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The EuroGOOS Marine Technology 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.

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5.	The EuroGOOS brochure, 1997	
6.	The Science Base of EuroGOOS	ISBN 0-90417530-8
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by J Bosman, N C Flemming, N Holden and K Taylor

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Preface: How to use this Report

Operational oceanography depends absolutely upon the availability of reliable, robust, low-maintenance, and cost-effective instrumentation. An operational service which obtains data from the coastal seas and deep ocean, and processes the data in order to provide nowcasts and forecasts in real time must be able to rely upon its instrumentation and field observations. Deployment and maintenance of instruments and equipment has to be managed according to a planned schedule, and maintenance costs must be kept to a minimum.

The organisations which are Members of EuroGOOS, and their associated agencies, have a great deal of experience of purchasing instrumentation for operational use, the field deployment and maintenance of instrumentation, and an understanding of the working life cycle of instrumentation under operational conditions. Nevertheless, this experience tends to be restricted within each laboratory and agency, or even to individuals and small sections within laboratories. There is very little opportunity for technical staff and managers responsible for operational observations to get together and share their experience.

The EuroGOOS Technology Plan Working Group Marine Technology Survey is designed, at least in part, to solve this problem.

We have asked every agency in EuroGOOS to list the instruments, instrument platforms, data transmission systems, and operational models which they use regularly. In each case they have provided information on the reliability, costs of routine operation, and some of the problems which they have experienced. In most cases, simply by indicating that they are regular users of an item of equipment, this amounts to some endorsement or confirmation that the equipment is reasonably reliable, or worth considering.

The key tables which list actual instruments, platforms, devices, and the agencies which use them are Tables 21 and 22 in the Appendix.
If you wish to obtain more information about a device than that shown in the tables of this report, please contact:

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This report is also available on the EuroGOOS Web page on: http://www.soc.soton.ac.uk/OTHERS/EUROGOOS/eurogoosindex.html.

This report combines all the results of the survey in statistical form, showing the frequency with which different types of instrument were used, the variables measured, and the different environments in which the work was carried out. The tables and statistics enable the reader to identify those instruments used most frequently, and to identify the laboratory or EuroGOOS Member agency where that instrument has been used. For obvious reasons in a report of this size it is not possible to include detailed comments on the performance of individual instruments or sensors. If you wish to obtain this information please contact the number shown above, and request the data from the original response form. If this information is not sufficient, the Environment Agency will provide the name of the contact person who originally provided the information, and you can consult them directly. See Annexe 1 for contact details of EuroGOOS Member agencies.

Summary

During the 1993 United Nations Conference on the Environment and Development (UNCED) at Rio de Janeiro, International Waters including coastal seas were defined as one of the four themes for future action. To further this aim, the Global Ocean Observing System (GOOS) was established by several United Nations Bodies. EuroGOOS is the association of European Marine Institutions with the objective of supporting the European components of GOOS and to maximise for Europe the benefits deriving from the application of marine environmental information. These objectives are enhanced by a concerted European approach to operational oceanography including collaboration towards achieving common and identified priorities. This includes the technology and systems used within this field of operation.

The Technology Plan Working Group (TPWG) is one of two working groups supporting EuroGOOS. Its objectives include identifying technology which is fully operational, under development now or needed in the foreseeable future. As a part of its work and to obtain necessary information, a survey was carried out by distributing questionnaires among EuroGOOS members and other groups practising operational oceanography in Europe. Individual questionnaires were prepared for six different Categories of technology described in the first section of the report.

A total of 260 replies were received and the responses were considered and tabulated in a number of different ways. These are set out in Tables 1 - 22. Almost half or the replies were for a single Category (Measuring devices, sensors and instruments) and 214 for equipment or systems described as "Fully operational". Specific comments on each of the Tables are included in the second and third sections of the main text. However, some more general conclusions may also be made.

Data on a wide range of physical, chemical, biochemical, biological and optical oceanographic variables are reported by EuroGOOS Members to be measured, stored, processed and distributed. Input to numerical models concentrates on physical parameters although some models may be used to predict non-physical parameters. The inclusion of non-physical parameters seems to be a major part of the technical frontier of numerical modelling.

The range of operational instrumentation shows a need for development in the measurement, directly or indirectly of nutrients, primary productivity, suspended sediments and petroleum contaminants. However, actual developments in measurement are concentrated upon improving the performance for variables already being measured operationally rather than introducing new parameters. This may suggest that the user community is largely conservative and/or that improved reliability, quality and cost are its main requirements. However, there was a lack of response and consistency to questions on Operational Procedure and Quality Control even for fully operational instruments. This seems to indicate the need for a common approach within EuroGOOS to these topics, in order to permit the exchange of data of demonstrable quality and thereby facilitate the wider co-operation between members which is one of the main objectives of the association.

Maximisation of the benefits for Europe of operational oceanography is another of the objectives of EuroGOOS. Data distribution systems, information products or forecasts from numerical models are the main outputs of data produced by its members to possible external users. Respondents in these Categories were asked to identify likely uses of the data they provide from a list of 117 individual uses (Applications) which was appended to the questionnaire. These were in 15 Application groups such as Mineral extraction, Engineering and Basic or strategic research. Only 45 of the 117 Applications were cited as using data from Information products, these falling into 9 of the 15 Application groups. The objectives cited for Numerical models fell into four Application groups. Many aspects of engineering, energy production, extraction processes etc. are not reported as using the data. Four entire Application groups (Tourism & recreation, Mineral extraction, Equipment sales and Algal collection & culture) are not included as users

of either Information products or the output of Numerical models. Details are set out in Tables 15-18. This could indicate the existence of a large number of possible additional uses for the existing data or that some changes to the content, presentation or availability could increase both the breadth of utilisation of oceanographic data and the benefits which might arise.

From the present report users can see what variables are being measured most frequently, and which instrument types are being used most frequently by which agencies, and for what applications.

Data from the survey will be available electronically on the EuroGOOS Web page. It is intended to maintain and update the database periodically with additional information. For more detailed information on instrument use, please contact the manufacturer.

Introduction

EuroGOOS is the association of European Marine Institutions with the main objective to support the European components of GOOS to maximise the benefits for Europe. These benefits arise from the application of marine environmental data and forecasts to the management of a wide range of industries and services. More specifically, EuroGOOS aims to:

- establish a concerted European approach to the planning and implementation of GOOS
- assess the European economic and social benefits of operational oceanography
- identify the European priorities for operational oceanography
- promote the development of scientific and technological systems for operational oceanography; and
- establish methods of collaboration between European inter/multi national agencies for the conduct of operational oceanography

EuroGOOS is supported by two working groups, the Science Advisory Working Group (SAWG) and the Technology Plan Working Group (TPWG). The TPWG will specify the technological opportunities and challenges applicable to operational oceanography in Europe. Its main objectives are to identify:

- existing technology which is adequately developed and tested to support operational oceanography
- new technology which is under development and which is needed by EuroGOOS; and
- gaps in technology which are problematic and which need to be resolved in the foreseeable future

These objectives are considered to be important in various ways to those involved with oceanography in Europe:

- the end users: to facilitate finding equipment or systems to meet their specific needs and whether user experience already exists
- the developer: to identify new technologies requiring further development and, possibly, co-operation in multi-national trials
- the manufacturer: to find opportunities for new products or the manufacture of successfully developed prototypes

The Technology Survey was begun by the TPWG in the second half of 1995 to meet these objectives. It aims to produce a representative inventory of marine technology relevant to operational oceanography.

Six separate Categories of technology were defined and individual questionnaires developed by a lead person for each Category. The Categories are:

A Measuring devices, sensors and instruments

B Platforms and carriers (including their control and telemetry systems)

C Support systems (including navigation, switches pingers etc.)

D Telematics, data communications, data management and archiving

E Operational numerical forecasting (including modelling and data assimilation)

F Information products and data product distribution systems

The purpose of the survey was to review those instruments and systems which are being used in a "routine" or "operational" role rather than solely in scientific research. For instruments or systems to be correctly described as "operational", they should fall within one or more of the sections below which are relevant to them.

- can be calibrated within a Quality Control system
- commercially available
- suitable user instructions or manuals available
- used routinely within a standardised protocol
- has self checking capability
- demonstrable reliability.

Results from the EuroGOOS Technology Survey database

Introduction

The responses to the survey comprise a substantial volume of paper in hard copy, and are held in commercial confidentiality by the EuroGOOS Office. The Access database for the survey was designed by the EuroGOOS Secretariat, and the data entered from the forms by the UK Environment Agency National Centre for Environmental Data and Surveillance. The results are presented as a series of tables illustrating first the general parameters of the data set, then the relationship between categories and the variables measured or processed, and finally an analysis of commercial systems by name and type. For further details of the characteristics of commercial available equipment readers are requested to contact either the manufacturer, or the EuroGOOS agency listed as using that equipment.

Statistics of the replies to the survey questionnaire

The total number of replies received is 260. The distribution of number of replies expressing comments on each type of device or system is shown in Table 1.

Number of replies by Category

Table 1 *Number of replies in the survey referring to each Category of Device*

	Category	Number of replies
A.	Measuring devices, sensors, instruments	126
B.	Platforms, carriers	42
C.	Support systems	23
D.	Telematics, data communications, data management, archiving	22
E.	Operational numerical forecasting	28
F.	Information products and data product distribution systems	19
	Total number of replies	**260**

The balance of replies shows the great interest in sensors and instruments and the very great diversity of these devices. All other Categories have lower frequency of occurrence but are of the same order of magnitude as each other. Note that each single reply does not mean that only one instrument is in use. It means that the responding Agency routinely uses instruments of a given type and may have many tens of devices in regular use.

Operational status

Each Device in each Category was classified according to its operational status, as shown in Table 2. The great majority of Devices, 214, were described as fully operational. Since status (iv) is entitled “Research mode only” and the majority of Devices are described as status (i) "Fully operational", these should be in use on a routine basis by agencies requiring data to be recorded in a standard way every day. Nevertheless, the replies need more careful analysis to see how many instruments are still being used only in research cruises.

Table 2 *Operational status of Devices reported in the survey. Categories A-F as in Table 1*

	Operational Status	**A**	**B**	**C**	**D**	**E**	**F**	
i)	Fully operational	104	34	22	18	20	16	214
ii)	Undergoing trials for operational use	10	3	1	3	2	1	20
iii)	Working model, pre-operational tests, scientific mode	7	1	0	0	3	0	11
iv)	Research mode only	2	1	0	0	2	0	5
v)	Technological principle established	0	1	0	1	1	1	4
	No status specified	3	2	0	0		1	6
	Total	126	42	23	22	28	19	260

Distribution of replies

EuroGOOS has Member agencies in 14 countries. Of these, 10 gave replies as shown in Table 3. The survey was conducted only in English and it is possible that the forms were not distributed to user groups in all countries. The distribution of replies does not indicate regional differences in the use of instruments or other systems but only in the number of replies completed. The uneven bias between countries should be taken into account when considering the other statistics from the survey and more detailed analyses.

Table 3 *Distribution of replies by country, showing the number of Devices in each Category described. Categories as in Table 1*

Country	**Category (Table 1)**						**Totals**
	A	**B**	**C**	**D**	**E**	**F**	
Belgium	1	0	0	1	3	1	6
Denmark	8	0	0	0	0	1	9
Finland	5	1	0	0	0	2	8
France	10	8	1	3	2	2	26
Germany	10	8	3	0	0	0	21
Ireland	1	1	1	0	0	0	3
Italy	0	0	0	0	1	0	1
The Netherlands	46	12	6	10	18	5	97
Spain	27	4	4	1	0	2	38
UK	18	8	8	7	4	6	51
Totals	126	42	23	22	28	19	260

Price information

Respondents were asked to provide information on price and costs of operation, wherever possible. Such information is necessarily rather subjective and could be out of date. Price and cost information may be from old catalogues, or from purchases made several years ago. Costs of monthly or annual operation may include or exclude various overheads and externalities. This report therefore does not include detailed information regarding this part of the questionnaire. All enquiries about costs of equipment should be made direct to the manufacturers. Nevertheless, just under half of all the replies in each category do include some information on prices and costs. This information will be regarded as confidential by EuroGOOS, and will only be used by EuroGOOS Members when conducting planning discussions in EuroGOOS projects. If non-EuroGOOS Members require this information, they should identify a user of the equipment from Table 22 and contact them to enquire about their experience with the equipment. Information on the original forms will only be provided to non-members of EuroGOOS after agreement is received from the manufacturers of the equipment.

Table 4 *Number of replies giving information on costs of equipment, and costs of operation*

Category	Number of forms with price information
A	62
B	15
C	10
D	8
E	14
F	3
Total	112

Variables included

In the broad sense there is a consistent suite of variables, mostly physical oceanographic variables, which are commonly measured by instruments, transmitted in telemetry systems, used in numerical models, and delivered in data products. This is demonstrated in Table 5. Whilst this consistency is not in itself surprising, or particularly significant, it does at least confirm that there is a generality of factors which are being most frequently measured, processed and delivered as data products. Since different agencies and individuals filled in the different forms, this consistency is genuinely confirmed by the survey.

The differences between the columns in Table 5 confirm a number of points about the status of operational oceanography at present. Numerical models are predominantly physical in nature and require a considerable range of meteorological forcing fields, whilst assimilating generally sea surface physical parameters and factors describing air-sea interaction, such as heat flux and precipitation. Biological, biogeochemical, chemical and optical variables rank much lower in the columns describing input to modelling than in the other columns of Table 5. As mentioned in the comments on Table 12, the output from numerical models is more likely to include biological and biogeochemical data than the operational real-time input. Reference back to Tables 10 and 12 shows that operational numerical models are beginning to include chemical, biological, and optical properties. This confirms the technical frontier, or growth point, of the present state of numerical modelling. The lower half of the Tables 7,9,10,12 and 13 indicate the growth area where present routine systems are not able to cope with the listed variables on a regular basis. This area is the key area for growth in the immediate future, and most of the frontier parameters defined here have been identified in principle in 'The Strategy for EuroGOOS'.

Table 5 *The first 20 ranked variables from Tables 7, 9, 10, 12 and 13 are listed in Table 5. The successive columns show the first 20 ranked variables from Category A (Instruments and sensors), Category D (Data transmission), Category E (Data input to numerical models), Category E (Data output from numerical models) and Category F (Data products).*

Category A		Category D		Category E - In		Category E - Out		Category F	
No.	**Name**	**No.**	**Name**	**No.**	**Name**	**No.**	**Name**	**No.**	**Name**
001	Sea surface temperature	001	Sea surface temperature	016	Hourly mean sea level/Instantaneous	016	Hourly mean sea level/Instantaneous	001	Sea surface temperature
003	Current Velocity	011	Wave height	118	Suspended sediments	013	Wave swell	008	Sea surface salinity
016	Hourly mean sea level/Instantaneous	012	Wave Period	152	Wind speed	118	Suspended sediments	097	Chlorophyll & Fluorescence
097	Chlorophyll & Fluorescence	016	Hourly mean sea level/Instantaneous	001	Sea surface temperature	010	Wave direction spectrum	011	Wave height
011	Wave height	003	Current Velocity	002	Sea surface Wind speed or direction	011	Wave height	003	Current Velocity
079	Bathymetry	098	Nitrate	003	Current Velocity	009	Wave spectrum	016	Hourly mean sea level/Instantaneous
008	Sea surface salinity/CTD	100	Oxygen	008	Sea surface salinity	003	Current Velocity	010	Wave direction spectrum
027	Upper ocean salinity	099	Phosphate	153	Wind direction	033	Salt transport	012	Wave Period
012	Wave Period	002	Sea surface Wind speed or direction	151	Atmospheric pressure	012	Wave Period	004	Current Direction
004	Current Direction	137	Year-long time series	010	Wave direction spectrum	001	Sea surface temperature	098	Nitrate
100	Oxygen	004	Current Direction	011	Wave height	038	Surface currents	002	Sea surface Wind speed or direction
118	Suspended sediments	072	Deep ocean salinity	005	Heat flux	106	Artificial radionuclides	101	Silicate
071	CTD sections	101	Silicate	007	Precipitation	098	Nitrate	118	Suspended sediments
121	Transmissivity	152	Wind speed	092	Stratification	110	PAHs	109	Trace metals
152	Wind speed	155	Air temperature	013	Wave swell	104	Pathogens	009	Wave spectrum
151	Atmospheric pressure	151	Atmospheric pressure	155	Air temperature	107	Petroleum hydrocarbons	020	Oceanic tides
009	Wave spectrum	097	Chlorophyll & Fluorescence	097	Chlorophyll & Fluorescence	111	Pharmaceutical wastes	100	Oxygen
153	Wind direction	071	CTD sections	071	CTD sections	008	Sea surface salinity/CTD	108	Pesticides & Herbicides
155	Air temperature	020	Oceanic tides	004	Current Direction	109	Trace metals	099	Phosphate
010	Wave direction spectrum	008	Sea surface salinity/CTD	120	Depth of photic zone	036	Upper ocean velocity fields	013	Wave swell

Generic characteristics of instrument use and variables measured

This section summarises the information on geographical scale and distribution of instrument usage, variables measured, and the management of different variables in data transmission systems, models, and product distribution. The tables summarising the information are set out in the Appendix with brief comments in this section.

Geographic scale (All Categories) Table 6

For every Category of Device the peak frequency of Geographical scale is either for the Shelf Seas or Coastal waters scale. Only slightly more than one third of devices are applied operationally at other scales. About 20% of devices are used at oceanic scale. Since most devices are applied at more than one scale, the total number of reported uses at various geographical scales is approximately twice that for the actual number of responses.

Frequency of citation of variables being measured by instruments etc. (Category A) Table 7a

Table 7a includes instruments in operation now, and under development. Since this table describes the status quo, there are very few surprises. Temperature, current velocity, sea level, wave data and chlorophyll are at the top of the table. Table 7a shows that about 40 marine variables are each measured operationally by at least one EuroGOOS agency. The table shows that a significant number of parameters are routinely measured in addition to physical oceanographic variables. These include chlorophyll, suspended sediments, depth of the photic zone, light transmissivity, nitrate, pesticides and herbicides. Unlisted variables (i.e. variables given by respondents but not listed in Annexe 2) are shown below in Table 7b.

Quality control (QC) systems in instruments etc. (Category A) Table 8

Of the 125 responses in this Category, 74 gave some information on Quality control or calibration. Table 8 sets out the QC information supplied classified by operational status and generic device type. Of the 104 fully operational systems, 58 give some information on QC varying from "by user" or "operator" (9 cases) to reference to external standards (6 cases) or comparison to laboratory analyses (5 cases).

Frequency of citation of variables handled in data management systems (Category D) Table 9

The data transmission and management system is handling data coming from sensors and being transferred to models, data being managed in delayed mode and being transferred into and out of archives, as well as data products coming from real time and delayed mode models. This is in addition to meteorological and marine meteorological data which are not included directly in the survey, apart from sea surface wind speed and precipitation. One would expect the data types which are being handled routinely by data management groups to correlate quite closely with the data types produced from operational sensors. Table 9 has 54 entries and Table 7a has 53, so there is not a great increase in the number of variables being handled off-line. However, there is naturally an additional volume of data measured in the scientific mode, which is processed in non-real time and merged into operational data systems. Sea surface temperature, waves and currents again appear near the top of the table. Nutrients and oxygen data are relatively higher on the table than they were in the list of variables from Category A, suggesting that these data are handled off-line or as the product of models. The bottom half of the table includes a number of parameters which do not occur in Category A as being routinely measured. This particularly refers to characteristics of the coastline, river run-off, bathymetry and wetland characteristics, as well as magnetic field. Comparisons between these ranked tables are shown in Table 5.

Data required to run operational models (Category E) Tables 10 & 11

Sea surface wind stress, speed and direction rank as the most important variables, followed by salinity, sea surface temperature, suspended sediments, and wave data. Again, there is a consistency between the dominant variables being measured operationally and those being handled by data management systems. Nutrient and chlorophyll data have slipped down the table somewhat, presumably because relatively few agencies are yet running models which incorporate biological productivity and nutrients as assimilated data. It is noticeable that the suspended sediment variable remain very high in the table. This probably reflects frequent use of inshore models for the management of navigational safety and coastal defence against erosion. Model groups requiring atmospheric forcing for marine numerical models have a high demand for wind stress, speed and wind vector data. There are, in addition, requirements for surface barometric pressure, solar radiation, humidity, cloud cover, precipitation and heat flux. There are no surprises in this list, but the information is rather incomplete. The dominant requirement is for wind field data and this is apparent in Table 11.

Frequency of citation of variables as output predictions from operational numerical models (Category E) Table 12

The traditional physical oceanographic variables are at the top of the table, with an emphasis on waves and currents. Suspended sediments remain high on the list, presumably because of the intense interest in coastal erosion, navigation and the management of sediment movements in the proximity to the major ports of Europe. Table 12 contains 65 entries but 14 of these are previously unlisted variables, mostly concerned with aspects of oil pollution and they occur only once at the end of the Table. Nutrients, pathogens and petroleum hydrocarbons appear surprisingly high in the Table. It seems that some models are incorporating off-line data, or calculating the movements of pathogens on the basis of their association with other characteristics, or on the basis of very sparse field data. It is possible that these derived predictions are satisfactory, but there is a strong suggestion that while the physical variables plus chlorophyll are being measured adequately in real time, the other variables are being predicted with greater difficulty and on the basis of sparse field data. The implication is that better operational instrumentation for these variables would be an asset.

Frequency of citation of variables included in data products (Category F) Table 13

Distributed data products show a great emphasis on tidal data, nutrients, pollution data, and suspended sediments. Biological, productivity data, chlorophyll, nutrients and pollutants, thus rank high in instrumental observations and high in data products, but are not yet being managed through input to numerical modelling systems (Table 10). This is consistent with the announced policies of several Members of EuroGOOS (see EuroGOOS publication No. 1 ‘The Strategy for EuroGOOS’) to progressively include suspended sediments, nutrient, chlorophyll and public health data in predictive numerical models.

Ice data occur consistently in all tables but ranked fairly low. This is probably explained by the lack of input information from Sweden and Norway.

Variables cited in instruments and sensors under different stages of operational development from research to fully operational (Category A) Table 14

The range of variables is a good deal more diverse than might have been expected. Readers are reminded that the number of responses does not indicate the actual number of instruments being used, but the number of agencies using that type of instrument. The range of observations shows clearly that data are being obtained and processed in the operational mode, although most of the biological and biogeochemical parameters can not yet be processed by assimilation into numerical models.

Part (ii) of Table 14 suggests that most instruments under development are designed to improve the performance of observations of variables which are already being measured operationally. No new parameters occur on this list which are not already in the top half of Part (i) of Table 14.

The classification ‘Undergoing trials’ includes aspects of acoustics and optics, suggesting that these principles may be more common in the newer instrument types. This is also true of the following two categories ‘Working model’ and

'Research mode'. Each successive section of Table 14 shows fewer entries in the table. This suggests that the number of new instruments being developed and tested by the Member agencies of EuroGOOS is quite small in comparison with the range of instrument types already deployed and in regular use. While it may be tempting to think of radically new instruments based on totally new physical principles, Table 14 suggests that the user community is very conservative, and introduces new equipment with justifiable caution and prudence. This is also consistent with the view that the strongest points in favour of an instrument for operational use is its reliability, quality, price, maintenance cycle, etc., rather than the novelty of its underlying principles. Totally new operating systems may make it possible to bring in instruments which can reduce price and increase reliability, but it is still the fundamental engineering, design and operating characteristics which will ensure wide-scale utilisation.

End uses of EuroGOOS data and products (Category F) Table 15

The most likely end uses for data and products derived from them are set out in the table of Applications in Table 1 of Annex 3 of the questionnaire. Applications for Category F cited by respondents (Table 15) and those attributed to Category E (Table 17) include 45 of the 117 Applications given in the questionnaire. However, 30 were cited only once and many of these are in a single Category E model which included 22 Applications (Table 16). The responses fall into 9 Application Groups with 4 entire Groups (Mineral extraction, Equipment sales, Tourism & recreation and Algal collection & culture) not currently being served by any of the Information Products. The Applications not cited by respondents are shown in Table 15b.

Objectives for numerical forecasting (Category E) Table 17

In order to consider end uses for the outputs of the models in this Category, the Objective described by respondents were considered and allocated to the most probable Application Group described above. This procedure indicates that only 4 Application Groups are currently being served by models in the survey. While this conclusion may be incorrect because only the main Objectives have been considered, it is quite likely that 10 Application Groups (Energy production, Mineral extraction, Food from the sea, Defence, Engineering & construction, Basic & strategic research, Tourism & recreation, Hinterland and Algal collection or culture) are not currently being served by models in the survey.

Since Information Products and Models (Categories F & E) comprise the outputs from respondents to external users, the Application Groups served by these Categories would summarise the current uses and indicate those not currently served by either direct data or predictive systems. This information is shown in Table 18.

The following tables are also included in the Appendix:-

List of EuroGOOS members and the acronym used in the other tables	Table 19
Frequency of citation of - Instrument type in Category A	Table 20a
Platform or carrier Type in Category B	Table 20b
Support system in Category C	Table 20c
Data system or telematic in Category D	Table 20d
Information or distribution system in Category F	Table 20f
List of organisations showing the generic devices and systems in each Category operated by that organisation	Table 21
List of the generic type, operational status device name and form number for Category A	Table 22

Conclusion

The survey shows a consistent picture of a wide range of operational instruments being used regularly to obtain real-time data for operational models, with a strong emphasis on physical hydrodynamic models, followed by chlorophyll and temperature salinity structure.

Consideration of the current end uses (Applications) of both Information Products and Operational Numerical Forecasting systems indicates that there are a number of possible additional uses for the information gathered and processed by EuroGOOS members. These additional uses include some entire Application Groups.

The survey of instrument types does not yield much information on those types of equipment under development which might improve the performance of field data gathering. On the other hand, the lower half of the data-variable tables show clearly the parameters which agencies are beginning to measure and model as well as they can with imperfect equipment. This implies a strong case for improved instrumentation to meet the need for these measurements.

The information showing which agencies are using which instruments is contained in Tables 21 and 22 of the Appendix, and further information can be obtained from the contacts listed in the Preface.

An opportunity exists to consider a common approach within EuroGOOS to the Quality Control and Operating Procedures for instruments and sensors. This would bring about a wider range of uses for the data gathered by ensuring consistency of methods within the group thus improving confidence and permitting full interchangeability of data.

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Appendix - Tables described in Sections 3 and 4

Table 6 *Distribution of Geographical scales correlated with Category of Device. Categories as in Table 1*

Geographical Scale	Category (Table 1)						Totals
	A	B	C	D	E	F	
Global	13	10	8	7	2	4	44
Oceanic	56	15	11	6	3	3	94
Shelf Seas	75	21	15	7	19	6	143
Coastal	87	21	12	11	14	12	157
Sea ice	10	1	0	0	0	0	11
Ice shelves	0	0	0	0	0	0	0
Totals	241	68	46	31	38	25	449

Table 7a *Ranked order of variables and parameters, by number of responses listing this variable. Data taken for Category A variables (Table 7a) measured by all instruments in operational use and under development*

Variable Number	Sector	Variable Name	Number of responses
001	Surface fields	Sea surface temperature	30
003	Surface fields	Current Velocity	15
016	Sea Surface topography	Hourly mean sea level/Instantaneous	14
097	Biogeochemical	Chlorophyll & Fluorescence	13
011	Surface fields	Wave height	13
079	Sea Bed	Bathymetry	11
008	Surface fields	Sea surface salinity/CTD	11
027	Upper Layer Fields	Upper ocean salinity	11
012	Surface fields	Wave Period	10
004	Surface fields	Current Direction	9
100	Biogeochemical	Oxygen	8
118	Biogeochemical	Suspended se diments	7
071	Deep Ocean	CTD sections	6
121	Optics	Transmissivity	6
152	Meteorological	Wind speed	6
151	Meteorological	Atmospheric pressure	5
009	Surface fields	Wave spectrum	5
153	Meteorological	Wind direction	5
155	Meteorological	Air temperature	4
010	Surface fields	Wave direction spectrum	4
072	Deep Ocean	Deep ocean salinity	3
098	Biogeochemical	Nitrate	3
099	Biogeochemical	Phosphate	3
101	Biogeochemical	Silicate	3
126	Acoustics	Sound velocity profiles	3
081	Sea Bed	Surface sediments	3
103	Biogeochemical	Biological pigments	2

Variable Number	Sector	Variable Name	Number of responses
073	Deep Ocean	Deep ocean ht storage	2
075	Deep Ocean	Deep ocean water storage	2
083	Sea Bed	Gravity	2
122	Optics	RS reflected light spectrum	2
089	Coastal & Shelf	Shelf bathymetry	2
109	Biogeochemical	Trace metals	2
013	Surface fields	Wave swell	2
128	Acoustics	Acoustic scattering	1
106	Biogeochemical	Artificial radionuclides	1
088	Coastal & Shelf	Coastal bathymetry	1
120	Optics	Depth of photic zone	1
119	Optics	Incident light spectrum	1
102	Biogeochemical	Iron	1
022	Sea Surface topography	Meteorological forcing	1
018	Sea Surface topography	Monthly mean sea level	1
020	Sea Surface topography	Oceanic tides	1
110	Biogeochemical	PAHs	1
108	Biogeochemical	Pesticides & Herbicides	1
112	Biogeochemical	Phytoplankton	1
019	Sea Surface topography	Sea level anomaly	1
002	Surface fields	Sea surface Wind speed or direction	1
095	Coastal & Shelf	Sediment transport	1
038	Upper Layer Fields	Surface currents	1
059	Ice Shelves	Surface state	1
049	Sea Ice	Thickness	1
036	Upper Layer Fields	Upper ocean velocity fields	1

Table 7a ranks in order of frequency the number of times which each variable is cited by a respondent as being observed by the equipment or instrument described in Category A. The Variable Numbers refer to the EuroGOOS/IACMST Variable list which is attached in Annexe 2.

Table 7b *Unlisted Variables*

Variable Number	Sector	Variable Name	Number of responses
000	Unlisted variable	Ammonium	2
000	Unlisted variable	Near sea bed current profile	2
000	Unlisted variable	Nitrite	2
000	Unlisted variable	Pressure	2
000	Unlisted variable	Turbidity	2
000	Unlisted variable	3-dimensional velocity	1
000	Unlisted variable	3-dimensional velocity (incl. turbulence)	1
000	Unlisted variable	All Rx of REDOX Potential	1
000	Unlisted variable	Alpha, Beta & Gamma radiation	1
000	Unlistedvariable	Average particle size	1
000	Unlisted variable	Current profile	1
000	Unlisted variable	Manganese	1
000	Unlistedvariable	Monthly mean sea level	1

Variable Number	Sector	Variable Name	Number of responses
000	Unlisted variable	Nephelometry	1
000	Unlisted variable	Observation of oil and chemical spills	1
000	Unlisted variable	Particle size distribution/concentrations	1
000	Unlisted variable	pH	1
000	Unlisted variable	pH, Trans, NO3, CPR, Current & wind vel/dir, solar rad	1
000	Unlisted variable	Photosynthetic capacity of algae.	1
000	Unlisted variable	Relative humidity	1
000	Unlisted variable	Total oxidised nitrogen	1
000	Unlisted variable	Ultra high resolution seismic	1
000	Unlisted variable	Urea	1

Table 8 *QC methods, self-checking and calibration*

Status	Form Number	Device type	QC - Method of testing	QC - Self checking	QC - Self calibration
i) Fully operational	085-IFRE-A	Acoustic		Yes	
i) Fully operational	128-ICM-A	CTD	By user		
i) Fully operational	246-RDAN-A	CTD	In situ water sampes & Lab.tests		
i) Fully operational	245-RDAN-A	CTD	In situ water samples & lab tests		
i) Fully operational	235-BSH-A	CTD, Fluorimeter, Turbidity	In situ comparison		
i) Fully operational	056-RIKZ-A	CTD, Turbidity	Use reference material (lab. solutions)	Partly	Partly
i) Fully operational	086-IFRE-A	Current meter		Yes	
i) Fully operational	177-RIKZ-A	Current meter		Yes	No
i) Fully operational	120-ICM-A	Current meter	Sea trials	Yes	
i) Fully operational	222-IMI-A	Current meter	Standard electrical and computer tests before use	Yes	Yes
i) Fully operational	016-RDAN-A	Current meter	Standard tests	Yes	
i) Fully operational	228-BSH-A	Current meter	Towing		
i) Fully operational	103-ICM-A	Echosounder	Built-in software		
i) Fully operational	102-ICM-A	Echosounder	Built-in software test		
i) Fully operational	105-ICM-A	Echosounder	Built-in software test		
i) Fully operational	104-ICM-A	Echosounder	Built-in test		
i) Fully operational	121-ICM-A	Echosounder	Sea	No	
i) Fully operational	116-RIKZ-A	Fluorimeter		Yes	
i) Fully operational	129-ICM-A	Fluorimeter	By user		
i) Fully operational	130-ICM-A	Fluorimeter	By user		
i) Fully operational	133-ICM-A	Fluorimeter	Self-test		
i) Fully operational	109-ICM-A	Gravitymeter	Operator		
i) Fully operational	039-METO-A	Heave sensor	Using in-house test facilities		
i) Fully operational	084-IFRE-A	Level gauge		Yes	
i) Fully operational	015-RDAN-A	Level gauge	Control measurements	Yes	Yes
i) Fully operational	162-RIKZ-A	Level gauge	Standard test prior to deployment	No	No
i) Fully operational	163-RIKZ-A	Level gauge	Standard test prior to deployment	Yes	No

Status	Form Number	Device type	QC - Method of testing	QC - Self checking	QC - Self calibration
i) Fully operational	164-RIKZ-A	Level gauge	Standard test prior to deployment	Yes	No
i) Fully operational	052-RIKZ-A	Level gauge, Wave analysis		Partly	Not necessary
i) Fully operational	055-RIKZ-A	Light meter	Calibration lamp	No	No
i) Fully operational	240-BSH-A	Logger			Partly
i) Fully operational	107-ICM-A	Magnetometer	Operator		
i) Fully operational	209-RIKZ-A	Meteorological	Only after improvements are implemented	Only after improvements are implemented	Only after improvements are implemented
i) Fully operational	045-METO-A	Meteorological	With the electronics system before operational use		
i) Fully operational	049-METO-A	Meteorological, Wind direction	Rotation through 360 degrees connected to processing electronics and pre-operational checks		
i) Fully operational	048-METO-A	Meteorological, Wind speed	In wind tunnel and pre operational test on buoy		
i) Fully operational	134-ICM-A	Nutrient analysis	By user		
i) Fully operational	139-NRA-A	Nutrient analysis	Check standards		
i) Fully operational	058-RIKZ-A	Nutrient analysis	Internal standards		
i) Fully operational	132-ICM-A	Particle counter	By user		
i) Fully operational	175-RIKZ-A	Particle mass			No
i) Fully operational	171-RIKZ-A	Particle transport	Against pump samples to be analysed for sediment content		
i) Fully operational	131-ICM-A	pH & Redox	By user		
i) Fully operational	127-ICM-A	Radiation	By user		
i) Fully operational	118-RIKZ-A	Remote sensing-Aerial		n/a	
i) Fully operational	160-RIKZ-A	Remote sensing-Aerial	Yes, artificial extermal sources	Yes	Yes
i) Fully operational	106-ICM-A	Seismic	Operator		
i) Fully operational	247-RDAN-A	Sonar	In situ test & lab. test		
i) Fully operational	043-METO-A	Surface drifting buoy	Compare O/P with check instruments over a period of time	Check sum in Tx data format	
i) Fully operational	047-METO-A	Thermometer	In temperature bath and preoperational in system against check observations		
i) Fully operational	161-RIKZ-A	Thermometer	Standard test prior to deployment	Yes	Yes

Status	Form Number	Device type	QC - Method of testing	QC - Self checking	QC - Self calibration
i) Fully operational	168-RIKZ-A	Wave analysis, Radar	In situ, against other instruments	Yes	Yes
i) Fully operational	077-METEO-A	Wave buoy	Constructor specification	Yes	Yes
i) Fully operational	053-RIKZ-A	Wave buoy	Rotating frame	Partly	no
i) Fully operational	057-RIKZ-A	Wave buoy	Rotating frame	Partly	No
i) Fully operational	051-RIKZ-A	Wave buoy	Rotating frame or swing frame	Partly	No
i) Fully operational	165-RIKZ-A	Wave buoy	Standard tests prior to deployment	No	Yes, reference param. are sent
i) Fully operational	166-RIKZ-A	Wave buoy	Standard tests prior to deployment	No	Yes, reference parameters are sent
i) Fully operational	167-RIKZ-A	Wave buoy	Standard tests, prior to deployment	No	Yes, reference param are sent
ii) Undergoing trials	054-RIKZ-A	Current meter	Stagnant water check, tilt and compass check	Partly	Partly

Table 9 *Ranked list of variables and parameters cited as being processed by data management systems (Category D)*

Variable Number	Sector	Variable Name	Number of responses
001	Surface fields	Sea surface temperature	10
011	Surface fields	Wave height	7
012	Surface fields	Wave Period	7
016	Sea Surface topography	Hourly mean sea level/Instantaneous	6
003	Surface fields	Current Velocity	4
098	Biogeochemical	Nitrate	4
100	Biogeochemical	Oxygen	4
099	Biogeochemical	Phosphate	4
002	Surface fields	Sea surface Wind speed or direction	4
137	Data Structure	Year-long time series	4
004	Surface fields	Current Direction	3
072	Deep Ocean	Deep ocean salinity	3
101	Biogeochemical	Silicate	3
152	Meteorological	Wind speed	3
155	Meteorological	Air temperature	2
151	Meteorological	Atmospheric pressure	2
097	Biogeochemical	Chlorophyll & Fluorescence	2
071	Deep Ocean	CTD sections	2
020	Sea Surface topography	Oceanic tides	2
008	Surface fields	Sea surface salinity/CTD	2
121	Optics	Transmissivity	2
025	Upper Layer Fields	Tropical upper ocean, structure	2
027	Upper Layer Fields	Upper ocean salinity	2
010	Surface fields	Wave direction spectrum	2
009	Surface fields	Wave spectrum	2
013	Surface fields	Wave swell	2
153	Meteorological	Wind direction	2
023	Upper Layer Fields	XBT sections	2
024	Upper Layer Fields	XCTD sections	2
079	Sea Bed	Bathymetry	1
103	Biogeochemical	Biological pigments	1
143	Data Structure	Composite multi-parameter products	1
073	Deep Ocean	Deep ocean ht storage	1
083	Sea Bed	Gravity	1
119	Optics	Incident light spectrum	1
078	Deep Ocean	Inter-basin straits currents	1
084	Sea Bed	Magnetics	1
018	Sea Surface topography	Monthly mean sea level	1
077	Deep Ocean	Ocean boundary currents	1
108	Biogeochemical	Pesticides & Herbicides	1
007	Surface fields	Precipitation	1
093	Coastal & Shelf	River runoff	1
122	Optics	RS reflected light spectrum	1
019	Sea Surface topography	Sea level anomaly	1
141	Data Structure	Spatial statistics	1
144	Data Structure	Spectra or other reduced statistics	1
038	Upper Layer Fields	Surface currents	1

Variable Number	Sector	Variable Name	Number of responses
118	Biogeochemical	Suspended sediments	1
090	Coastal & Shelf	Tidal constants	1
091	Coastal & Shelf	Tidal ellipses	1
109	Biogeochemical	Trace metals	1
000	Unlisted variable		1
036	Upper Layer Fields	Upper ocean velocity fields	1
096	Coastal & Shelf	Wetlands characteristics	1

Table 9 is compiled from the references to variables processed by different data management units, data banks, and data transmission systems.

Table10 *Ranking of variables which need to be observed as input data for operational models (Category E)*

Variable Number	Sector	Variable Name	Number of responses
016	Sea Surface topography	Hourly mean sea level/Instantaneous	9
118	Biogeochemical	Suspended sediments	6
152	Meteorological	Wind speed	6
001	Surface fields	Sea surface temperature	5
002	Surface fields	Sea surface Wind speed or direction	5
003	Surface fields	Current Velocity	4
008	Surface fields	Sea surface salinity	4
153	Meteorological	Wind direction	4
151	Meteorological	Atmospheric pressure	3
010	Surface fields	Wave direction spectrum	3
011	Surface fields	Wave height	3
005	Surface fields	Heat flux	2
007	Surface fields	Precipitation	2
092	Coastal & Shelf	Stratification	2
013	Surface fields	Wave swell	2
155	Meteorological	Air temperature	1
097	Biogeochemical	Chlorophyll & Fluorescence	1
071	Deep Ocean	CTD sections	1
004	Surface fields	Current Direction	1
120	Optics	Depth of photic zone	1
022	Sea Surface topography	Meteorological forcing	1
098	Biogeochemical	Nitrate	1
020	Sea Surface topography	Oceanic tides	1
099	Biogeochemical	Phosphate	1
093	Coastal & Shelf	River runoff	1
122	Optics	RS reflected light spectrum	1
019	Sea Surface topography	Sea level anomaly	1
101	Biogeochemical	Silicate	1
038	Upper Layer Fields	Surface currents	1
026	Upper Layer Fields	Upper ocean heat content	1
027	Upper Layer Fields	Upper ocean salinity	1
012	Surface fields	Wave Period	1
009	Surface fields	Wave spectrum	1

Variable Number	Sector	Variable Name	Number of responses
023	Upper Layer Fields	XBT sections	1
024	Upper Layer Fields	XCTD sections	1
000	Unlisted variable	Spilt volume	1
000	Unlisted variable	Oil density	1
000	Unlisted variable	Oil viscosity	1
000	Unlisted variable	Oil position	1
000	Unlisted variable	Evaporable fraction	1
000	Unlisted variable	Dye release	1
000	Unlisted variable	Cloud cover	1

Table 10 shows the variables listed on the respondents' forms describing the data required to run operational models (Category E). Table 10 omits most of the atmospheric forcing variables needed for operational models, which are listed in Table 11.

Table 11 *Variables listed by respondents as required atmospheric forcing for models (Category E)*

Variable Number	Sector	Variable Name	Number of responses
152	Meteorological	Wind speed	11
002	Surface fields	Sea surface wind speed or direction	9
153	Meteorological	Wind direction	8
151	Meteorological	Atmospheric pressure	7
005	Surface fields	Heat flux	3
007	Surface fields	Precipitation	3
003	Surface fields	Current Velocity	2
000	Unlisted variable	Relative humidity	2
001	Surface fields	Sea surface temperature	2
155	Meteorological	Air temperature	1
004	Surface fields	Current Direction	1
008	Surface fields	Sea surface salinity/CTD	1
000	Unlisted variable	Solar radiation	1
000	Unlisted variable	Cloud cover	1
000	Unlisted variable	Application dependant	1
000	Unlisted variable	Atmospheric deposition	1
000	Unlisted variable	Atmospheric pressure	1
000	Unlisted variable	Nebulosity	1
000	Unlisted variable	Non solar	1
000	Unlisted variable	Solar	1

The information shown in Table 11 is rather incomplete, but shows that model groups requiring atmospheric forcing for marine numerical models have a high demand for wind stress, speed, and wind vector data.

Table 12 *Variables provided as predicted outputs from marine numerical operational modesl (Category E)*

Variable number	Sector	Variable name	Number of responses
016	Sea Surface topography	Hourly mean sea level/instantaneous	10
013	Surface Layers	Wave swell	10
118	Biogeochemical	Suspended sediments	8
010	Surface Layers	Wave direction spectrum	8
011	Surface Layers	Wave height	8
009	Surface Layers	Wave spectrum	8
003	Surface Layers	Current velocity	7
033	Upper Layer Fields	Salt transport	6
012	Surface Layers	Wave period	6
001	Surface Layers	Sea surface temperature	5
038	Upper Layer Fields	Surface currents	5
106	Biogeochemical	Artificial radionuclides	4
098	Biogeochemical	Nitrate	4
110	Biogeochemical	PAHs	4
104	Biogeochemical	Pathogens	4
107	Biogeochemical	Petroleum hydrocarbons	4
111	Biogeochemical	Pharmaceutical wastes	4
008	Surface Layers	Sea surface salinity/CTD	4
109	Biogeochemical	Trace metals	4
036	Upper Layer Fields	Upper ocean velocity fields	4
116	Biogeochemical	Aquatic toxins	3
103	Biogeochemical	Biological pigments	3
114	Biogeochemical	Carbon dioxide	3
097	Biogeochemical	Chlorophyll & Fluorescence	3
117	Biogeochemical	Human health risks	3
102	Biogeochemical	Iron	3
020	Sea Surface topography	Oceanic tides	3
100	Biogeochemical	Oxygen	3
108	Biogeochemical	Pesticides & Herbicides	3
099	Biogeochemical	Phosphate	3
112	Biogeochemical	Phytoplankton	3
101	Biogeochemical	Silicate	3
092	Coastal & Shelf	Stratification	3
105	Biogeochemical	Synthetic organics	3
115	Biogeochemical	Tritium	3
113	Biogeochemical	Zooplankton	3
000	Unlisted variable	2D energy spectrum	2
042	Upper Layer Fields	Carbon transport	2
088	Coastal & Shelf	Coastal bathymetry	2
004	Surface fields	Current Direction	2
040	Upper Layer Fields	Downwelling velocities	2
095	Coastal & Shelf	Sediment transport	2
090	Coastal & Shelf	Tidal constants	2
121	Optics	Transmissivity	2
039	Upper Layer Fields	Upwelling velocities	2
000	Unlisted variable	Wind sea HT/dir	2
155	Meteorological	Air temperature	1
071	Deep Ocean	CTD sections	1

Variable number	Sector	Variable name	Number of responses
072	Deep Ocean	Deep ocean salinity	1
037	Upper Layer Fields	Momentum fields	1
077	Deep Ocean	Ocean boundary currents	1
019	Sea Surface topography	Sea level anomaly	1
091	Coastal & Shelf	Tidal ellipses	1
026	Upper Layer Fields	Upper ocean heat content	1
027	Upper Layer Fields	Upper ocean salinity	1
023	Upper Layer Fields	XBT sections	1
000	Unlisted variable	Bed currents	1
000	Unlisted variable	Chemical/biological variables	1
000	Unlisted variable	Concentration dissolvents	1
000	Unlisted variable	Depth-mean current	1
000	Unlisted variable	Mass balance	1
000	Unlisted variable	Oil density	1
000	Unlisted variable	Oil viscosity	1
000	Unlisted variable	Sedimentation	1
000	Unlisted variable	Spill position	1
000	Unlisted variable	Stream function	1
000	Unlisted variable	Temperature fields	1
000	Unlisted variable	Vorticity	1
000	Unlisted variable	Wind induced currents	1
000	Unlisted variable	Wind set up	1

Table 12 ranks in order of frequency cited the variables given as output predictions from operational numerical models.

Table 13 *Ranked list of variables and parameters listed as being included in data products (Category F)*

Variable Number	Sector	Variable Name	Number of responses
001	Surface fields	Sea surface temperature	9
008	Surface fields	Sea surface salinity	8
097	Biogeochemical	Chlorophyll & Fluorescence	6
011	Surface fields	Wave height	6
003	Surface fields	Current Velocity	5
016	Sea Surface topography	Hourly mean sea level/Instantaneous	5
010	Surface fields	Wave direction spectrum	5
012	Surface fields	Wave Period	5
004	Surface fields	Current Direction	4
098	Biogeochemical	Nitrate	4
002	Surface fields	Sea surface Wind speed or direction	4
101	Biogeochemical	Silicate	4
118	Biogeochemical	Suspended sediments	4
109	Biogeochemical	Trace metals	4
009	Surface fields	Wave spectrum	4
020	Sea Surface topography	Oceanic tides	3
100	Biogeochemical	Oxygen	3
108	Biogeochemical	Pesticides & Herbicides	3
099	Biogeochemical	Phosphate	3

Variable Number	Sector	Variable Name	Number of responses
013	Surface fields	Wave swell	3
140	Data Structure	Climatic statistics	2
143	Data Structure	Composite multi-parameter products	2
102	Biogeochemical	Iron	2
022	Sea Surface topography	Meteorological forcing	2
110	Biogeochemical	PAHs	2
093	Coastal & Shelf	River runoff	2
122	Optics	RS reflected light spectrum	2
144	Data Structure	Spectra or other reduced statistics	2
081	Sea Bed	Surface sediments	2
121	Optics	Transmissivity	2
153	Meteorological	Wind direction	2
152	Meteorological	Wind speed	2
155	Meteorological	Air temperature	1
116	Biogeochemical	Aquatic toxins	1
106	Biogeochemical	Artificial radionuclides	1
151	Meteorological	Atmospheric pressure	1
079	Sea Bed	Bathymetry	1
103	Biogeochemical	Biological pigments	1
114	Biogeochemical	Carbon dioxide	1
088	Coastal & Shelf	Coastal bathymetry	1
086	Coastal & Shelf	Coastline map	1
046	Sea Ice	Concentration	1
138	Data Structure	Decadal time series	1
040	Upper Layer Fields	Downwelling velocities	1
045	Sea Ice	Extent, boundary, leads, %	1
021	Sea Surface topography	Geostrophic currents	1
082	Sea Bed	Gridded bathymetry	1
087	Coastal & Shelf	Hinterland topography	1
117	Biogeochemical	Human health risks	1
052	Sea Ice	Ice motion	1
018	Sea Surface topography	Monthly mean sea level	1
142	Data Structure	Past model outputs	1
104	Biogeochemical	Pathogens	1
107	Biogeochemical	Petroleum hydrocarbons	1
111	Biogeochemical	Pharmaceutical wastes	1
112	Biogeochemical	Phytoplankton	1
019	Sea Surface topography	Sea level anomaly	1
125	Optics	Secchi disk depth	1
095	Coastal & Shelf	Sediment transport	1
089	Coastal & Shelf	Shelf bathymetry	1
141	Data Structure	Spatial statistics	1
038	Upper Layer Fields	Surface currents	1
080	Sea Bed	Surface outcrops	1
105	Biogeochemical	Synthetic organics	1
049	Sea Ice	Thickness	1
090	Coastal & Shelf	Tidal constants	1
115	Biogeochemical	Tritium	1
027	Upper Layer Fields	Upper ocean salinity	1
039	Upper Layer Fields	Upwelling velocities	1
137	Data Structure	Year-long time series	1

Variable Number	Sector	Variable Name	Number of responses
113	Biogeochemical	Zooplankton	1

Table 13 presents in rank order by frequency of citation the variables which are included in data products distributed by Member agencies of EuroGOOS. Data products can include many variables and parameters which are not routinely observed in the operational mode, and are not processed through numerical models. Thus the list of variables here differs considerably from that in Tables 8 and 10, and is slightly longer. Curiously, Table 13 lists 70 variables, all from the CCMST list, without any of the minority unlisted variables from Tables 11 or 12. In that sense, the range of variables in data products is 70, compared with 51 being processed in operational numerical models. As with Table 9, the implication is that some of the products being transmitted to customers include data types which can only be processed in delayed mode. This places operational real time modelling in the context of associated off-line models and accessory data processed in delayed mode.

Table *14* *Ranked listing of the frequency of citation of different variables sub-categorised by status of operational development, Category A*

i) Fully operational			
Variable Number	**Sector**	**Variable Name**	**Number of responses**
001	Surface fields	Sea surface temperature	23
016	Sea Surface topography	Hourly mean sea level/Instantaneous	12
011	Surface fields	Wave height	12
097	Biogeochemical	Chlorophyll & Fluorescence	11
003	Surface fields	Current Velocity	10
008	Surface fields	Sea surface salinity/CTD	9
012	Surface fields	Wave Period	9
079	Sea Bed	Bathymetry	8
027	Upper Layer Fields	Upper ocean salinity	8
071	Deep Ocean	CTD sections	6
004	Surface fields	Current Direction	6
151	Meteorological	Atmospheric pressure	5
100	Biogeochemical	Oxygen	5
118	Biogeochemical	Suspended sediments	5
121	Optics	Transmissivity	5
010	Surface fields	Wave direction spectrum	4
009	Surface fields	Wave spectrum	4
153	Meteorological	Wind direction	4
152	Meteorological	Wind speed	4
155	Meteorological	Air temperature	3
072	Deep Ocean	Deep ocean salinity	3
099	Biogeochemical	Phosphate	3
101	Biogeochemical	Silicate	3
081	Sea Bed	Surface sediments	3
000	Unlisted variable	Ammonium	2
103	Biogeochemical	Biological pigments	2
073	Deep Ocean	Deep ocean ht storage	2
075	Deep Ocean	Deep ocean water storage	2
083	Sea Bed	Gravity	2
098	Biogeochemical	Nitrate	2
000	Unlisted variable	Nitrite	2

i) Fully operational			
Variable Number	**Sector**	**Variable Name**	**Number of responses**
122	Optics	RS reflected light spectrum	2
126	Acoustics	Sound velocity profiles	2
109	Biogeochemical	Trace metals	2
000	Unlisted variable	Turbidity	2
000	Unlisted variable	All Rx of REDOX Potential	1
000	Unlisted variable	Alpha, Beta & Gamma radiation	1
106	Biogeochemical	Artificial radionuclides	1
088	Coastal & Shelf	Coastal bathymetry	1
000	Unlisted variable	Current profile	1
119	Optics	Incident light spectrum	1
102	Biogeochemical	Iron	1
000	Unlisted variable	Manganese	1
022	Sea Surface topography	Meteorological forcing	1
018	Sea Surface topography	Monthly mean sea level	1
000	Unlisted variable	Nephelometry	1
020	Sea Surface topography	Oceanic tides	1
110	Biogeochemical	PAHs	1
108	Biogeochemical	Pesticides & Herbicides	1
000	Unlisted variable	pH	1
112	Biogeochemical	Phytoplankton	1
000	Unlisted variable	Pressure	1
000	Unlisted variable	Relative humidity	1
019	Sea Surface topography	Sea level anomaly	1
002	Surface fields	Sea surface Wind speed or direction	1
089	Coastal & Shelf	Shelf bathymetry	1
038	Upper Layer Fields	Surface currents	1
059	Ice Shelves	Surface state	1
049	Sea Ice	Thickness	1
000	Unlisted variable	Total oxidised nitrogen	1
000	Unlisted variable	Ultra high resolution seismic	1
036	Upper Layer Fields	Upper ocean velocity fields	1
000	Unlisted variable	Urea	1
013	Surface fields	Wave swell	1

ii) Undergoing trials			
Variable Number	**Sector**	**Variable Name**	**Number responses**
001	Surface fields	Sea surface temperature	4
004	Surface fields	Current Direction	3
003	Surface fields	Current Velocity	3
097	Biogeochemical	Chlorophyll & Fluorescence	2
100	Biogeochemical	Oxygen	2
152	Meteorological	Wind speed	2
155	Meteorological	Air temperature	1
079	Sea Bed	Bathymetry	1
016	Sea Surface topography	Hourly mean sea level/Instantaneous	1
008	Surface fields	Sea surface salinity/CTD	1
089	Coastal & Shelf	Shelf bathymetry	1
126	Acoustics	Sound velocity profiles	1
121	Optics	Transmissivity	1

ii) Undergoing trials			
Variable Number	**Sector**	**Variable Name**	**Number responses**
027	Upper Layer Fields	Upper ocean salinity	1
011	Surface fields	Wave height	1
012	Surface fields	Wave Period	1
009	Surface fields	Wave spectrum	1
013	Surface fields	Wave swell	1
153	Meteorological	Wind direction	1
000	Unlisted variable	pH, Trans, NO3, CPR, Current & wind vel/dir, solar rad	1
000	Unlisted variable	Observation of oil and chemical spills	1
000	Unlisted variable	Monthly mean sea level	1
000	Unlisted variable	3 Dimensional velocity (incl. turbulence)	1
000	Unlisted variable	3 dimensional velocity	1
000	Unlisted variable	Photosynthetic capacity of algae.	1

iii) Working model			
Variable Number	**Sector**	**Variable Name**	**Number of responses**
003	Surface fields	Current Velocity	2
128	Acoustics	Acoustic scattering	1
079	Sea Bed	Bathymetry	1
016	Sea Surface topography	Hourly mean sea level/Instantaneous	1
098	Biogeochemical	Nitrate	1
100	Biogeochemical	Oxygen	1
008	Surface fields	Sea surface salinity/CTD	1
001	Surface fields	Sea surface temperature	1
118	Biogeochemical	Suspended sediments	1
000	Unlisted variable	Current profile near sea bottom.	1
000	Unlisted variable	Particle size distrib./concentrations	1
000	Unlisted variable	Pressure	1

iv) Research mode			
Variable Number	**Sector**	**Variable Name**	**Number of responses**
120	Optics	Depth of photic zone	1
095	Coastal & Shelf	Sediment transport	1
118	Biogeochemical	Suspended sediments	1
000	Unlisted variable	Average particle size	1
000	Unlisted variable	Near sea bed current profile	1

Unknown Status			
Variable Number	**Sector**	**Variable Name**	**Number of responses**
001	Surface fields	Sea surface temperature	2
027	Upper Layer Fields	Upper ocean salinity	2
079	Sea Bed	Bathymetry	1

Table 14 lists the frequency of citation of different variables according to the status of operational development. The list of variables which are fully operational represents the status quo of the present routine observation systems.

Table 15a *Number of Category F respondents in each Application Group*

Number of Information Products	Application Group
9	Environmental protection
7	Services
6	Transport
5	Basic & Strategic research
5	Engineering
4	Food from the sea
3	Defence
3	Energy production
3	Hinterland
0	Mineral extraction
0	Equipment sales
0	Tourism & recreation
0	Algal collection & culture

Table 15b *Applications included in the list but not given by any respondent in Category F*

Application ID	Description
004	Submersible/submarine operations/ROVs
005	Tunnel subsea operations
006	Barrage roads
007	Causeway
008	Bridges, sea channels
009	Navigational safety, lights etc. Electronic chart
015	OTEC
016	Wave energy
017	Tidal energy
018	Wind energy, offshore installation
024	Health hazards
025	Marine reserves
026	Species protection
029	Safe waste disposal
030	Amenity evaluation
033	Mineral extraction
034	Aggregate, sand, gravel
035	Deep ocean, Mn, hydrothermal muds, crusts
036	Placer minerals, diamonds, tin, etc.
037	Salts extraction, magnesia, bromine
038	Desalination
039	Phosphate
040	Coal, subsea
045	Shellfish, crustacea, farming
046	Fishing gear
116	Algae Collection
117	Algae Culture
050	Underwater weapons
051	Navigation, position fixing, etc.
052	Defence sales, equipment, components

Application ID	Description
053	Operations and efficiency, logistics, controls, co
058	Land reclamation
059	Barrage construction
060	Tunnel construction
061	Outfalls/intakes
062	Consulting engineering
063	Components, hydraulics, motors, pumps, batteries,
064	Cables, manufacture and operations, laying
065	Corrosion prevention, paint, antifouling, etc.
066	Heavy lifting, cranes, winches
067	Marine propulsion, efficient ship, automatic ships
069	Pipelaying, trenching, burial
070	Ship-building, non-defence, all kinds
072	Certification
073	Climate forecasting
075	Data services
076	Data transmission, telecommunications
077	Diving, including suppliers
078	Inspection, maintenance, repair
079	Insurance
083	Salvage, towing
086	Equipment sales
087	Marine electronics, instruments, radar, opto-elect
088	Sonar
089	Buoys
090	Tourism and recreation
092	Acoustics, electronics
093	Civil engineering
094	Climate change
095	Climate forecasting
097	Data centre
099	Estuarine modelling
100	Fisheries
101	Marine biology
103	Ocean modelling
104	Oceanography
105	Polar research
107	Shelf seas modelling
108	Shipping/naval architecture
110	Agriculture
111	Land use planning or zoning
114	Wetlands management
115	Public health

***Table* 16** *Number of Applications per Data product (Category F)*

Form Number	Name of product	Number of Applications
050-METO-F	Wave Forecasts	22
027-IEU-F	Tidal Annual Bulletin	12
075-RIKZ-F	DONAR	8
208-RIKZ-F	Multi Functional Presentational System (MFPS)	6
078-METEO-F	CLIOSTAT (Climatologies Oceanique Satellitaire)	6
157-NRA-F	UK coastal waters survey-data request system	5
004-MUMM-F	Monit B Database	5
219-RIKZ-F	Multi Purpose Presentational Unit (MPPU)	4
156-NRA-F	UK coastal water quality RS (CASI) output	3
153-NRA-F	Coastal waters quality maps (laboratory data)	3
154-NRA-F	Coastal water quality maps- Contin.monitoring data	2
251-RDAN-F	Oceanographic Information System	2
155-NRA-F	UK coastal waters- Thermal imagery videos	1
074-RIKZ-F	SUSD (Stormsurge Warning System)	1
013-FIMR-F	Information on algal blooms in the Baltic Sea	1

Table 17 *Application groups served by models (Category E)*

Form Number	Objective or goal	Application Group
202-RIKZ-E	Predict tidal elevaton and storm surge on c.shelf	28/55
030-METO-E	Forecast storm surges around UK coast	28/55
031-METO-E	Forecast surface waves up to 2(5) days ahead	28/55
206-RIKZ-E	Hindast & forecast wind waves in deep-shallow water	28/55
003-MUMM-E	Forecasting of sea waves & swell spectra	28/55
071-RIKZ-E	(Storm) Surge Prediction	28/55
032-METO-E	Forecast surface wave conditions up to 5d ahead	28/55
001-MUMM-E	Prevent risk of flooding on Belgian coast	28/55
005-MUMM-E	Oil spill forecasting model	Environmental protection
096-IFRE-E	Build ecol.models for fate of chemi/biol.cmpnds	Environmental protection
072-RIKZ-E	Modelling sea water quality	Environmental protection
201-RIKZ-E	Simulates transport & spreading from outfall/spill	Environmental protection
260-RIKZ-E	Transp.paths, concs.,distribs.& times solutes/seds	Environmental protection
203-RIKZ-E	Direct response model for spills of oils & toxics	Environmental protection
205-RIKZ-E	Re-initializatn of model concn fields with RS data	Environmental protection
259-RIKZ-E	Transport paths,dispersion patterns & plumes	Environmental protection
200-RIKZ-E	Assess & model water qual processes (space & time)	Environmental protection
097-IFRE-E	Analysis & predictn of TSV on mesoscale QG model	Services
029-METO-E	Global ocean temp/sal 5day forecasts. Synoptic	Services

Form Number	Objective or goal	Application Group
198-RIKZ-E	Integrated simul. flows,transports,waves,quality,e	Services
119-CNR-E	Seasonal/interannual predictns of currents/tracer	Services
199-RIKZ-E	Predicts nonsteady large scale 3D flows	Services
207-RIKZ-E	App.trained system in/outut to geophys.data&trends	Services
216-RIKZ-E	Operational avail.wind,wave & current data	Services
197-RIKZ-E	Integr simul.& modelling flows,sed.transp., waves	Services
196-RIKZ-E	Prediction of 0.03-0.1Hz wave energy for shipping	Transport
204-RIKZ-E	Actual depth offshore from online depth reduction	Transport
195-RIKZ-E	Navigational safety & harbour permission	Transport

Table 17a *Number of models (Category E) in each Application Group*

Application Group	Number of Models
Environmental protection	9
Services	8
28/55	8
Transport	3
Energy production	0
Mineral extraction	0
Food from the sea	0
Defence	0
Building, construction	0
Equipment sales	0
Basic & strategic research	0
Tourism & recreation	0
Hinterland	0
Algae	0

Table *18* *Number of Application groups in Models (Cat.E) and Information products (Cat.F)*

Application Group	No of Information Products	No of Models	Total of IP+Models / Application
Services	7	5	12
Environmental protection	9	3	12
Transport	6	1	7
Engineering	5	2	7
Basic & Strategic research	5	0	5
Food from the sea	4	0	4
Hinterland	3	0	3
Energy production	3	0	3
Defence	3	0	3
Tourism & recreation	0	0	0
Mineral extraction	0	0	0
Equipment sales	0	0	0
Algae	0	0	0
Total number of Applications	45	11	56

***Table* 19** *List of acronyms and full names of EuroGOOS Member agencies providing information in this survey*

Code	Organisation Name	Country
BSH	Bundesamt fur Seeschiffahrt und Hydrographie	Germany
CNR	Consiglio Nazionale Delle Ricerche	Italy
FIMR	Finnish Institute of Marine Research (FIMR)	Finland
IBSR	Institute for Baltic Sea Research	Germany
ICM	Instituto de Ciencias del Mar	Spain
IEO	Instituto Espanol de Oceanografia	Spain
IFRE	IFREMER	France
IMI	Irish Marine Institute	Ireland
METEO	Meteomer	France
METO	The Meteorological Office	UK
MUMM	Management Unit of the North Sea Mathematical Model (MUMM)	Belgium
NRA	Environment Agency (formerly National Rivers Authority)	UK
RDANH	Royal Danish Administration of Navigation and Hydrography	Denmark
RIKZ	Directoraat-Generaal Rijkswaterstaat	The Netherlands
SOC	Southampton Oceanography Centre	UK
STNMT	Service Technique de la Navigation Maritime et des Transmissions de l'Equipement	France

The list of acronyms is shown in Table 19.

Table *20* *Analysis of devices, generic devices, and commercial trade names*

In this section we present data listing instruments, devices, platforms, telecommunication systems, computer models, etc., described either as generic types, or with specific commercial names or brand names. We will first discuss the frequency of citation of each type of device in generic terms, and then list the data by user agency, so that people who require information can contact agencies that have already used this system.

Table 20 is presented in six sections, A-F, each sub-table relating to a category within the EuroGOOS Technology Survey (see Table 1)

Table 20a *Ranked list of frequency of citation of different instrument types by generic category*

Device type	No. of responses
Category A - Measuring devices, sensors, instruments	N = 126
Current meter	16
CTD	15
Level gauge	11
Wave buoy	9
Echosounder	8
Fluorimeter	7
Nutrient analysis	4
Remote Sensing-Aerial	4
Thermometer	4
Meteorological	3
Acoustic	2

Device type	No. of responses
Gravitymeter	2
Logger	2
Particle counter	2
Radiation	2
Sonar	2
Transmission	2
Wave analysis, Radar	2
Bathythermograph	1
Biosensor	1
Corer	1
CTD, Fluorimeter, Turbidity	1
CTD, Turbidity	1
Current gauge	1
DO	1
DO, pH	1
Fluorimeter, Biomass	1
Heave sensor	1
Level gauge, Wave analysis	1
Levels, Altimeter	1
Light meter	1
Magnetometer	1
Meteorological, Wind direction	1
Meteorological, Wind speed	1
Particle analysis	1
Particle mass	1
Particle transport	1
Remote Sensing-Satellite	1
Seismic	1
Sonar (SS)	1
Surface drifting buoy	1
Thermometer, Pressure	1
Transmission, Turbidity	1
WQ buoy	1
WQ, Meteorological buoy	1

Table 20a shows that the most frequently used instruments are current meters, CTDs, water level gauges, wave measuring buoys, echo sounders, and fluorimeters. It should be noted that when an agency reports that an instrument is being used in operational mode, it is not stated whether the agency is using one instrument, or 20 or 30. Thus the number of citations does not strictly indicate the proportion of instruments being used in operational mode. Nevertheless, the frequency of citation is strongly indicative of the types of instruments in most common use. Nutrient analysis rates high in the table.

Table 20b

Device type	No. of responses
Category B - Platforms and carriers	N = 42
Surface moored buoy	11
Ocean going ship	7
Fixed platform	5
Coastal vessel	3
Towed undulating vehicle	3
Aircraft	2
Shore based mounting	2
Sub surface drifting buoy	2
Sub surface moored buoy	2
Surface drifting buoy	2
Fixed platform, Sea bed mounting	1
Sub surface drifting buoy	1
Surface moored buoy, Surface drifting buoy	1

Table 20b indicates that the most commonly used operational platform is the moored buoy, and hence, probably, that most sensors are installed on moored buoys. All the expected platforms are regularly used. No response refers to satellite remote sensed systems, but these are obviously being used by some establishments in operational mode. No experiments are reported as being conducted with Autonomous Untethered Vehicles with a view to operational use.

Table 20c

Device type	No. of responses
Category C - Support systems	N = 23
GPS	5
Diesel generator	4
Acoustic release	3
Mooring system	3
Safety device	2
Calibration system	1
Communications system	1
Equipment housing	1
Navigation, Logger	1
Pinger	1
Platform ?	1

Table 20c confirms the importance of GPS as a cheap and reliable form of position fixing. The other data forms will provide information on technical support systems. The number of responses describing diesel generators is interesting, given the alternative options for power supply, and the low power requirements of modern instruments.

Table 20d

Device type	No. of responses
Category D - Telematics, data communications, archiving	N = 22
Data Assembly	5
Archive	4
Telecom	3
Analysis, Archive, Handling, QC	1
Archive, Handling	1
Data Assembly, Analysis, Archive, Handling, QC	1
Message switch	1
Modelling	1
Telecom, Analysis, QC	1
Telecom, Assembly, Analysis, Security, Handling, QC	1
Telecom, Assembly, Analysis, Archive, QC	1
Telecom, Assembly, Analysis, Archive, QC, Modelling	1
Telecom, Assembly, Archive, Handling, QC	1

The useful information in this Category, Table 20d, is contained in the forms themselves. Very little can be deduced from the numbers of replies.

Table 20e

Device type	No. of responses
Category E - Operational numerical forecasting, modelling	N = 28
3D flows, Estuaries, Shelf Seas	1
Dutch Coast, Transport paths, Distributions	1
English Channel, Ecological models	1
European Shelf, Storm surge prediction	1
European Shelf, Transport, Plumes	1
European wave model	1
Generic, Rivers, Est. Flows, Waves, Quality, Transports	1
Generic, Transport, Flows	1
Global salinity, temperature	1
Global wave model	1
Mediterranean, Current predictions	1
Nth East Atlantic, TSV	1
Nth Sea & Global waves, forecast, hindcasts	1
Nth Sea data & trends	1
Nth Sea waves, swell data	1
Nth Sea wind, wave, current data	1
Nth Sea, Flood risk	1
Nth Sea, Irish Sea Storm surge, elevation	1
Nth Sea, Irish Sea levels & depths	1
Nth Sea, Irish Sea, WQ processes	1
Nth Sea, Wadden Sea , WQ	1
Southern Nth Sea, Wave energy	1
Southern Nth Sea, Navigational safety	1
Southern Nth Sea, RS data	1
Spills model, Nth Sea	1
Spills model, Oil, Toxics	1
Spills, Discharges, Estuaries, Shelf Seas	1

UK Storm surge model	1

Table 20e lists the responses describing operational numerical models. Since no two models are identical, every reply is singular. The models are listed in alphabetical order. From Table 7 we know that no Arctic or sea ice models are included, and there are no data from Norway or Sweden (Table 5). The range of geographical scales is impressive, and we know that in addition there are operational wind-wave models around the coast of Spain. There is a concentration of data for the North Sea. Given the range of variables listed in Tables 10, 11 and 12, there is a great deal of useful information contained on these data forms. The development of operational modelling and forecasting is an extremely active sector, and we can expect a continuous increase in the range of variables processed, which in turn will place an increased demand on observations and instrumentation.

Table 20f

Device type	No. of responses
Category F - Information products and distribution	N = 19
Data product	7
Presentation	2
Data product, Distribution	1
Data product, Presentation	1
Data product, Service	1
Data product, Service, Distribution	1
Data product, Service, Data service	1
Data product, Text, Service	1
Data product, Text, Service, Distribution	1
Distribution	1
Service	1
Service, Distribution	1

Table 20f shows the generic listing of data products. Most of the descriptive information is on the response forms, and the variables processed are listed in Table 9.

Table 21

Table 21 below shows the acronym for the contact agency using different types of instruments, and the frequency with which that type of device is reported. It also indicates where a single agency is using a multiplicity of instruments of the same generic type, possibly the same commercial brand. The range of instruments or platforms or models reported by a single agency gives an indication of the profile of interest of that agency.

Table 21a *Generic instruments and other devices listed by frequency and category, and by agency using the device. See table 19 for agency acronyms*

Category	Agency Acronym	Device type	Number of devices
A	BSH	Logger	2
A	BSH	Thermometer	2
A	BSH	CTD	2
A	BSH	CTD, Fluorimeter, Turbidity	1
A	BSH	Current meter	1
A	BSH	DO	1
A	BSH	Radiation	1

Category	Agency Acronym	Device type	Number of devices
A	FIMR	CTD	2
A	FIMR	Current meter	1
A	FIMR	Fluorimeter, Biomass	1
A	FIMR	Level gauge	1
A	ICM	Echosounder	5
A	ICM	CTD	4
A	ICM	Fluorimeter	3
A	ICM	Gravitymeter	2
A	ICM	Bathythermograph	1
A	ICM	Magnetometer	1
A	ICM	Nutrient analysis	1
A	ICM	Particle counter	1
A	ICM	Radiation	1
A	ICM	Seismic	1
A	ICM	Titroprocesator	1
A	ICM	Current meter	1
A	IEO	CTD	2
A	IEO	Current gauge	1
A	IEO	Current meter	1
A	IEO	Level gauge	1
A	IFRE	Acoustic	1
A	IFRE	Biosensor	1
A	IFRE	Current meter	1
A	IFRE	Level gauge	1
A	IFRE	Particle counter	1
A	IFRE	Thermometer, Pressure	1
A	IFRE	Wave buoy	1
A	IFRE	WQ buoy	1
A	IMI	Current meter	1
A	METEO	Wave buoy	1
A	METO	Meteorological	2
A	METO	Thermometer	1
A	METO	Surface drifting buoy	1
A	METO	Meteorological, Wind speed	1
A	METO	Heave sensor	1
A	METO	Meteorological, Wind direction	1
A	MUMM	Remote Sensing-Aerial	1
A	NRA	Current meter	2
A	NRA	Fluorimeter	2
A	NRA	Remote sensing-Aerial	1
A	NRA	WQ, Meteorological buoy	1
A	NRA	Nutrient analysis	1
A	NRA	DO, pH	1
A	NRA	CTD	1
A	NRA	Transmission	1
A	RDANH	Current meter	3
A	RDANH	CTD	2
A	RDANH	Level gauge	2
A	RDANH	Sonar	1
A	RIKZ	Current Meter	6
A	RIKZ	Wave buoy	6
A	RIKZ	Level gauge	6
A	RIKZ	Echosounder	3
A	RIKZ	Remote sensing-Aerial	2
A	RIKZ	Fluorimeter	2
A	RIKZ	CTD	2
A	RIKZ	Wave analysis, Radar	2
A	RIKZ	Particle transport	1
A	RIKZ	Transmission	1
A	RIKZ	Thermometer	1
A	RIKZ	Sonar (SS)	1

Category	Agency Acronym	Device type	Number of devices
A	RIKZ	Remote Sensing-Satellite	1
A	RIKZ	Transmission, Turbidity	1
A	RIKZ	Particle analysis	1
A	RIKZ	Sonar	1
A	RIKZ	Nutrient analysis	1
A	RIKZ	Meteorological	1
A	RIKZ	Light meter	1
A	RIKZ	Levels, Altimeter	1
A	RIKZ	Level gauge, Wave analysis	1
A	RIKZ	CTD, Turbidity	1
A	RIKZ	Corer	1
A	RIKZ	Acoustic	1
A	RIKZ	Particle mass	1
A	SOC	Nutrient analysis	1
A	STNMT	Wave buoy	1

Table 21b

Category	Acronym	Device type	Number of devices
B	BSH	Fixed platform	2
B	BSH	Surface moored buoy	2
B	BSH	Towed undulating vehicle	1
B	BSH	Coastal vessel	1
B	FIMR	Ocean going ship	1
B	IBSR	Fixed platform, Sea bed mounting	1
B	IBSR	Surface moored buoy	1
B	ICM	Ocean going ship	2
B	IEO	Sub surface drifting buoy	1
B	IEO	Sub surface drifting buoy	1
B	IFRE	Sub surface moored buoy	2
B	IFRE	Surface moored buoy	2
B	IFRE	Surface drifting buoy	2
B	IFRE	Fixed platform	1
B	IFRE	Sub surface drifting buoy	1
B	IMI	Coastal vessel	1
B	METO	Surface moored buoy	3
B	NRA	Aircraft	1
B	NRA	Coastal vessel	1
B	NRA	Surface moored buoy	1
B	NRA	Towed undulating vehicle	1
B	RIKZ	Ocan going ship	4
B	RIKZ	Surface moored buoy	2
B	RIKZ	Fixed platform	2
B	RIKZ	Shore based mounting	2
B	RIKZ	Surface moored buoy, Surface drifting buoy	1
B	RIKZ	Aircraft	1
B	SOC	Towed undulating vehicle	1

Table 21c

Category	Acronym	Device type	Number of devices
C	BSH	Diesel generator	1
C	BSH	Equipment housing	1
C	BSH	Mooring system	1
C	ICM	GPS	2
C	IEO	Acoustic release	1
C	IEO	Pinger	1
C	IFRE	Acoustic release	1
C	IMI	Acoustic release	1
C	METO	Safety device	2
C	METO	Mooring system	1
C	METO	Communications system	1
C	METO	GPS	1
C	NRA	GPS	2
C	NRA	Navigation, Logger	1
C	RIKZ	Diesel generator	3
C	RIKZ	Calibration system	1
C	RIKZ	Mooring system	1
C	RIKZ	Platform ?	1

Table 21d

Category	Acronym	Device type	Number of devices
D	IEO	Telecom	1
D	IRFE	Data assembly	2
D	IFRE	Archive	1
D	METO	Telecom	2
D	METO	Data assembly	1
D	METO	Message switch	1
D	MUMM	Modelling	1
D	NRA	Archive	3
D	RIKZ	Data assembly	2
D	RIKZ	Telecom, Assembly, Analysis, Security, Handling, QC	1
D	RIKZ	Telecom, Assembly, Analysis, Archive, QC, Modelling	1
D	RIKZ	Telecom, Assembly, Analysis, Archive, QC	1
D	RIKZ	Data assembly, Analysis, Archive, Handling, QC	1
D	RIKZ	Archive, Handling	1
D	RIKZ	Analysis, Archive, Handling, QC	1
D	RIKZ	Telecom, Analysis, QC	1
D	RIKZ	Telecom, Assembly, Archive, Handling, QC	1

Table 21e

Category	Acronym	Device type	Number of devices
E	CNR	Mediterranean, Current predictions	1
E	IFRE	English Channel, Ecological models	1
E	IFRE	North East Atlantic, TSV	1
E	METO	UK Storm surge model	1
E	METO	European wave model	1
E	METO	Global salinity, temperature	1

Category	Acronym	Device type	Number of devices
E	METO	Global wave model	1
E	MUMM	Spills model, North Sea	1
E	MUMM	North Sea waves, Swell data	1
E	MUMM	North Sea, Flood risk	1
E	RIKZ	North Sea, Irish Sea Storm surge, elevation	1
E	RIKZ	Spills model, Oil, Toxics	1
E	RIKZ	Southern North Sea, RS data	1
E	RIKZ	Southern North Sea, Navigational safety	1
E	RIKZ	Southern North Sea, Wave energy	1
E	RIKZ	North Sea, Irish Sea levels & depths	1
E	RIKZ	North Sea, Irish Sea, WQ processes	1
E	RIKZ	Spills, Discharges, Estuaries, Shelf Seas	1
E	RIKZ	North Sea data & trends	1
E	RIKZ	North Sea & Global waves, forecast, hindcasts	1
E	RIKZ	Generic, Transport, Flows	1
E	RIKZ	Generic, Rivers, Est. Flows, Waves, Quality, Transports	1
E	RIKZ	European Shelf, Transport, Plumes	1
E	RIKZ	European Shelf, Storm surge prediction	1
E	RIKZ	Dutch Coast, Transport paths, Distributions	1
E	RIKZ	3D flows, Estuaries, Shelf Seas	1
E	RIKZ	North Sea, Wadden Sea, WQ	1
E	RIKZ	North Sea wind, wave, current data	1

Table 21f

Category	Acronym	Device type	Number of devices
F	FIMR	Data product, Distribution	1
F	FIMR	Service, Distribution	1
F	ICM	Distribution	1
F	IEO	Data product	1
F	METEO	Data product, Text, Service	1
F	MEO	Data product	1
F	MUMM	Data product, Service, Data service	1
F	NRA	Data product	3
F	NRA	Data product, Service, Distribution	1
F	NRA	Presentation	1
F	RDANH	Data product, Service	1
F	RIKZ	Data product	1
F	RIKZ	Data product, Presentation	1
F	RIKZ	Data product, Text, Service, Distribution	1
F	RIKZ	Presentation	1
F	RIKZ	Service	1
F	STNMT	Data product	1

***Table* 22** *Instruments in Category A listed in alphabetical order, showing operational status, generic type, agency using the instrument, and the EuroGOOS survey form number*

Device type	Status	Device name	Survey form No.
Acoustic	i) Fully operational	SUSLOS - Sound Velocimeter	085-IFRE-A
Acoustic	i) Fully operational	Odom Digiber	253-RIKZ-A
Bathythermograph	i) Fully operational	Thermosalinography	126-ICM-A
Biosensor	i) Fully operational	RLM Biointegrateur	099-IFRE-A
Corer	i) Fully operational	Coring systems	060-RIKZ-A
CTD	i) Fully operational	CTDO2	019-IEO-A
CTD	i) Fully operational	Falmouth ICTD	018-IEO-A
CTD	i) Fully operational	CTD system	059-RIKZ-A
CTD	iii) Working model	M E Meerestechnik Ecomemory	063-RIKZ-A
CTD	i) Fully operational	CTD MK-III	008-FIMR-A
CTD	i) Fully operational	Seabird 911+ CTD	007-FIMR-A
CTD	i) Fully operational	Conductivity sensor	226-BSH-A
CTD	i) Fully operational	CTD Seabird 25	123-ICN-A
CTD	i) Fully operational	CTD Mark IIIB EG&G	124-ICM-A
CTD	i) Fully operational	Salinometer	128-ICM-A
CTD	i) Fully operational	Aquapack	135-NRA-A
CTD	i) Fully operational	Conductivity sensor	225-BSH-A
CTD		Seacat Seabird SST	122-ICM-A
CTD	i) Fully operational	Seabird SBE9-O	245-RDAN-A
CTD	i) Fully operational	Meerestechnik ECO	246-RDAN-A
CTD, Fluorimeter, Turbidity	i) Fully operational	Delphin	235-BSH-A
CTD, Turbidity	i) Fully operational	Datasonde 3	056-RIKZ-A
Current gauge	iii) Working model	ADCP	020-IEO-A
Current meter	i) Fully operational	S4 Current Meter	142-NRA-A
Current meter	i) Fully operational	RCM4 Current Meter	141-NRA-A
Current meter	i) Fully operational	ADCP VM-150	120-ICM-A
Current meter	i) Fully operational	Aanderaa 2740 & 3590	248-RDAN-A
Current meter	i) Fully operational	Aanderaa DCM12	249-RDAN-A
Current meter	ii) Undergoing trials	ADCP	062-RIKZ-A
Current meter	ii) Undergoing trials	ADV Ocean Probe	061-RIKZ-A
Current meter	ii) Undergoing trials	UCM 60H	054-RIKZ-A
Current meter	i) Fully operational	MC360C - Current Meter	086-IFRE-A
Current meter	i) Fully operational	P-EMS	177-RIKZ-A
Current meter	i) Fully operational	Current Meter	017-IEO-A
Current meter	i) Fully operational	Aanderaa DCM12	016-RDAN-A
Current meter	iv) Research mode	Sediment Correlation Profiler (SCP)	211-RIKZ-A
Current meter	iii) Working model	Correlation Current Profiler (CCP)	212-RIKZ-A
Current meter	i) Fully operational	ACDP (Hull mounted)	222-IMI-A
Current meter	i) Fully operational	RDI ADCP	009-FIMR-A
Current meter	i) Fully operational	Current sensor	228-BSH-A
DO	i) Fully operational	Oxygen sensor	227-BSH-A
DO, pH	i) Fully operational	Chemitracka	137-NRA-A
Echosounder	i) Fully operational	Echosounder ED-500	121-ICM-A
Echosounder	i) Fully operational	Atlas-DESO 25	252-RIKZ-A
Echosounder	ii) Undergoing trials	Bathyscan Interferometric SwathSounder	257-RIKZ-A

Device type	Status	Device name	Survey form No.
Echosounder	i) Fully operational	EM1000 Multibeam echosounder	103-ICM-A
Echosounder	i) Fully operational	Edo Western 515, Deep Sea EchoSounder	255-RIKZ-A
Echosounder	i) Fully operational	EA500 - Hydrographic echosounder	105-ICM-A
Echosounder	i) Fully operational	Multibeam SIMRAD EM125120	102-ICM-A
Echosounder	i) Fully operational	EK-500	104-ICM-A
Fluorimeter	i) Fully operational	Fluorometer	130-ICM-A
Fluorimeter	i) Fully operational	Fluorimeter	140-NRA-A
Fluorimeter	ii) Undergoing trials	PAM fluorometer	117-RIKZ-A
Fluorimeter	i) Fully operational	Aquatracka III	136-NRA-A
Fluorimeter	i) Fully operational	Spectrofluorometer	133-ICM-A
Fluorimeter	i) Fully operational	Fluorometer	129-ICM-A
Fluorimeter	i) Fully operational	Aquatracka, fluorometer	116-RIKZ-A
Fluorimeter,Biomass	i) Fully operational	Flow-through chlorophyllmeasurement	012-FIMR-A
Gravitymeter	i) Fully operational	Marine gravitymeter BGM-3	109-ICM-A
Gravitymeter	i) Fully operational	WORDEN Master gravity meter	108-ICM-A
Heave sensor	i) Fully operational	Heave sensor Mk. II	039-METO-A
Level gauge	i) Fully operational	Lang Wave Logger	173-RIKZ-A
Level gauge	i) Fully operational	DNM	162-RIKZ-A
Level gauge	i) Fully operational	Step gauge Etrometa	164-RIKZ-A
Level gauge	i) Fully operational	Level-Log	174-RIKZ-A
Level gauge	i) Fully operational	Tide gauge	021-IEO-A
Level gauge	i) Fully operational	Step gauge 'Marine 300'	163-RIKZ-A
Level gauge	i) Fully operational	ORTM - Offshore Radio Tide Meter	172-RIKZ-A
Level gauge	i) Fully operational	OT 660S Tide Gauge	084-IFRE-A
Level gauge	i) Fully operational	Sonor Research 4PTM-01	015-RDAN-A
Level gauge	i) Fully operational	Mareographs	010-FIMR-A
Level gauge	i) Fully operational	Aanderaa WLR 7	250-RDAN-A
Level gauge, Wave analysis	i) Fully operational	Marine 300	052-RIKZ-A
Levels, Altimeter	iii) Working model	Radar Altimeter	064-RIKZ-A
Light meter	i) Fully operational	LI-COR 1925 Quantum Sensor	055-RIKZ-A
Logger	i) Fully operational	Data logger	240-BSH-A
Logger	ii) Undergoing trials	Data logger	241-BSH-A
Magnetometer	i) Fully operational	Magnetometer	107-ICM-A
Meteorological	i) Fully operational	PCRC-11 Humidity Sensor	045-METO-A

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Annexe 2 - EuroGOOS Variable List

A. Surface Fields

1. Sea surface temperature
2. Sea surface wind stress
3. Current velocity
4. Current 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

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