the political or social objectives defined by international bodies, UN agencies, and government agencies, which lead to consequential operational data requirements. There is overlap, because the same agencies may provide data commercially to end users as well as for government policy and UN agency purposes. For example, climate research can be identified as a political priority by key decision-makers, and it also ranks high as an application by the respondents to this survey.

Operational data products are defined as those which are delivered on the basis of repeated measurements and analysed through some kind of routine process, usually a computer numerical model, resulting in a description or forecast of the marine environment, including physical, biogeochemical, and biological parameters. This is distinct from other kinds of environmental knowledge or experiment, where data are obtained from a targeted area and time to solve a specific problem or answer a specific scientific or engineering question. For a fuller definition see EuroGOOS Publication No.1. 1996, p.10.

This survey does not evaluate the political or social importance of different data types or application. A customer requiring a forecast in order to increase the profits of a tourist centre is treated in the same way as a forecasting centre requiring data to prevent coastal floods and save lives. Each respondent, at the present level of analysis, is just a consumer of data products. Social and political priorities can be established separately by political or administrative meetings, and scientific workshops. The purpose of the present survey is to identify the stated requirement for operational data, as stated by the users and their intermediaries and data providers. Many of the respondents to this survey are commercial organisations which could pay for data products, and this factor will help to justify the investment in the observing system.

Other groups in GOOS or EuroGOOS will work "upstream" from these product descriptions to help design the observing and modelling system required. Similarly, the Products Working Group of EuroGOOS will use these specifications to help define marketable products which are of maximum value to users. The Regional Seas Task Teams of EuroGOOS can identify those products which are most required in their sea areas. The Economics Working Group of EuroGOOS can link the economic scale and value of different marine industries and services in Europe to the data required by that activity, and hence start the process of evaluating the economic return from investment in different observing systems, technologies, and products.

There are other analyses, workshops, (OOSDP 1995; IOC, GOOS 1998; Unninayar & Schiffer, 1997) of data required to meet specific research objectives, but no other survey, so far as we know, of the commercial and small company requirements by hundreds or thousands of end users. Since many of the respondents to the ERS are value-added and service organisations, they represent a substantial multiple of users over the actual number of responses. The data base used for this analysis includes data previously published from the UK survey in 1993 (IACMST 1993), and the Spanish EuroGOOS Survey published in Spain (AINCO-Interocean & Parrilla 1997)

This report includes an analysis of potential sources of error and bias, an analysis of the respondents and the applications for which they require marine data products, followed by analysis of the Variables required, the characteristics of the data, and finally a correlation between Application and data type. We conclude with some recommendations, and a forward look for ways to extract further information from the data set if needed, and ways to improve future surveys.

## 1.2 Design of the ERS

During 1993-94 The UK IACMST conducted a survey of UK organisations requiring operational marine data. (IACMST 1993) . The survey methodology was subsequently adapted and used by the SeaNet group (1995) and ESA (ESA 1995). The ESA Survey used a subset of the questionnaire design to obtain data requirements from 70 respondents working in the coastal zone. The techniques of the survey had therefore been well tested and published by the time that EuroGOOS decided to undertake a wider survey on a European scale in 1995. Some terms were added to include industries and services in the Mediterranean area, and to increase the range of terms available to describe the coastal zone and hinterland.

The enquiry addressed to the respondent in this survey relates to the characteristics of the product received by the customer. This could be a single ship wanting a storm-free route, or a meteorological office wanting gigabytes of data to assimilate into a model.

The specifications of accuracy, resolution, etc. described in this report refer to the data product required by the customer, not the specification of the observing system which generates the raw data. This must always be borne in mind. In general, the raw data observations will be obtained with high instrumental accuracy on a coarser sampling grid than the output from models. A forecast for an end user will usually specify a Variable to a fairly coarse accuracy, for example 0.1 degree centigrade, but showing predicted values on a fine resolution grid and with short time intervals. The more sophisticated user who requires raw or processed data to run a predictive model will want high accuracy and will conduct their own analysis. There is therefore a great range of customers who require different types of product from the same Variable and for quite different applications. There is no attempt to discover or define the ideal or “average product”. The various tables in this report show that if the product has or exceeds a certain specification, then it will satisfy a certain proportion of the market.

This range of users and range of requirements are facts of the market. The range of responses described in this document is, so far as possible, a description of that market, and is not a range of error about an imaginary mean. The range or spread of requirements is a genuine and measurable characteristic of the market. The analysis is structured to show the range of requirements for each type of data Variable and product.

If the highest required accuracy and resolution can be obtained with present science and technology, there is no problem. If not, the tables show what proportion of the market, and which Applications, would be serviced by a given level of achievement.

## 1.3 Characteristics of the design, limits and compromises

Key characteristics of the survey design have been selected to try and eliminate bias, maximise the efficiency and simplicity for the respondent, and to facilitate coding of the replies and analysis of data. These factors will be explained before we consider analysis of results.

### 1.3.1 Fixed lists of terminology

The questionnaire includes fixed lists of terms which the respondent uses to define his/her own organisation, his/her applications and activities for which he/she requires data, and the data Variables required. There are 116 Application terms to choose from, and 136 Variables (disregarding "Data Structure" and "Hinterland" in the context of this analysis; see Annexe 2, Table 1 and Annexe 2, Table 2). The use of fixed lists means that terms and responses are strictly comparable between all respondents, between surveys in different countries, and between surveys conducted by other organisations using the same lists. It also makes the response easier and quicker for the respondent.

The lists are designed to be comprehensive and unbiased in the sense that there is no subject or sub-division of a subject which could not be fitted into either a narrow category or one of the broad generic categories. There is no assumption that any topic is more important than another, and no topics have been included or excluded because they are assumed to be important or negligible. The sub-division of terms does however include a bias, since there are more specific terms in those areas where experience indicates that there are many specialised activities and industries. The removal of this bias in the analysis would require difficult assumptions and judgements, since it could only be removed by aggregating terms into new groupings so that they all appeared to have the same level of importance. It seems best to handle the terms at the logical level where sub-division is related to the level of general activity.

The construction of the lists of terms was based on various catalogues and indexes already in use to give, so far as possible, a complete coverage of marine science and applications. Broad categories such as "Marine Biology" are included to provide a catch-all category for those respondents whose Application is not included at a more detailed level. The catch-all generic categories may be ticked by respondents who also tick more detailed terms, and thus they appear to be ranked high. We have considered ways of eliminating this artefact, but it would probably require further arbitrary judgements or guesses as to respondents' intentions. We have therefore not corrected for this factor.

### 1.3.2 Effect of price of data

There is no enquiry about the price that the respondent would be prepared to pay. Experience of such surveys and enquiries has shown that no respondent is prepared to make admission or commitment about prices payable in written responses. It is almost impossible to define the exact product in such a way that people can assess what they are being asked to pay for, and different classes of customers have quite different expectations of price. Research bodies expect data free, while commercial companies expect to pay, but wish to bargain down the price as low as possible. They are not prepared to give away their bargaining position in writing.

Respondents were warned in the covering notes that they should state requirements for accuracy and resolution which are reasonable, and that requests for unrealistic quality will inevitably mean that research will take many years before that accuracy can be achieved. Internal checks on the data, and comparison between quality expected, and the quality presently delivered by EuroGOOS agencies, shows that respondents have acted carefully in this respect. They have not requested absurd performance because of the lack of a price factor.

The UK Inter-Agency Committee on Marine Science and Technology (IACMST) has conducted small workshops and study groups with 5-10 participants from narrow industrial and commercial Sectors, and in these circumstances people are prepared to discuss prices, and the economic benefit which they would expect from the use of data. This is an alternative or complementary technique to the present survey, and each workshop of 1-2 days only provides information on the needs of one industrial Sector and even one activity, such as construction of sea-walls, or beach replenishment (WHOI 1993). Similar techniques were used by Hauk Powell (National Research Council 1989).

### 1.3.3 Complexity versus simplicity

However one defines the range of Variables to be measured in the sea and included in data products, a practical list is bound to include many tens of terms, possibly over 100, and even many hundreds if one were to include extensive lists of chemical elements, chemical compounds, or biological species. The requirement for wave data can be defined in one word, or as many different parameters of the wave energy directional spectrum through time. Thus any questionnaire has to make simplifying assumptions. In this survey the table of Variables also includes some observational methods such as XBT or CTD.

To be useful in the design of the ERS the disaggregation of terms must be sufficient to relate the responses to single observing instruments or computer models. This results in a list of 136 Variables, including some composite terms which bracket and include other terms. These can be used as headings to simplify the preliminary analysis in broad groups (see Annexe 2, Table 2).

Similarly, the classification of applications and the activities of organisations could be treated in a dozen or so broad Sectors, or many tens of more precise activities. The same solution has been adopted, with 116 Application Sectors grouped into 12 broad categories (Annexe 2, Table 1).

This permits the matching of narrow definitions of user applications to narrow requirement for data, which is the most efficient use of the survey data.

This level of sophistication and complexity presupposes a level of informed expertise in the respondent. The questionnaire is unlikely to be answered by a harbour master or a trawler skipper, who would probably regard it as too fancy and unrealistic. To obtain the data demand directly from such people would require a narrow one-to-one response, and it would be necessary to have thousands of replies to build up a clear case. Almost certainly, such a survey could only be conducted by interviews, as people would be unlikely to respond to written questions. This would be expensive and slow.

The respondents to the ERS are therefore the specialist agencies, commercial companies, value-added organisations, researchers, and the environmental experts from large commercial companies such as oil and gas or construction or shipping companies, who are going to process data for delivery to many tens or thousands of further customers or users. This fact is compatible with the observation that the statistics of the responses become stable within each country after only a few tens of respondents have replied. We can also deduce that the great majority of respondents who take the trouble to read and understand the questionnaire are responsible individuals, and are unlikely to provide frivolous answers.

### 1.3.4 Associated characteristics of the Variables and Variable data set

For each Variable the respondent was able to report the scale at which they wish to obtain and use the data (estuarine to global); the accuracy and precision (0.1% to 10%); the horizontal spatial resolution, vertical resolution, and temporal resolution; the type of data (raw observations to complete analysis and statistics), the forecast period, the medium of delivery, and the acceptable delay or latency of delivery. (See Questionnaire form, Annexe 2, Form A).

The correlation between application, Variable, and characteristics of the Variable data set are potentially important in the design of a service. The number of potentially identifiable correlations is almost infinite, and this report presents some major correlations and connections. Others could be extracted from the data base to answer specific questions.

In order to avoid excessive complexity and work in completing the questionnaire the respondents were invited to list all their applications as a Sector, and the Variables they require as aggregated groups where groups of Variables have the same characteristics in terms of accuracy, geographical scale, etc. If this were not the case the respondents would have had 10-20 times as much work to carry out. The effect of aggregating the Applications and Variables is that the analysis is unable to detect direct causal connection unless the respondent has listed only one Application Sector. This is in fact the case for 55 respondents, and this sample provides the opportunity for some more detailed analysis (see Chapter 4).

### 1.3.5 Data base system

An ACCESS data base was created and the software provided on disc to each EuroGOOS Member conducting the survey. The questionnaire forms were translated by Members where needed, and the technical terminology checked backwards and forwards between English and the translated language several times. In Greece, respondents where provided with the forms both in Greek and English. Each country was free to conduct their own national analysis, which also included the addresses and identifications of the respondents. By agreement, this information was not included in the multi-national analysis.

## 1.4 Critique of sources of error and ambiguity

### 1.4.1 Bias in the sample of respondents

Each EuroGOOS Member conducting the survey generated its own mailing list. The six countries which conducted the survey are Denmark, Greece, Italy, Netherlands, Spain, and UK. This gives a reasonable balance between northern shelf seas, the Atlantic, and the Mediterranean. It would have been preferable to have one more country further north, and a large central country such as France or Germany, but the regional spread is just adequate from the point of view of likely requirements. It is weak from the point of view of assessing total economic implications and scales of industries in the whole of Europe. This will have to be complemented in later economic studies.

Bias can be caused through the mailing list itself containing a high proportion of those organisations which have easily identifiable addresses, such as university departments and government agencies. Members were advised strongly to construct robust and broad-based mailing lists by using marine trade exhibition catalogues, industrial trade associations, and operational and service agencies, in addition to the obvious public service contacts. The list of Applications Sectors (Fig. 2.1 and Table 2.1) provides a guidance as to the type of organisations which should be on the mailing list.

A second bias could be introduced if the recipients of the questionnaire self-selected a biased subset who were motivated to reply. It is possible that those people who have the most theoretical and “paper-oriented” life, or who have the fewest short-term commercial pressures, are likely to reply. On the other hand, if the survey is well-designed, many people in the commercial and industrial Sectors might perceive that the survey offers them the only chance they are ever going to get to influence the future design of a marine observing and service system which could improve their profits. This could be strong motivation.

Of the 116 Applications which respondents could use to describe their activities they reported a total of 110 Applications (Table 2.1). Only 6 Applications are not represented by the respondents, and these are all grouped in the marine minerals section, such as Deep Ocean Manganese Nodule Mining, Desalination, Phosphate and Bromine extraction. The ranked list of Applications reported by all respondents is shown in Fig. 2.2. The combined list for all countries is very broadly representative, covering all industries, services and sectors. Disaggregated at the national level the spread is more uneven, but these differences often reflect real national differences.

The mix of research, governmental, and commercial respondents is excellent, with all types of Application appearing in the first 20 of the ranked table (Table 2.1). Ten of the top 20 Applications fall into the Research Applications Sector, and the others include Commercial Services, Transport (Port Operations), Construction and Building, Commercial Consultancy, and Environmental protection. While this does suggest a possible bias in the sample towards research organisations, it is probable that research bodies and individual researchers are amongst the most intensive users of marine environmental data.

The list can be checked for internal consistency to see if the differences between countries, or the placing of individual applications is logical or anomalous. For example, certain activities such as remote sensing research, shipping operations, data services, navigational safety and, climate research would probably occur more or less proportionately in each country, and this is the case. On the other hand port construction is shown to be important in all countries except the Netherlands, which is clearly a lack of response from an important Sector.

Certain contrasts are apparent. Denmark reports a high ranking level of port construction, port operations, and dredging. This is reasonable, even if the effect is exaggerated. Fisheries, fish farming, and shellfish farming all show Spain ranked the highest, which is correct. Tunnel construction shows Denmark high, which is correct. UK ranks highest for military vessel and submarine construction, military ASW oceanography, and for offshore oil and gas prospecting, which is probably correct. In spite of some obvious gaps, the comparative values suggest that the responses are representing the real pattern of applications.

The absolute ranking of different Applications is also instructive, though somewhat problematical. For example, offshore oil and gas is a huge industry in value, but the number of companies is very small. Oil and gas production therefore ranks low in numbers of respondents. As if to emphasis this effect, those activities provided by contractors to the oil and gas companies, offshore prospecting, pipelaying, construction of platforms, diving, submersibles and ROVs, rate higher. Many aspects of research rank high, and this is partly a reflection of the real emphasis on the use of data which is inherent in this activity, but also probably biased by the ease of identifying this Sector, and their tendency to reply. The commercial and engineering activities which rank high all ring true: met-ocean services, port operations, environmental services, consulting engineering, coastal defences, oil pollution control, etc.

Fisheries rank low amongst the respondents, as does marine tourism, and in both cases this is either a failure to identify the interested parties, or a failure to reply. Economic analysis confirms the obvious fact that both these industries are large. On the other hand, both these Sectors may have a low utilisation or up-take of data, or have a low awareness of the data potentially available.

Ocean Thermal Energy Conversion (OTEC), tidal energy, and wave energy all rank low, which is probably a reflection of the true state of affairs. Wind energy ranks higher, which is correct.

In summary, the total assemblage of Applications Sectors represented by the respondents very broadly covers all the activities which one could realistically expect to be carried out in Europe. The frequency of occurrence of different Applications reflects common-sense and reasonable trends as between countries, and between absolute ranking in total. Viewed in detail at the national level there are obvious gaps and deficiencies or exaggerations caused by the small numbers.

It is difficult to envisage what it would mean to produce a perfectly balanced survey sample, or to try and correct or weight the present sample. Should the response rate or number of respondents in an ideal sample be proportional to the number of practitioners, the economic value of their industry, the volume of data they would require, how much they would pay for the data, or the sensitivity of their activity to the use of the data? How should we weight those activities which have a large environmental conservation value? Clearly there is no ideal sample, and, in view of the previous discussion, it is therefore reasonable to accept the present sample as a practical and useful cross-section of the potential users of operational marine data.

### 1.4.2 Reliability of translation

In the UK, Denmark, and Netherlands the survey was run in English. In Spain, Greece, and Italy the questionnaire was translated. The translation was carried out by experts in oceanography and engineering, and texts were compared and discussed in detail with checks against the original English. It is unlikely that errors arose from this source. During the national collection of responses the co-ordinators discussed terminology with the EuroGOOS Office to check categories and coding.

### 1.4.3 Bias because of terms, choice of limits

Terms such as "Shelf seas", "Oceanic", "Coastal" require the respondent to make decisions which, at the boundary, may go either way. In the absence of extensive notes defining every term, the person who works at 1000m on the continental slope may classify their Application as either of two categories. Similarly, when choosing between "Data Consultancy" of "Data Services", people may make arbitrary choices. There is no evidence that these choices were influenced by anything other than random selection. There is therefore an inevitable fuzziness or "noise" added to the data, but this should not create systematic bias.

The tables of choice for levels of accuracy and preferred scales of resolution might be taken as building in a bias. The full range was intended to be so wide that all reasonable choices would fall within the range, and there would be no tendency to bunch the choices into one value. In general, the choices seem to have been used sensibly. Thus if a respondent requests data products with a resolution less than 1km, this is always associated with a scale of geographical interest at the estuarine or coastal. People requesting chemical data products opt for a 10% accuracy as acceptable, while some customers for temperature data require 0.1% accuracy. This is reasonable.

The categories of Forecast Period have the shortest period set at " up to 10 days" which fails to resolve the different products with very short forecast periods which are becoming increasingly important. However, the category of "Nowcast" for data product type should catch general interest in diagnostic or analysed descriptions of the present state.

### 1.4.4 Broad and narrow terms

Some terms in the list of Applications and Variables are inherently broader than others. This was deliberate in order to catch the activities which could not be fitted exactly into the narrow terms, since the list could not be infinitely long, and we wished to avoid a free text "other" category. This has the effect that the generic broad terms have, in some cases, attracted a lot of responses, which moves them up the ranking. Some of the respondents have ticked both generic and narrow terms in the same group, and thus it could be logical to delete their ticking of the generic term, thus reducing its ranking. Conversely, as an experiment, related narrow terms could be bundled together within the nearest generic term, to check on the effect on ranking. This type of check has not been carried out systematically, but in the subsequent analysis the data are studied both at the level of the major groups headings, and at the fully disaggregated level. This treatment has the advantage of identifying broad trends with large numbers, and then focussing on detailed correlations.

### 1.4.5 Mixing of terms and cross-contamination

As explained in section 1.3.4, respondents were allowed to bundle together both Application terms and required Variable terms onto single response forms. In some cases this created apparently absurd correlations. Thus, if a respondent entered upper ocean temperature profiles, nutrient data, and wind stress onto the same form, they might also indicate that they required the data with a vertical resolution of 10m. This is a useful characteristic of 2 of the data types, but not applicable to the third. This is the principle example of this type of error. Where this type of pseudo-correlation occurs, the ranking has been deleted from the tables published in this report.

### 1.4.6 Internal consistency of choice of Variables

A further check on the reasonableness of the responses is to note that certain Variables are chosen preferentially in certain geographical regions or by certain industries. Thus Denmark, UK and Netherlands show an interest in aspects of sea ice, while the Mediterranean countries show almost none. The Mediterranean respondents show a high relative interest in precipitation and thermal properties of the upper ocean. Spain shows a high interest in estuaries and the properties of estuarine water bodies relevant to fish and shellfish farming. These correlations are just what one would expect, and confirm the consistency and general reliability of the respondents. The only repeated inconsistency in the survey results is the cross-contamination factor for vertical resolution mentioned in section (1.4.5). This can be eliminated. Many trends and correlations are identical as between countries, although the surveys were carried out by different co-ordinators, in different languages, and with totally independent populations of respondents.

## 1.5 Summary of survey design and reliability

The survey is complex, and multi-dimensional. Attempts to find one-to-one correlations will therefore tend to produce a spread of results caused by the variation of other factors. Users of the survey should therefore apply common-sense and caution when making judgements about priorities. The evidence regarding the design of the survey, the reliability of the respondents, and the internal consistency of the replies, indicates that the data base compiled from the responses is overwhelmingly correct, and represents a realistic picture of the relative demand for operational oceanographic data in Europe. The replies have been prepared conscientiously by the respondents, based on a good knowledge of their requirements. The sample of respondents covers all the prevalent activities and applications in Europe, with the exception only of deep sea mineral mining and extraction of minerals from seawater.

# 2 Respondents to the EuroGOOS Data Requirements Survey (ERS)

The EuroGOOS Requirement Survey (ERS) was completed in 1998. 155 companies and agencies from Denmark (31), United Kingdom (41), Greece (10), Italy (20), The Netherlands (20), and Spain (33) responded to the very comprehensive questionnaires (Fig.2.1; see Annexe 2 for full text of questionnaires). The return rate of distributed questionnaires was 20% in the UK, 21% in The Netherlands, 18% in Spain, 14% in Greece, and 30% in Denmark. Italy was in a similar range.

This Chapter analyses the population of respondents and their Applications for which they need oceanographic data.

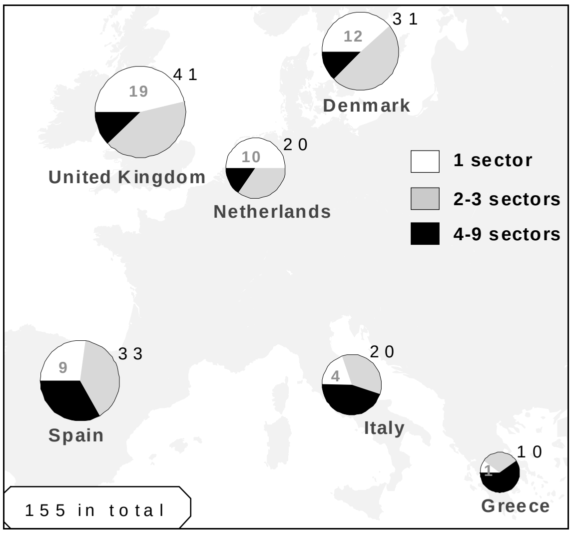


**Figure 2.1.** *Number of ERS respondents and degree of specialisation by countries. White: 1 Sector of Application; grey: 2-3 Sectors of Application.; black: 4-9 Sectors of Application. Number of respondents with one single Sector is given by the small number within the circles, total respondents of each country by the larger number besides the circles.*

## 2.1 Analysis of respondents by Sector of Application

Activities of respondents are arranged in 12 Sectors of Applications (Fig.2.2). Each respondent could identify as many Applications relevant to their activities as they wished.

Fig.2.2 lists the number of respondents for the different Sectors of Application (each Sector counting only once per respondent, no matter how many Applications within a Sector are selected).

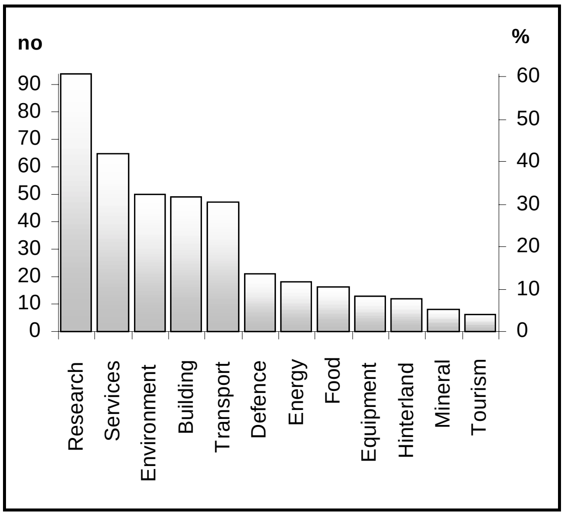


**Figure 2.2.** *Frequency of selection of Sectors of Applications in the ERS by number (no) and percentage (%) of all respondents. Numbers surpass 155 and percentages exceed 100 due to selection of more than one Sector by most respondents).*

More than 35% of the respondents identify only one of the Sectors as relevant for them, about 22% include two, another 18% three, and 25% of the respondents indicate that more than three and up to nine different Sectors of Applications are relevant to their activities. ERS respondents from north European countries tend to be more specialised (averaging 2 Sectors) then those from south European countries (averaging 3 to 4 different Sectors) (Fig.2.1).

The Sectors with the most respondents are Research (about 60% of respondents), Services (42%), Environment, Building, and Transport (all about 1 third) (Fig.2.2). Not many respondents are active in the areas of Tourism, Mineral Exploitation, Hinterland, Food, Energy, Defence, and Equipment (all less than 15%).

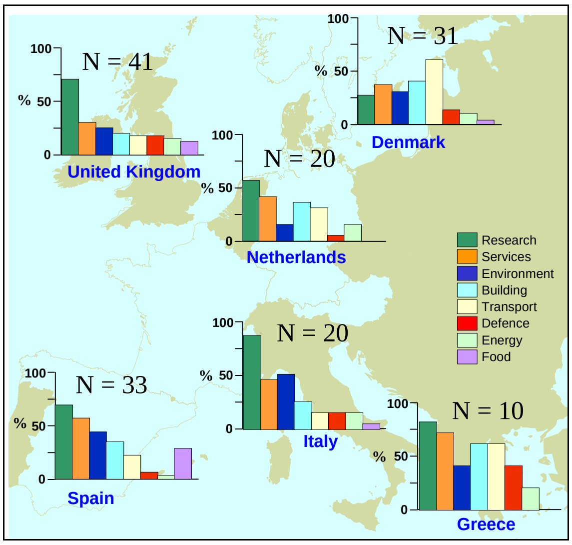


**Figure 2.3.** *Distribution of broad Sectors of Application selected by ERS respondents (100% = number of respondents within each* country)

Respondents from different countries tend to have slightly differing focus areas (Fig.2.3, Table 2.1). In Greece, relative numerical importance of Sectors of Application was generally high as most of the 10 respondents identified more than 3 Sectors as part of their activities. Danish respondents, for example, are mostly dealing with Transport (especially Port operations, see Table 2.1) and only relatively little with Research. Environment plays a more common role among respondents from south Europe (40-50%) than among those from north Europe (15-30%). Another striking feature is the relatively low number of respondents from the "Food" Sector in almost every country except Spain (27%). In section 1.4.1, these differences are discussed more thoroughly with the conclusion that the frequency of occurrence of different Application Sectors reflects reasonable trends as between countries, and between absolute ranking in total, with a few anomalies caused by biased sampling.

## 2.2 Analysis of respondents by narrower Application

ERS respondents can be further described by the frequency of individual Applications (Table 2.1.). In some cases, respondents do not specify their activities but prefer to refer only to a Sector of Application. In Table 2.1, those generic answers are displayed under the column "Application" and set off in bold lettering. For the purpose of this analyses, they are treated exactly like the other, specific Application answers.

Almost all Applications listed in the questionnaire are selected by at least one respondent. The only 6 exceptions are Applications shown under "Mineral Extraction" including "Deep ocean, Mn, hydrothermal muds, crusts", "Placer minerals, diamonds, tin, etc.", "Salts extraction, magnesia, bromine", "Desalination", "Phosphate", and "Coal, subsea" that are not among the activities of any respondent. In the ERS, Mineral Extraction, if specified, is restricted to "Aggregate, sand, gravel".

Research institutions have quite evenly distributed activities and often a broad focus reflected by a preference for general terms, such as "Oceanography", "Environmental sciences", "Data centre", "Basic and strategic research", "Climate change", and "Marine biology". The least mentioned activity among research institutions is "Shipping/naval architecture".

Applications within the "Service" Sector tend to be somewhat more defined than within "Research". Almost one fifth of all respondents are active in "Metocean survey, mapping, hydrographic surveys". However, more generic answers like "Project management, non-defence, consultancy", "Data consultancy", and "Data services" are found among the top four Applications within this Sector. "Weather fore-casting" and "Remote sensing" rank at 5 and 6.

Within the Sector "Environment" there are again some general descriptors like "Environmental quality control", "Environmental data services", "Environmental protection/preservation", and "Environmental forecasts" that figure among the top five Applications. Applications referring to Pollution control (oil, estuarine, non-oil) rank between 4 and 7 whereas "Flood protection" ranges fairly low on rank 9 within this Sector.

## Table 2.1. Frequency of Applications

| Sector | Application | % GB | % NL | % DK | % E | % I | % GR | % Total |
|---|---|---|---|---|---|---|---|---|
| Research | Oceanography | 32 | 15 | 13 | 52 | 25 | 30 | **29** |
| | Environmental sciences | 22 | 15 | 10 | 30 | 15 | 10 | **19** |
| | Coastal modelling | 17 | 5 | 6 | 27 | 25 | 20 | **17** |
| | Ocean modelling | 15 | 10 | 16 | 27 | 20 | 0 | **17** |
| | Remote sensing | 20 | 15 | 6 | 12 | 20 | 30 | **15** |
| | Data centre | 12 | 25 | 3 | 21 | 5 | 20 | **14** |
| | Shelf seas modelling | 20 | 10 | 6 | 18 | 10 | 10 | **14** |
| | **Basic and strategic research** | 12 | 20 | 3 | 24 | 10 | 0 | **13** |
| | Climate change | 17 | 5 | 6 | 15 | 20 | 10 | **13** |
| | Marine biology | 17 | 0 | 6 | 33 | 0 | 0 | **13** |
| | Estuarine modelling | 17 | 0 | 10 | 18 | 5 | 0 | **11** |
| | Acoustics, electronics | 7 | 10 | 3 | 9 | 20 | 30 | **10** |
| | marine weather forecasting | 2 | 15 | 10 | 12 | 10 | 10 | **9** |
| | Polar research | 12 | 0 | 6 | 9 | 20 | 0 | **9** |
| | Fisheries | 10 | 0 | 6 | 15 | 0 | 0 | **7** |
| | Climate forecasting | 7 | 5 | 6 | 12 | 0 | 10 | **7** |
| | Civil engineering | 5 | 0 | 0 | 12 | 5 | 20 | **6** |
| | shipping/naval architecture | 2 | 5 | 0 | 3 | 10 | 10 | **4** |
| Services | Metocean survey, mapping, hydrographic surveys | 15 | 20 | 26 | 18 | 20 | 20 | **19** |
| | Project management, non-defence, consultancy | 12 | 15 | 10 | 15 | 5 | 20 | **12** |
| | Data consultancy | 10 | 25 | 3 | 12 | 10 | 10 | **11** |
| | Data services | 10 | 20 | 3 | 15 | 10 | 10 | **11** |
| | Weather forecasting | 10 | 15 | 3 | 12 | 5 | 30 | **10** |
| | Remote sensing | 0 | 15 | 3 | 9 | 25 | 30 | **10** |
| | Data transmission, telecommunications | 5 | 15 | 0 | 12 | 5 | 30 | **8** |
| | Inspection, maintenance, repair | 2 | 5 | 10 | 12 | 10 | 0 | **7** |
| | Climate forecasting | 2 | 10 | 3 | 15 | 0 | 10 | **6** |
| | Ship routing | 5 | 10 | 3 | 3 | 0 | 30 | **6** |
| | Diving, including suppliers | 0 | 0 | 3 | 18 | 5 | 0 | **5** |
| | **Services** | 2 | 5 | 0 | 15 | 5 | 0 | **5** |
| | Salvage, towing | 2 | 5 | 6 | 6 | 0 | 0 | **4** |
| | Certification | 2 | 5 | 0 | 3 | 0 | 10 | **3** |
| | Insurance | 2 | 0 | 3 | 3 | 0 | 10 | **3** |
| Environment | Environmental quality control | 10 | 5 | 13 | 27 | 30 | 30 | **17** |
| | Environmental data services | 10 | 10 | 3 | 21 | 15 | 30 | **13** |
| | **Environmental protection/preservation** | 7 | 5 | 6 | 24 | 20 | 0 | **12** |
| | Oil pollution control | 17 | 5 | 10 | 15 | 10 | 0 | **12** |
| | Environmental forecasts | 15 | 0 | 3 | 18 | 15 | 0 | **10** |
| | Estuarine pollution | 15 | 0 | 0 | 18 | 15 | 10 | **10** |
| | Non-oil pollution control | 15 | 0 | 0 | 15 | 10 | 10 | **9** |
| | Species protection | 10 | 0 | 3 | 15 | 5 | 10 | **8** |
| | Flood protection | 10 | 0 | 6 | 3 | 10 | 0 | **6** |
| | Marine reserves | 10 | 0 | 3 | 6 | 5 | 10 | **6** |
| | Safe waste disposal | 10 | 0 | 3 | 6 | 0 | 10 | **5** |
| | Clean beaches | 7 | 0 | 0 | 12 | 0 | 0 | **5** |
| | Health hazards | 5 | 0 | 0 | 12 | 0 | 0 | **4** |
| | Amenity evaluation | 7 | 0 | 0 | 0 | 0 | 0 | **2** |
| Building | Port construction | 5 | 0 | 29 | 18 | 5 | 20 | **13** |
| | Consulting engineering | 10 | 10 | 16 | 18 | 5 | 10 | **12** |
| | Coastal defences | 10 | 0 | 13 | 12 | 15 | 30 | **12** |
| | Dredging | 5 | 5 | 19 | 9 | 0 | 20 | **9** |
| | Land reclamation | 2 | 5 | 13 | 15 | 0 | 10 | **8** |
| | Barrage construction | 2 | 0 | 6 | 18 | 10 | 0 | **7** |
| | Offshore construction, platforms, etc. | 5 | 5 | 6 | 3 | 10 | 20 | **6** |
| | **Building, construction, and engineering** | 0 | 10 | 6 | 12 | 0 | 10 | **6** |
| | Pipelining, trenching, burial | 2 | 10 | 3 | 9 | 0 | 20 | **6** |
| | Cables, manufacture and operations, laying | 2 | 10 | 3 | 6 | 5 | 10 | **5** |
| | Tunnel construction | 2 | 5 | 13 | 0 | 0 | 10 | **5** |
| | Corrosion prevention, paint, antifouling, etc | 0 | 0 | 6 | 0 | 10 | 20 | **4** |
| | Marine propulsion, efficient ship, automatic ships, DP, props | 0 | 10 | 0 | 0 | 10 | 10 | **3** |
| | Outfalls/intakes | 2 | 5 | 6 | 3 | 0 | 0 | **3** |
| | Heavy lifting, cranes, winches | 0 | 5 | 6 | 3 | 0 | 0 | **3** |
| | Ship-building, non-defence, all kinds | 0 | 5 | 0 | 0 | 0 | 10 | **1** |
| | Components, hydraulics, motors, pumps, batteries, etc. | 0 | 0 | 0 | 0 | 5 | 0 | **1** |

***Table 2.1*** *continues next page*

| Sector | Application | % GB | % NL | % DK | % E | % I | % GR | % Total |
|---|---|---|---|---|---|---|---|---|
| **Transport** | Port operations | 7 | 5 | 29 | 12 | 5 | 30 | **14** |
| | Shipping operations | 2 | 20 | 16 | 12 | 10 | 10 | **11** |
| | Navigational safety, lights etc. Electronic charts | 2 | 15 | 10 | 12 | 5 | 30 | **10** |
| | Safety services, rescue, life preserving, fire | 5 | 10 | 16 | 9 | 0 | 0 | **8** |
| | Submersible/submarine operations/ROVs | 7 | 0 | 0 | 6 | 10 | 20 | **6** |
| | Bridges, sea channels | 2 | 5 | 6 | 6 | 0 | 10 | **5** |
| | **Transport** | 2 | 5 | 3 | 12 | 0 | 0 | **5** |
| | Barrage roads | 0 | 0 | 0 | 9 | 0 | 10 | **3** |
| | Tunnel subsea operations | 0 | 0 | 3 | 9 | 0 | 0 | **3** |
| | Causeway | 0 | 0 | 3 | 6 | 0 | 0 | **2** |
| | Hovercraft operations | 0 | 0 | 3 | 3 | 5 | 0 | **2** |
| | Hydrofoil operations | 0 | 5 | 0 | 3 | 5 | 0 | **2** |
| **Defence** | ASW, oceanographic applications | 15 | 5 | 0 | 3 | 10 | 30 | **8** |
| | Military vessels, surface and submarine | 12 | 5 | 3 | 3 | 10 | 10 | **7** |
| | Navigation, position fixing, etc. | 2 | 5 | 3 | 3 | 15 | 30 | **6** |
| | **Defence** | 5 | 5 | 6 | 6 | 5 | 10 | **6** |
| | Operations and efficiency, logistics, controls, computing | 2 | 5 | 3 | 3 | 5 | 30 | **5** |
| | Defence sales, equipment, components | 2 | 5 | 0 | 3 | 5 | 10 | **3** |
| | Underwater weapons | 2 | 5 | 0 | 3 | 5 | 10 | **3** |
| **Energy** | Oil and gas exploration and prospecting, and drilling | 10 | 10 | 3 | 3 | 5 | 10 | **6** |
| | Wind energy, offshore installation | 2 | 0 | 10 | 0 | 5 | 10 | **4** |
| | Oil and gas production (Oil companies only) | 5 | 10 | 0 | 0 | 0 | 10 | **3** |
| | Wave energy | 5 | 0 | 0 | 0 | 5 | 0 | **2** |
| | **Energy production** | 2 | 0 | 0 | 0 | 0 | 0 | **1** |
| | OTEC | 2 | 0 | 0 | 0 | 0 | 0 | **1** |
| | Tidal energy | 2 | 0 | 0 | 0 | 0 | 0 | **1** |
| **Food** | Fish farming | 5 | 0 | 3 | 27 | 5 | 0 | **8** |
| | Fisheries, catching | 7 | 0 | 3 | 3 | 0 | 0 | **3** |
| | **Food from the sea** | 5 | 0 | 0 | 6 | 0 | 0 | **3** |
| | Shellfish, crustacea, farming | 2 | 0 | 0 | 9 | 0 | 0 | **3** |
| | Shellfisheries | 5 | 0 | 0 | 6 | 0 | 0 | **3** |
| | Fishing gear | 2 | 0 | 3 | 3 | 0 | 0 | **2** |
| **Equipment** | Marine electronics, instruments, radar, opto-electronics, | 0 | 0 | 0 | 6 | 20 | 30 | **6** |
| | Buoys | 0 | 0 | 0 | 12 | 5 | 30 | **5** |
| | Sonar | 0 | 0 | 0 | 3 | 5 | 20 | **3** |
| | **Equipment sales** | 0 | 0 | 0 | 3 | 0 | 0 | **1** |
| **Hinterland** | Land use planning or zoning | 0 | 0 | 3 | 18 | 10 | 10 | **6** |
| | Urban management | 0 | 0 | 0 | 15 | 0 | 0 | **3** |
| | Local government | 0 | 0 | 0 | 6 | 5 | 0 | **2** |
| | Agriculture | 0 | 0 | 3 | 3 | 0 | 0 | **1** |
| | Wetlands management | 0 | 0 | 0 | 6 | 0 | 0 | **1** |
| | **Hinterland** | 0 | 0 | 0 | 3 | 0 | 0 | **1** |
| | Public health | 0 | 0 | 0 | 3 | 0 | 0 | **1** |
| **Mineral** | Aggregate, sand, gravel | 5 | 5 | 3 | 6 | 5 | 0 | **5** |
| | **Mineral extraction** | 0 | 5 | 0 | 3 | 0 | 0 | **1** |
| **Tourism** | **Tourism and recreation** | 0 | 0 | 10 | 6 | 5 | 0 | **4** |

**Table 2.1.** *Relative frequency of Applications ranked by totals within each Sector. 100% = total number of respondents in that country. Due to multiple selections of Applications by each respondent sums can exceed 100. Applications set off in bold letters represent non-specified, generic answers.*

Another frequent Sector of Applications among ERS respondents is "Building". Here, coastal activities like "Port construction", "Coastal defences", "Dredging", "Land reclamation", and "Barrage construction" are all found among the top of the list, complemented by "Consulting engineering" on rank 2. Offshore activities, on the other hand, are not so prominent.

The Sector "Transport" is mainly represented by "Port operations", "Shipping operations", and "Navigational safety, lights etc., electronic charts"

"Defence" applications are relatively evenly distributed with "ASW, oceanographic applications" topping the list and "Underwater weapons" at the low end.

More than half of those respondents dealing with "Energy" are busy with Oil and gas related activities and about one third with regenerative energies (Wind, Wave, Tidal energy).

Respondents from the "Food" Sector mainly engage in Aquaculture activities. Only about one third are involved in catch fisheries (including shellfish).

"Equipment", "Hinterland", "Mineral" and "Tourism" are all Sectors that never stand alone as the sole activity of ERS respondents but are always accompanied by another Sector. Within the "Equipment" Sector, respondents mainly concentrate their activities on the making of marine instruments and buoys but rarely with sales. "Hinterland" activities are often represented by "Land use planning or zoning" and in only 1 case by "public health". As mentioned above, the "Mineral" Sector is solely represented by "aggregate, sand, gravel". The "Tourism" Sector, finally is not subdivided in the questionnaire.

# Data Requirements of ERS respondents 3

## 3.1 Variables overview

We omitted the Variable Groups "Data Structure" and "Hinterland" from the present analysis: the first because it only includes product characteristics, and the second because it consists of terrestrial Variables. This leaves us with 12 Variable Groups and 136 single Variables (Table 3.1 and Annexe 2).

Every Variable listed in the questionnaire turns out to be relevant to at least 4 respondents and 5 Variables are requested by more than half of all respondents. 21 out of the 40 most frequently requested Variables (Table 3.2) are connected to the sea surface ("Surface Fields", "Sea Surface Topography" or "Upper Layer Fields"). Of these, Current velocity and Current direction top the list (each requested by about 60% of respondents), followed by other Surface Variables, such as several Wave characteristics, Sea surface temperature and Sea surface salinity, Wind stress, Oceanic tides, Sea level, etc. Seven of the top 40 Variables are related to "Coastal and Shelf", e.g. Bathymetric measurements and Sediment transport.

| Variable Group | Variables |
|---|---|
| **Surface Fields** | **C**urrent Velocity; **C**urrent Direction; **W**ave Hs; **W**ave Period; **T**emperature; **W**ave direction spectrum; **W**ind stress; **W**ave spectrum; **W**ave swell; **S**alinity; **P**recipitation; **H**eat flux; **M**oisture flux; **C**$O_2$; **G**HGs |
| **Sea Surface Topography** | **H**ourly mean sea level; **O**ceanic tides; **G**eostrophic currents; **M**eteorological forcing; **M**onthly mean sea level; **S**ea level anomaly; **M**arine geoid |
| **Upper Layer Fields** | **S**urface currents; **S**alinity; **E**ddies; jets; fronts; **V**elocity fields; **U**pwelling velocities; **X**CTD sections; **X**BT sections; **D**ownwelling velocities; **F**resh water transport; **F**resh water; **S**alt transport; **F**resh water flux; **H**eat content; **M**omentum fields; **S**alt flux; **C**arbon transport; **B**uoyancy flux; **H**eat flux; **H**eat transport; **C**arbon budgets; **C**arbon inventory; **T**ropical upper ocean structure |
| **Sea Ice** | **A**lbedo; **E**xtent, boundary, leads, %; **C**oncentration; **A**ir, sea, ice, temperatures; **I**ce motion; **T**hickness; **S**urface ice state; **S**urface ice roughness; Temperature; ; **S**now on ice; **W**ater on ice |
| **Ice Shelves** | **E**xtent, **B**oundary; **S**urface ice velocity; **B**ottom topography; **S**ub-shelf ocean circulation; **S**urface temperature; **A**lbedo; **M**ass balance; **S**now line; **S**urface state; **T**opography; **R**oughness |
| **Icebergs** | **D**istribution; **N**umbers; **T**rajectories; **A**rea, volume |
| **Deep Ocean** | **C**TD sections; **S**alinity; **I**nter-basin straits currents; **O**cean boundary currents; **O**cean tracers; **H**t storage; **C**arbon storage; **W**ater storage |
| **Sea Bed** | **B**athymetry; **S**urface sediments; **G**ridded bathymetry; **S**urface outcrops; **M**agnetics; **G**ravity; **H**eat flow |
| **Coastal & Shelf** | **C**oastal bathymetry; **C**oastline map; **S**ediment transport; **S**helf bathymetry; **T**idal constants; **R**iver runoff; **S**tratification; **H**interland topography; **L**and non-river runoff; **T**idal ellipses; **W**etlands characteristics |
| **Biogeo-chemical** | **P**hytoplankton; **S**uspended sediments; **C**hlorophyll; **N**itrate; **O**xygen; **P**hosphate; **Z**ooplankton; **S**ilicate; **T**race metals; **B**iological pigments; **P**etroleum hydrocarbons; **A**quatic toxins; **A**rtificial radionuclides; **P**AHs; **P**esticides & Herbicides; **C**arbon dioxide; **I**ron; **H**uman health risks; **P**athogens; **S**ynthetic organics; **T**ritium; **P**harmaceutical wastes |
| **Optics** | **T**ransmissivity**;** **D**epth of photic zone; **S**ecchi disk depth; **B**ioluminescence; **P**hosphorescence; **I**ncident light spectrum; **R**S reflected light spectrum |
| **Acoustics** | **S**ound velocity profiles; **A**coustic scattering; **A**mbient noise spectrum; **S**eabed acoustic prop's; **A**coustic tomography; **A**coustic models (shelf); **S**ound ray paths; **R**everberation characteristics; **A**nthropogenic noise; **A**coustic models (oceanic); **A**coustic thermometry |

**Table 3.1.** *Variable Groups and Variables included in ERS questionnaire. Variables within each Group listed in order of frequency of request by respondents*

"Biogeochemical" Variables are not found on the highest ranks but Phytoplankton and Chlorophyll, nutrients like Nitrate and Phosphate, as well as Oxygen and Suspended sediments are each requested by about one fifth of respondents. Finally, CTD sections are a frequent "Deep Ocean" Variable ranking at 34, and from the "Acoustics" Group Sound velocity profiles are in relatively high demand (rank 37).

The two least requested Variables are from the Optics group: Incident light spectrum and RS reflected light spectrum. Phosphorescence (3%), Bioluminescence (5%), and Secchi disk depth (6%) are other rarely requested Variables of this Group. For only 4% of the respondents Pharmaceutical wastes are of some importance and other Variables from the "Biogeochemical" group indicating pollution, like Human health

| Common Variables | Group | No | Rare Variables | Group | No |
|---|---|---|---|---|---|
| Current Velocity | Surface Fields | **94** | Salt flux | Upper Layer Fields | **12** |
| Current Direction | Surface Fields | **93** | Human health risks | Biogeochemical | **12** |
| Waves Hs | Surface Fields | **85** | Pathogens | Biogeochemical | **12** |
| Wave Period | Surface Fields | **81** | Synthetic organics | Biogeochemical | **12** |
| Sea surface temperature | Surface Fields | **79** | Anthropogenic noise | Acoustics | **11** |
| Wave direction spectrum | Surface Fields | **75** | Temperature | Sea Ice | **11** |
| Sea surface Wind stress | Surface Fields | **71** | Carbon transport | Upper Layer Fields | **11** |
| Wave spectrum | Surface Fields | **68** | Sea surface GHGs | Surface Fields | **11** |
| Wave swell | Surface Fields | **67** | Area, volume | Icebergs | **10** |
| Coastal bathymetry | Coastal & Shelf | **60** | Secchi disk depth | Optics | **10** |
| Sea surface salinity | Surface Fields | **60** | Extent, boundary | Ice Shelves | **10** |
| Coastline map | Coastal & Shelf | **58** | Buoyancy flux | Upper Layer Fields | **10** |
| Bathymetry | Sea Bed | **56** | Upper ocean heat flux | Upper Layer Fields | **10** |
| Surface currents | Upper Layer Fields | **55** | Upper ocean heat transport | Upper Layer Fields | **10** |
| Hourly mean sea level | Sea Surface topography | **48** | Deep ocean ht storage | Deep Ocean | **9** |
| Sediment transport | Coastal & Shelf | **44** | Acoustic models (oceanic) | Acoustics | **9** |
| Shelf bathymetry | Coastal & Shelf | **41** | Snow on ice | Sea Ice | **9** |
| Surface sediments | Sea Bed | **39** | Water on ice | Sea Ice | **9** |
| Oceanic tides | Sea Surface topography | **38** | Heat flow | Sea Bed | **9** |
| Geostrophic currents | Sea Surface topography | **35** | Tritium | Biogeochemical | **9** |
| Tidal constants | Coastal & Shelf | **35** | Bioluminescence | Optics | **8** |
| Upper ocean salinity | Upper Layer Fields | **35** | Surface ice velocity | Ice Shelves | **8** |
| Precipitation | Surface Fields | **35** | Deep ocean carbon storage | Deep Ocean | **8** |
| Meteorological forcing | Sea Surface topography | **34** | Deep ocean water storage | Deep Ocean | **8** |
| Monthly mean sea level | Sea Surface topography | **34** | Carbon budgets | Upper Layer Fields | **8** |
| River runoff | Coastal & Shelf | **34** | Carbon inventory | Upper Layer Fields | **8** |
| Phytoplankton | Biogeochemical | **34** | Tropical upper ocean, structure | Upper Layer Fields | **8** |
| Suspended sediments | Biogeochemical | **34** | Bottom topography | Ice Shelves | **7** |
| Sea level anomaly | Sea Surface topography | **33** | Sub-shelf ocean circulation | Ice Shelves | **7** |
| Chlorophyll | Biogeochemical | **33** | Surface temperature | Ice Shelves | **7** |
| Gridded bathymetry | Sea Bed | **32** | Acoustic thermometry | Acoustics | **7** |
| Nitrate | Biogeochemical | **31** | Mass balance | Ice Shelves | **6** |
| Oxygen | Biogeochemical | **31** | Snow line | Ice Shelves | **6** |
| CTD sections | Deep Ocean | **30** | Surface state | Ice Shelves | **6** |
| Stratification | Coastal & Shelf | **30** | Topography | Ice Shelves | **6** |
| Eddies, jets, fronts | Upper Layer Fields | **30** | Pharmaceutical wastes | Biogeochemical | **6** |
| Sound velocity profiles | Acoustics | **29** | Phosphorescence | Optics | **5** |
| Velocity fields | Upper Layer Fields | **29** | Roughness | Ice Shelves | **5** |
| Phosphate | Biogeochemical | **29** | Incident light spectrum | Optics | **4** |
| Surface outcrops | Sea Bed | **26** | RS reflected light spectrum | Optics | **4** |

**Table 3.2.** *The 40 most (left column) and least (right column) frequently chosen variables (ranked). No = number of respondents requesting variable (see complete Table in Annexe 5, Table 1).*

risks, Pathogens, and Synthetic organics, only rank slightly higher (8%). For obvious reasons, Ice-related Variables are in very low demand in south Europe (Fig.3.2) and thus do not appear among the top forty. Almost half of the 20 rarest Variables relate to sea ice, especially ice shelves (e.g. Roughness, Topography, Surface state, Snow line etc.). Important Variables in climate research, such as Deep ocean storage of carbon, water, and heat, Upper layer carbon budget and Carbon and Heat transport as well as Buoyancy and Salt flux are of little value to most of ERS respondents and have been selected by less than 10%.

The average number of Variables chosen by respondents is twenty. British respondents are above average with 26 Variables each and Danish respondents usually chose only 14 (Fig.3.1).

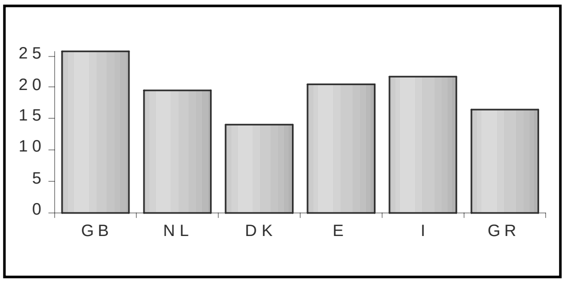


**Figure 3.1.** *Average number of variables chosen by respondents of the different countries*

No striking differences are observed among countries regarding the frequency with which different Variable Groups[1] are selected (ignoring multiple Variable selection within each Group) (Fig.3.2). In every country, more than 85% of respondents request surface-related data (from "Surface Fields", "Sea Surface Topography" and "Upper layer Fields". About half of respondents of most countries are interested in Variables from the "Coastal and Shelf" and from the "Sea Bed" Groups, with the unexpected exception of The Netherlands, where in spite of the strong coastal research tradition only a quarter of respondents show interest for any one of these Variable Groups. The "Biogeochemical" Group is usually selected by more than a third of respondents in any country except Denmark where less than a quarter show interest for "Biogeochemical" Variables. Not surprisingly, information on "Ice" is in relatively high demand only in northern countries, especially United Kingdom and Denmark.

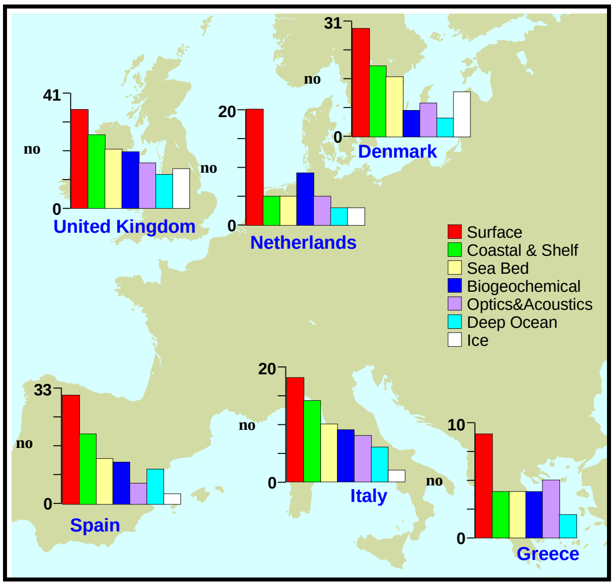


**Figure 3.2**. *Number of respondents requesting one or more Variables from the Variable Groups listed. Note different scales based on number of respondents per country.*

## 3.2 Product Grading

Each Variable chosen by a respondent was graded by them for preferred product type, geographic coverage, accuracy spatial, vertical and temporal resolution forecast period and delivery medium (see Annexe 2 for details of questionnaire). Precision and latency of delivery were omitted in this analysis. Respondents could either tick the values which they considered to be useful (equivalent to a grading of 3 = useful product), or grade the options on a scale of 1 (marginal usefulness) to 5 (high usefulness). In the following analysis, only gradings of 3 and higher were taken into account (without differentiating among them). The analyses are based on percentage distribution of answers for each Variable.

[1] *For this comparison based on Fig.3.2, several Variable Groups were aggregated to form "super" Groups, such as "Surface Fields, "Sea Surface Topography" and "Upper Layer Fields" to "Surface"; also "Sea Ice", "Ice Shelves", and "Icebergs" to "Ice"; and "Optics" and "Acoustics" to "Optics & Acoustics"*

### 3.2.1 Product Type

For any Variable never less than 18% of respondents selecting that Variable voted for processed data (Fig.3.3). On average, 28% of all classifications refer to processed data. In contrast, an average of 20% of all classifications refer to raw data. For only one Variable, Incident light spectrum, a majority (51%) of respondents selecting that Variable voted for raw data. Statistics are important to at least 5% (19% on average) for any Variable. On average, forecast products (11%) are slightly less requested than hindcast products (14%).

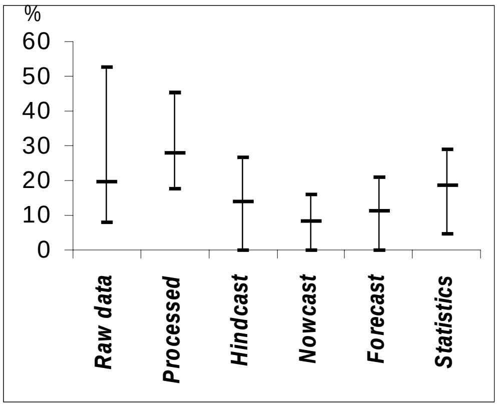


**Figure 3.3.** *Maximum, average and minimum frequency of product types by variable chosen by ERS respondents (% of all entries, all variables). The range bars show the highest and lowest votes (in %) for single Variables.*

### 3.2.2 Geographic Coverage

Respondents could chose between 6 geographic coverage areas for each Variable picked. As Fig.3.4 shows, near coast areas are chosen more frequently than larger oceanic to global scales. Shelf and Coastal Sea coverage is selected most (24% and 25% respectively): for any Variable never less than 15% of respondents selecting that Variable prefer Shelf Sea coverage and at least 8% prefer Coastal Sea coverage (see minima in Fig.3.4). On the other hand, for some Variables hemispheric and global coverage is not needed at all.

For almost all Variables from the "Deep Ocean" Group a large oceanic scale is selected relatively frequently (7 out of 8) (Fig.3.10). This also applies to most Variables connected to "Sea Ice", "Ice Shelves" or "Icebergs" (17 out of 25). In contrast to these results, a coastal or estuarine scale is mostly chosen for most Variables from the "Biogeochemical" Group (18 out of 22), with the remainder not surprisingly being mainly contained in the "Coastal & Shelf" Variable Group (6 out of 11).

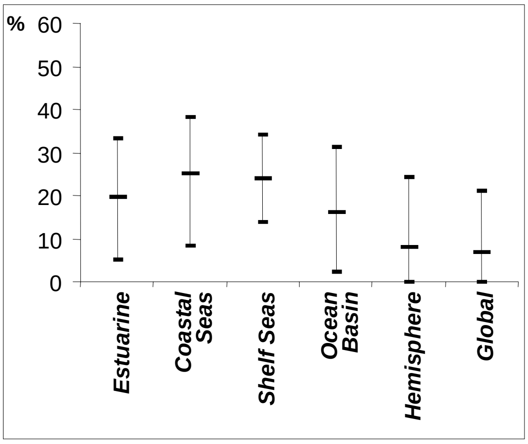


**Figure 3.4.** *Maximum, average and minimum frequency of geographic categories by variable chosen by ERS respondents (% of all entries, all variables). The range bars show the highest and lowest votes (in %) for single Variables.*

### 3.2.3 Variable Accuracy

On average, 40% of respondents tick the 1% accuracy level (Fig.3.5). Moreover, for any given Variable, never less than one fifth of respondents selecting that Variable choose a 1% accuracy level. A very low accuracy level of 20% or 30% is selected much less frequently (below 10% for each Variable on average) and is found to be non-acceptable for many Variables.

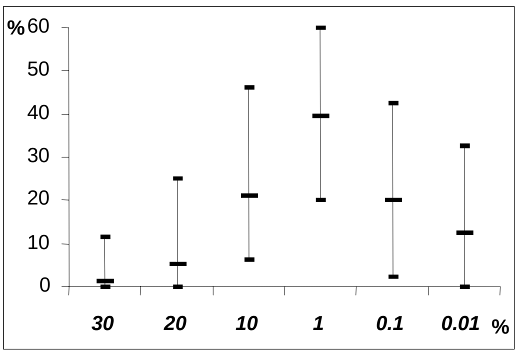


**Figure 3.5.** *Maximum, average and minimum frequency of variable accuracy specifications chosen by ERS respondents (all variables) (% of all entries). The range bars show the highest and lowest votes (in %) for single Variables.*

Low levels of Variable accuracy cannot readily be attributed to whole Variable Groups but tend to be distributed much more randomly among Variables from different groups than, for example, geographic coverage areas (Fig.3.11). They include Variables that are difficult or expensive to measure accurately (e.g Synthetic organics, Pharmaceutical wastes, Pesticides and herbicides, Trace metals, Iceberg area, volume) or that possess a rather transient nature (e.g. Incident and RS reflected light spectrum, River and Land runoff, Wave direction spectrum and Wave spectrum). On the other hand, high levels of accuracy are demanded for most Variables from the "Upper Layer Fields" Group (12 out of 22) (Fig.3.10) and for nearly all Variables from the "Deep ocean" Group (6 out of 8). In addition, there are a few ice-related Variables (5 out of 25) that rank high for accuracy.

### 3.2.4 Spatial Resolution

Respondents assigned a specific spatial resolution (<0.5 km, 0.5 km, 1 km, 10 km, 100 km, 500 km, 1000 km) for each Variable chosen. High preference for a spatial resolution of 1 km clearly emerged from the analysis: for any Variable at least one third of respondents selecting that Variable choose this spatial resolution (Fig.3.6). A lower resolution is preferred in roughly a quarter, a larger scale resolution in circa one third of all cases. Note, as always, that for most products the customer is specifying a resolution after analysis and probably after modelling or gridding.

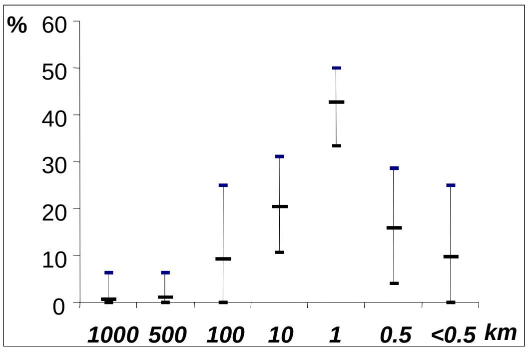


**Figure 3.6**. *Maximum, average and minimum frequency of spatial resolution scales chosen by ERS respondents (all variables) (% of all entries). The range bars show the highest and lowest votes (in %) for single Variables.*

It follows from the above that the differences between Variables regarding their preferred spatial resolution are not very high (Fig.3.12). Almost all "Deep Ocean" Variables (7 out of 8) do not require a fine spatial resolution as do many ice-related Variables (7 out of 25). Variables for which a fine spatial resolution is chosen relatively often, include most Variables from the "Coastal & Shelf" (9 out of 11) and the "Optics" (5 out of 7) Groups as well as many Variables from the "Biogeochemical" Group (7 out of 22).

### 3.2.5 Vertical Resolution

Respondents could assign a choice of 6 vertical resolutions from 1 m to 1000 m to each chosen Variable (omitting surface- and ice-related Variables plus some others that do not have a vertical extension). Preferences for vertical resolutions are very clear and range in the order of 1 and 10 m in about two third of all cases (Fig.3.7).

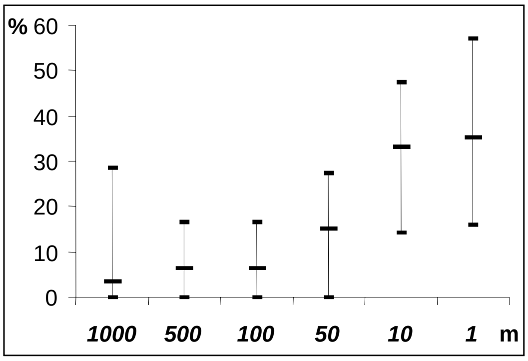


**Figure 3.7**. *Maximum, average and minimum frequency of vertical resolution scales chosen by ERS respondents (all variables) (% of all entries). The range bars show the highest and lowest votes (in %) for single Variables.*

Variables that tend to be requested on a relatively coarse vertical scale include all "Deep Sea" Variables and most Variables from the "Upper Layer Field" Group (14 out of 22) (Fig.3.13). Not unexpectedly, almost all "Optics" Variables (6 out of 7) are found among the top 10 of those for which a fine resolution is often required. Other Variables with a fine resolution emphasis are from the "Acoustics" Group (6 out of 11), the "Coastal & Shelf" Group (4 out of 11) and the "Sea Bed" Group (3 out of 7). Some mainly chemical Variables from the "Biogeochemical" Group (5 out of 22) are also found within the fine vertical resolution group. In the case of Heat flow, almost a quarter of respondents are satisfied with a vertical resolution of 1,000 m and a total of 43% select coarse resolutions between 1,000 and 50 m. However, an equally large proportion of respondents prefer a very fine resolution of 1 m. This leads to the curious result that the same Variable appears in the "coarse" sample as well as in the "fine" sample. The same is true for Upper ocean heat content for which a coarse vertical resolution of 50 m and more is preferred by as many respondents as a fine resolution of 1m (36% both).

### 3.2.6 Temporal Resolution

Regarding the eight temporal resolution categories (from 1 h to >1 y), differences in selection are not as striking as with spatial and vertical resolutions (Fig.3.8). However, in almost half of the cases a temporal resolution in the dimension of 6 hours to 1 day is preferred and very rarely do respondents select a resolution of more than 1 year.

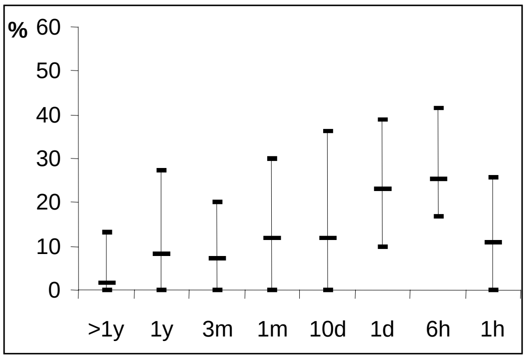


**Figure 3.8**. *Maximum, average and minimum frequency of temporal resolution scales chosen by ERS respondents (all variables) (% of all entries). The range bars show the highest and lowest votes (in %) for single Variables.*

Very coarse temporal Variable resolutions of one year and more are relatively often (between 10% and 25%) chosen for all "Ice Shelves" Variables (Fig.3.14) and for most "Sea Bed" Variables (6 out of 7). A fine temporal resolution (1 and 6 hours) is very often required for many "Surface Fields" Variables (6 out of 15) especially those related to waves that top the fine temporal resolution list.

### 3.2.7 Forecast Period

Differences in preference for particular forecast periods are even less pronounced than those in temporal resolution scales (Fig.3.9). Averages are slightly larger for shorter forecast periods than for longer and range between 8% for very long periods of 30 years to about 25% for very short periods of 10 days.

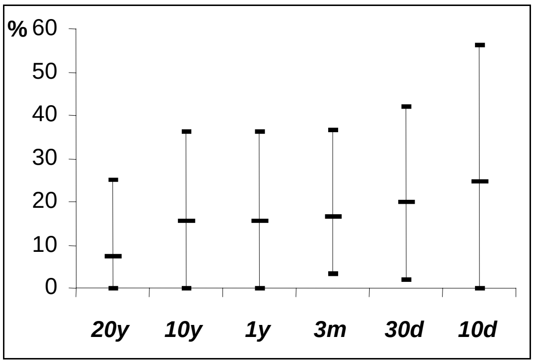


**Figure 3.9**. *Maximum, average and minimum frequency of forecast period chosen by ERS respondents (all variables) (% of all entries). The range bars show the highest and lowest votes (in %) for single Variables.*

Differences in preference for particular forecast periods are even less pronounced than those in temporal resolution scales (Fig.3.9). Averages are slightly larger for shorter forecast periods than for longer and range between 8% for very long periods of 30 years to about 25% for very short periods of 10 days.

A long forecast period is often requested for many "Biogeochemical" Variables (12 out of 22), of which quite a few are connected to anthropogenic contaminants (including pollution) and human health concerns (e.g. Synthetic organics, PAHs, Petroleum hydrocarbons, Pathogens, Pesticides and Herbicides, Human health risks, Artificial radionuclides) (Fig.3.15). Also, many respondents wish long-term forecast for a number of "Ice Shelves" Variables (6 out of 10). Short forecast periods of 10 days are relatively often requested for most Variables from the "Upper layer Field" Group (12 out of 22) and for all "Iceberg" Variables (in contrast to "Ice Shelves").

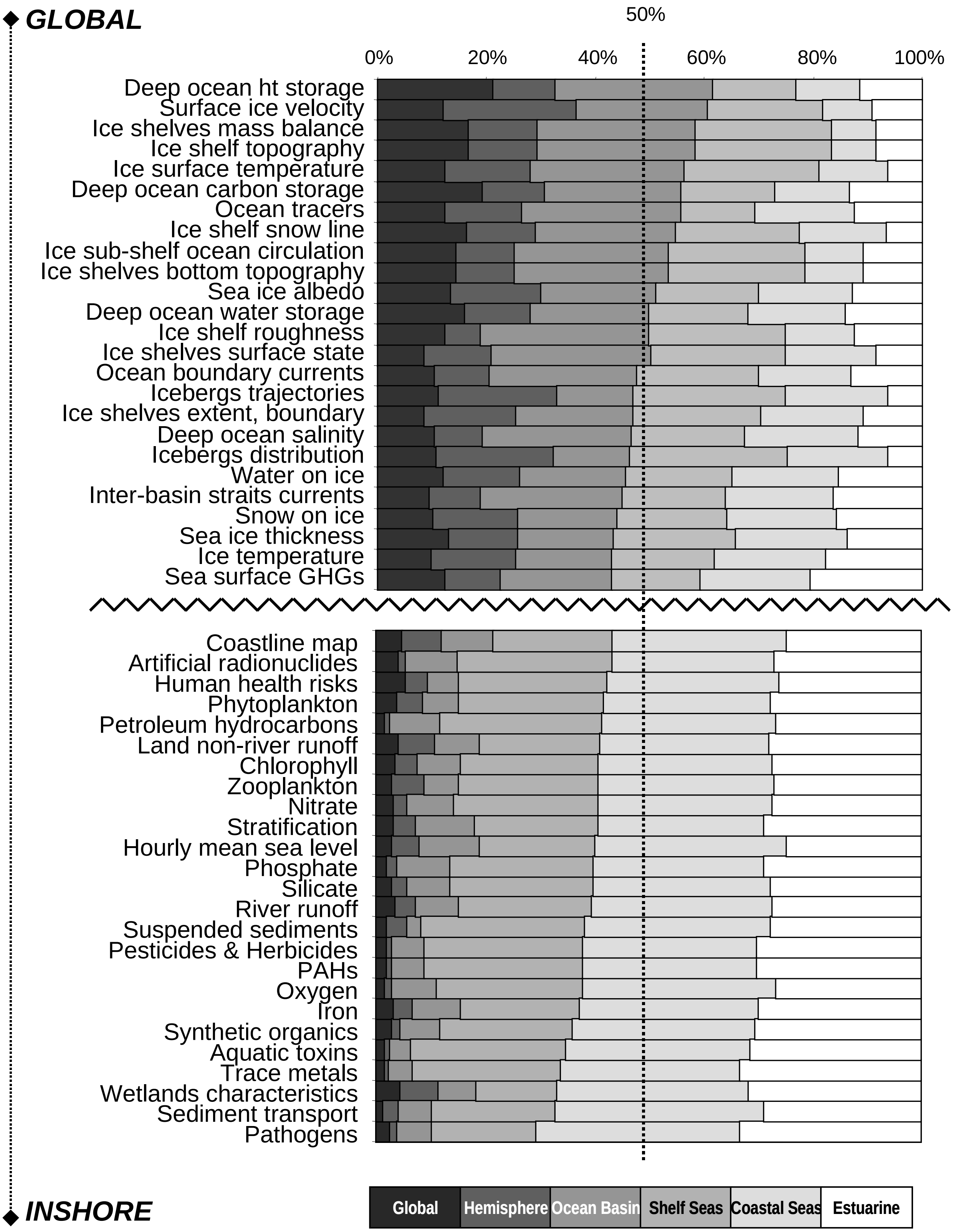


**Figure 3.10. Geographic Coverage**. *Frequency of selection (in % of requests of that variable) of different geographic scales. Above: Variables requested on large oceanic scales; ranked by Σ (Global, Hemisphere, Ocean Basin). Below: Variables requested for coastal areas, ranked by Σ (Estuarine, Coastal Sea) (reverse order). The meaning of the tint on each bar is given by the labels on the scale bar at the bottom of the diagram.*

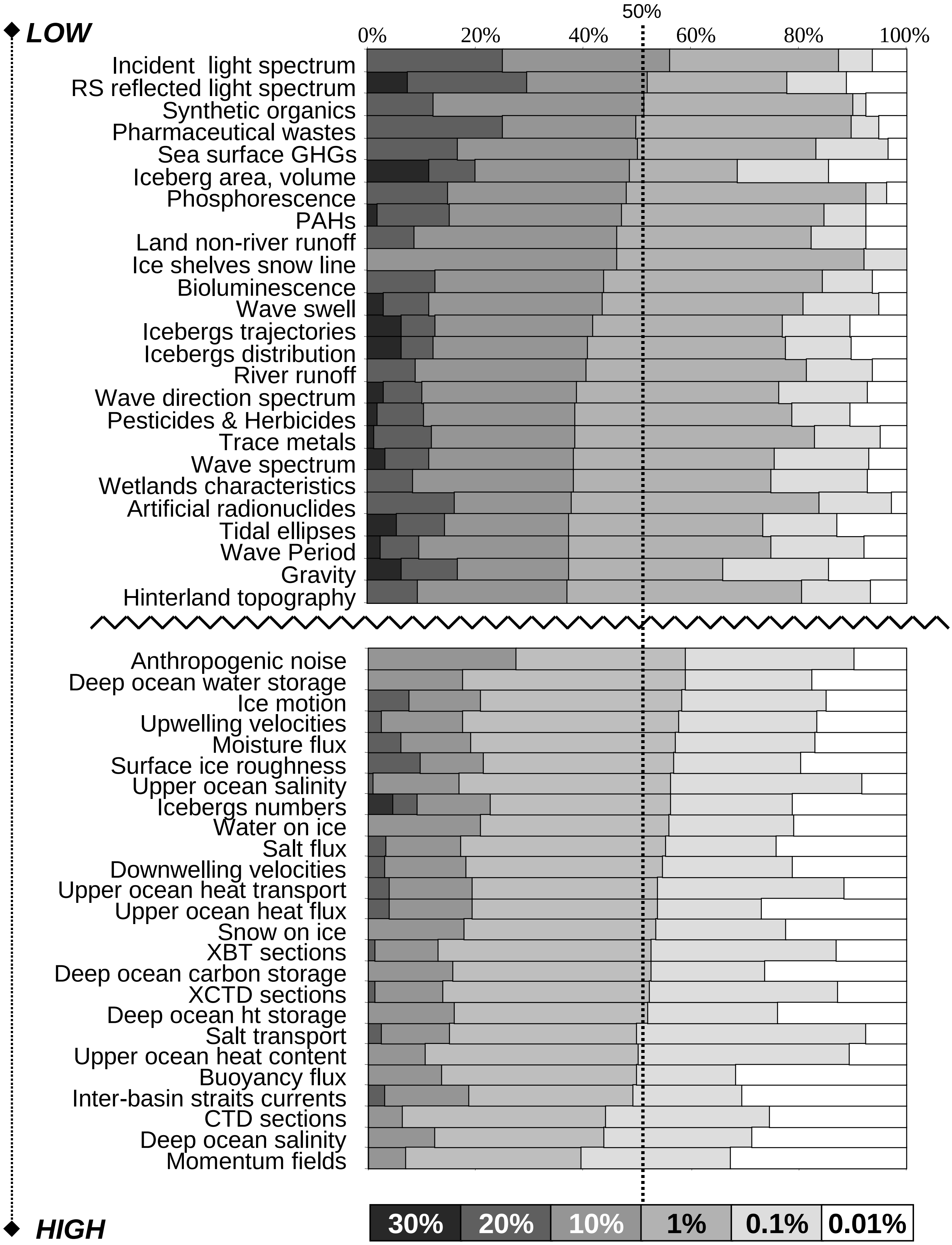


**Figure 3.11. Variable Accuracy**. *Frequency of selection (in % of requests of that variable) of different percentages of accuracy. Above: Variables requested with relatively low accuracy, ranked by Σ(30%, 20%, 10%). Below: Variables requested with relatively high accuracy, ranked by Σ(0.01%, 0.1%) (reverse order). The meaning of the tint on each bar is given by the labels on the scale bar at the bottom of the diagram.*

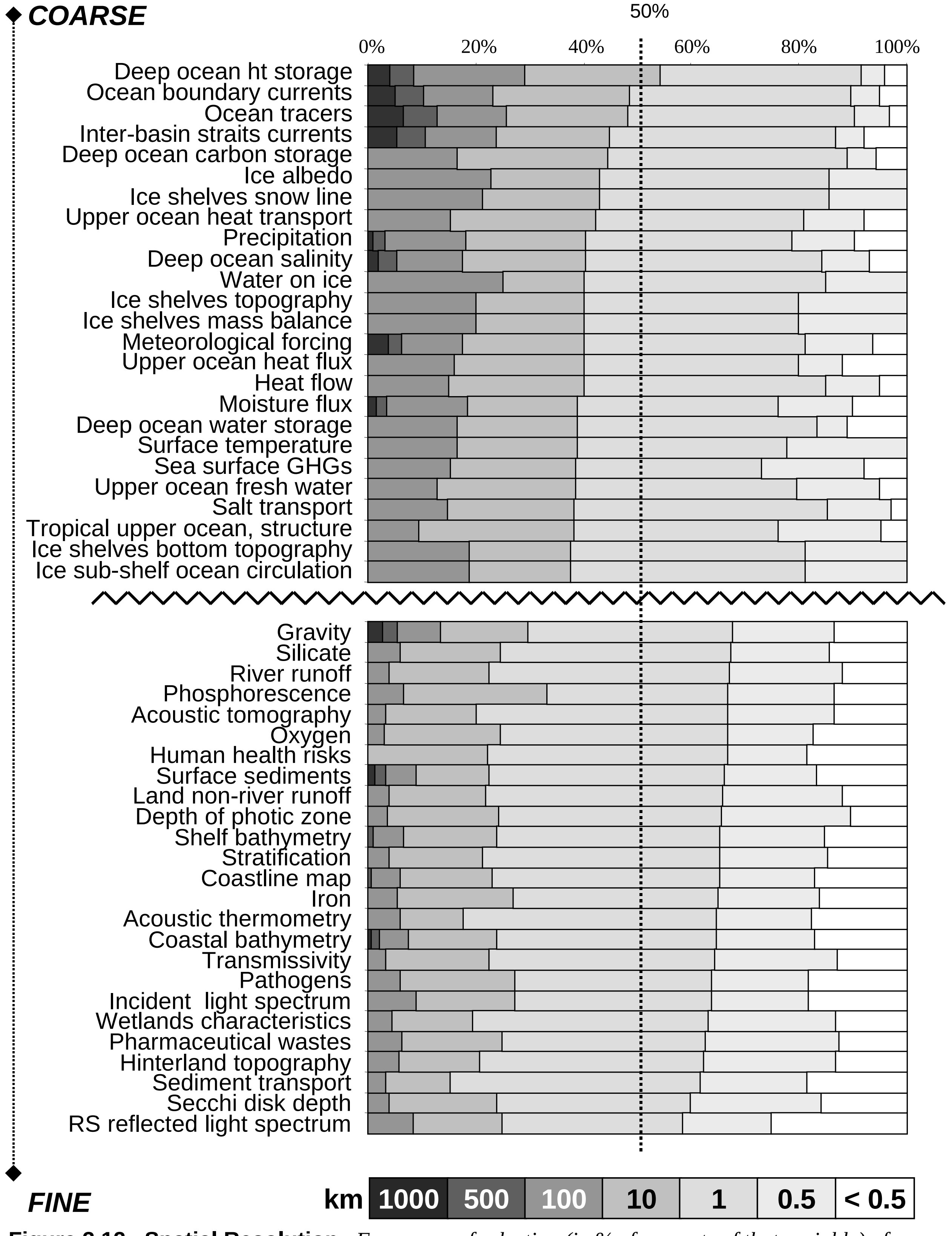


**Figure 3.12. Spatial Resolution**. *Frequency of selection (in % of requests of that variable) of different of spatial resolution in km. Above: Variables requested on a relatively coarse spatial resolution, ranked by Σ(1000km, 500km, 100km, 10km). Below: Variables requested on a relatively fine spatial resolution, ranked by Σ(<0.5km, 0.5km) (reverse order). The meaning of the tint on each bar is given by the labels on the scale bar at the bottom of the diagram.*

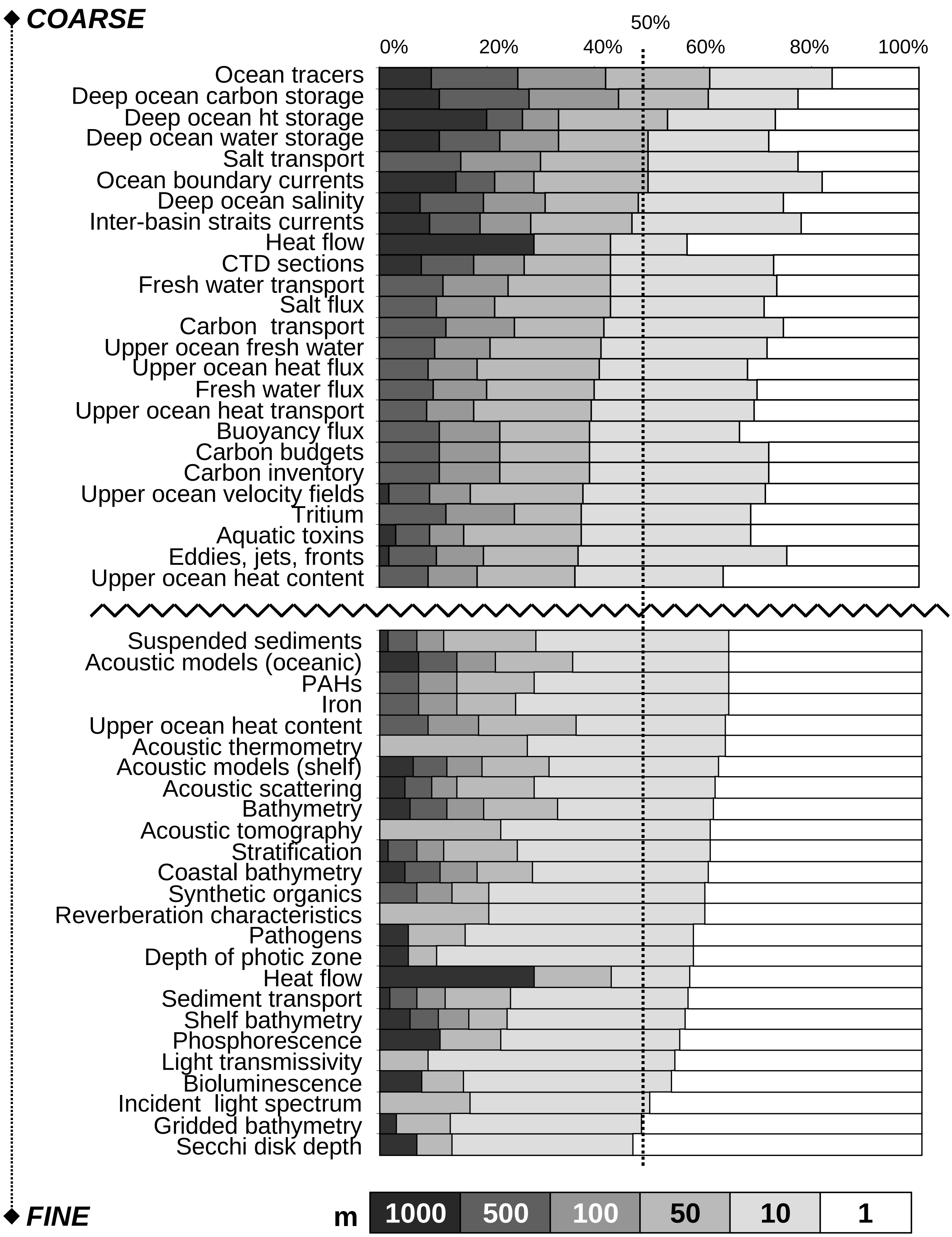


**Figure 3.13. Vertical Resolution**. *Frequency of selection (in % of requests of that variable) of different resolution on a vertical scale. Above: Variables requested with a relatively coarse vertical resolution, ranked by Σ(1000m, 500m, 100m, 50m). Below: Variables requested with relatively with a relatively fine vertical resolution, ranked by "1m" (reverse order). The meaning of the tint on each bar is given by the labels on the scale bar at the bottom of the diagram. The meaning of the tint on each bar is given by the labels on the scale bar at the bottom of the diagram.*

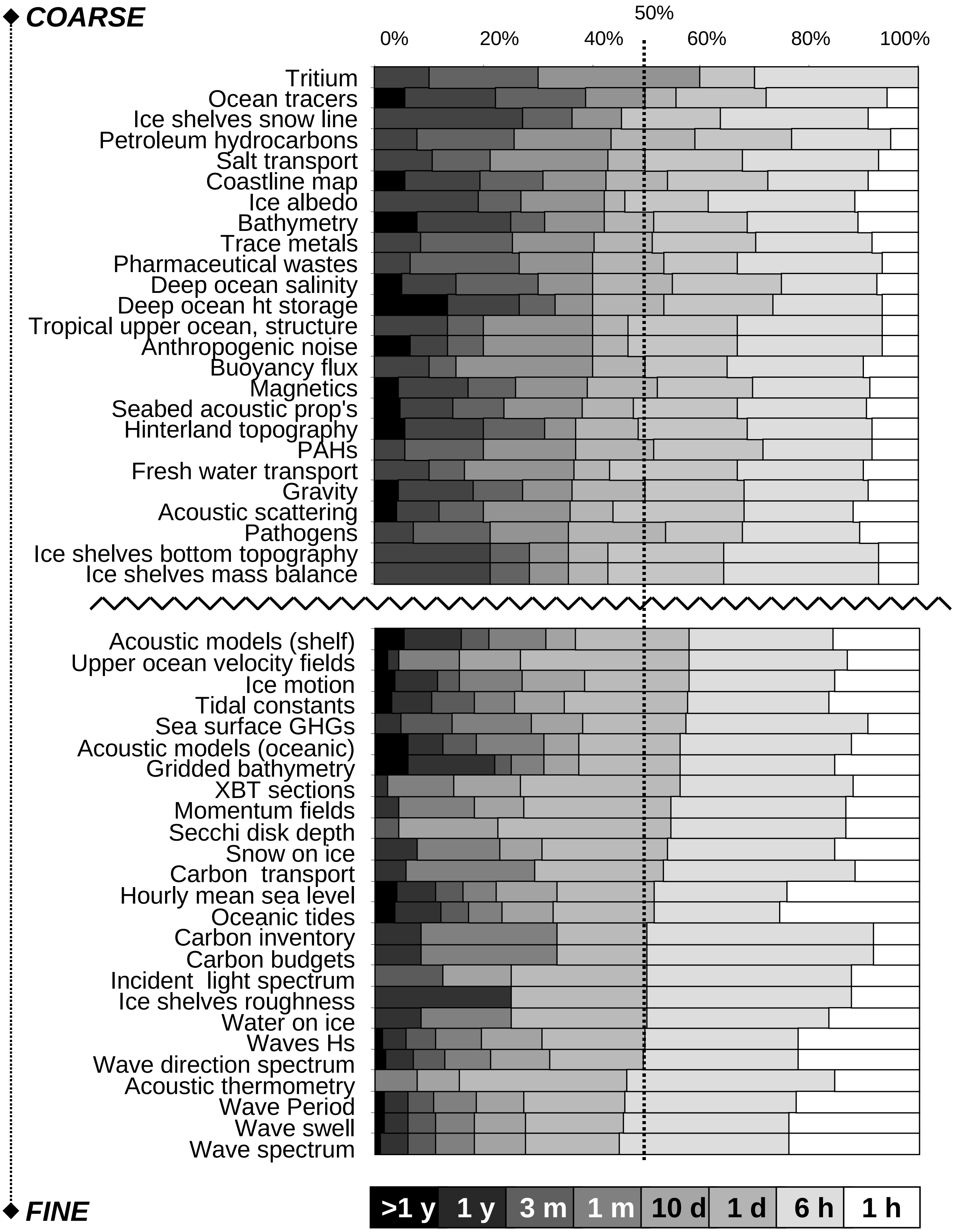


**Figure 3.14. Temporal Resolution**. *Frequency of selection (in % of requests of that variable) of different resolutions for variable sampling on a temporal scale. Above: Variables requested on a relatively coarse temporal scale, ranked by Σ(>1y, 1y, 3m, 1m). Below: Variables requested on a relatively fine temporal scale, ranked by Σ(1h, 6h) (reverse order). The meaning of the tint on each bar is given by the labels on the scale bar at the bottom of the diagram.*

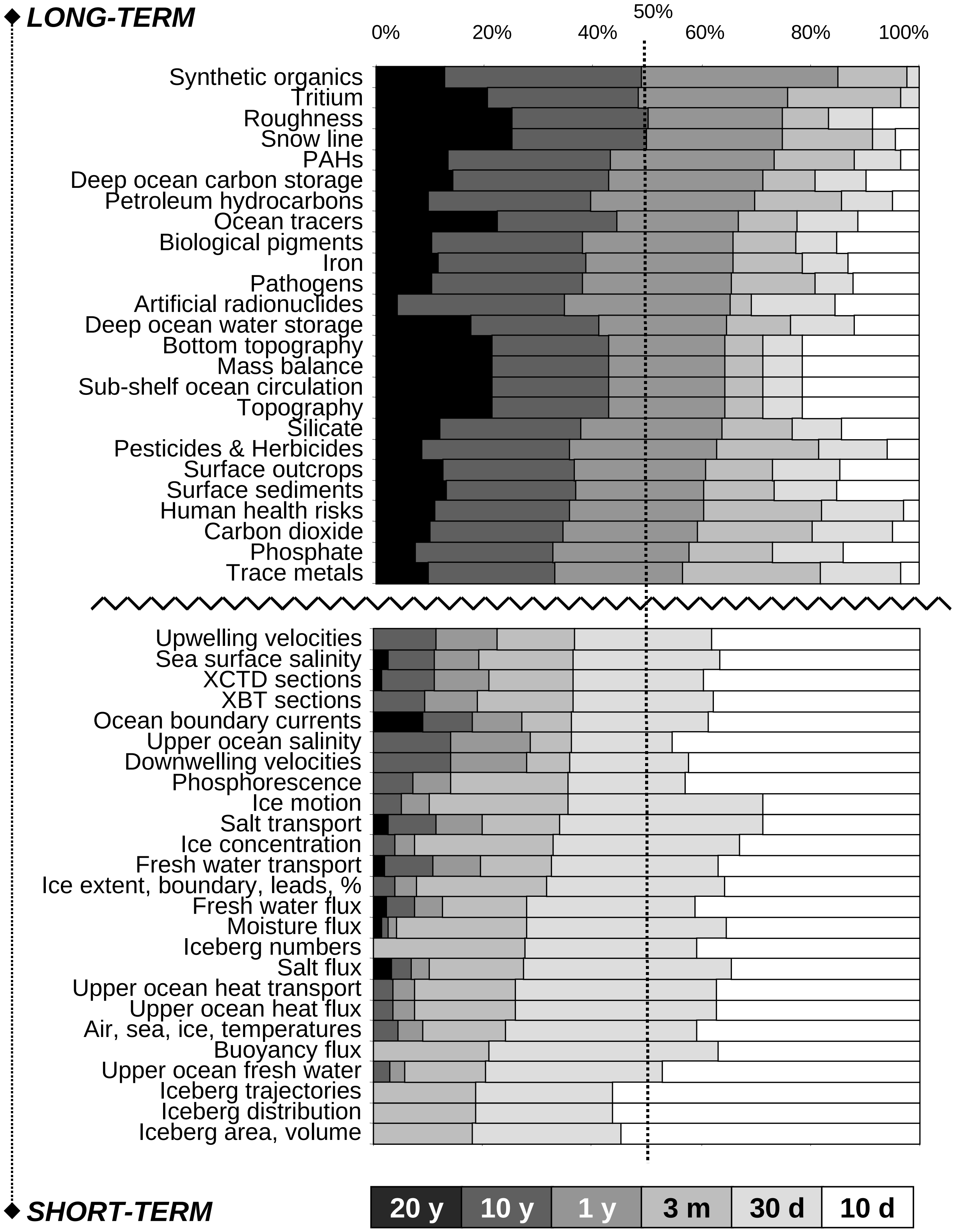


**Figure 3.15. Forecast Period.** *Frequency of selection (in % of requests of that variable) of different forecast periods for requested variables. Above: Variables requested for a long-term forecast period, ranked by Σ(20years, 10 years). Below: Variables requested on a short-term forecast period, ranked by 10 days. The meaning of the tint on each bar is given by the labels on the scale bar at the bottom of the diagram.*

# Links between Applications and Variables requested 4

## 4.1 Introduction

The data base of responses to the ERS questionnaire can be used to identify connections, correlations and trends in many different ways. In designing an observing system one is interested in finding what observations will provide useful information to the greatest number of users, or perhaps to specific industries, services, or environmental management bodies which are held to be particularly important. Alternatively, we may want to find what activities will benefit from provision or forecasting of particular Variables. This requires studying the correlation and linkages between the frequency with which respondents with different applications requested different variables. Are there Variables that are wanted by everybody? Are these Variables the ones they want most, or are they 5th or 10th on everybody's list of requirements? Are some of the high-ranking Variables urgently required by all the users in one Applications Sector, or scattered between Applications Sectors? Can we target the development of a particular channel of data and show that it will be useful to a user group which is active in all European countries?

Since many respondents listed two or more applications in different Sectors it is not possible in those cases to derive a necessary link between activity and Variable, even if one could make a sound guess. In Chapter 4 therefore, we analyse only the responses from institutes or companies which report Applications in only one Sector. In order to ensure that the number of cases are large enough to give meaningful comparisons, we correlate the number of respondents from a whole Applications Sector with their requests for different Variables, with some preliminary analysis by Variable Groups.

In principle it would be possible to analyse single Applications and their requirements for single Variables. For the Applications with most respondents this is possible with the present data base. But for many Applications the number of respondents is too small to identify trends. Nevertheless, even where a single reply form states that a shellfish farmer or a pipelaying company requires a particular type of data, this is a fact, and may be useful in identifying potential markets. Organisations with similar Applications are likely to have similar requirements. An additional problem is that the number of potential correlations between all Applications and their required Variables would require many tens of tables to display the information, and there is no space to do this in hard copy.

Readers of this report with particular detailed questions of this type are encouraged to contact their EuroGOOS Member which conducted the survey, or to request access to the electronic data base, where such questions can be posed.

## 4.2 The Single Application Sector subset

About one third (55) of the 155 respondents are engaged in just one single Application Sector. The Variables requested by Single-Sector respondents can give some insights in the diverse data requirements by different usage groups. As already remarked in 2.1, most single Sector respondents are from northern European countries (Table 4.1).

| Application Sectors | UK | DK | NL | E | I | GR | Total |
|---|---|---|---|---|---|---|---|
| Research | 12 | 3 | 4 | 4 | 3 | | 26 |
| Transport | 1 | 7 | 3 | | | | 11 |
| Environment | | 2 | | 1 | 1 | 1 | 5 |
| Building | 1 | | 2 | 1 | | | 4 |
| Defence | 3 | | | | | | 3 |
| Food | | | | 3 | | | 3 |
| Energy | 1 | | 1 | | | | 2 |
| Services | 1 | | | | | | 1 |
| Total | 19 | 12 | 10 | 9 | 4 | 1 | 55 |

**Table 4.1.** *Numbers of Single-Application-Sector respondents by country*

The only exceptions are respondents from the "Food" and "Environment" Sectors where south European respondents predominate. Almost half of the Single-Sector respondents represent Research institutions (26, 12 from UK) and a fifth deal with Transport (11, 7 from Denmark). The Service Sector that is the second most abundant Sector in the entire ERS, is almost always mentioned in conjunction with another set of activities and thus has been omitted from the single-Application analysis.

From the above it follows that our single-Sector sample has a different frequency of Sectors than the total ERS sample (Fig.4.1). However, this should not diminish the value of the subsequent analysis as the specific data requirements within Sectors are very likely to be less varied than those between Sectors.

## 4.3 Variables requested by single Sectors

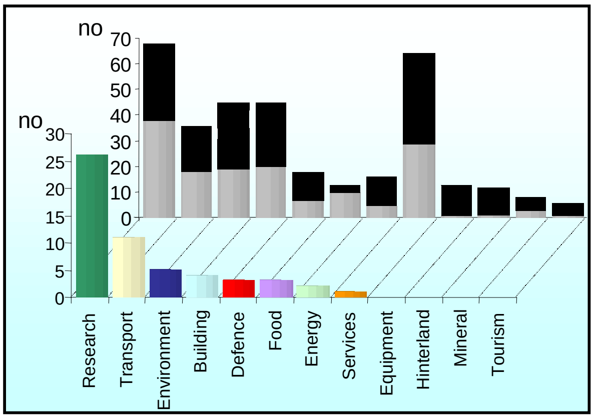


**Figure 4.1.** *Frequency of Application Sectors representing the only activity of individual ERS respondents (foreground columns) contrasted with the frequency of the same Sector where it is one out of two or three (grey column parts) or one out of four to nine (black column parts) Application Sectors within an individual company.*

Are there any Variables that would satisfy the needs of most customers? Table 4.2. represents a first approach to answer this question by listing all Variables that are requested by at least 4 of the 7 Single Application Sectors in our analyses. All Variables contained in the "Surface Fields", "Sea Surface Topography", and "Coastal & Shelf Group" appear in this table. 9 Variables from the "Sea Surface" Group top the list, i.e. Current measurements, Temperature and Wind stress as well as all Wave-related measurements. Other Variables significant to the majority of the Sectors are from the "Biogeochemical" (10 out of 22) and from the "Upper Layer Fields" (9 out of 22) Groups. "Biogeochemical" Variables include important biological measurements (Phytoplankton, Nitrate, Chlorophyll, Oxygen, and Biological pigments) as well as some ecosystem/human health related data (Artificial radionuclides, Human health risks, Pathogens, and Pesticides & herbicides). "Upper Layer Fields" Variables are often related to water transport (Surface currents, Upper ocean velocity fields, Upwelling velocities, Downwelling velocities, Fresh water transport) or general physico-chemical characteristics of the water (Upper ocean salinity, XCTD sections, XBT sections.

Figure 4.2. shows the data requirements of Single-Sector respondents by Application Sector and Variable Group("Surface Fields", "Sea Surface Topography" and "Upper Layer Fields" grouped as "Surface", and "Sea Ice", "Ice Shelves" and "Icebergs" grouped as "Ice"). Complementing this somewhat general information is Table 4.3 where Variables are ranked by the frequency with which they are selected by respondents within each of the Single Sectors.

Before going into details, it is worth mentioning that with the exception of Sea surface salinity, the top 15 Variables from Table 4.2 have not only been selected by at least one respondent from most Sectors but also form part of the top 20 Variables of most Sectors (Table 4.3). This is especially true for Current direction and Current velocity which appear among the top 20 ranked Variables in all Sectors. Only within the "Environment" Sector wave related measurements do not rank highly, and merely "Building" shows relatively little interest for Sea surface temperature, while only "Energy" respondents do not rank Sea surface wind stress very highly.

| Variable Group | Variable | Application Sectors | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Research | Transport | Environ-ment | Building | Defence | Food | Energy | Σ | # |
| Surface fields | Current Direction | 15 | 8 | 2 | 4 | 1 | 3 | 2 | **35** | **7** |
| Surface fields | Current Velocity | 15 | 7 | 2 | 4 | 1 | 3 | 2 | **34** | **7** |
| Surface fields | Sea surface temperature | 17 | 4 | 2 | 1 | 1 | 3 | 1 | **29** | **7** |
| Surface fields | Sea surface Wind stress | 14 | 4 | 2 | 2 | 1 | 2 | 1 | **26** | **7** |
| Surface fields | Wave direction spectrum | 9 | 4 | 1 | 4 | 2 | 3 | 2 | **25** | **7** |
| Surface fields | Waves Hs | 9 | 3 | 1 | 4 | 1 | 3 | 2 | **23** | **7** |
| Surface fields | Wave Period | 8 | 4 | 1 | 4 | 1 | 2 | 2 | **22** | **7** |
| Surface fields | Wave spectrum | 9 | 4 | 1 | 3 | 2 | 1 | 1 | **21** | **7** |
| Surface fields | Wave swell | 7 | 4 | 1 | 4 | 1 | 1 | 2 | **20** | **7** |
| Coastal & Shelf | Coastline map | 8 | 1 | 2 | 2 | 2 | 1 | 1 | **17** | **7** |
| Coastal & Shelf | Coastal bathymetry | 9 | | 2 | 2 | 1 | 1 | 1 | **16** | **6** |
| Sea Surface topography | Hourly mean sea level | 5 | 5 | 2 | 2 | 1 | | 1 | **16** | **6** |
| Surface fields | Sea surface salinity | 16 | 1 | 2 | 1 | | | 1 | **21** | **5** |
| Upper Layer Fields | Surface currents | 11 | | | 1 | 2 | 1 | 2 | **17** | **5** |
| Biogeochemical | Phytoplankton | 10 | | 2 | 1 | 1 | 1 | | **15** | **5** |
| Coastal & Shelf | River runoff | 8 | 1 | 1 | 2 | | | 1 | **13** | **5** |
| Sea Surface topography | Oceanic tides | 7 | 3 | 1 | 1 | | | 1 | **13** | **5** |
| Upper Layer Fields | Upper ocean velocity fields | 7 | | 1 | 2 | 1 | | 2 | **13** | **5** |
| Sea Bed | Gridded bathymetry | 7 | | 1 | 2 | 1 | | 1 | **12** | **5** |
| Coastal & Shelf | Sediment transport | 5 | 1 | 2 | 2 | | | 1 | **11** | **5** |
| Coastal & Shelf | Shelf bathymetry | 6 | | 1 | 2 | 1 | | 1 | **11** | **5** |
| Coastal & Shelf | Tidal constants | 6 | | 1 | 2 | 1 | | 1 | **11** | **5** |
| Upper Layer Fields | Upwelling velocities | 6 | | 1 | 1 | 1 | | 2 | **11** | **5** |
| Acoustics | Sound velocity profiles | 2 | 1 | | 1 | 2 | | 1 | **7** | **5** |
| Upper Layer Fields | Upper ocean salinity | 12 | | 1 | | 2 | | 1 | **16** | **4** |
| Biogeochemical | Nitrate | 9 | | 4 | 1 | 1 | | | **15** | **4** |
| Biogeochemical | Chlorophyll | 9 | | 3 | 1 | 1 | | | **14** | **4** |
| Deep Ocean | CTD sections | 11 | | | 1 | 1 | | 1 | **14** | **4** |
| Biogeochemical | Suspended sediments | 9 | | 1 | 1 | | 2 | | **13** | **4** |
| Biogeochemical | Oxygen | 6 | | 3 | 1 | | 2 | | **12** | **4** |
| Surface fields | Precipitation | 9 | | 1 | 1 | | | 1 | **12** | **4** |
| Upper Layer Fields | Eddies, jets, fronts | 8 | | | 1 | 1 | | 2 | **12** | **4** |
| Coastal & Shelf | Land non-river runoff | 7 | | 1 | 2 | | | 1 | **11** | **4** |
| Coastal & Shelf | Stratification | 7 | | 1 | 2 | | | 1 | **11** | **4** |
| Sea Surface topography | Geostrophic currents | 8 | | 1 | 1 | | | 1 | **11** | **4** |
| Sea Surface topography | Sea level anomaly | 7 | | 1 | 2 | | | 1 | **11** | **4** |
| Surface fields | Heat flux | 8 | | 1 | 1 | | | 1 | **11** | **4** |
| Upper Layer Fields | XCTD sections | 7 | | | 2 | 1 | | 1 | **11** | **4** |
| Deep Ocean | Deep ocean salinity | 7 | | | 1 | 1 | | 1 | **10** | **4** |
| Sea Surface topography | Marine geoid | 6 | | 1 | 2 | | | 1 | **10** | **4** |
| Sea Surface topography | Meteorological forcing | 6 | | 2 | 1 | | | 1 | **10** | **4** |
| Sea Surface topography | Monthly mean sea level | 6 | | 1 | 2 | | | 1 | **10** | **4** |
| Biogeochemical | Artificial radionuclides | 6 | | 1 | 1 | 1 | | | **9** | **4** |
| Biogeochemical | Biological pigments | 6 | | 1 | 1 | 1 | | | **9** | **4** |
| Surface fields | Moisture flux | 6 | | 1 | 1 | | | 1 | **9** | **4** |
| Upper Layer Fields | Downwelling velocities | 5 | | | 1 | 1 | | 2 | **9** | **4** |
| Upper Layer Fields | Fresh water transport | 6 | 1 | | 1 | | | 1 | **9** | **4** |
| Upper Layer Fields | XBT sections | 6 | | | 1 | 1 | | 1 | **9** | **4** |
| Coastal & Shelf | Tidal ellipses | 4 | | 1 | 2 | | | 1 | **8** | **4** |
| Coastal & Shelf | Wetlands characteristics | 4 | | 1 | 2 | | | 1 | **8** | **4** |
| Coastal & Shelf | Hinterland topography | 3 | | 1 | 2 | | | 1 | **7** | **4** |
| Sea Ice | Ice motion | 4 | 1 | | | 1 | | 1 | **7** | **4** |
| Surface fields | Sea surface CO2 | 4 | | 1 | 1 | | | 1 | **7** | **4** |
| Biogeochemical | Human health risks | 3 | | 1 | 1 | | 1 | | **6** | **4** |
| Biogeochemical | Pathogens | 2 | | 2 | 1 | | 1 | | **6** | **4** |
| Biogeochemical | Pesticides & Herbicides | 3 | | 1 | 1 | | 1 | | **6** | **4** |
| Surface fields | Sea surface GHGs | 2 | | 1 | 1 | | | 1 | **5** | **4** |

**Table 4.2**. *Variables requested by respondents from at least 4 Application Sectors (ranked by no of Sectors (#), then by no of respondents (Σ) requesting the Variable)*

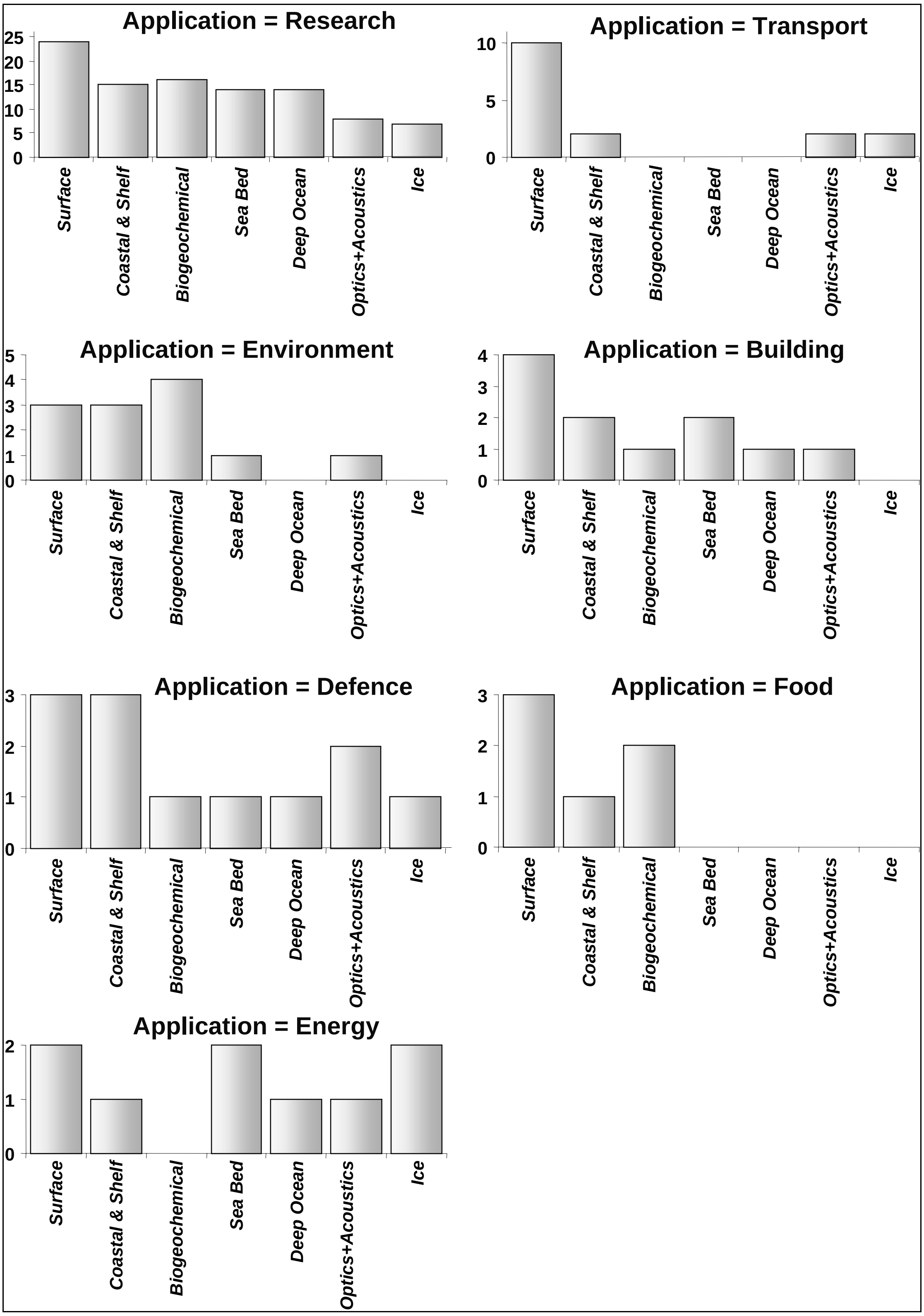


**Figure 4.2.** *Number of respondents within each of the 7 valid Single-Sectors selecting the different Variable Groups (note different vertical scales).*

| Rank | Variable Group | Variable |
|---|---|---|
| | **Research** | |
| **1** | Surface Fields | Sea surface temperature |
| **2** | Surface Fields | Sea surface salinity |
| **3** | Surface Fields | Current direction |
| **4** | Surface Fields | Current velocity |
| **5** | Surface Fields | Sea surface wind stress |
| **6** | Upper Layer Fields | Upper ocean salinity |
| **7** | Sea Bed | Bathymetry |
| **8** | Upper Layer Fields | Surface currents |
| **9** | Deep Ocean | CTD sections |
| **10** | Biogeochemical | Phytoplankton |
| **11** | Surface Fields | Wave direction spectrum |
| **12** | Surface Fields | Waves Hs |
| **13** | Surface Fields | Wave spectrum |
| **14** | Coastal & Shelf | Coastal bathymetry |
| **15** | Biogeochemical | Nitrate |
| **16** | Biogeochemical | Chlorophyll |
| **17** | Biogeochemical | Suspended sediments |
| **18** | Surface Fields | Precipitation |
| **19** | Surface Fields | Wave period |
| **20** | Coastal & Shelf | Coastline map |
| | **Transport** | |
| **1** | Surface Fields | Current direction |
| **2** | Surface Fields | Current velocity |
| **3** | Sea Surface topography | Hourly mean sea level |
| **4** | Surface Fields | Sea surface temperature |
| **5** | Surface Fields | Sea surface Wind stress |
| **6** | Surface Fields | Wave direction spectrum |
| **7** | Surface Fields | Wave Period |
| **8** | Surface Fields | Wave spectrum |
| **9** | Surface Fields | Wave swell |
| **10** | Surface Fields | Waves Hs |
| **11** | Sea Surface topography | Oceanic tides |
| **12** | Sea Ice | Air, sea, ice, temperatures |
| **13** | Coastal & Shelf | Coastline map |
| **14** | Surface Fields | Sea surface salinity |
| **15** | Coastal & Shelf | River runoff |
| **16** | Coastal & Shelf | Sediment transport |
| **17** | Acoustics | Sound velocity profiles |
| **18** | Upper Layer Fields | Fresh water transport |
| **19** | Sea Ice | Ice motion |
| **20** | Optics | Bioluminescence |
| | **Environment** | |
| **1** | Biogeochemical | Nitrate |
| **2** | Biogeochemical | Phosphate |
| **3** | Biogeochemical | Chlorophyll |
| **4** | Biogeochemical | Oxygen |
| **5** | Biogeochemical | Silicate |
| **6** | Biogeochemical | Iron |
| **7** | Surface Fields | Current Direction |
| **8** | Surface Fields | Current Velocity |
| **9** | Surface Fields | Sea surface temperature |
| **10** | Surface Fields | Sea surface Wind stress |
| **11** | Coastal & Shelf | Coastline map |
| **12** | Coastal & Shelf | Coastal bathymetry |
| **13** | Sea Surface topography | Hourly mean sea level |
| **14** | Surface Fields | Sea surface salinity |
| **15** | Biogeochemical | Phytoplankton |
| **16** | Coastal & Shelf | Sediment transport |
| **17** | Sea Surface topography | Meteorological forcing |
| **18** | Biogeochemical | Pathogens |
| **19** | Biogeochemical | Trace metals |
| **20** | Biogeochemical | PAHs |
| | **Building** | |
| **1** | Surface Fields | Current Direction |
| **2** | Surface Fields | Current Velocity |
| **3** | Surface Fields | Wave direction spectrum |
| **4** | Surface Fields | Waves Hs |
| **5** | Surface Fields | Wave Period |
| **6** | Surface Fields | Wave swell |
| **7** | Surface Fields | Wave spectrum |
| **8** | Surface Fields | Sea surface Wind stress |
| **9** | Coastal & Shelf | Coastline map |
| **10** | Coastal & Shelf | Coastal bathymetry |
| | **Building (cont.)** | |
| **11** | Sea Surface topography | Hourly mean sea level |
| **12** | Coastal & Shelf | River runoff |
| **13** | Upper Layer Fields | Upper ocean velocity fields |
| **14** | Sea Bed | Gridded bathymetry |
| **15** | Coastal & Shelf | Sediment transport |
| **16** | Coastal & Shelf | Shelf bathymetry |
| **17** | Coastal & Shelf | Tidal constants |
| **18** | Coastal & Shelf | Land non-river runoff |
| **19** | Coastal & Shelf | Stratification |
| **20** | Sea Surface topography | Sea level anomaly |
| | **Defence** | |
| **1** | Surface Fields | Wave direction spectrum |
| **2** | Surface Fields | Wave spectrum |
| **3** | Coastal & Shelf | Coastline map |
| **4** | Upper Layer Fields | Surface currents |
| **5** | Acoustics | Sound velocity profiles |
| **6** | Upper Layer Fields | Upper ocean salinity |
| **7** | Surface Fields | Current Direction |
| **8** | Surface Fields | Current Velocity |
| **9** | Surface Fields | Sea surface temperature |
| **10** | Surface Fields | Sea surface wind stress |
| **11** | Surface Fields | Waves Hs |
| **12** | Surface Fields | Wave Period |
| **13** | Surface Fields | Wave swell |
| **14** | Coastal & Shelf | Coastal bathymetry |
| **15** | Sea Surface topography | Hourly mean sea level |
| **16** | Biogeochemical | Phytoplankton |
| **17** | Upper Layer Fields | Upper ocean velocity fields |
| **18** | Sea Bed | Gridded bathymetry |
| **19** | Coastal & Shelf | Shelf bathymetry |
| **20** | Coastal & Shelf | Tidal constants |
| | **Food** | |
| **1** | Surface Fields | Current Direction |
| **2** | Surface Fields | Current Velocity |
| **3** | Surface Fields | Sea surface temperature |
| **4** | Surface Fields | Wave direction spectrum |
| **5** | Surface Fields | Waves Hs |
| **6** | Surface Fields | Sea surface Wind stress |
| **7** | Surface Fields | Wave Period |
| **8** | Biogeochemical | Suspended sediments |
| **9** | Biogeochemical | Oxygen |
| **10** | Biogeochemical | Aquatic toxins |
| **11** | Surface Fields | Wave spectrum |
| **12** | Surface Fields | Wave swell |
| **13** | Coastal & Shelf | Coastline map |
| **14** | Coastal & Shelf | Coastal bathymetry |
| **15** | Upper Layer Fields | Surface currents |
| **16** | Biogeochemical | Phytoplankton |
| **17** | Biogeochemical | Human health risks |
| **18** | Biogeochemical | Pathogens |
| **19** | Biogeochemical | Pesticides & Herbicides |
| **20** | - | - |
| | **Energy** | |
| **1** | Surface Fields | Current Direction |
| **2** | Surface Fields | Current Velocity |
| **3** | Surface Fields | Wave direction spectrum |
| **4** | Surface Fields | Waves Hs |
| **5** | Surface Fields | Wave Period |
| **6** | Surface Fields | Wave swell |
| **7** | Upper Layer Fields | Surface currents |
| **8** | Upper Layer Fields | Upper ocean velocity fields |
| **9** | Upper Layer Fields | Upwelling velocities |
| **10** | Upper Layer Fields | Eddies, jets, fronts |
| **11** | Upper Layer Fields | Downwelling velocities |
| **12** | Sea Bed | Bathymetry |
| **13** | Sea Bed | Surface sediments |
| **14** | Sea Ice | Extent, boundary, leads, % |
| **15** | Sea Ice | Concentration |
| **16** | Icebergs | Area, volume |
| **17** | Icebergs | Distribution |
| **18** | Icebergs | Numbers |
| **19** | Icebergs | Trajectories |
| **20** | Surface Fields | Sea surface temperature |

**Table 4.3**. *Top 20 variables of each Application Sector (ranked by no. of respondents requesting the variable)*

The list (Table 4.3) is led by "Research", a very open Sector dealing with every possible topic imaginable. Thus, it is not surprising that every single Variable offered in the questionnaire was selected by researchers. Also, of all the Sectors analysed, "Research" is the one which tends to react most quickly to the emergence of new questions and the improvement of methods. Thus, data requirements of the "Research" Sector found by the ERS might not necessarily reflect "Research" needs in the future. This should be borne in mind when looking at the results presented here.

Respondents from the "Research" Sector selected Variables from all Groups, "Surface Fields" being requested by almost all respondents from this Sector (24 out of 26) (Figure 4.2). In fact, half of the top 20 ranked Variables within the "Research" Sector, are from the "Surface Fields" Group (including Sea surface Temperature and Salinity, plus different current and wave measurements). The "Biogeochemical" Group also ranks high with "Research" respondents (Figure 4.2), especially biological Variables such as Phytoplankton, Nitrate, and Chlorophyll (Table 4.3). Only relatively few "Research" respondents request data on "Ice" (7) and "Optics & Acoustics" (9) (Figure 4.2) none of which appear among the top 20 ranked Variables (Table 4.3). "Research" Variables overlap most with "Defence" and "Food" (13 common Variables with each) and least with "Energy" (9 common Variables).

Respondents from the "Transport" Sector display a very pronounced interest for "Surface" Variables (Figure 4.2). Overall, the 11 respondents of "Transport" only choose 21 Variables, half (10) of which belong to the "Surface Fields" and 2 to the "Sea Surface Topography" (Hourly mean sea level and Oceanic tides) Group. Among the rest are 3 Variables from "Coastal & Shelf" (interestingly no Coastal bathymetry is ever required by any respondent), 3 from "Sea Ice" (Sea ice temperature being Variable 21 and thus not appearing in Table 4.3) plus Sound velocity profiles, and Bioluminescence. Agreement of the "Transport" top Variables is greatest with "Building" and "Defence" (12 common Variables with each) and smallest with "Environment" and "Energy" (8 common Variables with each).

"Environment" participants selected a total of 58 Variables (see Annexe 5). They mostly share an interest in the "Biogeochemical" Variable Group, and, to a lesser degree, in "Surface" and "Coastal & Shelf" data (Figure 4.2). "Deep Ocean" Variables are never chosen. 19 (out of 22) Variables from the "Biogeochemical" Group are requested by at least one of "Environment" respondents (see Annexe 5), of which the most important are of general biological relevance (nutrients, Oxygen, Silicate, Phytoplankton, Pathogens) (Table 4.3). "Environment" does not share many of the top Variables with other Sectors, the highest overlap occurs with "Research" (10 common Variables), and the smallest, as mentioned above, with "Energy" (3 common Variables).

Respondents from the "Building" Sector request a very large number of Variables (82 in total, see Annexe 5). All are interested in the "Surface" Variable Group, and half of them in the "Coastal & Shelf" and "Sea Bed" Groups (Figure 4.2, Table 4.3). As already mentioned, there exists a great overlap of the top 20 "Building" Sector Variables with those from "Defence" (16 common Variables). On the other hand, "Building" shares only 7 of the top 20 Variables with either "Environment" and "Energy".

Responses from the "Defence" Sector are almost as varied as those from the Research Sector, with all three respondents requesting data from the "Surface" and "Coastal & Shelf" Groups and two respondents requesting "Optics & Acoustics" data (Figure 4.2, Table 4.3). "Defence" top Variables have most in common with those from "Building" and least with those from "Environment" (7 shared Variables).

The three Single-Sector respondents from the "Food" Sector are interested in "Surface" Variables (all 3), in the "Biogeochemical" Group (2), and in "Coastal & Shelf" data (1) (Figure 4.2 and Table 4.3). 13 of the top Variables are shared with "Research" and with "Defence", only 8 are shared with "Energy".

Finally, there are two Single-Sector respondents from the "Energy" Sector. Both choose "Surface", "Sea Bed" and "Ice" data (Figure 4.2). This Sector stands out because of the 6 ice-related Variables requested due to the north European provenance of respondents (Table 4.3).

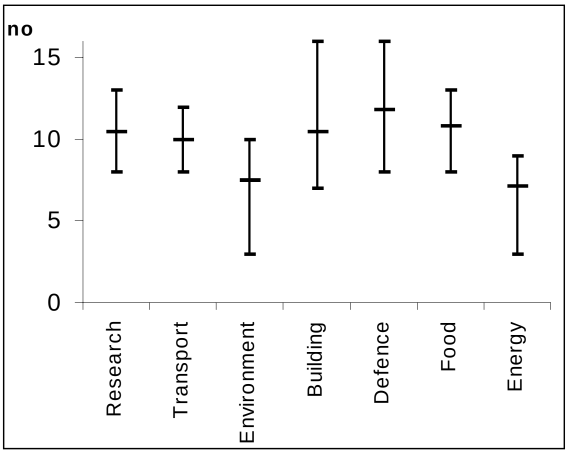


**Figure 4.3**. *Maximum, average, and minimum number of the top 20 Variables from each Single-Application Sector shared with other Sectors (for each Sector).*

On average, about half of the top 20 ranked Variables within each Sector overlap with those from the other Sectors (Figure 4.3 and Table 4.3). "Defence" tends to have the broadest overlap with other Sectors, at least 8 (40%) common Variables with any other Sector, on average 12 (60%), especially with "Building" with which it shares 80% of the top 20 Variables. The top 20 "Energy" Variables have relatively little in common with top Variables form other Sectors, overlap averaging at 7 (maximum 9). Data requirements of "Energy" respondents deviate particularly from those of "Environment" respondents (only 3 (15%) top Variables in common).

## 4.4 Product grading by single Sectors

Figure 4.5. summarises classification trends within each of the single Sectors without looking at specific Variables. The only product type that has been graded in a very similar way by all Sectors is Data Products. Sectors differ considerably in preferred resolutions for all other product types.

In contrast to other Sectors, "Research" respondents are interested in all scales and resolutions available as can be easily seen by the relatively even distribution among different resolutions of geographic coverage, variable accuracy, spatial, vertical, and temporal scales and forecast period.

"Transport" respondents tend to prefer coastal seas for geographic coverage, and are generally satisfied with Variable accuracy of 10% or 1%, vertical resolution of 50m, temporal resolution of 10 days, and forecast period of 1 day.

In preferences for Variable accuracy, and spatial distribution respondents from the "Environment" Sector are similar to those of the "Transport" Sector. However, they show an almost equal preference for estuarine as for coastal areas, strongly favour fine vertical resolutions of 1 and 10 meters but are more often satisfied with temporal resolutions of 1 month and more (about 50% on average) and always desire a forecast period in the order of 1 year.

The "Building" sector generally prefers estuarine and coastal coverage, but in about 20% of the cases a global geographic coverage is selected. A high Variable accuracy of 0.1% and better, is generally desired, as is a relatively fine spatial resolution of 1 km and less, a fine vertical resolution of 1 m (note that "Building" is the only Sector that in some cases is satisfied with vertical resolutions of 500 and 1,000 m), a temporal resolution of uniformly 1 month, and a forecast period of usually 30 days (however, in almost 40% of the cases, 10 and 20 years forecasts are requested, presumably to specify design criteria for long-lived structures).

The "Defence" Sector stands out because in about half of the cases a global coverage is requested. Also, a spatial resolution of less than 1 km is always requested. Variable accuracy of 10% is satisfactory in almost half of the responses. Vertical resolution of 1 and 10 meters and temporal resolution of 1 or 10 days is generally preferred as are forecast periods of 1 month and less.

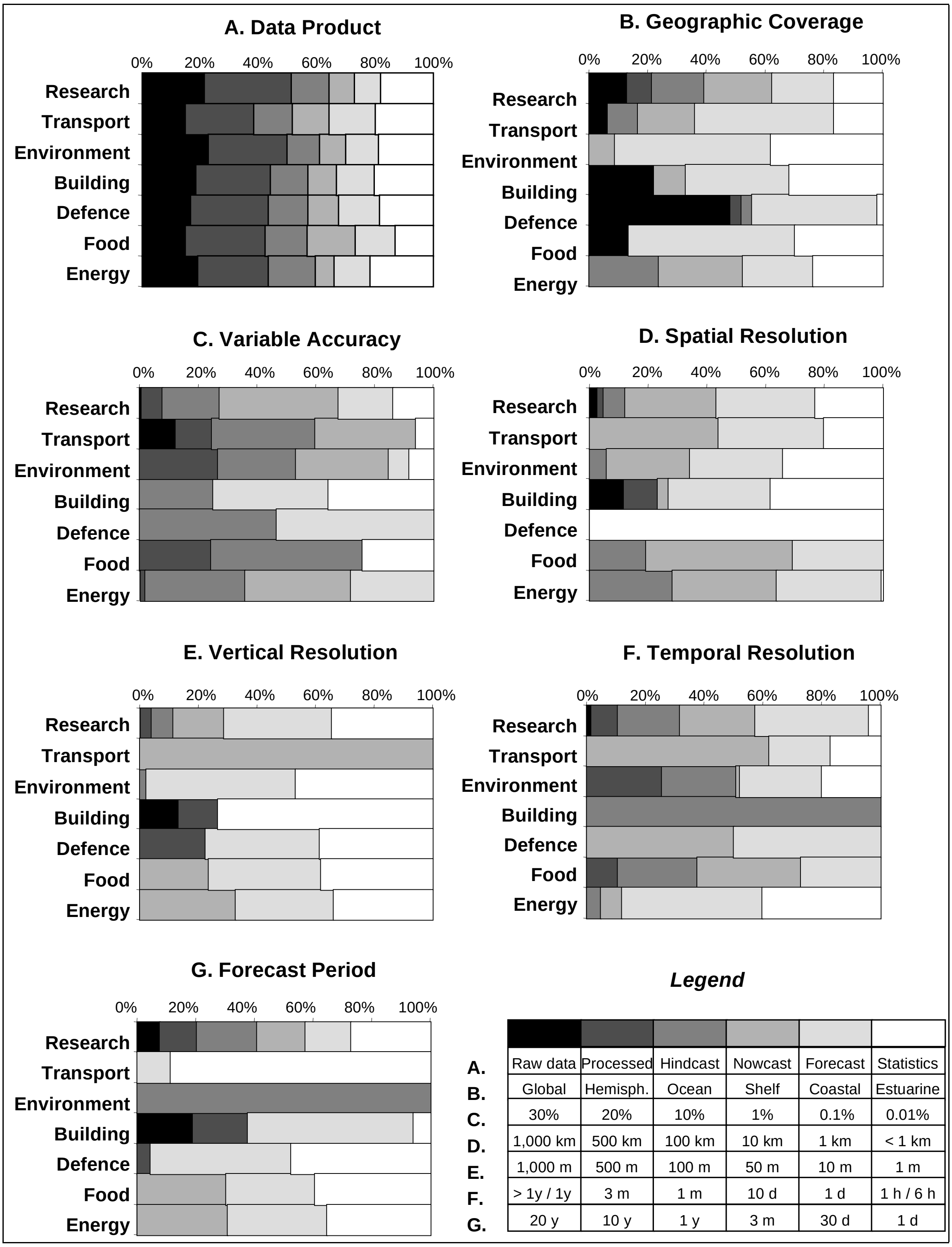


**Figure 4.5**. *Product classification by Single Sector respondents (total N = 55), average values for all Variables selected by % of respondents in that Sector. The meaning of the tint on each bar is given by the labels below the scale bar at the bottom of the diagram.*

The "Food" Sector tends to select coastal seas as relevant geographic coverage, and usually does not require high Variable accuracy (10% seems good enough in most case). In general, spatial resolution of 10 km, vertical resolution of 10 m and less, and forecast periods of 1or 30 days are requested. Temporal resolutions tend to be more discriminating in this Sector with almost even selection of 1 day to 3 months.

After "Research", the "Energy" Sector shows the most varied interest in different scales and resolutions; it, however, never requires hemispheric or global geographic coverage. "Energy" also tends to be satisfied with rather low Variable accuracy of 1% and less, and with coarse spatial resolutions of 10 km and less. Temporal resolution, on the other hand, is mostly chosen in the order of hours or 1 day and requested forecast periods never exceed 3 months.

# 5 Conclusions

It is not possible to list all the conclusions from this survey, and other readers may find other issues more important to different specialties. The following points are identified as generally relevant to the future design of EuroGOOS systems:

1. There is no such thing as the typical EuroGOOS customer. Data products must be designed and targeted at each potential user community or sector of the market.
2. By using a market research questionnaire, we have identified a number of variables which are in demand from a wide range of Application Sectors, and which, to suitable accuracy and resolution, would satisfy a great number of users.
3. The top variables of the ERS do not necessarily include some of the deep ocean variables needed for climate research or other environmental or global activities which are of great political and social importance.
4. Although physical (especially Sea Surface) Variables are in high demand by a majority of respondents (Table 3.2) as well as by most Single Application Sectors (Table 4.3), some biogeochemical variables (e.g. Phytoplankton, Chlorophyll, nutrients, Oxygen, Suspended Sediments) occur in the top 40 Variable list (Table 3.2), and they dominate the Variables in the "Environment" Sector, and feature strongly in the "Research" Sector and in the "Food" Sector (Table 4.3). We can foresee that with progress in ecosystem modelling, the measurement of such variables will become even more important in the future.
5. Coastal Variables (e.g. Bathymetric measurements, Sediment transport, River runoff, and Tidal constants) are important to considerable numbers of respondents (Table 3.2) as well as to the "Building" and the "Defence" Sector (Table 4.3).
6. Most of the choices of scale and resolution produce a spread of interest and requirements. Only relatively few respondents (20% on average) need raw data for their Applications (Fig.3.4); this appears to be largely true for all Application Sectors including Research (Fig.4.5).
7. European interest in operational oceanographic data spans all geographical scales from estuarine to global. For most Variables, however, coastal and shelf areas are more important to respondents than large-scale offshore areas (Fig.3.4). Exceptions are many Variables related to the deep ocean or to ice (Figure 3.10) as well as the "Defence" and, to a lesser degree, the "Building" Sector (Fig.4.5) that seek global scales relatively often.
8. For most Variables more than 50% of respondents requesting that Variable are satisfied with Variable Accuracy of 1% and less.
9. With the exception of deep ocean Variables, most Variables are preferred on a spatial resolution of less than 10 km (Fig.3.6 and Fig. 3.12) and a vertical resolution of up to 10 m (Fig.3.7 and Fig.3.13). Preferences for specific temporal resolutions are less pronounced; however, a tendency for temporal scales in the order of hours or a few days can be detected (Fig.3.8).
10. Forecast periods required range between 10 days and 20 years with only slight preferences for shorter periods (Fig.3.9). Long forecast periods are relatively often requested for Variables linked to anthropogenic contaminants (including pollution) and human health (Fig.3.15). The Building Sector shows a comparatively high interest in long-term forecast periods of over 10 years (Figure 4.5) in many deep sea Variables (e.g. Heat storage, Salinity, Ocean boundary currents, Geostrophic currents, and Interbasin straits currents) (see Annexe, Table 2) that have relevance to offshore oil construction on the outer shelf.
11. Many of the results reveal connections and correlations which confirm common sense and conventional logic. The respondents

who claim to be interested in Environmental Applications demand data on nutrients and water quality, productivity, and pollutants; respondents interested in building and construction want data on currents and waves, etc. The highest accuracy is requested for physical Variables whereas for difficult to measure chemical Variables a 10% accuracy satisfies most demands. These, and numerous other points confirm that the respondents to the survey have revealed genuine and well-informed requirements. The mono-variate discussion of the questionnaire itself, the bias, and balance of respondents (Chapters 1.3, 1.4, and 2), reveals some gaps at the national level, and fisheries and the tourist industry are under-presented at the European total level.

12. Granted the general reliability, though incompleteness, of the survey, the analysis shows many trends and correlations which could not have been anticipated with confidence. These factors will help both in the design of future observing and modelling system, and in the generation of products.

## Recommendations

1. The EuroGOOS Economics WG is conducting analysis of the scale of different industrial, commercial, and environmental sectors in European countries, and for Europe as a whole. In principle, it would be possible from this information to show which variables would have the greatest potential to create economic benefit or environmental benefit. This presupposes that we know the sensitivity of each sector to improved oceanographic data provision, and the rate of uptake of the data.
2. The data and results of this survey should be used as inputs to the EuroGOOS Products Working Group. The Technology Plan Working Group and the Science Advisory Working Group should consider the implications of data requirements for the design of observation and modelling systems.
3. The variables which show the greatest commonality across Europe, and across space scales and applications sectors should be designed into a common system, with the maximum savings and efficiency from common standards, instrumentation compatibility, quality control, and modelling criteria.
4. The Variables which show the strongest and exclusive links to local regions, particular applications Sectors, or particular environments, should be associated with specialised models designed to meet these special needs, and having as a possible input, the common-factor variables produced by the Europe-wide system.
5. An improved survey should be repeated in 3-5 years time. We suggest to prioritise finding links between Applications and Variables and identifying different needs by respondents with identical Applications but from different countries.
6. We recommend that the results of this survey should be available electronically to organisations wishing to work on the data in more detail, and that the national data sets should be made available in more detail to approved customers where possible.

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# EUROGOOS SURVEY

# RESPONSE COVER SHEET

**OFFICE USE ONLY**

FORM NO...................

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**1. Respondent to this survey**

Company/Institution ..........................................................................................................

Address ..........................................................................................................

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Form completed by (name) ..........................................................................................................

Position in organisation ..........................................................................................................

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**2. Application of EuroGOOS data and products**

Please list here the activities of your organisation for which you require data or products from EuroGOOS. Table 1 lists a range of industrial, commercial, service, and research activities. Select the activity from Table 1 which most closely describes your organisation, and enter the number, or numbers, in the box. You may add a note explaining your applications in more detail if you wish.

Sector of Application: Number(s) from Table 1 [ ]

Details of application (optional) ..........................................................................................................

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3. Please state below the number of forms A you are returning.

Form A ...........................

Data will be entered in a confidential computer data base and covered by the regulations of the Data Protection Act.

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Please return to:

Thank you.

See Table 1 over ➔

# EUROGOOS SURVEY

# TABLE 1 application of goos data and products

## sectors of application: PLEASE ENTER ON THE RESPONSE COVER SHEET

**00. Transport (excluding military)**
01. Shipping operations
02. Hovercraft operations
03. Hydrofoil operations
04. Submersible/submarine operations/ROVs
05. Tunnel subsea operations
06. Barrage roads
07. Causeway
08. Bridges, sea channels
09. Navigational safety, lights etc. Electronic charts
10. Safety services, rescue, life preserving, fire
11. Port operations

**12. Energy production**
13. Oil and gas production (Oil companies only)
14. Oil and gas exploration and prospecting, and drilling services
15. OTEC
16. Wave energy
17. Tidal energy
18. Wind energy, offshore installation

**19. Environmental protection/ preservation**
20. Clean beaches
21. Oil pollution control
22. Non-oil pollution control
23. Estuarine pollution
24. Health hazards
25. Marine reserves
26. Species protection
27. Environmental forecasts
28. Flood protection
29. Safe waste disposal
30. Amenity evaluation
31. Environmental quality control
32. Environmental data services

**33. Mineral extraction**
34. Aggregate, sand, gravel
35. Deep ocean, Mn, hydrothermal muds, crusts
36. Placer minerals, diamonds, tin, etc.
37. Salts extraction, magnesia, bromine
38. Desalination
39. Phosphate
40. Coal, subsea

**41. Food from the sea**
42. Fisheries, catching
43. Fish farming
44. Shellfisheries
45. Shellfish, crustacea, farming
46. Fishing gear

**47. Defence**
48. Military vessels, surface and submarine
49. ASW, oceanographic applications
50. Underwater weapons
51. Navigation, position fixing, etc.
52. Defence sales, equipment, components
53. Operations and efficiency, logistics, controls, computing

**54. Building, construction, and engineering**
55. Coastal defences
56. Port construction
57. Dredging
58. Land reclamation
59. Barrage construction
60. Tunnel construction
61. Outfalls/intakes
62. Consulting engineering
63. Components, hydraulics, motors, pumps, batteries, etc.
64. Cables, manufacture and operations, laying
65. Corrosion prevention, paint, antifouling, etc.
66. Heavy lifting, cranes, winches
67. Marine propulsion, efficient ship, automatic ships, DP, props
68. Offshore construction, platforms, etc.
69. Pipelaying, trenching, burial
70. Ship-building, non-defence, all kinds

**71. Services**
72. Certification
73. Climate forecasting
74. Data consultancy
75. Data services
76. Data transmission, telecommunications
77. Diving, including suppliers
78. Inspection, maintenance, repair
79. Insurance
80. Metocean survey, mapping, hydrographic surveys
81. Project management, non-defence, consultancy
82. Remote sensing
83. Salvage, towing
84. Ship routing
85. Weather forecasting

**86. Equipment sales**
87. Marine electronics, instruments, radar, opto-electronics, etc.
88. Sonar
89. Buoys

**90. Tourism and recreation**

**91. Basic and strategic research**
92. Acoustics, electronics
93. Civil engineering
94. Climate change
95. Climate forecasting
96. Coastal modelling
97. Data centre
98. Environmental sciences
99. Estuarine modelling
100. Fisheries
101. Marine biology
102. Marine weather forecasting
103. Ocean modelling
104. Oceanography
105. Polar research
106. Remote sensing
107. Shelf seas modelling
108. Shipping/naval architecture

**109. Hinterland**
110. Agriculture
111. Land use planning or zoning
112. Urban management
113. Local government
114. Wetlands management
115. Public health

**EUROGOOS SURVEY**
**FORM A**
**PRODUCT GRADING** PLEASE READ NOTES PART A BEFORE COMPLETING THIS FORM

**OFFICE USE ONLY**
COMPANY ID....................
SHEET NO.........................

| 1 | 2 | | 3 | | 4 | | 5 | | 6 | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Variable(s)** [from Table 2] | **Geographic Coverage** | **grade** | **Product Type** | **grade** | **Variable Accuracy** | **grade** | **Variable Precision** | **grade** | **Spatial Resolution** | **grade** |
| | Estuarine | | Raw data | | 0.01% | | 0.01% | | <0.5 km | |
| | Coastal seas | | Processed | | 0.10% | | 0.10% | | 0.5 km | |
| | Shelf seas | | Hindcast | | 1.00% | | 1.00% | | 1.0 km | |
| | Ocean basin | | Nowcast | | 10% | | 10% | | 10 km | |
| | Hemisphere | | Forecast | | 20% | | 20% | | 100 km | |
| | Global | | Statistics | | 30% | | 30% | | 500 km | |
| | | | | | | | | | 1000 km | |

| 7 | | 8 | | 9 | | 10 | | 11 | | 12 |
|---|---|---|---|---|---|---|---|---|---|---|
| **Vertical Resolution** | **grade** | **Temporal Resolution** | **grade** | **Latency Delivery** | **grade** | **Forecast Period** | **grade** | **Delivery Medium** | **grade** | **Notes** |
| 1 m | | 1 hour | | 6 hour | | 10 days | | Tape | | |
| 10 m | | 6 hour | | 12 hour | | 30 days | | Disc/CD | | |
| 50 m | | 1 day | | 1 day | | 3 months | | Network/e-mail | | |
| 100 m | | 10 days | | 5 day | | 1 year | | Shipboard | | |
| 500 m | | 1 month | | 1 month | | 10 years | | Fax | | |
| 1000 m | | 3 months | | 6 month | | 20 years | | Hard copy | | |
| | | 1 year | | 1 year | | | | Other* | | |
| | | >1 year | | | | | | | | |

Notes:
1) The characteristics defined by this form refer to the product delivered to you the user, not to the original observations carried out.
2) If you cannot give precise details in all columns a partially completed form will be appreciated.
3) The information on this form will be held on a computer and will be covered by the Data Protection Act.

* Please state preferred mode of delivery

Tick here if you wish to be kept informed of the development of GOOS products described on this form: ☐

Supplementary Notes to Form A

# EuroGOOS SURVEY OF REQUIREMENTS

## NOTES FOR COMPLETING FORMS

### PART A GOOS DATA AND PRODUCTS GRADING

If you might use data products and services from GOOS, please read Part A and complete Form(s) A. Refer to Table 2 for key terms and lists of variables. Partially completed forms are welcome if your requirements cannot be specified in this amount of detail.

**Required data types and products**

Table 2 lists most of the raw data variables proposed as properties of the ocean which could be measured operationally either globally by GOOS, or in coastal and regional sub-programmes or modules of GOOS. "The Case for GOOS" p. A15 Annexe 5 lists typical products.

The objective of Part A of the survey is to provide the following information:

1) What parameters or variables in the ocean or coastal seas are of use to you?
2) What types of products, scales, spatial resolution, and accuracy do you need?
3) For what period into the future is it most useful to have forecasts?
4) What medium for delivery of information would you prefer?

Your organisation probably only requires a small number of the possible data types shown in Table 2. For each data type or combination of data types which you require, please complete a survey Form A 'Product Grading'. Select from Table 2 the relevant variable(s) and enter in column 1 on the Form A. Then tick or grade the various accuracies, product types, and delivery media which you require. If you require data from a number of variables, you may group or aggregate them onto single forms, provided that you require all the variables on that form with similar levels of accuracy, resolution, latency, geographical coverage, etc. Data which require different sampling and treatments must be entered on different forms.

Photocopy as many extra copies of Form A as you need. Three forms are provided.

**Column 1 - Variables**

The variables and parameters which describe the physical state of the ocean, and a range of biological, chemical, and geological factors, are listed in 13 groups in Table 2. Certain concepts such as heat flux or currents appear in different groups, e.g., surface layers, deep ocean, boundary currents, etc. When entering your choice of variable(s) in Column 1 of the Form you need only enter the number(s) of each of the variable(s) from Table 2.

Some data types which are very dependent upon particular instruments, such as satellite remote sensed sea surface temperature, XBT, CTD etc., are listed as separate variables, but in each case only once.

The data are listed in Table 2 as basic physical and environmental variables in most cases because these are the lowest levels of information which are likely to be needed by users operating assimilation programmes for descriptive and forecasting models, conducting research, or acquiring data to develop specialised multi-parameter products. If you generally require combined products such as combined 10 day forecasts of wind speed, wave conditions, currents, and ice conditions, list the numbers of the most useful combination of variables in Column 1. If there are two or more such groupings which are likely to be useful, please enter them on separate Forms A.

In many cases the unit or dimension of the variable is obvious, e.g. °C or PSU or m $s^{-1}$. If possible, state the preferred or most generally used unit for the data type, e.g. μg $l^{-1}$, ppm, km/day, megawatts $km^{-2}$, or units of radioactivity, etc. This information will ensure that the accuracy and precision required are unambiguous.

At the end of Table 2 the following categories occur:

- Year-long or multi-year time series
- Decadal time series
- Multi-decade time series
- Climatic statistics
- Spatial statistics
- Past model outputs
- Composite multi-parameter products
- Spectra or other reduced statistics

These category numbers can be used in combination with the Variable or groups of Variables to qualify further the type of products which you need.

**Grading:** For Column 2 and subsequent columns you have the option to either tick the values which you consider to be useful, or to grade the options on a scale of 1-5. The grade scale is:

5. An ideal product which would meet the highest requirements.
4. A good product which would be very useful.
3. A useful product.
2. This might be useful, but it falls short of what we need.
1. Marginal. Might have some occasional use.

Blank. This is of no interest to my organisation.

If you do not wish to grade your choices, please make only one entry as a tick against the value which you consider useful. This will be valued as a Grade 3 mark in analysis of the Forms.

Allocation of Grades: The objective is to rank products in order, from those which are most useful to those which it would be pointless to develop. When allocating grades, please start at the coarse/low resolution/low value end for each characteristic and consider the values which would not be useful. Work upwards to values or products of greater use to you. When you reach a value or type of product which would be useful, give it a grade or tick. Allocate grade 5 to the accuracy/resolution/ delivery etc. which would satisfy your requirements. Please do not mark higher levels of accuracy/resolution/etc. than are needed. This would tend to delay development of an operational system. It is assumed that higher levels of accuracy/resolution/faster delivery etc. would satisfy your requirements

You can skip grades, marking one as '1', the next '3', and the next '5' if you wish.

In making your choice, do not be constrained by what you know to be available or measurable in 1993. In 10 years time it may be possible to create the product at the accuracy and speed you really need.

**Column 2 - Geographic Coverage**

Grade the typical areas of geographical coverage which you are most likely to require. There is no need to indicate actual oceans or sea areas, although this information can be added in Column 12 as an option. Coastal seas are defined as including wetlands and coastal waters out to a distance of 10-20km. Shelf Seas are defined as full continental shelf width, or out to 200 nautical miles. Ocean basin means North Atlantic, Southern Ocean, etc.

**Column 3 - Product Type**

This column allows you to grade the type of products or level of processing which you are most to require.

- Raw data defines a stream of observational data with time and geographical co-ordinates plus quality control information. Such data could be delivered operationally for assimilation into models, or for hazard or alert warnings.
- Processed data implies that a form of statistical treatment, contouring, averaging, gridding, has been applied, or that variables have been combined or corrected to obtain derived parameters. These data have not been assimilated into operational or research models.
- Hindcast data describes data sets which have been processed through a numerical model to provide the best possible description or approximation to a past state of the ocean. Hindcast model output

would resolve or detect details and process not shown by the raw data, and present fields at a higher resolution.

- Nowcast products are model outputs which seek to provide the most accurate and rapidly available description of the state of the ocean at the time of data distribution.
- Forecast products will be concentrated on periods of 10 days or longer.  See column 10 for detailed grading.
- Statistical products include a wide range of climatic and engineering summaries of data such as spectra, occurrence and exceedance diagrams, predicted maxima and minima, percentage probabilities, recurrence intervals, variability, co-occurrence probabilities, inter-annual changes, anomalies as departures from multi-year mean values, etc.

**Column 4 - Variable Accuracy**

Data or derived data products have an accuracy determined in part by the accuracy of the original observations, and in part by the subsequent transmission, processing, assimilation, and modelling.  If the product which you require is a set of raw data prior to assimilation, the accuracy you stipulate will define the accuracy of observation.  If you require a processed or modelled output, the accuracy refers to the accuracy of the product or data set provided to you as compared to a check of the predicted value subsequently observed in the field.

For those physical variables which are expressed in numerical fields, contours, or vectors, the accuracy is expressed as an error % of the typical mean value or range.  For chemical concentrations, this is also the case.  For characteristics or variables which are themselves composite, or are usually described with several component variables (e.g. time of arrival, phase, amplitude, position, direction, etc.) it is not possible to show all the components in Table 2.  Biological data often consist of qualitative, descriptive, and numerical data in combination.  Please assume that the necessary species information is included in the product, and apply the accuracy criteria to the quantitative data.  Comments on important criteria, species information, units, expected range of values, etc., may be added in Column 1 or Column 12 of the Form.  Please note that commercial fisheries data and fisheries monitoring and stock assessment are excluded from the observing system of GOOS as these activities are conducted by other agencies.

**Column 5 - Variable Precision**

Grade the precision required as a % of range or mean value for each variable.

**Column 6 - Spatial Resolution**

If you require raw data prior to modelling or processing, grade the lateral spatial resolution of field data sampling  which would be required.  Horizontal spatial resolution of products resulting from diagnostic and forecasting models can be significantly finer  and contain more detail than the original observing scheme.  Grade the spatial resolutions required.

**Column 7 - Vertical resolution**

Assuming a data set consisting of profiles or sections showing variable values and properties at standard depth intervals,  or a fully 3-dimensional data set, grade the vertical resolution which you require for each variable.  Table 2 allows you to select variables which are specified as sea surface, upper layer, or deep ocean, and you may specify different vertical resolutions depending on the depth.  Where Table 2 does not present the same variable in different depth ranges, but you wish to specify variable vertical resolution, please add notes in Column 12.

**Column 8 - Temporal Resolution**

Temporal resolution of an observing scheme or data product defines the time interval of observational data sampling or the time step of output data presentation at a single point, or within a defined standard area.  It is therefore linked to spatial resolution.  If you require unprocessed observational data, grade the temporal resolution which you would require within a square of the preferred spatial resolution indicated in Column 6.  If you require processed, assimilated, or model output data, the product may either include data sets repeated at the time step of the model, or reduced or averaged products, fluxes, velocities, etc., based on integrations of the model.  In either case, please grade the temporal resolution you require.

**Column 9 - Latency of Delivery**

The latency of delivery defines the time elapsed between observation of the last variable value at sea which is included in the data set, and the delivery of the data or product to the user. Thus a 10-day forecast which is computed rapidly and delivered within 6 hours will have a maximal value; the same forecast delivered after 5 days has less value. Long period forecasts will require a great deal of data and computation, and it would be reasonable to allow a latency of 1 month for a 1 year forecast.

**Column 10 - Forecast Period**

GOOS will concentrate on providing data sets describing oceanographic physical, chemical, and biological processes with periods of variability longer than atmospheric weather. There may be some overlap of interest with conventional marine meteorological services, but the intention is to provide a continuity of services, and to avoid duplication. Most GOOS forecasts will be for periods of 10 days or more. Accuracy and temporal and spatial resolution will tend to degrade with increased period of forecast

**Column 11 - Delivery Medium**

GOOS data and data products may be delivered through any global communications system, satellite links, academic networks, or dedicated operational links. Users requiring large volumes of data for operational models should select appropriate media for data delivery. The prioritised method of data delivery should be chosen for higher level data products. Very high data rate links may exist in a few years time, together with improved versions or additions to the WMO Global Telecommunications System.

Thank you for completing Form A. If there are further details of your activities or requirements which would help in the design of GOOS, please add them in the space for supplementary notes on the back of Form A.

# EuroGOOS SURVEY

# TABLE 2 data variables and parameters in goos data products

**PLEASE SELECT FROM THIS TABLE TO COMPLETE COLUMN 1 OF FORM(S) A**

## A. SURFACE FIELDS

1. Sea surface temperature
2. Sea surface Wind stress
3. Velocity
4. Direction
5. Heat flux
6. Moisture flux
7. Precipitation
8. Sea surface salinity
9. Wave spectrum
10. Wave direction spectrum
11. Waves Hs
12. Wave Period
13. Wave swell
14. Sea surface $CO_2$
15. Sea surface GHGs

## B. Sea surface TOPOGRAPHY

16. Hourly mean sea level
17. Marine geoid
18. Monthly mean sea level
19. Sea level anomaly
20. Oceanic tides
21. Geostrophic currents
22. Meteorological forcing

## C. UPPER LAYER FIELDS

23. XBT sections
24. XCTD sections
25. Tropical upper ocean, structure
26. Upper ocean heat content
27. Upper ocean salinity
28. Upper ocean fresh water
29. Upper ocean heat transport
30. Upper ocean heat flux
31. Fresh water transport
32. Fresh water flux
33. Salt transport
34. Salt flux
35. Buoyancy flux
36. Upper ocean velocity fields
37. Momentum fields
38. Surface currents
39. Upwelling velocities
40. Downwelling velocities
41. Eddies, jets, fronts
42. Carbon transport
43. Carbon inventory
44. Carbon budgets

## D. SEA ICE

45. Extent, boundary, leads, %
46. Concentration
47. Surface ice state
48. Surface ice roughness
49. Thickness
50. Temperature
51. Air, sea, ice, temperatures
52. Ice motion
53. Albedo
54. Snow on ice
55. Water on ice

## E. ICE SHELVES

56. Extent, boundary
57. Topography
58. Roughness
59. Surface state
60. Bottom topography
61. Snow line
62. Mass balance
63. Albedo
64. Surface temperature
65. Surface ice velocity
66. Sub-shelf ocean circulation

## F. ICEBERGS

67. Numbers
68. Distribution
69. Trajectories
70. Area, volume

## G. DEEP OCEAN

71. CTD sections
72. Deep ocean salinity
73. Deep ocean ht storage
74. Deep ocean carbon storage
75. Deep ocean water storage
76. Ocean tracers
77. Ocean boundary currents
78. Inter-basin straits currents

## H. SEA BED

79. Bathymetry
80. Surface outcrops
81. Surface sediments
82. Gridded bathymetry
83. Gravity

84. Magnetics
85. Heat flow

## I. COASTAL & SHELF

86. Coastline map
87. Hinterland topography
88. Coastal bathymetry
89. Shelf bathymetry
90. Tidal constants
91. Tidal ellipses
92. Stratification
93. River runoff
94. Land non-river runoff
95. Sediment transport
96. Wetlands characteristics

## J. BIO-GEOCHEMICAL

97. Chlorophyll
98. Nitrate
99. Phosphate
100. Oxygen
101. Silicate
102. Iron
103. Biological pigments
104. Pathogens
105. Synthetic organics
106. Artificial radionuclides
107. Petroleum hydrocarbons
108. Pesticides & Herbicides
109. Trace metals
110. PAHs
111. Pharmaceutical wastes
112. Phytoplankton
113. Zooplankton
114. Carbon dioxide
115. Tritium
116. Aquatic toxins
117. Human health risks
118. Suspended sediments

## K. OPTICS

119. Incident light spectrum
120. Depth of photic zone
121. Transmissivity
122. RS reflected light spectrum
123. Phosphorescence
124. Bioluminescence
125. Secchi disk depth

## L. ACOUSTICS

126. Sound velocity profiles
127. Sound ray paths
128. Acoustic scattering
129. Reverberation characteristics
130. Ambient noise spectrum
131. Anthropogenic noise
132. Seabed acoustic prop's
133. Acoustic tomography
134. Acoustic thermometry
135. Acoustic models (shelf)
136. Acoustic models (oceanic)

## M. DATA STRUCTURE

137. Year-long time series
138. Decadal time series
139. Multi-decade time series
140. Climatic statistics
141. Spatial statistics
142. Past model outputs
143. Composite multi-parameter products
144. Spectra or other reduced statistics

## N. HINTERLAND

145. Coastal land use
146. Vegetation cover
147. Agricultural crops
148. Urbanisation
149. Population density
150. Industrial characteristics

# Acronyms Annexe 3

| | |
|---|---|
| ASW | Anti-Submarine Warfare |
| CTD | Conductivity Temperature Depth |
| CZEW | Coastal Zone Earth Watch (ESA) |
| ERS | EuroGOOS Requirements Survey |
| ESA | European Space Agency |
| ESRIN | European Space Research Centre, Frascati, Italy |
| ESTEC | European Space Technology Centre, Netherlands |
| EuroGOOS | European Global Ocean Observing System |
| GHGs | Greenhouse gases |
| GOOS | Global Ocean Observing System |
| IACMST | Inter-Agency Committee on Marine Science and Technology |
| IOC | Intergovernmental Oceanographic Commission |
| OCCAM | Ocean Circulation and Climate Advanced Modelling |
| OECD | Organisation for Economic Co-operation and Development |
| OOSDP | Ocean Observing System Development Panel |
| OTEC | Ocean Thermal Energy Conversion |
| PAHs | Polycyclic Aromatic Hydrocarbons |
| ROV | Remote Operated Vehicle |
| WG | Working Group |
| WHOI | Woods Hole Oceanographic Institution |
| XBT | Expendable Bathythermograph |
| XCTD | Expendable Conductivity Temperature Depth sensor |

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# Tables, extended versions    Annexe 5

**Table 1**. *Variables ranked in the order of number of requests by all respondents. No = number of respondents requesting variable*

| Rank | Variable | Variable Group | No |
|---|---|---|---|
| 1 | Current Velocity | Surface fields | 94 |
| 2 | Current Direction | Surface fields | 93 |
| 3 | Waves Hs | Surface fields | 85 |
| 4 | Wave Period | Surface fields | 81 |
| 5 | Sea surface temperature | Surface fields | 79 |
| 6 | Wave direction spectrum | Surface fields | 75 |
| 7 | Sea surface Wind stress | Surface fields | 71 |
| 8 | Wave spectrum | Surface fields | 68 |
| 9 | Wave swell | Surface fields | 67 |
| 10 | Coastal bathymetry | Coastal & Shelf | 60 |
| 11 | Sea surface salinity | Surface fields | 60 |
| 12 | Coastline map | Coastal & Shelf | 58 |
| 13 | Bathymetry | Sea Bed | 56 |
| 14 | Surface currents | Upper Layer Fields | 55 |
| 15 | Hourly mean sea level | Sea Surface topogr. | 48 |
| 16 | Sediment transport | Coastal & Shelf | 44 |
| 17 | Shelf bathymetry | Coastal & Shelf | 41 |
| 18 | Surface sediments | Sea Bed | 39 |
| 19 | Oceanic tides | Sea Surface topogr. | 38 |
| 20 | Geostrophic currents | Sea Surface topogr. | 35 |
| 21 | Tidal constants | Coastal & Shelf | 35 |
| 22 | Upper ocean salinity | Upper Layer Fields | 35 |
| 23 | Precipitation | Surface fields | 35 |
| 24 | Meteorological forcing | Sea Surface topogr. | 34 |
| 25 | Monthly mean sea level | Sea Surface topogr. | 34 |
| 26 | River runoff | Coastal & Shelf | 34 |
| 27 | Phytoplankton | Biogeochemical | 34 |
| 28 | Suspended sediments | Biogeochemical | 34 |
| 29 | Sea level anomaly | Sea Surface topogr. | 33 |
| 30 | Chlorophyll | Biogeochemical | 33 |
| 31 | Gridded bathymetry | Sea Bed | 32 |
| 32 | Nitrate | Biogeochemical | 31 |
| 33 | Oxygen | Biogeochemical | 31 |
| 34 | CTD sections | Deep Ocean | 30 |
| 35 | Stratification | Coastal & Shelf | 30 |
| 36 | Eddies, jets, fronts | Upper Layer Fields | 30 |
| 37 | Sound velocity profiles | Acoustics | 29 |
| 38 | Upper ocean veloc.fields | Upper Layer Fields | 29 |
| 39 | Phosphate | Biogeochemical | 29 |
| 40 | Surface outcrops | Sea Bed | 26 |
| 41 | Heat flux | Surface fields | 26 |
| 42 | Deep ocean salinity | Deep Ocean | 25 |
| 43 | Extent, boundary, leads,% | Sea Ice | 25 |
| 44 | Upwelling velocities | Upper Layer Fields | 25 |
| 45 | Zooplankton | Biogeochemical | 24 |
| 46 | XCTD sections | Upper Layer Fields | 23 |
| 47 | Concentration | Sea Ice | 22 |
| 48 | Marine geoid | Sea Surface topogr. | 22 |
| 49 | Hinterland topography | Coastal & Shelf | 22 |
| 50 | Land non-river runoff | Coastal & Shelf | 22 |
| 51 | Tidal ellipses | Coastal & Shelf | 22 |
| 52 | XBT sections | Upper Layer Fields | 22 |
| 53 | Moisture flux | Surface fields | 22 |
| 54 | Downwelling velocities | Upper Layer Fields | 21 |
| 55 | Silicate | Biogeochemical | 21 |
| 56 | Wetlands characteristics | Coastal & Shelf | 20 |
| 57 | Trace metals | Biogeochemical | 20 |
| 58 | Biological pigments | Biogeochemical | 19 |
| 59 | Air, sea, ice, temperatures | Sea Ice | 18 |
| 60 | Fresh water transport | Upper Layer Fields | 18 |
| 61 | Petroleum hydrocarbons | Biogeochemical | 18 |
| 62 | Acoustic scattering | Acoustics | 17 |
| 63 | Aquatic toxins | Biogeochemical | 17 |
| 64 | Inter-basin straits currents | Deep Ocean | 16 |
| 65 | Ocean boundary currents | Deep Ocean | 16 |
| 66 | Ice motion | Sea Ice | 16 |
| 67 | Thickness | Sea Ice | 16 |
| 68 | Upper ocean fresh water | Upper Layer Fields | 16 |

| Rank | Variable | Variable Group | No |
|---|---|---|---|
| **69** | Artificial radionuclides | Biogeochemical | 16 |
| **70** | PAHs | Biogeochemical | 16 |
| 71 | Pesticides & Herbicides | Biogeochemical | 16 |
| 72 | Transmissivity | Optics | 15 |
| 73 | Albedo | Sea Ice | 15 |
| 74 | Ambient noise spectrum | Acoustics | 15 |
| 75 | Seabed acoustic prop's | Acoustics | 15 |
| **76** | Magnetics | Sea Bed | 15 |
| 77 | Salt transport | Upper Layer Fields | 15 |
| 78 | Carbon dioxide | Biogeochemical | 15 |
| 79 | Sea surface CO2 | Surface fields | 15 |
| 80 | Acoustic tomography | Acoustics | 14 |
| 81 | Gravity | Sea Bed | 14 |
| 82 | Fresh water flux | Upper Layer Fields | 14 |
| 83 | Upper ocean heat content | Upper Layer Fields | 14 |
| 84 | Iron | Biogeochemical | 14 |
| 85 | Distribution | Icebergs | 13 |
| 86 | Numbers | Icebergs | 13 |
| 87 | Trajectories | Icebergs | 13 |
| 88 | Depth of photic zone | Optics | 13 |
| 89 | Ocean tracers | Deep Ocean | 13 |
| 90 | Acoustic models (shelf) | Acoustics | 13 |
| 91 | Sound ray paths | Acoustics | 13 |
| 92 | Surface ice state | Sea Ice | 13 |
| 93 | Reverberation charact. | Acoustics | 12 |
| 94 | Surface ice roughness | Sea Ice | 12 |
| 95 | Momentum fields | Upper Layer Fields | 12 |
| 96 | Salt flux | Upper Layer Fields | 12 |
| 97 | Human health risks | Biogeochemical | 12 |
| 98 | Pathogens | Biogeochemical | 12 |
| 99 | Synthetic organics | Biogeochemical | 12 |
| 100 | Anthropogenic noise | Acoustics | 11 |
| 101 | Temperature | Sea Ice | 11 |
| 102 | Carbon transport | Upper Layer Fields | 11 |
| 103 | Sea surface GHGs | Surface fields | 11 |
| 104 | Area, volume | Icebergs | 10 |
| 105 | Secchi disk depth | Optics | 10 |
| 106 | Extent, boundary | Ice Shelves | 10 |
| 107 | Buoyancy flux | Upper Layer Fields | 10 |
| 108 | Upper ocean heat flux | Upper Layer Fields | 10 |
| 109 | Upper ocean heat transport | Upper Layer Fields | 10 |
| 110 | Deep ocean ht storage | Deep Ocean | 9 |
| 111 | Acoustic models (oceanic) | Acoustics | 9 |
| 112 | Snow on ice | Sea Ice | 9 |
| 113 | Water on ice | Sea Ice | 9 |
| 114 | Heat flow | Sea Bed | 9 |
| 115 | Tritium | Biogeochemical | 9 |
| 116 | Bioluminescence | Optics | 8 |
| 117 | Surface ice velocity | Ice Shelves | 8 |
| 118 | Deep ocean carbon stor. | Deep Ocean | 8 |
| 119 | Deep ocean water storage | Deep Ocean | 8 |
| 120 | Carbon budgets | Upper Layer Fields | 8 |
| 121 | Carbon inventory | Upper Layer Fields | 8 |
| 122 | Tropic.upper ocean, struct. | Upper Layer Fields | 8 |
| 123 | Bottom topography | Ice Shelves | 7 |
| 124 | Sub-shelf ocean circulation | Ice Shelves | 7 |
| 125 | Surface temperature | Ice Shelves | 7 |
| 126 | Acoustic thermometry | Acoustics | 7 |
| 127 | Mass balance | Ice Shelves | 6 |
| 128 | Snow line | Ice Shelves | 6 |
| 129 | Surface state | Ice Shelves | 6 |
| 130 | Topography | Ice Shelves | 6 |
| 131 | Pharmaceutical wastes | Biogeochemical | 6 |
| 132 | Phosphorescence | Optics | 5 |
| 133 | Roughness | Ice Shelves | 5 |
| 134 | Albedo | Ice Shelves | 5 |
| 135 | Incident light spectrum | Optics | 4 |
| 136 | RS reflected light spectrum | Optics | 4 |

**Table 2**. *Variables requested by Single Application Sector respondents. Ranked by no of Sectors (#), then by no of respondents requesting the Variable (Σ)*

.

| Sector | Description | Application Groups | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Building | Defence | Energy | Environ ment | Food | Research | Transport | Σ | # |
| Surface fields | Current Direction | 4 | 1 | 2 | 2 | 3 | 15 | 8 | **35** | **7** |
| Surface fields | Current Velocity | 4 | 1 | 2 | 2 | 3 | 15 | 7 | **34** | **7** |
| Surface fields | Sea surface temperature | 1 | 1 | 1 | 2 | 3 | 17 | 4 | **29** | **7** |
| Surface fields | Sea surface Wind stress | 2 | 1 | 1 | 2 | 2 | 14 | 4 | **26** | **7** |
| Surface fields | Wave direction spectrum | 4 | 2 | 2 | 1 | 3 | 9 | 4 | **25** | **7** |
| Surface fields | Waves Hs | 4 | 1 | 2 | 1 | 3 | 9 | 3 | **23** | **7** |
| Surface fields | Wave Period | 4 | 1 | 2 | 1 | 2 | 8 | 4 | **22** | **7** |
| Surface fields | Wave spectrum | 3 | 2 | 1 | 1 | 1 | 9 | 4 | **21** | **7** |
| Surface fields | Wave swell | 4 | 1 | 2 | 1 | 1 | 7 | 4 | **20** | **7** |
| Coastal & Shelf | Coastline map | 2 | 2 | 1 | 2 | 1 | 8 | 1 | **17** | **7** |
| Coastal & Shelf | Coastal bathymetry | 2 | 1 | 1 | 2 | 1 | 9 | | **16** | **6** |
| Sea Surface topogr. | Hourly mean sea level | 2 | 1 | 1 | 2 | | 5 | 5 | **16** | **6** |
| Surface fields | Sea surface salinity | 1 | | 1 | 2 | | 16 | 1 | **21** | **5** |
| Upper Layer Fields | Surface currents | 1 | 2 | 2 | | 1 | 11 | | **17** | **5** |
| Biogeochemical | Phytoplankton | 1 | 1 | | 2 | 1 | 10 | | **15** | **5** |
| Coastal & Shelf | River runoff | 2 | | 1 | 1 | | 8 | 1 | **13** | **5** |
| Sea Surface topogr. | Oceanic tides | 1 | | 1 | 1 | | 7 | 3 | **13** | **5** |
| Upper Layer Fields | Upper ocean velocity fields | 2 | 1 | 2 | 1 | | 7 | | **13** | **5** |
| Sea Bed | Gridded bathymetry | 2 | 1 | 1 | 1 | | 7 | | **12** | **5** |
| Coastal & Shelf | Sediment transport | 2 | | 1 | 2 | | 5 | 1 | **11** | **5** |
| Coastal & Shelf | Shelf bathymetry | 2 | 1 | 1 | 1 | | 6 | | **11** | **5** |
| Coastal & Shelf | Tidal constants | 2 | 1 | 1 | 1 | | 6 | | **11** | **5** |
| Upper Layer Fields | Upwelling velocities | 1 | 1 | 2 | 1 | | 6 | | **11** | **5** |
| Acoustics | Sound velocity profiles | 1 | 2 | 1 | | | 2 | 1 | **7** | **5** |
| Upper Layer Fields | Upper ocean salinity | | 2 | 1 | 1 | | 12 | | **16** | **4** |
| Biogeochemical | Nitrate | 1 | 1 | | 4 | | 9 | | **15** | **4** |
| Biogeochemical | Chlorophyll | 1 | 1 | | 3 | | 9 | | **14** | **4** |
| Deep Ocean | CTD sections | 1 | 1 | 1 | | | 11 | | **14** | **4** |
| Biogeochemical | Suspended sediments | 1 | | | 1 | 2 | 9 | | **13** | **4** |
| Biogeochemical | Oxygen | 1 | | | 3 | 2 | 6 | | **12** | **4** |
| Surface fields | Precipitation | 1 | | 1 | 1 | | 9 | | **12** | **4** |
| Upper Layer Fields | Eddies, jets, fronts | 1 | 1 | 2 | | | 8 | | **12** | **4** |
| Coastal & Shelf | Land non-river runoff | 2 | | 1 | 1 | | 7 | | **11** | **4** |
| Coastal & Shelf | Stratification | 2 | | 1 | 1 | | 7 | | **11** | **4** |
| Sea Surface topogr. | Geostrophic currents | 1 | | 1 | 1 | | 8 | | **11** | **4** |
| Sea Surface topogr. | Sea level anomaly | 2 | | 1 | 1 | | 7 | | **11** | **4** |
| Surface fields | Heat flux | 1 | | 1 | 1 | | 8 | | **11** | **4** |
| Upper Layer Fields | XCTD sections | 2 | 1 | 1 | | | 7 | | **11** | **4** |
| Deep Ocean | Deep ocean salinity | 1 | 1 | 1 | | | 7 | | **10** | **4** |
| Sea Surface topogr. | Marine geoid | 2 | | 1 | 1 | | 6 | | **10** | **4** |
| Sea Surface topogr. | Meteorological forcing | 1 | | 1 | 2 | | 6 | | **10** | **4** |
| Sea Surface topogr. | Monthly mean sea level | 2 | | 1 | 1 | | 6 | | **10** | **4** |
| Biogeochemical | Artificial radionuclides | 1 | 1 | | 1 | | 6 | | **9** | **4** |
| Biogeochemical | Biological pigments | 1 | 1 | | 1 | | 6 | | **9** | **4** |
| Surface fields | Moisture flux | 1 | | 1 | 1 | | 6 | | **9** | **4** |
| Upper Layer Fields | Downwelling velocities | 1 | 1 | 2 | | | 5 | | **9** | **4** |
| Upper Layer Fields | Fresh water transport | 1 | | 1 | | | 6 | 1 | **9** | **4** |
| Upper Layer Fields | XBT sections | 1 | 1 | 1 | | | 6 | | **9** | **4** |
| Coastal & Shelf | Tidal ellipses | 2 | | 1 | 1 | | 4 | | **8** | **4** |
| Coastal & Shelf | Wetlands characteristics | 2 | | 1 | 1 | | 4 | | **8** | **4** |
| Coastal & Shelf | Hinterland topography | 2 | | 1 | 1 | | 3 | | **7** | **4** |
| Sea Ice | Ice motion | | 1 | 1 | | | 4 | 1 | **7** | **4** |
| Surface fields | Sea surface CO2 | 1 | | 1 | 1 | | 4 | | **7** | **4** |
| Biogeochemical | Human health risks | 1 | | | 1 | 1 | 3 | | **6** | **4** |
| Biogeochemical | Pathogens | 1 | | | 2 | 1 | 2 | | **6** | **4** |
| Biogeochemical | Pesticides & Herbicides | 1 | | | 1 | 1 | 3 | | **6** | **4** |
| Surface fields | Sea surface GHGs | 1 | | 1 | 1 | | 2 | | **5** | **4** |
| Sea Bed | Bathymetry | 2 | | 2 | | | 12 | | **16** | **3** |
| Biogeochemical | Phosphate | 1 | | | 4 | | 8 | | **13** | **3** |
| Biogeochemical | Silicate | 1 | | | 3 | | 6 | | **10** | **3** |
| Biogeochemical | Zooplankton | 1 | | | 1 | | 8 | | **10** | **3** |
| Sea Bed | Surface sediments | 2 | | 2 | | | 6 | | **10** | **3** |
| Sea Ice | Extent, boundary, leads, % | | 1 | 2 | | | 7 | | **10** | **3** |
| Biogeochemical | Trace metals | 1 | | | 2 | | 5 | | **8** | **3** |
| Deep Ocean | Ocean tracers | 1 | | 1 | | | 6 | | **8** | **3** |
| Sea Ice | Concentration | | 1 | 2 | | | 5 | | **8** | **3** |
| Upper Layer Fields | Upper ocean fresh water | | 1 | 1 | | | 6 | | **8** | **3** |

| Sector | Description | Application Groups | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Building | Defence | Energy | Environ ment | Food | Research | Transport | Σ | # |
| Deep Ocean | Inter-basin straits currents | 1 | | 1 | | | 5 | | **7** | **3** |
| Deep Ocean | Ocean boundary currents | 1 | | 1 | | | 5 | | **7** | **3** |
| Sea Bed | Surface outcrops | 2 | | 1 | | | 4 | | **7** | **3** |
| Sea Ice | Air, sea, ice, temperatures | | | 1 | | | 4 | 2 | **7** | **3** |
| Upper Layer Fields | Fresh water flux | 1 | | 1 | | | 5 | | **7** | **3** |
| Upper Layer Fields | Salt transport | 1 | | 1 | | | 5 | | **7** | **3** |
| Biogeochemical | Aquatic toxins | 1 | | | | 2 | 3 | | **6** | **3** |
| Biogeochemical | Iron | 1 | | | 3 | | 2 | | **6** | **3** |
| Biogeochemical | PAHs | 1 | | | 2 | | 3 | | **6** | **3** |
| Biogeochemical | Petroleum hydrocarbons | 1 | | | 2 | | 3 | | **6** | **3** |
| Upper Layer Fields | Salt flux | 1 | | 1 | | | 4 | | **6** | **3** |
| Biogeochemical | Synthetic organics | 1 | | | 1 | | 3 | | **5** | **3** |
| Optics | Bioluminescence | | 1 | | | | 3 | 1 | **5** | **3** |
| Sea Bed | Magnetics | 1 | | 1 | | | 3 | | **5** | **3** |
| Sea Ice | Surface ice roughness | | 1 | 1 | | | 3 | | **5** | **3** |
| Sea Ice | Temperature | | | 1 | | | 3 | 1 | **5** | **3** |
| Sea Ice | Thickness | | 1 | 1 | | | 3 | | **5** | **3** |
| Upper Layer Fields | Buoyancy flux | 1 | | 1 | | | 3 | | **5** | **3** |
| Biogeochemical | Pharmaceutical wastes | 1 | | | 1 | | 2 | | **4** | **3** |
| Deep Ocean | Deep ocean ht storage | 1 | | 1 | | | 2 | | **4** | **3** |
| Sea Bed | Heat flow | 1 | | 1 | | | 2 | | **4** | **3** |
| Upper Layer Fields | Momentum fields | 1 | | 1 | | | 2 | | **4** | **3** |
| Upper Layer Fields | Upper ocean heat content | | | 1 | 1 | | 2 | | **4** | **3** |
| Sea Bed | Gravity | 1 | | 1 | | | 1 | | **3** | **3** |
| Biogeochemical | Carbon dioxide | 1 | | | | | 6 | | **7** | **2** |
| Optics | Depth of photic zone | | | | 1 | | 6 | | **7** | **2** |
| Optics | Transmissivity | | 1 | | | | 5 | | **6** | **2** |
| Upper Layer Fields | Carbon transport | | | 1 | | | 5 | | **6** | **2** |
| Upper Layer Fields | Carbon budgets | | | 1 | | | 5 | | **6** | **2** |
| Upper Layer Fields | Carbon inventory | | | 1 | | | 5 | | **6** | **2** |
| Biogeochemical | Tritium | 1 | | | | | 4 | | **5** | **2** |
| Icebergs | Area, volume | | | 2 | | | 3 | | **5** | **2** |
| Icebergs | Distribution | | | 2 | | | 3 | | **5** | **2** |
| Icebergs | Numbers | | | 2 | | | 3 | | **5** | **2** |
| Icebergs | Trajectories | | | 2 | | | 3 | | **5** | **2** |
| Deep Ocean | Deep ocean carbon storage | | | 1 | | | 3 | | **4** | **2** |
| Deep Ocean | Deep ocean water storage | | | 1 | | | 3 | | **4** | **2** |
| Ice Shelves | Bottom topography | | | 1 | | | 3 | | **4** | **2** |
| Ice Shelves | Extent, boundary | | | 1 | | | 3 | | **4** | **2** |
| Ice Shelves | Sub-shelf ocean circulation | | | 1 | | | 3 | | **4** | **2** |
| Ice Shelves | Surface ice velocity | | | 1 | | | 3 | | **4** | **2** |
| Sea Ice | Albedo | | | 1 | | | 3 | | **4** | **2** |
| Sea Ice | Snow on ice | | | 1 | | | 3 | | **4** | **2** |
| Sea Ice | Surface ice state | | | 1 | | | 3 | | **4** | **2** |
| Upper Layer Fields | Upper ocean heat flux | | | 1 | | | 3 | | **4** | **2** |
| Upper Layer Fields | Upper ocean heat transport | | | 1 | | | 3 | | **4** | **2** |
| Acoustics | Acoustic tomography | | 1 | | | | 2 | | **3** | **2** |
| Ice Shelves | Albedo | | | 1 | | | 2 | | **3** | **2** |
| Ice Shelves | Mass balance | | | 1 | | | 2 | | **3** | **2** |
| Ice Shelves | Roughness | | | 1 | | | 2 | | **3** | **2** |
| Ice Shelves | Snow line | | | 1 | | | 2 | | **3** | **2** |
| Ice Shelves | Surface state | | | 1 | | | 2 | | **3** | **2** |
| Ice Shelves | Surface temperature | | | 1 | | | 2 | | **3** | **2** |
| Ice Shelves | Topography | | | 1 | | | 2 | | **3** | **2** |
| Sea Ice | Water on ice | | | 1 | | | 2 | | **3** | **2** |
| Upper Layer Fields | Tropical upper ocean, struct | | | 1 | | | 2 | | **3** | **2** |
| Acoustics | Acoustic scattering | | 1 | | | | 1 | | **2** | **2** |
| Acoustics | Sound ray paths | | 1 | | | | 1 | | **2** | **2** |
| Acoustics | Seabed acoustic prop's | | | | | | 3 | | **3** | **1** |
| Optics | Secchi disk depth | | | | | | 3 | | **3** | **1** |
| Acoustics | Anthropogenic noise | | | | | | 2 | | **2** | **1** |
| Optics | Incident light spectrum | | | | | | 2 | | **2** | **1** |
| Optics | Phosphorescence | | | | | | 2 | | **2** | **1** |
| Acoustics | Acoustic models (oceanic) | | | | | | 1 | | **1** | **1** |
| Acoustics | Acoustic models (shelf) | | | | | | 1 | | **1** | **1** |
| Acoustics | Acoustic thermometry | | | | | | 1 | | **1** | **1** |
| Acoustics | Ambient noise spectrum | | | | | | 1 | | **1** | **1** |
| Acoustics | Reverberation charact. | | | | | | 1 | | **1** | **1** |
| Optics | RS reflected light spectrum | | | | | | 1 | | **1** | **1** |
| Grand Total | | 126 | 48 | 126 | 88 | 34 | 748 | 63 | **1233** | **7** |

# *Membership of EuroGOOS*

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ENEA, Italy
Environment Agency (EA) (formerly NRA), UK
Finnish Institute of Marine Research, Finland
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IFREMER, France
Institute of Marine Research, Bergen, Norway
Institute of Marine Sciences, Turkey
Institute of Oceanology, Polish Academy of Sciences, Poland
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Norwegian Meteorological Institute (DNMI), Norway
Polish Institute of Meteorology and Water Management, Maritime Branch, Poland
Puertos del Estado, Clima Marítimo, Spain
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Russian Federal Service for Hydrometeorology and Environmental Monitoring (Roshydromet), Russia
Swedish Meteorological and Hydrological Institute (SMHI), Sweden