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SCIENCE FOR A SUSTAINABLE DEVELOPMENT

RESUSCITATION OF THE DATA COLLECTED DURING THE FIRST YEARS OF MODERN OCEANOGRAPHY IN BELGIUM

"PMPZ-DBII"

R. LAGRING, K. DECAUWER, M. DEVOLDER, S. SCORY

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SCIENCE FOR A SUSTAINABLE DEVELOPMENT
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North Sea

FINAL REPORT

RESUSCITATION OF THE DATA COLLECTED DURING THE FIRST YEARS OF MODERN OCEANOGRAPHY IN BELGIUM

"PMPZ-DBII"

SD/NS/14A

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TABLE OF CONTENT

ACRONYMS AND ABBREVIATIONS 5
SUMMARY 7
1. INTRODUCTION 11
2. METHODOLOGY 13
 2.1. Step 1: Inventory 13
  2.1.1. Identification of information 13
  2.1.2. Overview and follow-up system of digitization effort 19
 2.2. Step 2: Digitization and import in database 20
  2.2.1. Tables and graphs of final reports 20
  2.2.2. Data storage and management 20
 2.3. Step 3: Valorisation and dissemination 22
3. RESULTS 23
 3.1. Disciplines and parameters overview 23
  3.1.1. Project Sea (1970–1976) 23
  3.1.2. CRA "Oceanology" (1977–1982) 25
 3.2. Overview data-originators 28
 3.3. Recovered data and digitization 30
  3.3.1. Campaigns 30
  3.3.2. Samples 32
  3.3.3. Analysis methods 36
  3.3.4. Values 37
 3.4. Chlorophyll a values: an example of data recovered and imported in IDOD 40
  3.4.1. Introduction 40
  3.4.2. Chlorophyll a values available in IDOD 41
  3.4.3. Conclusions 44
4. CASE STUDY: HEAVY METALS AND PESTICIDES IN SEDIMENT OF THE COASTAL ZONE 47
 4.1. Introduction 47
 4.2. Inventory of pollutants in the marine coastal area 1972–1975 47
  4.2.1. Hypothesis 1 - pollutants measured on fraction $< 37\ \mu m$ 48
  4.2.2. Hypothesis 2 - pollutants measured on whole sample 52
 4.3. Conclusions 56
5. POLICY SUPPORT 57
6. DISSEMINATION 59
7. ACKNOWLEDGEMENTS 61
8. REFERENCES 63
Annex I: "Rescuing historical marine data and making it accessible: the case of data collected during the first years of modern oceanography in Belgium" 67
Annex II: "170 years of oceanographic data collection in Belgium, evolving needs, evolving means" 68
Annex III: "Data from ship logger to onshore viewer" 69

ACRONYMS AND ABBREVIATIONS

BMDC	Belgian Marine Data Centre
BODC	British Oceanographic Data Centre
BSH	Bundesamt für Seeschifffahrt und Hydrographie (Federal Maritime and Hydrographic Agency)
CRA	Concerted Research Actions Oceanology, in the framework of the North Sea Research Programme (Phase II)
CSR	Cruise Summary Report (former ROSCOPS)
FLEX	Fladen Ground Experiment
ICES	International Council for the Exploration of the Sea
IOC	Intergovernmental Oceanographic Commission of the United Nations Educational, Scientific and Cultural Organization
IDOD	Integrated and dynamical oceanographic data management
GODAR	Global Oceanographic Data Archaeology and Rescue
JONSDAP	Joint North Sea Data Acquisition Programme
LaMIS	Laboratory of the Marine Information Systems of the Ukraine Institute of Biology of the Southern Seas (IBSS)
MSFD	Marine Strategy Framework Directive
MUMM	Management Unit Mathematical Model North Sea
OSD	Ocean Station Data
OSPAR	The Convention for the Protection of the marine Environment of the North-East Atlantic
PMPZ	Project Mer / Project Zee / Project Sea, in the framework of the North Sea Research Programme (Phase I)
PMPZ-DBII	Resuscitation of the data collected during the first years of modern oceanography in Belgium
QUASIMEME	Quality Assurance of Information for Marine Environmental Monitoring in Europe
RBINS	Royal Belgian Institute of Natural Sciences
ROSCOP	Report of Observations / Samples collected by Oceanographic Programmes (now CSR)
SBNS	Southern Bight of the North Sea
SSD	Science for Sustainable Development
WOD	World Ocean Database

SUMMARY

A. Context

Long term data sets are a valuable tool to study the impact of global climate change on the environment and to define the "good environmental status" of an ecosytem. First of all, it allows us to give an idea of the status of the environment at the time and furthermore, long-term assessments can be performed giving an insight in the evolution over the years.

Although the World's very first marine research station was established in 1843 in Ostend by Pr. Pierre–Joseph van Beneden, systematic oceanographic data collection in the Belgian part of the North Sea was initiated at the end of the XIXth century 1899 by Pr. Gustave Gilson. Over more than ten years of intensive sampling cruises, he collected about 14 000 samples, which are currently preserved in the collections of the Royal Belgian Institute of Natural Sciences. Work is in progress to digitize this material. Systematic sampling cruises resumed in the seventies with the "Projet Mer/Projekt Zee" (*aka* "Project Sea", PMPZ, 1970–1976). The "Project Sea" is the first phase (1970–1976) of the North Sea Research Programme funded by the Belgian Science Policy Office. It brought together over 200 scientists from different disciplines with the aim to develop a coastal sea management model. The corresponding dataset gives a broad overview of the status of the Belgian marine waters at that time. PMPZ was followed by the second phase of the North Sea Research Programme, *i.e.* the Concerted Research Actions "Oceanology" (CRA, 1977–1982), which provided us with a deeper and complementary insight into some specific aspects of the Belgian coastal and estuarine ecosystem. The unique and irreplaceable data that was gathered during those projects are today at risk of being lost and need to be resuscitated.

The results of Phase I and II of the Research Programme are published in printed reports. Data documentation however, is far from complete. Technical reports, stored at MUMM were consulted to retrieve metadata. This gave us the opportunity to reconstruct the metadata and data gathered during Phase I and II. Most data could be incorporated in the main database (IDOD) of the Belgian Marine Data Centre (BMDC) and the resulting dataset is thus available to users like any other recent data.

B. Objectives

The results of these two extensive projects were kept so far in forms and formats (paper reports, copies of magnetic tapes, archives of the researchers), and therefore the data were not readily usable for further scientific analyses. Nowadays, a lot of effort is done by data

centres to store and archive data with an increasing amount of information, allowing users to read the data correctly. The aim of PMPZ-DBII was to recover the data and metadata gathered in the framework of Phase I and II and to store them into an integrated database for long-term archival. That way, the results are available in a user-friendly documented and securely archived way for further research.

C. Conclusions

I. Inventory and digitization of data of Project Sea and of CRA "Oceanology"

The available information (*i.e.* final reports, technical reports, databases, *etc.*) has thoroughly been screened. After analyses, it could be concluded that it was possible to reconstruct all campaigns and retrieve a considerable share of the meta-data and data that were obtained during Phase I and II. Mainly in the technical reports, found in the archive for most disciplines, original sampling data was retrieved. Information about methodologies was found in the final reports, however with restrictions.

II. Availability of the data via IDOD

The IDOD database (http://www.mumm.ac.be/datacentre) was specifically developed to deal with multi disciplinary oceanographic data and was found to be an ideal tool to store and safeguard the historical data in the same way as recent data. A method to import the data in IDOD has been defined. The data is made compatible with data received recently from monitoring or research projects. Based on the available technical reports, information could be retrieved about the campaigns, sampling events, samples, values and analysis methodology. The data is now publicly available to registered users via the common IDOD interface and can be used for further research. Data that need further quality checks were temporarily marked as private.

III. Use of the data for research

The case study we developed has clearly demonstrated that historical data have to be used with care. Especially the lack of fully documented analysis methods can result in misinterpretation during import. Extracting and interpreting data proved to be a very useful quality control and is highly recommended for each dataset in order to correct possible errors. Also, with the eye on normalization of data, it is possible that specific parameters are missing and that other cofactors need therefore to be considered. With the historical data, it is however possible to give an indication on the temporal and spatial evolution.

IV. Recommendations

Within the limited time span of the project PMPZ-DBII the metadata, like campaigns and sampling events, have been defined. So far, ca. 40 % of the data has been imported. The BMDC will keep importing the data in the coming months.

Monitoring and research data collected between 1983 and 1991, which are to some extent available in electronic archives at MUMM should be imported as well, in order to make full time series available.

D. Contribution of the project in a context of scientific support to a sustainable development policy

The Marine Strategy Framework Directive (MSFD) is one of the key legal instruments of the European Union (EU) for the protection of the marine environment and its associated ecosystems and biodiversity. The main objective of the MSFD is to achieve or maintain a "Good Environmental Status" (GES) in the marine environment by 2020, which in terms of the Directive comprises "protecting species and habitats, preventing and reversing human-induced decline of biodiversity and ensuring that diverse biological components function in balance" (Directive 2008/56/EC; Belgische Staat / État belge, 2012). In order to assess the state of the marine environment and its natural evolution, it is of high additional value to have historical data at our disposal that can be used to compare with today's results and measurements.

Furthermore, as mentioned above, Project Sea and CRA "Oceanology" were the first phases of the Belgian Federal North Sea Research Programme which is still ongoing today. A lot of effort was put in the projects by many researchers and scientific institutions. Before the valuable data are completely lost it is important that we safeguard them so they can be stored and used for further research within the frame of sustainable development. PMPZ-DBII was for this reason financed within the SSD programme.

E. Keywords

Belgian North Sea Research Programme, Projet Mer/Projekt Zee (PMPZ), Data resuscitation, Data archival, Long-term historical datasets, Integrated and Dynamical Oceanographic Data management system (IDOD), Belgian Marine Data Center (BMDC), Marine Strategy Framework Directive (MSFD), Southern Bight of the North Sea (SBNS)

1. INTRODUCTION

By the end of the 1960's major environmental problems caused by human activities came to surface. Since then, a lot of effort was performed to reduce further environmental damage. For example today, the European Marine Strategy Framework Directive (MSFD, 2008/56/EC), adopted in July 2008, aims at achieving or maintaining a good environmental status by 2020. It is therefore necessary to define a "good environmental status" based on thorough scientific knowledge which can be assessed using long-term datasets.

Belgium started systematic and coordinated measurement campaigns in 1970 with "Projet Mer/Projekt Zee" (PMPZ). This first Phase (1970-1976) of the North Sea Research Programme was followed by the Concerted Research Actions (CRA, Phase II of the North Sea Research Programme, 1977-1982). These extensive programmes resulted in a massive amount of data, which was only available on paper or in formats that were not readily usable for today's needs, and needed to be recovered. During the project "Resuscitation of the data collected during the first years of modern oceanography in Belgium" the data were inventoried, digitized and imported in the existing IDOD database, ensuring long term archival and making the data publicly available for further research.

Phase I – Project Sea (1970-1976)

"In 1970 the Belgian Government set up a national Environment/Water research programme under the influence of the European Economic Community to study the impact of pollution on soil, water and crops and to propose solutions, amongst which Project Sea (1970-1976). This first major Belgian programme in marine science had the purpose to 'assemble a reliable scientific basis and develop modelling techniques to permit both qualitative and quantitative simulation of the impact of natural phenomena or anthropic effects'. Project Sea had a very marked interdisciplinary character, with the cooperation of over 200 physicists, chemists, biologists, and geologists. The results were collated in a range of mathematical models developed over the period. In 1976 the Management Unit of the Mathematical Model of the North Sea (MUMM) was installed, which is now part of the Belgian Royal Institute of Natural Sciences (RBINS)."

Phase II - Concerted Research Actions Oceanology (1977-1982)

"Project Sea was followed by Phase II of the Belgian Federal North Sea Research Programme: the Concerted Research Actions 'Oceanology' (CRA). These research actions promoted sustained research in a number of laboratories and facilitated the expansion and improvement of results already achieved. Unlike Project Sea, there was no central scientific coordination structure, and governmental funding was significantly reduced."

(Source: http://www.belspo.be/belspo/NorthSea/program)

A specific methodology needed to be developed for resuscitation of Belgian marine data obtained during the period 1970-1982. A three step procedure was suggested: 1. Inventory, 2. Digitization and 3. Dissemination. In the first step, a strategy was developed to create an inventory of available information, meanwhile verifying the feasibility of data import. Here, the availability of data, *e.g.* position and time of sampling and analyses methods, for the various disciplines during both phases was screened. This way, it was verified whether the data could be imported in the database with the highest level of detail, giving the necessary information to integrate and compare with recent research results. When the original data were not found, another approach with appropriate documentation needed to be considered.

As starting points, the research campaigns and platforms were identified. A lot of data was collected aboard the research vessel "A962 Mechelen" by many scientists and institutions, like: phytoplankton inventory, pigments and POM (1971-1975); biomass and respiration of zooplankton (1971-1974); heavy metals in water (1971-1974, 1977-1981), biota, sediments and atmosphere (1981); sorption (1972-1975); physico-chemistry of sediments (1974-1975); sediment in suspension (1971-1974); nutrients (1978-1981); results of the Interdisciplinary Working group "Organic Matter" (1977-1978); *etc*. Other platforms were also used, many of which provided by the Belgian Navy.

All information sources, mainly the complete paper archive consisting of final and technical reports, have been screened and presented in inventories describing the available data and links between the documents. Various researchers and disciplines were involved and the data was not readily available, leaving us with a complex puzzle of unknown dimensions, which was difficult to rebuild. Dealing with this multidisciplinary and multi-annual data series, where gaps needed to be identified, was therefore a big challenge. Creating an inventory went hand in hand with preparing the data for import in the database and thus digitizing, meaning that steps 1 and 2 happened partly in parallel. The process involved importing campaigns, sampling events, samples, values and methodologies of sampling and analyses. Furthermore, details of the scientists and projects were required. Special attention was paid to quality control of the data. In the last step "dissemination", a case study was worked out based on a selection of data series, providing another way of checking the data for consistency. Adding the data that result from Project Sea and CRA to the database expanded the valuable historic data with a time range of more than 10 years.

2. METHODOLOGY

No standard methods are available for resuscitation of historical data; however guidelines were developed by the Laboratory of the Marine Information Systems (LaMIS) of the Ukraine Institute of Biology of the Southern Seas (IBSS) (Sergeyeva *et al.,* 2010), by Houziaux at recovering the Gilson-collection (Houziaux *et al.*, 2008) and by the Global Oceanographic Data Archaeology and Rescue (GODAR) Project of the Intergovernmental Oceanographic Commission of the United Nations (Levitus S., 2004). Houziaux, for example, recently made available (Houziaux *et al.*, 2008) the archived collections of samples built by Gustave Gilson between 1899 and 1914 during numerous sampling campaigns in the southern North Sea.

Based on methodologies of abovementioned references, a strategy was developed for this project in order to identify the useful information, to reference it in a relational way and to actually digitize it. Furthermore the data need to be valorised and disseminated. The whole process of data resuscitation can be summarized as a three-step procedure: 1. Inventory, 2. Digitization, 3. Dissemination. An overview of the strategy is given in Figure 1. The different steps are described in more detail below, as well as the feedback mechanism between the different steps.

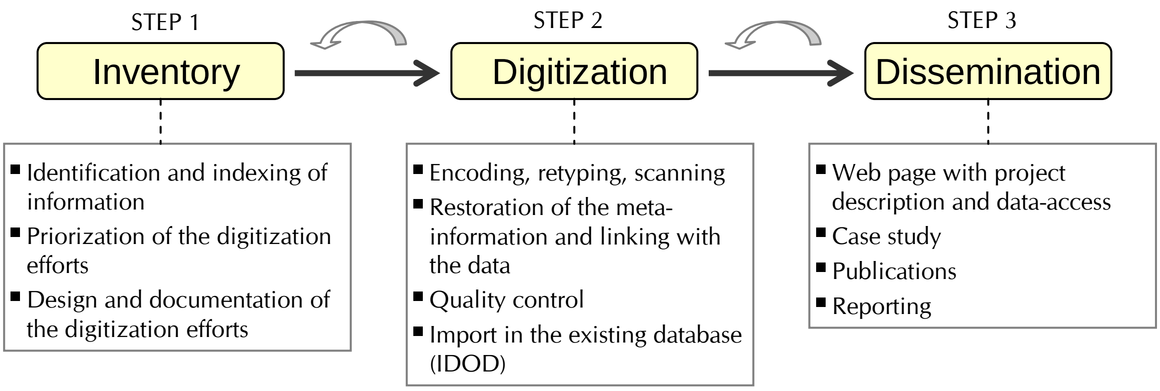


Figure 1: Strategy for historical data resuscitation.

2.1. Step 1: Inventory

2.1.1. Identification of information

In an initial phase, precise and extensive screening was performed of the information available about the project. Following documentation and information was identified for data resuscitation:

- Final reports of Phase I (11 volumes) and Phase 2 (4 volumes) (paper format),
- Progress reports and reports of study days (paper format),
- CDs, containing copies of some archived measurements (ASCII files),

- Technical reports of sampling campaigns (paper format),
- Scientific publications (paper and online),
- 1000-points map with station names and coordinates,
- Old database of monitoring data kept at MUMM: MONIT-B (converted to MS Access),
- ROSCOP's ("Report of Observations/Samples collected by Oceanographic Programmes") at ICES website.

Except for some documents kept in external archives, like the study on macrobenthos by Govaere kept at the RBINS head office, everything will be archived at the BMDC.

a. Final Reports

The results of Phase I (PMPZ) and II (CRA) are published as final reports which are a summary of the research performed in 1970–1982 by various scientists and institutions. These are available in paper format. Initially, a thorough screening of all final volumes was performed for contents, parameters, research subjects, authors, *etc*. This information was then linked to all tables and graphs that have been digitized (see step 2), resulting in an overview of the contents of the project. Next, it was verified what information could be extracted from the final reports. It can be noticed that the languages of the reports of Phase I are French and Dutch, depending on the executing laboratories and authors. The final reports of Phase II are in English. Also important to mention is that there is a structural difference between the reports of Phase I and Phase II, as a consequence of difference in coordination of the projects.

Phase I had a central coordinator, Pr. J.C.J. Nihoul (ULg), with a central goal to create a management model with a limited and well defined but representative amount of variables of the ecosystem. As a consequence, the report of Phase I is a clearly structured summary report with, per volume, well defined disciplines (*e.g.* sediment, pollution, biota...) which are sometimes overlapping (*e.g.* shell fraction within the section "sediment", or sediment distribution maps in the section of "benthos"). Extracting the type of parameter addressed in each volume is feasible (Figure 2). Note that volumes 1, 2, 3 and 5 describe the processes of creating an ecosystem model and data compilation, without direct output of data that would require preservation. They are based on data compiled in the other volumes, which were used for experimental validation and simulation of the model: Sedimentology (Volume 4); Inventory of pollutants (Volumes 6 and 11); Inventory of fauna and flora and ecosystem characterisation (Volumes 7 and 8); Contamination of marine organisms (Volume 9) and the Study of the Scheldt Estuary (Volume 10) (Nihoul *et al*., 1976).

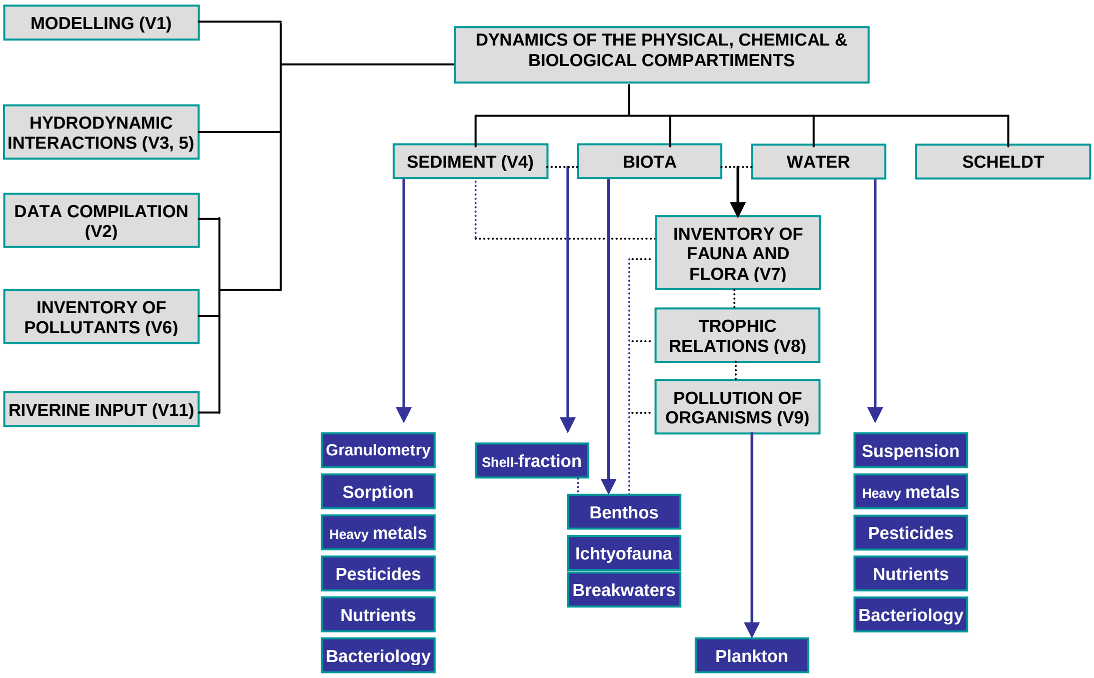


Figure 2: Structure of the final reports of Phase I, with the corresponding parameters shown in blue.

After Project Sea, governmental support and funding for research was reduced and limited in research groups. These few universities made the decisions on how funds were allocated. As a result, no programme structure was set up and coordination between the research groups was minimal. Each group functioned as an isolated cell with increased specialisation (Boissonnas *et al.*, 2004) and some working groups were set up (e.g. Workgroup Organic Matter). The final report of Phase II is a compilation of scientific publications per subject, with less clear delimitations: Hydrodynamic and dispersion models, boundary fluxes and boundary conditions (Volume 1) (Nihoul and Wollast, 1982); Distribution, transport and fate of heavy metals in the Belgian coastal marine environment (Volume 2) (Distèche and Elskens, 1982), Biological processes and translocations (Volume 3) (Heip and Polk, 1982) and Selected topics in marine aquaculture: Micro algae, Mollusc nursery, Artemia (Volume 4) (Persoone, 1982). An overview of the different disciplines of performed research and obtained parameters during Phase II can be found in Figure 3. Note that not all results are published in the final reports, e.g. additional data are found in reports of study days in 1979 and 1980 (Anon., 1979 and 1980).

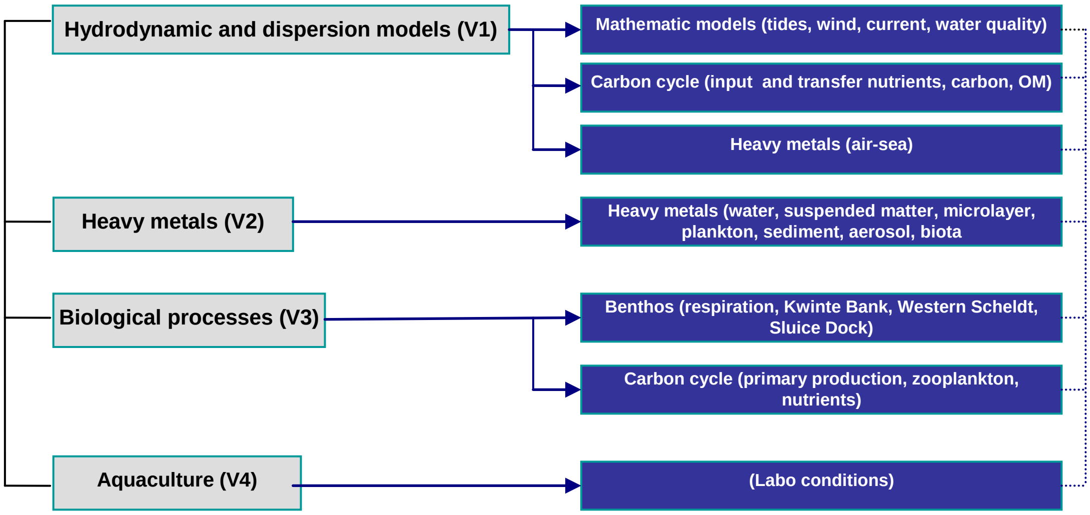


Figure 3: Structure of the final reports of Phase II with the corresponding parameters shown in blue.

In the final reports of Phase I and II, conclusions and sampling methods are often described, however the meta-information is incomplete and not readily usable for import in the IDOD database. For example campaign dates, platform, sampling time and coordinates are most often missing in the text. The data description in the text varies per author and per topic. A lot of results in the final reports are presented based on aggregated values. This means that there is no immediate link to the original data with sampling time and position. Examples of variable data availability in the final reports are given in Figure 5 and Figure 4.

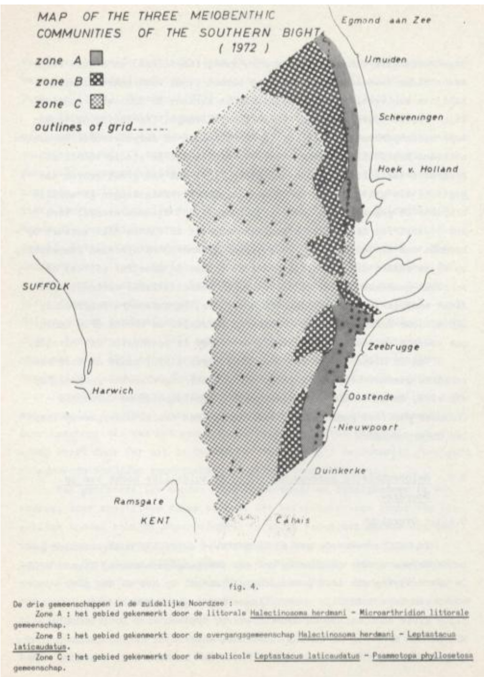


Figure 5: Map of the three meiobenthic communities of the Southern Bight in 1972 (Nihoul et al., 1976, Volume 7)

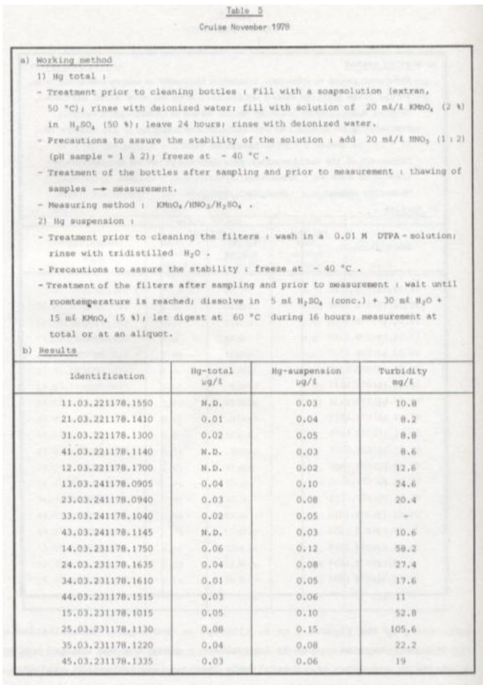


Table 5

Cruise November 1978

a) Working method

1) Hg total :

- Treatment prior to cleaning bottles : Fill with a soapsolution (extran, 50 °C); rinse with deionized water; fill with solution of 20 ml/l $KMnO_4$ (2 %) in H_2SO_4 (50 %); leave 24 hours; rinse with deionized water.
- Precautions to assure the stability of the solution : add 20 ml/l HNO_3 (1 : 2) (pH sample = 1 à 2); freeze at - 40 °C .
- Treatment of the bottles after sampling and prior to measurement : thawing of samples → measurement.
- Measuring method : $KMnO_4/HNO_3/H_2SO_4$.

2) Hg suspension :

- Treatment prior to cleaning the filters : wash in a 0.01 M DTPA - solution; rinse with tridistilled H_2O .
- Precautions to assure the stability : freeze at - 40 °C .
- Treatment of the filters after sampling and prior to measurement : wait until roomtemperature is reached; dissolve in 5 ml H_2SO_4 (conc.) + 30 ml H_2O + 15 ml $KMnO_4$ (5 %); let digest at 60 °C during 16 hours; measurement at total or at an aliquot.

b) Results

Identification	Hg-total µg/l	Hg-suspension µg/l	Turbidity mg/l
11.03.221178.1550	N.D.	0.03	10.8
21.03.221178.1410	0.01	0.04	8.2
31.03.221178.1300	0.02	0.05	8.8
41.03.221178.1140	N.D.	0.03	8.6
12.03.221178.1700	N.D.	0.02	12.6
13.03.241178.0905	0.04	0.10	24.6
23.03.241178.0940	0.03	0.08	20.4
33.03.241178.1040	0.02	0.05	-
43.03.241178.1145	N.D.	0.03	10.6
14.03.231178.1750	0.06	0.12	58.2
24.03.231178.1635	0.04	0.08	27.4
34.03.231178.1610	0.01	0.05	17.6
44.03.231178.1515	0.03	0.06	11
15.03.231178.1015	0.05	0.10	52.8
25.03.231178.1130	0.08	0.15	105.6
35.03.231178.1220	0.04	0.08	22.2
45.03.231178.1335	0.03	0.06	19

Figure 4: Data for the campaign in November 1978 on Hg by the Laboratorium voor Analytische Scheikunde (VUB) (Anon., 1979)

Figure 5 is a distribution map published in the final report of Project Sea with mean values obtained in 1972 for the study of meiobenthos by the "Laboratorium voor Morfologie en Systematiek" (RUG). The report does not contain the exact coordinates or the times of sampling and therefore important information is missing for data import. The table in Figure 4 on the other hand, provides complete information about one campaign (Hg in November 1978 by VUB), however no information is provided about the other campaigns. Furthermore, results from projects with laboratory experiments are not time and location related and will not be imported in the database.

b. Databases

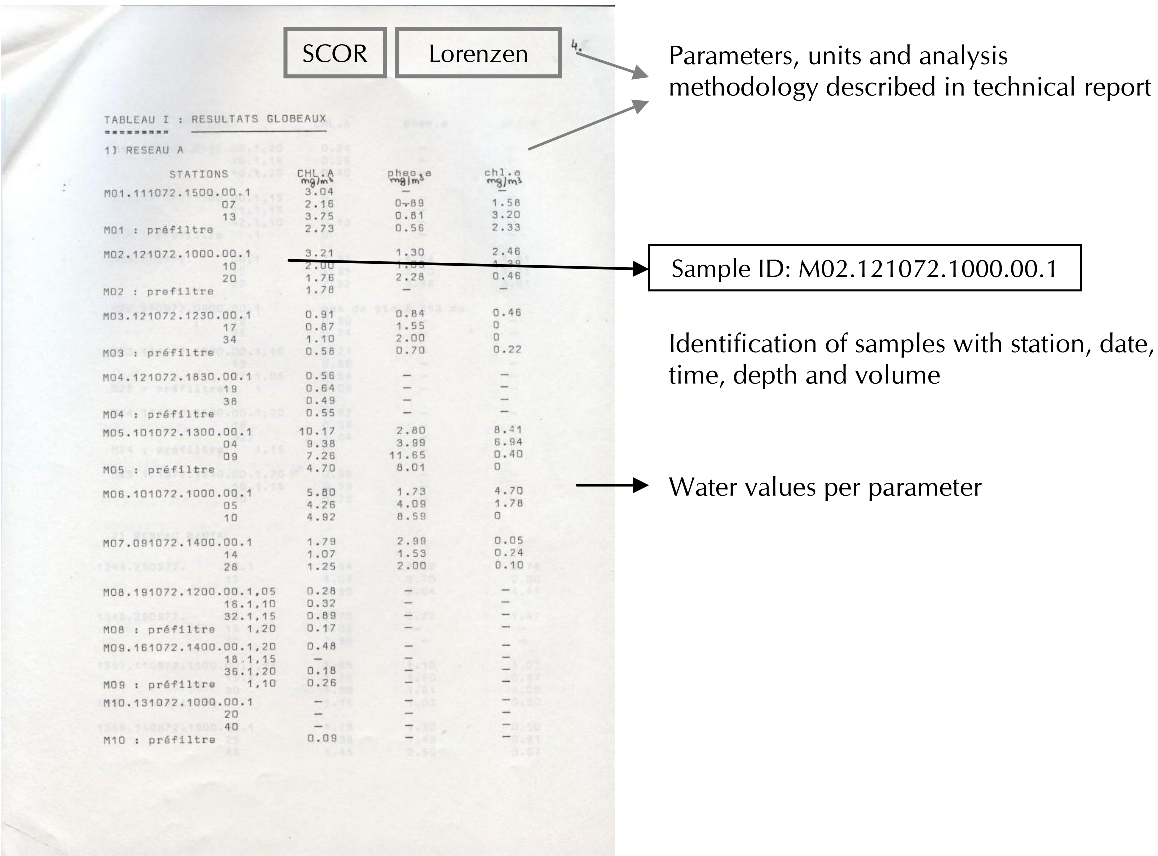
Meta-information about campaigns was looked for in ROSCOP/CSR metadata catalogues. The concept of ROSCOP (Report of Observations/Samples collected by Oceanographic Programmes) was defined by IOC (http://www.ioc-unesco.org) in the end of the 1960's with the aim to provide a low level inventory for tracking oceanographic data collected on research vessels. The ROSCOP form was revised in 1990, and was re-named the CSR (Cruise Summary Report). ROSCOP forms are available for Belgian ships since 1969 on the ICES website (http://ocean.ices.dk/Roscop/roscop.asp), with meta-data of campaigns aboard the navy ship "Mechelen" and the light vessel "West-Hinder" (also available in paper format at MUMM). For the data that were reported to ICES, it is possible to retrieve information about the number of campaigns with cruise dates, number of water bottles and parameters (physical, chemical, and biological oceanography, fisheries, marine contamination/pollution, and marine meteorology). The earliest Belgian report found on the SeaDataNet CSR Inventory (http://www.seadatanet.org/Metadata/CSR) dates from 1984 and describes a cruise aboard the platform "Belgica".

Ocean Station Data (OSD) on temperature and salinity (incl. platform, coordinates and time of sampling) are available on the World Ocean Database (WOD) covering phases I and II. OSD-data on temperature and salinity since 1970 is also available via GODAR (http://www.nodc.noaa.gov/General/NODC-dataexch/NODC-godar.html), which has the aim to acquire chlorophyll and plankton values worldwide (Levitus, 2004). However, OSD also contain data collected in Belgian waters by other countries, which are therefore not linked to this project.

Data and meta-information on water, sediment and biota samples collected since 1977 in the frame of the Belgian national monitoring programme are kept in an old data base structure ("Monit-B"), which has been converted in MS-Access format at the BMDC. Some of the corresponding parameters were in fact by dedicated CRA (*e.g.* heavy metals in the Belgian coastal marine environment) and could therefore easily be retrieved. Concerning concentration values in water, the Monit-B database is well documented and has information on: campaign, platform, laboratory, station codes and coordinates, parameters, values. Sampling and analysis methods, however, were recovered via the technical reports.

c. Technical reports

During coordination meetings in Phase I, it was decided that results needed to be reported to the central unit. The technical reports (paper format) of most disciplines and authors of sampling during Project Sea and the CRA "Oceanology" are stored in the archives of MUMM (*ca.* 12 boxes) and contain original information about sampling, both during Phase I and Phase II. These reports provide information on: station, date, time, depth, parameters, values (with units) and methodology (differing per author). This is the information required to import fully documented data in IDOD. As an example, Figure 6 is part of a technical report for phytoplankton analyses during Project Sea by the Laboratory of Oceanology (ULB) and RBINS. The codes labelling the samples were important for samples not to get lost when sent to the labs after the cruises. A typical sample label read "Pnn.ddmmyy.hhmm.zz[.v,vv]", where "P" stands for platform, "nn" for the name of the station, "ddmmyy.hhmm" for date and time, "zz" for depth and "v,vv" for volume.



4.

TABLEAU I : RESULTATS GLOBEAUX

1) RESEAU A

STATIONS	CHL.A mg/m³	pheo.a mg/m³	chl.a mg/m³
M01.111072.1500.00.1	3.04	—	—
07	2.16	0.89	1.58
13	3.75	0.81	3.20
M01 : préfiltre	2.73	0.56	2.33
M02.121072.1000.00.1	3.21	1.30	2.46
10	2.00	[illegible]	1.39
20	1.76	2.28	0.46
M02 : prefiltre	1.78	—	—
M03.121072.1230.00.1	0.91	0.84	0.46
17	0.87	1.55	0
34	1.10	2.00	0
M03 : préfiltre	0.58	0.70	0.22
M04.121072.1830.00.1	0.56	—	—
19	0.64	—	—
38	0.49	—	—
M04 : préfiltre	0.55	—	—
M05.101072.1300.00.1	10.17	2.80	8.41
04	9.38	3.99	6.94
09	7.26	11.65	0.40
M05 : préfiltre	4.70	8.01	0
M06.101072.1000.00.1	5.80	1.73	4.70
05	4.26	4.09	1.78
10	4.92	8.59	0
M07.091072.1400.00.1	1.79	2.99	0.05
14	1.07	1.53	0.24
28	1.25	2.00	0.10
M08.191072.1200.00.1,05	0.28	—	—
16.1,10	0.32	—	—
32.1,15	0.89	—	—
M08 : préfiltre 1,20	0.17	—	—
M09.161072.1400.00.1,20	0.48	—	—
18.1,15	—	—	—
36.1,20	0.18	—	—
M09 : préfiltre 1,10	0.26	—	—
M10.131072.1000.00.1	—	—	—
20	—	—	—
40	—	—	—
M10 : préfiltre	0.09	—	—

Figure 6: Technical report with detailed description of methodology, samples and results of phytoplankton analyses during Phase I (1972).

d. Other publications

More reports, summaries of study days during the projects, scientific publications, *etc*. of Phase I and II are available. Similar to the final reports, they do not always contain consistent information about the original data and sometimes incomplete lists are provided. One campaign, cruise or sample dataset can lead to various publications. If in the publication no information is found about the meta-data, it is very time consuming to trace it back, especially if the data-originator can no longer be contacted. Scientific publications in particular can provide information on analysis methods.

2.1.2. Overview and follow-up system of digitization effort

After identification of the available information, an overview was created of the parameters in different substrates (water, sediment and biota) and the responsible laboratories. This overview was structured per phase, per zone (the so called '1000-points' grid, coastal zone or Western Scheldt Estuary) and per discipline or group of parameters (e.g. heavy metals, nutrients, pesticides). This list was used as a follow-up system, to track what information is available for methodology (sampling and analysis) and original sampling data (location and time) of all samples and measurements of PMPZ and the CRA.

Based on the fields which are required to import data in the database (see Step 2), the mandatory information was verified. Missing information or gaps (Figure 7) could be at the level of unavailable or available but incomplete reports. To fill up the gaps, information was traced in the final reports, scientific publications and grey literature or via the data-originators (or the corresponding laboratories and institutions if these still exist). Within the scope of this project, we focussed on original values. Data available in the final reports, which are often aggregated values, will require a new methodology of import as extra information will need to be extracted from a variety of sources: distribution maps, graphs, tables, text from final reports and scientific publications.

This is a complex, intense and time consuming process, since it requires a view on all campaigns and sampling events that took place. Moreover, it is a step-by-step process of data resuscitation, where inventorying and digitizing go hand in hand (Figure 7). Relevant data with samples and values are entered in the standard format used for import ("Common Layout", see 2.2.2.), which is already part of the digitizing process (Step 2), and at the same time the follow-up system needed to be updated. Data that could not yet be imported was indexed and are stored at the archives for further import in the near future.

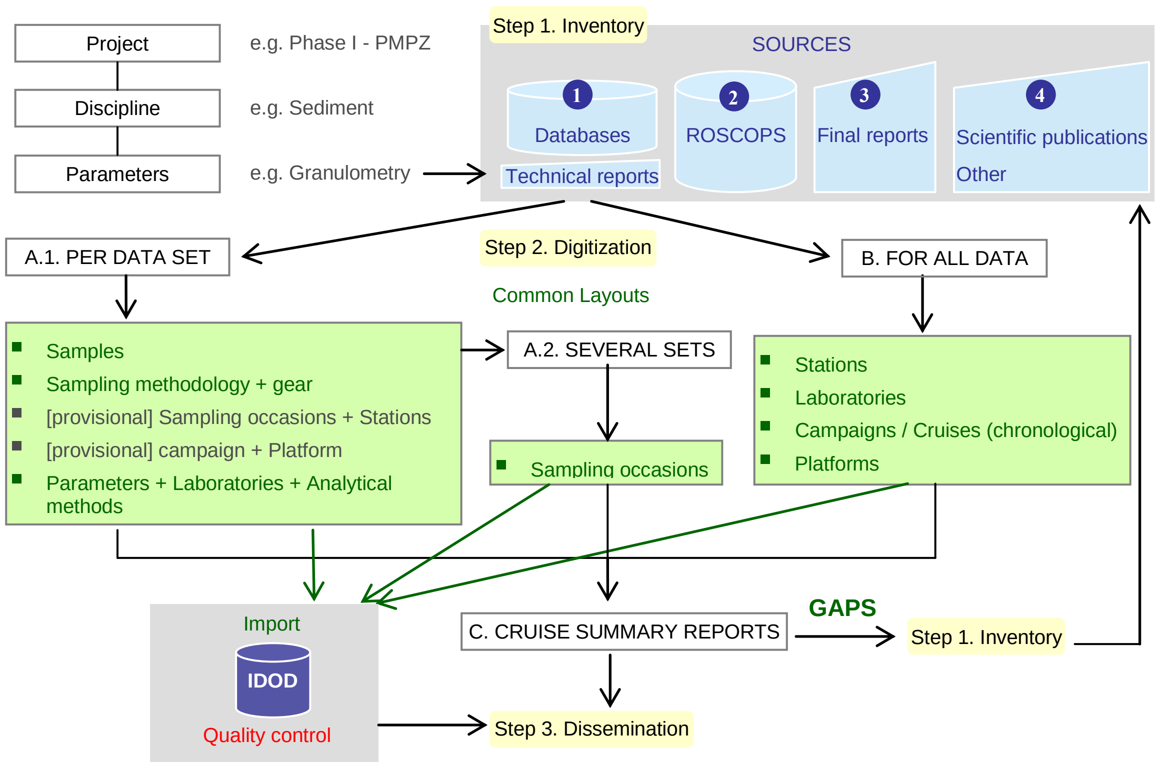


Figure 7: Step-by-step process of complete resuscitation of historical data. Step 1: identification of the disciplines with parameters and inventorying in the various types of available information. Step 2: digitization, import into the database identifying and filling up the gaps and finally step 3: dissemination.

2.2. Step 2: Digitization and import in database

2.2.1. Tables and graphs of final reports

As a first step of the digitization, all data from the final reports (Volume 1-11 of Phase I and Volumes 1-4 of Phase II) have been digitized in order not to loose any more information. Part of this process involved retyping tables and scanning graphs and maps from the final reports. For the tables, a master layout was designed in excel which could be used for extracting the necessary information. Graphs have been scanned in TIFF file format and information about the graph, like source, and title, was put in excel files. Data of the graphs can be extracted in case the original values cannot be retrieved in a more efficient way. Important information is also available in the format of distribution maps published in the final reports.

2.2.2. Data storage and management

Good data storage and management requires an adequate data system. The IDOD database or "Integrated and Dynamical Oceanographic Data management system" was specifically developed to deal with oceanographic data. It is made of five main modules, the core of which consisting in a relational database with more than a hundred tables. It is able to manage data of various substrates and types, like concentrations in air, water, sediment, tissues, granulometry of sediments, optical (spectral) properties of the seawater, population counts, physiological parameters, *etc*. Importing data in this system involves preparing and recovering all required fields to complete all the tables. Figure 8 is a simplified overview of IDOD, giving an idea of the information that needs to be available before data can be imported. Today, the IDOD system is fed with the measurements made aboard various sampling platforms (e.g. Belgica, Zeeleeuw, Tuimelaar), and currently contains *i.a.* over 60 000 sediment values, 125 000 water values and 120 000 biota values of over 600 parameters.

Nowadays, data providers are asked to preferably report their data using a BMDC standard format ("Common Layout", excel-files), which is then used for controlling the consistency and validity of the data and finally for importing them in IDOD. The CL-format varies with the data type to be reported (sediment, water, biota, biodiversity, air). Before a data set can be imported into the database, a strict procedure concerning documentation and quality control is followed. All data is manually checked for completeness and clearness by the data managers and often the data providers still have to be contacted for missing or explanatory information (Pichot *et al.*, 2002; K. De Cauwer *et al.*, 2006). For the data of PMPZ-DBII a similar methodology is applied, meaning that all data need to be transformed to the specific CL-format. An overview of the procedure of data import in IDOD is given in Figure 9.

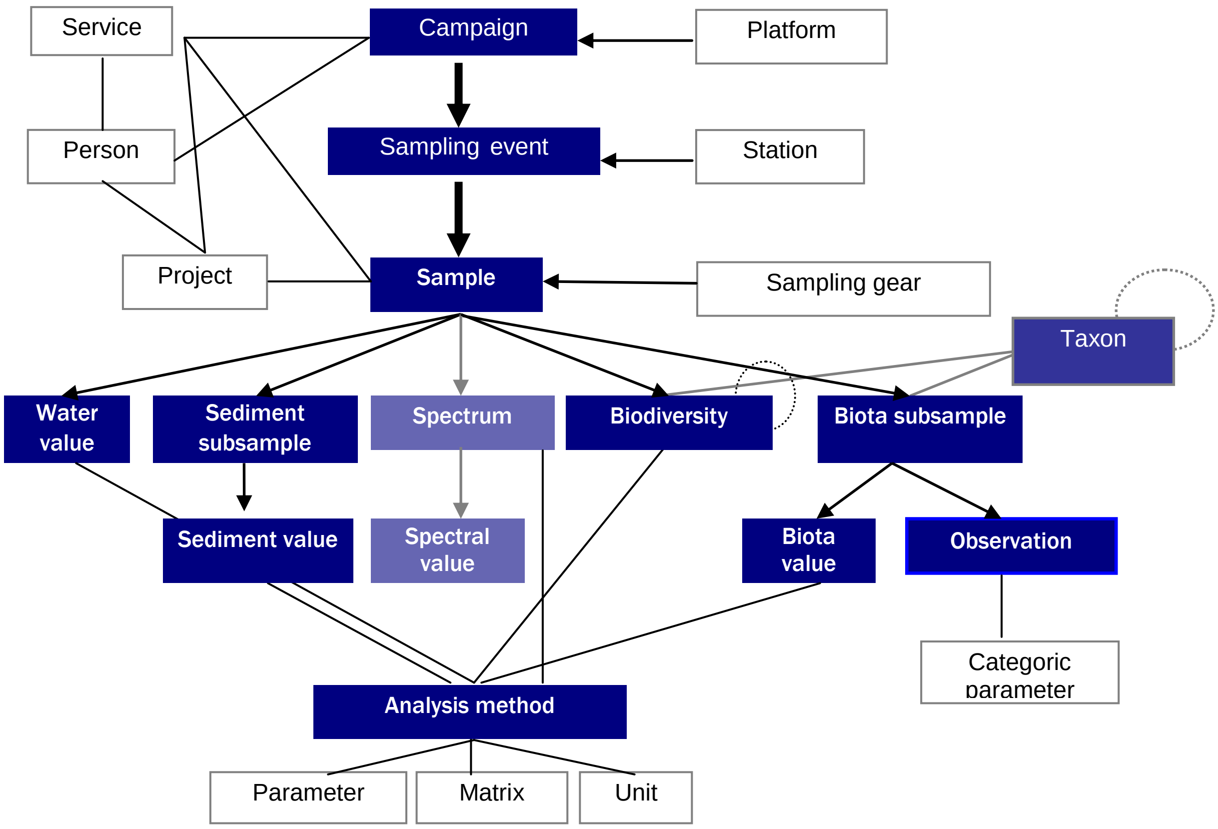


Figure 8: General structure of IDOD with required fields for import

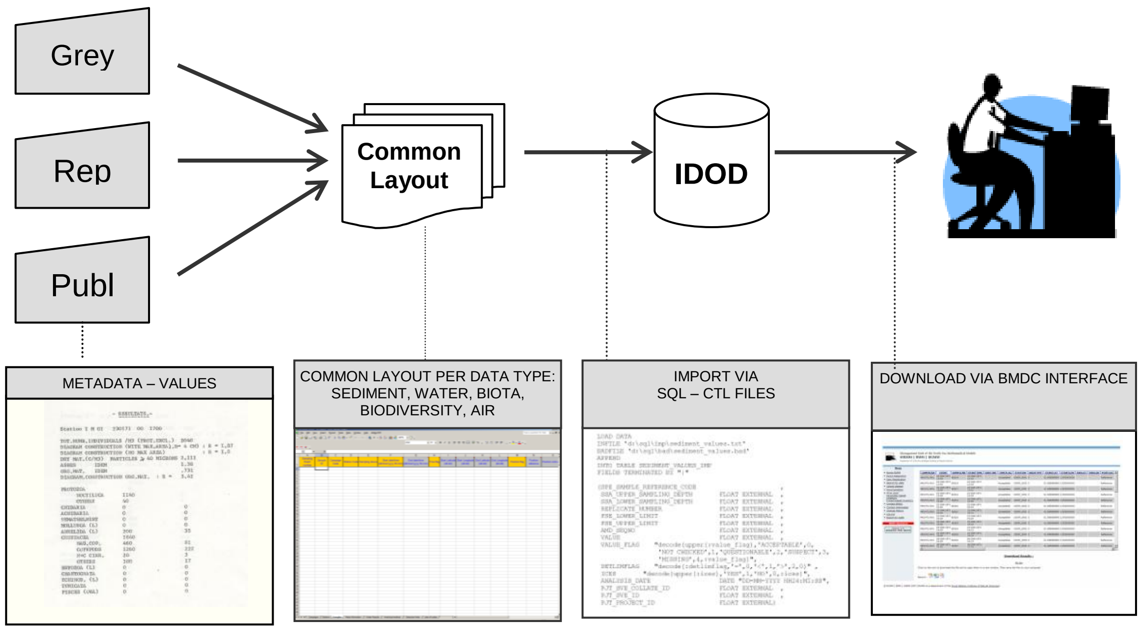


Figure 9: Data-flow from paper reports to the user, starting with import of data of grey literature, reports and other publications in common layout format to import in IDOD and download via the BMDC interface.

2.3. Step 3: Valorisation and dissemination

The data imported in IDOD are online accessible via the user interface at http://www.mumm.ac.be/datacentre. The data users are persons that have registered on the web and received a login name and password, allowing them to select and extract data online. Since its launch, 785 persons were registered.

A case study was carried out based on the obtained datasets, as an extra quality control of the imported data and also to show the use of the resuscitated data from 1971 until 1982 (Chapter 4). The case study demonstrates the data availability, extraction and importance of data documentation when comparing historical contaminants in sediment in the water column with recent data. This exercise proved to be a very useful step in the quality control of the considered dataset and is advisable for every historical data set.

3. RESULTS

3.1. Disciplines and parameters overview

3.1.1. Project Sea (1970–1976)

In Tables I to IV an overview is given of the parameters that were measured in the framework of Project Sea (1970-1976) for water, sediment and biota samples. For each group of parameters (also defined as "disciplines") the data–originators (LAB) were identified and reference was made to the final report (Volumes 1–11). To indicate the availability of information on "Methodology" (analytical & sampling; mostly in final reports), three levels are used: available (M1), partly available (M2), not available (M0). The same principle was applied to the availability of information on "Sampling" (position and time; most information retrieved in technical reports) information available (S1), partly available (S2), not available (S0).

The research during PMPZ was geographically divided in different locations and stations:
"*1000–points*" (Figure 14) concerns all research that was performed using stations of the 1000–points map aboard naval ships like the "A962 Mechelen".
"*Coast / beach*" (Figure 16) involves data that was collected in the coastal zone (up to 6 km with the hydrographic vessel "Paster Pype"), at breakwaters, in coastal canals, in the Sluice Dock *etc*.
"*Scheldt*" involves research in the Western Scheldt Estuary.

Table I: Parameters with data-originators in water and sediment recovered from PMPZ

Parameter	Data-originators (LAB)	Final report	Method	Sampling
WATER				
1000–points				
Suspended matter	F. Gullentops *et al.* (KUL), R. Wollast *et al.* (ULB)	V4	M1	S1
Nutrients	D. Janssens, I. Elskens (VUB), Wollast (ULB)	V8	M1	S1
Heavy metals	G. Gillain, G. Duyckaerts (ULg)	V6	M1	S2
Pesticides	J. Henriet *et al.* (Min. Agr.)	V6	M1	S0
Microbiology	C. Joiris *et al.* (VUB)	V8	M1	S1
Plankton (cfr biota)				
Coast / beach				
Heavy metals	J. Bouquiaux *et al.* (IHE)	V6, 11	M1	S1
Pesticides	J. Bouquiaux *et al.* (IHE)	V6, 11	M1	S1
Bacteriology	J. Bouquiaux *et al.* (IHE)	V6, 11	M1	S1
Western Scheldt Estuary				
Microbiology	G. Billen (VUB, ULB), J. Barbette (IHE), C. Joiris (VUB)		M1	S1
Nutrients	D. Janssens, I. Elskens (VUB)		M1	S1
Heavy metals	Gillain (ULg), M.F. Henry (IRSN)		M1	S1
Meteo and hydrology	(see below)			

Table II: Parameters with data-originators in sediment recovered from PMPZ

Parameter	Data-originators (LAB)	Final report	Method	Sampling
SEDIMENT				
1000–points				
'lichte mineralen'	F. Gullentops *et al.* (KUL)	V4	M2	S2
Granulometry	F. Gullentops *et al.* (KUL)	V4	M1	S0
Heavy metals	R. Wollast *et al.* (ULB)	V4	M1	S1
Sorption	A. Bastin *et al.* (RBINS)	V4	M1	S2
Nutrients	G. Billen *et al.* (ULB) - modelling	V4	M1	S1
Pesticides	J. Henriet *et al.* (Min. Agr.)	V6	M1	S0
Bacteriology	G. Billen *et al.* (ULB), A. Boeyé *et al.* (VUB)	V8, 7	M1	S1
Coast / beach				
Heavy metals	P. Herman (IRC), J. Bouquiaux *et al.* (IHE)	V6, 11	M1	S1
Pesticides	P. Herman (IRC), J. Bouquiaux *et al.* (IHE)	V6, 11	M1	S1
Bacteriology	P. Herman (IRC), J. Bouquiaux *et al.* (IHE)	V6, 11	M1	S1

Table III: Parameters with data-originators in biota recovered from PMPZ

Parameter	Type	LAB	Final Report	Method	Sampling
BIOTA					
1000–points					
Biota	Industrial discharges	Working group Biology	V5	M1	S2
Benthos	Heavy metals	P. Herman, R. Vanderstappen *et al.* (Min. Agr.; sampling by RvZ)	V9	M1	S2
	Heavy metals	C. Perpeet, M. Vloebergh (ULB)	V9	M1	S2
	Pesticides	P. Herman, R. Vanderstappen *et al.* (Min. Agr.; sampling by RvZ)	V9	M1	S2
- Meiobenthos	Inventory	D. Van Damme, C. Heip *et al.* (RUG)	V7	M1	S0
	Flux	D. Van Damme, C. Heip *et al.* (RUG)	V7, 8	M1	S0
- Macrobenthos	Inventory	J. Govaere (RUG)	V7	M1	S0
	Flux	R. De Boever, J. Govaere, L. Thielemans *et al.* (RUG)	V7, 8	M1	S0
	Bivalvia	F. Gullentops *et al.* (KUL)	V4	M1	S0
- Epibenthos	Inventory	F. Redant *et al.* (VUB)	V7	M1	S0
	Flux	L. De Coninck, F. Redant *et al.* (VUB)	V7, 8	M1	S0
Ichtyofauna					
	Heavy metals	R. Vanderstappen, P. Herman (IRC)	V9	M1	S2
- Demersal & pelagic fish (non-commercial)	Inventory	F. Redant (VUB / Min.Agr)	V7	M1	S0
- Embryonal & larval phase (fish-plankton)	Inventory	R. De Clerck, J. Van De Velde *et al.* (Min.Agr.)	V7	M1	S0
- Pre- and post recruiting phase (commercial)	Inventory	R. De Clerck, J. Van De Velde *et al.* (Min.Agr.)	V7	M1	S0
Plankton	Heavy metals	I. Elskens (VUB)	V9	M1	S2
	Pesticides	I. Elskens (VUB)	V9	M1	S0
Zooplankton	Biomass	M. Bossicart, Daro *et al.* (VUB)	V7, 8	M1	S1
	Flux	P. Polk, M. Bossicart, Daro *et al.* (VUB)	V8	M1	S1
	Respiration	J. Hecq *et al.* (ULg)	V8	M1	S2
	Hydromedusa	G. Houvenaghel *et al.* (ULB)	V7, 8	M1	S1
	Copepoda	P. Polk *et al.* (VUB)	V7	M1	S1
Phytoplankton	Biomass	Van der Ben *et al.* (RBINS)	V7	M1	S2

Parameter	Type	LAB	Final Report	Method	Sampling
	Inventory	Louis, Huys *et al.* (KUL)	V7	M1	S1
	Productivity	J.–P. Mommaerts *et al.* (VUB)	V8	M1	S1
	Pigments	G. Houvenaghel, Bouillon, Steyaert, C. Lancelot *et al.* (ULB)	V8	M1	S1
	POM	Bouillon, C. Lancelot (ULB)	V8	M1	S1
Coast / Beach					
Organisms 'breakwaters'	Inventory	C. Van der Ben, D. Van der Ben (RBINS), J. Van Goethem, M.H. Daro et al. (VUB)	V7	M1	S2
	Heavy metals	J. Bouquiaux *et al.* (IHE), Van der Ben *et al.* (RBINS)	V6	M1	S2
		P. Herman, R. Vanderstappen *et al.* (Min.Agr.)	V9	M1	S2
	Pesticides	J. Bouquiaux *et al.* (IHE), Van der Ben *et al.* (RBINS)	V6	M1	S2
	Bacteriology	J. Bouquiaux *et al.* (IHE), Van der Ben *et al.* (RBINS)	V6	M1	S2
Laboratory					
Biota: Physiology	Heavy metals	A. Disteche *et al.* (ULg)		M1	S2

Table IV: Meteorological and hydrological parameters with data-originators recovered from PMPZ

Parameter	Type	LAB	Final Report	Method	Sampling
METEO AND HYDROLOGY					
Meteo & hydro Scheldt		F.N. – Z.M.			
Alkalinity		R. Nadin (ULg)			
Temp & oxy		I. Elskens, Janssen (VUB)		M1	S1
Salinity		F.N.		M1	S1

3.1.2. CRA "Oceanology" (1977–1982)

An overview of the diverse disciplines of research during the CRA "Oceanology" (Phase II) is given in Tables V and VI. The data is grouped per subject based on the output in the final reports: Pollution (heavy metals), Micro layer water-air, Benthos and Carbon cycle.

Table V: Parameters with data-originators recovered from CRA

Subject	Sample	Parameters	Data-originators (LAB)	Report	Method	Sampling
Pollution - Heavy metals						
Distribution, transport and fate of Bi, Cd, Cu, Hg, Pb, Sb and Zn in the Belgian coastal marine environment	Water / sediment	Bi, Cd, Cu, Hg, Pb, Sb and Zn	W. Baeyens, M. Bogaert, G. Decadt, H. Dedeurwaerder, F. Dehairs, M. Dejonghe, G. Gillain, L. Goeyens, S. Wartel (ULg, VUB)	V2	M1	
Accumulation of heavy metals in marine organisms			J.–M. Bouquegneau, F. Noël–Lambot, C. Verthe, A. Distèche (ULg)	V2		
	Water and suspended matter	Zn, Cd, Pb, Cu, Sb and Bi	G. Gillain, G. Duyckaerts, A. Distèche (ULg)	1979-1980	M1	

Subject	Sample	Parameters	Data-originators (LAB)	Report	Method	Sampling
		Heavy metals and POM (1977, '78, '80, '81, '82)	G. Gillain	TR	M1	S1
	Water	Hg	W. Baeyens, G. Decadt, I. Elskens (MUMM, VUB)	1979	M1	S1
	Water, sediment, biota (plants)	Hg	G. Decadt, M. Bogaert, L. Goeyens, W. Baeyens (VUB)	1980	M1	S1
Microlayer water-air						
Boundary conditions for heavy metals at the air-sea interface	Water-Air	Cu, Cd, Pb, Zn, Fe, Mn	F. Dehairs, H. Dedeurwaerder, M. Dejonghe, G. Decadt, G. Gillain, W. Baeyens, I. Elskens (VUB, ULg)	V1	M1	S2
Strategy for the study of sea-air exchanges in the Belgian coastal zone	Water-Air	Chemical composition sea-surface microlayer, marine aerosols	H. Dedeurwaerder, M. Dejonghe, F. Dehairs (VUB)	1980	M1	
Benthos: Biological processes and translocations						
Benthic studies of the Southern Bight of the North Sea and its adjacent continental estuaries	Biota	Benthos	RUG	V3		
Meiobenthos	Biota	Energy flow Meiobenthos: respiration	C. Heip, P.M.J. Herman, N. Smol, D. Van Brussel, G. Vranken (RUG)	V3	M1	
		Density	R. Herman, M. Vincx, C. Heip (RUG)	V3	M1	
Benthos of the Kwinte Bank	Biota	Benthos	C. Vanosmael, K. Willems, M. Vincx, D. Claeys, C. Heip (RUG)	V3	M1	S1
Macrobenthos in the Western Schelde estuary	Biota, sediment	Macrobenthos	Y.M. Vermeulen, J.C.R. Govaere (RUG)	V3	M1	S1
Benthos in the Sluice Dock of Ostend during 1976-1981	Biota	Benthos	L.K.H. Thielemans, C. Heip, D. Van Gansbeke (RUG)	V3	M2	S0
			C. Heip, R. Herman, G. Bisschop, J.C.R. Govaere, M. Holvoet, D. Van Damme, C. Vanosmael, K.R. Willems, L.A.P. De Coninck (RUG)	V3		
			D. Van Damme, R. Herman, Y. Sharma, M. Holvoet, P. Martens (UG)	1980		
Subprojects biota						
Sedimentology of 18 stations nearshore the Belgian coast	Sediment	Grain size coast 1977-1978	R. Herman, D. Van Gansbeke, C. Heip (RUG)	TR	M1	S1

Subject	Sample	Parameters	Data-originators (LAB)	Report	Method	Sampling
Analyse van het benthos voor de Belgische Noordzeekust en in het Schelde-estuarium	Biota, sediment	Benthos and sediment '76-'77	R. Herman, C. Heip, G. Bisschop, C. Vanosmael, D. Van Gansbeke, A. Van Bost, L. De Coninck, J. Govaere (RUG)	TR	M1	S2
De invloed van zandwinning op de bodemfauna voor de Belgische kust	Biota, sediment	Benthos sandbanks	C. Vanosmael, C. Heip, M. Vincx, D. Claeys, G. Rappé, A. Braeckman, D. Van Gansbeke (RUG)	TR	M1	S2
Nutrientenanalyse van de monitoring van de kustzone door de automatische analyseketen	Nutrients	Nutrients	D. Van Gansbeke, A. Braeckman, M. De keere (RUG)	TR	M1	S1
Studie van een brakwaterhabitat: abiotische factoren (Dievengat)	Nutrients	Nutrients	N. Smol, C. Heip P. Herman, G. Vranken, M. Govaert, W. Gyselinck (RUG)	TR	M1	S2
Sedimentanalyse van de stations gelegen in het westerschelde-estuarium	Sediment	Sediment Western scheldt	R. Herman, C. Heip, D. Van Damme, A. Braeckman, D. Van Gansbeke (RUG)	TR	M1	S2
Macro- and meiobenthos of a sublittoral sandbank in the southern bight of the North Sea	Biota	Benthos Kwintebank	KA Willems, C. Vanosmael, D. Claeys, M. Vincx, C. Heip (RUG)	TR	M1	S1
Harpacticcoid copepod community structure in two north sea estuaries in relation to pollution	Biota	Copepods Western scheldt	D. Van Damme, C. Heip, R. Herman, M. Vaeremans (RUG)	TR	M1	S0

Table VI: Parameters with data-originators recovered from CRA in the study of the Carbon cycle

Subject	Sample	Parameters	Data-originators (LAB)	Report	Method	Sampling
Carbon cycle						
Behaviour of organic carbon, nitrogen and phosphorus	Water	Riverine input of organic matter and nutrients (organic C, N, P)	R. Wollast (ULB)	V1		
Biological processes and translocations	Water, biota	Foodweb: Inorganic carbon, phytoplankton, organic carbon, planktonic microheterotrophs, zooplankton, detritus-benthic organisms	Working group 'Organic matter' (*)	V3	M1	S2
Determination of marine phytoplanktonic biomass	Water	Phytoplankton (methodology): chl.a	E. Post, L.. Goeyens, A. Vandenhoudt (VUB)	V3	M1	
Nutrient uptake by marine phytoplankton	Water (lab)	Phytoplankton: chl.a, nutrients: Si, N, P	L. Goeyens, E. Post, A. Vandenhoudt, M. Declerck, W. Baeyens (VUB)	V3	M1	
The rate of utilization of nitrate-nitrite by natural phytoplankton populations in a reactor	Water	Phytoplankton: chl.a, nutrients: Si, N, P	L. Goeyens, A. Vandenhoudt, G. Decadt, W. Baeyens (VUB)	1980	M1	S1

Subject	Sample	Parameters	Data-originators (LAB)	Report	Method	Sampling
	Water	Phytoplankton: CHL A, chl a, pheo, CHL.B, CHL.C (CIPS 1977, 1978, 1980)	J. Nijs, A. Bertels (VUB)	TR	M1	S1

Table VII gives an overview of the data that was recovered from the old database structure (MONIT-B). The data that were measured in the framework of the CRA were selected.

Table VII: Data recovered from the old database

Water (+ Biota)	Laboratory
Nutrients (PO_4^{3-}, SiO_2, NO_3^-, NO_2^-, NH_4^+)	VUB, Laboratorium voor Analytische Scheikunde: G. Decadt, L. Goeyens (VUB112, VUB113)
Phytoplankton (CHL. A, CHL.B, CHL C., Caroten)	ULG, Laboratorium voor Analytische Scheikunde: Hecq (ULG21)
Zooplankton (POM, Prot, Lip, Sucr)	ULG, Laboratorium voor Analytische Scheikunde: Hecq (ULG21)
Heavy metals (Zn, Cd, Pb, Cu)	ULG: G. Gillain (ULG111, ULG112)
Heavy metals (Hg)	MUMM, VUB : Baeyens (BMM11, BMM21), Decadt, Elskens (VUB11, VUB12)
Physical	MUMM

3.2. Overview data-originators

Tables VIII and IX give an overview on all participating laboratories and persons that contributed during Project Sea and the Concerted Research Actions Oceanology. Table X is an overview of the scientists that were part of the Interdisciplinary Working group 'Organic Matter' during the CRA Oceanology.

Table VIII: Participating laboratories and data-originators recovered from Project Sea (1970-1976)

Institute	Laboratory	Persons
ULB	Laboratoire d'Océanologie	J. Steyaert, Bouillon, G. Hoevenaghel, C. Lancelot, G. Billen
ULB	Unité d'Océanologie et d'Anatomie comparée	J. Bouillon, Steyaert
ULB	Laboratoire d'anatomie comparée-histo-physiologie	M. Jangoux, M. Vloebergh (dir. Prof. J. Bouillon)
ULB	Institut de Chimie industrielle, Service Environnement	R. Wollast
ULB	Laboratoire de Géologie et Sédimentologie	R. Wollast, Hoenig, Lefèvre
KUL	Laboratorium voor syto-hydrobiologie / Algologie	M. Rabijns, J. Robijns, L. Huys, Prof. Louis
KUL	Laboratorium van Sedimentologie	F. Gullentops, Moens
RBINS	RBINS	C. van der Ben, D. van der Ben
RBINS	Laboratorium voor recente sedimentologie	M. Meeusen, A. Bastin
VUB	Lab. van Ekologie en Systematiek	J.P. Mommaerts, P. Polk, M. Bossicart, Daro, C. Joiris, F. Redant
VUB	Laboratorium voor Analytische Scheikunde	I. Elskens, D. Janssens
VUB	Laboratorium van Microbiologie en hygiëne	A. Boeyé, M. Aerts
IRC	Institut de Recherches chimiques, Tervuren	R. Vanderstappen, P. Herman
Min. Agr.	Ministry of Agriculture, Fisheries Research Station, Ostend / Rijksstation voor Visserij	R. De Clerck, J. Henriet, J. Van De Velde, F. Redant
IHE	Institut d'Hygiène et d'Épidemiologie	J. Bouquiaux *et al.*

Institute	Laboratory	Persons
RUG	Laboratorium voor biologisch onderzoek van milieuverontreiniging, Interfakultair centrum voor de studie van lucht-, bodem- en waterverontreiniging/Laboratory for Biological Research in environmental pollution	G. Persoone, G. Uyttersprot
RUG	Laboratorium voor Morfologie en Systematiek	L. De Coninck, D. Van Damme, C. Heip, J. Govaere, R. De Boever, L. Thielemans
ULg	Laboratoire de Chimie analytique	G. Ducykaerts, G. Gillain
ULg	Laboratoire de Biologie marine, Institut Van Beneden	J. Hecq, Heyden, Moermans
ULg	Department of General biology / Institut de zoologie / Laboratory of General biology	JM. Bouquegnau, C. Gerday, A. Disteche F. Noël-Lambot
ULg	Institut de Mathématique	G. Pichot, Runfola
ULg	(Departement de biologie generale, section physiologie,)	O. Marc
	Interdisciplinary Working group Biology	

Table IX: Participating laboratories and data-originators recovered from CRA

Institute	Laboratory	Persons
BAH	Biologisch Anstalt Helgoland	P. Weigel
UGMM / MUMM	Unité de Gestion des Modèles Mer et Estuaire	J.P. Mommaerts, H. Picard
RBINS		S. Wartel
ULB	Université Libre de Bruxelles, Laboratoire d'Océanographie	G. Billen, C. Lancelot, M. Somville
ULB	Modelling	R. Wollast
ULg	Université de Liège, Laboratoire d'Océanologie et de Biologie Générale	
ULg	Université de Liège, Laboratoire d'Océanologie, Institut de Chemie / Laboratory of Oceanology, Institute of Chemistry	G. Gillain, J.M. Bouquegneau, A. Disteche, G. Duyckaerts, F. Noël-Lambot, C. Verthe
ULg	Laboratoire de Biologie marine	J.H. Hecq, A. Gaspar
ULg	Mecanique des fluides géophysiques	J.C.J. Nihoul, Y. Runfola
VUB	Vrije Universiteit Brussel, Laboratoria voor Ekologie en Systematiek en voor Analytische Chemie	A. Bertels, M. Bossicart, N. Daro, M. Declerck, C. Joiris, J. Wijnant, C. Nihoul
VUB	Laboratorium voor Analytische Scheikunde	F. Dehairs, H. Dedeurwaerder, M. Dejonghe, G. Decadt , W. Baeyens, I. Elskens, Bogaert, L. Goeyens, E. Post, A. Vandenhoudt
RUG	Marine Biology Section, Zoology Institute	B. Bisschop, E. Bossuyt, D. Cleays, De Coninck, Govaere, C. Heip, Herman, M. Holvoet, P. Martens, N. Smol, Thielemans, D. Van Damme, D. Van Gansbeke, C. Vanosmael, M. Vinckx, G. Vranken, K. Willems
RUG	Laboratory for Mariculture	C. Claus, G. Persoone, L. Van Holderbeke
	Interdisciplinary Working group Organic Matter	(Table X)

Table X: Working group Organic Matter (Interdisciplinary Working group)

	BAH	UGMM	ULB	ULG	VUB
Phytoplankton	P. Weigel	J.–P. Mommaerts	C. Lancelot		A. Bertels, J. Nijs, C. Nihoul
	Treutner				
Zooplankton			M. Somville	J.H. Hecq	M.H. Daro, M. Bossicart
Microbiology	W. Hickel, G. Gassmann, P. Martens		G. Billen, J. Putman	G. Gillain	C. Joiris, J. Wijnant, R. Vanthomme, R. Swaelens
Nutrients	P. Mangelsdorf	J.–P. Mommaerts			I. Elskens, G. Decadt, L. Goeyens

3.3. Recovered data and digitization

In this chapter, the result of the process of digitization is presented in the same order of import in the database, starting with the campaigns and ending with the values (*cf.* Figure 8).

3.3.1. Campaigns

Based on the final reports, the technical reports, the ROSCOP's and MONIT-B, information on the campaigns between 1971 and 1982 was retrieved. This involves identification of platforms, begin- and end dates and participating laboratories. Codes of the platforms are internationally agreed (ICES). The main platform in this period was the "A962 Mechelen" (code 11ME) (Figure 10), which was a converted minesweeper equipped for oceanographic research.

Figure 10: A962 Mechelen, main research ship used in the period 1971-1982

In case the "Mechelen" was not available, or after her decommissioning, another naval ship was used (type minesweepers inland MSI and coastal MSC), like the "M472 Kortrijk" (11KK), "A963 Spa" (11SP) and "M471 Hasselt" (11HA). Some stations were sampled by more than one ship at the same time, in order to determine the gradient of specific data, for example station "M07" from 22/07/1971 until 9/07/1971. In this case, the participating vessels were anchored at *ca.* ½ mile distance under command of the "Mechelen". The "A958 Zénobe Gramme" (11ZG) (Figure 11) was used for diverse tasks, *e.g.* transport of samples between the various vessels. As a result, sometimes more than one campaign with the same start and end date was imported in IDOD (*e.g.* ME1971/A09 and NV1971/A09). The code 11NV (Naval Vessel) was used in case the reports did not explicitly mention what Mine Sweeper was used.

Figure 11: The A958 Zénobe Gramme

Some researchers or laboratories used other vessels or participated in cruises on other ships. For example, the "O29 Broodwinner" (11BR) was used by Fishery department. Furthermore, the "Paster Pype" (11PP) was used by the IHE for sampling in the coastal zone where the water was too shallow for naval vessels to navigate. Sometimes the names of the platforms were difficult to recover, because the platform was not consistently registered in reports, no ship logbooks are found for Project Sea (1970-1976) and for some disciplines commercial samples were used (e.g. biota, obtained at fish markets). From 1971 until 1982, 121 campaigns were recovered and imported in IDOD (Figure 12). Note that no data is available for 1976, because this was the transition period between Phase I and Phase II, however international projects took place, like JONSDAP and FLEX.

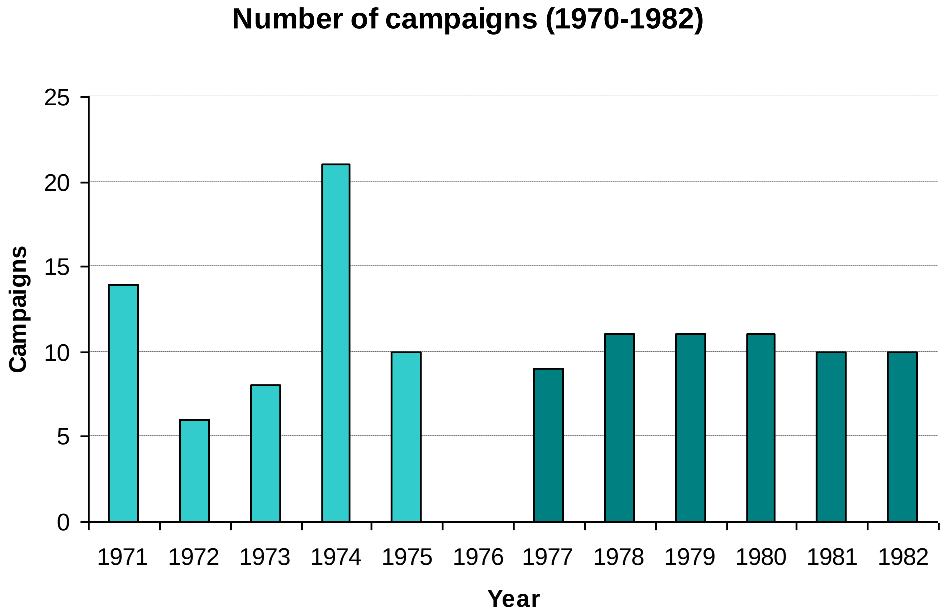


Figure 12: Annual number of campaigns recovered for Project Sea (1971–1976) and CRA "Oceanology" (1977–1982).

3.3.2. Samples

Importing samples in IDOD requires information about the time and coordinates of sampling, as described below (sampling events and stations). Information on the type of substrate, sampling depth, sampling gear, *etc.* was found in the reports and other publications.

a. Sampling events

Per campaign, during each sampling event, several samples are taken by different laboratories at a specific location in a specific time window. Based on the technical reports, the dates of sampling could often be retrieved. Some disciplines consider the time of sampling as not important or relevant and did not note the exact hour. In the frame of data management however, time is a crucial parameter while checking for duplicates, linking with other data and performing quality control (spatial errors). In a lot of technical reports, the time of sampling could be recovered via the sampling-id. In case it was impossible to retrieve, the dates were flagged as "Time missing". It had to be taken into account that in the seventies and eighties "Local Time" (LT) was generally registered in the reports instead of the "Coordinated Universal Time" (UTC). In Belgium, "daylight saving time" (LT = UTC + 2h) was introduced again in 1977. Prior to import in IDOD, LT had to be converted to UTC, according to the ISO-standards. Because of confusion about the time reference of samplings recovered from the old database of MUMM, these were temporarily flagged as "unknown". About 1 600 Sampling events between 1970 and 1982 have been imported in IDOD (Figure 13).

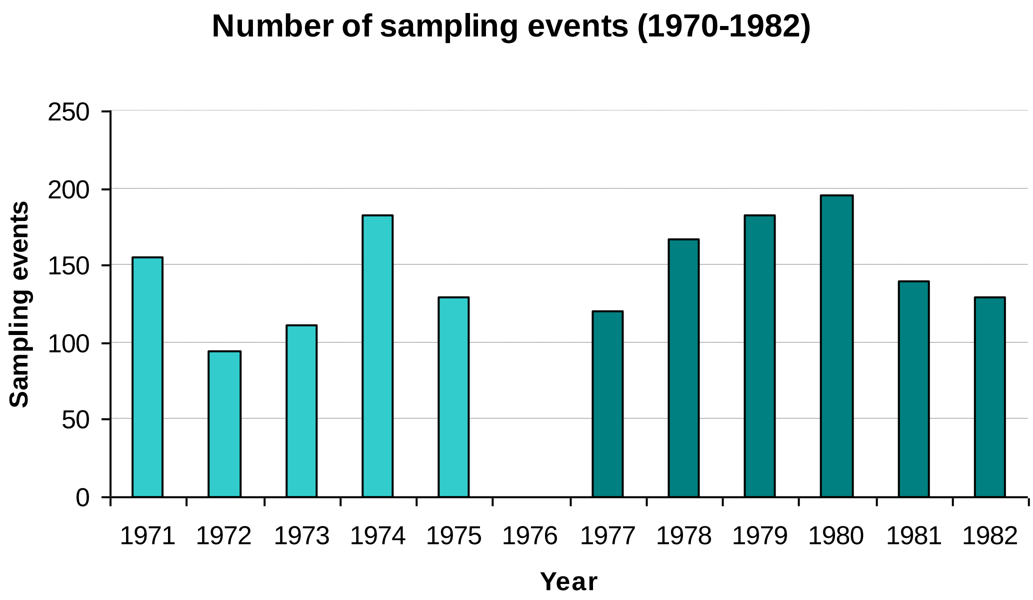


Figure 13: Annual number of sampling events recovered for Project Sea (1971–1976) and Concerted Research Actions "Oceanology" (1977–1982)

b. Stations

The exact coordinates of sampling are rarely found in the reports however station names are registered in the sample-id. These were recovered for Project Sea and some disciplines of the CRA.

Project Sea: 1000 stations

During Project Sea, a 1000–points map was designed with the objective to sample each point once in a period of 3 years ('one-off' sampling) by the "Laboratorium van Sedimentologie" (KUL). This map was based on a numerical grid which was used for model simulation of the Southern Bight of the North Sea (Figure 14). A station name was given to each point, starting with 25 stations, which was later extended to over 1000 stations (stations 1000P_0001 - 1000P_2841). These stations were commonly used by other researchers in other disciplines. Since the exact coordinates of sampling are not registered in the reports of Phase I, these could not be recovered. Therefore all samples were imported with the reference coordinates of the corresponding station (Figure 15).

A well documented sampling set of Project Sea are the technical reports of the discipline "the First trophic level: Analyses of photosynthetic pigments and phytoplankton" (1971–1976) by the Laboratoire d'Océanologie (ULB) (*cf.* Figure 6). Import of this dataset was given priority because of the completeness, giving us a full overview on the campaigns and sampling events (including times of sampling) during the whole Project Sea (1000 points stations). Looking at the general structure of IDOD (Figure 8), this means the two highest levels of the meta-data could be completed and samples of many other disciplines could and can be related to these campaigns and sampling events afterwards.

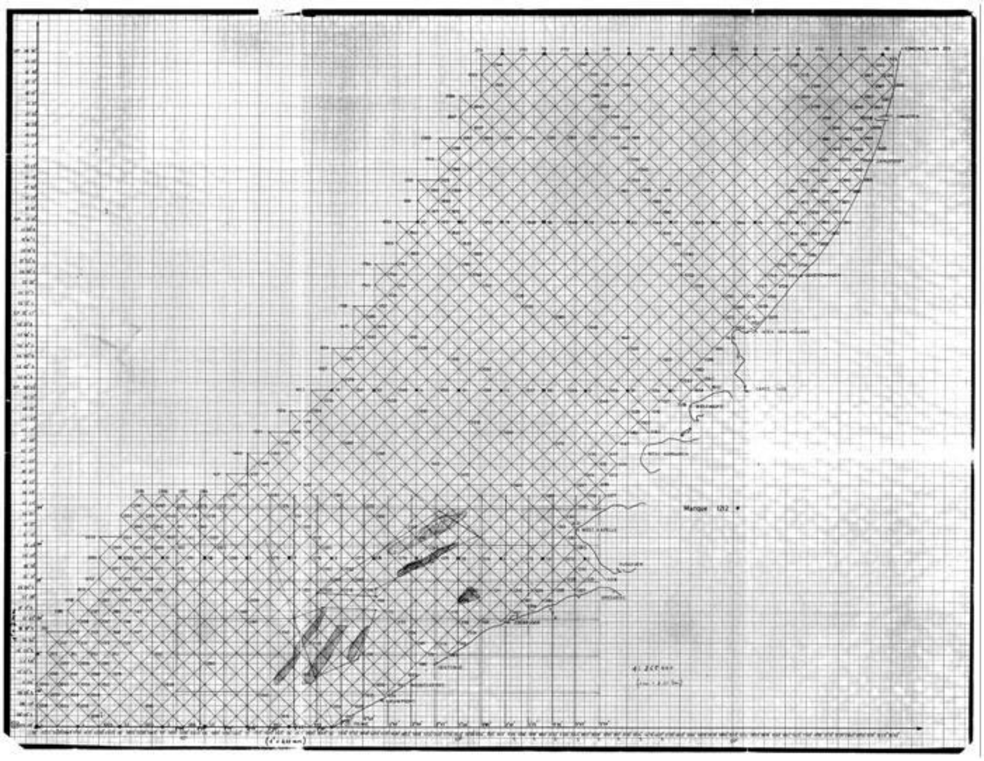


Figure 14: Scan of 1000–points map of Project Sea

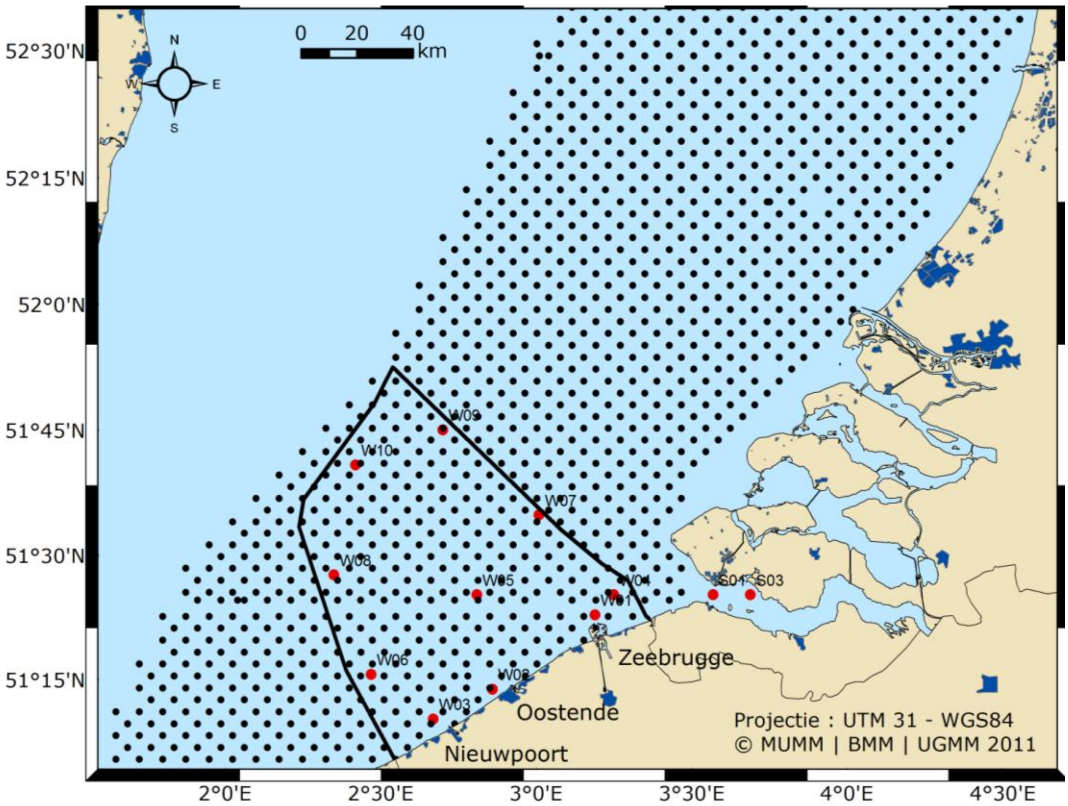


Figure 15: Digitized map of the '1000 stations' with today's monitoring stations W01 – W10.

Project Sea: coastal zone

In the framework of the study of pollutants in the coastal zone by the IHE (up to 6 km from the coast), the water was too shallow for naval vessels to circulate, therefore the hydrographic vessel Paster Pype was used. Sampling was performed along 12 locations at *ca*. 400 m, 3000 m and 6000 m and at the break waters (Figure 16). Water and sediment samples were taken simultaneously, with *ca*. 340 samples between 1971 and 1975. Sampling information (stations, dates and results) was published in the Final Report Volume 11 with conclusions in Volume 6 and could therefore be fully recovered. A case study has been worked out using this dataset (see Chapter 4).

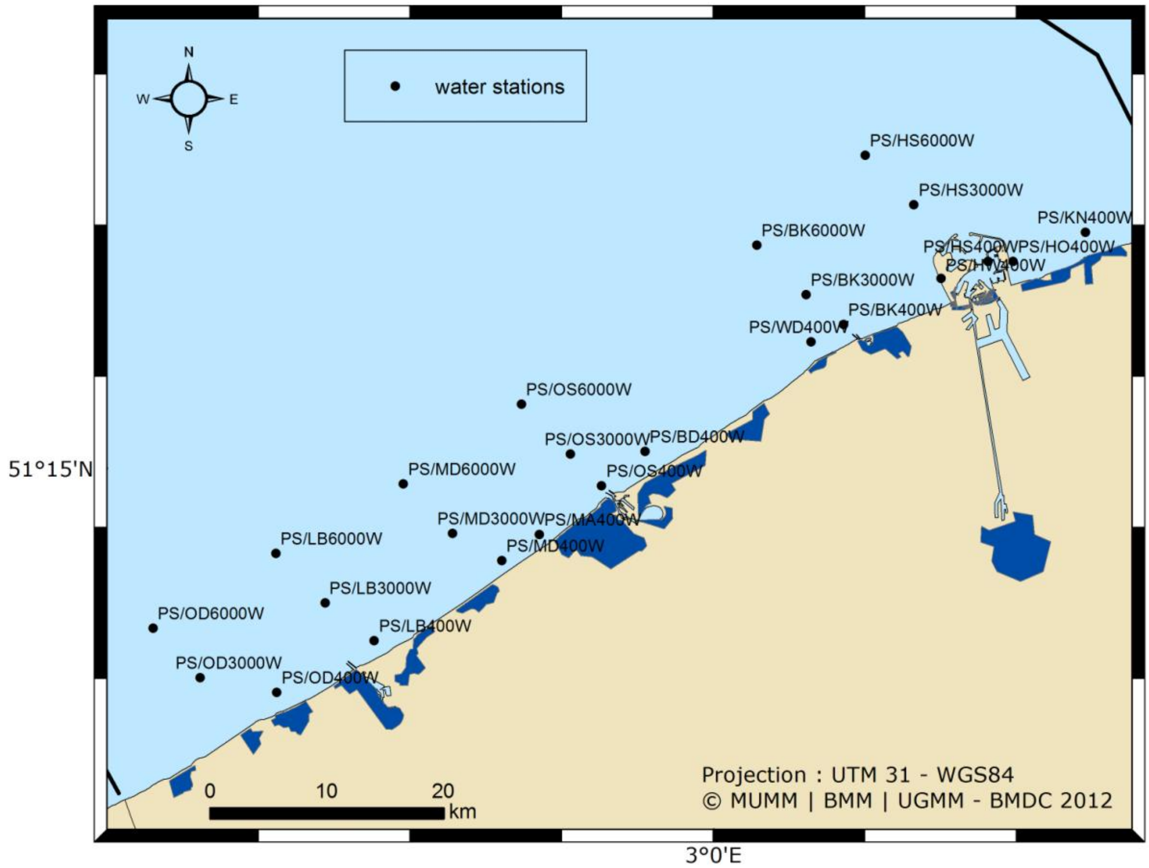


Figure 16: Sampling stations in the coastal zone by IHE and IRC (1971–1975).

CRA "Oceanology"

During the CRA "Oceanology" different sets of stations were used depending on the laboratory. The coordinates were found in reports. This reflects that the work during Phase II was less interdisciplinary and coordinated. Several laboratories used the same stations as the Belgian Monitoring Programme in the frame of international conventions like OSPAR, *e.g.* "the distribution of heavy metals" by the Laboratorium voor Analytische Scheikunde (VUB) and the Laboratoire d'Océanologie (ULg) and "the rate of utilization of nitrate-nitrite by phytoplankton populations" by the Laboratorium voor Analytische Scheikunde (VUB) from 1977-1982 (Figure 17).

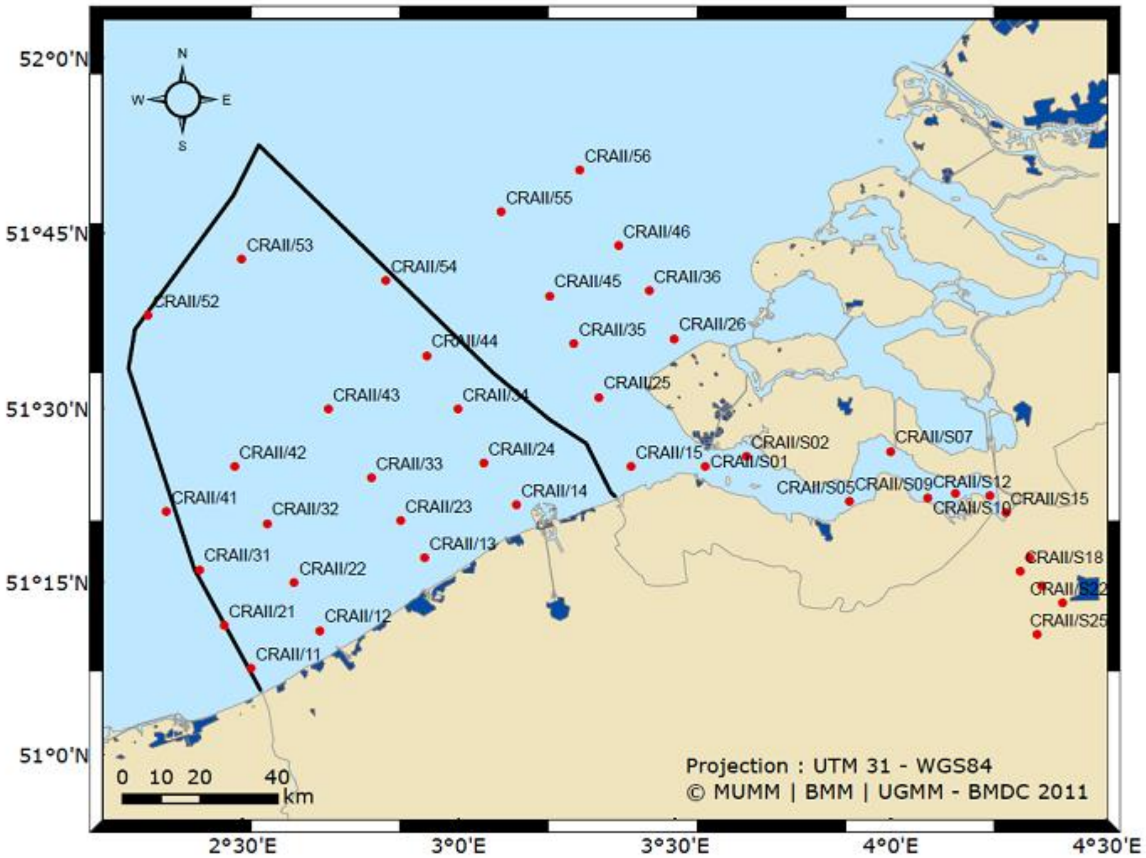


Figure 17: Sampling stations used between 1977 and 1982 for heavy metals, nutrients and phytoplankton in water.

3.3.3. Analysis methods

Archiving the analysis methodologies is probably the most time consuming but also the most important process. When comparing data over a long time period, the comparability of the analysis method should be taken into account. Depending on the author of a report or publication, the analysis methods are better or less documented. A lot of information about methodology was found in the final and technical reports. Extra information could be recovered via scientific publications. Some research performed during Phase I and II was focusing on methodology development. As an example, the determination of heavy metals based on anodic stripping voltametry by the Laboratoire de Chimie analytique (ULg) and (flameless) atomic absorption spectroscopy by the Laboratorium voor Analytische Scheikunde (VUB) in the period 1971-1974 is well documented via technical reports. Analysis methods were tested with intercalibration exercises, like the exercises performed by Belgium and the United Kingdom in 1971 for Zn, Cd, Pb, Cu and in 1972 for Cu. Later however, heavy metal concentrations in seawater were found to be very low and as a consequence, measurements were stopped in the 1990's (Belgische Staat / État belge, 2012). Some researchers used more than one analysis method (*e.g.* pigments using Scor and Lorenzen equations by the Laboratory of Oceanology (ULB) from 1971 to 1975). Over the years, analysis methods can change and therefore, these had to be carefully checked and documented. The description of the analysis methods is available online at http://www.mumm.ac.be/datacentre/Documentation/Codes/index.php. Note that, despite the fact that during the inventorying step the methodology was found to be well described in the reports (see Table I to V), it can still be concluded that during import in IDOD important information is missing. The importance of the analysis methods was demonstrated in the case study (see further).

3.3.4. Values

The results for measurements in water, sediment and biota are stored in the database in separate tables with specific characteristics. As mentioned before, in the final reports a lot of values are aggregated and are difficult to import in the database. Original values were found in the technical reports for water, sediment and biota per discipline. Furthermore, for Phase II (1977–1982), results of several laboratories were found in the old database of MUMM (see Table VI). Special attention was paid to the units of the values and where needed, appropriate conversion factors were applied to ensure the consistency of the information kept in IDOD.

To give an idea of the dimension and complexity of the data to be resuscitated, Figure 18 represents an estimation of the values identified during the inventorying step. These values are related to the substrates water, sediment and biota. Values of some disciplines that are not yet inventoried are not included (*e.g.* biota and diversity). This graphs shows that about 40 000 historical values are ready to be made publicly available. Within the time spam of the project we succeeded in importing *ca*. 16 000 of them in IDOD.

Biota and biodiversity values have not yet been imported. Special attention needs to be given to the taxonomy. To overcome several issues regarding taxonomy, the database contains a taxonomic module that allows the storage of vernacular names, taxonomic changes, determination to any level of detail as well as revised determinations of a given specimen (De Cauwer *et al.*, 2006). It will therefore be possible to add these values to the database linked to the same samples already imported, e.g. for phytoplankton and zooplankton.

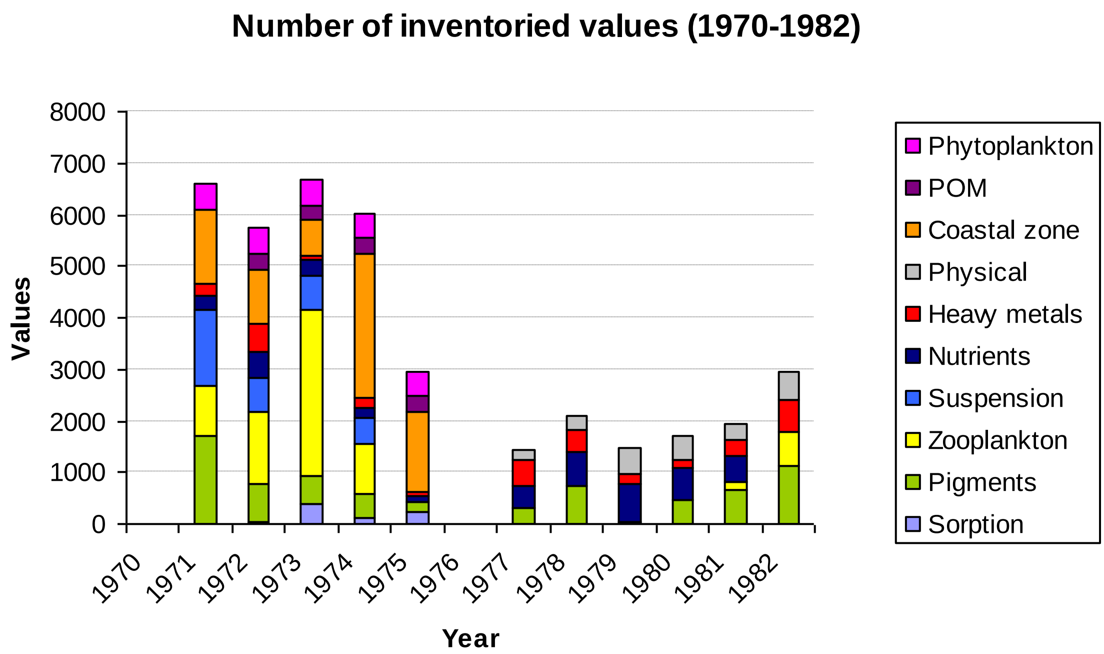


Figure 18: Number of values identified during the inventorying step and expected to be resuscitated during the project PMPZ–DBII.

Values that are currently imported in IDOD in the framework of PMPZ-DBII are presented below. From the Laboratoire d'Océanologie (ULB), ca 2 500 Chlorophyll a values in the 1000–points (1971–1976) are recovered using two methods, Lorenzen and Scor (Figure 17). About 3 600 sediment values (1971-1976) by IHE and IRC with measurements for grain size, organic matter, metals, oxides and pesticides are imported (Figure 18). Furthermore, ca. 10 000 water values (1977-1982) for Heavy metals, Nutrients, Pigments and Physical parameters are made available (Figure 19).

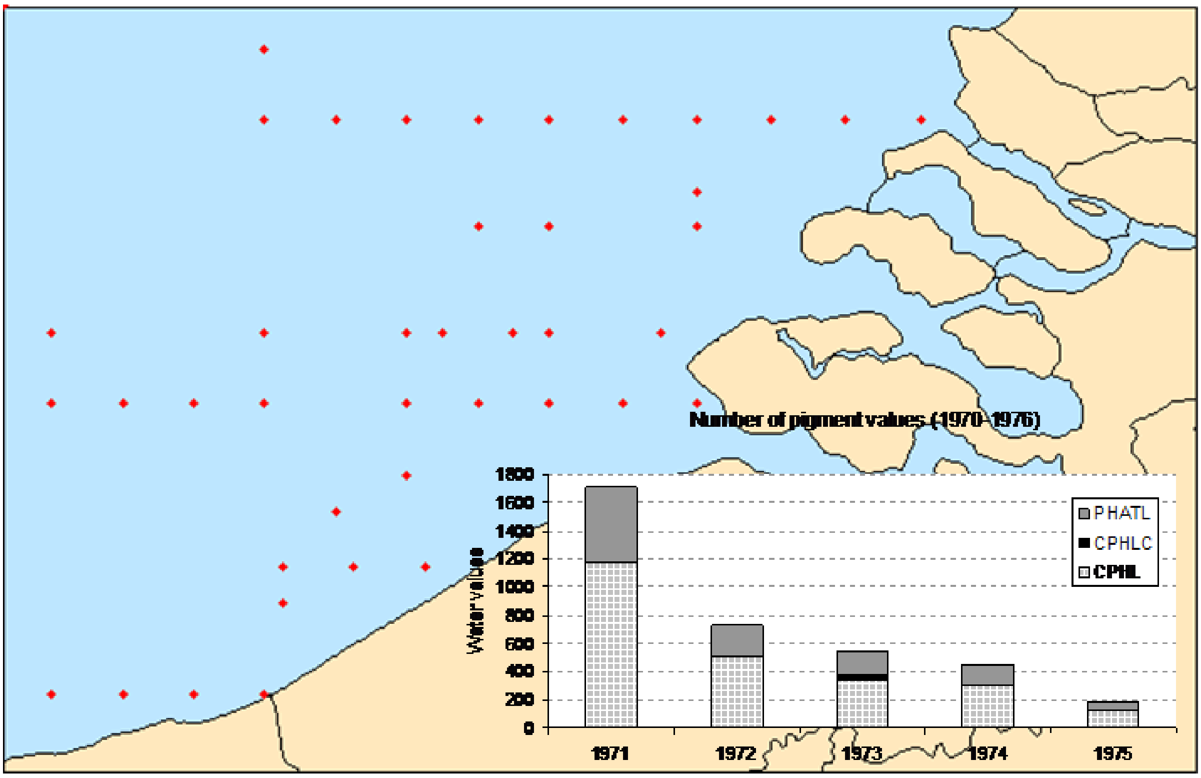


Figure 19: Snapshot of the stations of the 1000 points grid where Chlorophyll a values measured by the Laboratoire d'Océanologie (ULB) between 1971 and 1976 are available in IDOD, together with the graph showing the number of values per year.

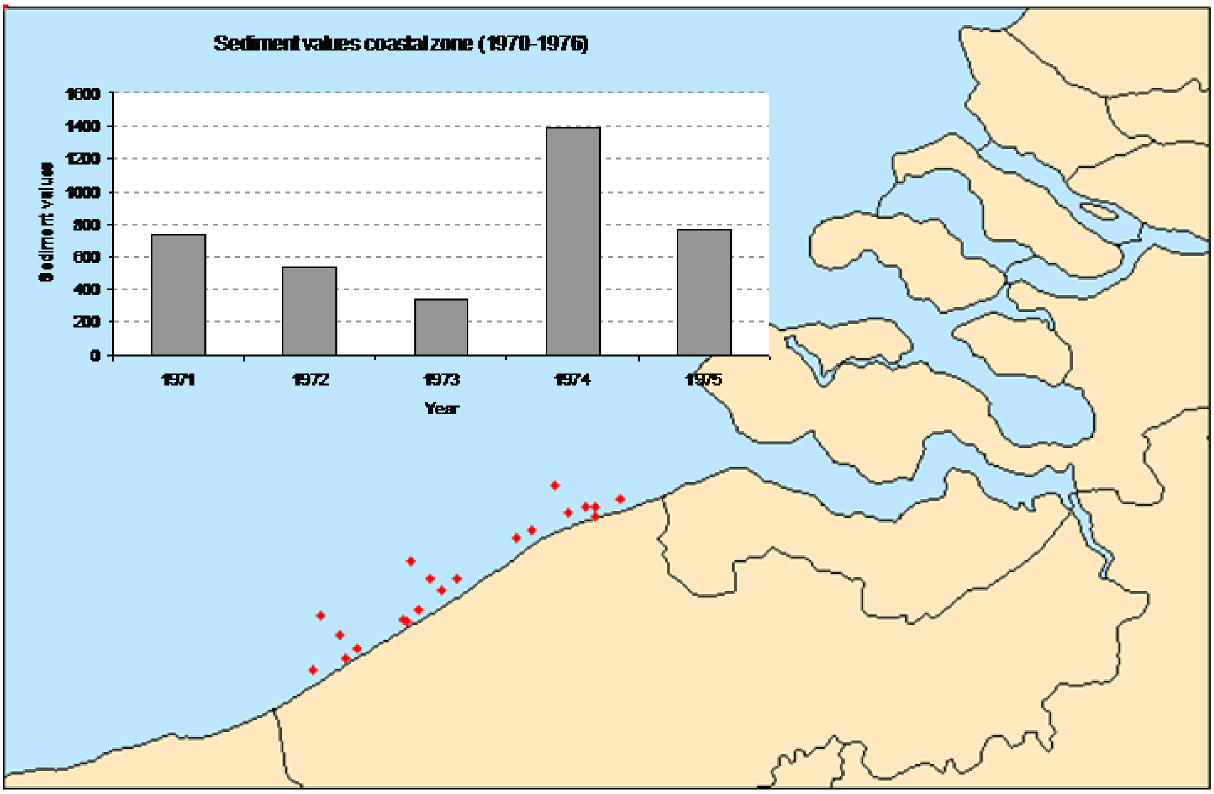


Figure 20: Snapshot of the stations in the coastal zone where sediment values measured by the IHE and IRC between 1971 and 1976 are available in IDOD, together with the graph showing the number of values per year.

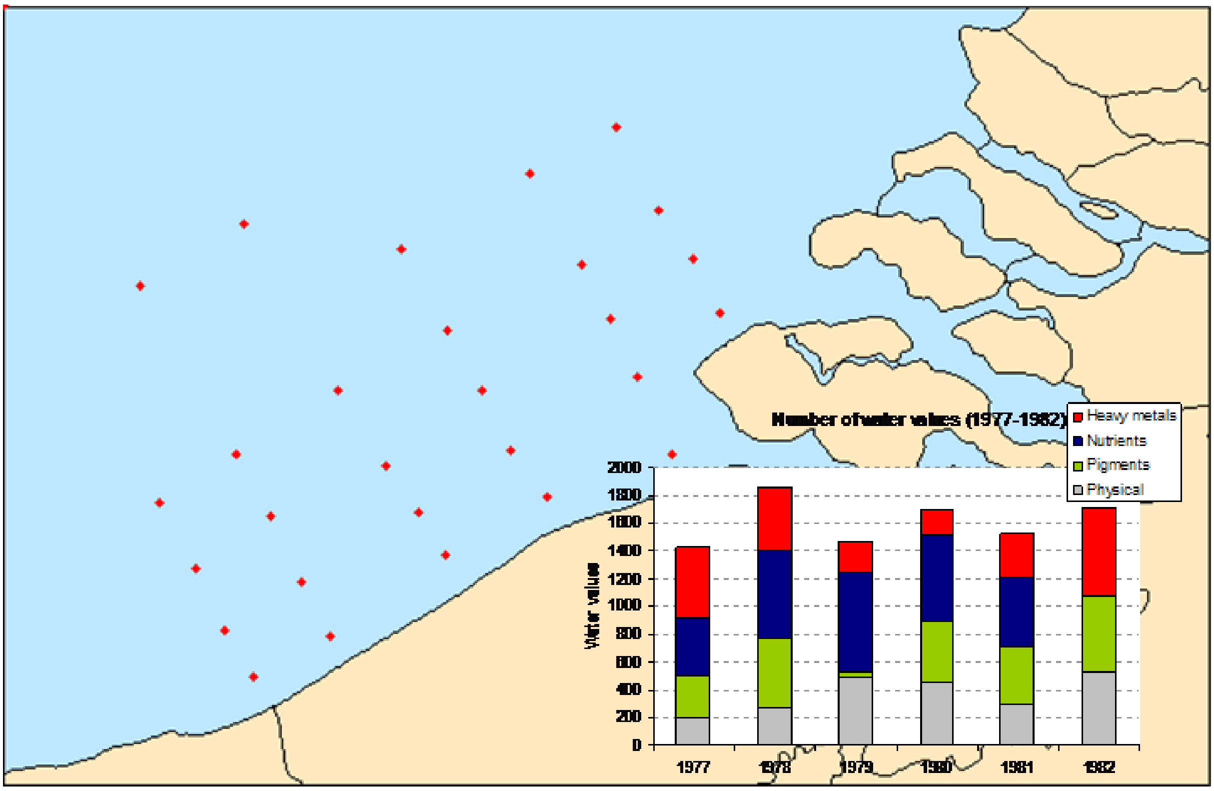


Figure 21: Snapshot of the stations between 1977 and 1982 where values are available in IDOD, together with the graph showing the number of values per year.

3.4. Chlorophyll a values: an example of data recovered and imported in IDOD

3.4.1. Introduction

As an example, a presentation is made of the chlorophyll a concentrations in water that are currently publicly available via the IDOD database. The chlorophyll a concentration is an indicator of the phytoplankton biomass. The amount of phytoplankton is one of the elements of biological water quality related to eutrophication (Belgische Staat / État belge, 2012). To study long term trends in eutrophication, the availability of data on phytoplankton, nutrients and oxygen since the 1970's in the IDOD database is of high value.

In the framework of Project Sea and the following CRA "Oceanology" Chlorophyll a has been monitored intensively (Lancelot, 1982). Two spectrophotometric methods have been used simultaneously: the Lorenzen and the Scor methods. Results of both methods are available in IDOD and due to the fact that they are not comparable, the user has to check the additional documentation provided.

3.4.2. Chlorophyll a values available in IDOD

Below an overview is given of the amount of water values for chlorophyll a (in *µ*g/l) available in IDOD since 1971 (Figure 22).

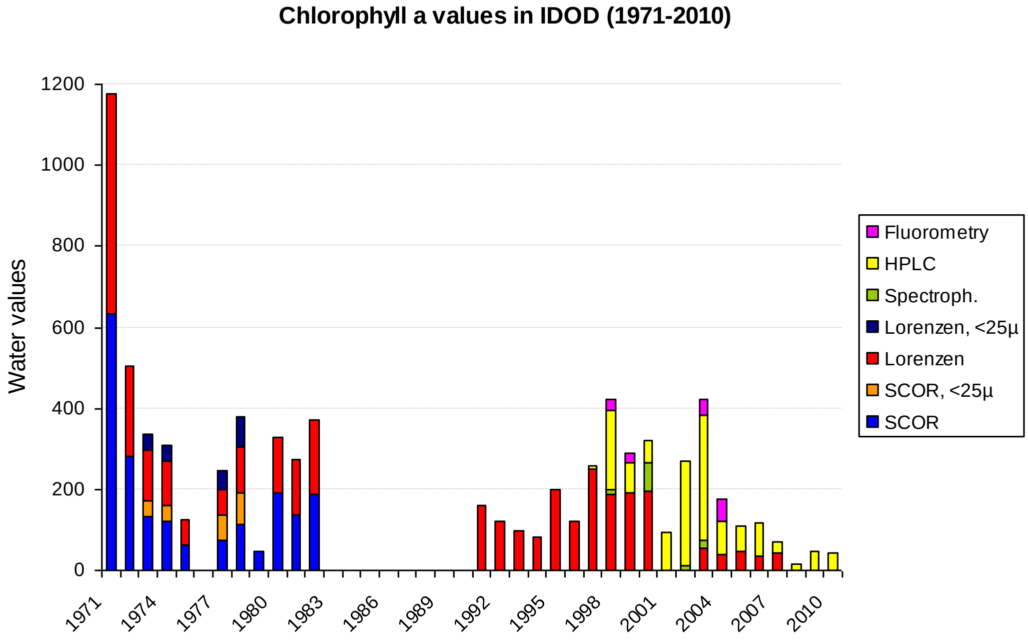


Figure 22: Chlorophyll a concentrations in water available in IDOD for the period 1971–2010 with their corresponding analysis methods

Requesting chlorophyll a via the BMDC interface results at the time of writing in 7 524 values sampled between 1971 and 2010. These are results from several projects over the years (http://www.mumm.ac.be/datacentre/Catalogues/datasets.php), like:

- Project Sea (PMPZ) (1970-1976) (this study);
- Concerted Research Actions "Oceanology" (CRA) (1977–1982) (this study);
- Monitoring the Belgian Continental Shelf and the Scheldt estuary (MONIT) (1976–ongoing);
- REgional VAlidation of MERIS chlorophyll Products in North Sea (REVAMP) (1997–2003);
- Advanced Modelling and Research on Eutrophication (AMORE I, II, II) (1997–2009);
- Other: IPMS, MULTICOLOR, BIOCHEM, TROPHOS, SISCO, CANOPY.

Chlorophyll values are highly dependent on the technique used. Several analysis methods for measuring chlorophyll a concentrations are applied with variable adequacy and accuracy. Standard procedures have been developed by scientists, and international conventions have always paid attention to intercalibration exercises. The method is selected by the laboratory, depending on the purpose of the programme and characteristics of the water (e.g. turbidity).

a. *Spectrophotometric method using trichromatic equations revised by SCOR-UNESCO* (1966): was used to measure chlorophylls a, b and c based on their maximum absorption wavelength. The trichromatic equation for chlorophyll a excludes interference of other chlorophylls, but includes all derivates or degradation products ("phaeopigments") that have absorbencies at the primary wavelength of chlorophyll a. Therefore, chlorophyll a calculations are intermediate values of chlorophyll a and its derivates, resulting in an overestimation. This error is in particular important when samples cannot be analysed immediately and need to be preserved, and chlorophyll pigments can thus start degrading. This was illustrated by Lancelot (1982) based on values obtained during Project Sea between 1972 and 1975 (Figure 23). This method was used during the projects PMPZ and CRA.

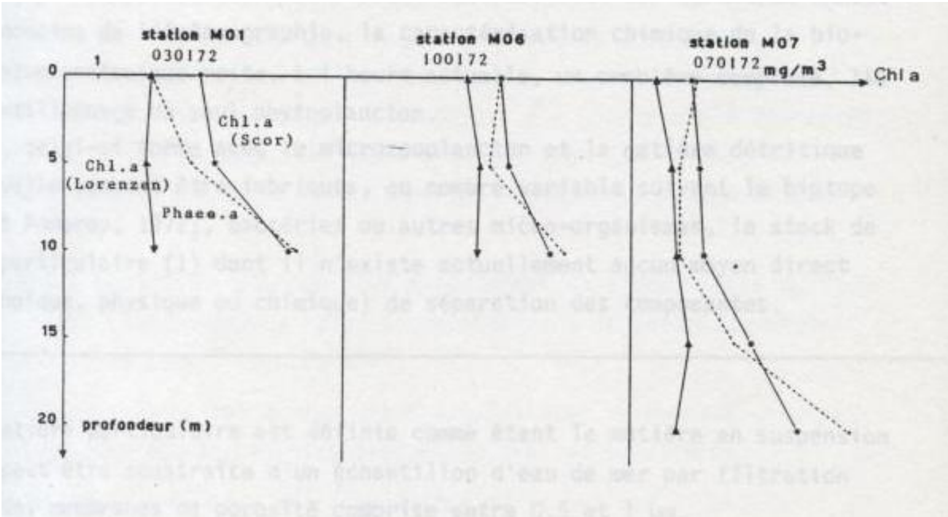


Figure 23: Spectrophotometric determination of chlorophyll a: comparison between methods Lorenzen and SCOR-UNESCO (Lancelot, 1982).

b. *Spectrophotometric monochromatic method of Lorenzen* (1967): was used more commonly than SCOR because it made it possible to distinguish degradation pigments directly from the total acetone extract. The Lorenzen method was already selected by Lancelot (1982) for providing better estimation of the errors by estimating the relative relation between chlorophyll a and its degradation products (Lancelot, 1982). This method was overall used and results are available from the projects PMPZ, CRA, AMORE, REVAMP, MULTICOLOR, IPMS, MONIT and TROPHOS.

c. *High Performance Liquid Chromatography separation (HPLC*): quantitative separation of chlorophylls and its degradation products present in an extract of acetone obtained from pure phytoplankton samples. This precise and sensible method can provide additional information, like taxonomic composition of phytoplankton and has increased usage, *e.g.* in the projects REVAMP, MONIT, SISCO.

d. *Fluorometry* (Yentsch and Menzel, 1963): the measurement and use of the fluorescence characteristics of chlorophyll in phytoplankton. This is a quantitative sensitive technique of optical measurement. This technique is more sensitive than spectrophotometric techniques and was used in the projects BIOCHEM, SISCO and CANOPY.

The validity of chlorophyll measurements furthermore depends on the sample handling, which is incorporated in the analysis methods, like:

a. *Sample pre-treatment*: In the frame of a study on nanoplankton, samples have been prefiltered with a plankton net (<25μ), during PMPZ and CRA.

b. *Sample separation*: For separation of chlorophyll pigments, Millipore membranes 0.8 μm (M80) were used during PMPZ (1971–1976) and MONIT (1991–1994). During the other projects Whatman glassfiber filters have been used: GFC (1.2 μm) and GFF (0.7 μm).

c. *Preservation method*: To keep the chlorophyll molecules intact until analyses, samples were frozen, with the exception of samples of the DMI (DK) during the REVAMP project, where values were determined immediately. No information was found on the preservation method of the samples between 1979 and 1982.

Figure 24 illustrates the availability of the values per method. Samples of PMPZ and CRA have both values measured after Scor and Lorenzen.

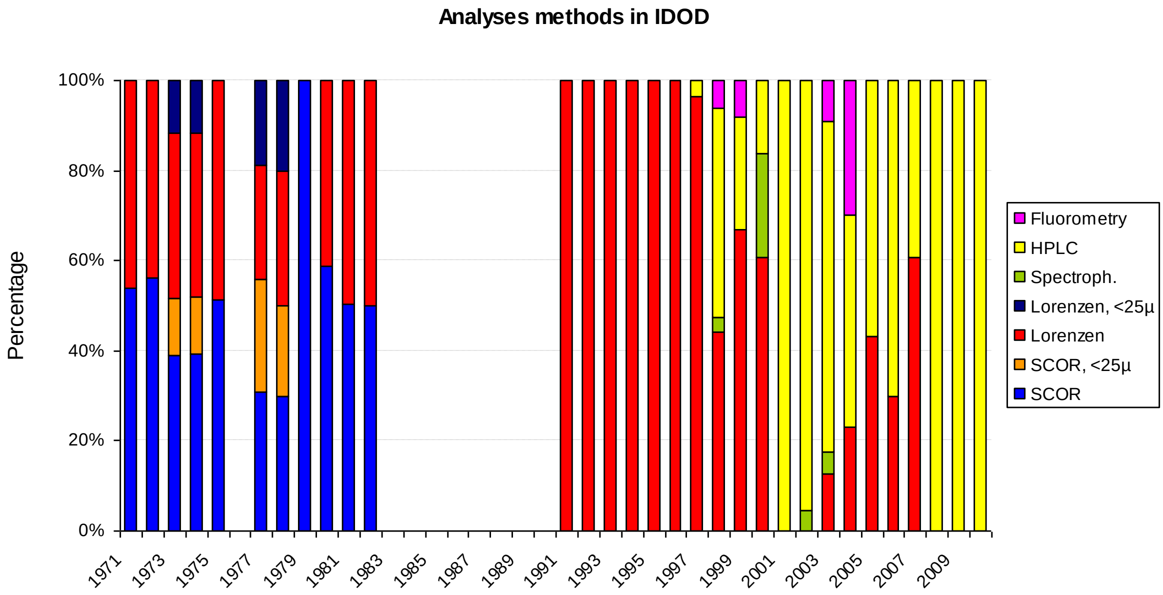


Figure 24: Relation water values for chlorophyll a per analyses method.

Over the years, sampling stations have changed (Figure 25). However sampling density effort shows a good coverage of sampling in the Belgian Coastal Zone in each time period. For long term analyses, the user can thus select stations based on the coordinates.

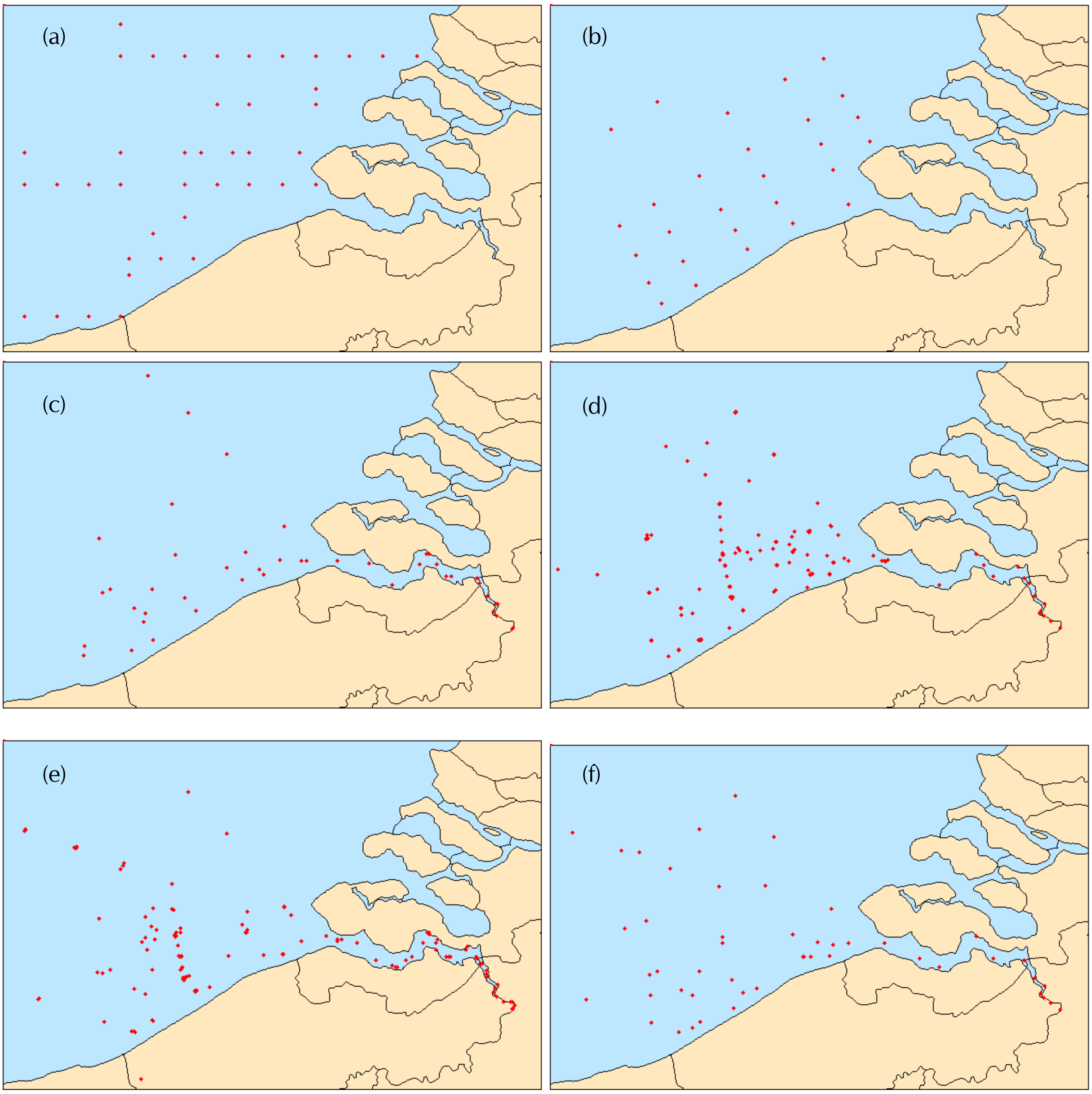


Figure 25: Distribution maps of samples. (a) 2 445 records for the period 1971–1976, (b) 1 646 records for 1977–1982, (c) 664 records for 1991–1995, (d) 1 502 records for 1996–2000, (e) 1 067 records for 2001–2005 and (f) 292 records for 2006–2010.

3.4.3. Conclusions

There is a good coverage of chlorophyll a concentrations over time for the periods 1971–1982 (PMPZ and CRA) and 1991–2010, with a high sampling density in the Belgian coastal zone. These are products of several projects. Concentrations are also available from the period between 1983 and 1990 in the archives of the BMDC and should be imported.

This would complete the time series, resulting in a dataset of 40 years. As sampling stations have evolved over the years, users should request data according to the coordinate box to study trends at a specific location. Concentrations are available based on different methods, which are not always comparable. The user has to check carefully the documentation on analysis methods and sampling handlings which is available on the BMDC interface.

4. CASE STUDY: HEAVY METALS AND PESTICIDES IN SEDIMENT OF THE COASTAL ZONE

4.1. Introduction

In the frame of recent assessments of the status of the Belgian marine waters (Federal Environmental Report, Anon., 2010; Marine Strategy Framework Directive initial assessment, Belgische Staat / État belge, 2012), the pollutant concentrations in sediments have been compared to the environmental quality assessment criteria defined by OSPAR and the European Union. Time series were investigated testing different methods for trend detection on the monitoring data relative to sediments then available at the BMDC. The most complete time series were found close to the coast, at the current monitoring stations W01, W03 and W04.

Mercury appeared to be significantly decreasing between 1990 and 2010 at station W01 and W03 as demonstrated by the "nonparametric robust least absolute residuals regression" (ROB-LAR) method. Copper revealed a decreasing trend at station W01. Among the pesticides, lindane showed for the same period a significant decreasing trend in the three stations. Dieldrin, hexachlorobenzene and DDE (p,p′) revealed a similar trend in at least one location. The aim of this case study was to analyze if the data of the PMPZ-DBII can be compared to recent monitoring data and eventually be used to extend time series.

4.2. Inventory of pollutants in the marine coastal area 1972–1975

Data analyzed during the Project Sea in the coastal area cover a wide range of parameters measured by IHE at 28 locations. Concentrations of metals, pesticides, PCBs together with granulometry, organic matter and loss on ignition were available in a tabular format along with meta-information like sampling position and sampling date. Data were not aggregated over time or location, nor synthesized in categories on a map. In this aspect, the dataset was one of the most complete to import.

Data from 28 locations at 400, 3 000 or 6 000 m from the coastline were imported into the IDOD database. For the case study, three stations were selected, based on proximity to the current monitoring stations: 3 km off Heist (PS_HS3000), 400 m off Mariakerke (PS_MA400) and 3 km off Lombardsijde (PS_LB3000) close to respectively W01, W02 and W03 (Figure 26). To increase the number of values to consider, additional stations have been selected in a later stage: PS_HS400 and PS_KN400 near W01, PS_OS3000 and PS_OS400 near W02, PS_OD400 and PS_NPBL near W03.

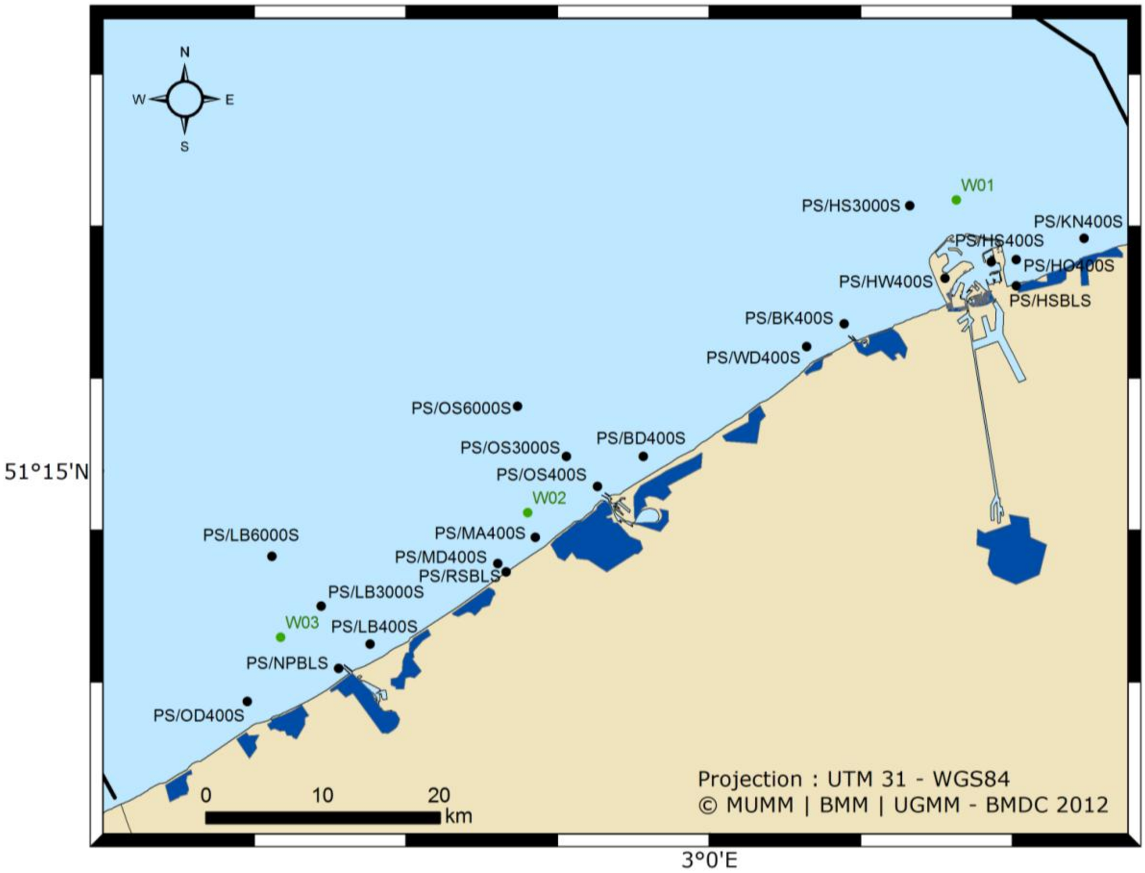


Figure 26: Map of the Belgian coastline with the coastal sediment stations of the project Sea (PS-stations) and the current monitoring stations (W-stations).

The sampling and analytical methodology however was not clearly described. Only very limited information could be extracted from the reports and technical papers. Further information on methodology has been requested from the IHE and is currently being gathered. Unfortunately, no unambiguous indication has been found about the sediment fraction on which the parameters were measured. The importance of the fine fraction (<37 µm) in relation to pollutants was clearly observed during the first years of the Project Sea. In the course of 1974, results related to grain size were limited to the fraction of 37 µm.

4.2.1. Hypothesis 1 - pollutants measured on fraction < 37 µm

During digitization, the assumption was made that contaminants were related to the sediment fraction lower than 37 µm. The current monitoring data are measured on the fraction lower than 63 µm. In the frame of international assessments, a lot of work on normalization has been done to compare pollutant data measured on different fractions.

Physical separation, *i.e.* the isolation of the fine fraction, is regarded as a first step in normalization. However, in a second step, normalization to a cofactor can further reduce the variability due to geochemical characteristics. Application of this two-tiered approach to fractions < 20 μm and < 63 μm would lead to results that can be directly compared (ICES, 2009). Aluminium, lithium or organic carbon (TOC) can be considered as cofactors for metals. Lithium is not available, neither for the old nor for the recent data. Organic contaminants show a high affinity for organic matter and organic carbon can act as a proxy for the latter.

In some areas the correlations between contaminant and cofactor concentrations may be weak or absent due to an inappropriate cofactor, a very variable contamination in time or space or a significant additional variance arising from the analysis of the cofactor concentration.

First, the correlation between metals and aluminium measured on the fine fraction (<63 μm) has been considered on data from the last 6 years for the three selected stations. No significant correlation is observed (Figure 27). As shown in Figure 28, the variation appears to increase after normalization.

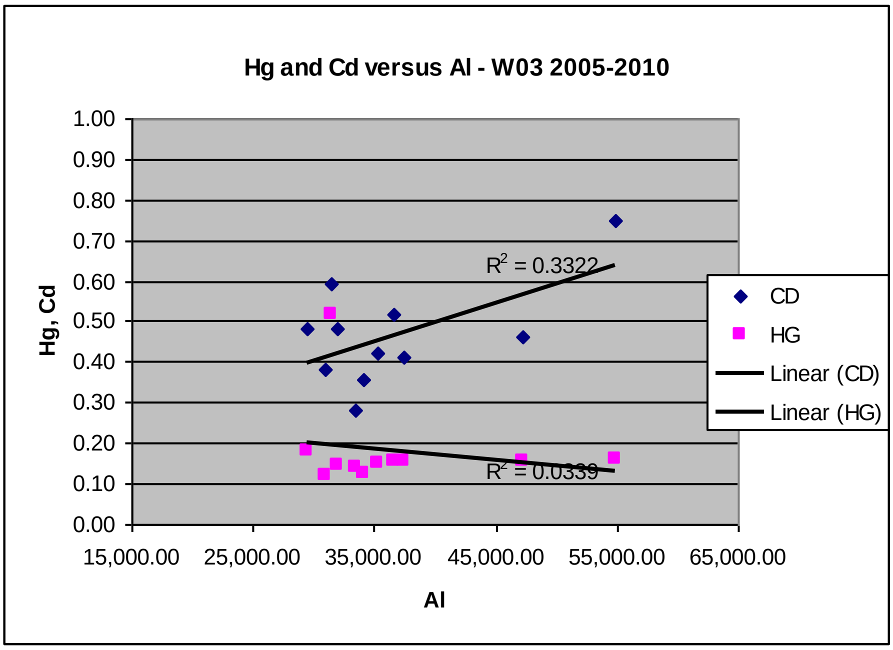


Figure 27: Hg and Cd (μg/g) versus Al at W03.

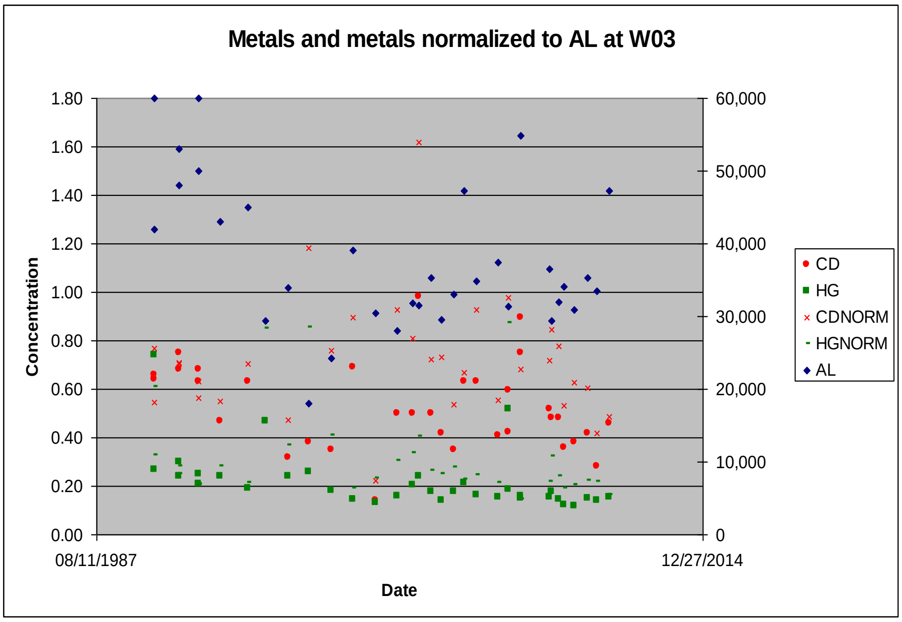


Figure 28: Cd, Hg and normalized Cd, Hg (μg/g) versus time at W03.

Secondly, no significant correlation could be found between metal concentrations (since 1990) and organic carbon in the fraction < 63 μm. For mercury and cadmium a negative slope is even observed at station W03. On station W02, not enough recent organic carbon data was available to show a correlation. The mercury and cadmium versus organic carbon concentrations in W01 are displayed in Figure 29. For lindane, as organic contaminant, no significant correlation with organic carbon was found (Figure 30).

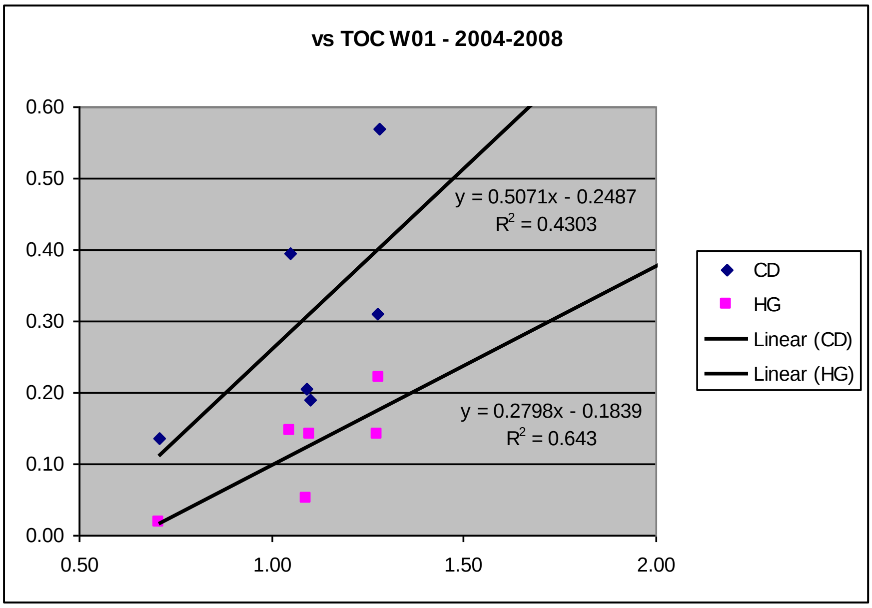


Figure 29: Cd and Hg concentrations versus total organic carbon (TOC) at W01.

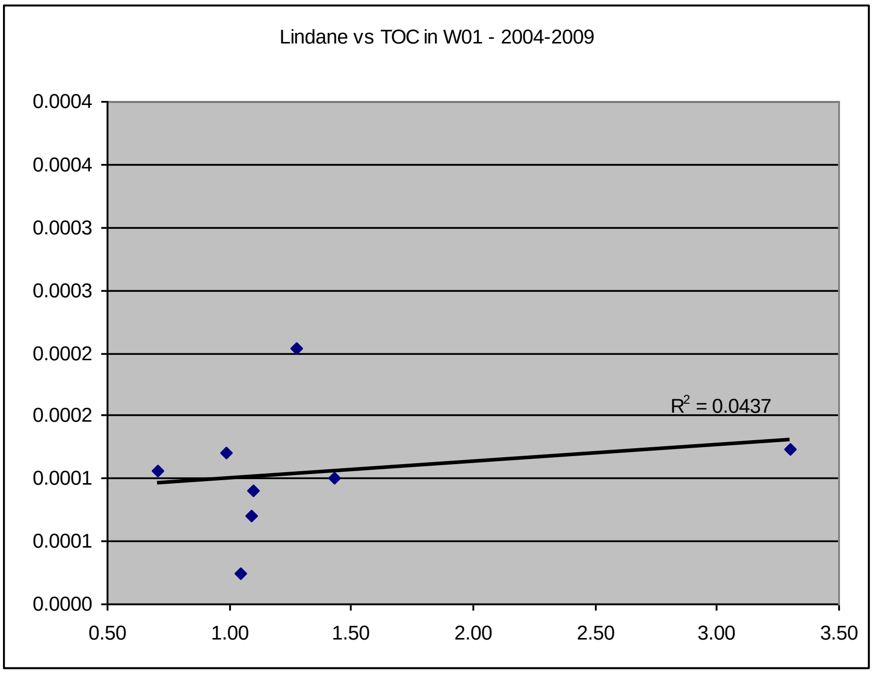


Figure 30: Lindane concentrations versus total organic carbon (TOC) at W01.

Trend detection

Due to unsatisfactory correlations and the assumption that the contaminants were measured on a fine sediment fraction, no normalization was applied for the trend analysis. In this case, concentrations in the fraction < 37 μm were directly compared with those in the fraction < 63 μm, whereby it is assumed that the contaminant is present in the same concentration in fraction 37-63 μm as in the fraction < 37 μm. This leads to an overestimation of the concentrations of the seventies because the proportion in the finer fraction is expected to be higher as the highest proportion of metals and organic contaminants are bound to particles < 2 μm (Kramer, 1997).

In this assumption, mercury decreases significantly at W03 and lindane in W01. It must be noted that the historical data show a high variation (Figure 31 and Figure 32). And more substantially, further investigation of the historical reports indicated that the earlier assumption, measurements done on the fine fraction, proved to be wrong.

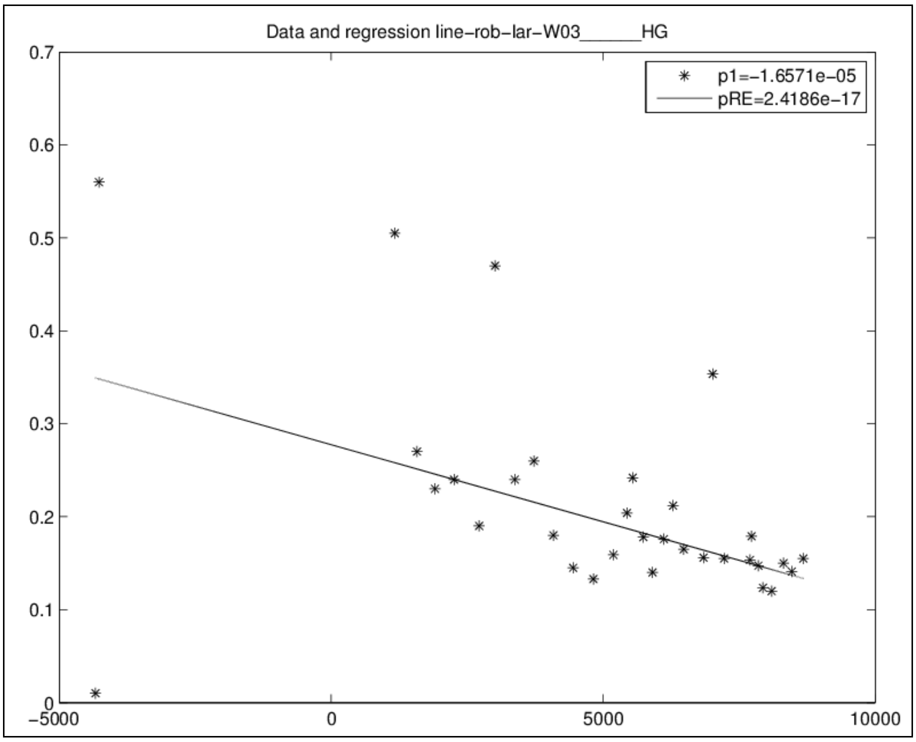


Figure 31: Indicative trends in mercury (difference in fraction) concentrations at W03 with robust least absolute residuals regression.

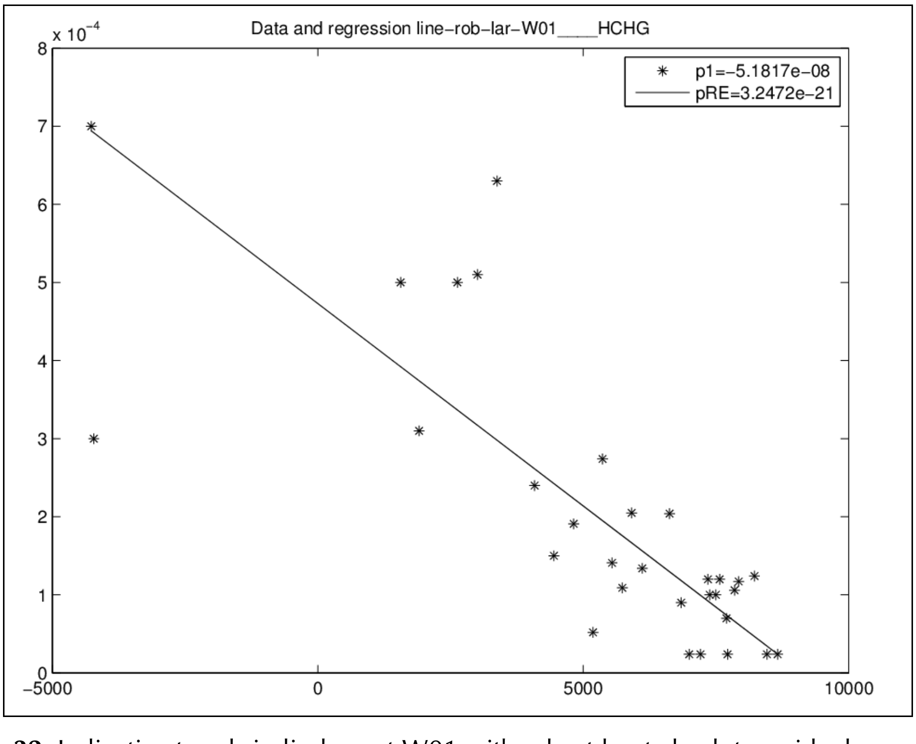


Figure 32: Indicative trends in lindane at W01 with robust least absolute residuals regression.

4.2.2. Hypothesis 2 - pollutants measured on whole sample

At a later stage, a reconstruction of metal concentrations in the fraction < 37 μm (Volume 6 of the PMPZ final report) was carefully checked with the reported data. It appeared that the data inventory (Volume 11) showed concentrations on the whole sample for stations sampled in 1971 and 1972. If these data were compared with recent data without any normalization, the former concentrations would be underestimated due to the affinity of metals and organic pollutants for the fine fraction. The decreasing trend will most likely remain valid. The high variation, *a.o.* induced by measurements on the whole sample, requires a more thorough look including more data.

The question on normalization arises again. Variability related to geochemical characteristics is now much higher than initially thought. Unfortunately, few data measured on the whole sample are available at one location to study the correlation with possible cofactors. Besides that, important questions related to the quality and the analysis methods of potential cofactors remain for the historical data. With regards to normalization to aluminium, a missing element in the old data is the extraction method for aluminium *i.e.* total, strong or weak digestion. The latter is needed to retrieve the appropriate normalization parameters with regards to the degree of aluminium extracted. A request to receive this information has been issued to CODA-CERVA, the former IRC.

Inaccurate analyses of organic carbon can also induce errors. In this case, a high variation was observed in the Project Sea dataset for total organic carbon. For instance, for station W01, the results of the seventies are all higher than 5 % while the results from the last 20 years showed only one outlier with a value of 3.3 % for this station. On Figure 33, boxplots for the stations are shown since 1990 while Figure 34 also includes the Project Sea data at the same stations. Were the samples not sieved to remove large detritus and benthic organisms before organic carbon analysis? To clarify this issue, more detailed information on the analytical method is awaited.

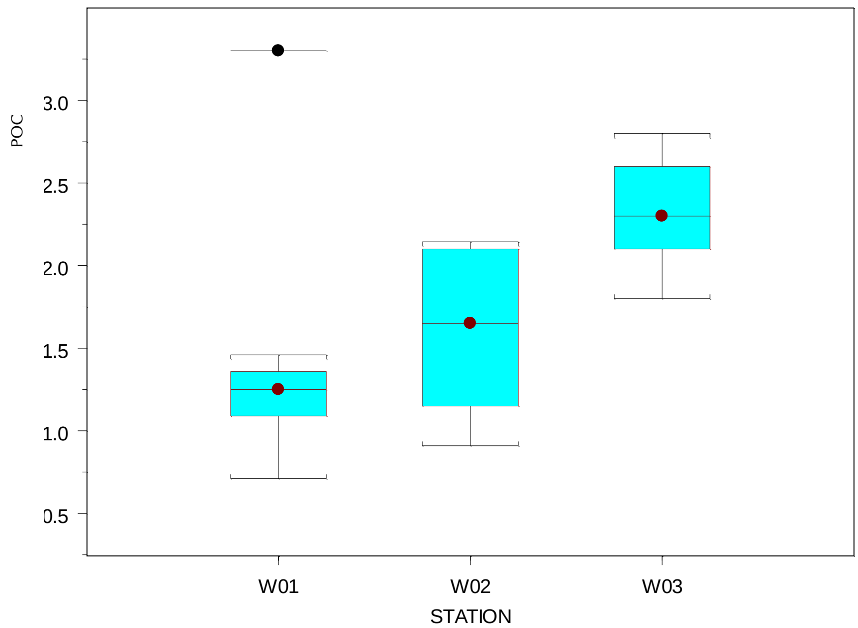


Figure 33: Boxplots of total organic carbon at stations W01, W02 and W03 since the nineties.

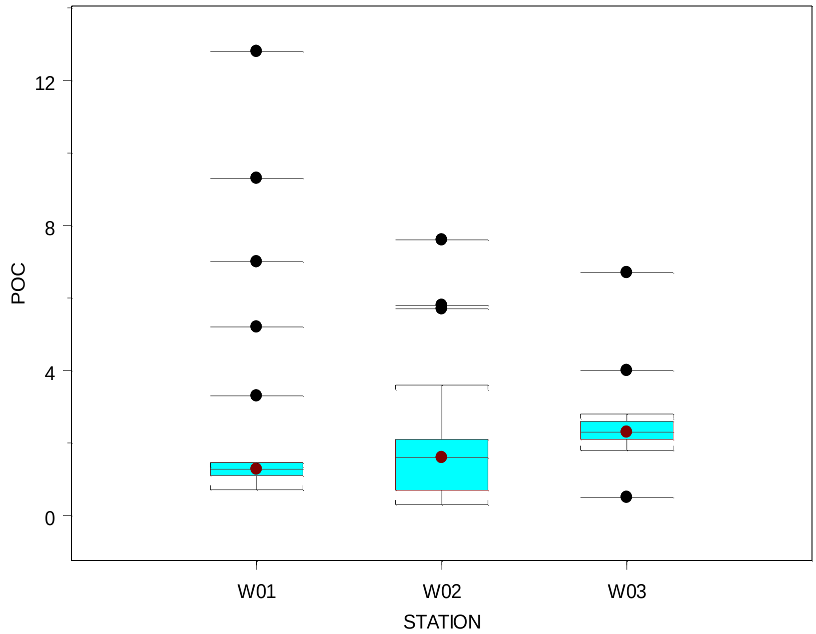


Figure 34: Boxplots of total organic carbon at stations W01, W02 and W03 since the seventies.

A temporary approach, which is made prior to receiving more information on the methods, consists in the contribution of the historical contaminants to the fine fraction before comparison. Most grain size measurements were only done in the fraction < 37 μm. As a result, these concentrations have been recalculated with the supposition that all of the contaminant was present in this fraction. The recalculated concentration therefore increased inversely with the amount of fine sediment.

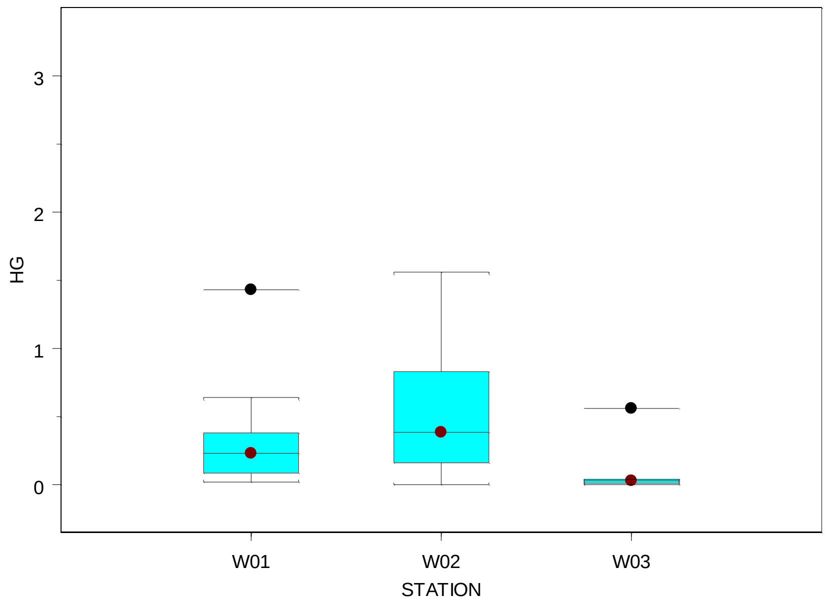


Figure 35: Boxplot of mercury concentration

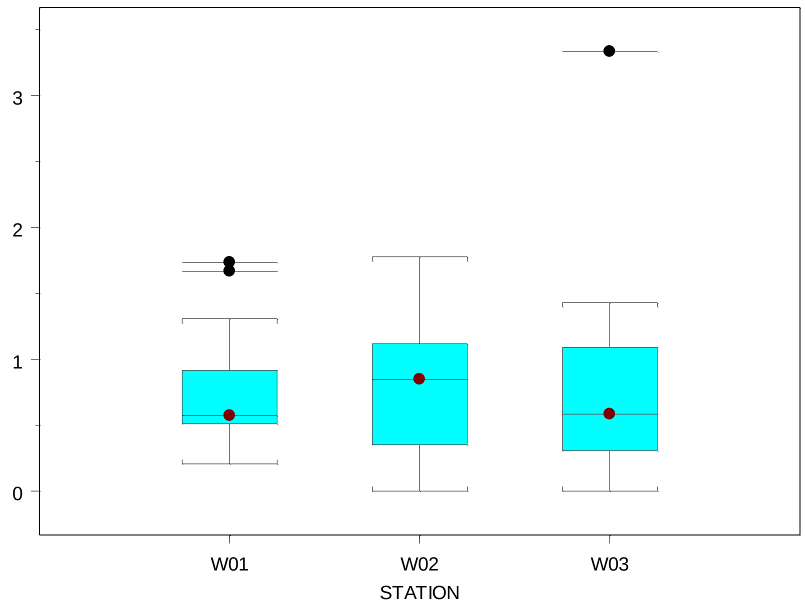


Figure 36: Boxplot of mercury concentration recalculated as all mercury in the fraction < 37 µm

Figure 35 shows lower mercury concentrations at W03. This difference is eliminated after recalculation of the concentration to the fraction lower than 37 µm, W03 being characterized by a low amount of mud (< 20%) (Figure 36). Both figures confirm the hypothesis of measurements being done on the whole sample.

The historical data are characterized by a high variability. All outliers have been checked once more with the values in the reports. One extreme value could be identified as a typing error and has been corrected. Outliers were not removed, they were accompanied, before recalculation by a high amount of small particles, after recalculation, by a very small amount of mud inducing large errors because (OSPAR Commission, 2002), or high concentration of other pollutants.

Figure 37 shows the mercury and lindane 50 % concentration range with their minimum and maximum value at station W01 and W03 at different time windows. For the '70s data, the concentration on the whole sample and the recalculated concentrations are shown. The actual pollutant concentration in the fine fraction (< 37 µm) could, in reality, have been slightly lower than the one recalculated for the fine fraction. Recent mercury and lindane concentrations appear to be lower than those of '90s and the '70s. To confirm the difference with the '70s, work on normalization has to be continued.

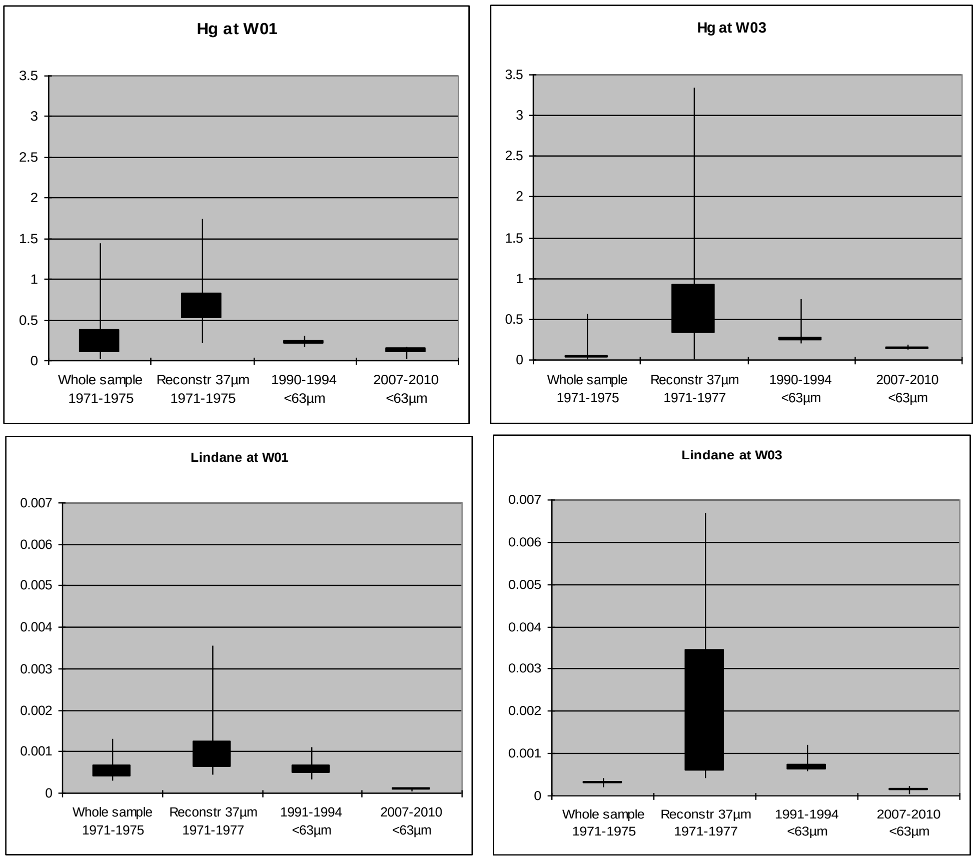


Figure 37: 25 percentile, 75 percentile, minimum and maximum concentrations of mercury (µg/g) (above) and lindane (µg/g) (below) at W01 and W03.

4.3. Conclusions

Using the historical data, a lot of questions arise related to the methodology and meta-information. The case study allowed us to control the consistency of the data and to make some corrections, for example on analysis methods. Studying concentrations of substances in sediments also shows the need for a detailed study of appropriate cofactors for the Belgian continental shelf in order to normalize data that has been measured in different fractions. However, for the historical data discussed here, there are a lot of limiting factors: lack of lithium as possible cofactor, lack of granulometry for all locations, unknown methodology of the digestion method (strong or weak) for metals, the pretreatment or the separation method (e.g. elimination of detritus prior to the analysis of total organic carbon). More information on methodology is expected soon, after which the possibilities for data comparison should be reviewed. Taking the possible ranges of concentrations into account, it is possible to give an indication of the temporal evolution.

5. POLICY SUPPORT

The major output of this project is the publishing, according to nowadays standards, formats and methods, of a highly valuable dataset of oceanographic and contaminant measurements made during the period 1970–1982.

These data fill an important gap in the setting up of continuous data series pertaining to the marine environment and covering the second half of the XXth century. They offer scientists and policymakers valuable complementary information on the evolution of our environment and, hopefully, will help in studying the local effects of Earth-wide phenomena like global warning and climate changes.

These data are also very useful assessing the evolution of the environmental status of the North Sea in the framework of the Marine Strategy Framework Directive, the major policy tool for the European seas for the coming 20 years.

6. DISSEMINATION

Borremans C., Scory S., De Cauwer K. and Devolder M., 2010. *Rescuing historical marine data and making them accessible: the case of data collected during the first years of modern oceanography in Belgium*. Poster presented at the International Conference on Marine Data and Information Systems (IMDIS), Paris (France), 29–31 March 2010. (Annex I)

Scory S., Houziaux J.-S. and Lagring R., 2011. *170 years of oceanographic data collection in Belgium: evolving needs, evolving means*. Presentation at the IODE 50th Anniversary International Conference, Liege (Belgium), 21–22 March 2011. (Annex II)

De Cauwer K., Devolder M., Lagring R., Scory S., Stojanov Y. and Van Lancker V., 2012. *Data from ship logger to onshore viewer*. Poster presented at the VLIZ Young Scientists' day, Bruges (Belgium), 24 February 2012. (Annex III)

BMDC news: http://www.mumm.ac.be/datacentre/News/item.php?ID=13

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We would like to thank all people that gave useful input during the project, by going far back in time in their memories, by digging in their archives or by providing specific expertise: our colleagues at MUMM and, especially, Georges Pichot, Head of MUMM and very first "Data Manager" of the "Projet Mer–Project Zee".

We are also grateful to all the scientists and technicians involved in the "Projet Mer–Project Zee" and in the Concerted Actions "Oceanology". The data and the documentation they left us are an evidence of the high value of their scientific work.

Patrick Roose and Alain Norro gave us a much appreciated scientific and technical support for the case study. Valuable information on former analyses methods was provided to us by Marc Guns of CODA-CERVA.

Jean–Sébastien Houziaux's experience in digitizing ancient data and sample collections has been a great help for this project. Furthermore, Frank Fiers introduced us to the collection of macrobenthos stored at the archives of the RBINS head office.

8. REFERENCES

Anon., 1977. Projekt Zee: overzicht van het eindverslag. Diensten van de Eerste Minister. Programmatie van het Wetenschapsbeleid. 14 pp.

Anon., 1979. Geconcerteerde Onderzoeksacties Interuniversitaire Actie Oceanologie: verslag van de studiedagen 1979. Diensten van de Eerste Minister. Programmatie van het Wetenschapsbeleid. / Actions de Recherche Concertées: rapports des journées d'études 1979. Services du Premier Ministre. Programmation de la Politique scientifique. 254 pp.

Anon., 1980. Geconcerteerde Onderzoeksacties Interuniversitaire Actie Oceanologie: verslag van de studiedagen 1980. Diensten van de Eerste Minister. Programmatie van het Wetenschapsbeleid. / Actions de Recherche Concertées: rapports des journées d'études 1980. Services du Premier Ministre. Programmation de la Politique scientifique. 302 pp.

Anon., 2010. Federaal Milieurapport 2004-2008. Finaal Rapport. FOD Volksgezondheid, Veiligheid van de Voedselketen en Leefmilieu, DG Leefmilieu. / Rapport Fédéral en matière d'environnement 2004-2008. Rapport final. SPF Santé publique, Sécurité de la Chaîne alimentaire et Environnement, DG Environnement, Brussels. 548 pp.

Belgische Staat / État belge, 2012. Évaluation initiale de l'écosystème marin belge pour la directive-cadre Stratégie pour le milieu marin. Version provisoire soumise à consultation publique. 93pp. / Initiële beoordeling van het Belgisch marien ecosysteem voor de Kaderrichtlijn Mariene Strategie. Voorlopige versie ingediend voor publieke consultatie, maart 2012. 88pp.

Boissonas J., Reid P.C., Wolff W.J., Donard O., 2004. The Belgian North Sea Programmes 1970-2002. Findings of the expert panel. Belgian Science Policy, Brussels. 187 pp.

De Cauwer K., Devolder M., Jans S., Meerhaeghe A. Scory S., 2006. IDOD: an integrated marine environmental database. ICES Annual Science Conference, Maastricht (The Netherlands), 19–23 September 2006, CM 2006/M:23.

Distèche A. and I. Elskens (Eds.), 1982. Geconcerteerde Onderzoeksacties Interuniversitaire Actie Oceanologie: eindverslag Vol 2. / Actions de Recherche Concertees: Rapport final Volume 2. Distribution, transport and fate of heavy metals in the Belgian coastal marine environment. Diensten van de Eerste Minister. Programmatie van het Wetenschapsbeleid. 173 pp.

Heip C. and Ph. Polk (Eds.), 1982. Geconcerteerde Onderzoeksacties Interuniversitaire Actie Oceanologie: eindverslag Vol 3. / Actions de Recherche Concertees: Rapport final Volume 3. Biological processes and translocations. Diensten van de Eerste Minister. Programmatie van het Wetenschapsbeleid. 227 pp.

Houziaux J.-S., Kerckhof F., Degrendele K., 2008. The Hinder banks: yet an important region for the Belgian marine biodiversity? Final report. Belgian Science Policy, Brussels, 249 pp.

ICES, 2009. Update of JAMP guidance on normalisation of contaminant concentrations in sediment. ICES Advice 2009, Book 1.

Kramer K.J.M., 1997. QUASH. Report on the proceedings of the quality assurance of sampling and handling (quash) launch workshop sponsored by the EU standards measurement and testing programme. Groningen, 32 pp.

Lancelot-Van Beveren C., 1982. Etude écophysiologique du phytoplankton de la zone cotière belge. Thèse présentée pour l'obtention du grade de Docteur en Sciences. 222pp.

Levitus S., 2004. History and results of the IOC GODAR Project. Presentation at the second International workshop for GODAR WESTPAC, Tokyo (Japan), 10–12 November 2004.

Lorenzen C.J., 1967. Determination of chlorophyll and phaeopigments: spectrophotometric equations. Limnol. Oceanogr., 12, 343–347.

Mommaerts J.P., 1995. La gestion des données du programme de surveillance de la qualité de l'environnement marin et programme connexes, à l'UGMM. 14 pp.

Nihoul J.C.J., Distèche A., Polk Ph., Boelen C., Elskens I., Deconinck L., Adam Y. (Ed.), 1976. Projekt Zee: Eindverslagen Volumes 1-11. Diensten van de Eerste Minister. Programmatie van het Wetenschapsbeleid. / Projet Mer: Rapports finals Volumes 1-11. Services du Premier Ministre. Programmation de la Politique scientifique.

Nihoul J.C.J. and R. Wollast (Eds.), 1982. Geconcerteerde Onderzoeksacties Interuniversitaire Actie Oceanologie: eindverslag Vol 1. / Actions de Recherche Concertees: Rapport final Volume 1. Hydrodynamic and dispersion models, boundary fluxes and boundary conditions. Diensten van de Eerste Minister. Programmatie van het Wetenschapsbeleid. 259 pp.

OSPAR Commission, 2002. JAMP guidelines for monitoring contaminants in sediments. 48 pp.

Persoone G., (Ed.), 1982. Geconcerteerde Onderzoeksacties Interuniversitaire Actie Oceanologie: eindverslag Vol 4. / Actions de Recherche Concertees: Rapport final Volume 4. Selected topics in marine aquaculture: Microalgae, Mollusc nursery, Artemia. Diensten van de Eerste Minister. Programmatie van het Wetenschapsbeleid.

Pichot G., Donnay J.P., Billiet J. and Van Dyck J., 2002. Integrated and dynamical oceanographic data management (IDOD). Joint final scientific report prepared for OSTC, contracts MN/DD/60, 61 & 62, Management Unit of the North Sea Mathematical Models, Brussels, 24 pp.

SCOR-UNESCO, 1966. Monographs on oceanographic methodology. Determination of photosynthetic pigments in sea-water. Unesco, Paris, 69 p.

Sergeyeva O., Vladymyrov V., Slipetskyy D., Gorbunov V., Skuratova K., Bilogurova Iu. 2010. Establishing best practice for the digitization, documentation and dissemination of historical marine biological data at IBSS. Poster presented at IMDIS conference 2010.

Yentsch, C.S., Menzel, D.W., 1963. A method for the determination of phytoplankton chlorophyll and phaeophytin by fluorescence. Deep-Sea Res. 10: 221-231.

Websites

BELSPO. The Belgian Federal North Sea Research Programme. Available at: http://www.belspo.be/belspo/Northsea/index_en.stm (accessed 12.04.12)

BMDC. http://www.mumm.ac.be/datacentre

GODAR. http://www.nodc.noaa.gov/General/NODC-dataexch/NODC-godar.html

ICES. ROSCOP. Available at: http://ocean.ices.dk/Roscop/Default.aspx (accessed 12.04.12)

IOC-UNESCO. http://www.ioc-unesco.org

SEADATANET. http://www.seadatanet.org/Metadata/CSR

SEADATANET BSH. SeaDataNet Cruise Summary Report Inventory (CSR). Available at: http://seadata.bsh.de/csr/retrieve/V1_index.html (accessed 12.04.12)

ANNEX I: "Rescuing historical marine data and making it accessible: the case of data collected during the first years of modern oceanography in Belgium"

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Most complete databases are needed for oceanographic and climate research. Particularly, historical ocean data are required to study global change and to define a "reference status" in the context of international agreements and directives. Access to these data is then a crucial issue for the scientific community.

Belgium has a long oceanographic data collection history but a lot of these data are only available on paper or on electronic media supports that are subjects to degradation over time. The aim of this project is then to identify the Belgian historical marine data recorded on media at risk of loss ("Data Archaeology") and to "rescue" as many of these data as possible ("Data Rescue"). The general method is the following:

- locate the data not yet in digital form or data on electronic media at risk of being lost,
- digitize the data and apply a quality control on these,
- import the data in a database and make them available internationally without restriction. The availability of these historical data should be advertised world wide.

The data planned to be rescued were collecting during the "Project Sea" (1970-1976) and the "Concerted Research Actions" (1977-1982) of the Belgian Federal North Sea Research Program. They give a broad overview of the Belgian marine waters and of the Scheldt estuary status during the 1970-1982 period. Almost all types of data will be processed: water, sediment, air and biota quality data, characterization of sediments, biodiversity values and physiology data (kinetics). As far as we know, these data are kept in the following forms and formats: (1) paper reports (written text, tables and graphs), (2) copies of magnetic tapes and (3) archives of the researchers. As no standard methodology exists to rescue data, procedures will be designed and they will be validated by the follow-up committee. Thereafter, these specific recovery procedures will be carefully documented and communicated to the marine data managers community. After a strict and precise inventory of all the available pieces of information and their type of content, a priority list will be established. Indeed, reference data must be imported first (e.g. stations, campaigns) in order to make easier and faster the data quality check and the data incorporation into the database. Additional information and data from other archives will be searched for and readable data on old digital supports will be identified. The data will be digitized and imported without embargo in the IDOD database that is the reference database for the Belgian Federal Science for a Sustainable Development Programs. Data will be available through the IDOD database interface and through the project specific interface. As metadata are of the outmost importance for the usefulness of the basic data, a special effort will be put on reconstructing this meta-information and on incorporating it in the database. Methods used to digitize the data will be added as metadata.

The dataset will be valorized through: (1) publication on the Belgian Marine Data Centre and the Belgian Science Policy websites, (2) two case studies of parameters trend over time, (3) publications and presentations at conferences. The result of this project will form a multidisciplinary documented and digitized dataset that will concern any marine or climate research where evolution over time is under consideration. Trend analyses and comparative studies resulting from that work will represent particularly important tools for policy makers in order to define strategies to reach regulatory objectives.

Annex II: "170 years of oceanographic data collection in Belgium, evolving needs, evolving means"

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In the present days, important legislations are being implemented at the international level targeting improved ocean health. Next to the issue of developing meaningful indices of "environmental health", a major problem remains the determination of "baselines", a necessary step to determine meaningful and feasible targets. When historical data are available, it becomes possible to test hypotheses with respect to the past status of the marine ecosystems and to check whether our present-day knowledge enables us to determine what a "healthy" environment is.

Historical data sets, even limited in time, and long time series, are thus of the outmost importance. The mechanisms for collecting, documenting, safeguarding and publishing data, as set up by IODE for 50 years now, are therefore of the highest relevance for addressing these scientific and societal needs.

Belgium has a long tradition in marine sciences. Next to natural history investigations performed during the 19th century, oceanographic and ecological research was undertaken in the early 1900s by G. Gilson. Part of his activity was already driven by the societal needs, as Gilson was a very active member of the recently born "International Council for the Exploration of the Sea". The archived collections of samples and archives of the period 1899–1914 have recently been made available in a digital format what already allowed some long-term research to be carried out on seafloor composition and benthos.

After Gilson's work, a long data gap characterizes the observation of our working area until the 1970s, when the large national integrated "Project Sea" took off. Data and results obtained during this intensive research and "hidden" in grey literature are presently being digitized and made available to the scientific community in order to enable tracking of environmental trends over the last forty years.

After an overview of some important milestones in oceanographic data collection in Belgium, we shall explain how the corresponding means have evolved over the years in order to meet the scientific and societal needs. We shall also describe some of the challenges we are confronted while recovering historical data, especially when they have to be mixed in a consistent way with "modern" data in order to support long–term analyses. We will conclude with some recommendations based on our always improving experience.

ANNEX III: "Data from ship logger to onshore viewer"

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The Belgian Marine Data Centre (BMDC, www.mumm.ac.be/datacentre) serves as national repository and processing centre for marine and environmental data, collected in the framework of national and international research and monitoring programmes. It ensures the data flow between data producers and end-users on a national and international level following international standards. The data cover most domains of oceanology as there are: physico-chemical measurements, optical properties of seawater, biodiversity, hydrodynamics, sedimentology, geology, geography and human interest. Most of the datasets relate to the Belgian Continental Shelf, the Scheldt estuary and its surrounding areas.

The integrated database on the quality of the marine environment contains the results of in situ measurements and observations and laboratory analyses of air, water, sediment and biota samples. Actually, historical data collected during the first phases of modern Belgian oceanography, Project Sea (1970-1976) and the Concerted Research Actions (1977-1982), are being digitized and imported. This will extend the range of time for which data is available, making it possible to perform long-term environmental change detection.

To disseminate high resolution data, the database is extended to refer to and document profiles, time series, trajectories… Also predictions of operational models at given locations are being processed for storage and for comparison with real measurements.

The BMDC is a node of the European SeaDataNet infrastructure (www.seadatanet.org), through which the data are made available on a European level in a standard way enabling the usage of common software packages like Ocean Data View (ODV).

As partner of the European project Geo-Seas, MUMM works on the archival of geological data according to international standards with regards to vocabularies and formats. This enables dissemination of data through the Geo-Seas portal (www.geoseas.eu) and usage of common tools, such as borehole viewers and interactive 3D seabed viewers.

During data processing, basic information on a measurement or gear deployment (e.g. location and time) often appeared to be missing or inaccurate. Unanticipated events or anomalies during acquisition are of importance for the subsequent processing and interpretation of marine data. In order to simplify the work for scientists onboard and data managers onshore, the data centre is also involved in the elaboration of a common software package used for logging events onboard, based on an ontology. This software, EARS (Eurofleets Automatic Reporting System) is produced in the frame of the European project Eurofleets (www.eurofleets.eu).