OPerational ECology

Ecosystem forecast products to enhance marine GMES applications

DG SPACE

Collaborative Project - small or medium-scale focused research project

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OPEC Overview

"OPEC provides an enhanced capability to predict indicators of good environmental status in European regional Seas"

The OPEC project (Operational Ecology) will help develop and evaluate ecosystem forecast tools to help assess and manage the risks posed by human activities on the marine environment, thus improving the ability to predict the "health" of European marine ecosystems. The programme will focus on four European regional seas (North-East Atlantic, Baltic, Mediterranean and Black Seas) and plans to implement a prototype ecological Marine Forecast System, which will include hydrodynamics, lower and higher trophic levels (plankton to fish) and biological data assimilation.

Products and services generated by OPEC will provide tools and information for environmental managers, policymakers and other related industries, laying the foundations for the next generation of operational ecological products and identification of knowledge / data gaps.

OPEC will use the EU's Global Monitoring for Environment and Security Marine Service as a framework and feed directly into the research and development of innovative global monitoring products or applications. This in turn will advise policies such as the European Marine Strategy Framework Directive and Common Fisheries Policy, as well as the continued monitoring of climate change and assessments of mitigation and adaptation strategies.

www.marineopec.eu

Contents

Executive Summary

The aim of WP5 is the assessment of ecological monitoring system and data needs for GMES ecological service. OPEC will evaluate the effectiveness of the current data availability for the delivery of operational ecology. By undertaking ecosystem monitoring system evaluation experiments for the planktonic ecosystem, OPEC will make recommendations for the future satellite and in situ monitoring of the system. The aim of this document is to collate information on the regular biogeochemical monitoring in each region, as a precursor to assessing its effectiveness in terms of spatio-temporal coverage. We have collated meta-data on the following categories long term time series: In-situ data buoys, regular ship based sampling including ferrybox and CPR, and river nutrient loads. The Baltic Sea and the NE Atlantic regions have the most comprehensive monitoring systems, the Baltic region being the best coordinated. The Black Sea has one regular survey per year, while the Mediterranean has very little regular monitoring.

Relevance to Policy

WP5 will evaluate existing in-situ monitoring systems and generate ideas for making existing European observing systems more effective and cost-effective. Furthermore, they will contribute towards the assessment of the potential for using observed data not only meeting operational oceanography needs and statutory obligations, but also to feed into environmental policy advice and to support the long-term science objectives as described in H2020. These recommendations will be feed to relevant bodies including ESA, the GMES Marine Service, the EC, OSPAR and HELCOM**.**

1. Introduction

The goal of WP5 is to assess effectiveness of the existing biogeochemical monitoring systems to inform the data requirements of Copernicus Marine Service (previously the GMES ecological service). The methodology for assessing effective coverage of a given monitoring network was developed by She et al. (2007) in ODON project and further applied by Fu et al. (2011) in ECOOP. Three steps are required:

1) Generation of a proxy ecosystem dataset (multi-year reanalysis)
2) Calculatation of a spatial-temporal correlation for BGC variables
3) Estimation of the effective coverage of the given sampling strategy

The proxy ecosystem dataset has been generated in WP2 and the 10-year reanalysis will be will be used. The proxy ecosystem dataset will be used to calculate the spatial-temporal correlation for selected biogeochemical variables. Using the metadata and spatial-temporal correlation data, the effective coverage of the current monitoring network can be estimated. Danish Meteorological Institute (DMI) has calculated the 2D spatial correlation eclipse. An example is shown for surface chl-a in Figure 1. The maps show significant inhomogeneous features in space which suggests that design sampling stations in optimal locations (with large correlation scale) can enlarge the effective coverage of a monitoring network.

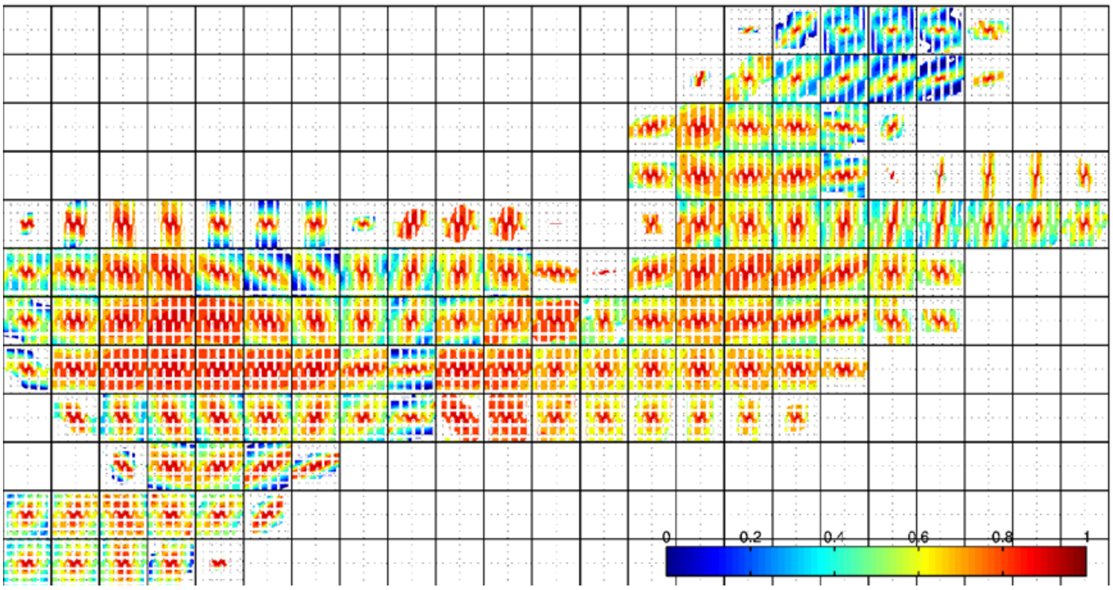

Figure 1. Baltic Sea spatial correlation map for surface chl.a: derived from the 10yr reanalysis from WP2 used 1.5°×1.5° bins

The work will be undertaken in all OPEC regions i.e. Baltic Sea, NE Atlantic (incl. North Sea), Mediterranean and Black Sea. In order to undertake the assessment we need to collate metadata which describes the current status of regular monitoring of biogeochemical properties in each region. The regular monitoring falls into four categories;

- Long term time series:
- In-situ data buoys
- Regular ship based sampling including ferrybox and CPR.
- River nutrient loads.

1.1 FerryBox (www.ferrybox.org)

Ferryboxes are packages of instruments placed on board commercial ships such as ferries to monitor temperature, salinity, fluorometric chlorophyll, oxygen and other water properties. We do this by sampling surface water while the ferry is on passage from between ports to detect long-term changes.The EU project FerryBox (2002-2005) amply demonstrated they can provide oceanographic data in a highly cost effective manner over a wide range of time and space scales. In Europe FerryBox output is now an integral part of the vision (EMODNET European Marine Observation and Data Network) for the gathering of data streams together into a pan European system for assimilating data in to the marine management cycle.

1.2 Continuous Plankton Survey (CPR www.sahfos.ac.uk)

The CPR Survey monitors the near-surface plankton of the North Atlantic and North Sea on a monthly basis, using Continuous Plankton Recorders on a network of shipping routes that cover the area. The CPR is a plankton sampling instrument designed to be towed from merchant ships on their normal sailings. The CPR has been deployed in the North Sea regularly since 1946, on a number of routes. The CPR works by filtering plankton from the water over long distances (up to 500 nautical miles) on a moving filter band of silk (270 micron mesh size). On return to the laboratory, the silk is removed from the mechanism and divided into samples (known as blocks) representing 10 nautical miles of towing. The plankton on these samples are then analysed according to standard procedures. Before cutting, the colour of the silk is compared to a colour chart and given a 'green-ness' value of 0 (no greenness), 1 (very pale green), 2 (pale green) or 6.5 (green). Other colours are not recorded. This is a subjective analysis, with arbitrary values returned, but it can be the first indication of phytoplankton blooms. A subsample of the block is examined under high power magnification to identify and count phytoplankton species present (the sub-sample is about 0.001 of the whole sample). Another sub-sample analysis for small zooplankton is then carried out under a lower magnification, where all individuals seen in a traverse of the silk are identified and counted. The last part of the analysis process is that all zooplankton larger than about 2mm are identified and counted from the whole sample. They are spotted by eye, but identified under the microscope. This is known as 'zooplankton eye count analysis'. After analysis, the counts are checked and added to the CPR database.

2. Meta data for existing monitoring systems

The temporal and spatial coverage of biogeochemical monitoring systems are highly variable from region to region, with the NE Atlantic and the Baltic Sea having the most comprehensive coverage. The WP5 assessment of the monitoring network will focus on collating metadata for monitoring active in the period 2011-2013 and support the information required for OPEC’s REA (Rapid Environment Assessment). Stations included in metadata shall have a minimum sampling frequency of once per year. For river load metadata, only the locations are required. Where possible the metadata shall include following information:

- Monitoring type
- Parameter
- Latitude
- Longitude
- Sampling frequency
- Station name
- Responsible institute.

2.1 Baltic Sea

2.1.1 Status of the biogeochemical monitoring system (2011-2013)

The regular Baltic Sea biogeochemical monitoring system mainly includes 3 components: one is a network of biogeochemical stations organized through HELCOM, another is a moored buoy array and the third is a network of ferrybox measurements.

<u>HELCOM monitoring network</u>

The HELCOM monitoring network measures key variables including temperature, salinity, nitrate, phosphate, oxygen and chlorophyll for the environment assessment by all Baltic countries. The monitoring was made by using research vessels with sampling frequencies between quarterly to biweekly (i.e. 4-26 observations per year). The spatial distribution of stations is relatively uniform.

The locations of regular HELCOM stations for Chl-a, DIN, DIP and DO are shown in figure 2 and figure 3 for year 2011 and 2012 respectively.

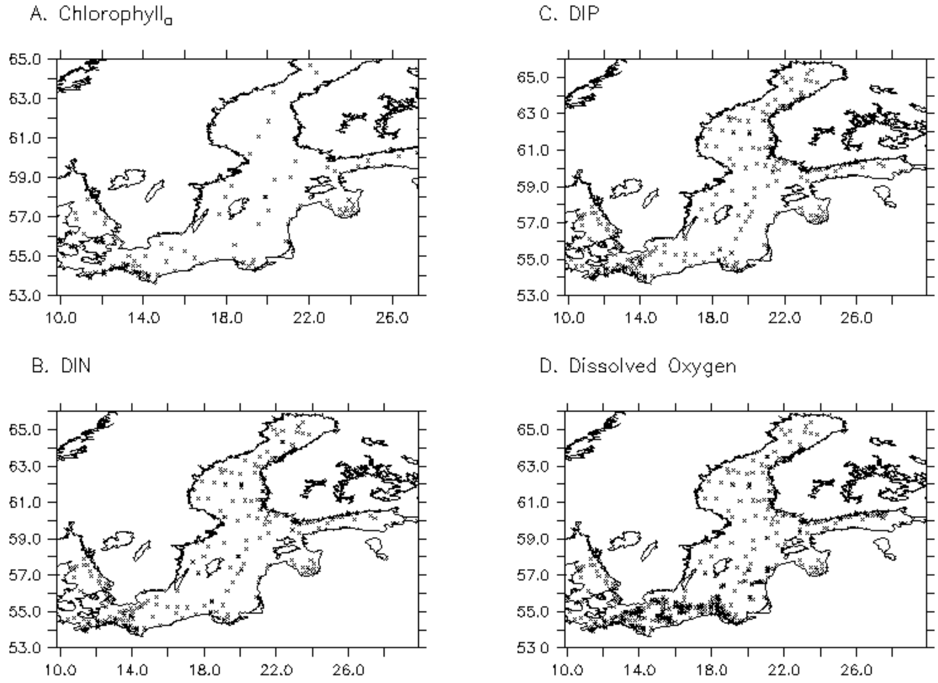

Figure 2. Locations of HELCOM stations in 2011.

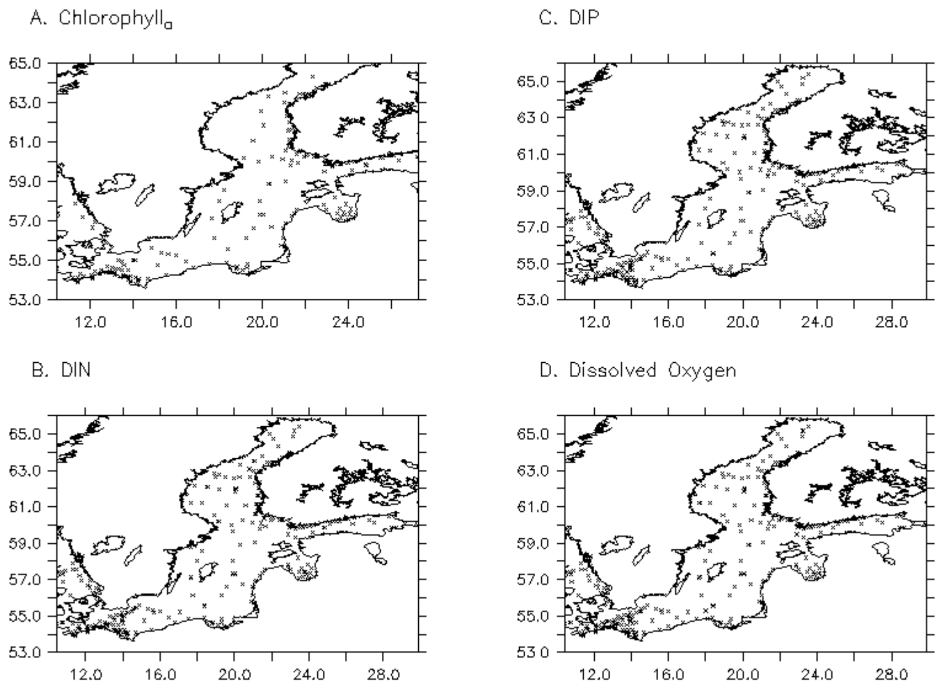

Figure 3. The same as Fig. 2 but for 2012.

Observations made by the HELCOM monitoring stations can be downloaded from ICES website (www.ices.dk). However, the observations are delayed by 13-36 months. Table 1 displays the number of observed records of ICES as downloaded in 15 January 2014. It shows that 2008-2010 has around 16000 records per year. Here one record is defined as all observations made at a given time, location and depth. No observations are available from 2013 yet. For 2011 and 2012, there lack of about 19% and 27% of data in comparison with 2008-2010. This means that current delivery time of HELCOM monitoring data to ICES does not meet requirements for the defined Rapid Environment Assessment (REA) which is a 12month rolling hindcast/reanalysis. Part of the HELCOM data such as measured by SMHI and NERI has a delayed time less than a few months. This makes it possible to assimilate the data for the REA. As an example, Table 2 shows the metadata of SMHI CTD monitoring stations which also measure chl-a and dissolved oxygen profiles. In total there are 96 stations.

Table 1. Number of observed records of ICES HELCOM Stations as available in 15 Jan. 2014.

	2008	2009	2010	2011	2012	2013
# of Observed records	16103	15176	16771	13038	11621	0

Table 2. Swedish CTD station list which also measuring FLUO and DO profiles

Station No.	**Station Name**	**Latitude**	**Longitude**	**Variable**
36001	ÖRESUND-12X	56.1267	12.5167	FLUO, DO
36002	HS5	57.7358	10.0077	FLUO, DO
36003	US5B/C1	62.5867	19.9750	FLUO, DO
36004	ÖRESUND-2	55.5542	12.7583	FLUO, DO
36005	BY15 GOTLANDSDJ	57.3333	20.0500	FLUO, DO
w36006	FLADEN	57.1917	11.6667	FLUO, DO
36007	BY11	57.0667	19.8333	FLUO, DO
36008	BY9 KLAIPEDA	56.1250	19.2833	FLUO, DO
36009	BY36	57.7167	17.3667	FLUO, DO
36010	US2 ULVÖDJ	62.8500	18.8917	FLUO, DO
36011	BY30	58.7833	19.1000	FLUO, DO
36012	SW VINGA GF4	57.5500	11.5250	FLUO, DO
36013	BO3/A3	64.3050	22.3583	FLUO, DO
36014	L:A MIDDELGRUND	56.9583	11.7583	FLUO, DO
36015	BY3 HAMRARNESUND	55.2917	14.4000	FLUO, DO
36016	BY19	57.6167	20.1667	FLUO, DO
36017	BY4 CHRISTIANSÖ	55.3833	15.3333	FLUO, DO
36018	G1 LAHOLMSBUKTEN	56.5708	12.6383	FLUO, DO
36019	PL-P1	54.8333	19.3333	FLUO, DO
36020	409 ÅLBORG BUGT	56.8567	10.7917	FLUO, DO
36021	LAHOLM-3 (YG)	56.5550	12.5667	FLUO, DO
36022	BY29	58.8833	20.3167	FLUO, DO
36023	BY28	59.0333	21.0833	FLUO, DO
36024	BY21	58.4417	20.3333	FLUO, DO

36025	BY27	59.2967	21.5667	FLUO, DO
36026	BY32 NORRKÖPINGS	58.0167	17.9833	FLUO, DO
36027	W LANDSKRONA	55.8667	12.7500	FLUO, DO
36028	SLÄGGÖ	58.2583	11.4333	FLUO, DO
36029	BY5 BORNHOLMSDJ	55.2500	15.9833	FLUO, DO
36030	PL-P63	55.3500	19.0583	FLUO, DO
36031	ÖRESUND-4	55.6467	12.9550	FLUO, DO
36032	ÖRESUND-7	55.7700	12.7967	FLUO, DO
36033	F9/A13	64.7083	22.0667	FLUO, DO
36034	F13	63.7917	21.4833	FLUO, DO
36035	441 STEVNS KLINT	55.2717	12.5750	FLUO, DO
36036	BY38 KARLSÖDJ	57.1167	17.6667	FLUO, DO
36037	Å13	58.3367	11.0333	FLUO, DO
36038	Å15	58.2950	10.8500	FLUO, DO
36039	Å14	58.3167	10.9417	FLUO, DO
36040	Å17	58.2750	10.5133	FLUO, DO
36041	Å16	58.2667	10.7250	FLUO, DO
36042	925 KATTEGAT SW	56.1317	11.1600	FLUO, DO
36043	SR3	61.1833	18.2333	FLUO, DO
36044	US3/C6	62.7500	19.2000	FLUO, DO
36045	SR8	61.1333	20.9333	FLUO, DO
36046	BY39 ÖLANDSSUDDE	56.1167	16.5333	FLUO, DO
36047	F26/C15	61.9833	20.0667	FLUO, DO
36048	GF6	57.5333	11.3250	FLUO, DO
36049	RR7	64.7333	23.8167	FLUO, DO
36050	DROGDEN E	55.5400	12.7292	FLUO, DO
36051	RR5	64.8367	23.1667	FLUO, DO
36052	RR1	64.9667	21.8667	FLUO, DO
36053	BCS III-10	55.5550	18.4000	FLUO, DO
36054	SKÄLDERVIKEN-2	56.3550	12.5500	FLUO, DO
36055	BY20 FÅRÖDJ	58.0000	19.8833	FLUO, DO
36056	F18 SYDOSTBROTTE	63.3083	20.2750	FLUO, DO
36057	GF8	57.4650	10.9000	FLUO, DO
36058	GF9	57.4333	10.7083	FLUO, DO
36059	STOLPE TRÖSKEL	55.2750	16.5167	FLUO, DO
36060	SR5/C4	61.0833	19.5833	FLUO, DO
36061	BY2 ARKONA	55.0000	14.0833	FLUO, DO
36062	F64 SOLOVJEVA	60.1833	19.1500	FLUO, DO
36063	SS29	61.1083	20.2667	FLUO, DO
36064	KULLEN	56.2333	12.3700	FLUO, DO
36065	N14 FALKENBERG	56.9400	12.2117	FLUO, DO
36066	LASO-E (SEABUOY)	57.1908	11.5325	FLUO, DO
36067	BY10	56.6333	19.5833	FLUO, DO
36068	BY13	57.3917	19.4333	FLUO, DO

36069	TRÖSKELN ÅLANDS	59.6600	19.8833	FLUO, DO
36070	ANHOLT E	56.6667	12.1167	FLUO, DO
36071	F33 GRUNDKALLEN	60.5417	18.9333	FLUO, DO
36072	SR1A	61.2333	17.6667	FLUO, DO
36073	BY31 LANDSORTSDJ	58.5833	18.2333	FLUO, DO
36074	MS2	62.1333	17.8500	FLUO, DO
36075	MS6	61.9833	19.1667	FLUO, DO
36076	US7	62.6000	20.8333	FLUO, DO
36077	BLÅ JUNGFRUN	57.4000	16.9500	FLUO, DO
36078	BY1	55.0000	13.3000	FLUO, DO
36079	BY7 STOLPE RÄNNA	55.2167	17.0667	FLUO, DO
36080	F16	63.5250	21.0833	FLUO, DO
36081	F2	65.3917	23.5000	FLUO, DO
36082	HANÖBUKTEN	55.6167	14.8667	FLUO, DO
36083	HANÖBUKTEN-KBV	55.8000	15.3333	FLUO, DO
36084	LÄSÖ RÄNNA	57.2933	10.7417	FLUO, DO
36085	MÅSESKÄR W(BUOY)	58.0583	11.2867	FLUO, DO
36086	P2	57.8667	11.3000	FLUO, DO
36087	REF M1V1	56.3708	16.2017	FLUO, DO
36088	ST MIDDELGRUND	56.5667	12.2167	FLUO, DO
36089	B1	58.8000	17.6300	FLUO, DO
36090	KNOLLS GRU(BUOY)	57.5167	17.6167	FLUO, DO
36091	L9 LAHOLMSBUKTEN	56.5650	12.7200	FLUO, DO
36092	W FÅRÖSUND	57.9400	19.0444	FLUO, DO
36093	LT1	56.1105	17.6055	FLUO, DO
36094	LT2	56.1457	17.7087	FLUO, DO
36095	LT3	56.3098	18.1807	FLUO, DO
36096	LT4	56.3330	18.3888	FLUO, DO

2.1.2 Moored buoy and fixed platforms

Currently there are 7 moored buoys and 8 fixed platforms operated by BOOS (Baltic Sea Operational Oceanography System) partners BSH, DMI, SMHI and MSI, in which 7 of them measure biogeochemical parameters. Detailed information of these stations is given in Table 3. These data are delivered in real time, shared in BOOS and MyOcean community.

Table 3. Baltic Sea moored buoy metadata for biogeochemical monitoring

Station	**Lat (˚N)**	**Long (˚E)**	**Sampling frequency, times per year**	**BGC Parameters**	**Institute**
Moored buoys					
LasoOst	57.2167	11.5667	Hourly	N/A	SMHI
HuvudskarOst	58.9333	19.1667	Hourly	Chl-a profiles	SMHI
Uusmadal	59.6867	24.6283	Hourly	Chl-a profiles	MSI

Finngrundet	60.9	18.6167	Hourly	N/A	SMHI
SodraOstersjon	55.9167	18.7833	Hourly	N/A	SMHI
Vaderoarna	58.4833	10.9333	Hourly	N/A	SMHI
Knollsgrund	57.2167	17.6167	Hourly	N/A	SMHI
Fixed platform					
Arkona	54.883333	13.866667	Hourly	DO profiles	BSH
FehmarnBelt	54.6	11.15	Hourly	DO profiles	BSH
LTKiel	54.5	10.266667	Hourly	DO profiles	BSH
Oderbank	54.083333	14.166667	Hourly	DO profiles	BSH
DarsserSill	54.7	12.7	Hourly	DO profiles	BSH
DrogdenCU	55.5358	12.7117	Hourly	N/A	DMI
VengeanceCU	55.2167	11.0833	Hourly	N/A	DMI
W26CU	55.4	10.95	Hourly	N/A	DMI

2.1.3 Ferrybox routes

Currently there are in total 13 Ferrybox lines operated in Baltic Sea. Tables 4a and 4b show detailed information of these lines. Among them 9 lines are operated by BOOS (Baltic Sea Operational Oceanography System) partners SYKE, SMHI and MSI, and the other 3 lines by SJOV – The Swedish Maritime Administration. Six lines measure biogeochemical parameters (Chl-a, DO) in the surface and the rest only measure water temperature and/or salinity. There are three Ferrybox lines delivering real time data which are shared in BOOS and MyOcean community (Table 4a).

Table 4a. Baltic Sea Ferrybox metadata for biogeochemical monitoring: data shared by BOOS and MyOcean community

BOOS St.No.	Ferrybox Name	Start	End	Sampling frequency	Institute	BGC parameters
38001	FinnMaid	Helsinsi Gdynia	Gdynia Rostock	Twice a week	SYKE	FLUO
38003	TransPaper	53.9741N, 10.7846E	65.6505N, 25.4055E	Twice a week	SMHI	CPHL TURB LGHT DOXY
38012	SiljaEuropa	59.4802N, 24.6506E	60.1197N, 24.9126E	Twice a week	MSI	CPHL

Table 4b. Other Baltic Sea Ferrybox lines

BOOS St.No.	Ferrybox Name	Institute	BGC parameters
38002	BalticPrincess	MSI	CPHL
38004	ArgosUWS	SMHI	CPHL
38005	Frej	SMHI	N/A
38006	Oden	SJOV	N/A
38007	Atle	SJOV	N/A
38008	Ymer	SJOV	N/A
38009	StenaNordica	SMHI	N/A
38010	Galaxy	SMHI	N/A
38011	SiljaSerenade	SMHI	CPHL

2.1.4 Integrated monitoring network

For REA and operational forecasting purpose, it is necessary to integrate the HELCOM offline data and BOOS/MyOcean near real time data, as well as to shorten the time of the HELCOM data delivery. Such integration will give significant amount of data for model validation and data assimilation. The spatial distribution of the surface chlorophyll monitoring stations and frequencies of HELCOM/BOOS monitoring network are given in figure 4. The sampling frequency is estimated for given 6nm x 6nm x 1week spatial-temporal boxes. The observations used for this figure is from 2009-2011. In figure 4 there are 336 surface chl-a stations from HELCOM monitoring network.

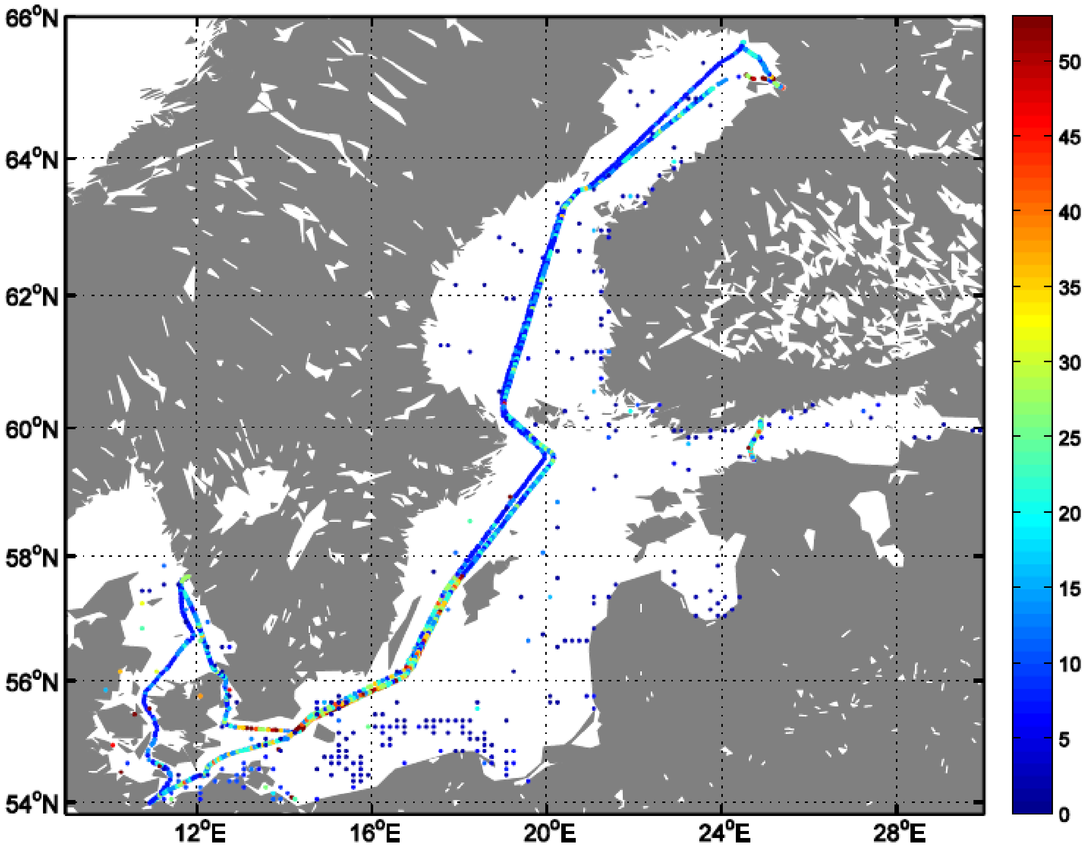

Figure 4. Spatial distribution of Baltic Sea stations and their sampling frequencies for surface Chl-a monitoring.

2.1.5 River Nutrient Sources

For river nutrient sources, please refer to D2.2

2.2 NE Atlantic

2.2.1 Status of the biogeochemical monitoring system (2011-2013)

The picture in the NE Atlantic is much more complicated (fig 5). The long term sampling falls into three categories a) long term time series, b) in-situ data buoys c) regular ship based sampling including ferrybox. The long term biological timeseries include the L4/E1 (PML), PAP (NOC), Stonehaven (Marine Scotland) and Helgoland (AWI). These are all collect a range of hydrographical, nutrient and biological data at fixed points on weekly or monthly timescales. Each of these monitoring sites are primarily motivated by research questions.

Secondly there are a number of buoy systems which deliver NRT hydrographical, nutrient and chlorophyll data e.g. Cefas smart buoys (S North Sea, Celtic Sea, Liverpool bay), PML-UKMO buoys in the western English channel (E1, L4) and PAP (NOC-UKMO). Finally there is the regular ship based monitoring primarily undertaken by agencies responsible for advising government on the implementation of the MSFD and CFP e.g. Cefas, Marine Scotland and AFBI.

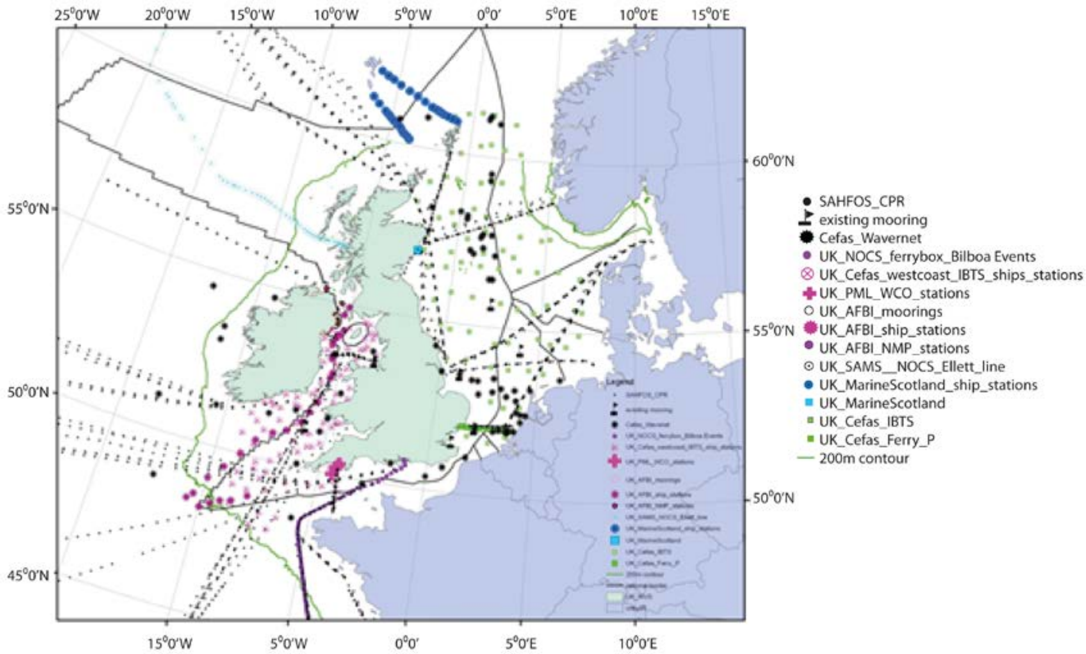

Figure 5. UK marine monitoring activities.

2.2.2 Biogeochemical Time series

Station	**Lat**	**Long**	**Sampling frequency, times per year**	**Parameters**	**Institute**
L4	50° 15.00' N	4° 13.02' W	50	No3, Po4, SiO4, Chl, phyto, zoo	PML / MBA
E1	50° 02.00' N	4° 22.00' W	26		PML / MBA
Helgoland	54.18833 N	7.900000 E	50	P,Z,NO3,NH4,PO4	AWI
Stonehaven	56.9632 N	2.1032 E	50	NO3, PO4, Chl, DIC, P	Marine Scotland

2.2.3 In-situ Data buoys

Station	**Lat.**	**Long.**	**Sampling frequency**	**Parameters**	**Institute**
L4	50° 15.00' N	4° 13.02' W	Hourly	NO_3, Chl, O2	PML / UK MO
E1	50° 02.00' N	4° 22.00' W	Hourly	NO3, Chl, O2	PML / UKMO
PAP	49° 0' 0" N	16° 30' 0" W	Hourly	Chl, NO3, O2, DIC	NOC /UKMO
Liverpool bay	53°32'.0N	003°21'.8W	Hourly, daily	Chl,NO3	Cefas
Celtic Deep	51°14'.99N	006°4'.80W	Hourly, daily	Chl,NO3	Cefas

West Gabbard	51°59'.0N 002°05'.0E	002°05'.0E	Hourly, daily	Chl,NO3	Cefas
Dowsing SmartBuoy,	53°31'.88N	001°3'.19E	Hourly, daily	Chl,NO3	Cefas
Oyster Ground SmartBuoy,	54°25'.0N	004°02'.0E	Hourly, daily	Chl,NO3	Cefas
Warp (TH1) NMMP SmartBuoy,	51 31'.5N	001 01'.9E	Hourly, daily	Chl,NO3	Cefas

2.2.4 Currently active Ferrybox

See www.ferrybox.org for details of the cruise track.

Route	***Sampling frequency***	***Parameters***	***Institute***
Bergen - Amsterdam		Chl, O_2	BCCR
Cork - Roscoff	weekly	Chl, O_2	CNRS -ISU
Plymouth – Roscoff	Daily	Chl, O_2	CNRS –ISU
Portsmouth – Santander	weekly	Chl, O_2	CNRS –ISU
Portsmouth St Malo	Daily	Chl, O_2	CNRS –ISU
Buesum – Helgoland	Daily	Chl, O_2	HZG
Immingham – Halden – Moss _ Ghent	Weekly	Chl, O_2	HZG
Lerwick – Aberdeen		Chl, O_2	MARLAB
Bergen Hirtstals		Chl, O_2	NIVA
Olso – Kiel		Chl, O_2	NIVA

2.2.5 Currently active CPR routes: all run by SAFHOS.

Route		Dates	Measurements
Plymouth	Roscoff	From march 2009	PCI, Phytoplankton, Zooplankton.
Liverpool	NewYork / Halifax	From May 2008	PCI, Phytoplankton, Zooplankton.
Portsmouth	Mid Atlantic	From Jan 2008	PCI, Phytoplankton, Zooplankton.
Cuxhaven	Immingham	From July 2012	PCI, Phytoplankton, Zooplankton.
Bilbao	Lands End	From April 2012	PCI, Phytoplankton, Zooplankton.
Humber	Gothenburg via Hanstholm lighthouse Denmark.	From July 2006	PCI, Phytoplankton, Zooplankton.
Hook of Holland	Harwich	From July 2000	PCI, Phytoplankton, Zooplankton.
Lerwick	Aberdeen	From March 2010	PCI, Phytoplankton, Zooplankton.
Dublin	Liverpool	From May 2004	PCI, Phytoplankton, Zooplankton.
Humber	Gothenburg	From August	PCI, Phytoplankton,

		2006	Zooplankton.
Aberdeen	Stavanger	From Sept. 2012	PCI, Phytoplankton, Zooplankton.
Lisbon	Dublin	From December 2011	PCI, Phytoplankton, Zooplankton.

2.2.6 River Nutrient Sources

For river nutrient sources, please refer to D2.2

2.3 Mediterranean Sea

2.3.1 Status of the biogeochemical monitoring system (2011-2013)

The biogeochemical monitoring in the Mediterranean is quite limited (figure 6). This includes a comprehensive long term time series (DYFAMED & POSEIDON E1-M3A) and some In-situ data buoys and a regular ship based sampling ferrybox route. In DYFAMED & POSEIDON E1-M3A, nutrients, phytoplankton and CO_2 related variables (pH, TCO2 etc) are regularly measured on a monthly basis. Biogeochemical data from Insitu buoys only include Chl and/or DO. Finally there is the regular ship based monitoring ferrybox route covering Athens-Crete on a daily basis.

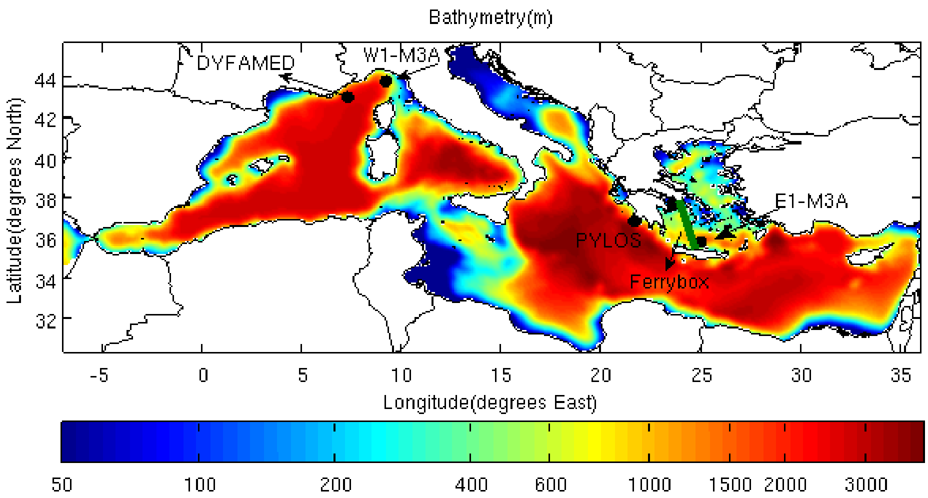

Figure 6. Mediterranean biogeochemical monitoring activities for 2011-2013 period.

2.3.2 Biogeochemical Timeseries

Station	**Lat**	**Long**	**Sampling frequency, times per year**	**Parameters**	**Institute**
DYFAMED	43.25N	7.25E	12	No3, Po4, SiO4, phyto(HPLC), DO, TA, TCO2, pH	CNRS-INSU/ France
POSEIDON-E1-M3A in situ	35.72	25.11	12	No3, Po4, SiO4, chl-a, phyto(HPLC), DO, pCO2	HCMR/ Greece

2.3.3 In-situ Data buoys

Station	**Lat.**	**Long.**	**Sampling frequency**	**Parameters**	**Institute**
POSEIDON-E1-M3A	35.78	24.93	Every 3hours	Chl-a, DO	HCMR/ Greece
W1-M3A	43.79N	9.16E	Every 3hours	Chl, DO, NO3	ODAS/Italy
POSEIDON-Petrokaravo	37.6N	23.56E	Every 3hours	Chl-a, DO, pCO2	HCMR/ Greece
POSEIDON-Pylos	36.82N	21.6E	Every 3hours	Chl-a, DO	HCMR/ Greece

2.3.4 Ferrybox routes

Type	**Start**	**End**	**Sampling frequency**	**Parameters**	**Institute**
POSEIDON-Ferrybox	Athens	Heraklion	daily	Chl-a, DO, pH	HCMR/Greece

2.3.5 River Nutrient Sources

For river nutrient sources, please refer to D2.2

2.4 Black Sea

2.4.1 Status of the biogeochemical monitoring system (2011-2013)

The biogeochemical monitoring in the Black Sea consists of cruises and river nutrient load measurements. Time-series measurements are conducted along the Bulgarian coast (IO-BAS) on different coastal stations. River nutrient loads are measured through different branches and locations of the rivers. In addition to the list provided below, there are multiple cruises conducted on the Romanian waters, Bulgarian waters and the Georgian waters in 2011. The metadata of these cruises are currently not available.

The riverine data consists of historical measurements conducted since 1990 and ongoing measurements of the major rivers and main branches.

2.4.2 Biogeochemical Timeseries

Station	Lat	Lon	Sampling frequency, times per year	Parameters	Institute
K593L00	41.001	28.999	1	Chla, DIN, DIP, Si, DO	IMS-METU
K593L012	41.026	28.998	1	Chla, DIN, DIP, Si, DO	IMS-METU
L04L015	41.036	29.018	1	Chla, DIN, DIP, Si, DO	IMS-METU
L034L050	41.091	29.068	1	Chla, DIN, DIP, Si, DO	IMS-METU
L051L072	41.129	29.089	1	Chla, DIN, DIP, Si, DO	IMS-METU

L044L0104	41.184	29.137	1	Chla, DIN, DIP, Si, DO	IMS-METU
L080L133	41.229	29.137	1	Chla, DIN, DIP, Si, DO	IMS-METU
L110L170	41.286	29.188	1	Chla, DIN, DIP, Si, DO	IMS-METU
L110L175	41.329	29.186	1	Chla, DIN, DIP, Si, DO	IMS-METU
L103L184	41.338	29.180	1	Chla, DIN, DIP, Si, DO	IMS-METU
KK3	41.359	29.099	1	Chla, DIN, DIP, Si, DO	IMS-METU
KK4	41.386	29.203	1	Chla, DIN, DIP, Si, DO	IMS-METU
KK5	41.383	26.306	1	Chla, DIN, DIP, Si, DO	IMS-METU
KK6	41.384	29.293	1	Chla, DIN, DIP, Si, DO	IMS-METU
AB-02	41.525	29.065	1	Chla, DIN, DIP, Si, DO	IMS-METU
AB-04	41.593	28.941	1	Chla, DIN, DIP, Si, DO	IMS-METU
AB-05	41.622	28.984	1	Chla, DIN, DIP, Si, DO	IMS-METU
AB-06	41.595	21.996	1	Chla, DIN, DIP, Si, DO	IMS-METU
L065L121	41.201	29.119	1	Chla, DIN, DIP, Si, DO	IMS-METU
L095L153	41.269	29.167	1	Chla, DIN, DIP, Si, DO	IMS-METU
L110L170	41.287	29.187	1	Chla, DIN, DIP, Si, DO	IMS-METU
AA9	41.510	29.056	1	Chla, DIN, DIP, Si, DO	IMS-METU
AA8	41.506	29.005	1	Chla, DIN, DIP, Si, DO	IMS-METU
AA7	41.502	28.921	1	Chla, DIN, DIP, Si, DO	IMS-METU
AA6	41.627	28.876	1	Chla, DIN, DIP, Si, DO	IMS-METU
AA5	41.586	28.843	1	Chla, DIN, DIP, Si, DO	IMS-METU
AA4	41.553	29.087	1	Chla, DIN, DIP, Si, DO	IMS-METU
AA2	41.509	29.157	1	Chla, DIN, DIP, Si, DO	IMS-METU
AA1	41.539	29.174	1	Chla, DIN, DIP, Si, DO	IMS-METU
AA10	41.435	29.161	1	Chla, DIN, DIP, Si, DO	IMS-METU

AA11	41.436	29.200	1	Chla, DIN, DIP, Si, DO	IMS-METU
AA15	43.020	29.709	1	Chla, DIN, DIP, Si, DO	IMS-METU
AA18	42.988	31.974	1	Chla, DIN, DIP, Si, DO	IMS-METU
AA17	41.708	29.965	1	Chla, DIN, DIP, Si, DO	IMS-METU
AA19	41.630	32.207	1	Chla, DIN, DIP, Si, DO	IMS-METU
AA25	41.569	30.420	1	Chla, DIN, DIP, Si, DO	IMS-METU
AA23	41.438	29.993	1	Chla, DIN, DIP, Si, DO	IMS-METU
AA29	41.624	32.627	1	Chla, DIN, DIP, Si, DO	IMS-METU
AA30	41.427	32.730	1	Chla, DIN, DIP, Si, DO	IMS-METU
AA32	41.466	30.561	1	Chla, DIN, DIP, Si, DO	IMS-METU
AA40	41.346	32.979	1	Chla, DIN, DIP, Si, DO	IMS-METU
AA44	43.826	30.819	1	Chla, DIN, DIP, Si, DO	IMS-METU
AA45	41.350	33.334	1	Chla, DIN, DIP, Si, DO	IMS-METU
AA46	41.303	30.968	1	Chla, DIN, DIP, Si, DO	IMS-METU
AA43	41.499	30.711	1	Chla, DIN, DIP, Si, DO	IMS-METU
AA39	41.447	33.127	1	Chla, DIN, DIP, Si, DO	IMS-METU
AA48	41.562	33.429	1	Chla, DIN, DIP, Si, DO	IMS-METU
AA52-a	42.710	33.078	1	Chla, DIN, DIP, Si, DO	IMS-METU
AA52	44.178	31.084	1	Chla, DIN, DIP, Si, DO	IMS-METU
AA54	43.964	33.048	1	Chla, DIN, DIP, Si, DO	IMS-METU
XX2	43.132	31.340	1	Chla, DIN, DIP, Si, DO	IMS-METU
XX1	41.422	30.768	1	Chla, DIN, DIP, Si, DO	IMS-METU
AA64	41.718	30.212	1	Chla, DIN, DIP, Si, DO	IMS-METU
AA65	30.141	42.202	1	Chla, DIN, DIP, Si, DO	IMS-METU
EL13-000	41.658	29.421	1	Chla, DIN, DIP, Si, DO	IMS-METU

ELL13-002	41.764	29.023	1	Chla, DIN, DIP, Si, DO	IMS-METU
EL13-003	42.230	29.766	1	Chla, DIN, DIP, Si, DO	IMS-METU
EL13-004	42.257	28.841	1	Chla, DIN, DIP, Si, DO	IMS-METU
EL-005	42.020	28.718	1	Chla, DIN, DIP, Si, DO	IMS-METU
EL13-006	41.989	28.565	1	Chla, DIN, DIP, Si, DO	IMS-METU
EL13-007	42.171	29.552	1	Chla, DIN, DIP, Si, DO	IMS-METU
EL13-008	41.761	28.749	1	Chla, DIN, DIP, Si, DO	IMS-METU
EL13-009	41.755	28.770	1	Chla, DIN, DIP, Si, DO	IMS-METU
EL13-010	41.755	28.770	1	Chla, DIN, DIP, Si, DO	IMS-METU
EL13-012	41.499	29.501	1	Chla, DIN, DIP, Si, DO	IMS-METU
EL13-013	42.001	29.511	1	Chla, DIN, DIP, Si, DO	IMS-METU
EL13-017	50.236	31.031	1	Chla, DIN, DIP, Si, DO	IMS-METU
EL13-27	40.011	33.011	1	Chla, DIN, DIP, Si, DO	IMS-METU
EL13-29	42.509	32.006	1	Chla, DIN, DIP, Si, DO	IMS-METU
EL13-31	42.499	31.018	1	Chla, DIN, DIP, Si, DO	IMS-METU
EL13-32	42.031	31.018	1	Chla, DIN, DIP, Si, DO	IMS-METU
EL13-33	42.024	30.712	1	Chla, DIN, DIP, Si, DO	IMS-METU
EL13-34	41.761	30.713	1	Chla, DIN, DIP, Si, DO	IMS-METU
EL13-35	42.251	30.261	1	Chla, DIN, DIP, Si, DO	IMS-METU
EL13-36	41.503	30.206	1	Chla, DIN, DIP, Si, DO	IMS-METU
EL13-37	41.264	30.749	1	Chla, DIN, DIP, Si, DO	IMS-METU
EL13-38	41.300	30.749	1	Chla, DIN, DIP, Si, DO	IMS-METU
EL13-40	41.754	30.506	1	Chla, DIN, DIP, Si, DO	IMS-METU
EL13-41	41.519	31.005	1	Chla, DIN, DIP, Si, DO	IMS-METU
EL13-42	41.157	31.003	1	Chla, DIN, DIP, Si, DO	IMS-METU

EL13-43	41.756	31.726	1	Chla, DIN, DIP, Si, DO	IMS-METU
EL13-44	42.225	31.751	1	Chla, DIN, DIP, Si, DO	IMS-METU
EL13-45	42.017	32.241	1	Chla, DIN, DIP, Si, DO	IMS-METU
EL13-46	41.758	32.219	1	Chla, DIN, DIP, Si, DO	IMS-METU
EL13-47	41.745	32.238	1	Chla, DIN, DIP, Si, DO	IMS-METU
EL13-052	42.506	34.735	1	Chla, DIN, DIP, Si, DO	IMS-METU
EL13-053	42.507	34.200	1	Chla, DIN, DIP, Si, DO	IMS-METU
EL13-054	42.508	33.501	1	Chla, DIN, DIP, Si, DO	IMS-METU
EL13-055	43.258	33.743	1	Chla, DIN, DIP, Si, DO	IMS-METU
EL13-056	43.003	34.193	1	Chla, DIN, DIP, Si, DO	IMS-METU
EL13-058	43.533	35.231	1	Chla, DIN, DIP, Si, DO	IMS-METU
EL13-59	43.215	35.245	1	Chla, DIN, DIP, Si, DO	IMS-METU
EL13-60	43.018	35.689	1	Chla, DIN, DIP, Si, DO	IMS-METU
EL13-61	43.488	35.736	1	Chla, DIN, DIP, Si, DO	IMS-METU
EL13-62	43.412	36.241	1	Chla, DIN, DIP, Si, DO	IMS-METU
EL13-63	43.064	36.224	1	Chla, DIN, DIP, Si, DO	IMS-METU
EL13-66	43.233	37.247	1	Chla, DIN, DIP, Si, DO	IMS-METU
EL13-67	42.538	37.247	1	Chla, DIN, DIP, Si, DO	IMS-METU
EL13-68	42.502	36.760	1	Chla, DIN, DIP, Si, DO	IMS-METU
EL13-69	42.519	36.225	1	Chla, DIN, DIP, Si, DO	IMS-METU
EL13-71	42.508	35.015	1	Chla, DIN, DIP, Si, DO	IMS-METU
EL13-72	42.152	35.022	1	Chla, DIN, DIP, Si, DO	IMS-METU
EL13-73	42.239	35.758	1	Chla, DIN, DIP, Si, DO	IMS-METU
EL13-74	42.158	35.754	1	Chla, DIN, DIP, Si, DO	IMS-METU
EL13-75	41.807	35.761	1	Chla, DIN, DIP, Si, DO	IMS-METU

EL13-76	41.716	35.536	1	Chla, DIN, DIP, Si, DO	IMS-METU
EL13-77	41.710	35.811	1	Chla, DIN, DIP, Si, DO	IMS-METU
EL13-78	42.061	36.011	1	Chla, DIN, DIP, Si, DO	IMS-METU
EL13-79	42.155	35.761	1	Chla, DIN, DIP, Si, DO	IMS-METU
EL13-80	42.252	35.779	1	Chla, DIN, DIP, Si, DO	IMS-METU
EL13-81	42.019	36.239	1	Chla, DIN, DIP, Si, DO	IMS-METU
EL13-82	41.903	36.025	1	Chla, DIN, DIP, Si, DO	IMS-METU
EL13-83	41.819	36.035	1	Chla, DIN, DIP, Si, DO	IMS-METU
EL13-86	42.235	36.290	1	Chla, DIN, DIP, Si, DO	IMS-METU
EL13-87	42.256	36.505	1	Chla, DIN, DIP, Si, DO	IMS-METU
EL13-90	41.949	36.745	1	Chla, DIN, DIP, Si, DO	IMS-METU
EL13-91	41.935	36.507	1	Chla, DIN, DIP, Si, DO	IMS-METU
EL13-92	41.835	36.500	1	Chla, DIN, DIP, Si, DO	IMS-METU
EL13-93	41.759	36.267	1	Chla, DIN, DIP, Si, DO	IMS-METU
EL13-94	41.507	36.437	1	Chla, DIN, DIP, Si, DO	IMS-METU
EL13-95	41.567	36.515	1	Chla, DIN, DIP, Si, DO	IMS-METU
EL13-96	41.703	36.547	1	Chla, DIN, DIP, Si, DO	IMS-METU
EL13-97	41.849	36.759	1	Chla, DIN, DIP, Si, DO	IMS-METU
EL13-98	41.746	37.003	1	Chla, DIN, DIP, Si, DO	IMS-METU
EL13-100	42.241	37.748	1	Chla, DIN, DIP, Si, DO	IMS-METU
EL13-101	42.506	37.752	1	Chla, DIN, DIP, Si, DO	IMS-METU
EL13-102	42.843	37.507	1	Chla, DIN, DIP, Si, DO	IMS-METU
EL13-103	42.739	38.052	1	Chla, DIN, DIP, Si, DO	IMS-METU
EL13-104	42.258	38.241	1	Chla, DIN, DIP, Si, DO	IMS-METU
EL13-107	42.517	39.256	1	Chla, DIN, DIP, Si, DO	IMS-METU

EL13-108	42.257	39.238	1	Chla, DIN, DIP, Si, DO	IMS-METU
EL13-110	41.751	38.759	1	Chla, DIN, DIP, Si, DO	IMS-METU
EL13-111	41.508	38.206	1	Chla, DIN, DIP, Si, DO	IMS-METU
EL13-112	41.714	37.565	1	Chla, DIN, DIP, Si, DO	IMS-METU
EL13-113	41.082	37.666	1	Chla, DIN, DIP, Si, DO	IMS-METU
EL13-114	41.242	38.234	1	Chla, DIN, DIP, Si, DO	IMS-METU
EL13-115	41.253	38.518	1	Chla, DIN, DIP, Si, DO	IMS-METU
EL13-117	41.220	39.508	1	Chla, DIN, DIP, Si, DO	IMS-METU
EL13-119	41.111	40.741	1	Chla, DIN, DIP, Si, DO	IMS-METU
EL13-120	41.747	40.736	1	Chla, DIN, DIP, Si, DO	IMS-METU
EL13-121	41.740	41.241	1	Chla, DIN, DIP, Si, DO	IMS-METU
EL13-124	41.818	41.047	1	Chla, DIN, DIP, Si, DO	IMS-METU
EL13-126	42.254	40.021	1	Chla, DIN, DIP, Si, DO	IMS-METU
EL13-127	42.261	39.532	1	Chla, DIN, DIP, Si, DO	IMS-METU
EL13-128	39.750	41.544	1	Chla, DIN, DIP, Si, DO	IMS-METU
Sozopol05	42.415	27.680	60	Pigments, Nutrients	IO-BAS
MN94/MN94B	43.797	31.008	2	Dissolved oxygen, dissolved inorganic nutrients	GeoEcoMar

2.4.3 River Nutrient Loads

River/Station	Parameters
Vostochny arm	Nitrate phosphate silicate dissolved gases
Starostambulski (km10) arm	“
Starostambulski (km0) arm	“
Prorva arm	“
Potapovsky arm	“
Poludenyi arm	“
Mile 71 station	“
Mile 68 station	“
Kilometer 96 M	“

Kilometer 96 L	"
Kilometer 49	"
Kilometer 39M	"
Kilometer 39L	"
Kilometer 32M	"
Kilometer 32L	"
Kilometer 21	"
Kilometer 17	"
Kilometer 103	"
Gneushev arm	"
Bystry (km9.5) arm	"
Bystry (km1) arm	"
Belgorodsky arm	"
Danube	Nitrate, Ammonia, Phosphate
Dnieper	
Dniester	
Bug	
Kizilirmak	
Sakarya	
Yesilirmak	
Coruh	
Filyos	
Rioni	
Kodori	
Dneiper+Southern Bug	