Biological Oceanography Committee

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REPORT OF THE
ICES/IOC WORKING GROUP ON HARMFUL ALGAL BLOOM DYNAMICS

Brest, France

17-20 April 1996

International Council for the Exploration of the Sea

Conseil International pour l'Exploration de la Mer

Palægade 2–4 DK–1261 Copenhagen K Denmark

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1. WELCOME AND OPENING OF THE MEETING

The ICES/IOC Working Group on Harmful Algal Bloom Dynamics (WGHABD) was convened at IFREMER (French Institute for Exploitation of the Sea) in Brest (17-20 April 1996). The meeting was chaired by Patrick Gentien (France). 25 scientists from 11 countries took part and are listed in Annex I. 4 more scientists were not able to participate and contributed by correspondence. The draft agenda of the meeting was briefly discussed and adopted by the participants. This approved agenda is appended to the report under Annex II.
Tim Wyatt was appointed as a rapporteur for the monitoring items. In plenary session of the WGHABD, individual participants introduced themselves and their institute and gave a concise description of their major field of research.

2. TERMS OF REFERENCE

At the 83rd ICES Annual Science Meeting in Aalborg (Danemark), the Council resolved (C.Res. 1995/2:52) that:

The ICES/IOC Working Group on Harmful Algal Bloom Dynamics (Chairman: P.Gentien, France) will meet in Brest (17-20 April 1996) to:

§ 1 - complete and discuss the logistic planning of the ICES/IOC Workshop on development of *in situ* growth rate measurements from 9 to 15 September 1996, and examine the results of intersessional progress;

§ 2 - continue the development of an understanding of the dynamics of harmful algal blooms, including presentations of recent experimental results;

§ 3 - collate and discuss national reports on HABs and initiate a synthesis of the national reports of the last ten years, and map outbreaks and compile time series of HABs in the ICES area;

§ 4 - review the updating of the ICES Cooperative Research Report n°181 on the "Effects of HABs on mariculture and marine fisheries" carried out in the intersessional period;

§ 5 - discuss items related to the monitoring of HABs based on the compilation of answers to the IOC-ICES questionnaire, and considerations by the IOC-FAO Intergovernmental Panel (IPHAB), in order to give advice on further activities, including planning of an international workshop on HAB monitoring and mitigation strategies;

§ 6 - review and discuss recent work on the effect of harmful algae on zooplankton, including discussion of methods to be applied in these studies.

§ 7 - examine feasibility, of, and potential contributions to an Environmental Status Report for the ICES Area on an annual basis, and report to ACME by the end of 1995.

§ 8 - elaborate recommendations about priorities in new research or intiatives to minimize transfer of harmful phytoplankton by ballast waters.

Term of Reference 1

To complete and discuss the logistic planning of the ICES/IOC Workshop on development of an in situ growth rate measurement from 9 to 15 September 1996, and examine the results of intersessional progress

In July 1994, a Workshop on "Intercomparison on *in situ* growth rate measurements" was held in Aveiro, Portugal. The results were presented in the report of the ICES/IOC WG on Harmful Algal Bloom Dynamics (ICES C.M. 1995/L:4, Annex IV). The overall conclusion was that "although significant progress was achieved, some of the applicable techniques were not fully developed and evaluated for dinoflagellates". Consequently, in the report, the WG recommended that a second workshop should be conducted "to bring to completion the activities initiated during the previous workshop". Furthermore, it was recommended that this workshop should be held at Kristineberg Marine Research Station, situated at the mouth of the Gullmar Fjord on the Swedish west coast, from September 9-15,1996 under the chairmanship of Dr Odd Lindahl. These recommendations were adopted by the ICES 83rd Statutory Meeting (C.Res. 1995/2:55).

At the WG meeting in May 1995 in Helsinki a Technical Planning Committee was appointed (D. Anderson, E. Dahl, E. Granéli, M.A. Sampayo and O. Lindahl) to prepare for the workshop. The following proposal was prepared for the experiments:

1. Although a variety of dinoflagellates will most likely dominate the phytoplankton in the Gullmar fjord in September , this typical pattern is too uncertain to be depended upon during the experiments.
2. Therefore, in addition to the natural dinoflagellate community, the group planned to prepare cultures of three different species, with each species growing at two different growth rates.

In Helsinki it was recommended that participants perform studies attempting to overcome methodological difficulties identified in the first workshop. This should include inter-sessional work on cultured reference species to be used during the workshop. In response to Term of Reference 1 of the present meeting, the suggestion was made that the results of intersessional progress should be examined. The sub-group decided to refer to the Workshop report of the Helsinki meeting (Annex IV, ICES C.M. 1995/L:4 and to the poster/paper presented at the 7:th Int. Symp. on Toxic Dinoflagellates in Sendai, Japan (Sampayo and Lindahl, 1996).

As a first step in planning the Workshop to be held in Kristineberg the list of participants and methods was completed (see appended list).

As a second step the proposed structure and organization of the Workshop was discussed, particularly with respect to the comparison of appropriate methodologies. The group agreed to the following layout:

Cell cycle methods	**Biomass/cell numbers**	**Photosynthetic activity**
Mitotic index	Cell counts	LIDAR
DNA/RNA ratios	Laser fluorometer	PAM
		O_2 production
		^{14}C single cell uptake
		^{14}C bulk uptake

The group further discussed the spatial scales of sampling and measurements which will be used during the workshop. Three different levels were identified: cultures, mesocosm and the natural community. Not all of the proposed methods can be run in parallel for all spatial scales. The microscale (cultures) will be the key spatial scale to focus upon since it is impossible to predict the exact composition of the flagellate assemblage in the natural community during September. An in depth discussion was pursued to establish a list of recommended species and designated reference strains to be tested prior to the workshop. All species should be delivered to Edna Graneli, who will be responsible for the handling and growth of the cultures. Once established in culture at the University of Lund, suitable inocula will be distributed to each key participant who wishes to conduct growth rate trials and\or intrument calibrations in advance. The prospective participants will be supplied with recommendations on appropriate growth media, irradiance, photoperiod and temperature to minimize the degree of physiological variation among cultures maintained at different laboratories If possible, at least one species (*P. minimum* was suggested due to its rapid growth and ease of maintenance in culture) will be grown at two different rates by manipulation of ambient nutrients or other environmental conditions. .We anticipate that 10 l of relatively dense culture in exponential growth will be sufficient for the growth rate trials. In selecting the optimal species for the workshop, it was judged important to standardize the strains as much as possible, to take into account that critical antibodies and cell cycle labels are currently available and tested for only a few phytoplankton. The use of particular species which have already been used to calibrate optical and remote sensors were also considered in this decision. As a preliminary recommendation, the sub-group suggested that the following species and strains would be appropriate.

Species	**Strain**	**Source**
Alexandrium tamarense	GT 429	Don Andersson
Alexandrium tamarense	ATA K1	Carla Micheli
Alexandrium lusitanicum		Carla Micheli
Prorocentrum micans		Louis Peperzak
Prorocentrum minimum		Edna Graneli
Gyrodinium aureolum		Louis Peperzak

Finally, the sub-group agreed on the following tentative agenda :

08 Sunday	Arrival
09 Monday	Briefing, setup of equipment
10 Tuesday	Test of methods and instruments, final evaluation of plans
11 Wednesday	Experiments
12 Tuesday	Experiments
13 Friday	Experiments
14 Saturday	Evaluation of experiments
15 Sunday	Departure

Additional information, to all participants, will be sent out during May.

Participants using the same techniques are recommended to contact each other before the workshop to make necessary comparisons of equipment, etc.

Registred participants	**Country**	**Additional information**
Anderson, Don	USA	Flow cytometry, DNA/RNA/cell
Dahl, Einar	Norway	Population growth, cell numbers
Garcés, Esther	Spain	Microfluorometry, DNA/cell
Edler, Lars	Sweden	^{14}C-method, ICES incubator
Gentien, Patrik	France	
Granèli, Edna Carlsson, Per Legrand, Catherine	Sweden	Flow cytometry, DNA
Lindahl, Odd Davidsson, Lennart Hernroth, Bodil	Sweden	Population growth, plankton cages
Micheli, Carla Fantoni, Roberta Palucci, Antonio Colao, Francesco Ribeho, Sergio	Italy	Lidar Fluorosensor System Laser Fluorometer system Growth rate (Ke) O_2-production
Peperzak, Louis Sandee, Ben	Netherlands	Flow cytometry, DNA

Interested to participate:

Cembella, Allan	Canada	Flow cytometry, DNA
Colijn, Franciscus	Germany	PAM technique
Gudmundsson, Kristinn	Island	^{14}C method
Reguera, Beatriz	Spain	Mitotic index
Maestrini, Serge	France	^{14}C-single cell uptake
Sampayo, Maria Antonio	Portugal	Population growth, cell numbers
Smayda, Ted	USA	Population growth, mesocosm exp.

Term of Reference 2

To assess progress made and continue to develop understanding of the dynamics of harmful algal blooms (HABs), including presentation of new experimental results.

The following oral presentions were made.

Biophysical control of harmful algal bloms (Tom Osborn & Percy Donaghay, John Hopkins Univ. & Univ. Rhode Island, USA)

Theoretical considerations and field observations suggest that the dynamics of sub-dominant toxic algae and their impacts on other organisms are controlled not only by physiological responses to in situ environmental conditions as modified by trophic interactions, but also by a series of bio-physical interactions occurring at the individual and population level.

A mathematical analysis of the underlying processes and interactions indicates that major gaps exist in our ability to measure and model the underlying physical processes and bio-physical interactions. Combining fluid continuity equation with a continuity [conservation] equation for population dynamics reveals how biological and physical processes and their interactions can affect the population dynamics of toxic algae and their potential impact on target organisms. Application of the resulting numerical and conceptual models to toxic blooms in buoyant plumes, upwelling systems, and pycnocline layers shows that bloom dynamics and impacts are sensitive to bio-physical interactions and that such interactions may be critical components of the life history strategy of these organisms.

Model of how a lumpy, shear-thinning polymer should change inter-particle velocity at different length scales in an isotropic , turbulent fluid with intermittence (Ian Jenkinson & Thomas Kiørboe, Acro, La Roche-Canillac, France)

In the sea, turbulence around the wavelength of dissipation eddies (cm) is approximately isotropic. Water movement is intermittent, that is its velocity shows a roughly lognormal distribution (in space and time). Values of excess viscosity and elasticity, contributed by polymers, are also close to lognormal. The relationship between polymeric viscosity and deformation rate has been found to follow a power law of the form $\eta_E = k.\gamma^{-P}$, where η_E is excess viscosity, k is a "thickening" coefficient,γ is shear rate and -P is a shear-thinning exponent.

The model uses, first a lognormal distribution in energy dissipation. Superimposed on this is is a lognormal (hierchaically lumpy) distribution of the excess viscoelastic modulus. A value of zero represents the perfectly dispersed case, but a value of 0.9 was used in the present case, corresponding to the value found in a study made in the Mediterranean.. Also superimposed was a value of 1.4 for P, corresponding to the value found in the same survey. Two scenarios were presented, with values of $\eta_E(\gamma)$ ($\gamma = 1\ s^{-1}$) of 10 and 1000 μPa.s, respectively equivalent to phytoplankton concentrations of 3.4 and 120 mg Chlorophyll *a*. m^{-3}, according to the relationship found between chlorophyll and excess viscosity, $\eta_E(1\ s^{-1}) = 2.0\ Chl^{1.3}$.

The case was presented with turbulence disspation, ε, of $10^{-2}\ cm^2\ s^{-3}$. The velocity between particles (mean and mean ± SD) was plotted against interparticle distance, from 1 mm to 10 cm. The distribution of velocity with distance was shown, for comparison, in each case with unthickened seawater and seawater 10 times more viscous at all deformation rates.

In the 3.4 mg Chl m^{-3} scenario, the phytoplankton mucus made very little difference to interparticle velocities, but at 120 mg m^{-3}, mean velocities at small scales were reduced by a factor of 2. More important, perhaps, is the fact that the SD of the log values is roughly doubled for the 120 mg.m^{-3} scenario. Implicitily, in this model, there is no assoaciation between flocculates and particles, but this could be built in using an "association" coefficient. While the present model was designed for diatom-induced thickening, and there is no term for swimming, any desired swimming, rising or sinking term could easily be built in. At large scales the changes in viscosity make no difference, as this represents the "inviscid" regime.

Using a fish as a rheometer: results using algal bloom organisms (Ian Jenkinson, ACRO, La Roche Canillac, France)

Fish produce a cross-gill hydrostatic pressure of mostly about 1 to 2 cm water when they are at maximum activity. A hypothesis was previously made that the fish-killing dinoflagellate, might thicken the water with mucus so that more oxygen would be needed to fuel the pumping of water over their gills, than could be extracted by the same water.

To test this hypothesis, a tank was mode with two compartments, A and B. This tank was demonstrated at the meeting. A hole between the compartments is fitted with a tap. On the tap is a nozzle. A freshly killed fish is then connected to the nozzle using a flexible rubber tube. The fish's mouth is kept open by inserting a tube into it, and the opercula are cut off. With the tap initially closed, the fish is suspended in compartment B, immersed in seawater. Test material, bloom water or a culture, is put into compartment A, so that the height of the surface is 5 cm above that in compartment B. The tap is opened and the change in level is timed. With Newtonian liquid, the height difference declines with time, with a negatively exponential relationship.

Results were shown, comparing cultures of *G.* cf *nagasakiense*, *Heterosigma, Pavlova* and seawater. The dense *Pavlova* culture behaved like the seawater. the *Heterosigma* showed flow properties difficult to reproduce, perhaps due to its proposity to associate with surfaces. The *Gymnodinium* cf *nagasakiense* culture, however, stopped flowing altogether at a hydrostatic pressure difference of 8 mm, suggesting that the original hypothesis may have been correct.

Bloom inoculation along the coast of the Bay of Biscay (Patrick Gentien & Pascal Lazure, IFREMER, Brest, France)

Along the Atlantic west coast of France, *G.* cf. *nagasakiense* blooms are usually confined to the Western part of Brittany coastline. The two largest events recorded occured in 1987 and 1995. The 1987 toxic event remain confined to the usual area. The July 1995 event occured all along the Atlantic coast down to Arcachon basin. Time lag between maximum cell appearance between the Northern and Southern stations was less than a fortnigth, excluding a transport of fully developed populations. A 3-D hydrometeorological model (10 layers) of the Atlantic shelf was used to examine transport prior to the toxic event. The hypotheses were that: 1- a seed population was present as early as March in the coastal area of Brittany and 2- the seed population was transported along the pycnocline (defined as the maximum gradient layer). The second hypothesis is based on the growing evidence that dinoflagellates are confined in pycnocline layers when the density gradient is sufficient. Differences in wind regimes between the two years induced different advection schemes in April-early May. In 1995, according to the model, a large proportion of particles released in April in the upper mixed layer reached the southern part of the bay of Biscay while they remained in the northern part of the Bay in 1987 or went north into the western part of the English Channel. Differences in circulation, 3 months ahead of any toxic event, due to different meteorological conditions influence the geographical extension of this toxic event. Feasability of predicting the extension of a bloom by satellite imagery is currently being investigated.

Biomass measurement by LIDAR (Antonio Palucci, ENEA, Frascati, Italy)

Laser fluorosensor systems are commonly used to investigate vegetation targets, since visible and near UV lasers are suitable to excite chromophores, especially chlorophyll pigments in living tissues of algae and plants. These apparatus, installed on board of a ship, are particularly suited for remote sensing of large seas areas: they are non-intrusive and provide real time data.

ENEA has developed a mobile lidar system which can operate in dual pulse emission (Pump and Probe). This permits the investigation of photosynthetic processes *in situ*. A feasibility study *in vitro* and under different natural conditions was successful in providing thematic maps of the different monitored substances.

The ENEA Lidar group will participate to the Kristineberg workshop on *in situ* growth rate measurement in order to compare this techniques to others.

Nutrient fluxes in mixed and stratified water columns in relation to a G. cf. nagasakiense bloom.
(Pascal Morin, Univ. de Bretagne Occidentale, Brest, France)

The Ushant front delimits two water masses: a well-mixed water column inshore and a stratified water column offshore. *G.* cf. *nagasakiense* blooms occur in summer in the stratified water column and are located in the pycnocline. Such a confinement was commonly explained by the fact that, the upper layer being depleted in nitrogen, the dinoflagellate was benefiting from the flux of nutrients diffused or pumped through the pycnocline.

Nitrogen fluxes measurements by ^{15}N tracer revealed that ammonium regeneration flux was balancing to 90% of population requirements in Nitrogen and that the algal assimilation was depending on nitrogen for only 10%, thus showing that the dinoflagellates were thriving on diatom decomposition. Such an example shows clearly that, in the absence of nutrient fluxes, observations may be misinterpretated

The role of polyamines as growth factors for dinoflagellates (Christiane Videau, Univ. de Bretagne Occidentale, Brest, France)

Putrescine (Put) is synthetized by decarboxylation of ornithine and arginine. Spermidine (Spd) and spermine (Spm) are synthetized from Put under the action of polyamine-synthetases. Transformation of putrescine into spermidine and spermine is important in cell division processes. Evolution of intracellular polyamines is related to DNA synthesis.

An increase of 30% in growth rate of *G.* cf. *nagasakiense* has been measured for very low concentrations (0.1 - 5 µM putrescine added to the growth medium). These levels are a 1000 times less than for other cells. Since the final culture yield is not different from blanks, putrescine cannot be considered as a complementary nitrogen source. Active concentrations of putrescine (0.1 µM) correspond to the concentrations measured on Ushant front, previously to the *G.* cf. *nagasakiense* bloom.

In conclusion of these preliminary results, decay of the previous diatom bloom seems to favour the *G.* cf. *nagasakiense* bloom development, not only in providing nitrogen (ammonium) from organic matter but also in elevating polyamines concentrations in sufficient quantities to stimulate the dinoflagellate growth rate.

Toxic transfer from phytoplankton to zooplankton (Jefferson Turner, Univ. Massachusetts, Datrmouth, USA)

Jefferson turner presented results of some recent studies on interactions between toxic zphytoplankton, zooplankton and larval fish. During studies in collaboration with Pat Tester of the US National Marine Fisheries Service in Beaufort, North Carolina, and Damian Shea of North Carolina State University; copepods (*Acartia tonsa* were fed upon the toxic dinoflagellate *Gymnodinium breve*, and these copepods were then fed to fish larvae (*Leiostomus xanthurus*). Accumulation of brevetoxins in copepods and fish was the mesured using cappilary electrophoresis. Fish larvae were not obviously adversed by toxins, and fish had high levels of toxins in the viscera within 2 hours. Toxins steadily declined in fish viscera as they accumulated in muscle tissue over a period of 2-25 hours. This revealed that results of previous studies by Alan White of vectorial intoxication of fish from ingesting copepods that had accumulated *Alexandrium fundyense* toxins may similarly apply to ingestion of *G. breve* by different species of copepods and fish. Further, for the first time, it was shown that dinoflagellate toxins in fish move from fish viscera to muscle tissues.

Turner also presented results of recent studies on egg production and egg hatchong rates for copepods eating toxic compard to non-toxic phytoplankton. In experiments from Beaufort with *A. tonsa* feeding upon *G. breve* and non-toxic *G. sanguineum,* rates of egg production were low when feeding upon *G. breve* in March and October 1995. However, rates of egg hatching on diets of non-toxic *G. sanguineum* were zero in March, but nearly 100 per cent in October. In similar experiments from June and August, 1995 in Moncton, Canada, in collaboration with Steve Bates and Claude Leger of the Department of Fisheries and Oceans, Canada and University of Massachusetts student Jean Lincoln, when *Acartia tonsa* were fed upon toxic *Pseudo-nitzschia multiseries* ans non-toxic *P. pungens*, there were no significant differences in egg production rates, which were low, and egg hatching success, which was high. In both the Beaufort and Moncton studies, egg production and hatching success were high on diets of natural mixed phytoplankton. These results reveal that diet affect copepod egg production and hatching success; but that results can be highly variable, complicated, and not as straightforward as whether phytoplankton are toxic versus non-toxic. The need for more experiments on both toxin accumulation in fish, and relations between copepod reproduction and diets of toxic and non-toxic phytoplankton is clearly indicated.

The Baltic Sea Pilot Study (Kaisa Kononen, Finnish Institute of Marine Research, Helsinki, Finland)
(This report was not presented before the Group because it has been received the last day)

The occurrence of cyanobacterial blooms in aquatic environments has been traditionally connected to eutrophication. However, in the Baltic Sea the most intense and toxic cyanobacterial blooms occur, in contrast to common belief, in open sea areas far from anthropogenic inflows. Furthermore, the analysis of satellite data in combination with high frequency mapping of surface layer chlorophyll in the Baltic Sea have showed persistance and reoccurrence of rich patches of cyanobacteria at same locations year after year.

Since 1990 Finnish Institute of Marine Research and Estonian Marine Institute have carried out a multidisciplinary research project studying the hydrodynamical mechanisms affecting nutrient availability for bloom-forming cyanobacteria at the entrance to the Gulf of Finland, the Baltic Sea. The project benefits from high-resolution physical and biological mearurements which are complemented with more traditional sampling of nutrients and biological parameters.

The Baltic Sea pilot project has focused on studying the processes which lie behind the mesoscale variability of the blooms. Altogether three research cruises were carried out during 1992-1994 in a frontal zone at the entrance to the Gulf of Finland. The studied front is formed by inflowing saltier waters of the Northern Baltic Proper and outflowing fresher waters from the gulf. We observed the response of the frontal behaviour to wind forcing. Easterly winds (parallel to the front) cause offshore movement of denser water, as well as a stronger inclination of the front to the sea surface. With westerly winds, the less dense water moves onshore and overrides the denser water, thus forming a shallower upper mixed layer. We also observed different modes of cyanobacterial bloom initiation, mostly controlled by hydrodynamics, for the two most important bloom-forming cyanobacteria. Decreased stratification and wind events cause nutrient pulses into the upper mixed layer and promote blooms of *Aphanizomenon flos-aquae.* On the contrary, increased stratification due to the heating of the upper layer or horizontal interplay of watermasses with different density trigger bloom-formation by *Nodularia spumigena.* The latter processes also stimulated coiling and aggregate formation by *Nodularia.*

Furthermore, we detected intrusive finestructures of the thermohaline and nutrient fields in the transition zone between the near-shore and open gulf waters, with vertical and horizontal scales of 5-20 m and 1-10 km correspondingly. Due to their small scale, this kind of nutrient transporting mechanisms remain overlooked in the routine monitoring studies, even though their role may be remarkable for plankton production.

In 1995 the project concentrated on publishing the results. Altogether 6 scientific paper were produced and submitted to be published. Until now the following papers have come out:

Heinänen, A., Kononen, K., Kuosa, H., Kuparinen, J. and Mäkelä, K. 1995. Bacterioplankton growth associated with physical fronts during cyanobacterial bloom. Marine Ecology Progress Series 116: 233-245.

Kononen, K., Kuparinen, J., Mäkelä, K., Laanemets, J. Pavelson, J. and, Nõmmann, S. 1996. Initiation of cyanobacterial blooms in a frontal region at the entrance to the Gulf of Finland, Baltic Sea. Limnol. Oceanogr. 41: 98-112.

In 1996 the project started a new phase, now concentrating on the effect of turbulence on the cyanobacterial bloom dynamics. This phase intends to be a joint multinational project for which funding will be applied from the EU.

Summary of conclusions on term of reference 2

1. The Working Group considered the history of the Pilot Studies and the fact that the planning, in several cases, did not lead to substantial implementation of international projects. Nevertheless, it was felt that this situation was not a negative development. Rather, it was felt that the proposed pilot studies were a valuable conceptual tool to assess the status and scope of our understanding of the dynamics of harmful algal blooms. The planning exercise served to clearly delineate critical gaps in our knowledge and techniques. Several studies were initiated in response to the planning discussions (*i.e.* measurement of species-specific *in situ* growth rates, development of intercalibration exercises,organization of a ICES-IOC modelling Workshop...) and diverse national projects on autoecology and population dynamics of noxious species, that include the microscale components of the pilot projects, have been initiated. These pilot studies have also helped to stimulate and focus the development of the US national research plan (ECOHAB). Projects proposals associating different countries were not successful in the EU-MAST III call for proposals, like "Advection Ecology". Since international funding was not available, pilot studies could only be split into national projects.
   In the case of the Gulf of Maine Pilot Study, no information was presented at this meeting in the absence of the appropriate people due to time constraints. Information on the Baltic Pilot Study were provided by Dr. K. Kononen by mail and not presented orally before the group. This report is included in the WG report.

2. Discussion of the role of modelling and the assessment of our understanding of the dynamics of HAB's led to the conclusion that detailed modelling of blooms is necessary. The function of models is to provide a quantitative framework to assess the role of the different biological and physical processes in the population dynamics of harmful algae. In some cases, useful management advice can be derived from presently available tools. Advice is not available in some cases but examples for risk assessment and decisions concerning management of monitoring and early warning services were presented. For instance, a March monitoring of *Alexandrium minutum* cysts in the silt of 30 bays along Brittany coast has allowed to define an optimized summer sampling scheme taking into account only the zones where some cysts were detected. Of course, this procedure cannot be applied directly to any coastal zone, but this example shows clearly how scientific advice may be provided, even in the absence of a comprehensive knowledge of the bloom dynamics.

3. A fundamental aspect for monitoring/management purposes is often to know where blooms originate, for instance, offshore or *in situ*. Where there are upwelling systems present (even weak ones) relaxation of upwelling brings blooms of offshore origin rapidly inshore, thereby impacting valuable resources. Cross-shelf transport of the different biological constitutents by physical processes is important. Two challenges concerning this transport to understand 1) the circulation dynamics and 2) the processes in pycnoclines, for the development of HAB populations. Algae often concentrate therein, where some organims have elegant strategies to exploit the hydrographic structures. Secondary effects can be important, also, such as development of diatom blooms (e.g. *Skeletonema*) which are necessary to condition the water to permit certain dinoflagellates (e.g. *Ceratium*) to bloom. New results were presented on the potential role of Putrescine (a water soluble polyamine produced by decomposition of organic matter) which were shown to act as a growth factor at concentrations comparable to those measured *in situ*.

4. The small scale physics of buoyant plumes are not sufficiently well known (or sampled) to permit realistic modelling of biological processes in them. Fine-scale (km's horizontally and m vertically) structure needs more work, in particular the development of methods to map physical and biological properties across pycnoclines, fronts and other structures.

5. The horizontal coherence of horizontal physical/biological structures needs more work.
Observations of aggregates in blooms have shown that aggregates lie along surfaces. Surface tension and adhesion should be investigated as a factor in both aggregation and association with pycnoclines and other surfaces.More work should be done on measuring viscoelasticity (rheology) of seawater. Also the implications of new data on polymeric viscoelasticity should be assessed and modelled in relation to blooms dynamics, in particular: 1) turbulence modification, 2) aggregate formation and breakup, 3) phytoplankton dynamics, and 4) grazing modification.

6. Study of how grazers exploit concentrated patches of prey, and the inverse, how prey algae, particularly in patches, produce anti-grazer substances, perhaps reducing diffusion, is required. More work is needed on control of grazer populations by non-lethal processes. More behavioural studies are needed on organisms in relation to vertical and small-scale migration. In some cases, a critical concentration of algae appears necessary to suppress grazing: it should be investigated in other cases. Mechanisms of concentration of algae need to be studies as part of the same problem.

7. Nutrient enrichment in relation to harmful algal blooms is discussed in WGPE

8. Determination of the Nitrogen budget, emphasizing fluxes rather than stocks, has been critical to understanding high biomass *G.* cf. *nagasakiense* bloom dynamics. The unknown relationships between blooms and sources of different nutrients (including dissolved and particulate organics) cannot be deciphered by relying on conventional wisdom in the absence of definitive measurements of fluxes.

9. Work on *G.* cf *nagasakiense* is making excellent progress, despite the lack of a coherent plan internationally. In this case, coordination was started by a call for proposals issued by the French National Programme on HABs.It has worked well and this may a good method to launch focused programmes on specific species.

10. The Working Group should have more participation by physical oceanographers. Delegates should be encouraged to send hydrographers in addition to biologists to the meeting.

Term of reference 3

collate and discuss national reports on HABs and initiate a synthesis of the national reports of the last ten years, and map outbreaks and compile time series of HABs in the ICES area

In the first three months of 1995 on Northern Europe, from the heavy rainfalls records, one was tempted to predict high occurrences of harmful algal events. No effect of these huge rainfalls can be deduced from national reports of European countries.

The compiled national reports are appended in Annex III . Country members presented a summary of their respective national reports. In the discussion following, it was agreed that the information provided in the reports could be modified slightly, but so far **they constitute the only available information on harmful events in the ICES domain and is quite often consulted** by managers and administrators. It was decided to make one addition to the format in which national reports are presented so that toxin levels, when relevant, are lso specified.

The group felt that an outline map should be added to the report to indicate the location of each event recorded. An example is attached.

Canada

Although PSP toxins were detected along the west coast, the St. Lawrence Estuary and the Bay of Fundy toxin levels tended to be unusually lower than previous years. For all areas except for the Bay of Fundy, Domoic acid, produced by *Pseudo-nitzschia pseudodelicatissima* was detected in shellfish from the southernmost Bay of Funday and resulted in the closure of shellfish harvesting areas during early September. This is the first time since 1989 that shellfish areas have been closed as a result of domoic acid since 1988 in the Bay of Fundy.

Denmark

Exceptionally high phytoplankton biomasses and concentrations were registred in the summer period, especially in the fiords. The biomasses were dominated by dinoflagellates (*Gymnodinium sanguineum*, *Prorocentrum minimum* and *Ceratium tripos*) and diatoms (*Skeletonema costatum* and *Dactyliosolen fragilissimus*). Neither DSP, PSP, ASP nor fish kills due to HABs were observed.

Death of cockles (*Cardium edule*), with the meat disconnected from the shells, was observed in August in the Limfjorden. The event coincided with a large bloom of the potentially toxic dinoflagellate *Gymnodinium sanguineum* (max. conc. 144000 cells/L) as well as low concentrations of *Gyrodinium aureolum* (2800 cells/L) during a period with oxygen deficiency. It has not been solved wether the death was a result of intoxication or of oxygen depletion. However, coincidence of a *G. sanguineum* bloom and such an observation has already been observed in US.

Finland

Toxic blooms of *Nodularia spumigena* producing nodularin occurred in the eastern part of the Gulf of Finland in August.

France

DSP toxicity (*Dinophysis* spp) affected few areas in 1995, rather less than in 1994. PSP toxicity (*Alexandrium minutum)* was recorded in the same two areas than the last years. The most important event in 1995 was the very extensive bloom of *Gymnodinium* cf . *nagasakiense*, along a great part of the Atlantic coast, from May to September, which led to massive kills of all sorts of marine animals. The presence of hemolytic toxins was observed in water and the consequences were very important for fisheries.

Ireland

DSP toxicity affected the southwest coast. *Gymnodinium* cf. *nagasakiense* was reported without any mortalities. An unknown toxin has been detected in mussels with DSP-like symptoms and toxicity persisted 5 months.

Latvia

In the gulf of Riga, from a long-term study (1972-1995), a significant increase of occurrence and abundance of harmful cyanobacteria and *Dinophysis acuminata* has been observed since the end of 1980ies.

The Netherlands

No DSP toxins have been detected in local mussels in 1995. *Pseudonitzchia pungens* f. *pungens* occurred regularly. No specimens of f. *multiseries*, nor the presence of domoic acid were found.

Norway

The occurrence of recurring harmful algae along the Norwegian coast *i.e. Alexandrium* spp., *Dinophysis* spp., *Gyrodinium* cf. *aureolum, Chrysochromulina* spp. and *Prymnesium* spp. in 1995 was below the average for the last ten years and so were associated events. The exceptional flood of local rivers in May and June brought high amounts of fresh water and nutrients to the southeast coast of Norway. This caused temporary and local enhanced biomass of phytoplankton, mainly diatoms.

Portugal

Domoic acid was detected for the first time in May in smooth callista (*Callista chione*) with shellfish areas closed to harvesting due to toxin levels in excess of the regulatory limit of 20 µg/g established by Canada. The organism responsible was *Pseudo-nitzschia australis*.

Russia

Time-series (1982-1995) of phytoplankton in the eastern Gulf of Finland are available and show that cyanobacteria compose up to 90% of total algal biomass. Due to low salinity, potentially toxic species from the Baltic proper have never been abundant in the eastern part of the Gulf of Finland.

Spain

On the Mediterranean coast, *Gyrodinium corsicum* occurred without any fish kills and PSP, for the first time, was recorded in Balearic Islands due to *Alexandrium minutum*. On the Atlantic coast, ASP was detected and associated to *Pseudo-nitzschia*. DSP toxicity was due to *Dinophysis acuminata, caudata* and *acuta*.

Sweden

In the Skagerrak and Kattegat area ther were no exceptional phytoplankton blooms in 1995. From October to the end of the year, however, cell densities of *Dinophysis* spp. were higher than normal.
Okadaic acid concentrations in mussels were in some places along the Swedish Skagerrak coast between 40 and 80 µg/100 g mussel meat in January and February. In the Goteborg area, January concentrations ranged between 40 and 140 µg okadaic acid/ 100 g mussel meat and along the Kattegat, January concentrations ranged between 40 and 75 µg okadaic acid/ 100g mussel meat. In all areas, the concentrations decreased during spring and very low values were measured between June and September. In October, an increase of the concentrations were again observed.

In the Baltic Sea, along the south coast of Sweden a bloom of *Coscinodiscus* cf. *radiatus* clogged fishing nets in October. No toxic effects were observed.
Blooms of cyanobacteria were common all over the Baltic Sea in August. In some cases, toxicity was measured. The death of a dog and a swan may be linked to toxic cyanobacteria. However, autopsy was not performed.

USA

No unusual event was recorded, other than fish kills in North Carolina, due to *Pfiesteria piscicida* and a very long red tide in Florida

Term of reference 4

review the updating of the ICES Cooperative Research Report n°181 on the "Effects of HABs on mariculture and marine fisheries" carried out in the intersessional period

The ICES Cooperative Research Report N° 181 on " Effects of Harmful Algal Blooms on Mariculture and Marine Fisheries" was not reviewed for the following reasons. There was a delay of three years in publishing the original report. It was completed in 1989 and published in 1992. In addition, the IOC manuals and Guides N° 33, "Manual on Harmful Marine Microalgae" and the IOC Technical Report N° 44, "Design and implementation of Harmful Monitoring Systems" address many of these issues. These two reports are in print and soon to be released.

Term of reference 5

discuss items related to the monitoring of HABs based on the compilation of answers to the IOC-ICES questionnaire, and considerations by the IOC-FAO Intergovernmental Panel (IPHAB), in order to give advice on further activities, including planning of an international workshop on HAB monitoring and mitigation strategies

The Working Group members considered :

1 - the report on monitoring of HABs based on the compilation of answers to the IOC-ICES questionnaire distributed in advance by H. Enevoldsen,

2 - the report of the meeting (Washington 7-8/01/96) of the IOC IHAP Task Team on the Design and Implementation of Harmful Algal Bloom Monitoring .

The answers of the IOC-ICES questionnaire were compiled by Bio/consult, Denmark, into the IOC Technical Report N° 44, "Design and Implementation of Harmful Algal Monitoring Systems". This report was prepared by some members of the ICES-IOC WGHAB, but does not necessarily reflect the views of ICES, IOC or all members of the Working Group. Concern was expressed as the title of the report could be misleading since it is actually a compilation of how some countries manage their existing harmful algal monitoring programmes as derived from the questionnaire. It is not the intent that it be considered strictly as a manual for design of future programmes, nor a compilation of all important monitoring programmes.

The planning of an international workshop on HAB monitoring and mitigation strategies was discussed. Alternate locations for the meeting included Argentina, Venezuela and Uruguay. It was suggested to have the meeting in February 1998. There were also suggestions to slightly modify the title and structure of the workshop and narrow its scope to monitoring and managing harmful algal events.

Term of reference 6

review and discuss recent work on the effect of harmful algae on zooplankton, including discussion of methods to be applied in these studies.

Jefferson Turner and Serge Poulet presented overviews before the entire working group of some aspects of interactions between harmful marine phytoplankton, zooplankton and higher trophic levels. This stimulated subsequent discussions within the group, which were summarized, discussed: their summary is reported here.

Turner noted that the reasons for phytoplankton toxicity may not necessarily be for grazing deterrents. If toxins were primarily antifeedants, they would be expected to act primarily upon zooplankton which are main phytoplankton grazers, rather than upon higher consumers such as shellfish, fish, birds or humans. There are also a variety of phytoplankton toxins with different effects upon vertebrate *vs.* invertebrate nervous systems. Some toxins are sodium ion channel blockers (PSP, ciguatera), others are activators (NSP, ciguatera), some cause neurological damage (domoic acid, *Pfiesteria piscicida* toxin), and others have other effects on membranes, or gastrointestinal systems (DSP). Some are water soluble (PSP, domoic acid), whereas other are lipid soluble (NSP, ciguatera, DSP). Other suggested roles of phytoplankton toxins include nucleic acid synthesis, precursors for subcellular organelles, cell wall degradation products, nitrogen storage, or inhibition of competing phytoplankters.

Turner reviewed modes of intoxication of grazers of toxic phytoplankton. There has been direct intoxication of copepods, phytoplanktivorous fish or bivalves from ingestion of toxic phytoplankton. There has also been vectorial intoxication, caused by eating grazers of toxic phytoplankton. This is known for fish that ate herbivorous copepods, sea birds that ate phytoplanktivorous fish, or whales that ate toxin-laden fish that had probably eaten toxin-laden zooplankton.

Effects of toxic phytoplankters on grazers are varied and inconsistent. Turner reviewed effects on metazoan grazers, including mortality of copepods or fish larvae due to direct or vectorial intoxication, refusal of copepods, rotifers or bivalves to eat toxic phytoplankters, regurgitation of toxic phytoplankton by copepods, reduced development and survival rates for copepod nauplii fed upon toxic phytoplankton, and lethargy or paralysis of copepods or fish after direct or vectorial intoxication. Effects of toxic phytoplankton on protists include backwards swimming of tintinnids, reduced tintinid growth rates or death of tintinnids upon exposure to various toxic phytoplankters. Conversely, there are numerous cases of no apparent adverse effects from ingesting toxic phytoplankton in some copepods, euphausiids, tintinnids, rotifers, and heterotrophic dinoflagellates.

Turner noted that impacts of grazing upon development and persistence of toxic phytoplankton blooms are varied and situation-specific. By definition, a large bloom of toxic phytoplankton implies inability of the grazer community to control phytoplankton bloom development; when grazers control blooms, blooms do not occur, and grazing goes unnoticed. Community grazing impact depends upon individual animal grazing rates (which can be affected by temperature and phytoplankton community abundance and composition), abundance and composition of zooplankton in the grazer population, and rates of increase of toxic phytoplankton due to growth and/or physical concentration. Community grazing by copepods and polychaete larvae was incapable of preventing spring blooms of *Alexandrium tamarense* in Cape Cod embayments, but grazing contributed to bloom decline. Conversely, copepod grazing in Japanese coastal waters could retard initial development of a bloom, but once established, the bloom was immune to grazing. In other cases, such as brown tides in Narragansett Bay, Long Island embayments, and Texas estuaries, blooms appear to have been ungrazed at several trophic levels. There is little information on grazing upon toxic phytoplankton during natural blooms when other non-toxic phytoplankton are abundant. Most studies of grazing have used unialgal cultures of toxic phytoplankters as diets. Since "selection" for or against toxic phytoplankters is a function of not only the behavior of the grazers, but also the relative proportions of different components of the phytoplankton community. Thus, most grazing studies with unialgal diets may have limited applicability to natural blooms. There are indications that the impact of protistan grazers may be substantial in triggering or causing the declines of several blooms.

Turner noted that responses of certain grazers to different blooms or clones of toxic phytoplankton are quite varied. Examples include studies in which some copepods either fed upon *Gymnodinium breve* with no apparent adverse effects during a natural bloom off North Carolina, but in the laboratory, certain copepods either exhibited regurgitation or lethargy when feeding upon the same dinoflagellate. Such variability is likely due to variations in potency and concentration of toxins, which may be due to differences in culture growth phase, culture conditions, or nutrient levels.

Turner mentioned several potential trophic complications affecting blooms of harmful phytoplankton caused by animals that may not be direct grazers. For instance, predation upon protists by metazoan omnivores such as copepods may actually reduce grazing pressure upon brown tide algae or single cells of *Phaeocystis*, by reducing abundances of the heterotrophic protists that are major grazers of these algae. Also, if a phytoplankter such as *Heterosigma carterae* inhibits its competitors such as *Skeletonema costatum* by allelopathy, *H. carterae* may bloom instead of *Skeletonema* even though the diatom can outgrow the flagellate. Further, if ctenophore predation does not substantially reduce copepod abundance, copepod grazing upon *Skeletonema* can remove this diatom as a competitor for *Heterosigma*.

Poulet noted that various phytoplankters may affect grazers through ingestion, digestion, fecundity or viability of reproductive products. For instance, some phytoplankters that are well-ingested and -digested may not be good for egg production and/or egg hatching in copepods. Also, for various phytoplankton taxa, Poulet noted that characteristics related to zooplankton grazing may be physical, such as concentration, size, ornamentation, or thickness of cells, or chemical or mucus, toxins, repellants, nutrient dificiency or egg hatching or embryonic inhibitors. Modes of action of various harmful phytoplankton on grazers may include short-term responses (seconds to hours) such as rejection prior to ingestion, poisoning after ingestion, or alterations of swimming behavior. Indirect, long-term responses over days to months, include alterations of growth and mortality rates, with subsequent effects on community demography. Poulet also emphasized that such responses are highly species dependent, in terms of both phytoplankton and grazer species.

Poulet outlined various methods for observing responses of grazers to harmful phytoplankters. Included, for direct observations, were bioassays, measurements of rates of feeding, growth, egg production, egg hatching, and mortality, and studies of behavior using video and/or film recording, and electrophysiology such as impedance. Indirect observations could include scanning electron microscope observations of contents of fecal pellets, and chemical, cellular or morphological studies. Field observations might include *in situ* filming, and simultaneous sampling of relative spatial and temporal distributions of phytoplankters and their grazers, and physical/chemical parameters, preferably using non-invasive techniques.

Subsequent discussions included effects of benthic grazing, grazing by meroplanktonic larvae, and different developmental stages of zooplankton, such as copepod nauplii compared to adults. It was also noted that there can be different effects of intracellular toxins that are ingested, and extracellular products that are exposed to zooplankters as ectocrines.

There was considerable discussion on the value of adding zooplankton sampling efforts to monitoring programs focused on toxic or otherwise harmful phytoplankton blooms. It was stated that, in most cases, for the time being, this could not be implemented on a routine basis due to economic considerations but rather as research programs using data from a monitoring network.

The major questions concerning the role of zooplankton in bloom dynamics to be addressed are:
1) are grazer populations controlling blooms?
2) are blooms impacting recruitment of grazer populations?
3) are phycotoxins transvectored through grazers to higher trophic levels?

The answers to these questions for a given bloom are likely variable and situation-specific. Although we would optimally like to address all three questions simultaneously, the relative level of effort used to address various combinations of these questions is frequently dependent upon management/economic considerations for a given geographic areas or fishery resource. Further, there are substantial impacts other than just vectorial transport of phycotoxins. For instance, harmful algal blooms may impact younger developmental stages of ecologically- or economically-important species, such as shellfish.

Term of reference 7

examine feasibility, of, and potential contributions to an Environmental Status Report for the ICES Area on an annual basis, and report to ACME by the end of 1995.

The purpose of plotting events on maps is to obtain a global and visual overview of harmful evnts for the preceeding ten years.

Information to be plotted on maps include :

* indication of regular monitoring sites
* indication of the frequency of harmful events during the last ten years.

Different types of events are:
DSP, PSP, ASP, NSP, CFP, cyanobacteria toxicity, animal and plant mortality (wild and cultured), or other observed toxic effects. The information plotted should concern the presence of toxins, or observations of animal or plant mortality if detected, regardless of the level of toxicity.

Details on responsible species, toxins and year of occurrence being given in the NATIONAL REPORTS, should not appear on the maps. Blooms of potentially toxic species with non detectable levels of toxicity will been omitted from the maps.

DSP, PSP, ASP and cyanobacteria toxicity will be presented on separate maps, whereas NSP and CFP may be combined for the ten year period.
Each map will include:

* A thickened coast line for all regions with regular monitoring.

* Circles of up to 3 different sizes, depending on the number years an area or zone that was affected. For example:
  sampled, but no toxins detected in the ten years (open circles).
  one time (one year) during the ten year period
  2-5 times during the period
  6-10 times during the period

For uniformity, the "zones" or areas should represent the same length of coast line. A length of 50 km is recommended, with changes when necessary to preferably 25 and 75 km.
In conclusion 10 different maps will be generated (5 for Europe and 5 for North America) for the following events:

DSP
PSP
NSP and ASP
animal and plant mortalities
cyanobacteria and other toxic effects

The maps could be updated annually and be included in the appendix of the WGHABD.
When adding a year, the first year of the last 10 year period is deleted resulting each year in maps of the last 10 years.

It has been decided that each participants should send To C. Belin before the 1rst of June, the information to finalize these maps for the period including 1986-1995. Data will be entered on a GIS (Arcview, ArcInfo).
Examples of presentation maps are presented in Annex V.

Term of reference 8

elaborate recommendations about priorities in new research or intiatives to minimize transfer of harmful phytoplankton by ballast waters. These recommendations should be forwarded to WG-ITMO in time for their meeting in Gdynia

Due to financial or time-constraints, specialists of cyst investigation could not attend the meeting; therefore, recommendations are probably not exhaustive and should be reexamined at the next Working Group meeting. Two contributions to this ToR are appended in Annex IV.

In order to limit introduction of harmful algal species by ballast water, the Working Group on Harmful Algal Bloom Dynamics recommends that:

1- local algal populations in harbours where ballast water may be pumped be investigated
2- the problems of ballasting at sea be considered not only in terms of safety and cost, but also in terms of effectiveness
3- the deposition of cysts in ballast sediment be investigated
4- physical or chemical treatments commonly envisaged be listed in order to define their effectiveness in terms of algal cysts
5- harmful algae and their resting stages be added to the list of species for concern.

The WGHABD considers that mollusk shipments may help in the spreading of cysts of harmful algae.

These recommendations have been forwarded to WG-ITMO the 20 of April for their meeting in Gdynia.

Recommendations, Proposals of Terms of Reference for next year's Meeting

The group suggested to meet in late March, early April 1997 at ACRO in La Roche Canillac (France) where Dr. Ian Jenkinson kindly proposed to host the group. Individual contributions from oceanographers and microphysicists on items focused on advection, shelf-sea transport, buoyant plumes microphysics and fine scale structures are thought to be preferable to a joint group meetings with WGSSO for next year. A special theme session on this subject is proposed for the 1997 Annual Science Conference.

The Working Group on Harmful Algal Blooms Dynamics recommends that :

Proposed terms of reference for 1997 meeting:

- examine the results of the workshop on "Development of *in situ* growth rate measurements for dinoflagellates" and consider their publication
- collate the National Reports in the usual form
- review the mapping exercise and propose a format for inclusion in an ICES Environmental Status Report.
- establish recommendations concerning the limitation of transfer of harmful phytoplankters through ballast water discharges.
- define a methodology for an estimation of the impact of grazers on a given HAB and impact of HAB on recruitment of grazer populations and assess the experimental biases inherent in each method
- evaluate the role of microorganic nutrient dynamics and heterotrophic interactions in the initiation and maintenance of HAB
- evaluate and assess the use of remote and in situ optical sensing technology in HAB dynamics studies.

Working Group on Harmful Algal Boom Dynamics
(IOC-ICES WGHABD)

ANNEX I

- List of participants -

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Working Group on Harmful Algal Boom Dynamics
(IOC-ICES WGHABD)

ANNEX II

- AGENDA -
WG- HABD
17-20 April 1996

Wednesday, the 17th

09h30 Opening of the meeting
List of Participants
Discussion and adoption of the Agenda
General discussion and organization (nomination of a rapporteur)

Terms of reference §1
complete and discuss the logistic planning of the ICES/IOC Workshop on development of in situ growth rate measurements from 9 to 15 September 1996, and examine the results of intersessional progress;

§3
collate and discuss national reports on HABs and initiate a synthesis of the national reports of the last ten years, and map outbreaks and compile time series of HABs in the ICES area;

§7
examine feasibility, of, and potential contributions to an Environmental Status Report for the ICES Area on an annual basis, and report to ACME by the end of 1995.

§ *Cyst item*
- general discussion
- Subgroups for items 1 & 3(7)

14h00 SubGroups work on the workshop
- on National reports,
- on Cysts ballast water transfers.

Thursday, the 18th

09h00 ToR 2 : *continue the development of an understanding of the dynamics of harmful, including presentation of new experimental results.*

Presentations (non-limitative list)
* What's new in Pilot Studies?
* Bio-physical control of HAB (Donaghay and Osborn)
* Control by viscosity (Jenkinson)
* Bloom inoculation in the Bay of Biscay (Gentien)
* Biomass measurement by LIDAR (Palucci)
* Nutrient fluxes in mixed and stratified water columns (Morin)
* The role of polyamines as growth factors for dinoflagellates (Videau)
* Toxic transfer from phytoplankton to zooplankton (Turner)

General discussion :

14h00 Sub group meetings : ToR 2
ToR 1
ToR 3

Friday, the 19th

09h00 Presentation of ToR 6 : *review and discuss the effect of harmful algae on zooplankton, including discussion of methods*
ToR 5 : *discuss items related to the monitoring of HABs basd on the compilation of answers to the IOC-ICES questionnaire and considerations by the IOC-FAO Intergovernmental Panel, in order to give advice on further strategies, including planning of an international workshop on HAB monitoring and mitigation strategies*
ToR 8 : *recommendations to ITMO in terms of limitation of the risks in cyst ballast water transfer, including monitoring*

14h00 Sub groups meetings

Saturday, the 20th

Presentation and adoption of the sub-groups reports
A specific effort will have to be put on item 8

Working Group on Harmful Algal Boom Dynamics
(IOC-ICES WGHABD)

ANNEX III

- 1995 National Reports -

Canada
Danmark
France
Finland
Ireland
Latvia
The Netherlands
Norway
Portugal
Russia
Spain
Sweden
USA

Harmful Algal Events in 1995 - Canada
Domoic Acid

1. Location: Bay of Fundy

2. Date of Occurrence: Late August - mid September, 1995.

3. Effects: The highest level of domoic acid measured was 106,1 µg/g in *Mytitus edulis* on Sept. 2, 1995 at Lepreau Harbour.

4. Management Decision: Shellfish harvesting areas in the south-western Bay of Fundy were closed to harvesting due to levels of domoic acid exceeding the regulatory limit of 20 µg/g.

5. Causative Species: *Pseudo-nitzschia pseudodecatissima.* Cells were observed throughout the year with highest concentrations observed during June and August. Highest concentrations observe during 1995 were 1,374,144 cells/liter on August 28 at an offshore sampling location at the Wolves.

6. Environment: Temperature range: 8-12°C, Salinity - 32 ppt, Water Column - mixed.

7. Advected Population or in situ Growth: In situ as well as advected.

8. Previous occurrences: Although *P. pseudodelicatissima* has been observed annually in the Bay of Fundy, the only other year that shellfish harvesting areas were closed to harvesting was during 1988.

9. Additional Comments:

10. Individual to contact :

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Harmful Algal Events in 1995 - Canada
Domoic Acid

1. Location: Gulf of St. Lawrence

2. Date of Occurrence: October, 1995.

3. Effects: The highest level of domoic acid measured was 4,6 µg/g in *Mytitus edulis* on October 18, 1995 at New London Bay.

4. Management Decision: No toxins in shellfish exceeded the regulatory limit of 20 µg/g. Therefore there were non closures due to domoic acid.

5. Causative Species: *Pseudo-nitzschia multiseries*. Although observed through the Gulf of St. Lawrence, highest concentrations were observed at New London Bay (438,000 cells/liter) on October 18, 1995.

6. Environment:

7. Advected Population or in situ Growth: In situ as well as advected.

8. Previous occurrences: Domoic acid was first detected during 1987 in the Gulf of St. Lawrence and domoic acid has been detected most years since.

9. Additional Comments:

10. Individual to contact :

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Harmful Algal Events in 1995 - Canada
Paralytic Shellfish Poisoning

1. Location: Bay of Fundy

2. Date of Occurrence: The majority of the shellfish harvesting areas were closed to harvesting for some time between late May - mid August.

3. Effects: The highest level of paralytic shellfish poisoning toxins were measured at Crow Harbour on July 27, 1995 (2600 µg/100g in *Mya arenaria*).

4. Management Decision: Shellfish harvesting areas in the southwestern Bay of Fundy were closed to harvesting due to levels of psp toxins exceeding the regulatory limit of 80 µg/100g. The Bay of Fundy is closed year round to the harvesting of blue mussels.

5. Causative Species: Alexandrium fundyense. Cells were observed from mid May to late August with highest concentration observed during 1995 (28,600 cells/liter) on July 17 at an inshore sampling location at Deadmand Harbour.

6. Environment: Temperature range: 8 - 12°C, Salinity - 32 ppt, Water Column - mixed.

7. Advected Population or in situ Growth: Advected.

8. Previous occurrences: Shellfish harvesting areas are closed to harvesting annually (generally during summer months) in the Bay of Fundy due to unsafe levels of psp toxins in shellfish tissues.

9. Additional Comments:

10. Individual to contact :

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Jlmartin@sta.dfo.ca (e-mail)

Harmful Algal Events in 1995 - Canada
Domoic Acid

1. Location: Gulf of St. Lawrence

2. Date of Occurrence: June - October, 1995.

3. Effects: No PSP toxins were detected.

4. Management Decision: None.

5. Causative Species: *Alexandrium tamarense*. Although observed at various locations, the highest levels detected were 5600 cells/liter in northern New Brunswick.

6. Environment:

7. Advected Population or in situ Growth:

8. Previous occurrences: PSP toxins are occasionally detected in shellfish from this region - but not annually.

9. Additional Comments:

10. Individual to contact :

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Gulf Fisheries Center
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Canada, B1C 9B6
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arseneaulte@gfc.dfo.ca (e-mail)

Harmful Algal Events in 1995 - Canada
Domoic Acid

1. Location: Various sites in Newfoundland coastal waters

2. Date of Occurrence: Various times in 1995.

3. Effects: No PSP toxins were detected.

4. Management Decision: None.

5. Causative Species: *Alexandrium fundyense*. Although observed at various locations, no toxins were detected in shellfish.

6. Environment:

7. Advected Population or in situ Growth: Unknown.

8. Previous occurrences: PSP toxins are occasionally detected in shellfish from this region - but not annually.

9. Additional Comments:

10. Individual to contact :
J. Conrad Powell
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NAFC, Inspection Services Branch
St. John's, Newfoundland
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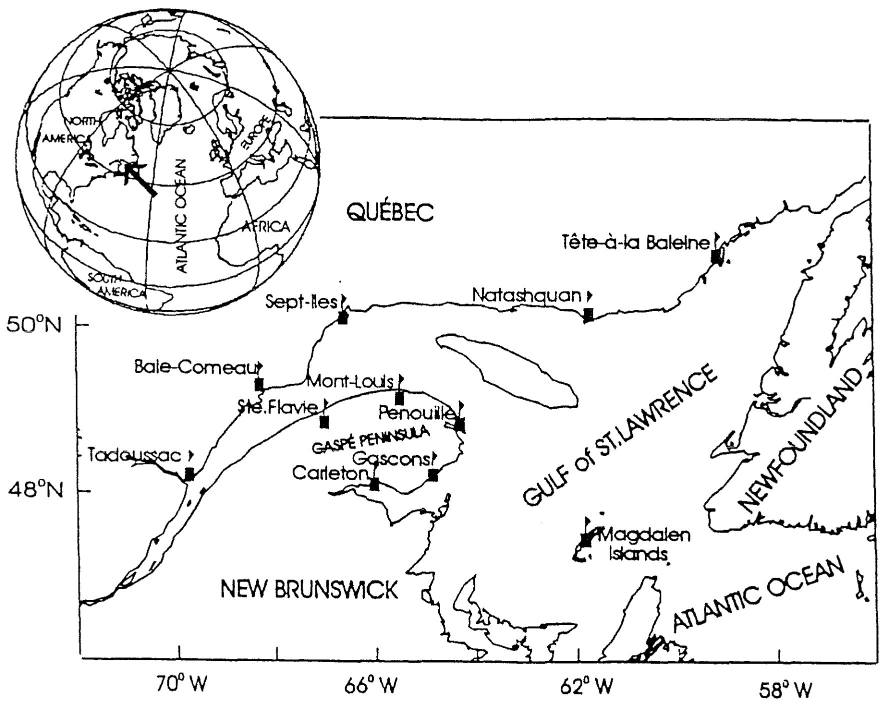
HARMFUL ALGAL EVENTS IN CANADA - 1995
QUEBEC REGION

1. **Location:** Harmful algae are monitored on a weekly basis at 11 stations in the Gulf of St. Lawrence since 1989 (Figure 1).



2. **Date of Occurrence:** Eight potentially harmful species have been found at the eleven coastal stations. Location and date of maximum occurrence are presented in Table 1.

Species	Stations	Dates	Maximum abundances (cells l^{-1})
Alexandriun tamarense	Penouille	June 12	2680
Alexandrium ostenfeldii	Penouille	June 12	1620
Dinophysis acuminata	Mont-Louis	August 02	1720
Dinophysis norvegica	Carleton	June 25	3660
Prorocentrum lima	Havre-aux-Maisons	August 30	2600
Prorocentrum minimum	Tête à la Baleine	August 27	5280
Pseudo-nitzschia delicatissima	Tête à la Baleine	August 20	91306
Pseudo-nitzschia seriata	Ste-Flavie	August 15	120680

3. **Effects:** Paralytic shellfish toxins concentration have exceeded 80 µg STX equi./100 g (as determined by the mouse bioassay technique) at several stations.

4. **Management decision:** Shellfish areas with paralytic shellfish toxins concentration exceeding 80 µg STX equi./100 g (as determined by the mouse bioassay technique) were closed to harvesting during variable periods of time during summer months.

5. **Causative species:** *Alexandrium tamarense* and *Alexandrium ostenfeldii*.

6. **Environment:** The year 1995 was atypical. The summer period was very sunny and warm with little precipitation. These special climatic conditions seem to have influenced the phytoplankton assemblage since unusually low concentrations of *Alexandrium* spp. and shellfish toxicity were observed.

7. **Advected population or in situ growth:** in situ growth.

8. **Previous occurrences:** PSP toxicity has been measured by the mouse bioassay technique on a regular basis since 1961 in the St. Lawrence. Algae are monitored at the coastal stations only since 1989.

9. **Individuals to contact:**

Phytoplankton

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Shellfish toxicity

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PA 15.04.96

Status of HAB's for Danish waters in 1995

Compiled by Dr. Per Andersen, associated consultant for IOC, Danish Ministry of Fisheries and The Association of the Danish Musselfisheries. Bio/consult as, Johs. Ewaldsvej 42-44, 8230 Aabyhøj, Denmark.
phone. 45 86 25 18 11, fax. 45 86 25 81 73, E-mail: bioconjp@inet.uni-c.dk.

The phytoplankton situation in Danish coastal waters and fjords in 1995 was characterized by high concencentrations and biomasses in the spring and summer periods. During summer the biomasses were dominated by diatoms e.g. *Rhizosolenia fragilissima* and *Skeletonema costatum* and dinoflagellates *Prorocentrum minimum, Prorocentrum micans* and *Gymnodinium sanguineum.* The high biomasses during the summer period were the result of high input of inorganic nutrients from the sediments as a result of oxygen deficiency in the calm and sunny summerperiod.

The following toxic and potentially toxic algae were registred in high concentrations:

Dinoflagellates
Dinophysis acuminata

Prorocentrum minimum
Prorocentrum micans

Gymnodinium sanguineum

where as the following toxic and potentially toxic algae were registred in low concentrations:

Dinoflagellates
Alexandrium ostenfeldii
Alexandrium tamarense

Dinophysis norvegica
Dinophysis acuta
Dinophysis rotundata

Gyrodinium aureolum

Noctiluca scintillans

Diatoms
Pseudonitzschia delicatissima-group
Pseudonitzschia seriata-group

Others
Phaeocystis pouchetii
Chrysochromulina spp.
Nodularia spumigena

No fishkills caused by HAB's were registred in 1995.

Harvesting for mussels were closed or restricted during several periods because of high concentrations of *Dinophysis acuminata* and *Dinophysis norvegica*, figure 1 and 2.

DSP, PSP and ASP were not registred in 1995.

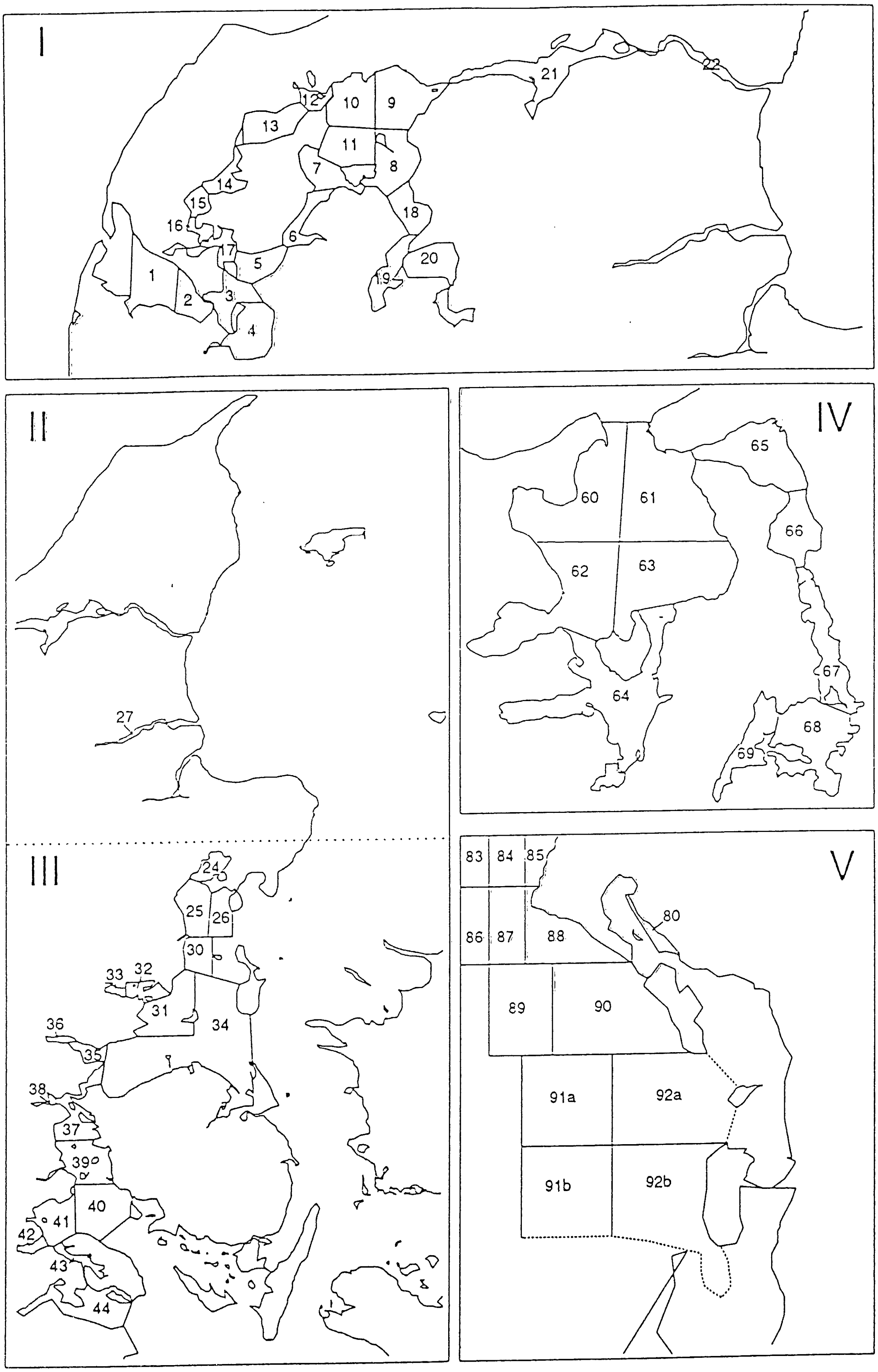


Figure 1. Map showing the different areas used in the monitoring for toxic algae in relation to the Danish musselfisheries, 1995.

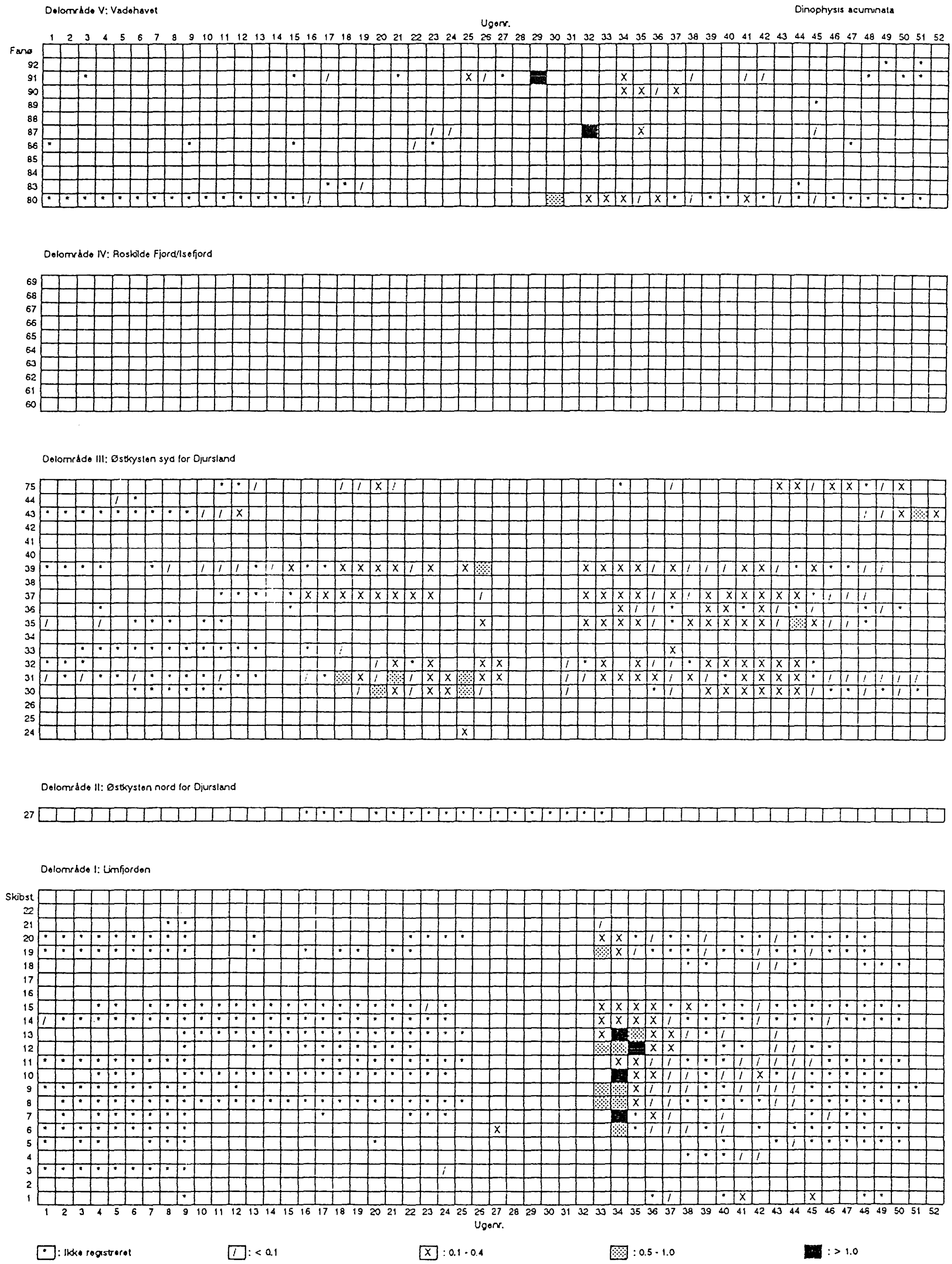


Figure 2. The temporal and geographical distribution of *Dinophysis acuminata* in 1995. NB: Only data from the monitoring programme for toxic algae in relation to the Danish musselfisheries, 1995.

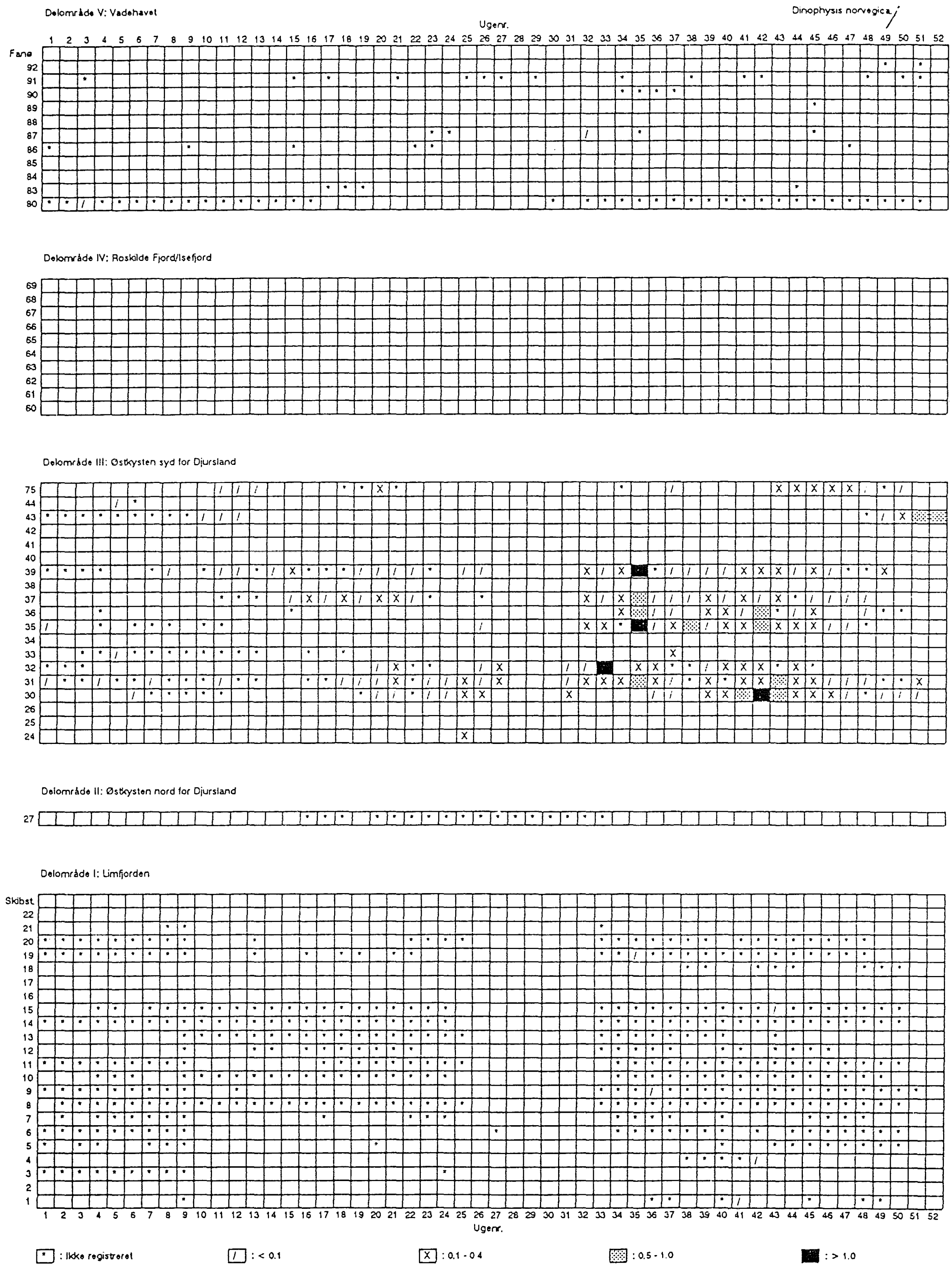


Figure 3. The temporal and geographical distribution of *Dinophysis norvegica* in 1995. NB: only data from the monitoring programme for toxic algae in relation to the Danish musselfisheries, 1995.

FRANCE
NATIONAL REPORT
1995

DSP toxicity (*Dinophysis* spp) affected few areas in 1995, rather less than in 1994 (Fig. 1). Therefore, after the increase of the number of areas affected by DSP toxicity between 1987 and 1991, it seems that there has been a stability since 1991.

PSP toxicity (*Alexandrium minutum*) was recorded in the same two areas than the last years (Fig. 1).

Fish and shellfish mortality

The most important event in 1995 in France was the very extensive bloom of *Gymnodinium* cf. *nagasakiense*, along a great part of Atlantic coast (Fig. 2).

The species which is present in French waters, is similar to three species of *Gyrodinium* or *Gymnodinium*. Its name is consequently : *Gymnodinium* cf. *nagasakiense* = *Gyrodinium* cf. *aureolum* = *Gymnodinium* cf. *mikimotoi*.

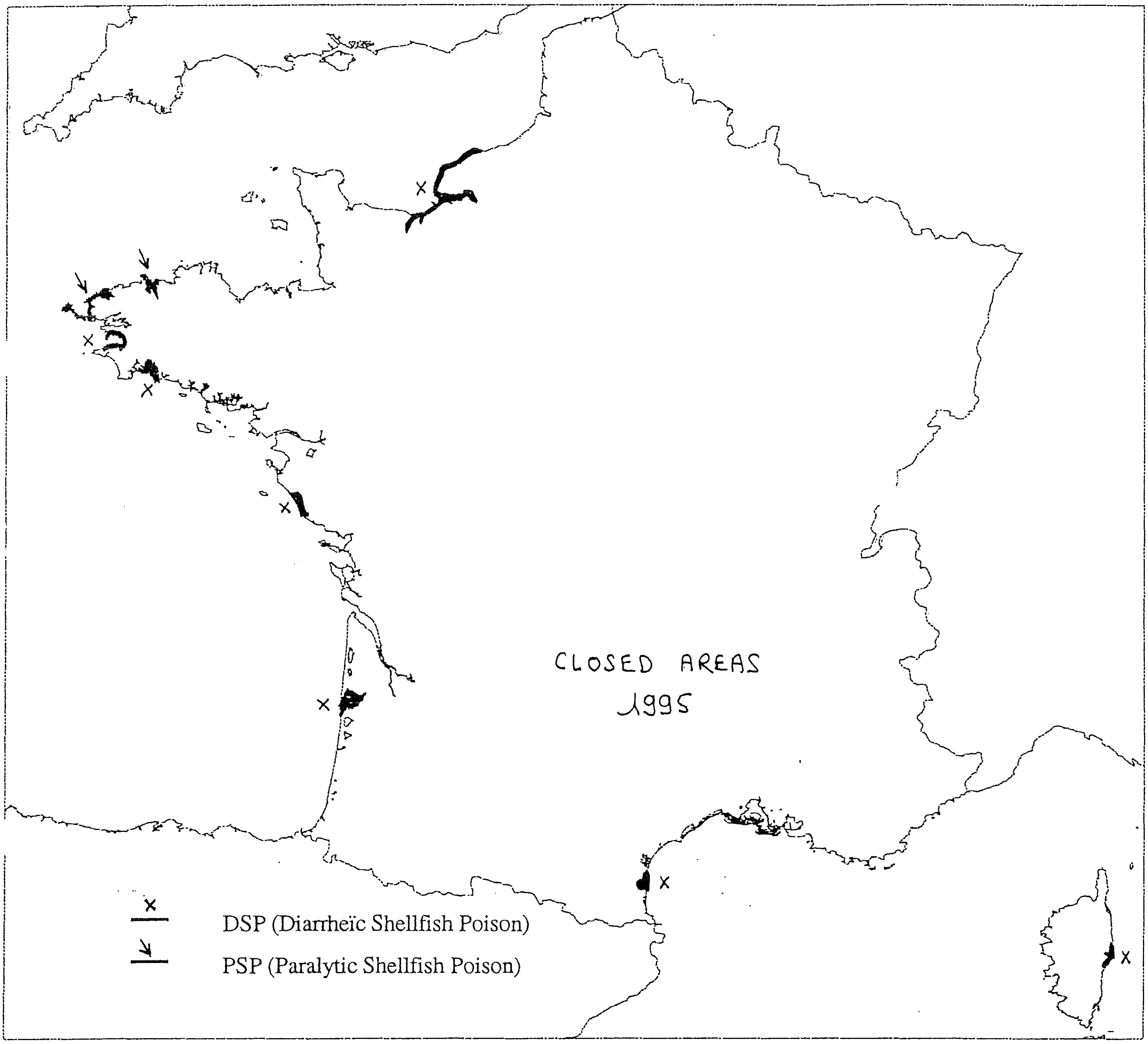
Before 1995, it was primarily observed along the West and South coast of Brittany, and between 1976 and 1987, high concentrations of this species were associated with harmful events for scallops : post-larval mortality, inhibited juvenile growth, "disturbance growth ring" on adult shells.

In June-July 1995, the exceptional blooms along the Atlantic coasts led to massive kills of all sorts of marine animals : fish (wild ones or in cage), shellfish (mussels, oysters...), gastropods, urchins, worms, etc...

The bloom was extremely important, concerning both the aspects of concentration in water (several millions cells per liter), and the geographical spreading (the affected coast was about 800 kms).

The presence of hemolytic toxins was observed in water, several times and in several locations. It seems that, in some cases, mortality was due both to toxins produced by *Gymnodinium*, and to anoxia in the water masses during the bloom ; however, it was showed that, in fish cages and shellfish docks, oxygenation could increase the action of hemolytic toxins.

The first observations were made on late May in Western Brittany, then there was an extension along Southern Brittany (late June), then towards South. The event finished from August to October, depending on the areas. The consequences were very important for mussel fisheries (some of them lost their whole production), sometimes for oysters fisheries, fish in cages, etc...


CLOSED AREAS
1995
DSP (Diarrheïc Shellfish Poison)
PSP (Paralytic Shellfish Poison)

Finland National Report 1995

1. Locations : Gulf of Finland, Baltic proper
2. Date of Occurrence : June, Augst
3. Effects : not reported
4. Management Decision : The public was informed
5. Causative species : *Nodularia spumigena, Aphanizomenon* sp.
6. Environment : open sea and coastal areas
7. Advected population or *in situ* growth : *in situ*
8. Previous occurrences : yerly phenomena in the Baltic Sea
9. Additional comments : In August, the bloom started exceptionally in the eastern part of the Gulf of Finland, where the dominating species were exceptionally *Nodularia spumigena.* The blooms were proven toxic, due to the presence of nodularin
10. Individual to contact :

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FIN-00931 Helsinki
e-mail : algaline@fimr.fi

Monitoring of Harmful Algal Blooms in Ireland 1994, 1995.

A network of sampling stations at sites of both finfish and shellfish production has been established. Water samples for phytoplankton analysis and shellfish samples for toxin analysis are sent to the Fisheries Research Centre Dublin once a month during the winter and once each week during the summer.

The toxic events recorded are described below.

1994

DSP

With the exception of samples from Cork Harbour, DSP toxins were detected in samples from all other areas tested and closures of these areas were put in place. The length of the closure period varied but in the southwest region closures were in place for up to 10 months, from May 1994 - February 1995. This was the first occasion that DSP toxicity persisted through the winter months in Ireland. Losses to the industry in the southwest of the country resulting from contamination of shellfish with DSP toxins have been estimated at £1.2 million.

The toxins detected in shellfish were Okadaic acid and DTX-2. Some seasonal variation was observed with Okadaic acid being the dominant toxin in the early part of the season (May-mid August) and DTX-2 being dominant thereafter. The maximum concentration of Okadaic acid measured was 1.7 µg/g hepatopancreas while the maximum concentration of DTX-2 measured was 13.5 µg/g hepatopancreas. The toxicity in the shellfish was associated was linked with the presence of *Dinophysis acuta* and *Dinophysis acuminata.*

Discoloured water

Discoloured water, due to the presence of *Gymnodinium* cf *nagasakiense* was recorded on the southeast coast in August. The maximum recorded cell number was 560,000 cells/litre. Mortalities of the lugworm *Arenicola marina* were recorded.

1995

DSP

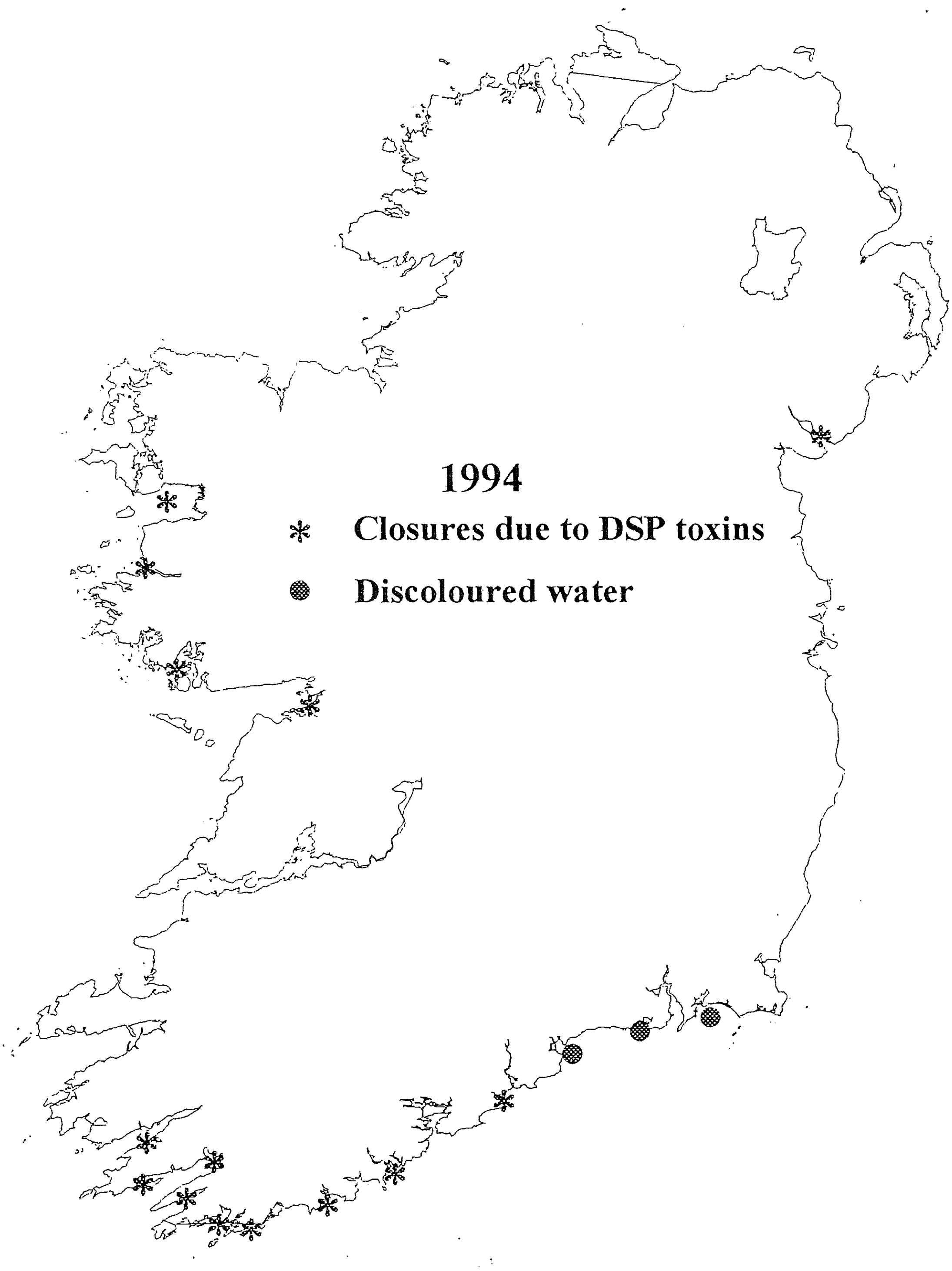
As for 1994 DSP toxins were detected in samples of shellfish from all the main shellfish growing areas in the southwest of the country as well as in Killary Harbour and Clew Bay on the west coast. The length of the toxic season was, however, considerably shorter in 1995 than in 1994. The growing areas in the southwest were closed from June - September. Toxicity was linked to the presence of *Dinophysis spp.* The concentration of toxins measured in shellfish samples was less than that measured in 1994. The maximum concentration of Okadaic acid measured was 1.5 µg/g hepatopancreas while the maximum concentration of DTX-2 measured was 1.6 μg/g hepatopancreas.

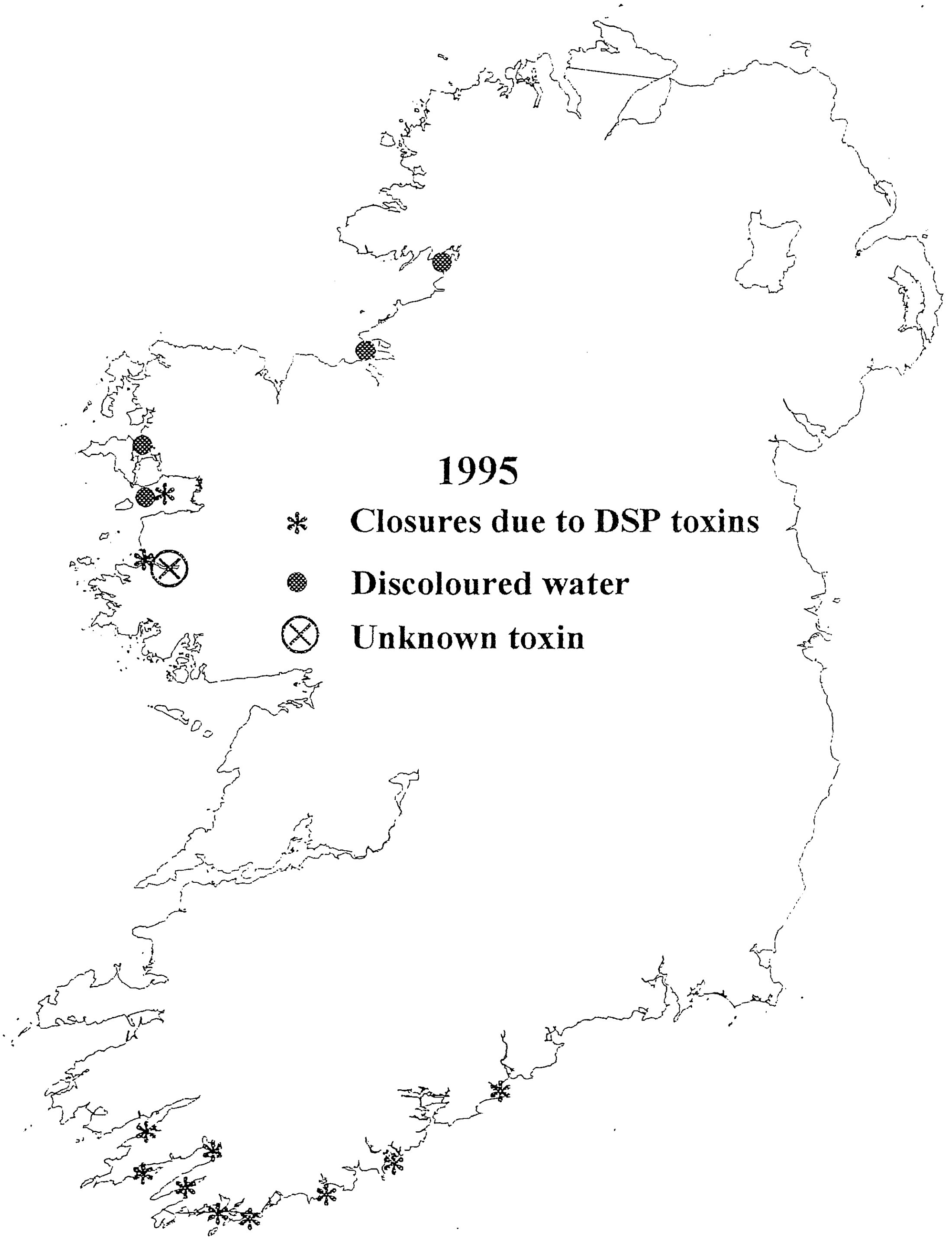
Discoloured water

Discoloured water, due to the presence of *Gymnodinium* cf *nagasakiense* was recorded on the northwest and west coasts in August. The maximum cell count recorded was 6 million cells/litre in Donegal Bay. No reports of mortalities of finfish of shellfish were received but as in 1994 mortalities of the lugworm *Arenicola marina* were recorded.

Unknown toxin

An unknown toxin was recorded in samples of mussels from Killary Harbour in November 1995. This toxin gave DSP like symptoms in consumers and gave strongly positive (+++) results in rat bioassays. Mouse bioassays gave mouse death times of approximately 90 minutes. No toxic phytoplankton species were associated with this event. The toxicity has persisted for 5 months.


1994
Closures due to DSP toxins
Discoloured water


1995
Closures due to DSP toxins
Discoloured water
Unknown toxin

National report of Latvian delegation

Harmful algal blooms in the Gulf of Riga (Baltic Sea)

Since 1993, blooms of cyanobacteria and dinoflagellates have been responsible for allergic and gastrointestinal problems in humans and dogs.

A long-term study (1972-95) of the phytoplankton community structure in the Gulf of Riga showed a significant increase of occurence and abundance of harmful cyanobacteria and dinoflagellates since the end of the 1980ies. High water temperature (> 20°C) and a decrease in the DIN:DIP ratio (frequently < 16) during summer were the main factors responsible for harmful cyanobacterial blooms. Potentially-toxic cyanobacteria Aphanizomenon flos-aquae, Nodularia spumigena, and the dinoflagellate Dinophysis acuminata were the dominant species in summer communities since 1993, representing more than 50 % of the total phytoplankton biomass, and produced the second annual maximum in phytoplankton abundance. An increasing role of Nodularia spumigena has been observed since 1993. The highest biomass of harmful cyanobacteria (130 g m^{-3}) at the surface was found in late July 1993; maximum abundance of D. acuminata ($6.7x10^4$ cells l^{1}) was recorded at the end of the cyanobacterial bloom (4 August).

In total, 10 potentially neuro- or hepato-toxic species have been identified: Anabaena flos-aquae, A. lemmermannii, A. spiroides, Aphanizomenon flos-aquae, Microcystis aeruginosa, Nodularia spumigena, Snowella lacustris, Dinophysis acuminata, D. rotundata, Prorocentrum balticum. Distribution of these species was patchy; nevertheless, from nearshore to offshore, abundance of cyanobacteria typically decreased whereas that of D. acuminata increased. In the coastal zone and at the river mouths, high nitrogen loads have favoured growth of diatoms.

HARMFUL ALGAL BLOOMS IN LATVIA 1995

Location:	Gulf of Riga, litoral of the southern part
Date of occurrence:	June-September 1995
Effects:	Not observed
Management decisions:	
Causative species:	*Prorocentrum balticum, Heterocapsa triquetra*
Environment:	During maximal abundance of *Prorocentrum balticum* (39000cells/l), *Heterocapsa triquetra* (34000cells/l) the water temperature was above 16°C, salinity 2-4‰
Advected populations or in situ Growth:	*In situ*
Previous occurrence:	Blooms occurred every summer since 1993
Additional comments:	The bloom of *Prorocentrum baltica* and *Heterocapsa triquetra* observed during and after the bloom of *Aphanizomenon flos-aquae*
Individual to contact:	Maija Balode, Institute of Aquatic ecology, University of Latvia, 3 Miera street, Salaspils LV-2169, Latvia. Tel.: 371 2 954399 Fax: 371 7 820113 Email: maija@hydro.edu.lv

HARMFUL ALGAL BLOOMS IN LATVIA 1995

Location: Gulf of Riga, southern part of the nearshore area

Date of occurrence: July- August 1995

Effects: Not observed

Management decisions:

Causative species: *Aphanizomenon flos-aquae, Nodularia spumigena, Anabaena spiroides*

Environment: Calm and sunny weather, water temperature on the surface reach 20-24°C, low concentrations of N-NO3

Advected populations or in situ Growth: *In situ*

Previous occurrence: Blooms reoccurred every summer since 1993

Additional comments: High temperature and low concentration of N-NO3 during summer are the most important factors regulating development of *Nodularia spumigena*

Individual to contact: Maija Balode, Institute of Aquatic ecology, University of Latvia, 3 Miera street, Salaspils LV-2169, Latvia. Tel.: 371 2 954399
Fax: 371 7 820113 Email: maija@hydro.edu.lv

Latvia

At the end of July and the beggining of August 1995, a high abundance of harmful algal species was recorded in nearshore waters of the southern part of Gulf of Riga: cyanobacteria - *Aphanizomenon flos-aquae* (maximum biomass: 2.1 g m^{-3}), *Nodularia spumigena* (1.0 g m^{-3}); dinoflagellates - *Dinophysis acuminata* (maximum cell density: $11x10^3$ cells l^{-1}), *Prorocentrum balticum* ($39x10^3$ cells l^{-1}) and *Heterocapsa triquetra* ($34x10^3$ cells l^{-1})..

HARMFUL ALGAL BLOOMS IN LATVIA 1995

Location: Gulf of Riga, southern part of the nearshore area

Date of occurrence: July 1995

Effects: Not observed

Management decisions:

Causative species: *Dinophysis acuminata, Dinophysis rotundata*

Environment: Calm and sunny weather, high water temperature, salinity 4-6‰

Advected populations or in situ Growth: *In situ*

Previous occurrence: Increase of cells density was observed since 1988

Additional comments: The maximal cells concentration of *Dinophysis acuminata* was 11000cells/l. The highest concentrations of *D. acuminata* were marked in the zone of brackish waters- at 20m, 30m stations (above the termocline)

Individual to contact: Maija Balode, Institute of Aquatic ecology, University of Latvia, 3 Miera street, Salaspils LV-2169, Latvia. Tel.: 371 2 954399 Fax: 371 7 820113 Email: maija@hydro.edu.lv

National report of Latvian delegation

Harmful algal blooms in the Gulf of Riga (Baltic Sea)

A long-term study (1972-95) of the phytoplankton community structure in the Gulf of Riga showed a significant increase of occurence and abundance of harmful cyanobacteria and dinoflagellates since the end of the 1980ies. High water temperature (> 20°C) and a decrease in the DIN:DIP ratio (frequently < 16) during summer were the main factors responsible for harmful cyanobacterial blooms. Potentially-toxic cyanobacteria *Aphanizomenon flos-aquae, Nodularia spumigena,* and the dinoflagellate *Dinophysis acuminata* were the dominant species in summer communities since 1993, representing more than 50 % of the total phytoplankton biomass, and have been responsible for allergic and gastrointestinal problems in humans and dogs. An increasing role of *Nodularia spumigena* has been observed since 1993. The highest biomass of harmful cyanobacteria (130 g m^{-3}) at the surface was found in late July 1993; maximum abundance of *D. acuminata* ($6.7x10^4$ cells l^{-1}) was recorded at the end of the cyanobacterial bloom (4 August).

In total, 10 potentially neuro- or hepato-toxic species have been identified: *Anabaena flos-aquae, A. lemmermannii, A. spiroides, Aphanizomenon flos-aquae, Microcystis aeruginosa, Nodularia spumigena, Snowella lacustris, Dinophysis acuminata, D. rotundata, Prorocentrum balticum.* Distribution of these species was patchy; nevertheless, from nearshore to offshore, abundance of cyanobacteria typically decreased whereas that of *D. acuminata* increased. In the coastal zone and at the river mouths, high nitrogen loads have favoured growth of diatoms.

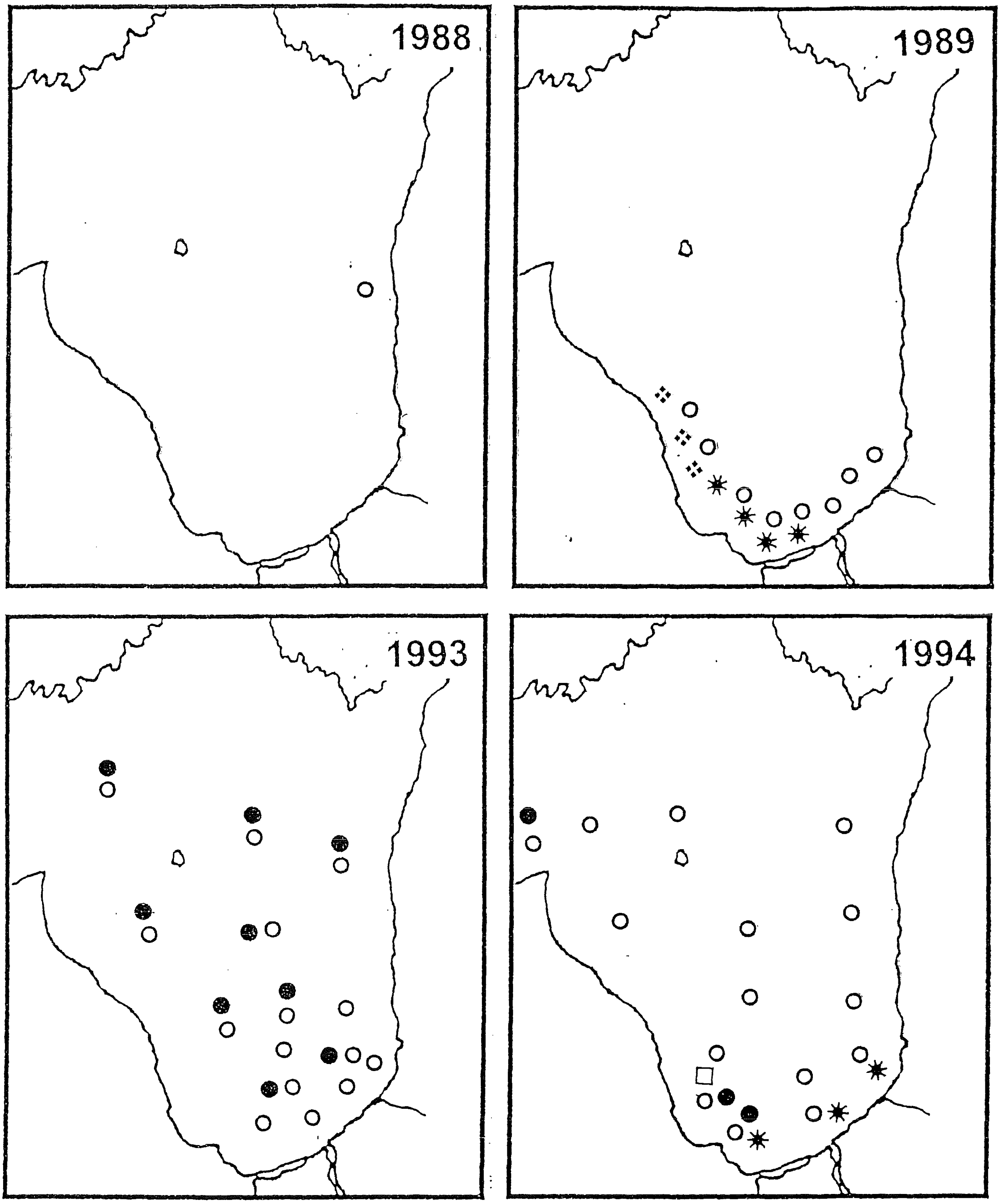


Fig. Potentially neiro- and hepatotoxic **cyanobacteria** bloom events in the Gulf of Riga, Eastern Baltic

●- Nodularia spumigena
○- Aphanizomenon flos-aquae
□- Anabaena spp. (A. spiroides & A. flosaquae)
✱- Snowella lacustris
⁘- Microcystis aeruginosa

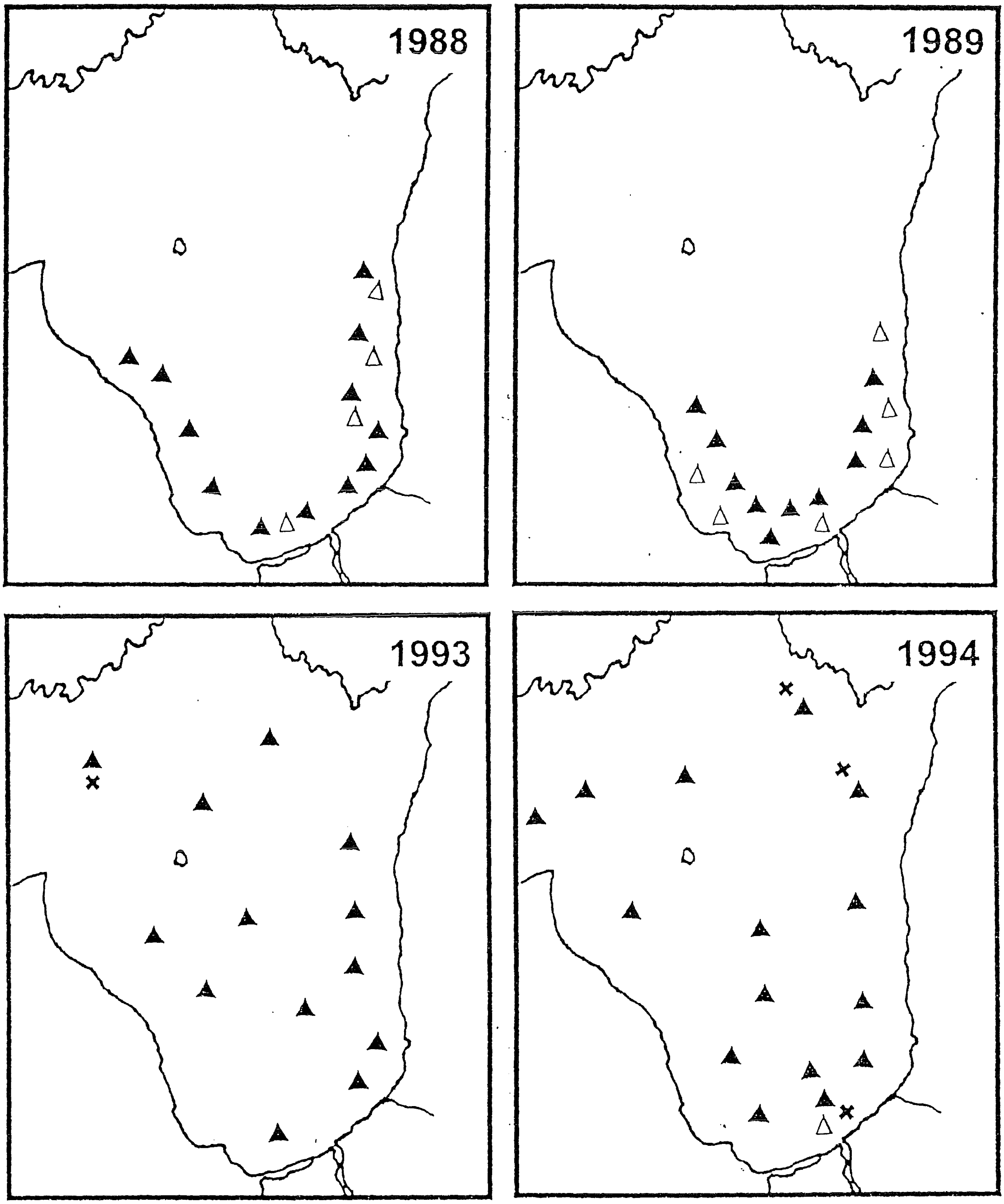


Fig. Potentially toxic **dinoflagellates** bloom events in the Gulf of Riga, Eastern Baltic

▲- Dinophysis spp. (D. acuminata & D. rotundata)
✕ - Heterocapsa triquetra
△- Prorocentrum baltica

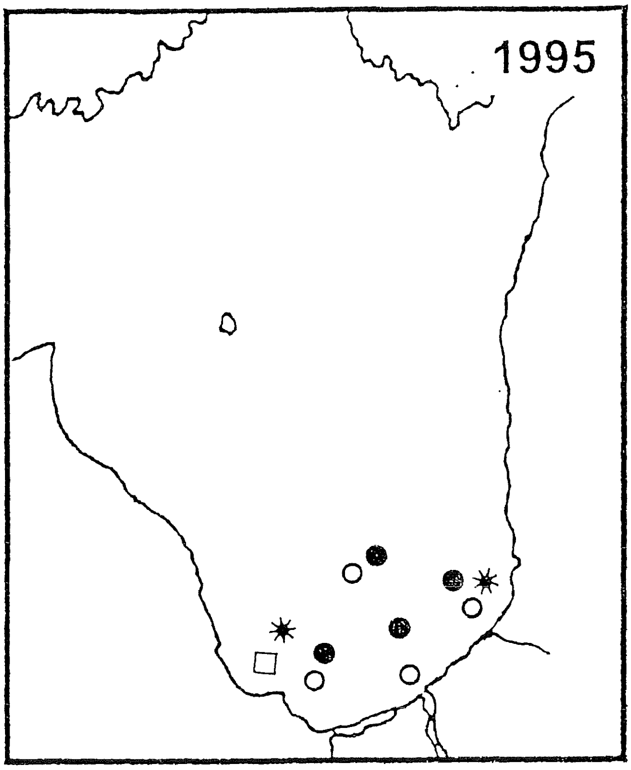


Fig. Potentially neiro- and hepatotoxic **cyanobacteria** bloom events in the Gulf of Riga, Eastern Baltic

Cyanobacteria:

●- Nodularia spumigena

○- Aphanizomenon flos-aquae

□- Anabaena spp. (A. spiroides & A. flosaquae)

✷- Snowella lacustris

✣- Microcystis aeruginosa

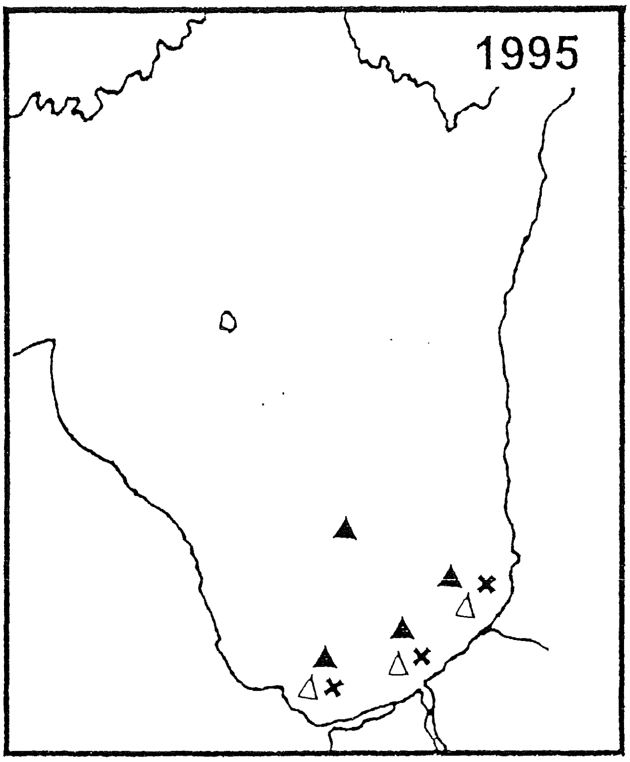


Fig. Potentially toxic **dinoflagellates** bloom events in the Gulf of Riga, Eastern Baltic

Dinoflagellates:

▲- Dinophysis spp. (D. acuminata & D. rotundata)

✖ - Heterocapsa triquetra

Δ- Prorocentrum baltica

National reports 1994 and 1995
DLO Netherlands Institute for Fishery Research (RIVO-DLO)

by Renger Dijkema

1994

Monitoring and research activities

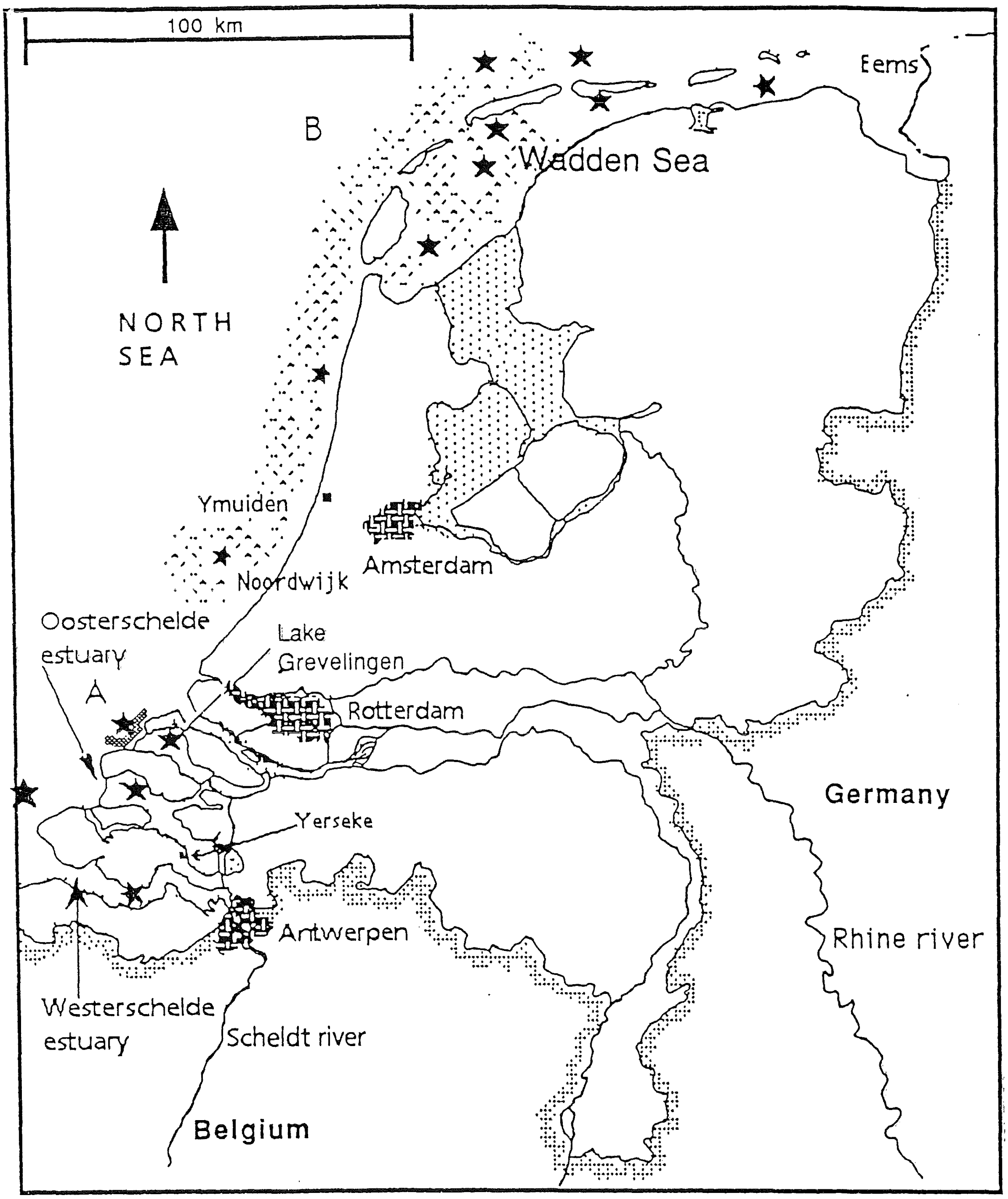
During the period May-December of 1994, the Netherlands Institute for Fisheries Research (RIVO-DLO) carried out the monitoring programme of PSP, DSP and ASP toxins in bivalve shellfish hepatopancreas and of the presence of (potentially) harmful phytoplankton species in the following bivalve production areas: the mussel production and re-watering areas in the Wadden Sea and the Oosterschelde (weekly), the cockle (Cerastoderma edule) fishing areas in the Wadden Sea, at the North Sea Coast and in the Westerschelde in cockles (every two weeks) and the oyster (Ostrea edulis) production areas in the Oosterschelde and lake Grevelingen in oysters (monthly). Phytoplankton was sampled in 60 l of surface water, strained through 25 µm plankton gauze. Toxin determinations were made in hepatopancreas tissue by means of rat bioassay (DSP toxins) and HPLC (PSP and ASP toxins). Samples were processed within 24 h after sampling. The results of the monitoring programme are communicated weekly to the shellfish growing and fishing organisations, and to the Dutch Government, following EU Directive 91/492.

Bloom events

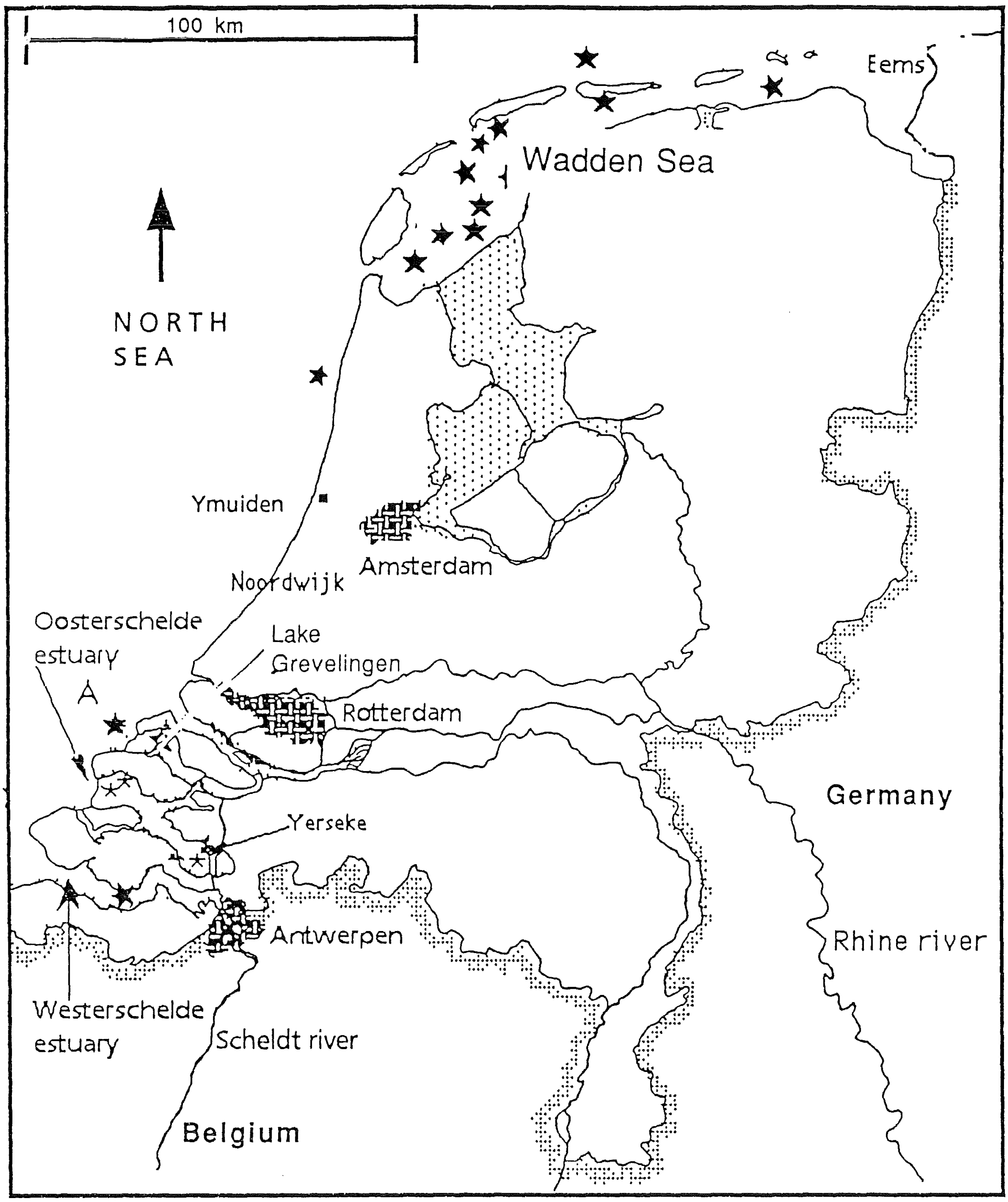
July 20, 4000 cells/l of Dinophysis acuminata were found in the western part of Lake Grevelingen, resulting in toxicity of mussels (Mytilus. edulis). No toxicity was found in oysters Ostrea. edulis. The opening of the oyster harvesting season was delayed until October. As the monitoring program for toxicity is restricted to the oyster harvesting season starting in September, toxicity was only detected after a number of people became intoxicated after eating mussels, hand-collected from the lake. This was the first time toxicity was reported in this tide-less sea water lake. D. acuminata counts reverted to nil by the first week of September, toxicity in the mussels remained until two weeks after. Water temperature was 18°C.

On November 28, 98 cells/l of Dinophysis acuminata were found in lake Grevelingen, at a water temperature of 11.5°C. The meat of oysters showed a red colour, indicating the presence of Mesodinium rubrum. Its presence could, however, not be verified in the water.

A bloom of Dinophysis acuminata was detected by the RIVO-DLO Early Warning System in week 30 in the North Sea, 10 km off Noordwijk, moving north with the residual current. As this bloom took place offshore, no toxicity was determined in shellfish. Cell numbers, reaching 5000 cells/l, were followed in close cooperation with RWS/RIKZ laboratory and NIOZ- Texel (L. Peperzak and G. Cadee). The bloom reached the Marsdiep, the southernmost inlet of the Wadden Sea (600 cells/l), in week 32, and subsequently, increased cell counts (40 - 70 cells/l) were reported on one station in the Wadden Sea. A preventive, partial closure of mussel culture areas in the western Waddden Sea was effectuated for one week. No increased toxicity was found in mussels. This bloom, the first since a number of years without Dinophysis blooms, enabled us to calibrate the current sampling method, straining 60 litre through 25 µ plankton mesh, in an experiment, jointly with RIKZ (L. Peperzak) and the University of Groningen (E.G. Vrieling). It was concluded that, probably as a result of irregularities in the plankton gauze mesh size and relatively small Dinophysis cells, cells were



RESULTS OF THE MONITORING PROGRAMME FOR TOXIC PHYTOPLANKTON BLOOMS IN THE DUTCH MOLLUSC SHELLFISH PRODUCTION AREAS. A AND B REPRESENT BLOOMS OF RESPECTIVELY DINOPHYSIS ACUMINATA AND cf. PROROCENTRUM LIMA IN 1995 (SEE TEXT). ASTERISKS INDICATE SAMPLING STATION.S



SAMPLING STATIONS OF THE MONITORING PROGRAMME FOR PHYTOPLANKTON TOXINS DSP, PSP AND ASP IN THE DUTCH MOLLUSCAN SHELLFISH PRODUCTION AND REWATERING AREAS (MUSSELS, COCKLES, OYSTERS AND SPISULA'S), CARRIED OUT BY RIVO-DLO IN 1995.

HARMFUL ALGAL BLOOM IN NORWAY 1995

Diarrhoeic Shellfish Toxins

In 1992 a regular monitoring of algae, in 1995 at 23 stations, and control of shellfish toxicity by mouse bioassay along the Norwegian coast were established. The 1995 results from this programme concerning Diarrhoeic Shellfish Toxins are summarised.

LOCATION	*Dinophysis* spp. were recorded all along the Norwegian coast but most numerous along the south and in the innermost part of the Sognefjord at the west coast.
DATES	In the period April-July toxin levels slightly above action level were recorded at some few stations along the coast. However, in general the problems in 1995 were minor.
EFFECTS	Toxins recorded above the action level according to mouse bioassay at one or another station from April-July.
MANAGEMENT DECISIONS	Harvesting was locally banned. The public was warned against picking toxic mussels.
CAUSATIVE SPECIES	Most probably *Dinophysis* spp., with *D. acuminata* and *D. acuta* as the most potent species.
ENVIRONMENT	The problem occur over a wide range of temperatures and salinities.
ADVECTED POPULATION	Along the southern coast there are some evidence that the algae and toxin problems are spread by advection. But along the west coast the "hot spots" seems to be rather patchy which indicate local concentration of the algae and/or *in situ* growth.
PREVIOUS OCCURRENCES	A few more dubious historical records. A yearly, more or less large scale and long lasting phenomenon since 1984 according to mouse bioassay. The phenomenon has never been so extensively monitored as since 1992.
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HARMFUL ALGAL BLOOM IN NORWAY 1995
Gyrodinium* cf. *aureolum

LOCATION	The southern and south-western coast of Norway.
DATES	September 1995.
EFFECTS	No
MANAGEMENT DECISIONS	Intensified local algae monitoring.
CAUSATIVE SPECIES	*Gyrodinium cf. aureolum*, up to 220 000 cells per litre were recorded in the Flødevigen Bay.
ENVIRONMENT	
ADVECTED POPULATION	The bloom was probably due to a combination of advected populations and *in situ* growth.
PREVIOUS OCCURRENCES	*Gyrodinium* bloomed in the area in 1966, 1976, 1981, 1982, 1985, 1988, 1990, 1991, 1992 and 1994
ADDITIONAL COMMENTS	The bloom in 1995 was small
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HARMFUL ALGAL BLOOM IN NORWAY 1995
Polykrikos schwartzii

LOCATION	Fossingfjord, southern Norway
DATES	Late August 1995
EFFECTS	Reddish bands along shore. Very local phenomenon. Crabs and shrimps seemed to dislike the reddish water.
MANAGEMENT DECISIONS	
CAUSATIVE	*Polykrikos schwartzii*
ENVIRONMENT	No information
ADVECTED POPULATION	
PREVIOUS OCCURRENCE	
ADDITIONAL COMMENTS	
INDIVIDUAL TO CONTACT	Einar Dahl, Institute of Marine Research, Flødevigen Marine Research Station, N-4817 His tel. +47 370 59000, fax. +47 370 59001. E.mail: einar.dahl@imr.no

HARMFUL ALGAL BLOOM IN NORWAY 1995

Paralytic Shellfish Toxins

In 1992 a regular monitoring of algae, in 1995 at 23 stations, and control of shellfish toxicity by mouse bioassay along the Norwegian coast were established. The results from this monitoring programme concerning Paralytic Shellfish Toxins in 1995 are summarised.

LOCATION	Along the west coast.
DATES	March - June 1995. 500 ME/100g recorded at one station in March. Highest toxicity recorded in May, 1.400 ME/100g.
EFFECTS	Toxins recorded above the action level (400 ME/100g) according to mouse bioassay.
MANAGEMENT DECISIONS	Harvesting was locally banned. The public was warned against picking toxic mussels.
CAUSATIVE SPECIES	*Alexandrium* spp.
ENVIRONMENT	No information
ADVECTED POPULATION	Mainly due to *in situ* growth ?
PREVIOUS OCCURRENCES	A few historical records, and more or less regular occurrences along the west coast the recent years, however, the spatial and temporal extent may vary significantly from one year to another.
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HARMFUL ALGAL BLOOM IN NORWAY 1995
***Prymnesium* spp.**

LOCATION	Ryfylke, Sandsfjord system, the westcoast of Norway.
DATES	July-August 1995
EFFECTS	48 tonnes Atlantic salmon and 35.000 smolt were killed.
MANAGEMENT DECISIONS	Monitoring.
CAUSATIVE	*Prymnesium parvum/patteliferum*
ENVIRONMENT	Brackish water.
ADVECTED POPULATION	Mainly *in situ* growth.
PREVIOUS OCCURRENCE	Yearly blooms since 1989
ADDITIONAL COMMENTS	
INDIVIDUAL TO CONTACT	Torbjørn M. Johnsen, Norwegian Institute for Water Research, Regional Office, Bergen, Bergen High-Techn. Center, Thormøhlensgt. 55, N-5008 Bergen, Norway tel. +47 55 32 56 40, fax. +47 55 32 88 33 E.mail: torbjoern.johnsen@niva.no

HARMFUL ALGAL BLOOM IN NORWAY 1995
Chrysochromulina spp.

LOCATION	Along the Norwegian Skagerrak Coast
DATES	May-June 1995
EFFECTS	The bloom was non- or only slightly toxic to fish, and slightly toxic to *Artemia salina* in a bio-test. One fishfarm experienced enhanced mortalities which possibly can attribute algae.
MANAGEMENT DECISIONS	Intensivation of monitoring activity
CAUSATIVE	It was a mixed bloom of *Chrysochromulina* spp. Up to 5 500 000 cells/L recorded in the Flødevigen, among them *C. polylepis*.
ENVIRONMENT	The *Chrysochromulina* spp. were found in the upper 10m of the water column.
ADVECTED POPULATION	The algae seemed to follow the Norwegian Coastal current.
PREVIOUS OCCURRENCE	A harmful bloom of *Chrysochromulina polylepis* occurred in May 1988. Since then monitoring has revealed regular occurrence, about 1 000 000 cells/L, of*Chrysochromulina* spp. each year in May-June, and as much as 6 000 000 cells/L in 1994.
ADDITIONAL COMMENTS	
INDIVIDUAL TO CONTACT	Einar Dahl, Institute of Marine Research, Flødevigen Marine Research Station, N-4817 His tel. +47 370 59 000, fax. +47 370 59 001, E.mail: einar.dahl@imr.no

PORTUGAL 1995

DSP

DSP toxins were detected at Aveiro, Minho, Lima and Mondego estuaries.

1. and 2. **Location and data of occurrences**

- Minho estuary: January 1- April 3; November 13 - 27, December 11 - 31.
- Lima estuary: October 30 - November 27.
- Aveiro Lagoon: May 29 - July 30 (*Mitylus edulis*); August14 - October 7 (all bivalves); October 16 - December 12 (*Mitylus edulis*).
- Mondego estuary: January 1 - March 26 (*Mitylus edulis* and *Scrobicularia plana*); June 29 - December 16 (*Mitylus edulis* and *Scrobicularia plana*).

3. **Effects:**

Mostly mussels (*M. edulis*) from these regions presented DSP toxins.

DSP toxins were determined both by the mouse bioassay and through HPLC.

4. **Management decisions:**

Harvest of affected species closed during toxication.

5. **Causative species:**

Dinophysis cf. *acuminata* and/or *D. acuta* cells/l:

The highest detected concentrations (cells/l) were:

- Litoral North Aveiro Lagoon: *D.*cf *acuminata* 1500 plus D. *skagi* 400 (October 27); *D. acuta* 2950 (July 27)
- Aveiro Lagoon: *D.* cf. *acuminata* 2600 plus *D. skagi* 100 (July 7); *D. acuta* 30250 plus *D. dens* 2050 (August 9)
- Mondego estuary: *D.* cf. *acuminata* 550 (May 22); *D. acuta* 2000 (October 10)

6. **Environment:**

Temperature range: 16° - 19°C
Salinity range: 24 - $36^{0}/_{00}$

7. **Advected population or *in situ* growth:**

Most probably a combination of both.

8. **Previous occurrences:**

Since 1987, the first year of confirmed occurrence, the problem has occurred every year, with a break in 1993. This year the most affected areas were Minho estuary, Aveiro Lagoon and Mondego estuary.

9. **Individual to contact:**

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PORTUGAL 1995

PSP

All the Portuguese coast was affected.

1. and 2.- **Location and areas of occurrence:**

- Aveiro litoral north: January 1 - 15.
- Aveiro coast: January 1 - 15.
- Aveiro Lagoon: January 1 - February 12.
- Figueira da Foz coast: January 1 - 8.
- Mondego estuary (Figueira da Foz): January 1 - March 27.
- Nazaré (Óbidos Lagoon): January 1 - February 26.
- Cascais, Ericeira, Peniche, S.Martinho: January 1, April 9.
- Lisboa coast: January 1 - April 9.
- Tagus estuary (Lisboa): January 1 - April 17.
- Albufeira Lagoon (Setúbal): November 6 - 12.
- Setúbal coast: January 1 - March 5, June 12 - December 17 (only *Callista chione*).
- Sines coast: January 1 - 15.
- Mira estuary (Sines): January 1 - May 15, September 4 - December 17.
- Algarve coast (Sagres): August 28 - November 6; November 20 - December 10.
- Algarve coast (Lagos/Portimão): October 16 - December 17.
- Alvor Lagoon (Portimão): September 11 - November 19.
- Arado estuary (Portimão): closed all the year due to bacterial contamination.
- Algarve coast (Faro/Vila Moura): September 18 - November 19.
- Formosa Lagoon (Faro/Tavira): September 18 - December 17.
- Algarve coast (Faro/Vila Real de St°. António): September 18 - November 19.
- Guadiana estuary (Vila Real de St°. António): September 18 - November 19.

3. **Effects:**

Almost all the exploited bivalve molluscs from these regions presented PSP toxins (highest detected values):

- Minho estuary: *Mytilus edulis* 109 ug/100g (September 26)
- Cávado estuary: *Scrobicularia plana* 53 ug/100g (October 10)
- Aveiro coast: *Spisula solida* 154 ug/100g (January 9)
- Aveiro Lagoon: *Ruditapes decussata* 217 ug/100g (January 2)
  Mytilus edulis 119 ug/100g (August 28)
- Mondego estuary (Figueira da Foz): *Scrobicularia plana* 163 ug/100g (February 22),
  195 ug/100g (April 24), 173 ug/100g (June 27)
  Mytilus edulis 83 ug/100g (February 22).

- Nazaré (Óbidos Lagoon): *Spisula solida*, *Mytilus edulis* 247 ug/100g (January 3),
Venerupis pullastra 106 ug/100g (January 10)
Cerastoderma edule 115 ug/100g (October 17)
- Cascais, Ericeira, Peniche, S.Martinho: *Mytilus edulis* 227 ug/100g (January 2)
- Setúbal coast: *Ensis siliqua* 121 ug/100g (January 3)
Calista chione 261 ug/100g (January 10)
Donax spp 261 ug/100g (January 10)
- Sado estuary (.Setúbal.): *Venerupis pullastra* 1844 ug/100g (January 9),
Venus verrucosa 893 ug/100g (January 10)
- Sines Lagoons - *Mytilus edulis* 183 ug/100g (January 5)
- Algarve coast (Sagres): *Mytilus edulis* 5999 ug/100g (October 19)
Crassostrea angulata 486 ug/100g (October 17)
- Algarve coast (Portimão/Lagos): Solenidae Family 230 ug/100g (October 17),
Donax spp. 121 ug/100g (November 21)
- Alvor Lagoon: all bivalves 3360 ug/100g (*Ruditapes decussata*, October 26)
- Arado estuary (Portimão): all bivalves 436 ug/100g (*Ostrea edulis*, October 24)
- Algarve coast (Faro/Vila Moura): all bivalves 980 ug/100g (*Donax* spp.,September 29)
- Formosa Lagoon (Faro/Olhão): all bivalves 1783 ug/100g (*Ruditapes decussata*,
September 26)
- Algarve coast (Faro/Vila Real de St. António): all bivalves 99 ug/100g (*Spisula solida*,
November 3)
- Guadiana estuary (Vila Real de St. António): all bivalves 229 ug/100g (*Venerupis pullastra*)

4. **Management decisions:**

Bivalve species with PSP values over 80 ug/100g closed to harvest.

5. **Causative species:**

The causative species was *Gymnodinium catenatum*.

The highest detected concentrations (cells/l) were:

- Algarve coast (Faro/Olhão): 44500 (Litoral Fuseta, October 28)
- Formosa Lagoon (Faro/Olhão): 107000 (Mar Santo, September 26)
- Arado estuary (Portimão): 1000 (September 12)
- Alvor Lagoon: 42200 (October 19)
- Sagres coast: 49000 (October 26)
- Sines coast: 1700 (August 30)
- Albufeira Lagoon (Setúbal): 10600 (November 3)
- Setúbal coast: 18500 (November 6)
- Lisboa coast: 800 (August 30)
- Cascais, Ericeira, Peniche, S.Martinho: 8200 (June 6)
- Nazaré (Óbidos Lagoon): 1100 (October 10)
- Mondego estuary (Figueira da Foz): 4800 (October 10)
- Aveiro coast: 5000 (November 6)
- Aveiro Lagoon: 19250 (November 7)
- Lima estuary (Viana do Castelo): 100 (October 24)

6. **Environment:**

Temperature range: 14° - 22 °C
Salinity range: 20 - $37^{0}/_{00}$

7. **Advected population or *in situ* growth:**

A combination of both

8. **Previous occurrences:**

Since 1986 , with a break in 1991, *G. catenatum* has been the responsible species for PSP at the Portuguese coastal zone. In 1993 and 1994 all the coast has been affected beginning in the South and spreading to the North. This year the winter occurrence at the northern coast is, as far as we can unerstand due to the 1994 toxication. In 1995 the main affected area was Algarve coast, in an extensive way, covering all litoral, sea Lagoons and Estuaries.

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P O R T U G A L 1995

ASP

Domoic acid was detected in Smooth callista (*Callista chione*).

1. and 2. **Location and data of occurrences:**

Setúbal coast in May

3. **Effects:**

ASP (Domoic acid) was determined through HPLC .

4. **Management decisions:**

Harvest of affected species closed during toxication.

5. **Causative species:**

Pseudonitzschia australis 268000 cells/l (May 30)

6. **Environment:**

Temperature range: 16° - 18°C
Salinity: 35 - $37^{0}/_{00}$

7. **Advected population or *in situ* growth:**

Most probably a combination of both.

8. **Previous occurrences:**

It is the first time that we have detected Domoic acid in bivalves over 20 ug/g.

9. **Individual to contact:**

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PORTUGAL 1995

Red Tides Without Harmful Effect

1. and 2. **Location and data of occurrences:**

- Óbidos Lagoon: March 28 - April 28 and May 9
- S. Martinho Bay: May 9
- Aveiro litoral: June 6 - 9

3. **Effects:**

Water discoloration

4. **Management decisions:**

None

5. **Causative species** (highest detected concentrations in cells/l) were:

Óbidos Lagoon - March 28, April 28: *Skeletonema costatum* (14×10^7) and small flagellates (5.7×10^7).
May 9: *Prorocentrum minimum* (6×10^7) and small flagellates (4×10^7).

S. Martinho Bay - May 9: *Heterosigma inlandica* (4×10^6), *Skeletonema costatum* (1.3×10^6) and small flagellates (1.4×10^7).
Litoral Aveiro - Several diatoms including: *Chaetoceros gracilis* (10×10^7), *Leptocylindrus danicus* (11.5×10^7), *Nitzschia* sp (2.4×10^7), *Pseudonitzschia* spp (2.7×10^7), *Rhizosolenia delicatula*(10^7), *Rh. fragilissima* (1.3×10^7), *Rh. stolterfothii* (0.7×10^6) *Thalassiosira pseudonana* (11×10^7), *Skeletonema costatum* (5×10^6) and small flagellates (11×10^7).

6. **Environment:**

Óbidos Lagoon - March, April: Temperature range 14° - 17 °C
Salinity range 30 - $35^0/_{00}$
May 9: Temperature 21.5 °C
Salinity $26.5^0/_{00}$
S. Martinho Bay - May 9: Temperature 19°C
Salinity $33^0/_{00}$
Aveiro litoral - June 6 - 9: Temperature 16°C
Salinity $36^0/_{00}$

7. **Advected population or *in situ* growth:**

Most probably a combination of both at Aveiro litoral and S. Martinho Bay, *in situ* growth at Óbidos Lagoon.

9. **Individual to contact:**

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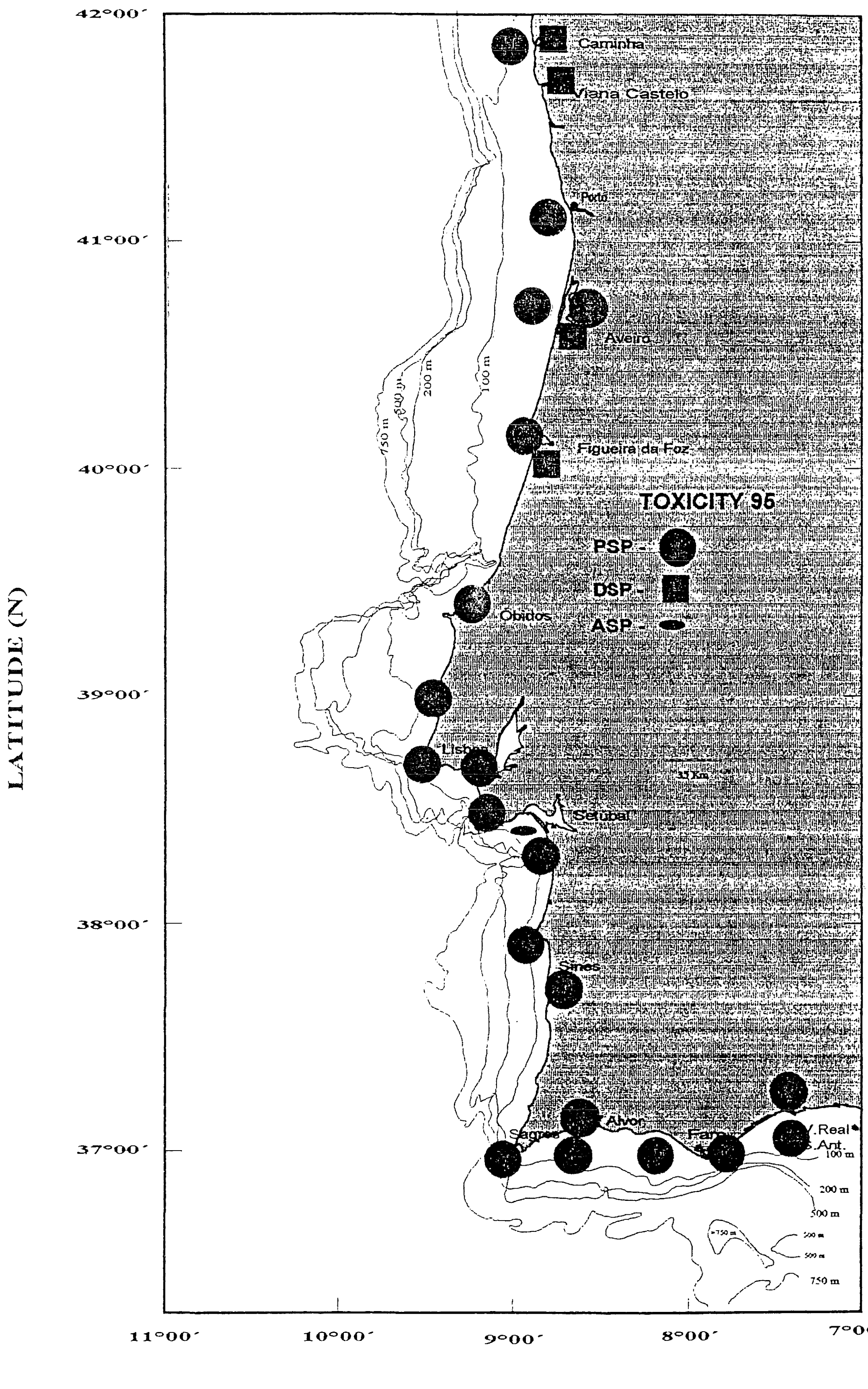

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LATITUDE (N)
LONGITUDE (W)
Caminha
Viana Castelo
Porto
Aveiro
Figueira da Foz
TOXICITY 95
PSP -
DSP -
ASP -
Óbidos
Setubal
Sines
Alvor
Sagres
V.Real
S.Ant.
750 m
500 m
200 m
100 m

ZONAS ENCERRADAS POR PSP-1995 (Caminha - Sines)

		MÊS/SEM.	Janeiro				Fevereiro					Março				Abril				Maio					Junho				Julho				Agosto				Setembro					Outubro				Novembro				Dezembro				
CAPITANIA	ZONA	ESPÉCIE	1/8	9/15	16/22	23/29	30/5	6/12	13/19	20/26	27/5	6/12	13/19	20/26	27/2	3/9	10/16	17/23	24/30	1/7	8/14	15/21	22/28	29/4	5/11	12/18	19/25	26/2	3/9	10/16	17/23	24/30	31/6	7/13	14/20	21/27	28/3	4/10	11/17	18/24	25/1	2/8	9/15	16/22	23/29	30/5	6/12	13/19	20/26	27/3	4/10	11/17	18/24	25/31
Caminha	Est Minho	Mexilhão																																																		
V. Castelo	Esposende	Lambujinha																																							■	■	■	■	■	■	■	■	■	■		
	E Cávado	Lambujinha																																																		
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Póv Varzim		T bivalves	■	■																																																
Leixões		T bivalves																																																		
Douro		T bivalves																																																		
Aveiro	Ria Aveiro	A -boa	■	■																																																
		A -macha	■	■																																																
		Mexilhão	■	■	■	■	■	■																																												
Fig. Foz	Est. Mond.	Berbigão	■	■	■	■	■	■	■	■	■	■	■	■	■																																					
		Lambujinha	■	■	■	■	■	■	■	■	■	■	■	■																												■	■	■	■	■	■						
		Mexilhão	■	■	■	■	■	■	■	■	■	■	■	■																																						
		T bivalves	■																																																	
Nazaré		T.bivalves	■	■	■	■	■	■	■	■	■	■	■	■	■	■																																				
Peniche	L. Óbidos	A.-macha	■	■	■																																															
		Berbigão	■																																								■	■	■								
		Mexilhão	■	■	■	■	■	■	■	■																																										
Cascais	Ericeira	T.bivalves	■	■	■	■	■	■	■	■	■	■	■	■	■	■																																				
Lisboa		A.-macha	■	■	■	■	■	■	■	■	■	■	■	■	■	■																																				
Setúbal	Estuário	A.-macha	■	■	■	■	■	■	■	■	■	■	■	■		■	■	■																																		
		Pé-de-burro	■	■	■	■	■	■	■	■	■	■	■	■		■	■	■																																		
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		Navalha	■	■	■	■	■	■																																												
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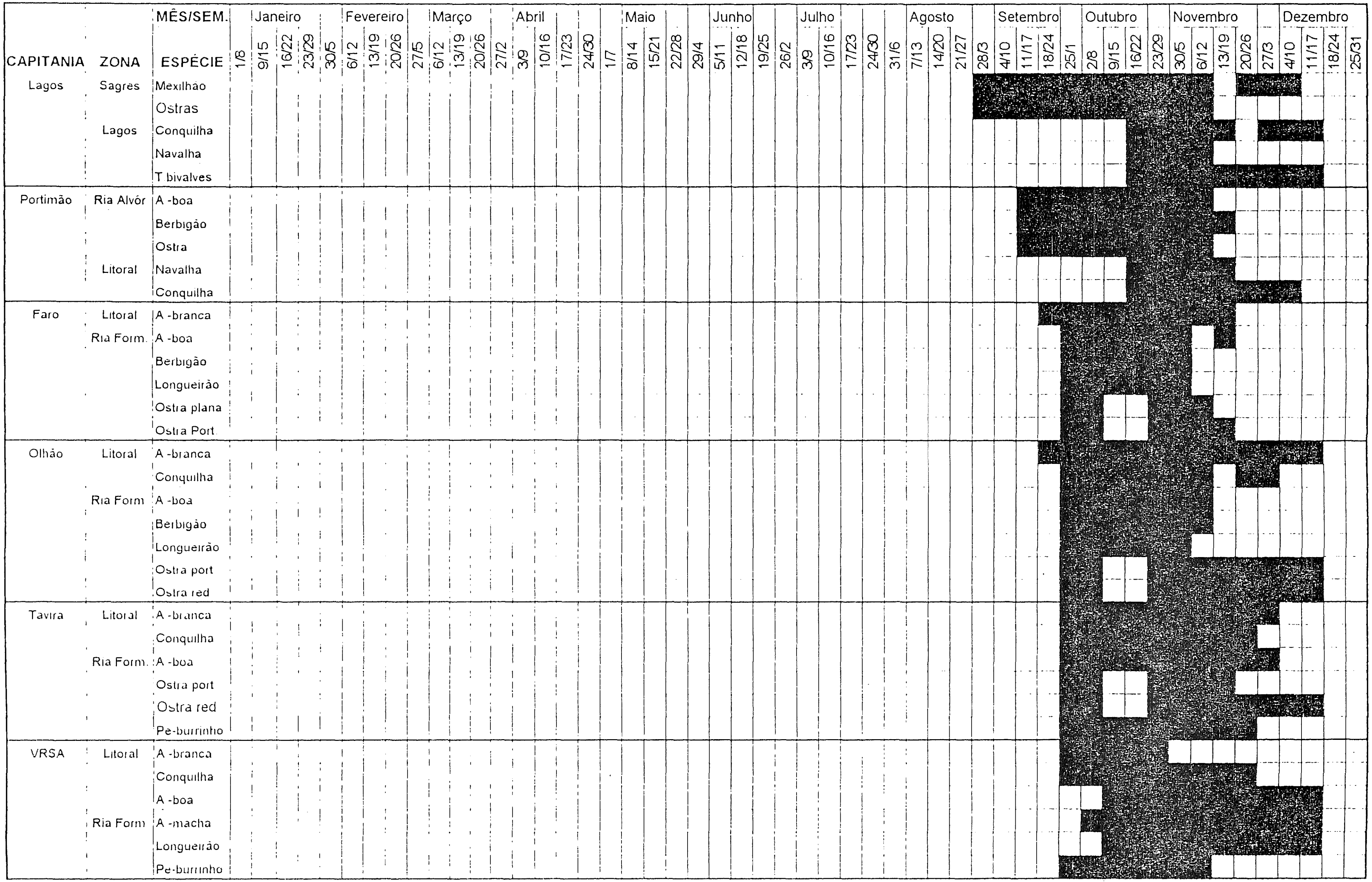
	L Albufeira	Mexilhão																																												■							
Sines		T bivalves	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■																■	■	■	■	■	■	■	■	■	■	■	■	■	■	■		

Legenda: Preto - Zonas encerradas à apanha e comercialização   T.Bivalves- Todos os Bivalves

ZONAS ENCERRADAS POR PSP-1995 (Sagres - V. Real St. António)



Legenda: Preto - Zonas encerradas à apanha e comercialização T. Bivalves - Todos os bivalves

ZONAS ENCERRADAS POR DSP-1995

MÊS/SEM.: Janeiro | Fevereiro | Março | Abril | Maio | Junho | Julho | Agosto | Setembro | Outubro | Novembro | Dezembro

CAPITANIA	ZONA	ESPÉCIE
Caminha	Rio Minho	Mexilhão
V do Castelo	Est. Lima	Mexilhão
Leixões		Mexilhão
Douro		Mexilhão
Aveiro	R.Aveiro	Mexilhão
		T.Bivalves
Fig da Foz	Est.Mond	Lambujinha
		Mexilhão
Nazaré	S M Porto	Mexilhão
Peniche	L.Óbidos	Mexilhão
Cascais	Ericeira	Mexilhão

Legenda: Preto- zona encerrada à apanha e comercialização

T.Bivalves- Todos os bivalves

NATIONAL REPORT OF DELEGATION OF RUSSIAN FEDERTION OTHE
ICES IOC Workshop, Brest

Many algal species known as toxic inhabit Russian seas, some of them develop blooms. Nodularia spumigena blooms every summer in the westhern gulf of Finland, as in the rest of the Baltic. In Black Sea, Azov Sea and Kspian Sea, cyanobacterial blooms are regular at the sites of discharge of eutrophic freshwater. Blooms of Alexandrium species are frequent at the Pacific coast of Kamchatka and several lethal cases with PSP symptoms following shellfish consumption are known from this region. Dangerous densities (ten thousands cell per liter) of several potential toxic Dinohysis species occur every summer at the Russian coast of the Japan Sea. Blooms of fish killing Chattonella sp. also were observed there.

Blue-green algae (Cyanobacteria) are the main part of late summer phytoplankton in the esatern gulf of Finland, forming up to 50-90 % of the total algal biomass. According to results of long-trem investigations of the State Hydrological Institute, St Petersburg (1982-1995) 48 species of blue-green were found in the eastern gulf of Finland. Potentially toxic species, which frequently are found in summer plankton of this water are: Microcystis aeruguinosa, Snowellaospheria lacustris, Anabaena spiroides, Planktothrix agardhii (hepathotoxic species); Aphanizomenon flos-aquae, Anabaena flos-aquae, Anabaena lemmermanii (neurotoxic species). The highest concentrations in the eutrophic zone were reported for three species: Aphanizomenon flos-aquae (up to 7.8 µg l^{1}), Microcystis aeruguinosa (up to 8.0 µg l^{1}), Planktothrix agardhii (up to 3.5 µg l^{1}). Nodularia spumigena, which forms toxic blooms in the western part of the gulf of Finland and in some other parts of the Baltic Proper, has never been abundant in the eastern part, because of low salinity.

The main tasks for the Russian scientists might be summarized as follows:

1. To study PSP, DSP, ASP of algae and shellfish at Russian coasts.
2. To study the toxicity of blooming brackish cyanobacteria and their impact on aquatic fauna.
3. To investigate factors determining toxin production, functions of the algal toxins, biology of toxic species.

The purpose of the research project is the elucidation of algal toxicological situation and elaboration of recommandations for the Natural Ressources and Sanitary Authorities.

The accomplish this tasks special research group is formed in Shirsov Institute of Oceanology, in Moscow. Specialists from different regions of Russia are being identified to participate in this project. As a routine method for toxin quantitation receptor assays have been choosen.

No systematic research on harmful algae has been yet performed in Russia, and there are no legal regulations on the algal toxin control in Russian Federation. On the other hand, numerous data indicate that harmful algal problems do really exist in Russia. That urged the Ministry of Sciences and Technology Policy of RF to start a research project dedicated to harmful algae, within the frame of " Dynamics of ecosystems, Biostructure and Biological Resources of Russian Seas and Oceans ", which is one of the main parts of the Russian National Research Program on " Comprehensive Investigations of Oceans and Seas, the Arctic and Antractic ".

HARMFUL ALGAL BLOOMS IN 1995 - SPAIN
GALICIA

1. Location: Parts of the Rias de Muros , Arosa, Pontevedra and Vigo (Rias Baixas), and Ria de Ares-Betanzos (Rias Altas).

2. Date of Occurrence: From the end of March to mid June.

3. Effects: Presence of DSP bivalve toxicity.

4. Management Decision: Harvesting was closed when DSP toxin content was equal or higher than the quarantine level.

5. Causative Species: Dinophysis acuminata. The maximum cell concentration was 7040 cel/l.

6. Environment: During maximum cell numbers, the temperature ranged from 12.5 C to 16.0 C and salinity from 32.0 to 35.5 USP.

7. Advected Population or In Situ Growth: Probably "in situ" growth.

8. Previous Occurrences: Common every year in this period.

9. Additional Comments:

10. Individual to Contact:

J. Marino; J. Maneiro, Y. Pazos
Condicions Oceanograficas e Fitoplancton
Centro de Control da Calidade do Medio Marino
Peirao de Vilaxoan, s/n
36600 Vilagarcaa de Arousa
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Telf: +34 86 512320
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HARMFUL ALGAL BLOOMS IN 1995 - SPAIN
GALICIA

1. Location: Parts of the Rias de Muros, Arosa, Pontevedra and Vigo (Rias Baixas), and Ria de Ares-Betanzos (Rias Altas).

2. Date of Occurrence: From the begin of August to the end of September.

3. Effects: Presence of DSP bivalve toxicity.

4. Management Decision: Harvesting was closed when DSP toxin content was equal or higher than the quarantine levels.

5. Causative Species: Dinophysis acuminata, D. caudata and D. acuta. The maximum cell concentration was 30520 cel/l for D. acuminata, 3480 for D. caudata and 52200 for D. acuta.

6. Environment: During maximum cell numbers the temperature ranged from 13.5 C to 17.5 C and salinity from 34.5 to 35.8 USP.

7. Advected Population or In Situ Growth: Probably Advected Population.

8. Previous Occurrences: Common in this time of the year, but not in such high levels.

9. Additional Comments:

10. Individual to Contact:

J. Marino; J. Maneiro, Y. Pazos
Condicions Oceanograficas e Fitoplancton
Centro de Control da Calidade do Medio Marino
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HARMFUL ALGAL BLOOMS IN 1995 - SPAIN
GALICIA

1. Location: Parts of Rias de Muros, Arosa, Pontevedra and Vigo (Rias Baixas) and Ria de Ares-Betanzos (Rias Altas).

2. Date of Occurrence: From the end of October to the begin of December.

3. Effects: Presence of DSP bivalve toxicity.

4. Management Decision: Harvesting was closed when DSP toxin content was equal or higher than the quarantine level.

5. Causative Species: Dinophysis acuminata, D. caudata and D. acuta. The maximum cell concentration was 1760 cel/l for D. acuminata, 1520 for D. caudata and 1760 for D. acuta.

6. Environment: During maximum cell numbers the temperature ranged from 14.0 C to 16.5 C and salinity from 31.0 to 35.5 USP.

7. Advected Population or In Situ Growth: Probably advected population.

8. Previous Occurrences: Is not common this concentrations (but just presence) so late in the year.

9. Additional Comments:

10. Individual to Contact:

J. Marino; J. Maneiro, Y. Pazos
Condicions Oceanograficas e Fitoplancton
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HARMFUL ALGAL BLOOMS IN 1995 - SPAIN
GALICIA

1. Location: Parts of Ria of Pontevedra.

2. Date of Occurrence: From the end of April to the first week of May.

3. Effects: Presence of ASP toxicity in bivalves.

4. Management Decision: Harvesting was closed when ASP toxin content was equal or higher than 20 ppm.

5. Causative Species: Pseudo-nitzschia species. Most likely, P. australis. Maximum cell concentration of Pseudo-nitzschia species was 1.106.640 cells/l.

6. Environment: During maximum cell numbers the temperature ranged from 12.5 C to 15.6 C and salinity from 32.8 to 35.5 USP.

7. Advected Population or In Situ Growth: Probably "in situ" growth.

8. Previous Occurrences:Not previous ocurrences of ASP toxicity higher than 20 ppm were registred in the Galician Rías.

9. Additional Comments: Pseudo-nitzschia spp are common in the Galician Rías during the whole year, and usually not associated with ASP events.

10. Individual to Contact:

J. Marino; J. Maneiro, Y. Pazos
Condicions Oceanograficas e Fitoplancton
Centro de Control da Calidade do Medio Marino
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HARMFUL ALGAL BLOOMS IN 1995 - SPAIN
GALICIA

1. Location: Parts of the Rías de Muros, Arosa, Pontevedra and Vigo (Rias Baixas).

2. Date of Occurrence: First half of August.

3. Effects: Presence of ASP toxicity in bivalves.

4. Management Decision: Harvesting was closed when ASP toxin content was cqual or higher than 20 ppm.

5. Causative Species: Pseudo-nitzschia species. Most likely, P. australis. Maximum cell concentration of Pseudo-nitzschia species was 534.180 cel/l.

6. Environment: During maximum cell numbers the temperature ranged from 13.5 C to 17.8 C and salinity from 35.0 to 35.7 USP.

7. Advected Population or In Situ Growth: Probably "in situ" growth.

8. Previous Occurrences:Not previous ocurrences of ASP toxicity higher than 20 ppm were registred in thc Galician Rías.

9. Additional Comments: Pseudo-nitzschia spp are common in the Galician Rías during the whole year, and usually not associated with ASP events.

10. Individual to Contact:

J. Marino; J. Maneiro, Y. Pazos
Condicions Oceanograficas e Fitoplancton
Centro de Control da Calidade do Medio Marino
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HARMFUL ALGAL BLOOMS IN 1995 - SPAIN
CATALUÑA

1. Location: Beaches of Southern Catalonia.

2. Date of Occurrence: July and August 1995

3. Effects: Mucilage aggregates in the coast, affecting negatively tourism and fisheries.

4. Management Decision:

5. Causative Species: Unknown

6. Environment: Calm weather.

7. Advected Population or In Situ Growth: probably advected.

8. Previous Occurrences:

9. Additional Comments:

10. Individual to Contact:

Maximino Delgado
Instituto de Ciencias del mar
Ps. Joan de Borbo, s/n
08039 Barcelona
Telf: 34 3 2216450
Fax: 34 3 2217340

HARMFUL ALGAL BLOOMS IN 1995 - SPAIN
CATALUÑA

1. Location: La Fosca Beach (Costa Brava, Catalonia).

2. Date of Occurrence: July-August 1995.

3. Effects: Presence of green patches in the beach, affecting negatively tourism.

4. Management Decision:

5. Causative Species: Alexandrium taylori Balech.

6. Environment: Calm weather. Temperature of water: 20-26 C, salinity: 37-38 psu.

7. Advected Population or In Situ Growth: In situ growth.

8. Previous Occurrences: July-August 1994.

9. Additional Comments: Non-toxic bloom that seems to be yearly recurrent.

10. Individual to Contact: Maximino Delgado
Instituto de Ciencias del mar
Ps. Joan de Borbo, s/n
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HARMFUL ALGAL BLOOMS IN 1995 - SPAIN
CATALUÑA

1. Location: The Alfacs Bay (Ebro Delta, Catalonia).

2. Date of Occurrence: From December 1995 to March 1996.

3. Effects:

4. Management Decision: Monitoring the dinoflagellate concentration before pumping of water to ponds.

5. Causative Species: Gyrodinium corsicum Paulmier.

6. Environment: Salinity 35-36 psu, temperature 6-17 C..

7. Advected Population or In Situ Growth: In situ growth.

8. Previous Occurrences: Previous year on the same dates.

9. Additional Comments: This species was associated the previous year on the same dates with fish mortalities in culture ponds but not this year. This result was in relation with lower concentration of the dinoflagellate in the ponds during this year.

10. Individual to Contact:
Maximino Delgado
Instituto de Ciencias del mar
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Fax: 34 3 2217340

HARMFUL ALGAL BLOOMS IN 1995 - SPAIN
BALEARES

1. Location: Harbour of Palma de Mallorca.

2. Date of Occurrence: April and May, 1995

3. Effects: PSP detection in mussels; red patches in the Bay.

4. Management Decision:

5. Causative Species: Alexandrium minutum Halim.

6. Environment: Calm weather, temperature: 16-24 C, salinity: 27-37 psu.

7. Advected Population or In Situ Growth: In situ.

8. Previous Occurrences: Is the first report of PSP in Balearic Islands.

9. Additional Comments: The organism was isolated and cultures. The toxin profile is similar to that of Alexandrium minutum from Galicia.

10. Individual to Contact:

Maximino Delgado
Instituto de Ciencias del mar
Ps. Joan de Borbo, s/n
08039 Barcelona
Telf: 34 3 2216450
Fax: 34 3 2217340

REPORT TO THE ICES/IOC WORKING GROUP ON HARMFUL ALGAL BLOOM DYNAMICS (WGHABD)
Brest France, 17-20 April, 1996

NATIONAL REPORT OF HARMFUL ALGAL EVENTS AND SHELLFISH POISONING 1995 **SWEDEN**

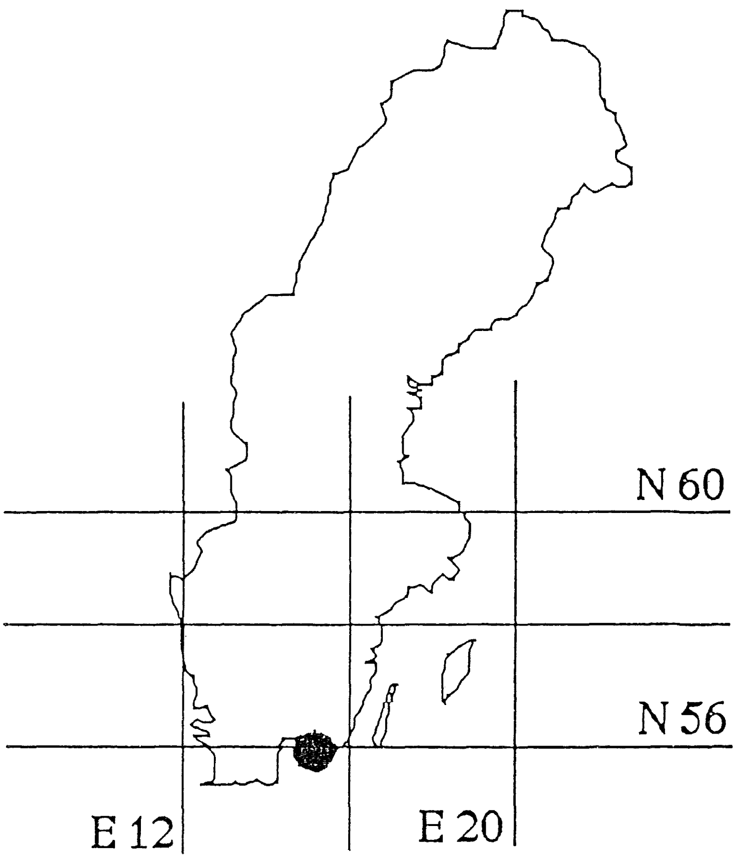
In the Skagerrak and Kattegat area there were no exceptional phytoplankton blooms in 1995. From October to the end of the year, however, cell densities of Dinophysis spp. were higher than normal. Okadaic acid concentrations in mussels were in some places along the Swedish Skagerrak coast between 40 and 80 µg/100 g mussel meat in January and February. In the Göteborg area January concentrations ranged between 40 and 140 µg Okadaic acid/100 g mussel meat and along the Kattegat coast January concentrations ranged between 40 and 75 µg Okadaic acid/100 g mussel meat. In all areas the concentrations decreased during spring and very low values were measured between June and September. In October an increase of the concentrations were again observed.
In the Baltic Sea, along the south coast of Sweden a bloom of Coscinodiscus cf. radiatus clogged fishing nets in October. No toxic effects were observed.
Blooms of cyanobacteria were common all over the Baltic Sea in August. In some cases toxicity was measured. The death of a dog and a swan may be linked to toxic cyanobacteria. However, autopsy was not performed.

CONTACT PERSONS:

Lars Edler, SMHI, Oceanographical Lab., Doktorsg. 9D, S-262 52 Ängelholm
Lars Edebo, Dept. of Clin. Bacteriology, Guldhedsg. 10, S-413 46 Göteborg
Roland Mattsson, National Veterinary Institute, Box 7073, S-750 07 Uppsala
Per Olsson, Toxicon AB, Rosenhällsv. 23, S-261 92 Landskrona
Susanna Hajdu, Dept of Systems Ecology, Box 7050, S-750 07, Uppsala,
Gunnar Aneer, Information Office for the Baltic proper,Box 22067, S-104 22 Stockholm

NATIONAL REPORT OF HARMFUL ALGAL EVENTS AND SHELLFISH POISONING 1995 — SWEDEN

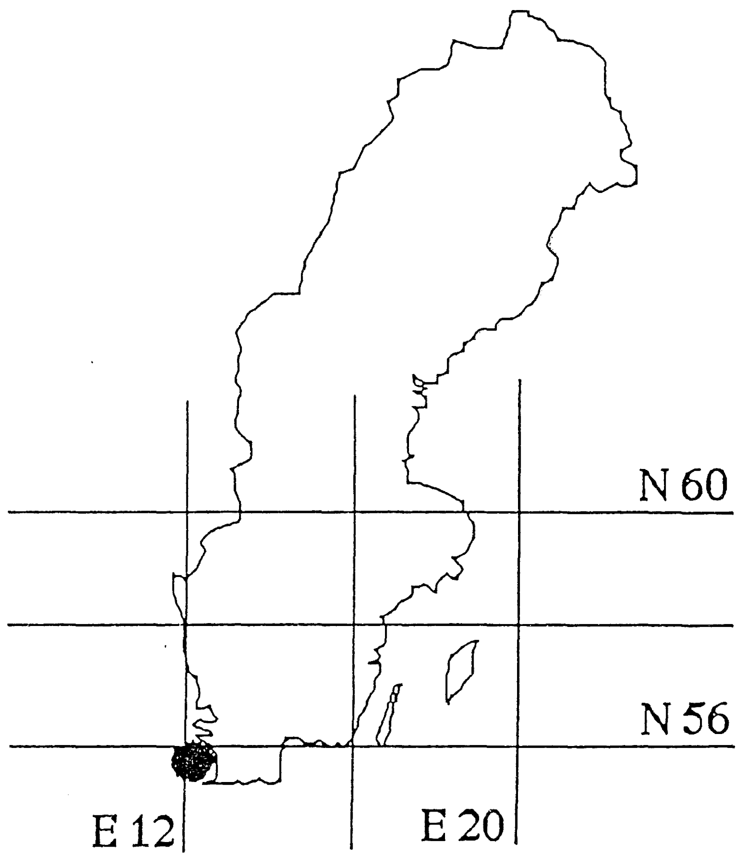
LOCATION:	Archipelago of Blekinge, approx. N 56.10, E15 - E16
DATE:	Around 15 July and around 30 July
SPECIES:	Nodularia spumigena (90%) Aphanizomenon "baltica" 15 July Nodularia spumigena (75%) Aphanizomenon "baltica" (10%), Anabaena circinalis (15%).
CELL DENSITY:	no data
TOXICITY CONCENTRATION:	Sample 30 July showed +++, high toxicity
TOXICITY ANALYSIS METHOD:	-
EFFECTS:	not reported
MANAGEMENTS DECISIONS:	Information to national and local news media. The public informed that children and domestic animals should be kept away from blooms.
ENVIRONMENT:	Water temperature 19 °C.
ADVECTED POPULATION: IN SITU GROWTH:	
PREVIOUS OCCURRENCE:	First week of July
ADDITIONAL COMMENTS:	
CONTACT PERSON:	Thomas Gummesson, Environmental and Health Office, Ronneby, Marita Karlström Environmental and Health Office,Karlshamn. Roland Mattsson, National Veterinary Institute, Uppsala



NATIONAL REPORT OF HARMFUL ALGAL EVENTS AND SHELLFISH POISONING 1995 — SWEDEN

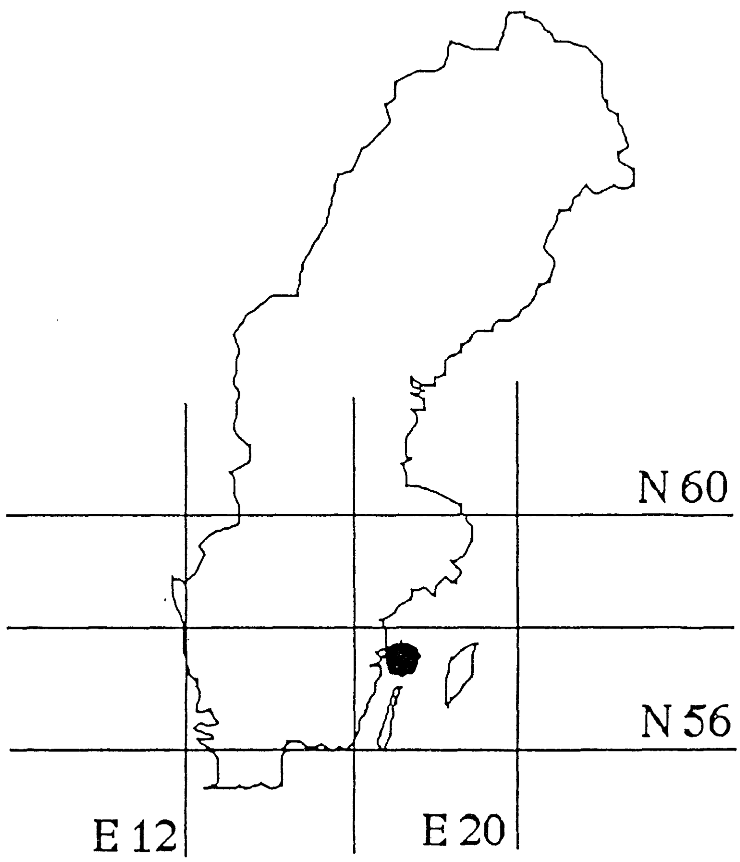
LOCATION:	Central Öresund, approx. N 55.50, E12.40
DATE:	3 August
SPECIES:	Nodularia spumigena
CELL DENSITY:	Surface accumulation in the whole area
TOXICITY CONCENTRATION:	Sample 30 July showed +++, high toxicity
TOXICITY ANALYSIS METHOD:	-
EFFECTS:	not reported
MANAGEMENTS DECISIONS:	
ENVIRONMENT:	Water temperature 21-22 °C.
ADVECTED POPULATION: IN SITU GROWTH:	
PREVIOUS OCCURRENCE:	
ADDITIONAL COMMENTS:	Occassionally very turbid water along the shores

CONTACT PERSON: Per Olsson, Toxicon, Landskrona, tel 46 418 70700, fax 46 418 70300, e-mail toxicon@pop.landskrona.se.



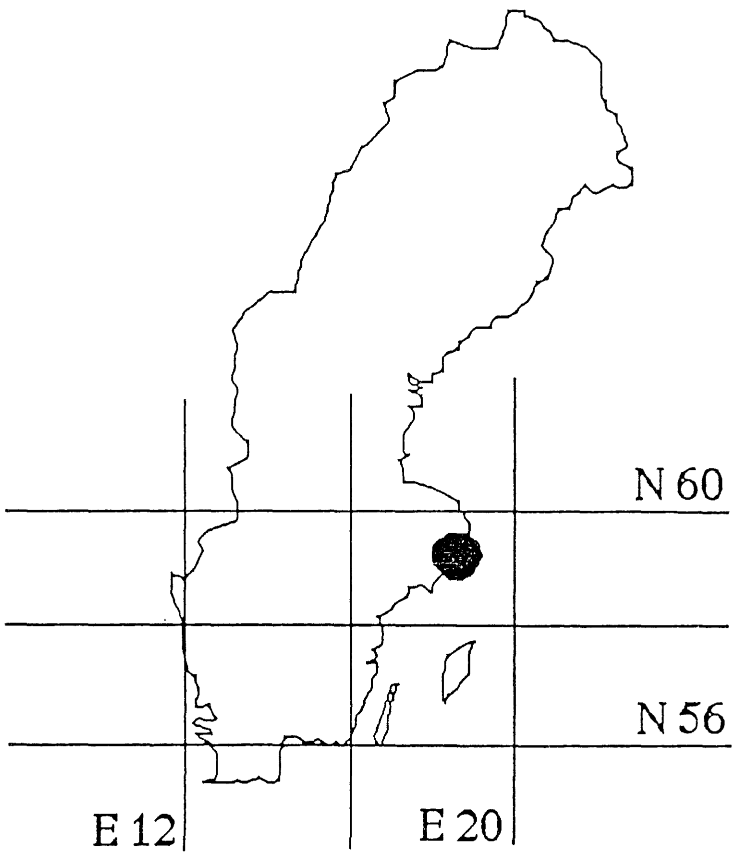
NATIONAL REPORT OF HARMFUL ALGAL EVENTS AND SHELLFISH POISONING 1995 — SWEDEN

LOCATION:	Grönö, south archipelago of Västervik , the Baltic, approx. N 57.35 E16.40
DATE:	2-6 August and 11-13 August
SPECIES:	Nodularia spumigena, Anabaena lemmermannii.
CELL DENSITY:	no data
TOXICITY CONCENTRATION:	no data
TOXICITY ANALYSIS METHOD:	-
EFFECTS:	A mute swan found dead among the accumulated algae. Cause of death unknown.
MANAGEMENTS DECISIONS:	-
ENVIRONMENT:	Water temperature 22 -24 °C.
ADVECTED POPULATION: IN SITU GROWTH:	
PREVIOUS OCCURRENCE:	First week of July algal bloom reported in the vicinity
ADDITIONAL COMMENTS:	
CONTACT PERSON:	Gun Lindberg, Environmental and Health Office,Västervik. Swan sent to the National Veterinary Institute (T. Mörner)



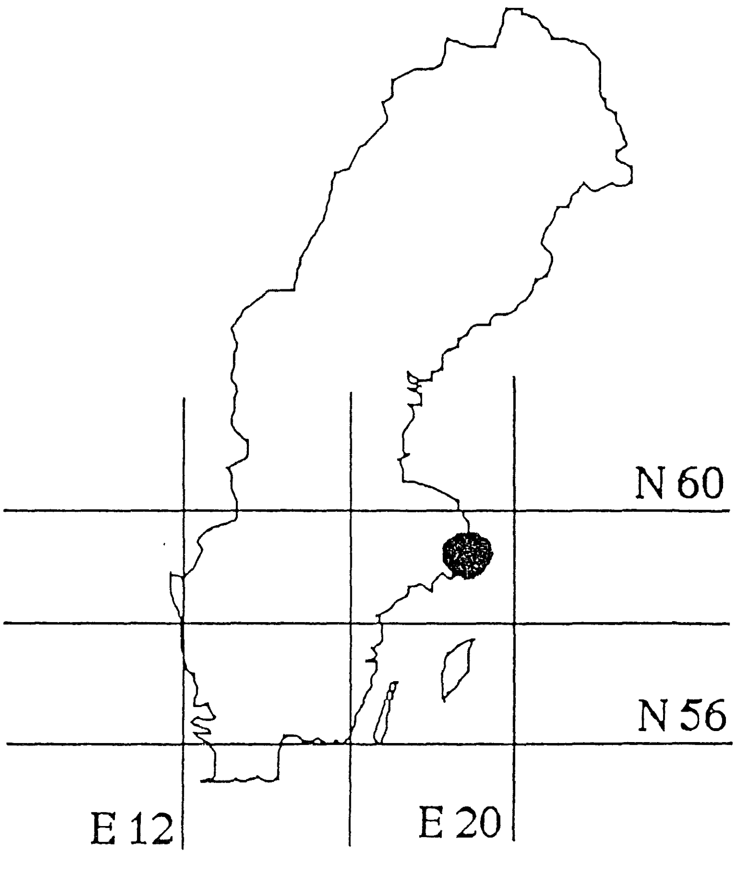
NATIONAL REPORT OF HARMFUL ALGAL EVENTS AND SHELLFISH POISONING 1995 — SWEDEN

LOCATION:	Inner part of Stockholm archipelago, N 59.20 - 59.30, E18.00 - 18.30
DATE:	7 September
SPECIES:	Aphanizomenon "baltica" (90%), Nodularia spumigena (10%)
CELL DENSITY:	no data
TOXICITY CONCENTRATION:	Some samples showed toxicity (++), others not.
TOXICITY ANALYSIS METHOD:	
EFFECTS:	not reported
MANAGEMENTS DECISIONS:	
ENVIRONMENT:	
ADVECTED POPULATION: IN SITU GROWTH:	
PREVIOUS OCCURRENCE:	
ADDITIONAL COMMENTS:	
CONTACT PERSON:	Ingegerd Örnstedt, Environmental and Health Office, Värmdö

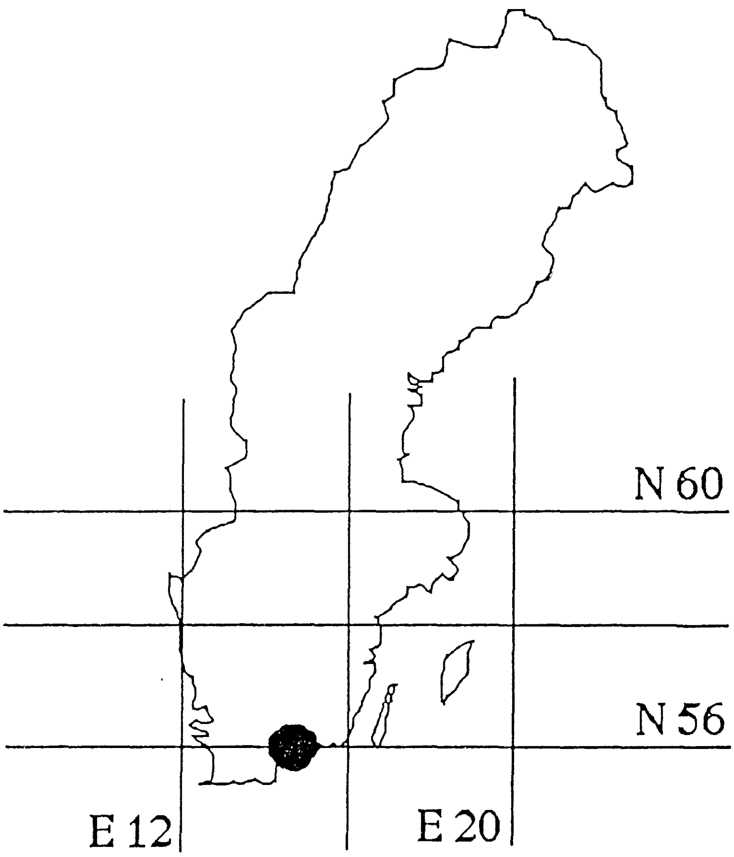


NATIONAL REPORT OF HARMFUL ALGAL EVENTS AND SHELLFISH POISONING 1995 — SWEDEN

LOCATION:	Stockholm archipelago, N 59.20 - 59.30, E18.00 - 18.40
DATE:	9 - 15 September
SPECIES:	Microcystis aeruginosa, Aphanizomenon "baltica", Nodularia spumigena
CELL DENSITY:	no data
TOXICITY CONCENTRATION:	toxicity, hepatotoxin
TOXICITY ANALYSIS METHOD:	-
EFFECTS:	not reported
MANAGEMENTS DECISIONS:	Report of the bloom published and broadcasted with recommendations to stay away from accumulations of the algae.
ENVIRONMENT:	
ADVECTED POPULATION: IN SITU GROWTH:	
PREVIOUS OCCURRENCE:	
ADDITIONAL COMMENTS:	
CONTACT PERSON:	Environmental and Health Office, Stockholm, Lidingö, Värmdö, Christer Lännergren, Stockholm Vatten AB, Gunnar Aneer, Kerstin Bohm, Information Office for the Baltic proper, Roland Mattsson, National Veterinary Institute, Uppsala



LOCATION:	Pukaviksbukten and Karlshamn area, N 56.15, E 14.50
DATE:	13 September
SPECIES:	Aphanizomenon "baltica",
CELL DENSITY:	no data
TOXICITY CONCENTRATION:	no data
TOXICITY ANALYSIS METHOD:	-
EFFECTS:	not reported
MANAGEMENTS DECISIONS:	
ENVIRONMENT:	Reduced seechi depth (2-3 m)
ADVECTED POPULATION: IN SITU GROWTH:	
PREVIOUS OCCURRENCE:	
ADDITIONAL COMMENTS:	Neon-blue aggregations of algae along the shores
CONTACT PERSON:	Roland Engkvist, Kalmarsundslab. Kalmar Högskola

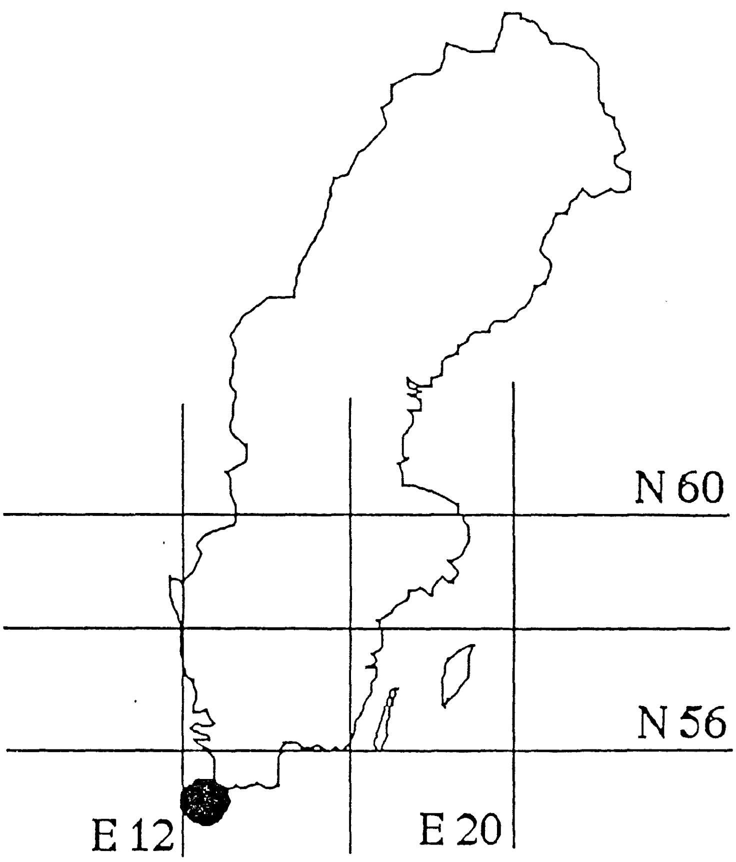


NATIONAL REPORT OF HARMFUL ALGAL EVENTS AND SHELLFISH POISONING 1995

SWEDEN

LOCATION:	South coast of Sweden, N 55.40 , E13.00
DATE:	27 September and 24 October
SPECIES:	Coscinodiscus cf. radiatus
CELL DENSITY:	1 000 - 3 000 cells/L
TOXICITY CONCENTRATION:	no data
TOXICITY ANALYSIS METHOD:	
EFFECTS:	Reports from fishermen that nets clogged. Low or no fish catch. No toxic effects reported.
MANAGEMENTS DECISIONS:	None
ENVIRONMENT:	8.7 psu, 15°C, 0.06-0.16 µM PO4, 0.1-0.4 µM NO3, 0.07-0.9 µM NH¤,3-7 µM SiO2, 2-5 µg CHL/L
ADVECTED POPULATION: IN SITU GROWTH:	not known
PREVIOUS OCCURRENCE:	Present most years in lower densities. Clogging of fish nets not reported before.
ADDITIONAL COMMENTS:	Obviously also present in the south part of Öresund.

CONTACT PERSON: Per Olsson, Toxicon, Landskrona, tel 46 418 70700, fax 46 418 70300, e-mail toxicon@pop.landskrona.se.



NATIONAL REPORT OF HARMFUL ALGAL EVENTS AND SHELLFISH POISONING 1995

SWEDEN

LOCATION: Western Gräsö, southern Bothnian Sea, N 60.20, E18.40

DATE: 14 - 15 October

SPECIES: Aphanizomenon "baltica"

CELL DENSITY:

TOXICITY CONCENTRATION:

TOXICITY ANALYSIS METHOD:

EFFECTS: A dog died near this bloom on 25 September. Intoxication by cyanobacteria cannot be rueled out.

MANAGEMENTS DECISIONS:

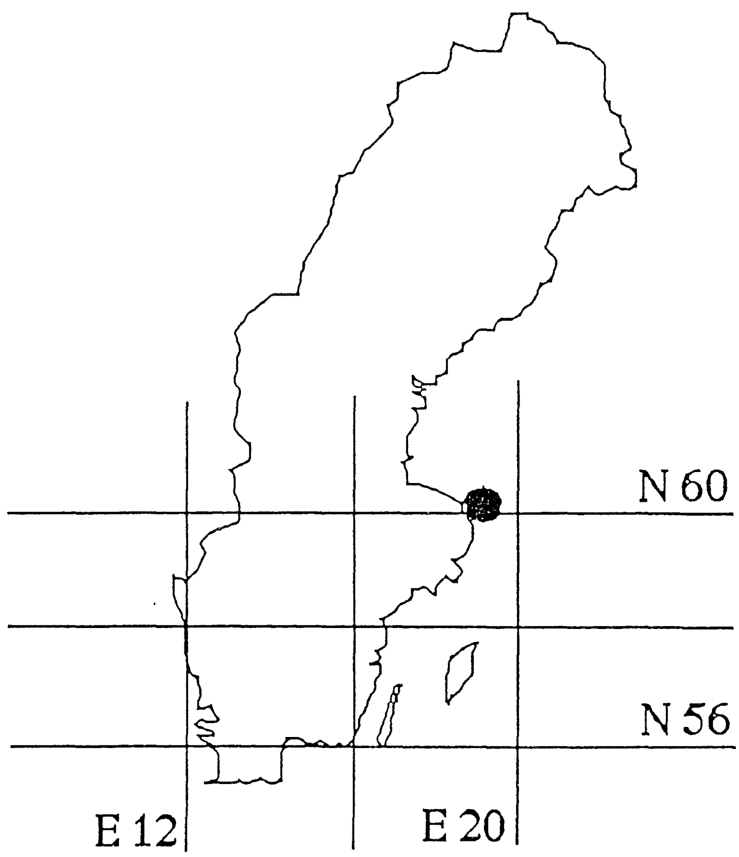
ENVIRONMENT:

ADVECTED POPULATION:
IN SITU GROWTH:

PREVIOUS OCCURRENCE:

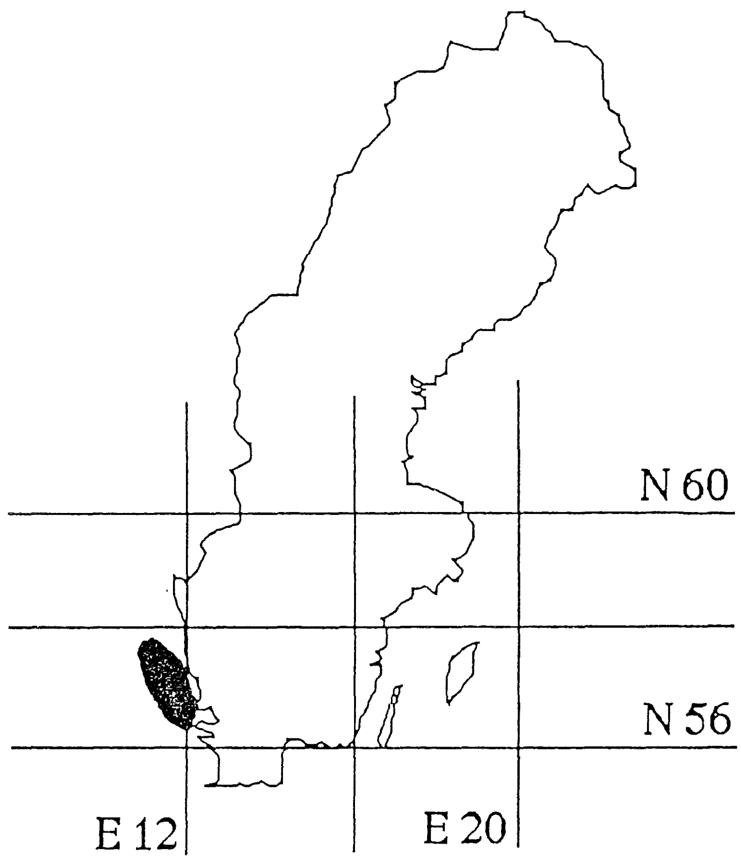
ADDITIONAL COMMENTS:

CONTACT PERSON: Ulrik Kautsky, Dept of Systems Ecology, Stockholm University



NATIONAL REPORT OF HARMFUL ALGAL EVENTS AND SHELLFISH POISONING 1995 — SWEDEN

LOCATION:	The Kattegat, N 56.28 - 57.20 , E12.00 - 12.33
DATE:	October - December
SPECIES:	Dinophysis norvegica
CELL DENSITY:	3 500 - 9 500 cells/L
TOXICITY CONCENTRATION:	no data
TOXICITY ANALYSIS METHOD:	
EFFECTS:	No toxic effects reported.
MANAGEMENTS DECISIONS:	None
ENVIRONMENT:	
ADVECTED POPULATION:	
IN SITU GROWTH:	X
PREVIOUS OCCURRENCE:	Present every year.
ADDITIONAL COMMENTS:	
CONTACT PERSON:	Per Olsson, Toxicon, Landskrona, tel 46 418 70700, fax 46 418 70300, e-mail toxicon@pop.landskrona.se.



NATIONAL REPORT OF HARMFUL ALGAL EVENTS AND SHELLFISH POISONING 1995 — SWEDEN

LOCATION: Baltic proper,

DATE: End of July - beginning of August

SPECIES: Nodularia spumigena

CELL DENSITY: Accumulation on the surface

TOXICITY CONCENTRATION: toxic

TOXICITY ANALYSIS METHOD:

EFFECTS: no reports

MANAGEMENTS DECISIONS:

ENVIRONMENT:

ADVECTED POPULATION: X
IN SITU GROWTH: X

PREVIOUS OCCURRENCE: These blooms occur more or less every year

ADDITIONAL COMMENTS:

CONTACT PERSON: Susanna Hajdu, Dept of Systems Ecology, Stockholm University, Uppsala, Ove Rud, Dept. of Physical Geography, Stockholm University, Gunnar Aneer, Information Office for the Baltic proper

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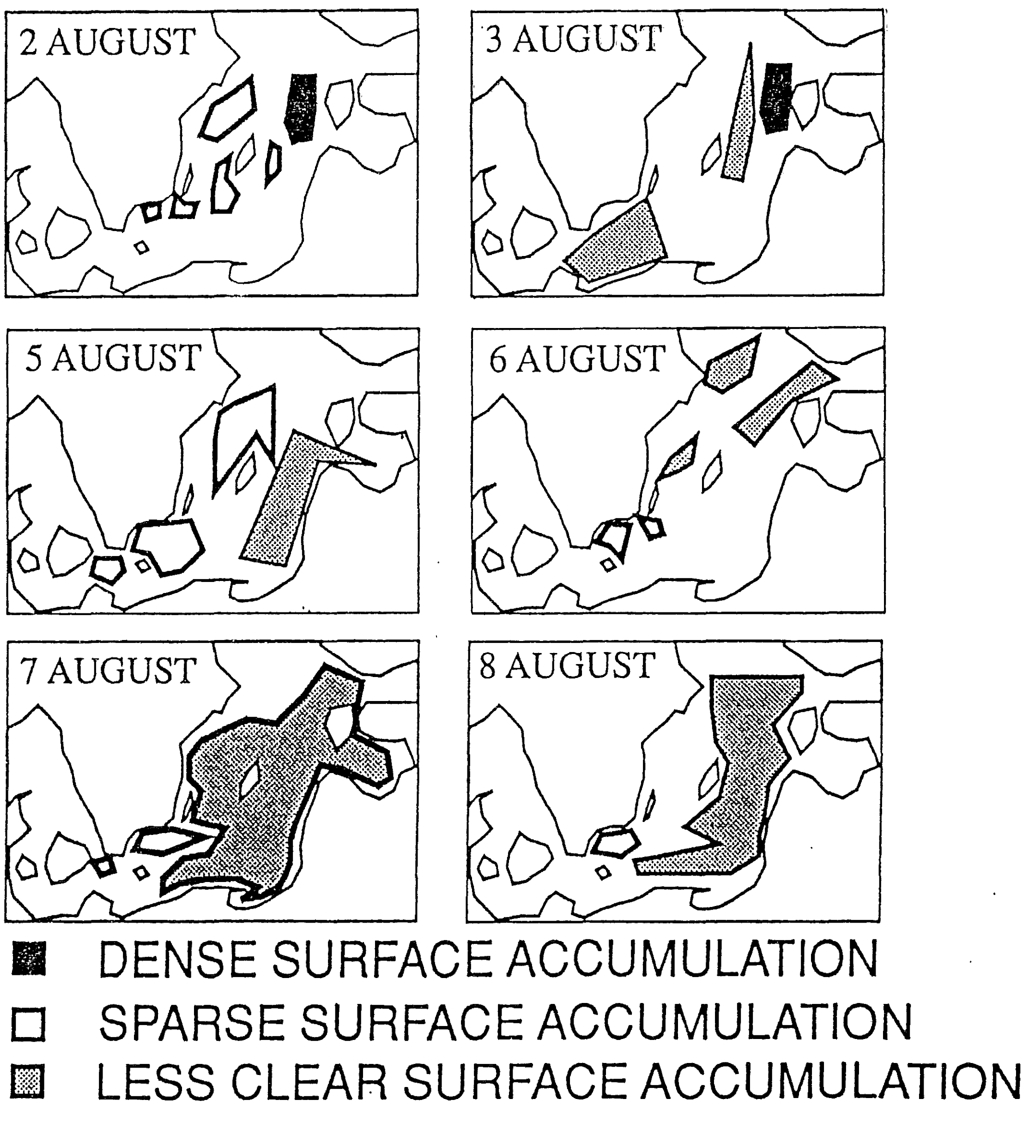

HARMFUL ALGAL BLOOMS IN THE UNITED STATES - 1995

MAINE

1. Location: Tremont, Maine to the Canadian border. Area 1.

2. Date of Occurrence: Toxicity in shellfish May to August, 1995. (*Arctica islandica* remain toxic)

3. Effects: PSP in shellfish (*Mytilus edulis*, *Mya arenaria*, *Modiolus modiolus*, *Arctica islandica*, and *Placopecten magellanicus*.

4. Management Action: Affected areas closed to the harvest of specific species.

5. Causative Species: *Alexandrium tamarense*.

6. Environment: Occurred inshore and offshore, thus over a wide range of temperatures and salinities.

7. Advected Population or In Situ Growth:

8. Previous Occurrences: Monitoring began and closures were made beginning in 1958.

9. Additional Comments: A precautionary closure was made on September 5, 1995 for Domoic acid, along the outer shore of Cobscook Bay, during a toxic event occurring in neighboring Canadian waters.

10. Individual to Contact: John W. Hurst, Jr.
Department of Marine Resources
West Boothbay Harbor, Maine 04575

HARMFUL ALGAL BLOOMS IN THE UNITED STATES - 1995

MAINE

1. Location: Kittery - Stonington, Maine. Area 2.

2. Date of Occurrence: Toxicity in shellfish May to August, 1995.

3. Effects: PSP in shellfish (*Mytilus edulis*, *Mya arenaria*, *Spisula solidissima*, *Modiolus modiolus*, *Euspira heros*.

4. Management Action: Affected areas closed to the harvest of specific species.

5. Causative Species: *Alexandrium tamarense*.

6. Environment:

7. Advected Population or In Situ Growth:

8. Previous Occurrences: Monitoring began and closures were made beginning in 1958.

9. Additional Comments:

10. Individual to Contact: John W. Hurst, Jr.
Department of Marine Resources
West Boothbay Harbor, Maine 04575

HARMFUL ALGAL BLOOMS IN THE UNITED STATES — 1995

NEW YORK

1. **Locations:** Throughout the Peconic Estuary System, on the eastern end of Long Island, New York.

2. **Dates of Occurrence**: From late April through September. During July, concentrations exceeded 10^6 cells/ml at 12 of the 31 sites sampled. A peak concentration of >1.7 x 10^6 cells/ml was found in Coecles Harbor (Shelter Island) on 7/18/95.

3. **Effects**: Impacts on various shellfish species (scallops, hard clams, & mussels) and on submerged aquatic vegetation (eelgrass) have previously been reported. Other effects are aesthetic - water discoloration and reduced transparency.

4. **Management Decisions**: Continue weekly monitoring program.

5. **Causative Species**: *Aureococcus anophagefferens*

6. **Environment**: Temperature: 10-29 deg.C
Salinity: 10-30 ppt
Dissolved oxygen: 2.0-10.0 mg/l
Water column stability: mixed

7. **Advected population or in-situ growth**: in-situ growth

8. **Previous Occurrences**: The bloom was present throughout the entire Peconic system from 1985 through 1987, with densities occasionally exceeding 10^6 cells/ml. Cell numbers declined through 1988 and 1989, and were generally undetectable during 1990 with the exception of those from West Neck Bay. During 1991, densities of up to 2 x 10^6 cells/ml occurred in Flanders Bay and West Neck Bay. During 1992, numbers approached 8.5 x 10^5 cells/ml in Coecles Harbor and 10^6 cells/ml in West Neck Bay. It occurred briefly in May of 1994 in Flanders Bay (up to 1.4 x 10^4 cells/ml) and in Great Peconic Bay (1.1 x 10^4 cells/ml).

9. **Additional comments**:

10. **Individual to Contact**:

Dr. Robert Nuzzi
Bureau of Marine Resources
Suffolk County Dep't. of Health Services
Riverhead, New York 11901
516-852-2082

HARMFUL ALGAL BLOOMS IN THE UNITED STATES — 1995

NEW YORK

1. **Locations:** Great South Bay, New York. The bloom was present at all sites sampled, from the Carmans River mouth on the east to the waters off Lindenhurst on the west.

2. **Dates of Occurrence**: From January through August (sampling was not continued after 8/30). Cell numbers peaked on 7/5, ranging from 2.8 x 10^5 to >10^6 cells/ml.

3. **Effects**: Impacts on various shellfish species (scallops, hard clams, & mussels) and on submerged aquatic vegetation (eelgrass) have previously been reported. Other effects are aesthetic - water discoloration and reduced transparency.

4. **Management Decisions**: Continue weekly monitoring program.

5. **Causative Species**: *Aureococcus anophagefferens*

6. **Environment**: Temperature: <1-28 deg.C
Salinity: 23-31 ppt
Dissolved oxygen: 5.5-12.6 mg/l
Water column stability: mixed

7. **Advected population or in-situ growth**: in-situ growth

8. **Previous Occurrences**: 1985, 1986: >10^6 cells/ml
1988: 10^3 - 5 x 10^5 cells/ml (June-Aug)
1989: <2.5 x 10^4 cells/ml (April-Sept)
1990: <1 x 10^4 cells/ml (May-Dec)
1991: <10^4 cells/ml (Jan-June)
1992: 10^3 - 10^6 cells/ml (Jan-Dec)
1993: <10^3 - 2.6 x 10^5 cells/ml (Jan-Mar, Aug-Nov)
1994: up to 10^6 cells/ml (June-July)
up to 1.2 x 10^4 cells/ml (Aug-Oct)

9. **Additional comments**:

10. **Individual to Contact**:

Dr. Robert Nuzzi
Bureau of Marine Resources
Suffolk County Dep't. of Health Services
Riverhead, New York 11901
516-852-2082

HARMFUL ALGAL BLOOMS IN THE UNITED STATES — 1995

NEW YORK

1. **Locations:** Moriches and Shinnecock Bays, New York. The bloom was present throughout both bays, with highest concentrations in eastern Moriches Bay, Quantuck Bay, and western Shinnecock Bay.

2. **Dates of Occurrence**: From January through August in Moriches Bay (sampling was not continued after 8/23), and from January through October in Shinnecock Bay (sampling was terminated on 10/5). Peak concentrations of >1.5 x 10^6 occurred from late June to mid July.

3. **Effects**: Impacts on various shellfish species (scallops, hard clams, & mussels) and on submerged aquatic vegetation (eelgrass) have previously been reported. Other effects are aesthetic - water discoloration and reduced transparency.

4. **Management Decisions**: Continue weekly monitoring program.

5. **Causative Species**: *Aureococcus anophagefferens*

6. **Environment**: Temperature: 2.5-28.6 deg.C
Salinity: 25-31 ppt
Dissolved oxygen: 4.8-11.0 mg/l
Water column stability: mixed

7. **Advected population or in-situ growth**: in-situ growth

8. **Previous Occurrences**: 1989: <1.3 x 10^5 cells/ml in Moriches Bay
<2.3 x 10^4 cells/ml in Shinnecock Bay
1990: <10^3 to 9.6 x 10^5 cells/ml
1991: <10^3 to >10^6 cells/ml
1992: >10^6 cells/ml
1993: up to 2 x 10^5 cells/ml
1994: up to 3.8 x 10^4 cells/ml

9. **Additional comments**:

10. **Individual to Contact**:

Dr. Robert Nuzzi
Bureau of Marine Resources
Suffolk County Dep't. of Health Services
Riverhead, New York 11901
516-852-2082

HARMFUL ALGAL BLOOMS IN THE UNITED STATES — 1995

NEW JERSEY

1. **Location:** New Jersey-Hudson/Raritan estuary, southern portion (Raritan Bay to Sandy Hook Bay) and a few locales along the adjacent New Jersey oceanfront.

2. **Date of Occurrence:** Late May through June, mixed diatom blooms pervaded the area; 5-18 July, patchy but intense flagellate blooms occurred within the area. gust).

3. **Effects:** Dead fish found along the south shore, 19-24 July, just west and east of Keyport Harbor at Cliffwood Beach and Union Beach

4. **Management Action:** Response teams from NOAA (Sandy Hook), USEPA Region II, and Monmouth County Health Department, collected samples and field data ASAP after the kills; coordinated by New Jersey Department of Environmental Protection; routine surveillance increased.

5. **Causative Species:** Dominant diatoms *Skeletonema costatum. Thalassiosira gravida* and *nordenskioldii, Cerataulina pelagica, Rhizosolenia delicatula;* individual cell counts to 4×10^4 ml^{-1}, total counts > 10^5 ml^{-1}. Dominant flagellates *Olisthodiscus luteus, Katodinium rotundatum, Prorocentrum* spp. and *Eutreptia lanowii*; individual counts to 2×10^4, totals to 5×10^4.

6. **Environment:** Bottom dissolved oxygen as low as 0.4-1.1 mgl^{-1} at 2-4 M depth; nighttime surface dissolved oxygen as low as 0.28 mgl^{-1} at times and place of kills; temperature 24(26) to 29(30)°C; salinity around 27‰.

7. **Advected Population or In Situ Growth:** In-situ growth; some diatoms of neritic origin from adjacent New York Bight waters.

8. **Previous Occurrences:** On our records from 1992-93, 1988-99, 1976, 1985, 1981 in the same general vicinity, within a 16 km segment from about Keyport to Atlantic Highlands.

9. **Additional Comments:** Fish kills are attributed to hypoxia from bloom collapse and consequent algal decomposition in the several weeks preceding kills.

10. **Individual to Contact:**
Dr. Paul Olsen
New Jersey Department
of Environmental Protection

HARMFUL ALGAL BLOOMS IN THE UNITED STATES — 1995

NEW JERSEY

1. **Location:** New Jersey-Hudson/Raritan estuary, southern portion (Raritan Bay to Sandy Hook Bay) and a few locales along the adjacent New Jersey oceanfront.

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5. **Causative Species:** Dominant diatoms *Skeletonema costatum. Thalassiosira gravida* and *nordenskioldii, Cerataulina pelagica, Rhizosolenia delicatula;* individual cell counts to 4×10^4 ml^{-1}, total counts > 10^5 ml^{-1}. Dominant flagellates *Olisthodiscus luteus, Katodinium rotundatum, Prorocentrum* spp. and *Eutreptia lanowii*; individual counts to 2×10^4, totals to 5×10^4.

6. **Environment:** Bottom dissolved oxygen as low as 0.4-1.1 mgl^{-1} at 2-4 M depth; nighttime surface dissolved oxygen as low as 0.28 mgl^{-1} at times and place of kills; temperature 24(26) to 29(30)°C; salinity around 27‰.

7. **Advected Population or In Situ Growth:** In-situ growth; some diatoms of neritic origin from adjacent New York Bight waters.

8. **Previous Occurrences:** On our records from 1992-93, 1988-99, 1976, 1985, 1981 in the same general vicinity, within a 16 km segment from about Keyport to Atlantic Highlands.

9. **Additional Comments:** Fish kills are attributed to hypoxia from bloom collapse and consequent algal decomposition in the several weeks preceding kills.

10. **Individual to Contact:**

Dr. Paul Olsen
New Jersey Department
of Environmental Protection
Division of Science and Research
Bureau of Water Monitoring, CN422
Trenton, New Jersey 08625

HARMFUL ALGAL BLOOMS IN THE UNITED STATES — 1995

NORTH CAROLINA

1. **Location:** Coastal estuaries of central North Carolina (Neuse River Estuary, Pamlico River Estuary).

2. **Date of Occurrence:** 20 July to 20 October 1995

3. **Effects:** Fish kills, invertebrate kills.

4. **Management Action:** 10 mi run of Neuse River closed to fishing for approximately two weeks.

5. **Causative Species:** *Pfiesteria piscicida* implicated in mills. *Phaeocystis* also in area during one kill in New River after pollution "event" (= raw sewage).

6. **Environment:** Estuarine to riverine.

7. **Advected Population or In Situ Growth:** In situ growth.

8. **Previous Occurrences:**

9. **Additional Comments:** Low oxygen and *Gymnodinium sanguineum* present also. Hypoxia and anoxia implicated in some kills. Dominant species affected was young of the year (peanut) menhaden. These fish are sensitive to low O_2. *Pfiesteria* and low O_2 could have combined to worsen the situation.

10. **Individual to Contact:**

Dr. Pat Tester
National Marine Fisheries Service
NOAA
101 Pivers Island Road
Beaufort, North Carolina 28516
Tel.: (919) 728-8792
Fax: (919) 728-8784
E-Mail: ptester@hatteras.bea.nmfs.gov

Ecosystem	Days	No. of fish	Cause
New River	4	4,000	High ammonia, hypoxia (hog spill; fresh water)
New River Estuary	1?	ca. 10,000	Lethal *Pfiesteria* densities preceding kill; second harmful alga, *Phaeocystis*, also known to be stimulated by raw sewage (Hallegraeff 1993); sublethal *Pfiesteria* two days after kill*
Neuse River Estuary	5	100,000s	Hypoxia; sublethal *Pfiesteria* two days after kill*
Pamlico River Estuary	11	100,000s	Lethal *Pfiesteria* during kill; low dissolved oxygen in lower third of water column
Black River	2	10,000s	Anoxia (hog effluent spill?; fresh water)
Roanoke River	2	100,000s	Industrial discharge from faulty management upstream, reservoir water level (hypoxia/anoxia)
Goose Creek (Neuse)	2	110,000	Anoxia, heavy and noxious H_2S fumes; also lethal *Pfiesteria* during kill
Neuse River Estuary	90**	11,000,000	*Pfiesteria* swarming at lethal densities

* In the New River and first Neuse River estuary kills, data were not available for *Pfiesteria* densities as fish were dying. Note: Many other kills were anecdotally reported by fishermen who maintain that few adult menhaden were available to die in the Pamlico because the young had been dying throughout the late spring and summer.

** Fish deaths from July 20 to Oct. 20; most fish died between Sept. 20 and Oct. 20.

Fig. 2. Major fish kills (more than 1,000 fish affected) in North Carolina's rivers and estuaries during the summer of 1995. Information supplied by J. Burkholder.*

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HARMFUL ALGAL BLOOMS IN THE UNITED STATES — 1995

CALIFORNIA

1. Locations: MARIN COUNTY, CALIFORNIA, Drakes Bay, Chimney Rock, Kehoe Beach, Rodeo Beach, Drakes Estero, Muir Beach, Tomales Bay

2. Date of Occurrence: April, May, July, August, September, October, November, December

3. **Effects:** Low but detectable levels of PSP toxin in sentinel mussel tissue during April, May, Sept.thru Dec. In July toxin levels at Chimney Rock, Drakes Bay increased to 700 ug, at Drakes Estero PSP concentration was 420 ug, in Tomales Bay 130 ug, and Rodeo Beach mussel samples assayed at 240 ug/100 g tissue.

4. **Management Decisions:** The annual quarantine on sport harvesting of mussels was put in effect on May 1, 1995 and continued until October 31, 1995

5. **Causative Species:** *Alexandrium catenella*

6. **Environment:** No data available

7. **Advected Population or In Situ Growth:** Although difficult to assess it is probable that both in situ and advected populations contributed to the high phytoplankton population

8. **Previous Occurrences:** 1927, '29, '32, '54, '62-'66, '70, '71, '76, '80-'84, '86-'95

9. **Additional Comments:** The phytoplankton monitoring program was able to show the concentration of *A. catenella* increase from a very low number <10 cells/L beginning in February to >500 cells/L in July through August and again decrease to <10 cells/L until the end of December. The program has been worthwhile the effort. More volunteers are needed to carry out this comprehensive study.

10. **Individual to Contact:**
Dr. Maria R. Ross
Biology Department
University of California at Los Angeles
405 Hilgard Avenue
Los Angeles, California 90024
(310) 206-3528
FAX (310) 559-5120

Ref: State of California Department of Health Services (SCDHS) Shellfish Monitoring Program Technical Reports 95-05 thru -10, -15 thru -20, -22, -23, -25 thru -28, -30 thru -33.

HARMFUL ALGAL BLOOMS IN THE UNITED STATES — 1995

CALIFORNIA

1. Locations: MENDOCINO COUNTY, CALIFORNIA Anchor Bay and Fort Bragg (Virgin Creek) areas

2. Date of Occurrence: August 8th Anchor Bay, August 29th Fort Bragg (Virgin Creek)

3. Effects: Samples of mussels collected at the Anchor Bay site contained 300 ug of toxin per 100 g tissue while samples of mussels collected at Fort Bragg site contained 660 ug of toxin

4. Management Decisions: Since the regular annual quarantine on sport-harvested mussels was in effect no other management decision was implemented

5. Causative Species: Alexandrium catenella? however, from the Phytoplankton monitoring data the high levels of PSP was not associated with any concentration of the above dinoflagellate.

6. Environment: No data available

7. Advected Population or In Situ Growth: It would be difficult to assess the origin of the population that caused the high PSP levels.

8. Previous Occurrences: 1932, '62, '66, '67, '69, '75, '82, '84, '89, '90, '95

9. Additional Comments: Throughout the year no toxic dinoflagellate species were detected by the phytoplankton monitoring program yet the mussels collected at the two sites contained high PSP levels.

10. Individual to Contact:
Dr. Maria R. Ross
Biology Department
University of California at Los Angeles
405 Hilgard Avenue
Los Angeles, California 90024
(310) 206-3528
FAX (310) 559-5120

Ref: State of California Department of Health Services (SCDHS) Shellfish Monitoring Program Technical Reports 95-09, -10, -15 thru -20, -22, -27, -30, -31, -33

CALIFORNIA COUNTIES PSP CONCENTRATION — 1995

DEL NORTE - In September measurable level of PSP was noted in mussels, however it did not exceed the alert level. During the entire year no PSP levels were detected.
Previous occurrences: 1981, '91, '92, '93

HUMBOLDT - No detectable levels of PSP during the entire year except for low measurable PSP concentration during the month of July.
Previous occurrences: 1969, '71, '73, '89, '92, '93

MENDOCINO - During January, February, March, Sept. and Dec. no samples were submitted. In August the toxin level at two sites reached 660 ug and 300 ug/100 g shellfish.
Previous occurrences: 1932, '62, '66, '67, '69, '75, ''82, '84, '89, '90, '91, '92, '93, '95

SONOMA - PSP level was detectable below the alert concentration in July and August. Rest of the months either no dection was noted or no samples were submitted.
Previous occurrences: 1927, '29, '30, '32, '37, '54, '62, '68, '69, 70, '71, '76, '80, '81, '82, '87, '89, '90, '91, '92, '93

MARIN -Low detectable levels of PSP were recoded for sentinel mussel tissue during April, May, September thru December (<80 ug). In July toxin levels increased to 700 ug at the Chimney Rock station, 420 ug at Drakes Estero, 240 ug at Rodeo Beach and 130 ug at Tomales Bay.
Previous occurrences: 1927, '29, '32, '54, '62-'66, '70, '71, '76, '80-'84, '86-'95.

SAN FRANCISCO - During the year when samples were submitted PSP was detected in July and August below the alert level.
Previous occurrences: 1970, '71, '80, '83, '84, '86

SAN MATEO - A single PSP occurrence in June of <80 ug/100 g tissue.
Previous occurrences: 1970, '71, '82, '83, '84, '86, '87, '89, '90, '91, '92, '93, '94

SANTA CRUZ - One episode of PSP concentration of <80 ug occurred in May. In
Ptrevious occurrences: 1971, '84, '89, '91, '92, '93

MONTEREY - Low PSP levels detected in May and July.
Previous occurrences: 1988, '89, '94

SAN LOUIS OBISPO - No PSP was detected until July and September when measurable below alert levels were recorded.
Previous occurrences: 1979, '89, '90

SANTA BARBARA - Was free of PSP for the entire 1995, no detectable PSP levels.
Previous occurrences: 1978, '85, '89

VENTURA - When samples were submitted nodetectable levels were recorded.
Previous occurrences: 1980, '89

LOS ANGELES - No detectable concentration of PSP was reported.
Previous occurrences: 1970, '71, '72, '83, '85, '86, '87, '88 '89, '91, '92, '93

ORANGE - Less than 80 ug PSP detected in shellfish during May and July.
Previous occurrences: 1974, '76, '80, '84, '85, '89

SAN DIEGO - Free of PSP except for below the alert levels detected in May, June June and August.
Previous occurrences: 1985

INDIVIDUAL TO CONTACT: Dr. Maria R. Ross
Biology Department
University of California at Los Angeles
405 Hilgard Avenue
Los Angeles, California 90024
(310) 206-3528
FAX (310) 559-5120

Ref: State ofCalifornia Department of Health Services, Shellfish Monitoring Program Technical Reports 95-02, -05, -07, -09, -15, -17, -19, -22, -25, -27, -30, -32.

HARMFUL ALGAL BLOOMS IN THE UNITED STATES — 1995

OREGON

1. **Location:** Oregon coast from Tillamook Head near Seaside to the Columbia River. This area is called the Clatsop Beaches.

2. **Date of Occurrence:** Toxicity in razor clams began 11/95 when domoic acid levels exceeded 5 ppm for the first time since 4/94. Levels were 8.6 ppm by 12/20/95. (By 1/19/96 DA levels increased to 17.2, and by 1/31/96 to 21.6 ppm. Domoic acid was not seen in mussels from this area.

3. **Effects:** The razor clam fishery resource was not very good during the fall of 1995, there was little economic effect.

4. **Management Action:** Lot sampled during the end of January 1996; harvest closed in February 1996.

5. **Causative Species:** Not known

6. **Environment:**

7. **Advected Population or In Situ Growth:**

8. **Previous Occurrences:**

9. **Additional Comments:**

10. **Individual to Contact:**

Deb Cannon, Shellfish Program Specialist
Oregon Department of Agriculture
635 Capitol St. NE
Salem, OR 97310 USA
Phone: (503) 986-4728

DURATION OF TOXIC EPISODES

TYPE OF TOXICITY (PSP, DSP, ASP, NSP, ETC.): ASP

YEAR	area		code	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Maximum toxicity (ug/100g)
1995			22											x	x	8.6 ppm, but up to
																21.6 ppm in late
																January 1996

This table should be used to indicate the duration of the toxic episodes and the maximum level of measured toxicity.

HARMFUL ALGAL BLOOMS IN THE UNITED STATES — 1995

OREGON

1. **Location:** Oregon coast from Yachats to the Columbia River (ca. 44.2-46.7 N), includes Clatsop, Tillamook, and Lincoln counties.

2. **Date of Occurrence:** Low toxicity in shellfish began 3/95. Mussels in Lincoln Co. were 38 ug/100 g in mid-March, rising to 40-50 ug in May. Razor clams had levels in the 40's in June, never exceeded 60 ug/100 g, and remained in the 40's to the end of the year. Mussels peaked at 98 ug/100 g in late July.

3. **Effects:**
Seafood processors and coastal tourism were affected by shellfish closures. Closures also increase the laboratory costs for the Shellfish Program.

4. **Management Action:** Commercial and recreational shellfish harvesting (mussels and clams) was closed from the Columbia River to Yachats in July, reopened in August Bays and estuaries were not closed. Commercial oysters and clams were lot sampled during the peak of the event.

5. **Causative Species:**
Not confirmed; thought to be Alexandrium catenella. Field staff trained to examine the species recorded an increased abundance.

6. **Environment:** Warmer than normal spring temperatures occurred in March and June. The summer was hot and sunny in July.

7. **Advected Population or In Situ Growth:** Not known

8. **Previous Occurrences:** The last Oregon PSP alert began in June 1994 and continued into August. The 1994 closure included the south coast; PSP levels in mussels were higher at 280 ug/100 g.

9. **Additional Comments:** No human illnesses confirmed.

10. **Individual to Contact:**
Deb Cannon, Shellfish Program Specialist
Oregon Department of Agriculture
635 Capitol St. NE
Salem, OR 97310 USA
phone: (503) 986-4728

DURATION OF TOXIC EPISODES

TYPE OF TOXICITY (PSP, DSP, ASP, NSP, ETC.): PSP

YEAR	area		code	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Maximum toxicity (ug/100g)
1995	22		22						x	x						98 ug/100 g shellfish

This table should be used to indicate the duration of the toxic episodes and the maximum level of measured toxicity.

HARMFUL ALGAL BLOOMS IN THE UNITED STATES — 1995

WASHINGTON STATE

1. **Location:** Pacific coast of Washington State

2. **Date of Occurrence:** mid-August - October, 1995

3. **Effects:** Razor clams (*Siliqua patula*) meat turned pink; cells retained in oyster viscera for several days and turned canning liquid pink in about 2 days. Commercial growers could not sell their oysters.

4. **Management Action:** None

5. **Causative Species:** *Ceratium furca*, *C. pulchellum* cf., and *Prorocentrum micans*

6. **Environment:** Local weather conditions were normal for the time of year.

7. **Advected Population or In Situ Growth:** Probably in situ growth

8. **Previous Occurrences:** Fall 1994

9. **Additional Comments:** The 1995 bloom lasted nearly three times as long as the 1994 bloom. As in 1994, razor clams were harvested and consumed without questioning the color. Oyster growers were frustrated by not being able to sell their product. Japanese seafood distributors wanted to know when the bloom would end.

10. **Individual to Contact:**

Rita Horner
School of Oceanography, Box 357940
University of Washington
Seattle, WA 98195-7940
Phone: (206) 543-8599

HARMFUL ALGAL BLOOMS IN THE UNITED STATES — 1995

ALASKA

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1. **Location:** Humpback Bay (55° 52'N; 159° 20'W) on the south side of the Alaska Peninsula near Perryville, Alaska

2. **Date of Occurrence:** 2 April 1995

3. **Effects:** 7 individuals with varying symptoms of nausea, numbness of hands and feet, dizziness and numbness in mouth

4. **Management Action:** Press release made

5. **Causative Species:** Suspect *Alexandrium*

6. **Environment:** Relatively flat bottom bay with depths to 21 fathoms

7. **Advected Population or In Situ Growth:** No identification made of water sample

8. **Previous Occurrences:** 1982 outbreak at Second Hand Beach in the general vicinity showed mussels with levels of greater than 5,000 μg/100 grams that affected five people

9. **Additional Comments:**

Butter clams:	141 μg/100 gms PSP
Razor clams:	
Tissue	544 μg/100 gms
Viscera	3294 μg/100 gms PSP
Razor clams (4/2/95):	
Whole animals	979 μg/100 gms PSP

10. **Individual to Contact:**

Michael J. Ostasz
Shellfish Coordinator, Seafood Program
State of Alaska
Department of Environmental Conservation
Dimond Center
800 East Dimond Boulevard, Suite 3-455
Anchorage, AKASKA 99515
Telephone: (907) 349-7343

HARMFUL ALGAL BLOOMS IN THE UNITED STATES — 1995

ALASKA

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1. **Location:** Crooked Island, NE of Kodiak Island, Alaska (57°46'30"N, 152°23'30"W)

2. **Date of Occurrence:** 25 April 1995

3. **Effects:** 1 person hospitalized. Experienced 30 minutes of numbness and tingling in the facial area

4. **Management Action:** Press release two weeks before incident

5. **Causative Species:** Butter clam (*Saxidomus gigonteus*)

6. **Environment:** N/A

7. **Advected Population or In Situ Growth:** Small island north of main Kodiak Island

8. **Previous Occurrences:** Toxicity and epidemiology documented in area

9. **Additional Comments:**

Raw butter clams:	265 μg/100 gms (2/25/95 harvest)
	242 μg/100 gms (2/27/95 harvest)
Cooked clams:	137 μg/100 gms

10. **Individual to Contact:**

Michael J. Ostasz
Shellfish Coordinator, Seafood Program
State of Alaska
Department of Environmental Conservation
Dimond Center
800 East Dimond Boulevard, Suite 3-455
Anchorage, AKASKA 99515
Telephone: (907) 349-7343

HARMFUL ALGAL BLOOMS IN 1995 - UNITED STATES

1. **Locations:** Florida
   Bay to Monroe County (1995) Area 16
   Monroe to Palm Beach County (1995) Area 15

2. **Date of Occurrence:** September 16, 1994 and on-going (as of 4/10/96) in Florida west coast waters.

3. **Effects:** Dead fish - inshore and offshore. Water discoloration brownish-red, green, or yellow. Respiratory irritation from Pinellas to Collier County. Two confirmed cases of Neurotoxic Shellfish Poisoning in Sarasota County; two unconfirmed cases of NSP in Lee County.

4. **Management Decision:** Shellfish harvest bans due to _Gymnodinium breve_ red tide - lower Tampa Bay, 4/24/95 to 1/21/96; Boca Ciega, 4/24/95 to 10/21/95 ; New Pass, 4/20/95 to 1/20/96; Lemon Bay, 4/12/94 to 11/8/95 to 1/20/96; Gasparilla Sound, 4/13/95 to 6/9/95, 8/22/95 to 10/15/95, and 11/8/95 to 1/25/96; Pine Island Sound, 4/18/95 to 6/9/95, 8/24/95 to 1/21/96.

5. **Causative Species:** _Gymnodinium breve_
   Inshore and coastal surface water samples up to 12 miles offshore had cell concentrations ranging from negative to 10^7 cells $Liter^{-1}$

6. **Environment:** Occurred in nearshore and shelf waters with wide salinity and temperature ranges, > 10 o/oo and 15 C differential.

7. **Advected Population or In Situ Growth:** Advected population from offshore waters between Tampa Bay and Charlotte Harbor. In January-February, _G. breve_ bloom in southwest Florida offshore shelf waters entrained and transported south, as in 1994. Brevetoxins detected in seawater on the Atlantic side in February.

8. **Previous Occurrences:** Sept 1994 into 1995; Sept 1992-Jan 1993; Jan-Feb 1991; Feb-Mar, Oct-Nov, 1990; March-May 1989; Oct-Dec, 1988; Jan/Feb, May-July, Sept/Oct, 1987; Sept-Dec 1986, Sept-Dec 1985, Jan-March, May-Aug, 1984, Jan/Feb, Oct-

Dec, 1983; Jan-April, July-Oct, 1982; Sept/Oct, 1981; Jan/Feb, June-Nov, 1980; and before.

9. **Additional Comments:** In 1995 red tide was documented from Panama City to the Florida Keys in very low to very high concentrations. This red tide (1994-1996) is comparable to the 1953-1955 red tide in length and has been associated with fish kills, cormorant and pelican illness and mortality, sponge mortality, and other marine resource impacts.

10. **Individual to Contact:**

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Florida Department of Environmental Protection
Florida Marine Research Institute
100 Eighth Avenue S. E.
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Fax: 813-823-0166
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steidinger_k@sellers.dep.state.fl.us

HARMFUL ALGAL BLOOMS IN 1995 - UNITED STATES

1. **Location:** Florida
Florida Bay, Area 16

2. **Date of Occurrence:** January 1995 - January 1996

3. **Effects:** Yellow-green to pea green discolored sea water with decreased water clarity. In a previous year, sponge mortality conicidental with bloom areas.

4. **Management Action:** Restoration of the bay is the long term goal of an interagency plan, part of the restoration involves freshwater delivery.

5. **Causative Species:** Cyanobacterium, *Synechococcus elongatus*. Cell concentrations up to 10^7 cells ml^{-1}. Can co-occur with small (< 10 μm) centric diatoms and other cyanobacteria. Chlorophyll a levels up to > 30 μg $liter^{-1}$.

6. **Environment:** Shallow subtropical lagoon with salinites from essentially freshwater to marine (up to 39 o/oo) and temperatures from 16.8 to 32.0 C. In previous years, the bay has been hypersaline. Resuspension events from winds and tidal action common.

7. **Advected Population or In Situ Growth:** In situ growth within sub-basins of bay. High residency time within sub-basins, but sub-basins flushed by rain and storm events through narrow channels.

8. **Previous Occurrences:** Bloom has been on-going since 1991 but the intensity and geographic coverage varies seasonally.

9. **Additional Comments:**

10. Individual to Contact:
Dr. Karen A. Steidinger
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steidinger@sellers.dep.state.fl.us

1. **Location:** Lower Laguna Madre, South Texas

2. **Date of Occurrence:** 25-26 Sept. 1995

3. **Effects:** Menhaden Fish Kill, single species kill lasting 2-3 days.

4. **Management Action:** None Taken

5. **Causative Species:** Gymnodinium breve

6. **Environment:** Initial bloon occurred in marina channel, spread to shallow lagoon environmnet. Seagrass dominated bottom, water depth 1meter. Salinities 35-38 o/oo; Temperature 27-29

7. **Advected Population or In Situ Growth:**

   Assumed to be advected from Gulf of Mexico.

8. **Previous Occurrences:**

   Brownsville Ship Channel, Dec. 1990.

9. **Additional Comments:**

   Cell concentrations ranged from 56 to 600 cells/ml.

10. **Individual to Contact:**

    Dean A. Stockwell, 512 749 6705
    Tony Reisinger, 210 399 7757

DURATION OF TOXIC EPISODES

TYPE OF TOXICITY (PSP, DSP, ASP, NSP, ETC.): GYMNODINIUM BREVE Brevetoxin (?)

YEAR	area		code	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Maximum toxicity (ug/100g)
'95			11									X				NOT MEASURED

This table should be used to indicate the duration of the toxic episodes and the maximum level of measured toxicity.

MORTALITY OF FISH AND OTHER MARINE ORGANISMS

YEAR	MONTH	AREA (CODE)	COMMENTS
95	SEPT	11	Menhaden fish kill/a single species kill
			2-3 days duration, Gymnodinium breve present.
			Contact: Tony Reisinger 210 399 7757
95	Oct	11	Hardhead catfish kill; dead fish reported all along the
			Texas coast. Suspect a parasitic amoeba.
			Contact Dave Buzan, Texas Parks and Wildlife Dept.
			512 389 4634

Working Group on Harmful Algal Boom Dynamics
(IOC-ICES WGHABD)

ANNEX IV

- Cysts transfers -

PHYTOPLANKTON/CYSTS BALLAST WATER TRANSFERS: A JOINT USA-DUTCH PILOT STUDY

Contribution by The Netherlands to the ICES/IOC Working Group on Harmful Algal Blooms, Brest 17-20 April 1996.

INTRODUCTION

The possibly threatening role of ballast water in the introduction and transfer of "exotic" species in marine waters has attracted global attention over the last five years, and in particular the attention of east USA and the Netherlands on either side of the Atlantic Ocean.
In August 1995, a joint study on transfer and fate of plankton in ballast water was set up by the Smithsonian Environmental Research Center (SERC) in the USA and three Institutes in the Netherlands: Directorate General of Shipping and Maritime Affairs (DGSM), RWS-North Sea Directorate (RWS-DNZ) and TRIPOS (contracted by RWS-DNZ).
The aim of this study is to examine the abundance and fate of phytoplankton, cysts and zooplankton in ballast water of ships sailing frequently between the east coast of the USA (with a radius of about 150 miles around the SERC-laboratory in Maryland) and Dutch harbours (Rotterdam and IJmuiden). Since both areas have comparable climate and weather conditions it is expected that organisms in ballast water taken from Dutch coastal waters will survive in coastal waters around Maryland and vice versa.
This paper shortly describes the experimental design and some preliminary results of this joint study.

EXPERIMENTAL DESIGN

The first step in the programme was to harmonize sampling and analytical procedures between the participating institutes. Protocols were exchanged, and harmonized. They are strictly followed, allowing thus full comparison of results.

The second step in the programme is to identify continuously relevant ships well in advance of departure from "Maryland" harbours and subsequent arrival in Rotterdam harbour, and vice versa, and to make sure that all necessary shipping- and harbour rules are followed.

The third step is to take and analyse samples of ballast water from arriving and departing ships at and from Rotterdam and Maryland harbours, respectively.

The final step is to compare all ballast water results, and to draw conclusions on abundance and fate of "exotic" species in ballast water transfers and discharges in Dutch and east-USA coastal waters.

PRELIMINARY RESULTS

Up til now only three departing ships in Rotterdam harbour could be sampled, due to logistic problems to meet more frequently the second step in the programme. These difficulties have now been solved, sothat more sampling campaigns may well become feasible in 1996.
Table 1 gives some preliminary results on phytoplankton present in ballast water of two different ships departing from Rotterdam to Maryland harbour, September and November 1995. Results of netplankton samples are not available yet.
The first impression is that species composition and relative abundance of diatoms and dinoflagellates in ballast water of ships departing Rotterdam harbour are comparable with those present in Dutch coastal waters at that period (late-autumn) of the year.

Contact persons

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The Netherlands

A SYNOPSIS OF THE CANADIAN SITUATION REGARDING SHIP-TRANSPORTED BALLAST WATER

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Gauthier, D., and D.A. Steel. 1995. A synopsis of the Canadian situation regarding ship-transported ballast water. Proceedings of ICES session Ballast Water: Ecological and Fisheries Implications, September 1995, Aalborg, Denmark *in* J.T. Carlton (ed) (in press). The ICES cooperative research report. ICES. xx pp.

Abstract

With the longest navigable coastline in the world, bordering on the Atlantic, Arctic and Pacific Oceans, Canada is a country where shipping plays an important role in national and international trade. This synopsis describes the situation in Canada with regards to vessel traffic, regulations, management activities and scientific studies concerning the introduction in Canadian waters of unwanted species by ship-transported ballast water.

Many nuisance species have been introduced into Canadian ports and coastal waters, which annually receive at least 52 million tonnes of discharged ballast waters. Canadian waters are unprotected from this threat because there are presently no specific ballast water regulations or national policies. However, there are two sets of voluntary guidelines for mid-ocean ballast water exchange, of questionable effectiveness and which are geographically limited to the Great Lakes and the Îles-de-la-Madeleine. Canadian management activities are segmented by region and not integrated between official authorities. Recent scientific studies focus mostly on the ecology of invading species while few address the transport mechanism of organisms by way of ballast waters. Thus, there is a need for a national action plan, developed in consultation with shipping, fishing and aquaculture industries, which could lead to policies, regulations and an integrated research program regarding ship-transported ballast water.

Ayant la plus longue côte navigable du monde, bordant les océans Atlantique, Arctique et Pacifique, le Canada est un pays où la navigation joue un rôle important dans le commerce national et international. Ce résume décrit la situation au Canada en regard du trafic maritime, des règlements, des activités de gestion et des études scientifiques relatives à l'introduction d'organismes non desirés via les eaux de ballast transportées par les navires.

Plusieurs espèces nuisibles ont été introduites dans les ports et les eaux côtières du Canada lesquels reçoivent annuellement au moins 52 millions de tonnes d'eaux de ballast. La plupart des eaux canadiennes ne sont pas protégées de cette menace puisqu'il n'y a présentement aucune reglementation ou politique nationale spécifique aux eaux de ballast. Toutefois, il y a deux ensembles de lignes directrices volontaires pour l'échange des eaux de ballast en haute mer, d'efficacité discutable et qui sont limitées géographiquement aux Grands-Lacs et aux Îles-de-la-Madeleine. Les activités canadiennes de gestion sont segmentées par région et non intégrées entre les diverses instances concernées. Les études scientifiques récentes visent surtout l'écologie des espèces envahissantes et rares sont celles qui portent sur le mécanisme de transport des organismes via les eaux de ballast. Il y a donc un besoin d'un plan d'action national, élabore de concert avec les industries du transport maritime, des pêches et de l'aquiculture, qui pourrait mener à des politiques, règlements et à un programme integré de recherche sur les eaux de ballast transportées par les navires.

1.0 Introduction

Worldwide introductions of plants, animals and pathogens to new habitats as a result of human activities, are having dramatic impacts on terrestrial and aquatic ecosystems (Biodiversity Science Assessment Team 1994). Ballast water, taken on for vessel stability in one port of call and released in another, has been identified as a likely vector for the introduction of numerous species in coastal waterways in Canada and around the world (Leach *et al.* 1995, Locke *et al.* 1993, Mills *et al.* 1993a,b). Shipping routes traverse sections of Canada's coastline along the Atlantic, Pacific and Arctic Oceans, and Gulf of St. Lawrence, into the interior Great Lakes via the St. Lawrence Seaway (Figure 1.0). The St. Lawrence Seaway is initially under Canadian jurisdiction at Montreal and then American at Massena, New York, prior to entering the Great Lakes. This series of locks allows the navigation of vessels to the head of Lake Superior, a distance of 3,769 km from the Atlantic Ocean. With the problem gaining increasing environmental and economic recognition, the purpose of this report is to overview vessel traffic, regulations, management activities and scientific studies concerning the introduction of non-native species by ship-transported ballast water in Canadian waters.

2.0 Vessel Traffic

For the Canadian Atlantic coast, the Eastern Canada Region Vessel Traffic Services (ECAREG–VTS) database reported 1,377 foreign vessel entries in 1991 of which 1012 originated from a last-port-of-call (LPOC) that was outside the Northwest Atlantic zone, as defined by the FAO "waters of the world" (Table 1). These vessels originated from ports bordering the Northeast Atlantic, Northwest Atlantic and West Central Atlantic in respective proportions of 40%, 24% and 11%, although their ballast waters may have been taken on during the voyage. Of these 1012 vessels, respectively 68%, 30% and 2% entered the ports of Halifax in Nova Scotia, St. John in New Brunswick and St. John's in Newfoundland, discharging 2.1, 2.6 and 0.02 million tonnes of ballast water for an estimated total of 4.7 million tonnes (D.M. Reid, pers. comm.).

Based on the ECAREG–VTS database, a total of 762 vessels of which 612 foreign vessels entered the major ports of the Estuary and Gulf of St. Lawrence in 1993 (DFO unpubl.). Of these, 526 originated from a LPOC that was outside the Northwest Atlantic zone, some 47%, 26% and 18% originating respectively from Northeast Atlantic (excluding Mediterranea), the United States and Mediterranea. These ships entered the ports of Port-Cartier, Sept-Îles and Baie-Comeau in proportions of 23%, 21% and 14 %, respectively. Based on estimates of discharges of ballast water in ports from Montreal to Québec City and taking into account the proportions of vessels arriving "in ballast" or "in cargo" (D.M. Reid, pers. comm.), it is estimated that about 6.1 million tonnes of ballast water were discharged in the Estuary and Gulf of St Lawrence during 1993 (Table 1) of which 1.7, 1.6 and 0.7 million tonnes were discharged respectively in the ports of Port-Cartier, Sept-Îles and Baie-Comeau (DFO unpubl.).

For the Great Lakes – St. Lawrence River system, the ECAREG–VTS database reported 755 vessel entries in 1991 of which 735 originated from a last-port-of-call (LPOC) that was outside the Northwest Atlantic zone. Of these 735 vessels, 56% and 16% originated respectively from Northeast Atlantic (excluding Mediterranea) and Mediterranea (D.M. Reid, pers. comm.). Of these 735 vessels, 56.6% and 43.4% entered respectively the ports upstream of Montreal and those from Québec City to Montreal. Since ships entering the Great Lakes typically contained about 7,500 m^3 of ballast water (Sprules *et al.* 1990), it is estimated that respectively 1.4 and 1.1 million tonnes of ballast water were discharged in the Great Lakes – St. Lawrence River system in 1991 (D.M. Reid, pers. comm.).

St. Lawrence – Great Lakes Seaway

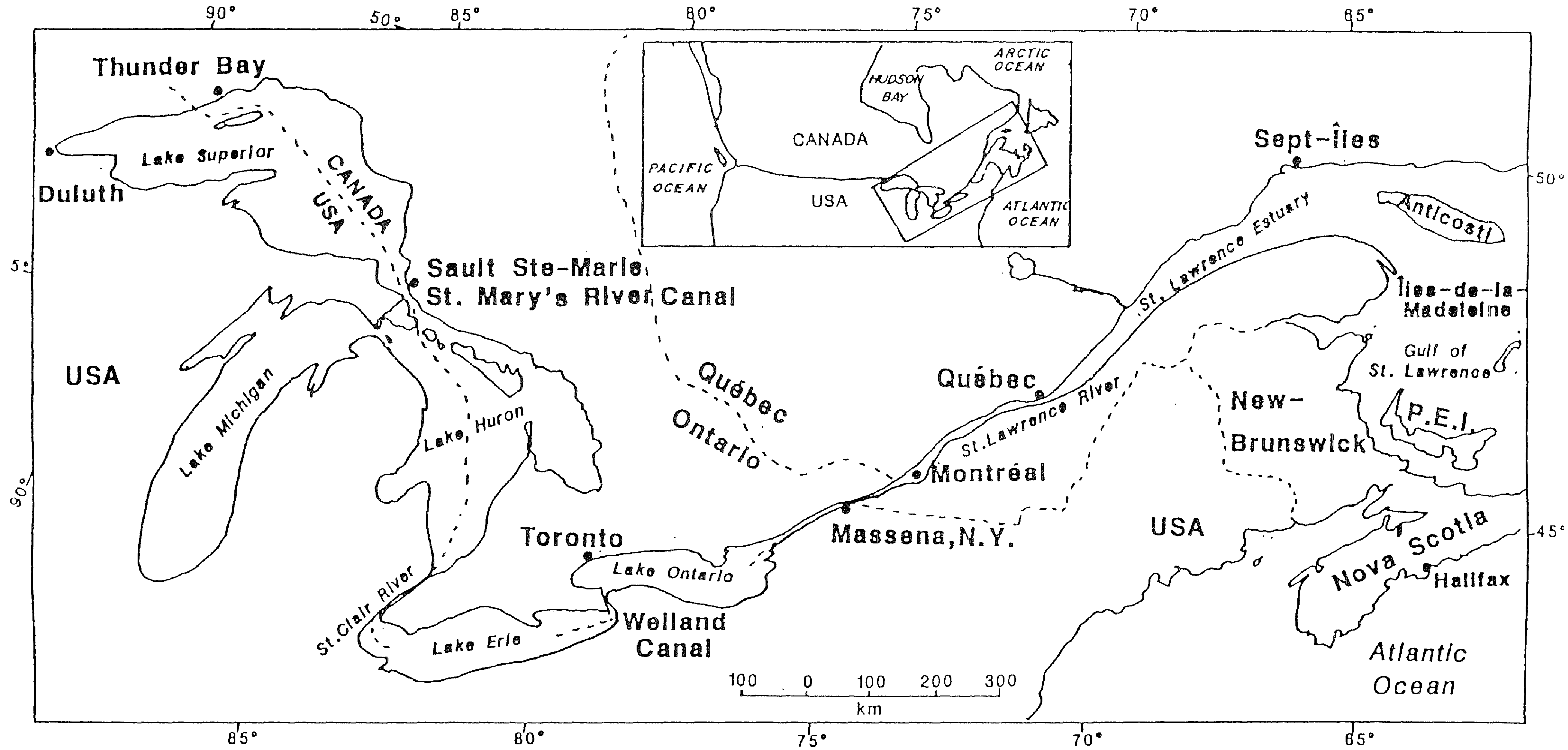

Figure 1. The St. Lawrence-Great Lakes Seaway

For the Pacific coast, the Vancouver and Prince-Rupert port authorities reported respectively 3117 and 398 foreign vessel entries in 1991, of which 3023 and 386 originated from a last-port-of-call (LPOC) that was outside the Northeast Pacific. Respectively 78%, 13% and 3% of these vessels originated from ports bordering the Northwest Pacific, West Central Pacific – Indonesia – and Northeast Pacific. These vessels discharged respectively an estimated 33.5 and 5.4 million tonnes of ballast water in the ports of Vancouver and Prince-Rupert, for a total of about 38.9 million tonnes (Table 1) (D.M. Reid, pers. comm.).

Table 1. Vessel traffic and estimated discharges of ballast water from foreign FAO Regions.

Ports	Year	Vessels	Discharges (10^6 t)
Atlantic: Halifax (N.S.), St. John (N.B.) St. John's (Nfld.)	1991	1,012 [1]	4.7 [3]
Estuary and Gulf of St. Lawrence: Sept-Îles, Port-Cartier, Baie-Comeau, Gaspe and Cacouna (Que.), Cornerbrook and Stephenville (Nfld), Dalhousie and Belledune (N.B.), and Summerside (P.E.I.)	1993	520 [1]	6.1 [4]
Great Lakes: Canadian and U.S. ports, Montréal and Québec (Qué.)	1991	744 [1]	2.5 [3]
Pacific: Vancouver and Prince-Rupert (B.C.)	1991	3409 [2]	38.9 [3]

[1] FAO zones other than Northwest Atlantic – mostly Northeast Atlantic and the Mediterranean
[2] FAO zones other than Northeast Pacific – mostly Northwest Pacific, West central Pacific (Indonesia) and Northeast Pacific
[3] D.M. Reid, pers. comm.
[4] Department of Fisheries and Oceans, unpubl. data

3.0 Regulatory aspects and management activities

By prohibiting the release of a pollutant into harbour or coastal waters, the Oil Pollution Prevention Regulation, Part XV under the *Canada Shipping Act*, is currently the only regulation related to ballast water which applies to all vessels entering Canadian ports. Typically, this refers to various types of oil products, however, according to the definition of pollutant under Part XV, this also encompasses "any this definition, ballast waters are considered to be clean and can be released in, or taken on from any Canadian harbour or coastal waters, with a few exceptions, as discussed below.

Aside from regional activities described below, Canada participated in the 34th to 37th meetings held from 1993 to 1995 by the Marine Environment Protection Committee (MEPC) of the International Maritime Organization (IMO). This Committee requested the Ballast Water Working Group to develop a possible new Annex to MARPOL 73/78 regarding ballast water management. S. Gosselin and D. Gauthier of DFO's Maurice Lamontagne Institute in Mont-Joli, Québec, successively represented Canada.

3.1 Lower Estuary and Gulf of St. Lawrence

The threat of introductions of toxic phytoplankton to local mussel farming industries prompted the Canadian Coast Guard in 1982 to issue the Notice to Mariners #995. This yearly renewed notice prohibits ships bound for the Mines Seleine's pier, situated in the Grande-Entree Lagoon of the Îles-de-la-Madeleine, Gulf of St. Lawrence (Figure 1.0), from discharging their ballast waters within 10 nautical miles of the Islands unless these waters had been taken on in a well-defined area off Canada's east coast, at a distance of 5 miles or greater from the shoreline.

3.2 Great Lakes – St.Lawrence River and Estuary

Jurisdictional management of the Great Lakes – St. Lawrence River system is complex as two federal, two provincial and eight state governments, and numerous environmental groups and transport associations are concerned. Policies and management perspectives are now provided by the International Joint Commission and the Great Lakes Fishery Commission in accordance with binational treaties and agreements (Leach *et al.* 1995). The latter Commission was created in 1955 by the Governments of Canada and the United States, to address the problem of the devastation wreaked on the Great Lakes commercial fisheries by the invading sea lamprey (*Petromyzon marinus*) in the early 1940's and 1950's. Its primary mandate is to advise governments on measures and issues affecting fish stocks of common concern to Great Lakes fisheries, including the introduction of exotic species via ballast water discharges (Dochoda 1991).

In May 1989, the Canadian Coast Guard, after consultation with the U.S. Coast Guard, the Great Lakes Fishery Commission, the Department of Fisheries and Oceans, the Department of Environment, as well as representatives from the shipping industry, promulgated the Voluntary Guidelines for the Control of Ballast Water Discharges from Ships. These guidelines apply to all vessels carrying ballast water entering the St. Lawrence Seaway from outside the Exclusive Economic Zone (EEZ) – beyond 200 nautical miles from shore – bound for the St. Lawrence Seaway and Great Lakes ports west of 63° W longitude – modified to 64°W in 1995. Vessels are requested to exchange their ballast water on the high seas where depths are greater than 2000 m before entering the Gulf of St. Lawrence. The guidelines are based upon the rationale that most freshwater organisms do not survive in salinities above 8 parts per thousand, and as open ocean salinities are typically around 35 parts per thousand, any organisms present during ballast water exchange would be subject to lethal osmotic stresses.

Control of compliance with these guidelines begins with information supplied to the ECAREG–VTS operators from vessels entering entering Canadian waters. If a ship is proceeding up the seaway and into the Great Lakes, it will be requested to exchange its ballast water in open ocean at depths greater than 2000 m. If this is not technically feasible, ships are permitted to conduct an exchange in a "backup exchange zone" within the Laurentian Channel of the lower St. Lawrence Estuary, to the southeast of 64° W longitude in water depths greater than 300 m. Once contact with ECAREG–VTS operators has been established, foreign vessels typically pick up a pilot at Les Escoumins within the St. Lawrence Estuary, where they are given a "Ballast Water Exchange Form" to be completed prior to their arrival in Montreal. Upon arrival at the St. Lambert locks in Montreal, the ballast water information provided on the form is verbally verified with respect to ballast water exchange. Vessels are considered to be in compliance with these guidelines if they carry: no ballast water; only residual ballast water that could not be completely expelled; permanent ballast water; ballast water that is not intended to be discharged in the Great Lakes; or only ballast water that has been exchanged offshore or in the Laurentian Channel (Hall-Armstrong 1994). In regards to ballast water, a fine of up to $50,000 may be imposed for providing false information to a Pollution Prevention Officer of the Canadian Coast Guard, where such information is requested for the promotion of environmental protection (Hall-Armstrong 1994).

In general, for tankers and carriers of greater than 50,000 dry weight tonnage, the number of such vessels exchanging their ballast waters is low, generally because of safety issues, such as structural integrity of the vessel, demonstrated loss of stability and propeller exposure during the exchange process and associated time delays to complete the procedure (Prior 1995). Laker carriers or "lakers" are not subject to these guidelines as they do not operate outside the EEZ (D.M. Reid, pers. comm.). Although these guidelines apply to all vessels bound for the St. Lawrence River and Great Lakes ports west of 64° W longitude, compliance is not as easily monitored or enforceable for vessel traffic frequenting ports within the Lower St. Lawrence Estuary such as Sept-Îles and Port-Cartier on the Québec north shore (C. Wiley, pers. comm.).

Section 207 of the United States Public Law 101-225, the *Great Lakes Exotic Species Prevention Act* of 1989, directed the U.S. Coast Guard to report to Congress on methods for preventing the introductions of non-native species into U.S. waters by ballast discharge, with mid-ocean exchange considered the most feasible method (Kelly 1992). In March 1991, the Canadian and U.S. Coast Guards jointly issued guidelines based on those established in Canada, which were in effect until 10 May 1993. Subsequently, U.S. Public Law 101-646 concerning mandatory ballast water exchange for ships entering American waters came into effect under the *Nonindigenous Aquatic Nuisance Prevention and Control Act* of 1990. In addition to specific regulations, this Act called for a number of federal agencies to administer a "National Ballast Water Control Program", which included a Biological Study, a Ballast Exchange Study and a Shipping Study (Carlton *et al.* 1995). Under this law, the U.S. Coast Guard issued regulations that apply to vessels from outside of the EEZ and passing through the Snell Lock at Massena, New York (Figure 1.0) and bound for any Canadian or American port within the Great Lakes (Prior 1995).

Essentially, the law requires that all vessels exchange ballast water, if possible, on the high seas – in depths greater than 2,000 m – such that the salinity of the ballast water is at least 30 parts per thousand. Vessels travelling "in ballast" through the Snell Lock are checked for sufficient salinity to indicate that the required exchange has occurred. Vessels will be allowed to proceed if: 1) problem ballast tanks are sealed for the duration of the voyage into the Great Lakes; 2) the vessel returns to sea or the "backup exchange zone" to conduct a proper exchange and subsequently passes inspection at the U.S. lock; or 3) conducts a mutually agreeable procedure to remove the possibility of nonindigenous species being introduced into the Great Lakes via their ballast water discharge. Under the regulations, those vessels that opt to have their ballast tanks sealed are reboarded on their way out of the Great Lakes for verification of seals, water levels and salinity (Hall-Armstrong 1994).

Lakewide Management Plans (LaMPs) have been required since 1987 under the Great Lakes Water Quality Agreement, which was signed by the governments of Canada and the United States. Article VI and Annexes 4 to 9 of that Agreement all address " Pollution from Shipping Activities" and assign specific coordinating, enforcement and reporting function to the U.S. and Canadian Coast Guards (Dochoda *et al.* 1990). Administered by two federal governments, four states, one province and several native governments, LaMPs are currently ongoing for both Lake Erie and Lake Superior, tending to focus primarily on the ecological effects of introduced species such as the sea lamprey and zebra mussel (*Dreissena polymorpha*), rather than their mode of entry via ballast water discharges (O. Johannsson, pers. comm.).

Within the context of the American *Nonindigenous Aquatic Nuisance Prevention and Control Act* of 1990, there is only one set of guidelines in place which attempts to curb the spread of the ruffe, (*Gymnocephalus cernuus*), a small percid fish introduced into the Great Lakes via ballast water discharges. Joint American and Canadian government and industry initiatives led to these guidelines, implemented in 1995, which request that ships that have to take on ballast water from ruffe-inhabited ports, exchange ballast waters in the open waters of Lake Superior, west of a line drawn between the U.S./Canada boundary and the Ontagon River, Michigan, U.S.A. If ballast cannot be exchanged in that zóne, it must be undertaken in other locations with water depths exceeding 75 m and at least 28 km from shore. Both the U.S. and Canadian Coast Guards have access to ballasting records from the shipping companies to monitor compliance with the plan (Busiahn and McClain 1995). In spite of these measures, the ruffe has recently invaded Lake Huron (J.T. Carlton, pers. comm.).

3.3 Pacific region

There are no regulations or voluntary guidelines for the exchange of ballast water along the Pacific coast. However, the 1992 Environmental Cooperation Agreement between Washington State and British Columbia called for an increase in the sharing of information and the initiation of joint monitoring and research, resulting in formation of the British Columbia/Washington State Joint Environmental Council. The Council produced a Marine Science Panel Report entitled "Task Force Recommendations for Action to Protect Shared Waters", including a section entitled "Minimize Introduction of Exotic Species", which served as the basis for its mandate.

Under the auspices of the B.C./Washington State Joint Environmental Council and as an initiative of the Puget Sound/Georgia Basin International Task Force, the B.C. Working Group on Minimizing the Introduction of Exotic Species held its first meeting at the University of British Columbia on June 13, 1995. Participants included representatives from the B.C. departments of Agriculture, Fisheries and Food, Fisheries and Oceans Canada, and the Department of Oceanography at the University of British Columbia. Their mandate is: 1) to review the current status and management actions concerning exotic species already introduced in inland waters of B.C.; 2) to examine the routes and risks of new introductions; 3) to assess the practicality of control measures against potential new introductions; 4) to hold a symposium/workshop to seek solutions; and 5) to develop a cooperative strategy for dealing with exotic species and their long-term management in jointly shared waters. A parallel working group has been established in Washington under the leadership of the United States Environmental Protection Agency in Seattle, and participants are from state, local and tribal governments, aquaculture industries and the U.S. Coast Guard. The final output of both working groups should be a set of complementary policy recommendations to the B.C. Ministry of the Environment and to the Washington Department of Ecology.

4.0 Scientific knowledge and activities

4.1 Species

For the Great Lakes basin, Mills *et al.* (1993b) have estimated that 139 nonindigenous species have become established since 1810; of these, 40% became established after 1950, and approximately 10% have had significant impacts, such as the sea lamprey (*Petromyzon marinus*) and the zebra mussel (*Dreissena polymorpha*) (Table 2) (Leach *et al.* 1995).

Native to the Atlantic Ocean, the sea lamprey invaded the upper Great Lakes in the 1930's, possibly via migration through the shipping route of the Welland Canal, and quickly parasitized and devasted local commercial fish stocks. This event is of note because it was one of the first biologically and economically significant appearances by a non-native species as a result of shipping activities. Furthermore, this resulted in the formation of the Great Lakes Fishery Commission designated to monitor subsequent species invasions and their impact on local fisheries. Despite expenditures by the Great Lakes Fishery Commission on research, chemical control and habitat modification – $168 millions in 1993, an estimated 575,000 adult sea lampreys presently live in the five Great Lakes (Leach 1995).

The Eurasian zebra mussel has become successfully established in all five of the Great Lakes and connecting waterways, including the lower Hudson and Mississippi Rivers, mainly as a result of this species' high fecundity, free-swimming larval stage and tenacious "holdfast" in adult mussels. A second non-native and related species of mussel, the quagga mussel (*Dreissena bugensis*), has also been found in two locations in Lake Erie (Kelly 1992, Mills *et al.* 1994), and it is not unlikely that both species could progress downstream towards the St. Lawrence Estuary. Their predicted combined ecological impacts on resident biota is extensive and calculated costs associated with the population control and cleaning of fouled surfaces and intake waterpipes has been estimated to be up to 5 billion dollars by the year 2000 (Fifth International Zebra Mussel Conference 1995).

The ruffe, a fish native to fresh and brackish European and Asian lakes and rivers, is an ecological and economic threat to the native yellow perch (*Perca flavescens*) and other fisheries of the Great Lakes (Pratt *et al.* 1992). This species was first discovered in Duluth Harbour on Lake Superior in 1986 and speculated as being due to discharge of ballast water from an ocean-going freighter in the early 1980's. It has rapidly spread to several estuaries along the south shore of Lake Superior and in 1991, seven ruffe were collected in Thunder Bay, Ontario, 300 km to the northeast of its initial sighting, probably transported there in ballast water from the St. Louis River, the westernmost tributary of Lake Superior (Busiahn and McClain 1995).

Other introductions of species into the Great Lakes via ballast water since the 1980's include the European or spiny water flea (*Bythotrephes cederstroemi*) (Sprules *et al.* 1990) and several fish species such as the Black Sea or tubenose goby (*Proterorphinus marmoratus*) and Mediterranean or round goby (*Neogobious melanostomus*), which have all become successfully established with observable ecological and economic consequences (Mills *et al.* 1993b, Leach 1995).

A few miscellaneous captures of species have also been recorded, and based on their country of origin, are most likely a result of ballast water discharges. Once again, in 1994, juvenile specimens of Chinese mitten crabs (*Eriochier sinensis*) and European flounder (*Platichthys flesus*), previously caught in 1974 and 1976 in Lake Erie (Emery and Teleki 1978), were reported in the Great Lakes (Leach *et al.* 1995).

Table 2. Examples of suspected ballast-water mediated introductions.

First sighting	Species	Invaded areas
1974	European flounder *(Platichthys flesus)*	Lake Erie
1980's	European or spiny water flea *(Bythotrephes cederstroemi)*	Great Lakes
	Eurasian zebra mussel (*Dreissena polymorpha*)	Great Lakes, tributaries, St. Lawrence River
	European ruffe (*Gymnocephalus cernuus*)	Lake Superior
1989 to 1994	Eurasian quagga mussel (*D. bugensis*)	Lake Erie
	Black Sea goby or tubenose goby (*Proterorphinus marmoratus*)	St. Clair River, Great Lakes
	Mediterranean or round goby (*Neogobious melanostomus*)	St. Clair River, Great Lakes
	Chinese mitten crab (*Eriochier sinensis*)	Various locations in the Great Lakes
1990's	Asian species: parasitic copepod *(Mytilicola orientalis)* several species of oyster drill marine wood borers (*Limnoria tripunctata* and *Toredo nirvalis*) brown alga *(Sargassum muticum)* soft-shell clam (*Mya arenaria)* seagrasses *(Zostera marina* and *Z. japonica).*	Pacific coastal waters of British Columbia

(Source: modified from Chesapeake Bay Commission 1995).

These findings are not surprising as it has been shown that certain zooplankton taxa which live in brackish and salt water can survive, and apparently adapt to freshwater environments such as the Great Lakes (Locke *et al.* 1993).

To date, phytoplankton sampling in Atlantic Canada has shown that the frequency of toxic algal blooms in and around Nova Scotia during summer months has tripled over the past 15 years, but a definitive connection with ballast water releases has yet to be established (Smith and Kerr 1992). Concern over the import of toxic algae carried by ships bound for the Îles-de-la-Madeleine was subsequently investigated by Gosselin *et al.* (1993), who determined that 60% of ballast waters from ships whose last ports of call were all in Canadian waters contained small concentrations of four potentially toxic dinoflagellate species of *Alexandrium spp.* and *Dinophysis spp.*

In British Columbia, unintentional introductions that have induced significant ecosystem or economic effects include the parasitic copepod *Mytilicola orientalis*, several species of oyster drill, marine wood borers, including *Limnoria tripunctata* and *Toredo nirvalis*, the brown alga *Sargassum muticum*, the soft-shell clam *Mya arenaria* and the seagrasses *Zostera marina* and *Z. japonica*. In the latter case, different tidal habitat preferences has resulted in an overall increased area of coastal seagrasses which has had a beneficial impact on resident invertebrates, fish and birds (Harrison and Tarbotton 1995).

Several other organisms are recent introductions, such as the varnish clam (*Nutallia obscurata*), or are considered likely candidates as a result of recent establishment in adjacent U.S. coastal waters, such as the asian calanoid copepod (*Pseudodiaptomus inopinus*)and the Asian brackish-water clam (*Potamocorbula amurensis*) (R.C. Wilson and R. Forbes, pers. comm.). The European green crab (*Carcinus maenas*) has recently become successfully established in San Fransisco Bay (Cohen *et al.* 1995, Grosholz and Ruiz 1995). Considering the extensive ballast water-carrying vessel traffic along the B.C. coast between the Puget Sound/Strait of Georgia complex and this Bay, this crustacean is another species likely to be introduced into Pacific Canadian waters in the near future. Ecological and economic implications are potentially significant as this would be the first large predator species to be introduced into Canadian west coast waters (G. Jamieson, pers. comm.)

4.2 Scientific studies

The earliest study on ballast water in Canadian waters was commissioned in 1980 by Environment Canada and conducted by Bio-Environmental Services Ltd. (1981). Sampling of ballast water in 55 ships from 10 worldwide locations entering the Great Lakes – St. Lawrence system revealed that all contained viable aquatic organisms and even raw sewage in one instance. However, most notably, this study predicted that the zebra mussel could be introduced to the Great Lakes as a result of ballast water discharges (Bio-Environmental Services Ltd. 1981).

At a workshop entitled "The Risk to Canada's Marine Resources of Species Carried in Ship's Ballast Waters" sponsored by DFO in 1991 at the Bedford Institute of Oceanography in Halifax, one of the recommendations was to identify exotic organisms and their potential risk of introduction into Atlantic Canada's coastal waters (Smith and Kerr 1992).

In 1991, the Great Lakes Fishery Commission convened a workshop entitled "What's Next? The Prediction and Management of Exotic Species in the Great Lakes", the results of which were published by Mills *et al.* (1993a). Through literature reviews, Mills *et al.* (1993b, 1994) developed and published an extensive list of documented introductions of non-indigenous aquatic flora and fauna into the Great Lakes basin since the early 1800's.

A review and evaluation of ballast water management and treatment options to reduce the potential for the introduction of non-native species to the Great Lakes was prepared for the Ship Safety Branch of the Canadian Coast Guard in Sarnia, Ontario, by Pollutech Environment Limited (1992). Phase I reviewed control, management and treatment options, and provided supporting documentation of the abiotic and biotic characteristics of ballast water. Phase II examined and ranked each treatment option in regards to cost, effectiveness, safety concerns and environmental acceptability, the results of which favored physical measures such as mid-ocean exchange or discharges to a shore-based treatment facility over chemical treatments. Two of the more significant conclusions of this report were that a comprehensive characterization of ballast waters and sediments was not yet available and secondly, that based upon the variety of organisms and life stages, e.g. larvae and resting cysts, the most effective control measure may never achieve 100% effectiveness in eliminating the risk of exotic species introduction (Pollutech Environment Limited 1992).

From May to December 1990 and March to May 1991, Locke *et al.* (1991, 1993) examined the extent of compliance with the voluntary ballast water exchange guidelines by 455 ocean-going foreign vessels entering the St. Lawrence Seaway. Based on information from the 90% of vessels who submitted Ballast Water Exchange Reports to the Canadian Coast Guard and St. Lawrence Seaway Authority, 89% of vessels carrying ballast water conducted exchange procedures as per the voluntary guidelines. In a subsequent paper, Locke *et al.* (1993) calculated the effectiveness of ballast water exchange by examining the living zooplankton in the ballast water carried by 24 vessels originating in fresh or brackish ports, having reported saltwater ballast exchange and proceeding up the Seaway. Locke *et al.* (1993) calculated that ballast water exchange was 67% effective – 16 of 24 vessels – in eliminating all living freshwater-tolerant zooplankton. They concluded that the effectiveness of ballast water exchange is also limited by the possible resuspension of organisms carried in residual water or bottom sediments, thus becoming potentially available for discharge in subsequent ports of call (Locke *et al.* 1993).

From May to September 1992, 62% of 60 ballast water samples taken from ships docked at Îles-de-la-Madeleine carried small concentrations of four potentially toxic dinoflagellates, *Alexandrium* spp. and three *Dinophysis* spp. (Gosselin *et al.* 1993). Eight of nine sediment samples collected from the ballast tanks of three ships contained resting cysts of *Alexandrium* spp. (Roy 1994).

Subba Rao *et al.* (1994) examined ballast water samples from 86 ocean-going foreign vessels – originally collected by Locke *et al.* (1991), to inventory type and abundance of potentially toxic phytoplankton species. A variety of organisms were found, including 69 diatom and 30 dinoflagellate species, several for the first time in Canadian waters. Of these, *Pseudonitzschia pungens* and *Dinophysis acuminata* are toxigenic and have occurred in bloom proportions on Canada's east coast. The hypothesis of whether or not such blooms occur more frequently in coastal sites that receive ballast water discharges has yet to be tested (Subba Rao *et al.* 1994) and the level of risk of introduction also remains unquantified (Forbes 1994).

The 1995 meeting of the ICES Working Group on Introductions and Transfers of Marine Organisms was held in Kiel, Germany, from April 10 to 13, and D. Kieser, of the Pacific Biological Station in Nanaimo, B.C., was the Canadian representative. Although the main focus was the control of planned species introductions, several papers were presented on ballast water issues, including the survival of the life stages of various plankton and fish species and research by Lloyd's of London to investigate the possibilities of ballast water treatment during passage (D. Kieser, pers. comm.).

In June 1995, the American Association for the Advancement of Science – Pacific Division met at the University of British Columbia to discuss "Shipping-Associated Introductions of Exotic Marine Organisms into the Pacific Northwest: How Serious is the Problem?". Presentation topics included marine exotics and the shellfish industry of British Columbia, the introduction of seaweeds, the asian calanoid copepod *Pseudodiaptomus inopinus* and harmful marine phytoplankton species by ballast water, interactions of an introduced seagrass and the native eelgrass and a risk assessment of the introduction of non-native organisms to Pacific northwest ports. From a review of the presented papers, there is active concern that B.C. fisheries and aquaculture will be threatened by the introduction of exotic organisms in ballast water of ships. While the impact of algal introductions along the west coast appears to have been minimal, more detailed distributions of marine phytoplankton and benthic microalgae are required in combination with regional population genetics, in order to fully evaluate the potential effects of viable phytoplankton spores from ballast waters.

4.3 Ongoing and proposed research

Phase I of an ongoing project being conducted by the Canadian Coast Guard (Prior 1995) aims at validating and quantifying the concerns regarding the safety aspects of mid-ocean ballast water exchange such as hull stresses and loss of stability, and possible alternatives for ships unable to comply. The results of a study on two bulk carriers transiting the Laurentian Channel, showed that due to structural limitations, both would be physically unable to comply with the mid-ocean Voluntary Ballast Water Exchange Guidelines. Although all relevant stability criteria were met during the ballast exchange operation, changes in forward and aft drafts produced several instances of propeller emergence as well as increased risk of forward slamming. Subsequent phases of this study will involve investigating different initial base ballast conditions (Prior 1995).

In 1994, Aquatic Sciences Inc. initiated a study for the Canadian Coast Guard (CCG), Ship Safety – Central Region, designed to further investigate the work of Locke *et al.* (1991) on the effectiveness of ballast water exchanges. To obtain data on salinity stratification, unpumpable ballast and sediment and the potential of basin to basin transfer of organisms, preliminary sampling protocol and prototype equipment were developed for double bottom ballast tanks (Aquatic Sciences Inc. 1995).

Initiated in 1993 at DFO's Maurice Lamontagne Institute in Mont-Joli, Québec, an ongoing study has to date, identified nine species of organisms which may be considered to be high risk potential invaders of the St. Lawrence Gulf and Estuary and 31 additional species representing lesser risk of introduction, or more likely to be introduced by methods other than in ballast water (Reid and Gauthier, in prep.). Maritime traffic patterns and current ballast water management practices are also being investigated and sampling of 100 vessels entering ports of the Gulf of St. Lawrence was initiated in July 1995.

On the Pacific coast, the B.C. and Washington Working Groups on Minimizing the Introduction of Exotic Species, hope to produce by June 1996, a report describing introduced species in the inland waters of Washington State and British Columbia, with policy recommendations on minimizing the risk of potential future introductions and responses to already introduced exotic organisms.

5.0 Conclusions

- There are presently no ballast water exchange regulations in Canada. Two sets of voluntary guidelines for ballast water exchange apply only to vessels entering the Great Lakes inland waterways through the St. Lawrence Seaway or those bound for Îles-de-la-Madeleine in the Gulf of St. Lawrence.
- Management activities are segmented by region and not integrated between official authorities.
- The Voluntary Ballast Water Management Plan for the control of ruffe in Lake Superior ports is currently the only action to limit potential inter-basin transport of nonindigenous organisms in ballast water.

- Regulations enforced by the U.S. Coast Guard, under the *1990 Nonindigenous Aquatic Nuisance Prevention and Control Act*, are presently the only ones that protect the Great Lakes.

- Overall effectiveness is questionable because of the following factors:

  - The existing voluntary guidelines have a limited geographic coverage;
  - Due to current ship design and safety considerations, ballast water exchange is limited to certain vessel types;
  - Tanks with exchanged ballast water or those with unpumpable ballast water and sediments may still contain live organisms.

- To address the risks to Canada's aquatic habitats and resources, there is a need for a national action plan, in consultation with shipping, fishing and aquaculture industries, which could lead to policies, regulations and an integrated research program regarding ship-transported ballast water.

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Working Group on Harmful Algal Boom Dynamics
(IOC-ICES WGHABD)

ANNEX V

- Examples of possible contribution to an annual QSR -
(Europe only)

Mapping of harmful events related to phytoplankton blooms in ICES countries

ICES / IOC WG ON HARMFUL ALGAL BLOOMS DYNAMICS

The purpose of plotting events on maps is to obtain A GLOBAL AND VISUAL OVERVIEW OF HARMFUL EVENTS FOR THE PRECEEDING TEN YEARS.

Information to be plotted on maps includes:

. indication of regular monitoring sites,

. indication of the frequency of harmful events during the last ten years.

Different types of events are:
DSP, PSP, ASP, NSP, CFP, animal and plant mortality (wild and cultured), and other observed toxic effects (cyanobacteria toxicity...). The information plotted is the **presence of toxins, or observations of animal or plant mortality** if detected, regardless of the level of toxicity.

DSP, PSP, animal and plant mortality, and other toxic effects are presented on separate maps, whereas NSP and ASP may be combined for the ten year period.

Details on responsible species, toxins and year of occurrence are located in the NATIONAL REPORTS and do not appear on the maps. Blooms of potentially toxic species with non detectable levels of toxicity have been ommitted from the maps.

Each map includes :

. a thickened coast line for all regions with regular monitoring,

. circles of up to 3 different sizes, depending on the number years an area or zone that was affected ;

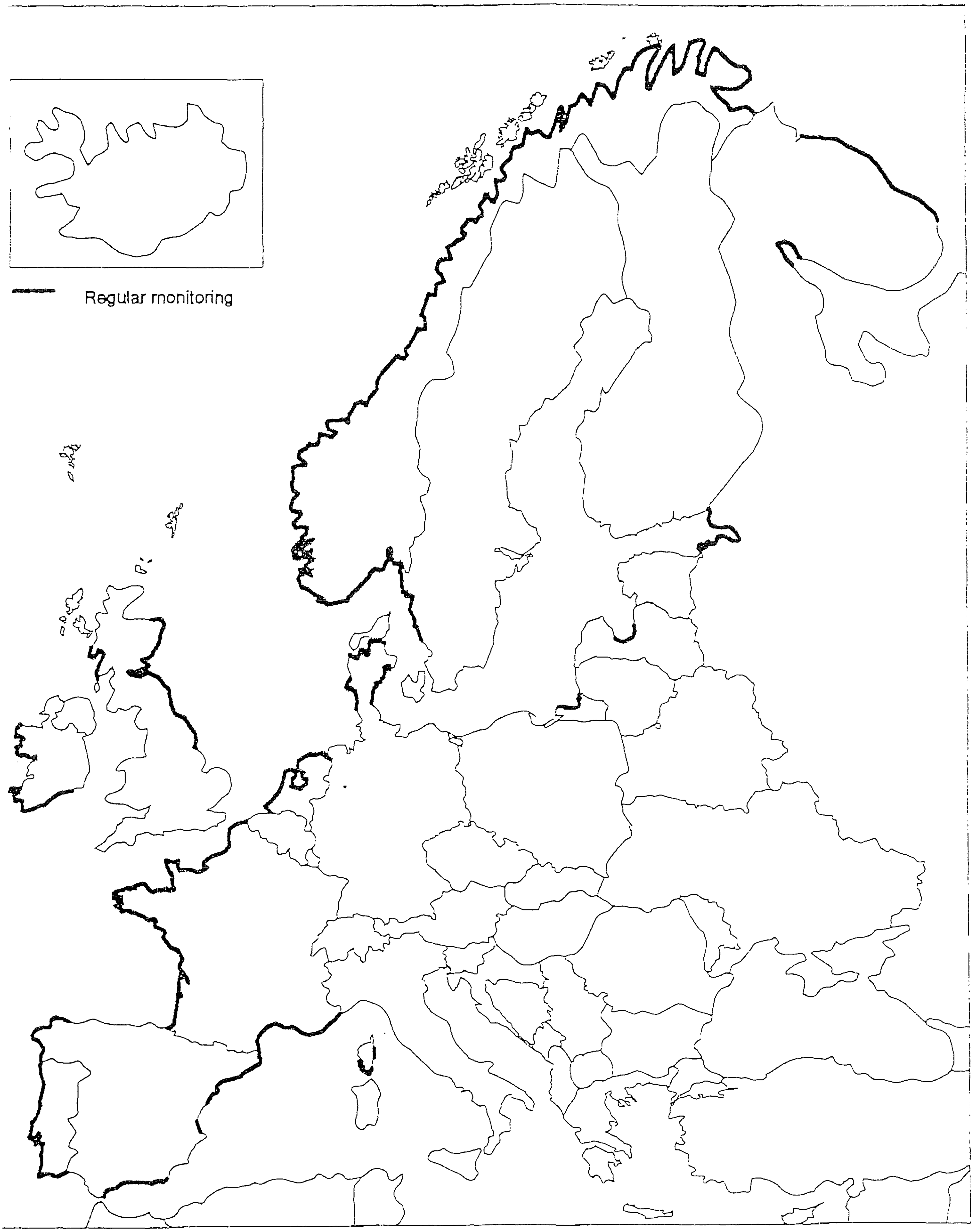
(empty circle)	sampled, but no toxins detected in the ten years,
(little full circle)	one time (one year) during the ten year period,
(medium full circle)	2–5 times during the period,
(big full circle)	6–10 times during the period.

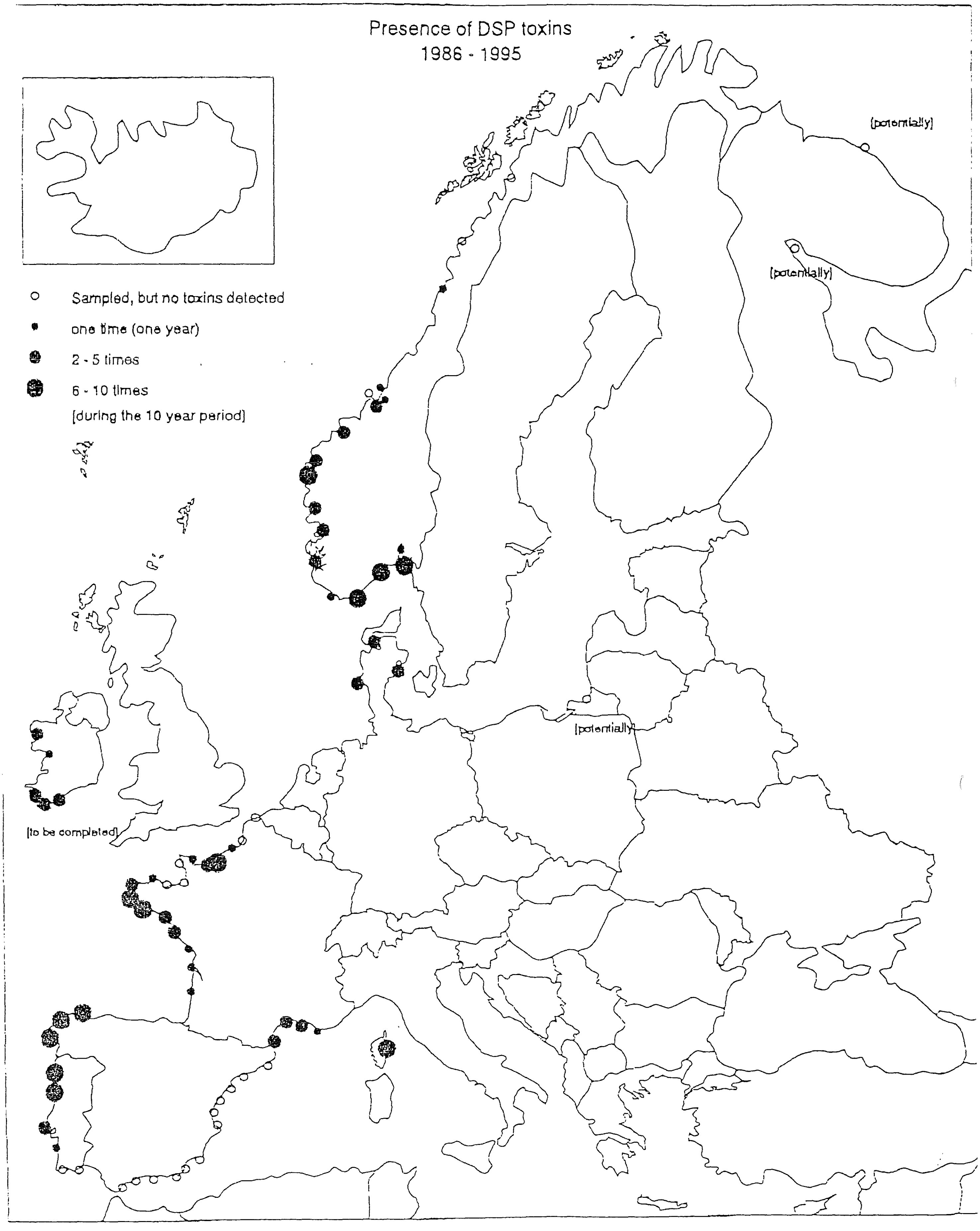
For uniformity the "zones" or areas should represent the same length of coast line. A length of 100 to 200 km is recommended, with adoptions when necessary.

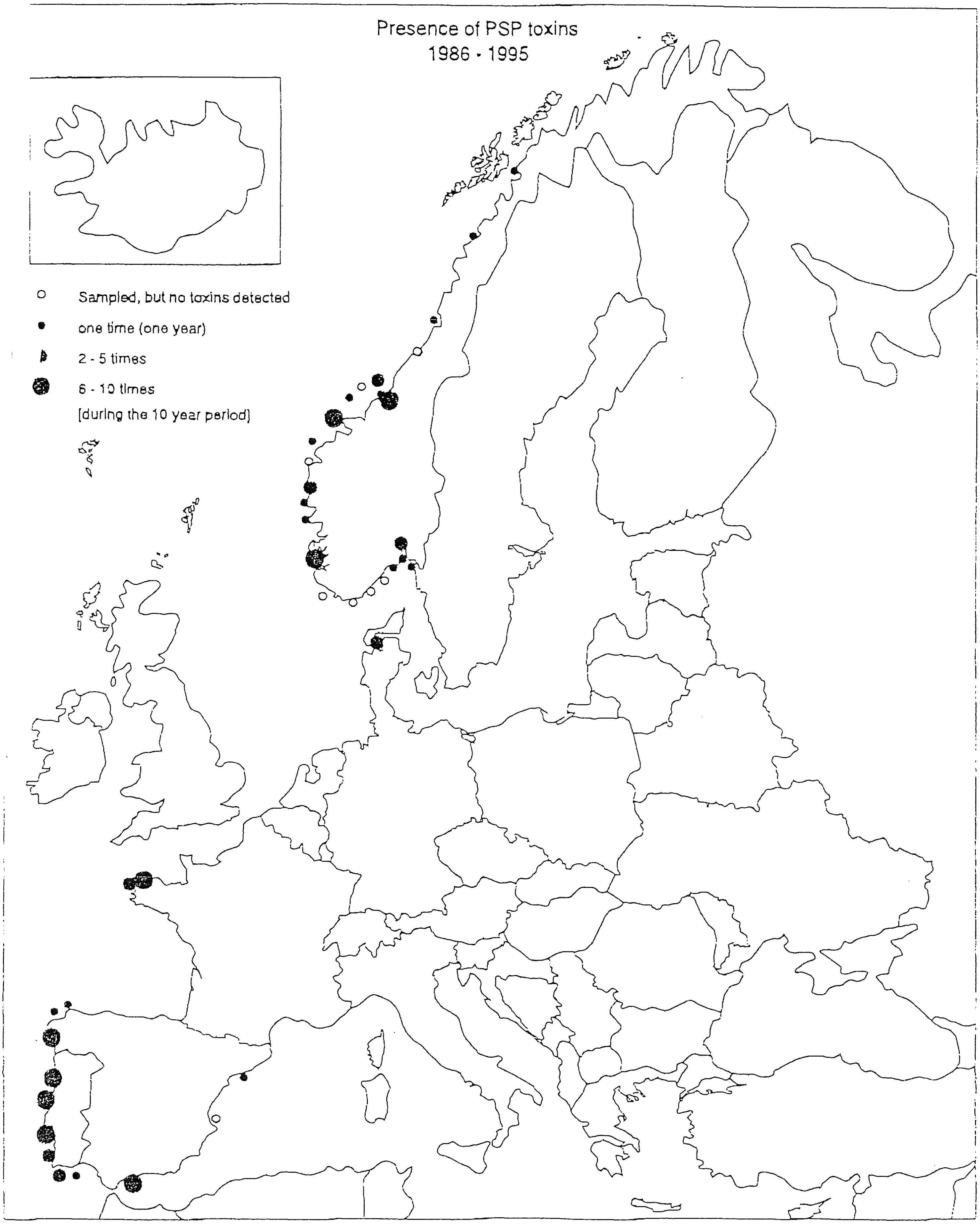
In conclusion 10 different maps should be generated (5 for Europe and 5 for North America) for the following events : DSP, PSP , NSP and ASP, animal and plant mortalities, other toxic effects.

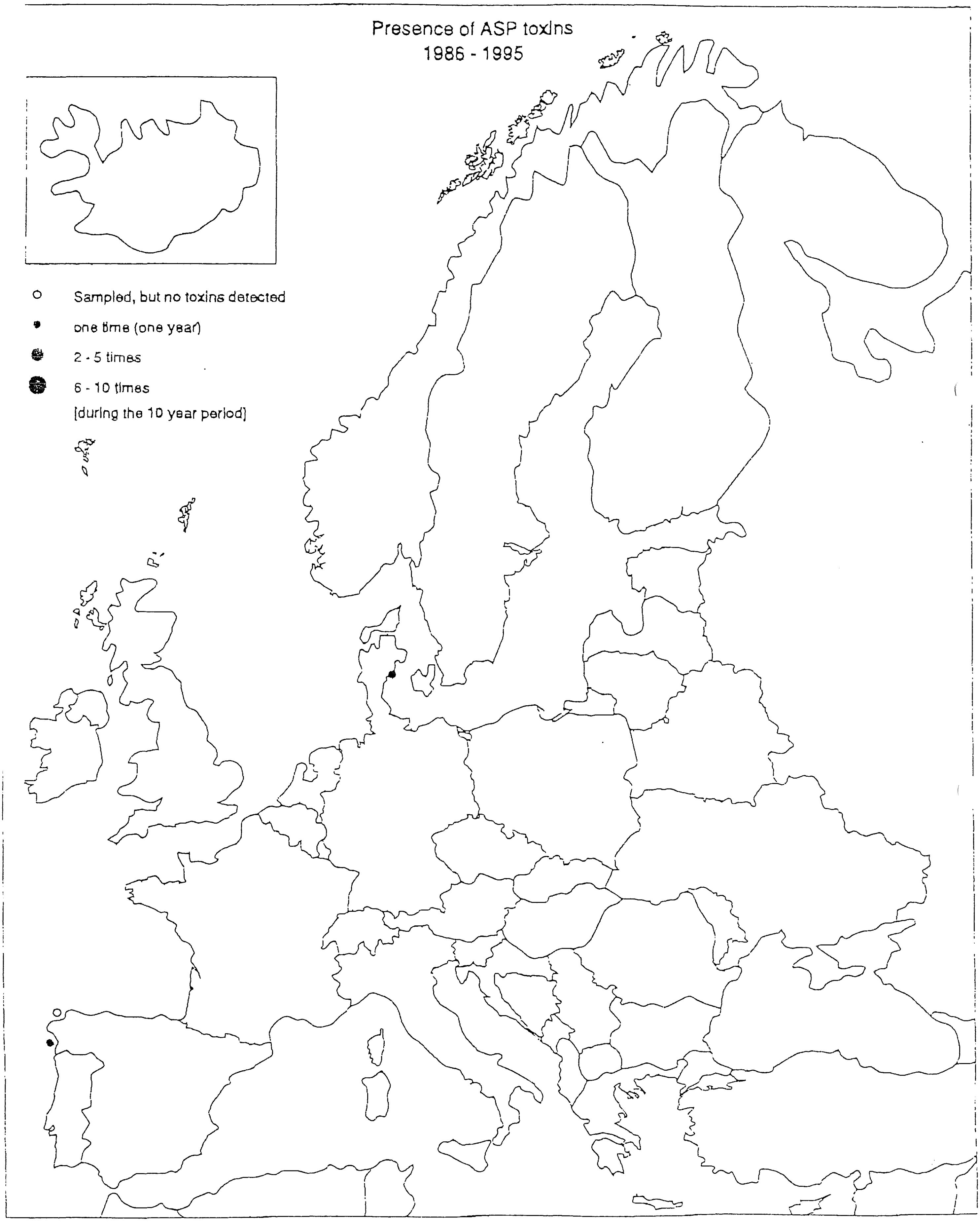
The maps will be updated annually and be included in the appendix of the WGHABD.
When adding a year, the first year of the last 10 year period is deleted resulting each year in maps of the last 10 years.

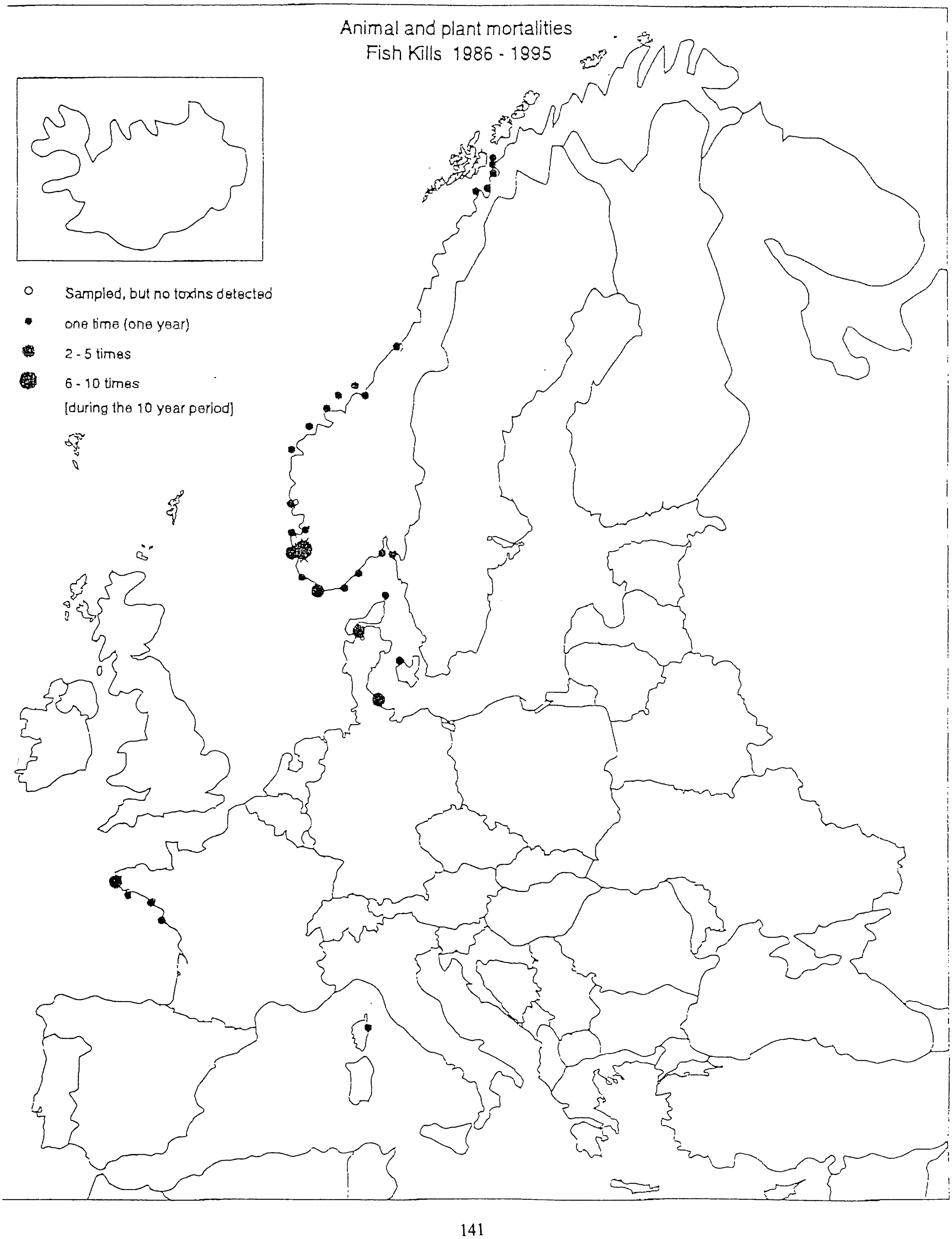
For this first map, answers were received from the following countries : Denmark, Latvia, Norway, Portugal, Russia, Spain (and France). So it is an example of what we could do next years with more information.

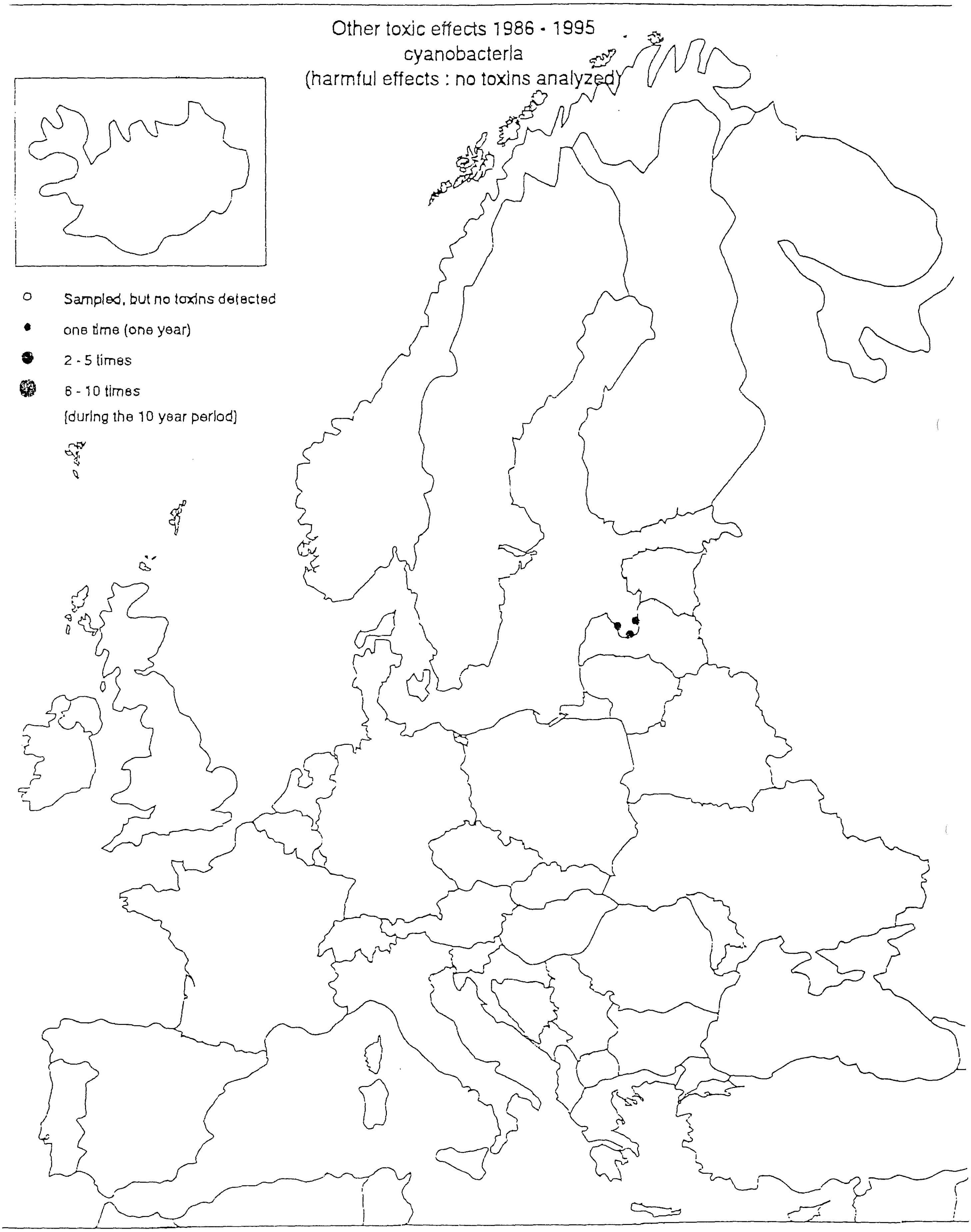

Regular monitoring


Presence of DSP toxins
1986 - 1995
Sampled, but no toxins detected
one time (one year)
2 - 5 times
6 - 10 times
[during the 10 year period]
[potentially]
[potentially]
[potentially]
[to be completed]


Presence of PSP toxins
1986 - 1995
Sampled, but no toxins detected
one time (one year)
2 - 5 times
6 - 10 times
[during the 10 year period]


Presence of ASP toxins
1986 - 1995
Sampled, but no toxins detected
one time (one year)
2 - 5 times
6 - 10 times
[during the 10 year period]


Animal and plant mortalities
Fish Kills 1986 - 1995
Sampled, but no toxins detected
one time (one year)
2 - 5 times
6 - 10 times
[during the 10 year period]


Other toxic effects 1986 - 1995
cyanobacterla
(harmful effects : no toxins analyzed)
Sampled, but no toxins detected
one time (one year)
2 - 5 times
6 - 10 times
(during the 10 year period)