ICES Oceanography Committee
ICES CM 2004/C:01, Ref. ACME

Report of the Working Group on Phytoplankton Ecology (WGPE)

19–21 February 2004
Gijón, Spain

International Council for the Exploration of the Sea

Conseil International pour l'Exploration de la Mer

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Contents

1 Executive summary

The Working Group on Phytoplankton (WGPE) meeting was held at Centro Oceanográfico de Gijón, Spain, from the 19–21 February 2004. Nine scientists from six countries participated.

The situation about the ICES phytoplankton checklist is still a problem. Concern about what kind of list ICES really needs and what kind of list is expected to be made with the ITIS structure was expressed. Although several preliminary checklists in the ICES countries exist, most of them have not been published and there is resistance to deliver them. It was suggested that the WGPE could compile the existing lists, which will include the vast majority of the species present in the ICES area. In order to have homogeneity in the names used certain literature should be used. .It was shown that comparisons of the compiled lists could relatively easy be done with the ITIS list in order to sort the names in the lists as matching, or not matching. However, due to lack of manpower in the WGPE it was agreed that ICES should do this. Existing lists should be delivered to F. Rey for compilation. The compiled list will be presented at the next meeting of the WGPE, in order to make a last check and thereafter officially deliver it to ICES.

Annual Phytoplankton Summary Reports were presented by Norway, Germany, the Netherlands, Spain and Sweden. The WG outlined a format for future reports.

WGPE was asked to prepare contributions to WKFDPBI. WGPE suggested discussions of the initiation and duration of the spring bloom, of the differentiation between new and regenerated production in models of phytoplankton growth, and implementation of the microbial loop in biological models. The improvement regarding free and attached bacteria also needs consideration, as well as simulation of phytoplankton growth models with nutrient variability and under different climate scenarios.

The result of the questionnaire of Primary Production was discussed. Of 38 questionnaires returned, 17 laboratories measure Primary Production. It was emphasized that the measurements of Primary Production is problematic. After the intercomparison exercise in 1987, WGPE produced a Working Manual and Supporting Papers on the Use of a Standardized Incubator-Technique in Primary Production Measurements by Colijn and Edler. Still, however, there is no agreement on what is really measured, and comparisons with other methods than ^{14}C-uptake have shown conflicting results. It was concluded that, if ICES wants to include Primary Production in its database, a standardized method must be used.

For the review of the current state of the art and new findings in phytoplankton ecology Enrique Nogueira had studied more than 500 abstracts. They were divided into *In situ*, *in vitro* and *in silico* studies. The conclusion is that there is a lot of traditional sampling going on, even if funding focus on combinations of the three approaches. There is a tendency to study several processes at the same time. There is a discussion on what critical processes that need to be measured.

The request from the Ecosystem Study Group for the North Sea (REGNS) was discussed It aims to assess the trends and status of the key components of the North Sea ecosystem. Concerning the phytoplankton this would mean to collect data of chlorophyll, abundance, biomass, species composition, primary production and more parameters relevant for phytoplankton. The first draft version of the report has to be finished until the next years meeting of the working group. One responsible member from the group has to join one or two extra meetings during this year. The WGPE agreed that the work can not be managed by a member of the WG, as there is no funding from ICES. Experiences from similar projects have shown that it would be a full time job for half a year or more. Despite this the WGPE decided to support the request by the preparation of the report with available means. The compromise plan is to provide data for one, or only a few, sampling sites from each country. These data should include bulk components, such as phytoplankton biomass as chlorophyll, information about the start and the duration of the spring bloom, about dominating species and on any unusual blooms and species. Francisco Rey (Norway) will be the responsible coordinator for the phytoplankton chapter in the REGNS report. The national delegates will collect the necessary data and send them to the coordinator.

The future activities of the Group closely aligned to the ICES Action Plan were discussed. The WGPE can focus on goals 1, 2, 5 and 6 of the Action Plan. The past work and terms of references have answered questions like: Are they there? How many are they?, and that the group should now focus on more holistic views of the phytoplankton ecology, and also direct attention to questions like: Why are they there? It was stressed that the aims and directions of work in the group must come from the group itself. For a long time, the terms of references have been given from “above”. It was also commented that the terms of references far too often deal with reviewing the work of other groups, which has led to vicious circles, and has gained little for the real subjects of the Working Group. It must also be made clear to ICES that the group can only take on tasks that are in accordance with the work done by the individual members of the Working Group. The WGPE suggested that the plan for the future work of the group should include:

- Phytoplankton-eutrophication aspects;
- Analyses and syntheses of existing phytoplankton data;
- Increased exchange with modellers;
- Phytoplankton-zooplankton-fish interactions; and
- Phytoplankton-climate aspects.

2 Welcome and opening of the meeting

The ICES Working Group on Phytoplankton Ecology (WGPE) meeting was hosted by the Centro Oceanográfico de Gijón, Spain, from 19 – 21 February 2004. Nine scientists from six countries participated. The list of participants is given in Annex 1. The Meeting Agenda is presented in Annex 2.

The Chair, Dr Lars Edler, opened the meeting at 9.30 am. He welcomed the participants to the Working Group meeting. The Director of the Laboratory, Professor Luis Valdes, welcomed the participants and gave a short presentation of the laboratory.

3 Terms of reference

At the 91st Statutory Meeting, 2003, in Tallinn, Estonia, the Council approved the WGPE Terms of Reference for 2004: The **Working Group on Phytoplankton Ecology** [WGPE] (Co-Chairs L. Edler, Sweden and Francisco Rey, Norway) will meet in Gijón , Spain, from 19–21 February 2004 to:

a) review the Phytoplankton Checklist compiled intersessionally and compare if species from the checklist fit into ITIS structure to report phytoplankton data to ICES;
b) review annual Phytoplankton Summary Reports and complete discussion on standardization of data sets;
c) prepare contributions to the Workshop on Future Directions in Modelling Physical-Biological Interactions;
d) summarise the results of the primary production questionnaire;
e) prepare a review of the current state of the art of, and new findings in, phytoplankton ecology;
f) start preparations to summarise status and trends of phytoplankton communities in the North Sea (biomass, species and size composition, spatial distribution) for the period 2000–2004, and any trends over recent decades in these communities; for input to the Regional Ecosystem Study Group for the North Sea in 2006;
g) prepare a plan for the future activities of the Group which is closely aligned to the ICES Action Plan.

WGPE will report by 15 March 2004 for the attention of the Oceanography Committee and ACME.

4 Discussion of terms of reference

TOR a review the Phytoplankton Checklist compiled intersessionally and compare if species from checklist fit into ITIS structure to report phytoplankton data to ICES

Peter Bot started his presentation by informing that no new lists have been delivered to him intersessionally. He also expressed some concerns about what kind of list ICES really need and what kind of list is expected to be made with the ITIS structure.

A long discussion about the nature of the list started. It is was expressed that, although there exists several preliminary checklists in the ICES countries, most of them have not been published and the owners of the lists have shown resistance to deliver them, since, among other things, they are not quality controlled. This is a time consuming process, and there was a general agreement that the WGPE cannot extend this issue any longer.

It was suggested that the WGPE could compile the existing lists without referring to them as checklists. Probably this compiled list will include the vast majority of the species present in the ICES area. In order to have homogeneity in the names used in the compiled list, the book "Identifying phytoplankton", edited by Carmelo Tomas and collaborators, should be used as a reference. As an auxiliary reference it was suggested that the newly published "Norsk Kystplankton Flora", by Throndsen, Hasle and Tangen (Almater forlag AS, Oslo, ISBN 82-7858-037-5), could also be used. The name check should be done both at the genus and species levels.

A presentation of the website of ITIS (www.itis.usda.gov) was made by Dr Angel Lopez Urrutia, Centro Oceanográfico de Gijón. It became clear that a comparison of the compiled list could relatively easy be done in order to sort the names in the lists as matching, or not matching. Further work should be done in order to resolve the problem of the non-matching names. However, the WGPE does not have the manpower to carry out this task. Since also a periodical control of the names, for instance every two years, will be necessary, in order to keep the list updated (quality control), the WGPE agreed that ICES should do this.

Dr. Lopez Urrutia also showed a comparison of phytoplankton lists from northern Spain (Santander) and the English Channel (Safos), and pointed out the big differences, despite the relative vicinity of the two areas. This underlines the need for the compilation of the phytoplankton species list in the ICES area. These lists were also compared with the ITIS list and the results show that 62% of the species matched the ITIS list, whereas 33% did not and the remaining 5% were invalid names according to the ITIS list.

The following lists are already available or could be promptly available after contact with the scientist responsible for them. The WGPE agreed on carrying out this task in the intersessional period. The responsibility of obtaining the various lists was distributed as follows:

- Spain (Enrique Nogueira) the list, originally prepared by Manuel Varela, was presented at the meeting by Enrique and should be used as an example.
- Germany (Claus Dürselen) There was some uncertainty about getting hold of the list, but Claus will work on it.
- Sweden (Lars Edler)
- The Netherlands (Peter Bot)
- Iceland (Kristinn Gudmundson)
- East coast of the USA. Lars will contact Ted Smayda.
- UK. Peter will contact Dave Mills.
- Scotland. Claus will contact scientists at Millport.
- Norway. Francisco will contact Einar Dahl at Flødevigen.
- Finland. Lars will contact FIMR.
- Farøe Island. Kristinn will contact Eilif Gaarder.

All lists will be sent to Francisco Rey, who will compile them and do the checking against ITIS.

The compiled list will be presented at the next meeting of the WGPE, in order to make a last check and thereafter officially deliver it to ICES. This should be included in the ToR for the next meeting.

ToR b review annual Phytoplankton Summary Reports and complete discussion on standardization of data sets

In 2003 the WGPE presented annual Phytoplankton Summary Reports from Germany, the Netherlands and Sweden. This year the WG thoroughly discussed the standardization of a format for future reports. The scheme of possible input from each WG member was outlined and the contributions are attached as Annex 3. A suggestion for a format of the report was made and an example is attached as Annex 4.

Dr Luis Valdes informed that WGZE will include phytoplankton in the annual Zooplankton report this year. He also expressed the wish that WGZE and WGPE make a Plankton Report together.

This year phytoplankton annual reports were presented by Norway, Germany, the Netherlands, Spain and Sweden (Annex 5).

ToR c prepare contributions to WKFDPBI

WKFDPBI (Workshop on Future Directions in Modelling Physical-Biological Interactions) will meet in, Barcelona, Spain, 8–9 March 2004 to:

a) review the current state of the art in several fields that require modelling physical-biological interactions and are relevant to ICES: e.g. fisheries recruitment, harmful algal blooms, eutrophication;

b) identify the key areas where model improvements are required.

Among the proposed themes of the workshop WGPE is able to have views about Harmful algal blooms/Eutrophication, Modelling approaches, and Ecosystem integration and questions of scale.

One important question for the ecology and dynamics of phytoplankton is the initiation and duration of the spring bloom. Not only the presence of the seeding population is fundamental, but also the biological control executed by grazers, and the physical forcing.

Models of phytoplankton growth should include the differentiation between new and regenerated production, and as a next step the microbial loop should be implemented in biological models. There is also a need for an improvement regarding free and attached bacteria.

Simulation of phytoplankton growth models with nutrient variability (eutrophication) under different load scenarios and nutrient ratios is of considerable interest for phytoplanktologists, especially in the light of the Water Frame Directives.

The global warming and a changed climate will most certainly affect the primary production of phytoplankton and also result in a shift in the community structure. The simulation of the phytoplankton dynamic under different climate scenarios is of a major interest.

ToR d summarise the results of the primary production questionnaire

The questionnaire of Primary Production was sent out 2003 to 54 institutes/organisations in 21 countries. A total of 38 questionnaires were returned. Of these 17 laboratories measure Primary Production. The results are compiled in the report, which is annexed (Annex 6). After the presentation of the questionnaire a discussion, where additional remarks were pointed out, followed.

It was emphasized that the measurements of Primary Production is problematic. After the intercomparison 1987, which highlighted many problems, WGPE got the task of developing an ICES incubator. This was accomplished in 1996 (Working Manual and Supporting Papers on the Use of a Standardized Incubator-Technique in Primary Production Measurements by Colijn and Edler). Still, however, there is no agreement on what is really measured, and comparisons with other methods than ^{14}C-uptake have shown conflicting results. It was concluded that, if ICES wants to include Primary Production in its database a standardized method must be used.

ToR e prepare a review of the current state of the art of, and new findings in, phytoplankton ecology

Enrique Nogueira had prepared a comprehensive review on state of the art phytoplankton ecology. More than 500 abstract had been studied. The survey was divided into *In situ* (sampling, measurements in the sea), *in vitro* (experiments in the laboratory) and *in silico* (modelling). The review is annexed as Annex 7.

There is a lot of traditional sampling going on, even if for instance EU tends to prefer funding combinations of the three approaches. The topics are in many cases more or less the same, but approached in different ways. There is a tendency to study several processes at the same time, and not only one any more. There is a discussion on what critical processes that need to be measured. This also includes how often and where the measurements should be made. There seems to be a tendency to start all incubations at night.

ToR f start preparations to summarise status and trends of phytoplankton communities in the North Sea (biomass, species and size composition, spatial distribution) for the period 2000–2004, and any trends over recent decades in these communities; for input to REGNS in 2006

Claus Dürselen presented an introduction of the intention of the Ecosystem Study Group for the North Sea (REGNS). This group wants to draw up an integrated assessment of the trends and status of the key components of the North Sea ecosystem, including human pressures and impacts. Concerning the phytoplankton this would mean to collect all the data from the North Sea countries since 2000 for chlorophyll, abundance, biomass, species composition, primary production and more parameters relevant for phytoplankton. Because the time period of five years is too short for tracing trends, additionally historical data from the last decades have to be collected. The first draft version of the report has to be finished until the next years meeting of the working group. One responsible member from the group has to join one or two extra meetings during this year.

The WGPE discussed the request by REGNS at length. All members of WGPE agreed that a member of the WG could not manage a work of this magnitude. There is simply no time for intersessional work of this size. A person working with this would have to do it beside the normal work and without any additional support. It would mean to collect all the data, to adapt all to a uniform format, to make statistical analyses, to build charts, to write the text and to participate in extra meetings, and for nothing of this there would be funds from ICES, who asks for this workload. Experiences from similar projects have shown that it would be a full time job for half a year or more.

Despite this the WGPE decided to support the request by the preparation of the report with available means. The compromise plan is to provide data for one, or only a few, sampling sites from each country. These data should include bulk components, such as phytoplankton biomass as chlorophyll, information about the start and the duration of the spring bloom, about dominating species and on any unusual blooms and species. If available, data for primary production will be added.

Francisco Rey (Norway) will be the responsible coordinator for the phytoplankton chapter in the REGNS report. The national delegates will collect the necessary data and send them to the coordinator.

ToR g prepare a plan for the future activities of the Group, which is closely aligned, to the ICES Action Plan

Francisco Rey presented an overview of ICES Action Plan and introduced the goals set up by ICES. Among these, WGPE can focus on goal 1, 2, 5 and 6, which cover items relevant for WGPE. The different subgoals were then highlighted, and the WGPE agreed about important directions for the future work of the WGPE in accordance with the goals.

The past work and terms of references were discussed and Peter Bot commented that the WGPE up to now has answered questions like; Are they there? How many are they?, and that the group should now focus on more holistic views of the phytoplankton ecology, and also direct attention to questions like; Why are they there? He also reminded that the WGPE, during the meeting in Bergen 2001, had agreed on widen the scope of interest to physiology and interactions.

Francisco Rey stressed the need of aims and directions of work in the group must come from the group itself. For a long time the terms of references have been given from "above". It was also commented that the terms of references far too often deal with reviewing the work of other groups, which has led to vicious circles, and has gained little for the real subjects of the working group. It must also be made clear to ICES that the group can only take on tasks that are in accordance with the work done by the individual members of the working group. Several directions of future focus for the group were suggested and discussed.

The link between phytoplankton and zooplankton is fundamental, and deserves more attention. The importance of picoplankton should be noted. Phytoplankton-eutrophication aspects are becoming more important through the Water Frame Directive and in the work of groups like OSPAR and HELCOM. It is of importance that WGPE can show the modellers what phytoplankton ecologists need, as well as showing what they can provide. It was suggested that the WGPE should find ways to analyse and synthesize the load of existing phytoplankton data.

During the discussions it was expressed a wish that the WGPE should formulate more precise questions, like – What mechanisms trigger phytoplankton blooms? What is the fate of a bloom? How important is a bloom? How important is the critical depth for the bloom development in different areas? Are we measuring the right parameters to get answers on the important questions? Does the reduction of nutrients have an effect on the timing of the spring bloom and the summer production? Is there a connection between production and loss? But at the same time it was noted that the WGPE activities should not be too detailed. The future work of the group would then run the risk of going into research, instead of assessing the state and directions and compile overviews.

The WGPE suggested that the plan for the future work of the group should include:

- Phytoplankton-eutrophication aspects
- Analyses and syntheses of existing phytoplankton data
- Increased exchange with modellers
- Phytoplankton-zooplankton-fish interactions
- Phytoplankton-climate aspects

5 Any other business

a) Scientific presentation

During the meeting Dr. Jose Luis Acuna gave a talk on Dynamics of Spring Phytoplankton Blooms in the Cantabrian Coast. The abstract is attached as Annex 8.

b) Election of Chair

The Chair, Lars Edler, has now served for three years and therefore a new Chair should be appointed. The WGPE unanimously elected Francisco Rey. This election needs approval from the ICES Delegates.

c) Concluding business

Dr Claus Dürselen, Oldenburg, Germany, kindly offered to host the WGPE meeting 2005.

d) The WGPE thanked Dr. Enrique Nogueira, Centro Oceanográfico de Gijón . Instituto Espanol de Oceanografia, for hosting the 2003 meeting.

6 Actions

Phytoplankton checklists to be compiled and sent to F. Rey by 1 October 2004, by all members of WGPE.

Merging of the checklists and the comparison with the ITIS checklist will be done by F. Rey before the 2005 meeting.

All members to send data for one, or a few, sampling sites. The data should include bulk components, such as phytoplankton biomass as chlorophyll, information about the start and the duration of the spring bloom, about dominating species and on any unusual blooms and species. If available, data for primary production will be added.

F. Rey to coordinate the phytoplankton data for the REGNS report.

7 Draft resolutions

Proposed Terms of Reference for the WGPE 2005 Meeting.

The **ICES Working Group of Phytoplankton Ecology** [WGPE] (Chair F. Rey, Norway) will meet in Oldenurg, Germany, 16–18 March 2005 to:

a) Evaluate/review annual Phytoplankton Summary Reports and the standardization of the data sets;
b) Review the Phytoplankton Checklist compiled intersessionally and compare if species from checklist fit into ITIS structure to report phytoplankton data to ICES;
c) Plan a Workshop devoted to evaluation of new methods of PP measurements in Bergen 2007;
d) Continue preparations to summarise status and trends of phytoplankton communities in the North Sea (biomass, species and size composition, spatial distribution) for the period 2000–2004, and any trends over recent decades in these communities; for input to REGNS in 2006;
e) Discuss and start assessing the importance of micro- and picoplankton;
f) Discuss and start assessing eutrophication and toxic effects of metals to phytoplankton;
g) Discuss signs of phytoplankton changes in relation to climate changes.

The WGPE will report within six weeks to the Oceanographic Committee.

Supporting Information

Priority:	The activities of this group are fundamental to the work of the Oceanography Committee. They are critical in understanding links between physics and Living Marine Resources and play an important role in identifying environmental change. The work of this group is regarded as high priority.
Scientific Justification and relation to Action Plan:	Action Plan Nos: 1, 2, 5 and 6 a) The WGPE recognises the need for disseminating information of the phytoplankton status in a timely manner. The material presented will be used to prepare the annual Summary Status Report on Phytoplankton in the ICES area. Reporting results must be supported by significant observations and trends based on time-series sampling programmes. It is of importance that the reporting is increased to cover all ICES countries. Standardization of the reports will simplify the compilation of the status report. b) The ICES Phytoplankton Checklist is a much-needed product, which has been delayed. The WGPE is now making efforts to finalize the compilation of the submitted national checklists into one. It is a complex task as the taxonomic nomenclature differs considerably and the different checklists have a wide range of layouts. The new ICES Phytoplankton Checklist will contain considerably more species than the ITIS list. As ICES have decided that the ITIS list must be

	used for phytoplankton submissions the list must be updated to contain all species present in the ICES area. c) The result of the Questionnaire on Primary Production indicated that there are major problems to compare data submitted to the ICES. It is thought that a well-planned workshop on aspects covering methodology and standardization of Primary Production measurements will help ICES to arrive at a useful database on Primary Production. d) The task of summarising status and trends of phytoplankton communities in the North Sea (biomass, species and size composition, spatial distribution) for the period 2000–2004, and any trends over recent decades in these communities; for input to REGNS in 2006 has started during 2004. The first compilation will be ready for discussion and possible amendment during the WG meeting in 2005. e) During the 2004 meeting it was agreed that the WGPE should focus on the importance of micro- and picoplankton. There is a need to evaluate progress in the field of picoplankton dynamics. The WGPE will review the relevant topics and invite presentations. f) During the 2004 meeting it was agreed that the WGPE should focus on eutrophication and toxic effects of metals on phytoplankton, with the aim at understanding their role on the phytoplankton dynamics. There is a need to evaluate progress in this field, in the light of the Water Frame Directives. The WGPE will review the relevant topics and invite presentations. g) During the 2004 meeting it was agreed that the WGPE should start focusing on connection between phytoplankton and climate changes, with the aim at understanding the influence of climatic changes on phytoplankton dynamics. There is a need to evaluate progress in this field. The WGPE will review the relevant topics and invite presentations.
Resource Requirements:	None required
Participants:	Despite new members, the WGPE continues to see the need to encourage wider participation to the group.
Secretariat Facilities:	None required
Financial:	None, apart from report’s reproduction cost
Linkages To Advisory Committees:	The Group reports to ACME, mainly for the provision of scientific information on phytoplankton and their role in ecosystem function.
Linkages To other Committees or Groups:	Members of the WGPE are active participants in range of other committees and groups including SGQAB and SGQAE
Linkages to other Organisations:	Members of this group are active in IOC HAB Programme, HELCOM, EuroGOOS and OSPAR
Secretariat Marginal Cost Share:	ICES: 100%

8 Annexes

Annex 1 List of participants

Name	Address	Telephone	Fax	E-mail
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Annex 2 Meeting Agenda

Preliminary Agenda WGPE 2004

Thursday 19 February

9.30 – 10.00	Welcome and practical matters
10.00 – 10.45	Outcome of Actions from 2003
10.45 – 11.15	COFFEE
11.15 – 12.30	**ToR a:** review the Phytoplankton Checklist compiled intersessionally and compare if species from checklist fit into ITIS structure to report phytoplankton data to ICES; *Responsible: Peter Bot*
12.30 – 14.00	**ToR b:** review annual Phytoplankton Summary Reports and complete discussion on standardization of data sets; *Responsible: Lars Edler*
14.00 – 15.30	LUNCH
15.30 – 16.30	**ToR d:** summarise the results of the primary production questionnaire; *Responsible: Lars Edler*
16.30 – 16.45	COFFEE
16.45 – 17.15	Update on Web links to relevant data products; *Responsible: Francisco Rey*

Friday 20 February

9.00 – 10.00	ICES Oceanographic Committee 2004 and into the future; *Einar Svendsen, Chair, OC*
10.00 – 10.30	Dynamics of Spring Phytoplankton Blooms in the Cantabrian Coast; *José Luís Acuña*
10.30 – 11.00	COFFEE
11.00 – 12.30	**ToR e:** prepare a review of the current state of the art of, and new findings in, phytoplankton ecology; *Responsible: Enrique Nogueira*
12.30 – 14.00	**ToR f:** start preparations to summarise status and trends of phytoplankton communities in the North Sea (biomass, species and size composition, spatial distribution) for the period 2000-2004, and any trends over recent decades in these communities; for input to REGNS in 2006. *Responsible: Claus Dürselen*
14.00 – 15.30	LUNCH
15.30 – 16.30	**ToR g:** prepare a plan for the future activities of the Group, which is closely aligned, to the ICES Action Plan. *Responsible: Francisco Rey*
16.30 – 16.45	COFFEE
16.45 – 17.15	**ToR g:** continue

Saturday 21 February

9.30 – 10.30	**ToR c:** prepare contributions to WKFDPBI; *Responsible: Francisco Rey*
10.30 – 10.45	COFFEE
10.45 – 11.30	Any other business
11.30 – 13.00	Actions and recommendations for 2005
13.00	Closing of the meeting

Annex 3 Scheme of input to the Phytoplankton Status Report

Country	Germany	Germany
Monitoring programme	North Sea	Baltic Sea
Sampling location	Helgoland Reede	Heiligendamm
Latitude (N)	54°11.30' N	54°08.55' N
Longitude (E-W)	7°54.00' E	11°50.60' E
Station Depth (m)		3 m
Period of data available	since 1962	since 1988
Frequency (no of cruises/yr)	daily, workdays	weekly
Depth of sampling (m)	surface	0 m
Contact person	Karen Wiltshire	Norbert Wasmund
Email address	Karen.Wiltshire@awi.bremerhafen.de	Norbert.Wasmund@io-warnemuende.de
Location of data	AWI Bremerhaven, BAH Helgoland	Baltic Sea Research Inst. Warnemuende
OBSERVATIONS		
Chlorophyll	Fluor, HPLC	Lorenzen method
Phytoplankton counts	x	x
Phytoplankton biovolume		x
Phytoplankton carbon	x	x
Spring blooms	x	x
Unusual blooms	x	x
Secchi depth	x	
Primary Production	x	
Ancillary data		
Salinity	x	x
Temperature SST	x	x
Nutrients	x	x
PAR		
Meteorology		
Zooplankton	x	until 1994
Remote sensing (ocean color)		
Oxygen		

Country		
Monitoring programme	National	National
Sampling location	Siglunes 3	Selvogsbanki 2
Latitude (N)	N 66,5	N 63,5
Longitude (E-W)	W 18,8	W 20,9
Station Depth (m)	460	85
Period of data available	1974-	1974-
Frequency (no of cruises/yr)	1	1
Depth of sampling (m)	10	10
Contact person	Kristinn Gudmunsson	Kristinn Gudmunsson
Email address	kristinn@hafro.is	kristinn@hafro.is
Location of data	MRI	MRI
OBSERVATIONS		
Chlorophyll	x	x
Phytoplankton counts		
Phytoplankton biovolume		
Phytoplankton carbon		
Spring blooms		
Unusual blooms		
Secchi depth	x	x
Primary Production	x	x
Ancillary data		
Salinity	x	x
Temperature SST	x	x
Nutrients	x	x
PAR		
Meteorology	x	x
Zooplankton	x	x
Remote sensing (ocean color)		
Oxygen		

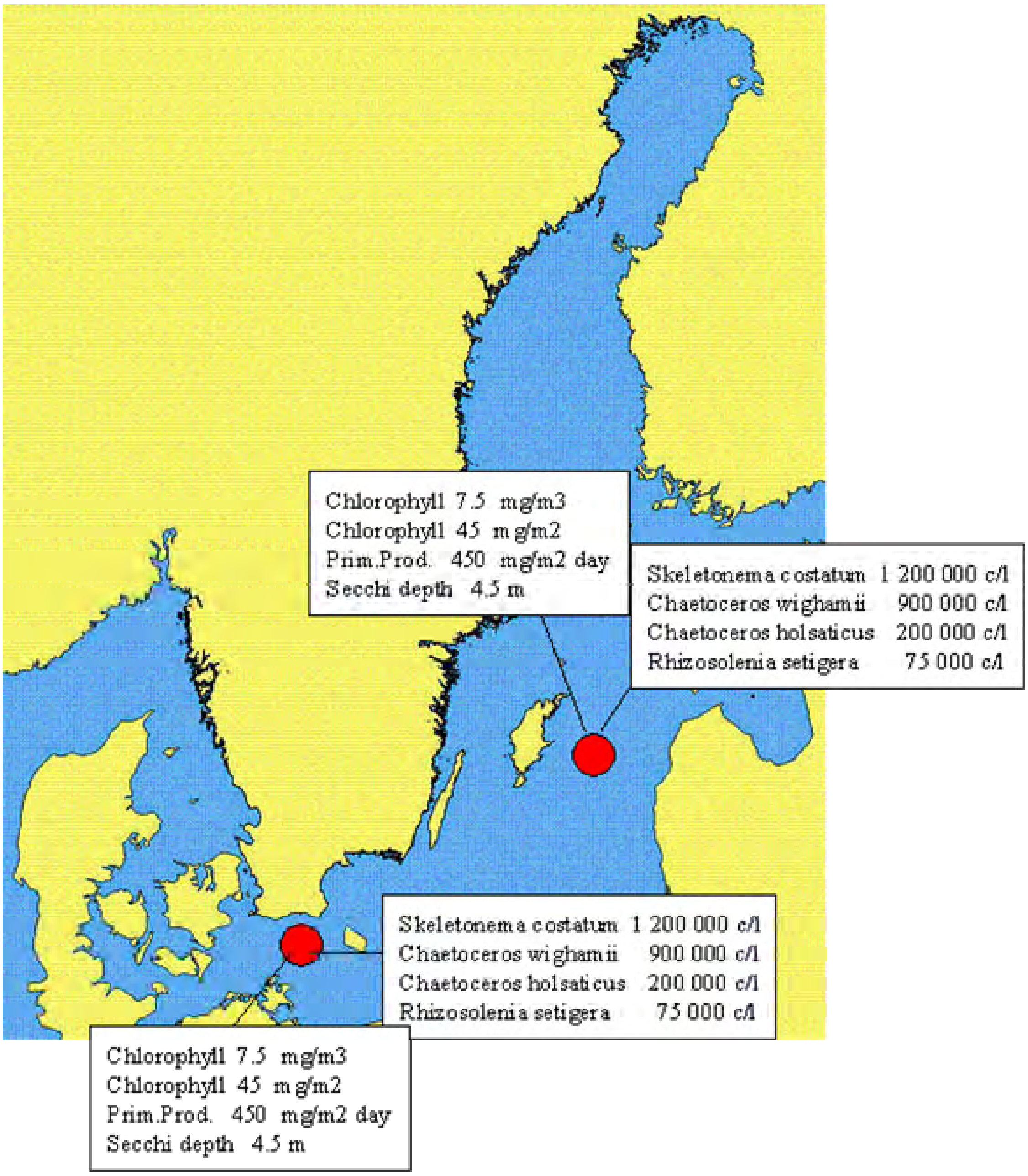
Country	The Netherlands	The Netherlands	The Netherlands
Monitoring programme	MWTL	MWTL	MWTL
Sampling location	Noordwijk 10	Noordwijk 70	Terschelling 50
Latitude (N)	52 18 08	52 35 10	52 46 03
Longitude (E-W)	04 18 09	03 31 53	04 46 01
Station Depth (m)	15	25	40
Period of data available	1975 -, phytopl 1990	1975 -, phytopl 1990	1975 -, phytopl 1990
Frequency (no of cruises/yr)	33	21	21
Depth of sampling (m)	1	1	1
Contact person	Peter Bot	Peter Bot	Peter Bot
Email address		p.v.m.bot@rikz.rws.minvenw.nl	
Location of data	Donar database	Donar database	Donar database
OBSERVATIONS			
Chlorophyll	x	x	x
Phytoplankton counts	x	x	x
Phytoplankton biovolume	no	no	no
Phytoplankton carbon			
Spring blooms	x	x	x
Unusual blooms	x	x	x
Secchi depth	x	x	x
Primary Production			
Ancillary data			
Salinity	x	x	x
Temperature SST	x	x	x
Nutrients	x	x	x
PAR			
Meteorology			
Zooplankton			
Remote sensing (ocean color)			
Oxygen			

Country			
Monitoring programme			
Sampling location	OWS MIKE	Flödevigen	Norwegian Sea
Latitude (N)	66		62-72
Longitude (E-W)	E 2		W 10 - E 20
Station Depth (m)	2000	30	variable
Period of data available	1991-	1985-	1992-
Frequency (no of cruises/yr)	weekly	weekly	once a year
Depth of sampling (m)	ICES standard	surface	ICES standard
Contact person	Francisco Ray	Einar Dahl	Francisco Ray
Email address	pancho@IMR.no	einar.dahl@imr.no	pancho@IMR.no
Location of data	IMR Bergen	IMR Flödevigen	IMR Bergen
OBSERVATIONS			
Chlorophyll	Fluor	Fluor	Fluor
Phytoplankton counts		x	
Phytoplankton biovolume			
Phytoplankton carbon		x	
Spring blooms	x	x	
Unusual blooms		x	
Secchi depth	x	x	x
Primary Production			
Ancillary data			
Salinity			
Temperature SST			
Nutrients	x	x	x
PAR			
Meteorology	x		x
Zooplankton			
Remote sensing (ocean color)			
Oxygen	x		

Country	Spain	Spain	Spain	Spain	Spain
Monitoring programme	Time series progr.	Time series progr.	Time series progr.	Pelagic cruise	
Sampling location	off A Curuna	off Cudoro	off Gijon	NW-N Iberian shelf	off Santander
Latitude (N)	43.5 N	43.8 N	43.5 N	40-44	
Longitude (E-W)	w 9	W 6.5	W 5.5	W 1-10	
Station Depth (m)				20-200	
Period of data available	1989 -	1992 -	2001 -	2002 -	1994 -
Frequency (no of cruises/yr)	monthly	monthly	monthly	1(1 March-April)	
Depth of sampling (m)					
Contact person	Enrique Noguera				
Email address	mailto:enrique.nogueira@gi.ieo.es				
Location of data					
OBSERVATIONS					
Chlorophyll	x	x	x	x	x
Phytoplankton counts	x	x	x	x	x
Phytoplankton biovolume					
Phytoplankton carbon					
Spring blooms	x	x	x	x	x
Unusual blooms					
Secchi depth					
Primary Production	x	x	x	x	x
Ancillary data					
Salinity					
Temperature SST					
Nutrients					
PAR					
Meteorology					
Zooplankton					
Remote sensing (ocean color)					
Oxygen					

Country			
Monitoring programme	National/OSPAR	National/HELCOM	National/HELCOM
Sampling location	Skagerrak Å17	Kattegat Anholt E	Baltic Arkona, BY2
Latitude (N)	N5816.5	N5640.0	N5500.0
Longitude (E-W)	E1030.8	E1207.0	E1350.0
Station Depth (m)	200	55	50
Period of data available	1997 ->	1979 ->	1979 ->
Frequency (no of cruises/yr)	12	25	12
Depth of sampling (m)	0-30	0-30	0-30
Contact person	Lars Edler		
Email address	lars.edler@smhi.se		
Location of data	www.smhi.se		
OBSERVATIONS			
Chlorophyll	Fluor	Fluor	Fluor
Phytoplankton counts	x	x	x
Phytoplankton biovolume	x	x	
Phytoplankton carbon	x	x	
Spring blooms	x	x	x
Unusual blooms	x	x	x
Secchi depth	x	x	x
Primary Production		x	
Ancillary data			
Salinity	x	x	x
Temperature SST	x	x	x
Nutrients	x	x	x
PAR			
Meteorology	x	x	x
Zooplankton			
Remote sensing (ocean color)			
Oxygen	x	x	x

Annex 4 Example of suggested Status Report Format



Annex 5 Phytoplankton Status Reports

Baltic Sea 2002

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Phytoplankton at the coastal station Heiligendamm

The results of the weekly sampling at the sea-bridge Heiligendamm (54°08,55' N; 11°50,60' E, 300 m off shore, 3 m water depth), performed by the Baltic Sea Research Institute Warnemuende (IOW) are shown in Figure. 1. The line shows the chlorophyll a concentration and the columns the phytoplankton wet weight. Columns are lacking on particular sampling dates if quantitative microscopical counting was not possible due to high content of resuspended sediments in the samples owing to strong wind. Respective chlorophyll data are sometimes unreliable and therefore also not shown.

Until 5 February 2002, the cryptophycee *Teleaulax* sp. was the dominant species, while the sub-dominant photo-autotrophic ciliate *Mesodinium rubrum* decreased. On 19.02.2002 (week 8), the diatom *Thalassiosira anguste-lineata* developed to a wet weight of 22.6 mg m^{-3} (total chl.*a* = 1.4 mg m^{-3}). On 05.03.2002, the flagellate *Eutreptiella* sp. and the ciliate *Mesodinium rubrum* dominated. After a further strong growth of *Mesodinim rubrum* by the 11.03.2002 (week 11), the diatom spring bloom developed to a peak chl.*a* concentration of 3.0 mg m^{-3}. It was mainly composed of *Chaetoceros species* (e.g. *Ch. diadema, Ch. debilis, Ch. curvisetus*), *Rhizosolenia setigera* and *Thalassiosira anguste-lineata*. Also the silico-flagellate *Dictyocha speculum* (here counted as "others") was important. The mentioned species decreased by the 19.03.2002 and were replaced by the typical late-bloom diatom *Skeletonema costatum*, which increased to 641 mg m^{-3} by the 26.03.2002 (week 13). The diatom bloom disappeared abruptly by the 09.04.2002. A mass growth of an unidentified athecate dinoflagellate (40-50 µm length, perhaps *Gymnodinium* cf. *lohmannii*) followed. This change of population was accompanied by a development of *Mesodinium rubrum*. At the end of April, all species decreased.

The post-bloom phase was dominated by cryptophyceae (*Teleaulax* sp. *Hemiselmis* sp.). After a short pulse of *Mesodinium rubrum* (week 22) and *Heterocapsa rotundata* (week 24), the typical summer bloom of the large diatom species *Dactyliosolen fragilissimus* starts. The maximum of this species was reached on 10.07.2002 (week 27) with a wet weight of 11,801 mg m^{-3}. The high biomass is not reflected in the chlorophyll concentration because the biomass of the large diatoms is mainly based on a large vacuole that does not contain chlorophyll. On 30.07.2002, also *Cerataulina pelagica* was important (394 mg m^{-3}). A cyanobacteria bloom did not occur.

On 27.08.2002 (week 34), the last pulse of *Dactyliosolen fragilissimus* (382 mg m^{-3}) was noticed. The dinoflagellates *Ceratium tripos* and *Prorocentrum minimum* developed. The autumn bloom of dinoflagellates started as early as 10.09.2002 (week 36), with *Ceratium tripos* (902 mg m^{-3}) und *C. fusus* (180 mg m^{-3}). They disappeared already in the following week due to currents that transported the diatom *Coscinodiscus granii* (24.09.2002: 164 mg m^{-3}) to the sampling station. The biomass peak of the bloom was noticed on 01.10.2002 (week 39), composed mainly of *Coscinodiscus granii* (1,323 mg m^{-3}) und *Ceratium tripos* (634 mg m^{-3}). After a storm, these species disappeared almost completely for the benefit of *Cerataulina pelagica* (week 44 and 45). Quick changes in dominance of *Ceratium tripos*, *C. fusus*, *Thalassiosira anguste-lineata* and *Actinocyclus* sp. occurred in the following weeks due to hydrographical instabilities.

The three big blooms are roughly reflected in the chlorophyll *a* concentrations which exceeded 1.5 – 2 mg m^{-3} during bloom situations. Therefore, the spring bloom lasted from weeks 11 to 13 (14), the summer bloom from weeks 25 to 31, and the autumn bloom from week 34 to 42 (with interruptions).

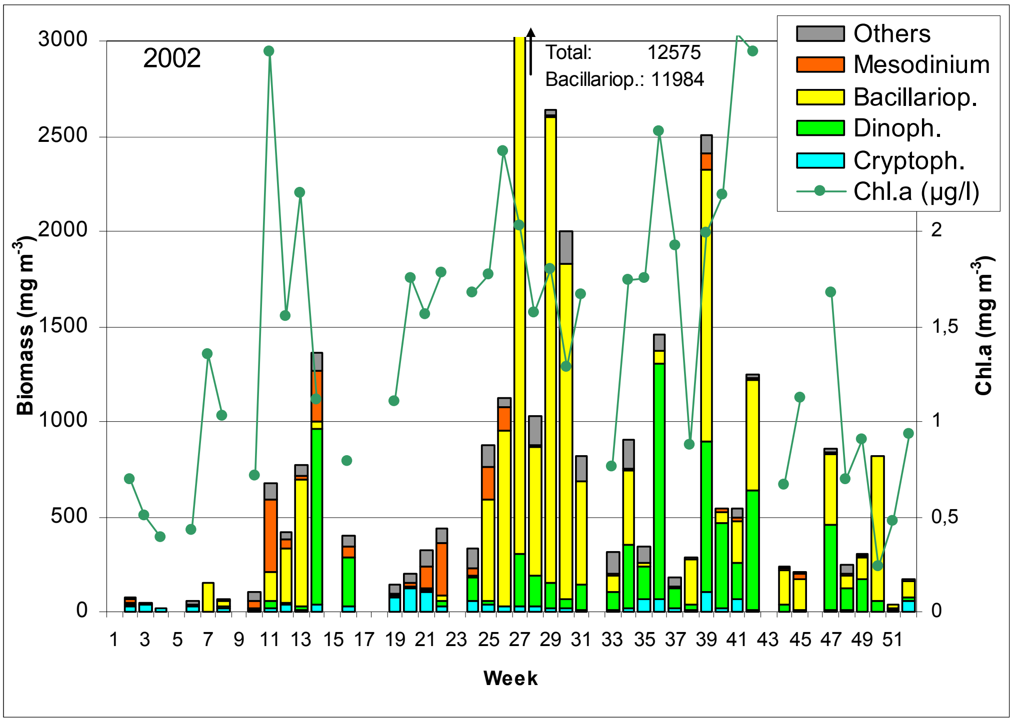

Figure 1. Chlorophyll *a* concentration and composition of phytoplankton biomass (wet weight) from 02.01.2002 to 30.12.2002 at the coastal station Heiligendamm (surface water).

Baltic Sea 2003

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In the first weeks of 2003, phytoplankton biomass was low and dominated by cryptophyceae (mainly *Teleaulax* sp.). A slight development of diatoms (*Skeletonema costatum*, *Thalassiosira anguste-lineata, T. levanderi*) started already at the end of January. During a sunny period (9. week), diatoms grew abruptly, dominated by *Skeletonema costatum* (1,662 mg m^{-3}). The chlorophyll *a* peak of 8.8 mg m^{-3} was reached on 26.02.2003. This was a very early date of the spring bloom. At the peak of the biomass on 04.03.2003, also the naked form of the chrysophyceae *Dictyocha speculum* occurred (648 mg m^{-3}). The water temperature was still <1 °C. Only in the 12th week (18.3.2003), when the bloom was over, it increased to 3 °C. After the spring bloom, cryptophyceae developed. Surprisingly, dinoflagellates grew very sparse.

The period of low biomass extended until the 23.6.2003 (week 26), when the diatom *Guinardia flaccida* started growth. This species reached its peak (1,398 mg m^{-3}) already on 02.07.2003 (week 27). Also *Dactyliosolen fragilissimus* (143 mg m^{-3}) and *Proboscia alata* (129 mg m^{-3}) were important. Until the 14.07.2003 (week 29), only *Dactyliosolen fragilissimus* (238 mg m^{-3}) remained as important diatom. One week later, *Guinardia flaccida* reappeared with 759 mg m^{-3}. The dominance of *Guinardia flaccida* instead of the usual *Dactyliosolen fragilissimus* is noteworthy.

Nitrogen-fixing cyanobacteria (*Nodularia spumigena, Aphanizomenon* sp.) appeared on 29.07.2003 (week 31) at our coastal station. This bloom stayed until 10.08.2003 in front of Warnemuende and Heiligendamm. During this time, also *Dactyliosolen fragilissimus* and *Prorocentrum minimum* occurred in high biomass. The biomass decreased by the 26.08.2003 (week 35) because of strong wind. On 09.09.2003 (week 37), *Ceratium tripos* was found with a biomass of 437 mg m^{-3} but was replaced by *Dactyliosolen fragilissimus* (444 mg m^{-3}) until 16.09.2003. The quick changes in species composition seem to reflect quick drifting of different water masses within Mecklenburg Bight. A real succession occurred however until 23.09.2003 (week 39) when *Dactyliosolen fragilissimus* was replaced by *Coscinodiscus granii*. In week 48 and 49, a stable bloom of *Ceratium tripos* and *C. fusus* established. It was accompanied by *Cerataulina pelagica, Thalassiosira baltica, Th. anguste-lineata, Th. eccentrica, Teleaulax* sp. and *Mesodinium rubrum*. The decrease in chlorophyll *a* concentrations indicates the disappearance of the bloom by the end of the year.

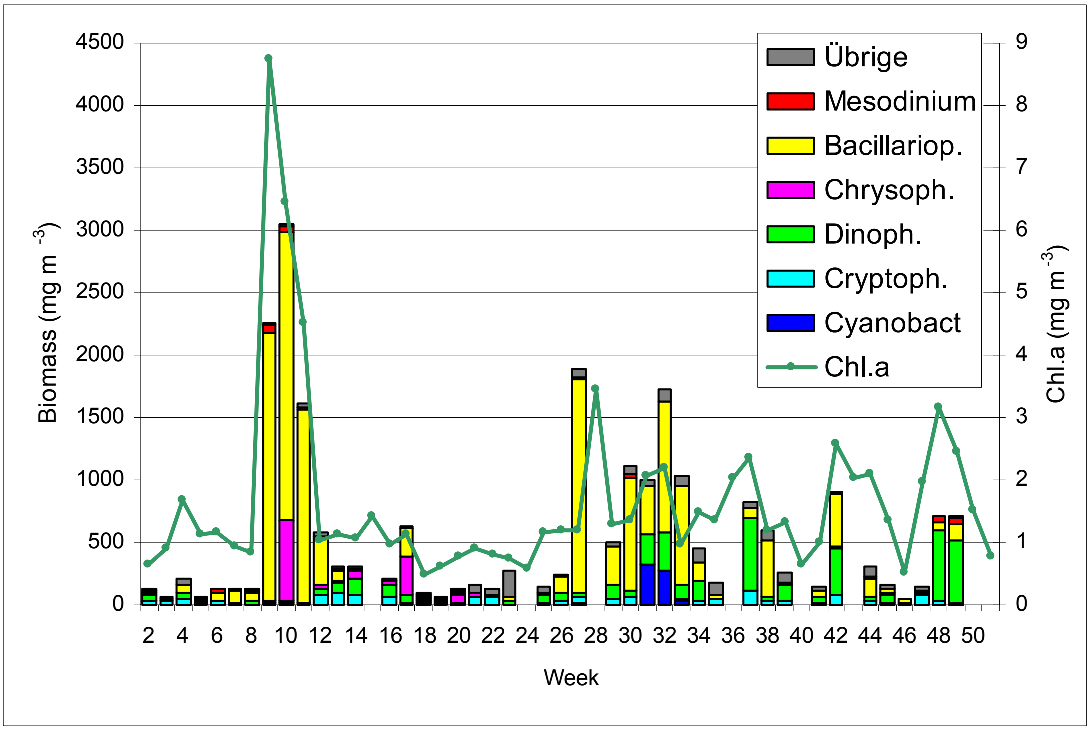


Figure 1. Chlorophyll *a* concentration and composition of phytoplankton biomass (wet weight) from 07.01.2003 to 17.12.2003 at the coastal station Heiligendamm (surface water).

MURSYS
Marine Environment Reporting System
Information from the North Sea and Baltic Sea
prepared by BSH Hamburg

BUNDESAMT FÜR SEESCHIFFFAHRT UND HYDROGRAPHIE

Phytoplankton - Summary (2003) for the North Sea

Coastal waters of Lower Saxony
After a strong winter with ice coverage followed by a long and cold spring phase, cell numbers of the bioluminescent alga *Noctiluca* rose to unexpectedly high levels of 1139 cells/litre by 5 May near Norderney, at a water temperature of 12.9 °C; until mid-April, water temperatures had still been below 10 °C. On 9 May, sea sparkle was observed during very calm weather. The first "red tides" were reported from the German Bight. At the same time, the abundance of *Noctiluca* near Norderney dropped steeply to 40 cells/litre.

The mucilage and foam producing spherical alga *Phaeocystis* had also exceeded its spring maximum by that time. On 22 April, colony numbers were about 107 per litre, which was far below the bloom level, and continued to decrease. *Phaeocystis* was almost non-existent.

Helgoland Roads
Phytoplankton growth began at about the same time as in 2002, in early April. The dominant species initially was *Thalassiosira punctigera*, later also *Odontella aurita* and, in mid-April, *Thalassiosira nordenskioeldii*. By late April, the cell concentrations and carbon values of phytoplankton had decreased again. The abundance of small flagellates was at about the same level as in March and April of the preceding year. *Dinophysis acuminata* was slightly more abundant in April 2003 than in 2002. In early to mid-May, the abundance of phytoplankton was low. In mid-May, many copepods, even phyllopods, larvae of many benthic organisms and pelagic fish eggs were found in plankton. Small and larger ciliates were surprisingly abundant, especially *Myrionecta rubra* toward the end of the month. Among diatoms, *Cerataulina pelagica* and *Rhizosolenia shrubsolei* had become more abundant. In June, phytoplankton continued to increase. The dominant diatoms initially were *Nitzschia seriata* s.l. and *Cerataulina pelagica*, followed by *Rhizosolenia shrubsolei* toward the end of the month. Flagellates became more abundant in the course of June, especially *Noctiluca* assemblages. *Ceratium fusus* was replaced by *Ceratium longipes* at the end of the month. Among ciliates, the abundance of *Myrionecta rubra* decreased markedly.

North Sylt Wadden Sea

The species diversity of phytoplankton was determined weekly. The method used was to enrich the phytoplankton from several cubic metres of water using plankton nets (20 and 80 µm). The unpreserved, living plankton was determined immediately by means of an immersion microscope.

This year's winter was the coldest winter since 1996. The mean water temperature between January and March was about 0.8 °C. Between late February and mid-April, temperatures rose from -0.6 °C to 5 - 6 °C. Salinity was about 28. The maximum nutrient levels of this winter were: Si: 25 - 35 µM; PO4: 1.2 µM; NO3: 50 µM; NO2: 1.2 µM; NO4: 10 µM.

In keeping with the low winter temperatures, this year's spring algal bloom was intensive and relatively early. On 20 March, a maximum chlorophyll concentration of about 50 µg/l was observed. In comparison: the year before (2002) was rather warm (3.4 °C), and the bloom was about 14 days later with maximum levels of some 28 µg Chla/l.

Nutrient consumption by the algae during the bloom led to a strong decrease in concentrations. Si, PO4 and NH4 reached values of 0.2, 0.05, and 0.3 µM respectively. Data on NO3 and NO2 is not yet available.

The species spectrum was dominated by diatoms, as every winter. The number of species was about 40. The number of dinoflagellate species was 3 or 4, rising to 8 by April. Before and during the bloom, *Odontella aurita* and *Porosira glacialis* were the dominant species. During and after the spring bloom, also *Skeletonema costatum* was very frequent. *Odontella* and *Thalassiosira* were the diatom group with the highest species diversity in the last months.

Coastal waters of Schleswig-Holstein

At the end of May, the diversity of phytoplankton summer species in the coastal waters was low, with clearly different distributions. Diatoms prevailed, with increased cell concentrations west of Sylt. In June, with diatoms still dominant, the species spectrum of dinoflagellates increased. The bioluminescent *Noctiluca scintillans* and foam-forming alga *Phaeocystis globosa* were frequent until mid-June but declined toward the end of the month.

Phytoplankton - Summary (2003) for the Baltic Sea

Baltic coast of Schleswig-Holstein

When sampling started in early June, diatoms in the Flensburg and Kiel Fjords had already increased strongly and were forming first algal blooms. In the other areas off Heiligenhafen and in the Bay of Lübeck, relatively little plankton was observed. Filamentous blue-green algae occurred only in the outer Bay of Lübeck. The situation continued largely unchanged until the end of June.

Monitoring station "Seebrücke Heiligendamm"

The phytoplankton biomass was small until mid-February. At the end of February, there was an explosive growth of diatoms, with the *Skeletonema costatum* bloom continuing until mid-March. This was followed by the development of Cryptophyceae (especially *Teleaulax* sp.). The usual replacement of diatoms by large, athecate dinoflagellates was very weak in 2003. In late April, mainly *Dictyocha speculum* and *Pseudopedinella* sp. were found. A phase of very low phytoplankton biomass dominated by Cryptophyceae (*Hemiselmis*, *Teleaulax*, *Plagioselmis*) continued until the end of May. After a moderate increase in biomass in mid-June, Ceratium tripos for the first time became clearly noticeable. The typical summer bloom of diatoms began in late June, represented by *Guinardia flaccida*.

Outer coastal waters of Mecklenburg-Vorpommern

In January and February, chlorophyll-a values between 1.2 mg/m^3 and 4.8 mg/m^3 were measured between Warnemünde and Darßer Ort. Off Warnemünde, concentrations were up to five times higher than the long-term monthly mean (LMM). In the winter months, cryptoflagellates of the genera *Plagioselmis* and *Teleaulax* were present, as expected. Besides *Skeletonema costatum*, unspecified centric diatoms of the genus *Thalassiosira* continued to be found (0.4 mm^3/l).

In March, chlorophyll-*a* levels in the waters between Boltenhagen and Darßer Ort were far below the LMM levels. However, between NW Hiddensee and E Saßnitz, measured values clearly exceeded the LMM values (3.5 mg/m^3). A *Skeletonema* bloom was observed in this sea area. The biovolumes reached up to 1.8 mm^3/l at about 8 million cells per liter, which explains the elevated chlorophyll-a values in this sea area.

In April, chlorophyll-*a* levels along the entire outer coast generally reached only 30 - 40 % of LMM. An exception was the Pomeranian Bight, where the measured value of 23.1 mg/m^3 was 2.5 times higher than LMM. Also the phytoplankton biovolumes were clearly below the long-term monthly means. Besides *Heterocapsa rotundata*, small Cryptophyceae of the genera *Teleaulax* and *Plagioselmis* prevailed. *Diatoma elongatum* and *Achnanthes taeniata* occurred in the Pomeranian Bight.

Chlorophyll-a levels in May were, sometimes markedly, below the long-term monthly mean (LMM). In the Pomeranian Bight, just under 20% of LMM was reached. The biovolumes in May were very low. The highest value, at 0.6 mm^3/l, was measured in the Pomeranian Bight, where the dominant genus was *Chaetoceros*.

In June, chlorophyll-a concentrations in the waters between Boltenhagen and north-west Hiddensee were largely within the range of the long-term means for June, although the value of 6.0 mg/m^3 found in the Pomeranian Bight was only 35 % of LMM. The biovolumes were clearly below LMM. Potentially toxic Cyanophyceae such as *Nodularia* *spumigena* and *Aphanizomenon* "*balticum*" occurred only sporadically in negligible quantities. In the Pomeranian Bight, the non-toxic species *Pseudanabaena limnetica* was observed at a concentration of 0.1 mm^3/l.

Inner coastal waters of Mecklenburg-Vorpommern

Chlorophyll *a* levels at the stations Lower Warnow, Strelasund, and Darß Lagoons, the only ones that could be sampled in winter, were rather low.

In the Strelasund waters, cryptoflagellates of the genera *Plagioselmis* and *Teleaulax* prevailed, besides the diatom *Skeletonema costatum*. They reached a biovolume of 0.2 mm^3/l.

Also in March, chlorophyll *a* levels in the Wismar Bight and at the stations in the Darß Lagoons were clearly below LMM. In the Salzhaff area, the chlorophyll *a* value was 2.3 mg/m^3. *Heterocapsa rotundata* reached a biovolume of 0.3 mm^3/l. Chlorophyll *a* levels in the Lower Warnow reached approximately 50 - 60 % of LMM. Small, unspecified centric diatoms (0.4 mm^3/l) were the dominant algae. A lower chlorophyll *a* level was also found in the Kubitzer Lagoon. The other stations of the monitoring network in the inner coastal waters could not be checked, mainly because of the long period of ice cover.

Also in April, the chlorophyll *a* concentrations were below LMM. Chlorophyll *a* levels in the Lower Warnow, Wismar Bight, and Darß Lagoons reached only 25–36 % of LMM.

The phytoplankton biovolumes ranged between 0.1 mm^3/l in the Wismar Bight and Salzhaff, and 0.6 mm^3/l in the Strelasund waters. In all inner coastal waters with an open connection to the Baltic Sea, *Heterocapsa rotundata* was found together with Cryptophyceae of the genera *Plagioselmis* and Teleaulax. In the Greifswald Lagoon and Strelasund, phytoplankton was dominated by *Achnanthes taeniata* (0.4 mm^3/l and about 850,000 cells).

In May, chlorophyll *a* concentrations in the Wismar Bight and Darß Lagoons were mostly below the long-term levels, as in the outer coastal waters. At the Lower Warnow monitoring stations, only 15 % and 23 % of the long-term mean for May was reached.

Phytoplankton was dominated by unspecified Chrysophyceae. Also small Cryptophyceae and the extremely small dinoflagellate *Heterocapsa rotundata* were found, although at very small biovolumes. Total biovolumes ranged between <0.1 and 0.7 mm^3/l.

In June, chlorophyll *a* in the waters between Lower Warnow and Peenestrom mostly reached normal levels. Locally, however, major deviations were found, e.g. in the Lower Warnow (10 times higher), Darß Lagoons (14 times), and Wismar Bight (4 times).

Biovolumes ranged between <0.1 mm^3/l and 1.0 mm^3/l. Large masses of microalgae in the Greifswald Lagoon, with an abundance of about 314 million cells/liter, produced a biovolume of as much as 0.9 mm^3/l.

Above-average biomass was also observed in the Wismar Bight, at 0.9 mm^3/l due to a mass development of flagellates (6.6 million cells/l) which probably belonged to the genus *Chrysochromulina*. Also in the inner coastal waters, blue-green algae were without significance.

Summary of the Dutch phytoplankton monitoring program 2002

In the framework of a biological monitoring programme of the National lnstitute for Coastal and Marine Management / RIKZ, phytoplankton has been sampled on a regular base in the Dutch coastal waters since 1990. The programme covers 31 permanent sample stations situated in the North Sea (17 stations), the Dutch Wadden Sea and Ems-Dollard estuary (5), and four areas in the Rhine-Scheldt-Meuse estuary, Oosterschelde (4), Westerschelde (3), and two (embanked) salt-water lakes: Lake Grevelingen and Lake Veere (one station in each lake). In general, stations were sampled 1-4 times each month. Samples were normally taken from the surface. If the water column was stratified on a station during summer, however, samples were also collected from the thermocline and from approximately 3 m above the Seabed. In the microscopically analysis, the species composition and the concentration of each individual species were assessed in a standardized procedure.

In order to summarize the results, phytoplankton was categorized into three species groups (dinoflagellates, diatoms and other species). Both the seasonal and the spatial development of phytoplankton in 2002 showed more or less the same patterns as in previous years. During winter, phytoplankton densities were generally fow. Subsequently, spring blooms of diatoms arose at most stations. Particularly, diatoms reached much higher densities at inshore- than at offshore stations. In 2002, remarkably, a clear bloom of Phaeocystis did not occur along the West coast. During summer, blooms of various species and species groups were observed. Flagellates (dinoflagellates and others) were more dominant on offshore than on inshore stations. After September, the densities decreased substantially at all stations. In the two salt-water lakes, Lake Grevelingen and Lake Veere, picoplankton was numerically important.

On six selected stations in the North Sea (GOEREE 6, NOORDWIJK 2, NOORDWIJK 10, NOORDWIJK 70, TERSCHELLING 4 and TERSCHELLING 135), the incidence in 2002 of 17 selected species of potentially toxic or otherwise harmful algae was compared to available data about both their frequencies and monthly maxima on these stations during 1990- 2001. During 2002, densities of most species remained below the monthly maxima during previous years. The exceptions were *Pseudo-nitzschia delicatissima cf* (exceeding the previous maxima at TERSCHELLING 135), *Chattonella s pp.* (at NOORDWIJK 2) and *Chrysochromulina pp. (at* NOORDWIJK 2 and 10). On a few other than the selected six stations, exceptionally high densities of *Dinophysis acumi*nata (on station ROTTUMERPLAAT 70) and *Chattonella pp*. (on station DREISCHOR, Lake Grevelingen) were observed. Such high densities have not been found in the Dutch coastal waters before. The study on potentially harmful species provided some more noteworthy observations. Both during 2001 and 2002, *Dinophysis acuminata* was the most common *Dinophysis* species. Prior to 2001, this position was taken by *D. rotundata*. These two species were spatially segregated during 2002. Relatively high densities of D. rotundata were found on offshore stations, such as TERSCHELLING 135, while *D. acuminata* was observed mainly on inshore stations. On station TERSCHELLING 135, *D. acuminata* was found once only during 2002, in a thermocline sample. In contrast, during the period 1990-2001 most observations of *D. acuminata* were made at this station. In 2002, *Heterosigma akashiwo* was observed for the first time at the stations GOEREE 6, NOORDWIJK 70 and TERSCHELLING 4. In previous years, this species had been found on only two of the selected six North Sea stations (viz. NOORDWIJK 2 and 10). The spatial distribution of *Phaeocystis* in 2002 was atypical. Spring maxima did not occur on stations where *Phaeocystis* blooms were common in the past. On such stations, like NOORDWIJK 2, this flagellate was observed in 2002 mainly in June. On stations where a spring maximum was observed in 2002, densities in June were relatively low, for instance on station NOORDWIJK 70.

During 2002, the concentrations of species from the genera A*lexandrium*, *Dinophysis*, Pseudo-*nitzschia* and *Phaeocystis* exceeded the limit value on several stations. The observed maximum concentrations of *Dinophysis* were much higher than in 2001, though high values were only found on offshore stations, particularly on stations NOORDWIJK 20 and ROTTUMERPLAAT 50 and 70. In contrast, the maximum concentrations of Phaeocystis along the West coast of the Netherlands were lower than in 2001. Later during 2002, however, *Phaeocystis* blooms, exceeding the limit value, were observed in the western Wadden Sea and on the stations TERSCHELLING 4 and 10. Maximum concentrations of *Pseudo-nitzschia* remained somewhat lower than in 2001, but were frequent I y exceeding the limit value along the coast and in Lake Grevelingen. In 2002, the toxic species P. seriata f seriata has been recorded far offshore only, most frequently on the offshore stations of the TERSCHELLING-transect. Also the presence of the toxic species P. pseudodelicatissima, was confirmed only for offshore stations along the TERSCHELLING-transect. Another toxic species, *P. multiseries* cannot yet be distinguished from the non-toxic species *P. pungens* by conventional light microscopy. In order to detect toxic species in the framework of regular monitoring programmes, knowledge of the temporal and spatial distribution of individual species can be an important tool to optimise these programmes.

In order to assess *Coccolithophorids*, samples were collected on an almost monthly base on one station (TERSCHELLING 135), and processed separately. These samples were fixed in formaldehyde solution. *Coccolithophorids* were not found in samples taken during the period January–April 2002. However, from May onwards, they appeared in virtually every sample. *Emiliania huxleyi* was the most common of six detected species. In samples taken in August and September, *Calyptrolithina wettsteinii* was found. This is probably the first recording of this species for the North Sea.

Below time-series of chlorophyll at three selected stations in the North Sea. Terschelling 100, Noordwijk 70 and Noordwijk 10 (see map Figure 5).

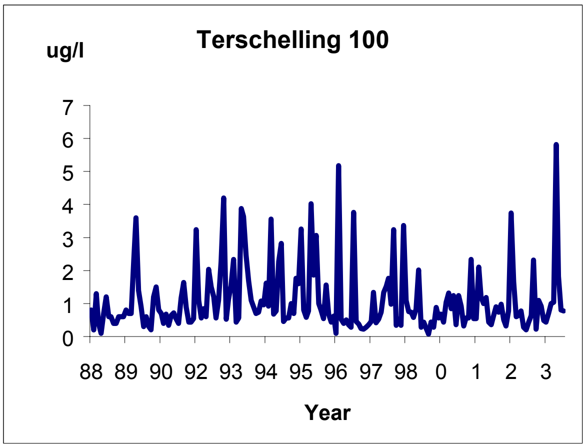


Figure 1. Time-series of chlorophyll at the station Terschelling 100.

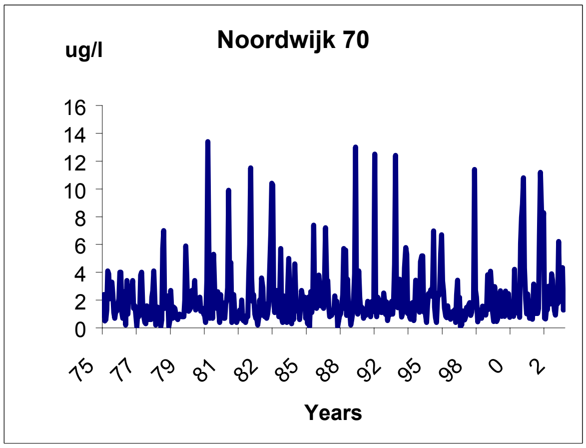
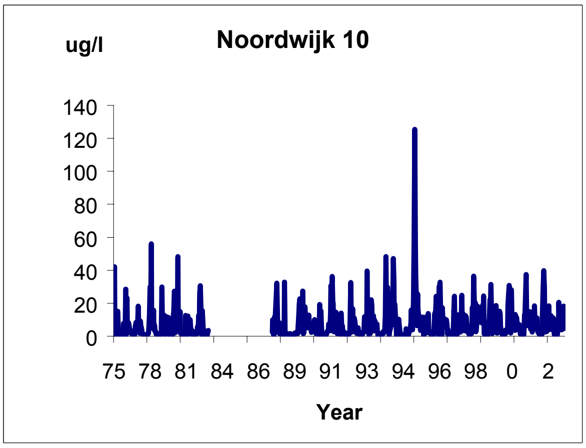


Figure 2. Time-series of chlorophyll at the station Noordwijk 70



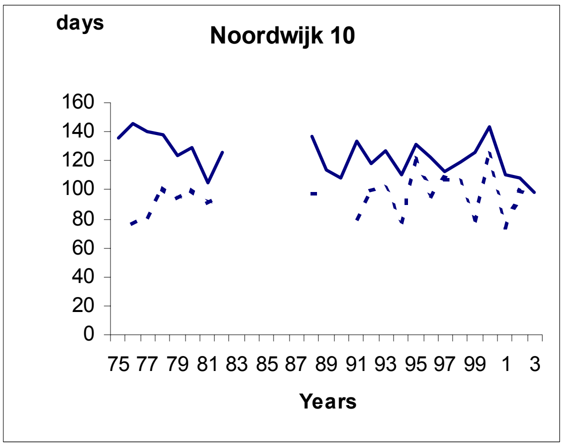


Figure. 3. Time-series of chlorophyll at the station

Figure 4. Onset of the spring bloom (broken line) and Noordwijk 10. maximum chlorophyll value (solid line) in day numbers.

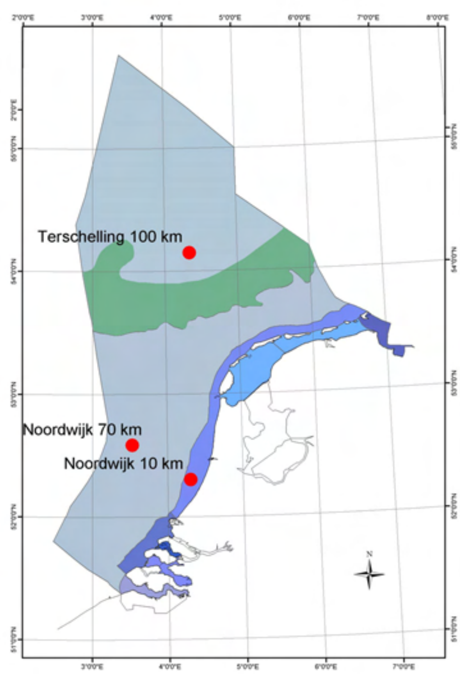


Figure 5. Map of the stations selected .

Phytoplankton report from Spain

Information compiled by E. Nogueira (IEO-Xixón)

Time-series programme of the Instituto Español de Oceanografía

Information compiled by E. Nogueira (IEO-Xixón)

Figure 1 shows the map of stations sampled monthly in the north Spanish shelf within the frame of the time-series programme conducted by the Instituto Espãnol de Oceanografía (IEO). The transect off Cudillero is maintained by the University of Oviedo and the collaboration of the IEO The blue lines represent the tracks of continuous surface underway sampling (temperature, salinity and photopigments –Ferry Box Project).

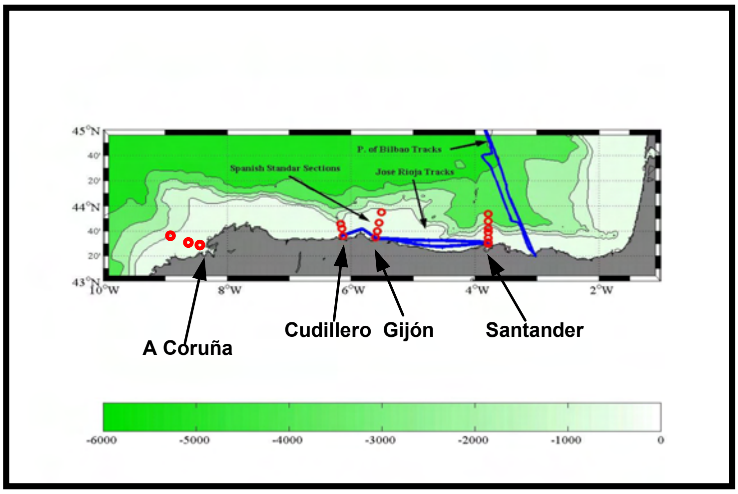


Figure 1.

Integrated chlorophyll *a* (Chl a)and primary production (PP) off A Coruña (NW Iberian shelf) (Antonio Bode and Manuel Varela, IEO-A Coruña)

The 12-year time-series of integrated Chl a PP off A Coruña is represented in Figure 2. The bimodal seasonality, associated with the spring and autumn blooms, is conspicuous most of the years. Interannual changes are also an important component of variation, specially in the series of primary production (Figure 2b), where average annual values in years of high primary production (between 600-1000 $mgC \cdot m^{-2} \cdot h^{-1}$) (e.g. 1995, 1999-2002) double those in years of low production (e.g. 1997). Integrated values of Chl a and PP don not show marked differences between oceanic (station 4) and coastal stations (2 and 3).

Figure 2a

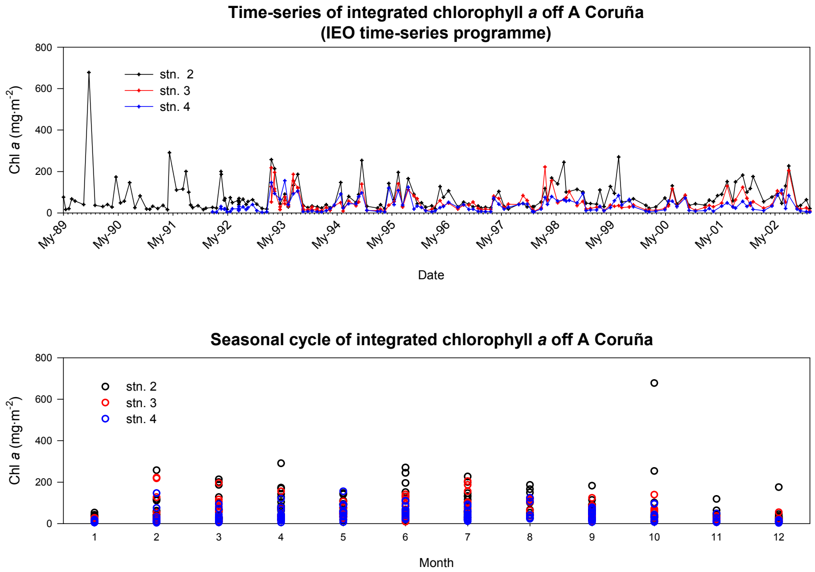
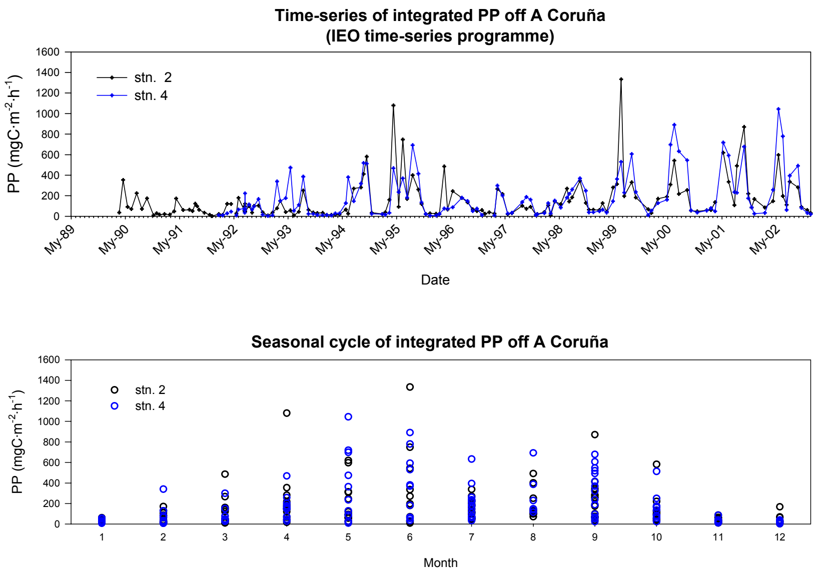


Figure 2b



Integrated chlorophyll *a* off Cudillero (Central Cantabrian Sea, West Cape Peñas) (R Anadón, Universidad de Oviedo).

The 10-year time-series of integrated chlorophyll *a* off Cudillero from coastal (top figure) to oceanic stations (bottom figure) is shown in Figure 3. Note the coastal off-shore gradient, with integrated values higher at the coastal stations) and the unimodal seasonality in the stations of the coastal transition zone and ocean.

Integrated and surface chlorophyll *a* and abundance of dinoflagellates and diatoms off Xixón (Central Cantabrian Sea, East Cape Peñas) (XAG Morán, E Nogueira, M Maiques)

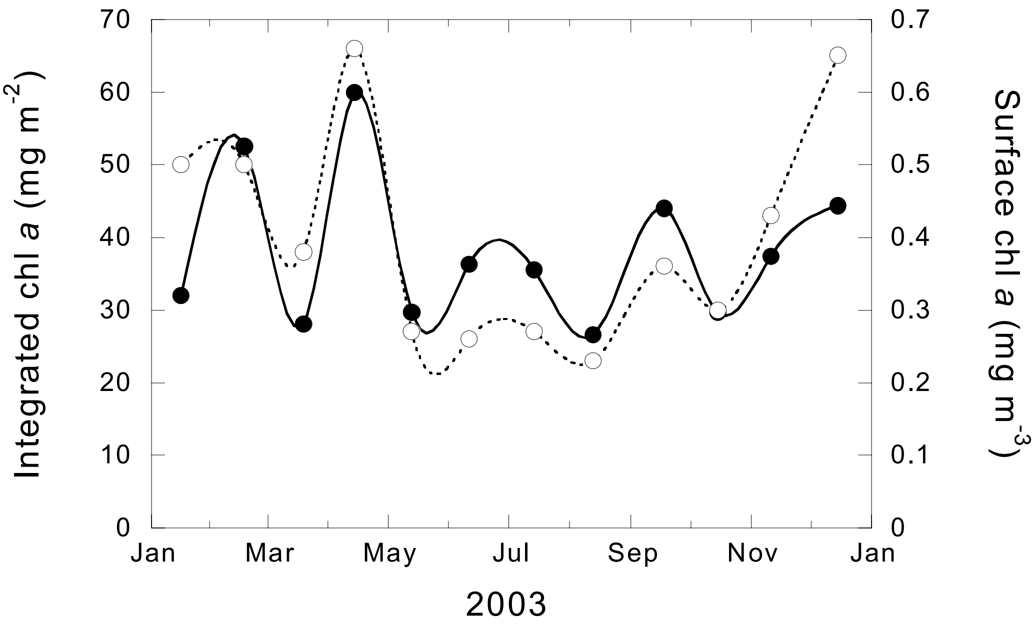


Figure 3

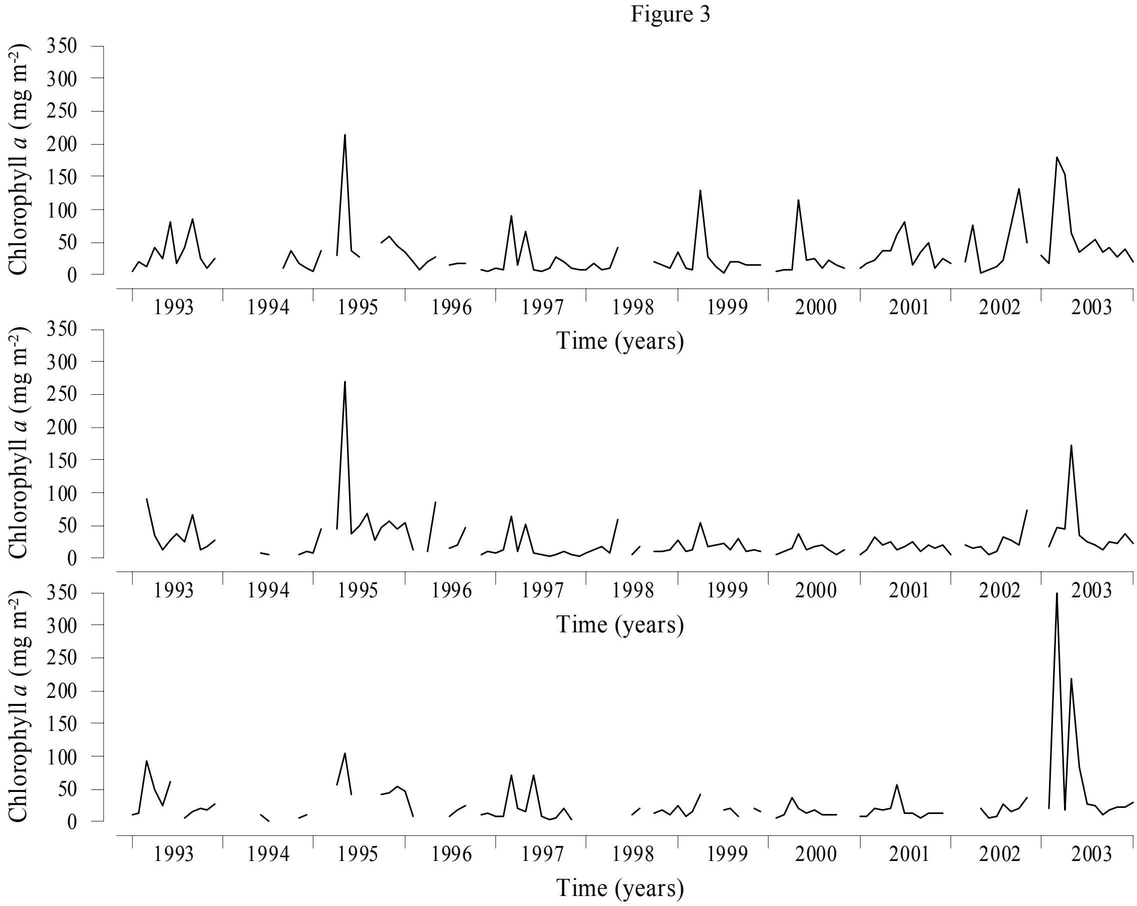


Figure 4

Figure 4 shows the seasonal variation of surface (solid symbols) and integrated chl *a* (upper 75 m, open symbols) at a shelf station off Xixón during 2003. Data were obtained at the shelf station (43.67ºN, 5.58ºW, 110 m) of a section sampled monthly within the IEO core project RADIALES. No clear temporal pattern was observed, with maximum values observed during the winter-spring transition. Although a general good agreement was observed between surface and areal values ($r=0.73$, $p<0.05$, $n=12$), seasonal differences in thermohaline properties affected the vertical distribution of phytoplankton biomass. The occurrence of subsurface peaks of algal biomass during the stratification period (aprox. Jun–Sep) yielded an average factor of 118 for converting surface to integrated values. As expected, mixing conditions yielded a significantly lower factor (65).

Phytoplankton Report, Sweden 2003

Lars Edler,SMHI

Skagerrak

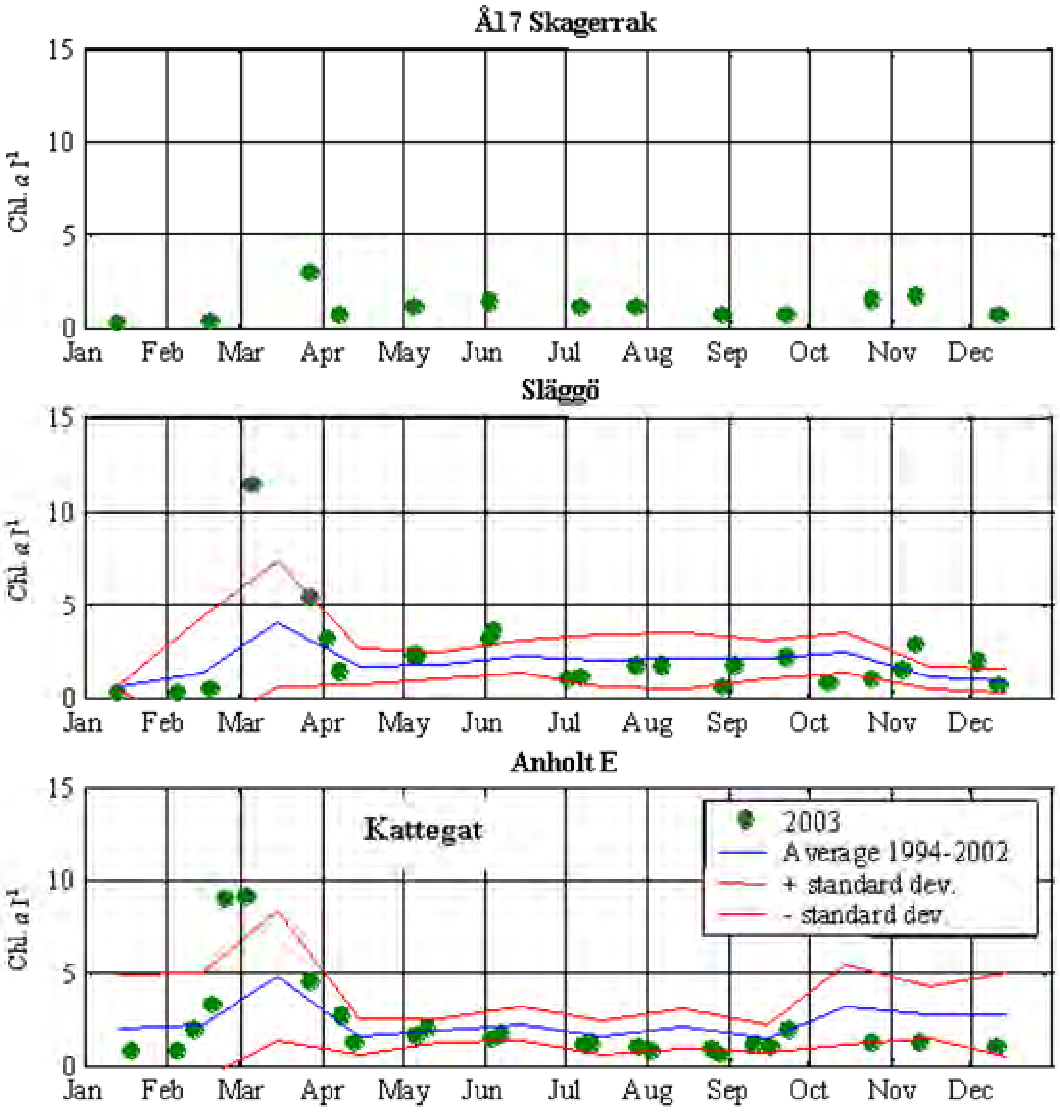
In January and February the plankton flora was poor with only small amounts of *Skeletonema costatum, Thalassionema nitzschioides* and *Navicula transitans*. Near the coast the early start of the spring bloom was evident in the middle of February. By the end of March the spring bloom was declining, even if there were still large numbers of diatoms, e.g. *Chaetoceros* spp.. The beginning of April was charachterized by small flagellates and otherwise a poor plankton flora. *Alexandrium* species were present in small amounts. In the open Skagerrak the plankton flora was very poor in May, whereas considerably more species and higher cell densities were seen at the coastal station. Among diatoms *Attheya septentrionalis, Chaetoceros debilis* and *Skeletonema costatum* were the most important. Several dinoflagellates were present, with *Heterocapsa rotundata* forming the highest density. *Dinophysis acuminata* and *D.norvegica* were present in cell numbers close to the critical limit. Smaller blooms of *Dactyliosolen fragilissimus*, *Pseudo-nitzschia delicatissima*-group, *Cerataulina pelagica* and *Proboscia alata* had developed in early June, but they had disappered in July, when the flora was again poor. In August there was a mixed flora of diatoms, dinoflagellates, prymnesiophyceans and other small flagellates, but all in low or moderate cell numbers. A few cells of cf. *Alexandrium pseudogonyaulax* were seen. In the end of August the flora was poor in the open areas of Skagerrak, but relatively rich in diatoms in the inner area. By late September the autumn bloom of diatoms was developing and a large diversity of diatoms was seen. Typical autumn species *Ditylum brightwellii* and *Pseudo-nitzschia pungens* were common, together with several species of *Chaetoceros*. *Asterionellopsis glacialis*, usually not present in autumn, but rather a rare guest during the spring bloom, was now very common. In late October there were only remains of the autumn bloom. Some diatoms, e.g. *Guinardia delicatula* and *Chaetoceros tenuissimus*, low in cell numbers, were present together with *Prorocentrum minimum*. In December the winter situation with very small amounts of phytoplankton was obvious.

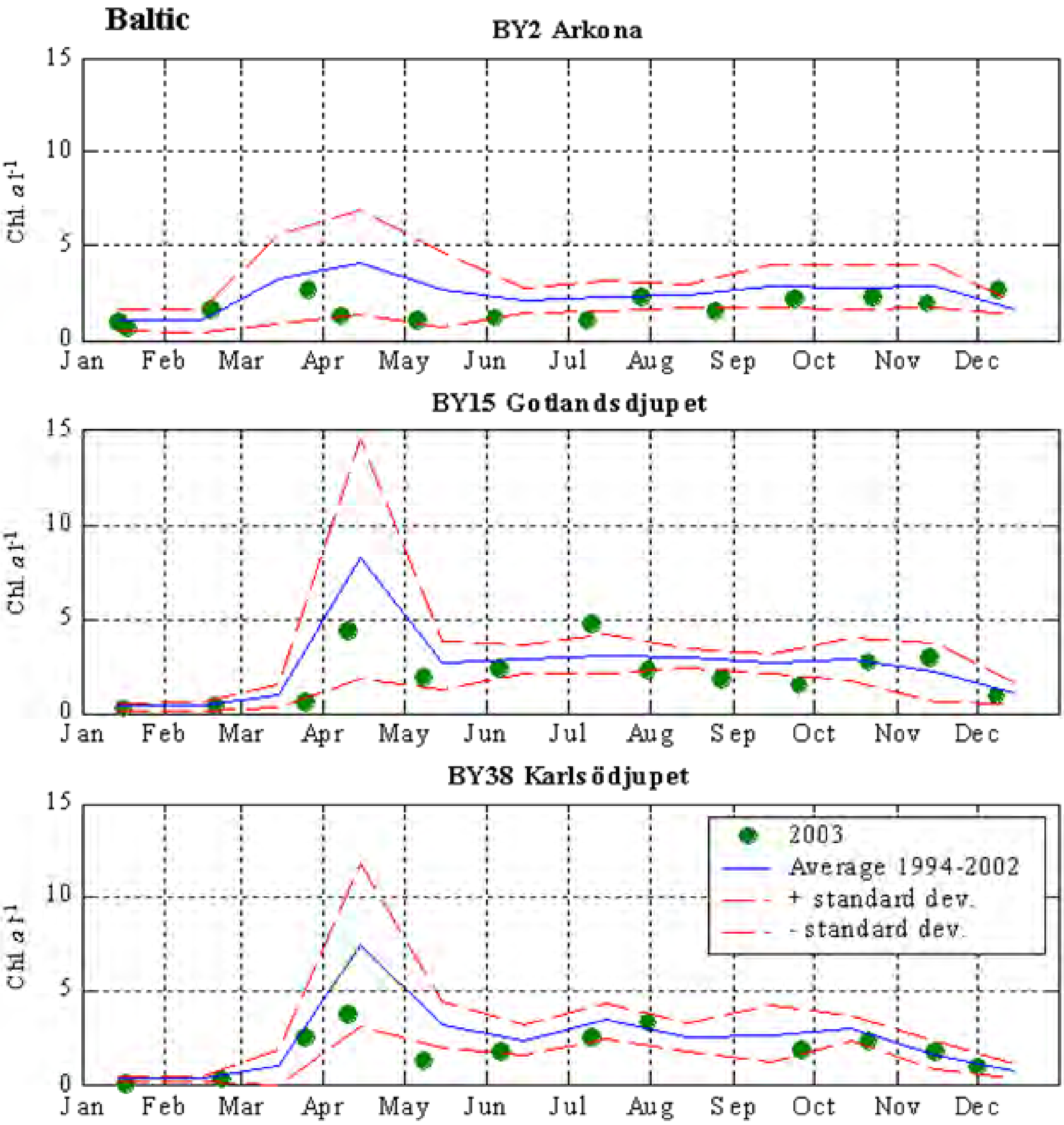
Kattegat

The small amounts of phytoplankton in January were dominated by *Skeletonema costatum*. Also *Guinardia delicatula*, *Guinardia flaccida* and *Pseudo-nitzschia delicatissima* were present. Between the 15th and 25th of February the spring bloom developed. Chlorophyll increased by a factor 4 in less than a week. E.g. *Skeletonema costatum* increased from 1.8 to 10 million cells per liter in 5 days. In the end of March the spring bloom had passed and the phytoplankton was dominated by small flagellates. Small amounts of *Chattonella* sp. were present. In April the flora was thin, but there were some potentially toxic *Pseudo-nitzschia delicatissima, Chrysochromulina* sp., *Dinophysis norvegica* and *Alexandrium* sp.. In May the flora continued to be very thin. The bloom of *Dactyliosolen fragilissimus* was also present in the Kattegat, but the cell density was lower than in the Skagerrak. Also *Pseudo-nitzschia delicatissima*-group was much reduced compared to the Skagerrak. Instead *Dinophysis acuminata* was common with densities far above the critical value. In July the amounts of phytoplankton were low. There were, however, some species, e.g. *Planctonema lauterbornii* and *Anabaena* cf. *baltica*, indicating an outflow of low saline Baltic water to the Kattegat. Diatoms were common with the highest cell densities of *Proboscia alata*, *Guinardia flaccida* and *Dactyliosolen fragilissimus* in the beginning of August, but they had completely disappeared by the end of the month. At that time *Chrysochromulina* spp. was of importance. The autumn bloom of diatoms, with a large number of species was developing in late September. The plankton flora was poor in late October and only a few diatoms were present together with even fewer dinoflagellates. In December the winter situation with very small amounts of phytoplankton was obvious.

Baltic Sea

In January and February the flora was very poor. In the southern Baltic the spring bloom was going on, or had even passed by the end of March. In the central Baltic it was about to start. *Skeletonema costatum* and *Scrippsiella hangoei* were the most common species. In April there were still remains of the spring bloom in the southwest Baltic and it was going on in the southeast and central Baltic, with high numbers of *Skeletonema costatum, Chaetoceros wighamii*, *Peridiniella catenata* and *Scrippsiella hangoei*. There were also single filaments of *Aphanizomenon* sp.. In May dinoflagellates, especially *Peridiniella catenata* and *Scrippsiella hangoei* were dominating together with small flagellates. Cyanobacteria had still not started to increase, but in June the increase of *Aphanizomenon* sp. and *Nodularia spumigena* was obvious. The cyanobacteria started to be of importance in most areas of the Baltic by July. The highest concentrations of *Aphanizomenon* sp. and *Nodularia spumigena* were found east of Gotland, where there were also high densities of *Chrysochromulina* spp. In the southwest Baltic cyanobacteria were very common and *Nodularia* was covered with the diatom *Nitzschia paleacea* in early August. This is a sign of decay of the bluegreen algae. In this part there was also a bloom of *Prorocentrum minimum*, reaching densities of about 0.7 million cells per liter. In the other parts of the Baltic the cyanobacteria were also present, but in lower concentrations. By the end of August *Aphanizomenon* sp. was present with about 10 m/l. in the sothwest part of the Baltic, but relatively scarce in other parts of the Baltic. *Dactyliosolen fragilissimus* with about 50 000 cells/l was found in the Arkona basin. This is uncommon in the low saline water of the southern Baltic. The cyanobacteria had decreased considerably by the end of September and only remains were still present. Diatoms were seen in most places and some dinoflagellates were present. East of Gotland *Prorocentrum minimum* had a bloom. In a 20 m thick layer at 130 m depth, 16 600 cells/l of *Prorocentrum minimum* were found and north of Gotland, about 90 000 cells/l were found at 20–30 m depth in the thermocline. In October cyanobacteria had almost disappeared and the plankton turned into a winter flora. Some dinoflagellates were still present and *Prorocentrum minimum* was now blooming west of Gotland. In December the winter situation with very small amounts of phytoplankton was obvious.


Å17 Skagerrak
Chl. a l-1
15
10
5
0
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Släggö
Anholt E
Kattegat
2003
Average 1994-2002
+ standard dev.
- standard dev.



Baltic
BY2 Arkona
BY15 Gotlandsdjupet
BY38 Karlsödjupet
Chl. a l-1
15
10
5
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Jan
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Oct
Nov
Dec
2003
Average 1994-2002
+ standard dev.
- standard dev.

Annex 6 Results of questionnaire of Primary Production

QA/AQC ACTIVITIES RELATED TO STUDIES OF BIOLOGICAL COMMUNITIES IN THE ICES AREA

Primary Production
Lars Edler, SMHI
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Introduction
In 2003 the ICES/HELCOM Steering Group on Quality Assurance of Biological Measurements in the Baltic Sea (SGQAB) and the ICES Steering Group on Quality Assurance of Biological Measurements in the Northeast Atlantic (SGQAE) circulated a questionnaire in order to improve the available information on Quality Assurance (QA) and associated Analytical Quality Control (AQC) activities in the studies of marine biological communities. The questionnaire concerned the nature of current commitments to QA/AQC activity in relation to Primary Production measurements. The purpose was to obtain an up-to-date summary of present efforts. Such information will help to set priorities for the future work of SGQAE and SGQAB and the laboratories involved. The questionnaire contained a list of questions, which could be answered with relatively little effort, which increase the likelihood of responses. The questionnaire was circulated electronically through a net of contacts. A copy of the questionnaire is given as Annex. The following account summarises the main findings from the returns, and provides an overview of the significance of the outcome from the standpoint of future developments in the quality assurance and quality control of biological community studies.

Results
The questionnaire was sent to 54 institutes/organisations in 21 countries. A total of 38 (70 %) questionnaires were returned. Of these 17 laboratories measure Primary Production.

The majority of responses from laboratories, measuring Primary Production, came from government laboratories. A smaller number came from universities, while 2 responses were from non-profit research organisations and one from a commercial consultancy.

Governmental laboratory	9
University laboratory	5
Non-profit research organization	2
Commercial consultancy	1

Responses were received from 17 countries within the ICES/OSPAR area, with multiple submissions from eight. One country outside the ICES area also responded.
Involvement in QA/AQC (quality assurance/analytical quality control) activity related to these targets? Written in-house procedures? Accreditation or planned accreditation?

This question was obviously misunderstood in many cases, as most answers referred to any QA/AQC activity, and not specifically to the measurements of Primary Production.

Country	PP measurment	No PP measurment
Canada	1	-
Denmark	1	1
Estonia	-	1
Finland	1	-
France	1	-
Germany	2	6
Iceland	1	-
Ireland	1	-
Italy	-	1
Latvia	-	1
Lithuania	-	1
Netherlands	1	2
Norway	1	2
Poland	1	1
Portugal	1	-
Sweden	4	-
United Kingdom	1	2
USA	-	2

Nine out of 17 laboratories are engaged in some form of QA/AQC activity. About 70 % of the laboratories follow their own in-house procedures, whereas there are no between-laboratory and between-country calibrations/comparisons. No laboratory is accredited for Primary Production, and only 5 are planning to do so.

Laboratory	QA/AQC activity	In-house procedures	Accreditation	Plan Accreditation
Governmental laboratory	6 (67%)	5 (56%)	0	2 (22%)
University laboratory	2 (40%)	5 (100%)	0	2 (40%)
Non-profit research organization	0	1 (50%)	0	0
Commercial consultancy	1 (100%)	1 (100%)	0	1 (100%)

Improvement and secure professional skills

Also this question was obviously misunderstood in many cases,and the answers did not always refer to measurements of Primary Production.

Sampling and sample-handling Workshops	3
Intercalibrations	5
Ring-tests	3
Reading and testing new methods described in the international scientific literature	4

Purpose of Primary Production measurements

Laboratory	Regional monitoring	National monitoring	International monitoring	Research
Governmental laboratory	2	5	3	4
University laboratory	0	2	1	5
Non-profit research organization	1	1	1	1
Commercial consultancy	-	-	-	1

Method of Primary Production measurements

Laboratory	*In situ*	Simulated *In situ*	Incubator
Governmental laboratory	4	5	6
University laboratory	3	1	4
Non-profit research organization	1	0	1
Commercial consultancy	1	1	1

Details of *in situ* measurements.

Sampling depths: Of the 6 answers 3 use fixed depths, and 3 light depths. Most common is the use of 5-8 depths between 0 and 15 m.
Incubation time: Varies between 2, 4 (usually around noon), 6-16, 24 hours.
Bottles: polycarbonate flasks, glass bottles

One lab reports the use of **LET GO device** (Dandonneau, Y., Le Bouteiller, A., 1992. A simple and rapid device for measuring planktonic primary production by *in situ* sampling, and ^{14}C injection and incubation. Deep Sea Research 39, 795–803).

Type of incubator

L ry	ICES incubator	Home built or other
Governmental laboratory	3	6
University laboratory	2	2
Non-profit research organization	-	1
Commercial consultancy	-	1

Incubator method

Three laboratories follow the ICES method, described in the HELCOM COMBINE Manual.

Sampling depths: There is a considerable difference between laboratories, ranging from integrated 0-10m to 1, 2, 3 or 4 discrete depths.
Incubation time: Varies between 0.5, 1, 2, 4 and 6 hours.
Incubation irradiance: Maximum light intensity varies between 350, 400, 600, 700, 800, 1500 and 2000 µmol/m^2/s.
"Shadowing" to different light intensities: Varies between "natural filters", perforated nickel-metal plates and "neutral density filter based on gold-plated bottles". At one lab a photosynthetron is used, where the distances from the light source give the range of irradiances.

Discussion and Conclusions
The outcome of the questionnaire provides useful insights of Primary Production measurements and to some extent QA/AQC activities in the ICES area. It is clear that the questionnaire has not reached all laboratories occupied with Primary Production measurements in the ICES area. It is also quite clear that a number of laboratories involved in such measurements preferred not to take part in this inquiry.

Measurements of Primary Production seem to have decreased in the ICES area. This obviously have two main reasons; high cost, and worry about radiation safety. In the HELCOM Combine Programme Primary Production is not a mandatory variable any more. Several countries have therefore terminated these measurements.

There is a considerable difference in all different steps of the measurements among the laboratories. This applies to type of measurement (*in situ*, incubator), sampling depths, incubation time and irradiance levels.
Although many laboratories deal with QA/AQC activities and have in-house procedures, there is little chance of receiving comparable results as long as methods are so variable. This implies a concern especially for the monitoring and the maintenance of a Primary Production Database for the ICES area.

If a Primary Production Database is to be developed at ICES, it is necessary to take serious steps to unify the methods. These steps must involve workshops, intercomparisons and ring tests.

Questionnaire on the present extent of primary production measurements in the ICES area

1) Which type of institution are you in?

- ☐ University laboratory
- ☐ Governmental laboratory
- ☐ Non-profit research organization
- ☐ Large commercial organization
- ☐ Commercial consultancy

1) What country are you located in? (the address of your institution is optional: see question 9, below)

2) Are you or your organization taking part in any type of quality assurance/analytical quality control activity related to these targets?

- ☐ No
- ☐ Yes If Yes, at which level:
  - ☐ in-house only
  - ☐ between laboratories
  - ☐ between countries

3) What is the name of any organised scheme that you participate in, and for how long have you participated?

4) Do you have written in-house procedures for the conduct of Primary Production studies (covering field sampling, laboratory analysis and/or data management), for example, in the form of Standard Operating Procedures?

- ☐ Yes
- ☐ No If No, please specify what other procedures you follow (*e.g.* published national/international guidelines)?

5) Is your laboratory/organisation accredited?

- ☐ No
- ☐ Yes If Yes, what form does the accreditation take and what is the name of the of the accreditation organization?

- ☐ Are you planning to seek accreditation?

6) Are you measuring Primary Production for…………….

- ☐ Regional (sub-national) monitoring
- ☐ National monitoring
- ☐ International monitoring
- ☐ Research (specify)
- ☐ No ………….. THANK YOU FOR YOUR PARTICIPATION

7) How do you improve and secure your personal professional skills?

- ☐ Sampling and sample-handling Workshops (if yes, how often?)
- ☐ Taxonomic training Workshops (if yes, how often?)
- ☐ Intercalibrations (if yes, how often?)
- ☐ Take part in ring-tests (if yes, how often?)
- ☐ Other (please specify)

8) May we refer to your institution by name in connection with any examples of "best practice"? (NB. We will NOT refer to named institutions/individuals under any other circumstances, and the confidential nature of your response is therefore assured)

- [ ] Yes
- [ ] No

9) Which method do you use for Primary Production measurements at your lab in general?

- [ ] *in situ*
- [ ] Incubator
- [ ] Simulated *in situ*

10) Is your lab measuring Primary Production according to the HELCOM COMBINE Manual?

- [ ] Yes
- [ ] No

11) If using incubator, what kind are you using?

- [ ] ICES incubator
- [ ] Home built incubator
- [ ] Other incubator

12) In case you measure *in situ*, please outline details such as depth, incubation time, incubation duration etc.

13) In case you use incubator, please outline details such as depth, incubation time, incubation duration etc.

14) What kind of bottles do you use and how are they "shadowed" to different light intensities?

15) In case you are not using the ICES incubator, what are the intercomparison results?

Annex 7 State of the art of, and new findings in, phytoplankton ecology

Enrique Nogueira (IEO)
WGPE, Centro Oceanográfico de Gijón, 19–21 March 2004

This contribution is a summary of a revision of international peer review papers on phytoplankton ecology that have being published mainly during 2003 (although some papers published up to the year 2001 were also considered). It was presented on the annual meeting of the ICES Working Group on Phytoplankton Ecology (WGPE), held in the Centro Oceanográfico de Gijón from the 19th to the 21st of March 2004. The revision does not pretend to be complete and is biased by the scientific interests (and limitations in knowledge) of the author. Its intention is to show some of the questions that are nowadays on the agenda of phytoplankton ecology research.

Introduction

This revision about the state of the art and new findings in phytoplankton ecology was organised on the basis of the three scientific approaches that are nowadays applied in plankton ecology research (Gentleman, 2002): the *in situ*, the *in vitro* and the *in silico* approaches. The *in situ* approach consists in the acquisition of field data, at sea or from the space, with the aims of understanding the spatial distribution and temporal changes (at multiples scales) of state variables at different ecosystem levels (species, populations and communities). The *in vitro* approach is based on laboratory and incubation experiments at different scales (micro-, meso- and macrocosms), and focuses on the study of process functions and process rates, from the individual level (physiology) to the community level (e.g. competition, trophic interactions). These are the classical approaches applied in plankton ecology research. The *in silico* approach has being developed in the last fifty years, and is based on the use of computer models to study marine ecosystems. The in silico approach has become the tool to integrate knowledge acquired by the *in situ* and in vitro approaches.

Documentation and data sources

About 500 papers published in the main international journals relate to marine ecology research in the year 2003 reviewed (although some papers up to the year 2001 were also included). The bibliographic search was done using the ISI Web of Knowledge, the Cambridge Scientific Abstracts (CSA) and the Current Contents (Institute for Scientific Information®). The basic key words to perform the search were phytop*, ecol*, physiol*, model*, *cosms, mar*, identif*.

The *in situ* approach

Three different aspects of the *in situ* approach were considered in relation to data collection, collation and analysis. In relation to the collection of data, traditional sampling methods of data acquisition at sea, co-exist with new, continuous (e.g. Romano *et al*. 2003), automatic (e.g. FRRF, http://www.pml.ac.uk, Sugget *et al*. 2003), semi-automatic (e.g. FlowCAM; http://www.bigelow.org), or autonomous (e.g. Wiebe and Benfiled 2003) methods. The methods focus in the acquisition of information about:

- Bulk properties. From photopigment analysis (i.e. functional groups: chlorophytes, cryptophytes, cyanobacteria, diatoms and dinoflagellates) as indicators of ecosystem health (Paerl *et al*. 2003), or from acoustical monitoring (multi-frequency echo-ranging sensors) (Holliday *et al*. 2003).
- Rates. Primary productivity from fast repetition-rate fluorometer (FRRF) (Moore *et al*. 2003). Growth rates from submersible flow cytometer (FlowCytobot) (Sosik *et al*. 2003).
- ‘Species’ identification/quantification. From immunological probes to label macromolecules (e.g. for *Phaeocystis* exopolymers) (Orellana *et al*. 2003), or molecular techniques (from allozyme electrophoresis to genomics) for identification, differentiation and phylogenetics (de Bruin *et al*. 2003).
- Community structure. Food-web studies based on stable isotopes ($\delta13C$ and $\delta15N$) (Fredriksen 2003; Melville and Connolly 2003; Jennings and Warr, 2003).

Acquisition of data from the space has experience new advances in the last years. Topics focus on the implementation of multispectral sensors to obtain phytoplankton ‘composition’, mounted on satellites (Barnes *et al*. 2003; Aguirre-Gómez *et al*. 2001) or aircrafts (CASI, Herut *et al*. 2002; Sathyendranath *et al*. 2004). A considerable amount of research focus on inter-comparison of ocean colour data from different sources (Switzer *et al*. 2003) and the synergy of optical and radar satellite data (i.e. wind and wave field, sea-ice extent…) (Lehner *et al*. 2002). The interference of CDOC (yellow substances) (Kirkpatrck *et al*. 2003; Binding *et al*. 2003) and particulate matter (i.e. spectral signature in green waters) (Doxaran *et al*. 2002) was also a recurrent topic.

The Continuous Plankton Recorder (CPR) constitutes an excellent example of collation of data acquired by ships of opportunity (http://www.sahfos.org). Integration of data acquired at sea and from the space (Schoefield *et al*. 2003) is another hot topic.

Diverse topics can be considered under the epigraph of data analysis, from image processing techniques applied to automate counting of phytoplankton (Embleton *et al*. 2003), to investigations dealing with empirical models that relate photosynthesis or pigment concentrations derived from *in situ* HPLC signatures with environmental parameters, such as wind, euphotic depth and mixed layer depth (Oliver *et al*. 2003) or temperature and nitrate concentrations (Kamykowsky and Zentara, 2003). We can consider also here those investigations to derive algorithms for ocean colour remote sensing (CZCS, SeaWIFS, OCTS) (Sathyendranath *et al*. 2001). The application of different mathematical techniques, such as neural networks (Scardi 2001), geostatistics and geographic information systems (GIS) (Doney *et al*. 2003) was also explored.

The *in vitro* approach

Different processes were studied following the in vitro approach. These can be classified on the basis of the ecosystem level considered. At the individual level, investigations focus for instances on topics such as the estimation of growth rates from cell cycle patterns (Reguera *et al*. 2003), or the effect of iron deficiency on thylacoid membrane structure and composition (Geiss *et al*. 2003). At the level of populations, investigations deal with aspects ranging from the relationships between carbon content and biovolume under different nutrient regimes (Davidson *et al*. 2002), the description and modelling of non-linear and chaotic dynamics using recurrence quantification analysis (Dippner *et al*. 2002), the effect of substrate-limitation versus light-limitation in chemostats (Smith 2002; Huisman *et al*. 2002), the relationships between light-dark cycles and turbulence in photobioreactors (Wu and Merchuk 2001), or the effects of UV-B radiation and mixing conditions on nitrogen uptake under nitrate and silicate deficiency (Fouilland *et al*. 2003). Most of the papers focus on the community level. The processes studied cover the effects of nutrient ratios on food-web structure (N:Si ratio, Dearman *et al*. 2003, or N:P ratio, Lignell *et al*. 2003), the ecological consequences of unpalatable preys (Bell 2002), the interaction between trace metals (Fe and Zn) on nitrate uptake kinetics (Franck *et al*. 2003), the effect of higher trophic levels, such as *Crassostrea virginica* (Pietros and Rice 2003) or invasive species (zebra mussel, Wilson 2003), on lower trophic levels, or the effect of pollutants, such as water soluble fractions of heavy oil (Ohwada 2003) or insecticides (e.g. atrazine) (Seguin *et al*. 2002).

A series of papers point out the difficulty of the extrapolations from laboratory experiments to natural systems (i.e. ‘incubation’ artefacts), focusing on the evaluation of potential limitations associated to in vitro experiments in relation to sample manipulation (Quevedo and Anadón 2001), ‘bottle-effect’ (Mine Berg *et al* 1999), or incubation time (Fernández *et al*. 2004).

Mathematical modelling and monitoring of closed artificial ecosystems is the focus of a series of papers (Watts and Bigg, 2001; De Angelis 2003), dealing with different aspects such as the influence of the complexity of the autotroph compartment (Dearman *et al*. 2003) or the application of flow network and inverse modelling (Olsen *et al*. 2001).

The *in silico* approach

The *in silico* approach has experienced a considerable development in the last five years. The models considered a wide range of problems and consider an extent range of scales, model formulations and structures, physical forcing and biological processes, coupling between model compartments, parameter specification and process functions or data assimilation.

- Scales. The revised models cover a wide range of scales (hierarchical and spatio-temporal): from molecular-physiological to ecosystem level (Menge *et al*. 2002), and from sub-grid (Broekhuizen *et al*. 2003), local (Yamamoto and Hatta 2004), mesoscale (Levy 2003;), regional (ACC, Hense *et al*. 2003); basin-scale (HNLC regions, Fenel *et al*. 2003; North Atlantic, Reid *et al*. 2001), or global (e.g. phytoplankton on the global radiation budget, Frouin and Iacobellis 2002).
- Formulation. Model formulation range from simple, budgetary, steady-state models (Farias 2003) to Lagrangian (particle tracking) models (Broekhuizen *et al*. 2003), and from 0D, phytoplankton-zooplankton models (Chattopadhyay 2002) to 3D, coupled AGCM-OCGM-BGQ (i.e. coupling of atmospheric general circulation with oceanic general circulation models with the implementation of biogeochemical modules (Shell *et al*. 2003).
- Structure. Some papers stress the relevance of increasing the complexity of ecological models or ecological ‘texture’ (Denman 2003). Model structure range from NPZ (food-chain) models (it is worth to mention in this sense the intercomparison of NPZ models by Newberger 2003) to multi-species (food-web) models (Lima *et al* 2002).
- Physical processes. The influence of a variety of physical processes on phytoplankton ecology is investigated, from the role of turbulence (Chen and Annan 2000), atmospheric forcing (Lacroix and Gregoire 2002), upwelling (Berntsen 2002) or winter convection (Wiggert *et al*. 2002).
- Biological processes. The biological processes included in the models range from the role of aggregation (⇒ mediated C export) (Waite and Johnson, 2003; Kriest 2002), photophysiology (photo-acclimation, photo-inhibition, package effect, production of photo-protecting carotenoids…) (Wozniak *et al*. 2003; Wozniak *et al*. 2002), nutrient uptake dynamics of silicate (Kristiansen and Hoell 2002) or nitrate inhibition by ammonium (Yajnik and Sharada 2003), interaction among biological components, such as phytoplankton host-virus systems (Thyrhaug *et al*. 2003) or predator-prey (Mitra *et al*. 2003), multi-nutrient interactions (Flynn 2003) or co-limitation (e.g. Fe, Si and P; Aumonts *et al*. 2003), the incorporation of DOM dynamics (Pahlow and Vezina 2003), the effect of turbidity (phytoplankton shading) on predation (Fiksen *et al*. 2002), or the role of vertical migration (Flynn and Fasham 2002).

- Coupling of sub-models. The most complex models, in terms of coupling of processes are the AGCM-OCGM-BGQ models (Shell *et al*. 2003). The coupling of benthic-pelagic systems (Lee *et al*. 2002) and bacterial processes (Allen *et al*. 2002) are also considered. Biofeedback effects –e.g. radiation absorbed by phytoplankton (Shell *et al*. 2003) is another hot topic.
- Parameterisation. Some papers deal with the comparison of models with different parameterisation (Kishi *et al* 2004). The effect of threshold feeding response (Leising *et al*. 2003) and techniques of optimal parameterisation by means of genetic algorithms (Whigham and Recknagel 2001) are also considered.
- Data assimilation. Assimilation of ecological data in marine ecosystems models is one of the key research topics in ecological modelling of marine ecosystems (Solidoro *et al*. 2003; Hemmings *et al*. 2003).

Main research areas in phytoplankton ecology

In this epigraph, the revised papers were classified in terms of the most recurrent topics they deal in relation to theoretical issues and community structure, spatio-temporal scales, climate change, biogeochemical cycles, physiological processes and community structure.

Some theoretical issues of concern were the mechanisms promoting species co-existence, such as non-equilibrium dynamics, spatial heterogeneity and multiple species interaction (Sheffer *et al*. 2003), the role of mixotrophy as a competitive advantage and as a factor structuring the ecosystem (Tittel *et al*. 2003), or the role of disturbances (i.e. intermediate disturbance hypothesis, IDH) (Quintana 2002; Elliot *et al*. 2001). It is also of interest the study of processes that promote the emergence of patterns, from species to build populations that ensemble in communities which determine ecosystem function (Reynolds, 2001). In this context circumscribe the concepts of adaptive strategies (r- versus K-selection, or competitor-(C) species, disturbance-(R) and stress-(S) tolerant species), latitude gradients, optimality, threshold behaviour and the maintenance of diversity (Reynolds 2002), bottom-up versus top-down control and trophic cascades (Daskalov 2002). Another debated topic refers to predictability (Roelke *et al* 2003) versus unpredictability (Huisman and Weissing 2001) of multi-species competition. Many papers dealing with community structure stress the relevance of pico- and nanophytoplankton (Ducklow *et al*. 2002). Another salient topics focus on pelagic-benthic coupling in coastal and shelf areas (Darrow *et al*. 2003), biodiversity, community structure and the interaction between limiting resources (nitrogen, phosphorous, silicate and light) (Interlandi and Kilham 2001) or silicate and DOC (Havskum 2003).

In relation to the scales, in the last years attentions has being paid to processes occurring at the smaller scales (or fine structure) (Druet, 2003; Holliday *et al*. 2003), such as the interaction between individuals and turbulent mixing processes, the effects on fine structure on processes such as bloom initiation (Ghosal and Mandre 2003, Huisman *et al*. 1999), competition (Huisman and Sommeijer 2002), predation (encounter rates, visual effects) (Peters *et al*. 2002), or cell physiology (exploitation of nutrients and light) (Broekhuizen *et al*. 2003). At the mesoscale, most papers focus on the effect of eddies on primary production (Goldman and McGillicuddy 2003), community structure (Lima *et al*. 2002) and biogeochemical cycles in oligotrophic environments (Letelier *et al*. 2000). Large-scale and climatic forcing (i.e. NAO and ENSO) is considered in relation to fisheries, primary production and (quantity/quality) (Reid *et al*. 2001) and ecosystem dynamics (Waters *et al*. 2003).

The topic of climate change is investigated in relation to ecosystem dynamics, at regional (Vichi *et al*. 2003; Boyd and Doney 2002) and global scales (Waters *et al*. 2003). Biofeedback on climate, such as atmospheric response to solar radiation absorbed by phytoplankton (Shell *et al*. 2003), DMS production on climate (trough cloud condensation) (Bopp *et al* 2003) is explored by means of the modelling approach.

In relation to biogeochemical cycles, it is considered the relevance of the silicate cycle in the sequestration of anthropogenic CO_2 (i.e. diatoms, through sedimentation, as a sink of anthropogenic CO_2 (Yool and Tyrrell 2003), and the biogeochemical cycles of nitrogen, sulphur and iron as limiting factors of primary production (Chu *et al*. 2003), and the role of dissolved organic carbon (DOC) in the C cycle (Dafher and Wangersky 2002).

The physiological processes that have attracted attention in the last year refer to multi-nutrient interactions (Flynn 2003), the extension of elemental composition and cellular quotas to trace metals (Ho *et al*. 2003), the effect on nutrient uptake of trace metals (Frank *et al*. 2003) and UV-B radiation and vertical mixing (Fouilland *et al*. 2003), or the effect of trace metals on productivity and food-web structure (Wang 2002).

References

Aguirre-Gómez R *et al*., 2001, International Journal of Remote Sensing, 22 (2–3): 315–338.
Arrigo KR *et al*., 2003, Journal of Geophysical Research, 108 (C5): art. No. -3154.
Backhaus JO *et al*., 2003, Marine Ecology Progress Series, 251: 1–14.
Barnes RA *et al*., 2003, International Journal of Remote Sensing, 24 (20): 4047–4064.
Bell T, 2002, Oikos, 99 (1): 59–68.
Berntsen J *et al*., 2002, Hidrobiología, 484 (1–3): 177–190.
Bopp L *et al*., 2003, Tellus Series B – Chemical and Physical Meteorology, 55 (1): 11–22.
Botsford LW *et al*., 2003, Fisheries Oceanography, 12 (4–5): 245–259.
Boyd PW and Doney SC, 2002, Geophysical Research Letters, 29 (16): art. No. -1806.
Broekhuizen N, *et al*., 2003, Marine Ecology Progress Series, 252: 61–76.
Chattopadhyay J *et al*., 2003, Journal of Mathematics Applied in Medicine and Biology, 19 (2): 137–161.

Chu SP *et al*., 2003, Chemosphere, 50 (2): 223–235.
Dafher EV and Wangersky PJ, 2002, Journal of Environmental Monitoring, 4 (1): 55–69.
Darrow BP *et al*., 2003, Continental Shelf Research, 23 (14–15): 1265–1283.
Daskalov GM, 2002, Marine Ecology Progress Series, 225: 53–63.
Davidson K *et al*., 2002, European Journal of Phycology, 37 (4): 501–507.
De Bruin *et al*., 2003, Hydrobiologia, 49 (1–3) : 47–63.
Dearman JR *et al*., 2003, Marine Ecology Progress Series, 250: 13–28.
Denman KL, 2003, Progress in Oceanography, 57 (3–4): 429–452.
Dippner JW *et al*., 2002, Marine Ecology Progress Series, 242: 29–37.
Druet C. 2003, Oceanologia, 45 (4): 517–555.
Ducklow HW *et al*., 2002, Limnology and Oceanography, 47 (6): 1684–1693.
Edwards VR *et al*., 2003, Continental Shelf Research, 23 (17–19), 1771–1785.
Elliot JA *et al*., 2001, Freshwater Biology, 46 (10): 1291–1297.
Farias L, 2003, Estuarine Coastal and Shelf Science, 57 (5–6): 829–841.
Fennel K and Boss E, 2003, Limnology and Oceanography, 48 (4): 1521–1534.
Fennel K, 2003, Deep-Sea Research Part II, 50 (3–4): 769–798.
Fiksen O *et al*., 2002, Hydrobiologia, 484 (1–3): 49–59.
Flynn KJ and Fasham MJR, 2002, Journal of Theoretical Biology, 218 (4): 471–484.
Flynn KJ. 2003, Progress in Oceanography, 56 (2): 249–279.
Fredriksen S. 2003, Marine Ecology Progress Series, 260: 71–81.
Gentleman W, 2002, Hydrobiología, 480 (1–3): 69–85.
Goldman JC and McGillicuddy DJ, 2003, Limnology and Oceanography, 48 (3): 1176–1182.
Guillanders BM and Kingsford MJ, 2002, Oceanography and Marine Biology, Vol. 40, 40: 233–309.
Hemmings JCP *et al*., 2003, Philosophical Transactions of the Royal Society of London Series A – Mathematical, Physical and Engineering Sciences, 361 (1802): 33–39.
Herut B. *et al*., 2002, Fresenius Environmental Bulletin, 11 (10A): 782–787.
Ho TY *et al*. 2003, Journal of Phycology, 39 (6): 1145–1159.
Holliday DV *et al*., 2003, Aquatic Living Resources, 16 (3): 131–136.
Huisman J *et al*., 2002, Antoni.e. van Leeuwenhoek International Journal of General and Molecular Microbiology, 81: (1–4), 117–133.
Interlandi SJ and Kilham SS, 2001, Ecology, 82 (5): 1270–1282.
Jennings S and Warr KJ, 2003, Marine Biology, 142 (6): 1131–1140.
Kamykowski D and Zentara SJ. 2003, Remote Sensing of the Environment, 86 (4): 444–457.
Kimmerer WJ, 2002, Marine Ecology Progress Series, 243: 39–55
Kriest I, 2002, Deep–Sea Resarch Part I, 49 (12): 2133–2162.
Lacroix G and Gregoire A, 2002, Journal of Marine Systems, 37 (4): 229–258.
Lee JY *et al*., 2002, Journal of Sea Research, 48 (4): 287–331.
Lefevre M *et al*., 2002, Deep–Sea Resarch Part I, 49 (12): 2221–2239.
Lehner S, 2002, Land Surface Characterization and Remote Sensing of Ocean Processes, 29 (1): 23–32.
Letelier RM *et al*., 2000, Journal of Geophysical Research – Oceans, 105 (C12): 28723–28739.
Lignel R, 2003, Limnology and Oceanography, 48 (1): 189–209.
Lima ID *et al*., 2002, Journal of Geophysical Research – Oceans, 107 (C8): art. No. -3111.
Mckee D *et al*., 2002, Journal of Plankton Resrach, 24 (11): 1163–1171.
Melville AJ and Connolly, RM. 2003, Oecologia, 136 (4): 499–507.
Mitra A *et al*., 2003, Acta Oecologica- International Journal of Ecology, 24: S359–S367.
Moll A and Radach G, 2003, Progress in Oceanography, 57 (2): 175–217.
Moore CM *et al*., 2003, Ecology Progress Series, 259: 29–45.
Oliver RL *et al*., 2003, Journal of Plankton Resrach, 25 (9): 1011–1019.
Orellana M *et al*., 2003. Marine Chemistry, 83 (1–2): 89–99.
Paerl HW *et al*., 2003, Bioscience, 53 (10): 953–964.
Pahlow M and Vezina AF, Journal of Marine Resrach, 61 (1): 127–146.
Petrovskii SV, 2002, Oceanology, 42 (3): 363–372.
Quintana XD, 2002, Journal of Plankton Research, 24 (3): 255–265.
Ray S et a., 2001, Ecological Modelling, 140 (3): 219–234.
Reguera B *et al*., 2003, Marine Ecology Progress Series, 249: 117–131.
Reid PC *et al*., 2001, Fisheries Research, 50 (1–2): 163–171.
Reybolds CS, 2002, Ecological Modelling, 158 (3) 181.
Reynolds CS, 2001, Scientia Marina, 65 (Suppl. 30): 5–30.
Rixen M *et al*., 2003, Geophysical Research Letters, 30 (1): art. No.- 1017.
Sathyendranath S *et al*., 2001, International Journal of Remote Sensing, 22 (2–3): 249–273.
Sathyendranath S *et al*., 2004, International Journal of Remote Sensing, 25 (5): 893–919.
Scardi M, 2001, Ecological Modelling, 146 (1–3): 33–45.
Scarrat MG *et al*., 2002, Marine Ecology Progress Series, 244: 49–61.

Scheffer M *et al*., 2003, Hydrobiologia, 491 (1–3) : 9–18.
Shell KM *et al*., 2003, Journal of Geophysical Research – Atmospheres, 108 (D15): art. No. -4445.
Smith VH, 2002, Antoni.e. van Leeuwenhoek International Journal of General and Molecular Microbiology, 81: (1–4), 99–106.
Solidoro C. 2003, Journal of Marine Systems, 40: 79–97.
Sosik HM *et al*., 2003, Limnology and Oceanography, 48 (5): 1756–1765.
Switzer AC *et al*., 2003, Journal of Geophysical Research, 108 (C8): art. No. -3280.
Tett P *et al*., 2003, Continental Shelf Research, 23 (17–19), 1635–1671.
Thyrhaug R, *et al*., 2003, Marine Ecology Progress Series, 254: 27–35.
Tittel J *et al*., 2003, Proceedings of the National Academy of Sciences of the United States of America, 100 (22): 12776–12781.
Vichi M *et al*., 2003, Climate Research, 24 (2): 141–159.
Wang, WX, 2002, Marine Ecology Progress Series, 243: 295–309.
Waite AM and Johnson D, 2003, Geophysical Resarch Letters, 30 (13): art. No. -1690.
Wischmeyer AG *et al*., 2003, Marine Chemistry, 82 (1–2): 13–298.
Wozniak B *et al*., 2003, Oceanologia, 45 (2): 171–245.
Wozniak B, *et al*., 2003, Optica Applicata, 32 (4): 731–747.
Wu XX and Merchuk JC, 2001, Chemical Engineering Science, 56 (11): 3527–3538.
Yool A and Tyrrell T, 2003, Global Biogeochemical Cycles, 17 (4): art. No.- 1103.

Annex 8 Dynamics of Spring Phytoplankton Blooms in the Cantabrian Coast

Dynamics of Spring Phytoplankton Blooms in the Cantabrian Coast (Spanish national project DINAPROFIT: REN2003-09549-C03-02/MAR)

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Bursts of microphytoplankton (or net phytoplankton), of which the Spring Phytoplankton Bloom (SPB) in mid and high latitudes is the most conspicuous and best known example, represent the main contribution to atmospheric CO_2 sequestration in ocean sediments and to fish production, because large particles sink fast and are readily consumed by large predators. The SPB does not proceed as an isolated, sudden event, but as trains of small blooms, or microsuccessional (MS) events which are consequence of successive "windows of opportunity". DINAPROFIT aims at identifying the conditions that determine the initiation, dynamics and fate of MS events during the SPB in the Cantabrian Sea, and to develop tools for their prediction from meteorological and hydrographic data. To this end, DINAPROFIT will follow 3 complementary approaches: 1) Retrospective analysis of satellite imagery, time-series data and stored samples, that will allow the statistical characterisation (initiation, frequency, intensity and species composition) of MS events, their empirical modelling using meteorological and hydrographic variables and the identification of optimal periods for the development of subsequent DINAPROFIT cruises; 2) A meso-scale cruise using automated probes calibrated against manual methods and repeated at very short (3 days) intervals during the month of maximal variability of chlorophyll distributions. The high temporal resolution of this cruise, in combination with the low average residual current velocity in this area should allow close control of horizontal advection and clear resolution of the relative role of different factors on the initiation of MS events and their propagation to upper trophic levels. A further cruise along time series transects at weekly intervals during the following year will give an indication of interannual variability of the observed patterns; 3) Microcosm experiments to determine the role of upper trophic levels in determining the dynamics and fate of the SPB.