Distribution and impacts of Harmful Algal Blooms in the ICES area

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Summary
Harmful Algal Blooms (HABs) represent a major hazard for the exploitation of coastal resources in ICES countries. Blooms of toxin-producing (low biomass) HABs are recurrent throughout the whole ICES region leading to prolonged shellfish harvesting bans when regulatory levels are exceeded; fish-killing (high biomass) HABs affect intensive caged-fish aquaculture in Scandinavia, Scotland and western Canada. Emerging benthic HABs have caused isolated events of Ciguatera Fish Poisoning (CFP) in Macaronesia (Canary, Madeira Islands) and outbreaks of toxic sea-spray on Mediterranean beaches. In the Baltic Sea, cyanobacteria aggregate in surface scums in tourist areas, and may kill domestic animals. Since the establishment of HAB related ICES activities (1984), we have witnessed the decline of some toxin-producers and PSP outbreaks in Iberia, the wax and wane of DSP outbreaks in Europe, and their emergence in North America, and the description of new lipophilic toxins (i.e. azaspiracids) that were unnoticed before, co-extracted with the most common diarrhetic shellfish toxins. Here we provide a checklist of the causative agents of harmful microalgal outbreaks in the ICES area, and a qualitative appraisal of the most outstanding patterns observed in the two last decades and reported to the ICES-IOC Working Group on Harmful Algal Bloom Dynamics.

Introduction
The ICES "Special meeting on the causes of exceptional algal blooms", held in 1984, represented the first effort to coordinate HAB activities on a regional level. This was followed by the establishment of the ICES "Working Group on Phytoplankton and Management of their Effects (WGPME)" (1985-1991) followed by the more interdisciplinary ICES-IOC Study Group (1992-1993) and later "Working Group on Harmful Algal Bloom Dynamics" (WGHABD) (1994 to date). For 30 years one common objective that has persisted in all these groups has been to compile a record of annual harmful events in different ICES countries, including information on the causative organisms and newly discovered toxins. Most of this information is kept in the "ICES-IOC Harmful Algal Blooms Database" (HAEDAT). With this long term regional perspective, the international community can now confirm the high-risk areas for different noxious events and appraise the inter-annual fluctuations of these phenomena and their relation with climate variability.

Material and Methods
Information presented here results from the activity of national monitoring programmes on harmful phytoplankton and phycotoxins, where weekly sampling and analyses are carried out according to standard methods on phytoplankton identification/quantification and toxin analyses. In addition, national and regional projects endorsed by the SCOR-IOC GEOHAB programme with a focus on HAB dynamics have routinely reported new results to the group.

Results and Discussion
Paralytic shellfish poisoning (PSP) events have long been known on W North American coasts. Official public health concern started in 1927 following a major outbreak in California, which led to the establishment of the first toxin monitoring programme by mouse bioassay. PSP sampling programmes on the East Coast started in 1958 following an outbreak in New Brunswick (Canada). In

more recent years, a severe PSP outbreak in autumn 1972 in New England marked the initiation of endemic outbreaks in the Gulf of Maine, an area with no previous history of such blooms (Lewitus et al. 2012). Blooms of *Alexandrium catenella* in western and of *A. fundyense* in eastern North American waters constitute the most damaging toxin-producing HABs for the shellfish industry. Trend analyses of *A. fundyense* in the Bay of Fundy showed large inter-annual variability and phenological changes but no evidence of intensification of the events (ICES 2014). A historic PSP outbreak on the northeast coast of England in 1968 was the first of a new series of PSP events that have affected Europe in recent times. These include the first PSP event caused by *Gymnodinium catenatum* in the Galician Rías Baixas, and by *Alexandrium minutum* in the northern Rías Altas (Trainer et al., 2010). A main issue in NW Europe is the co-occurrence of toxic and non toxic strains of *Alexandrium minutum*, and of the *Alexandrium tamarense/fundyense/catenella* complex. The use of molecular techniques to discriminate between species/strains with identical morphology is in progress.

Diarrhetic Shellfish Poisoning (DSP) events caused by *Dinophysis* species, in particular *D. acuminata* and *D. acuta*, are the most damaging HABs in Western Europe in terms of lengthy shellfish harvesting bans. There seems to have been an intensification of events in the last decade and a relation was found between exceptional early and intense blooms o *D. acuminata* and winter anomalies in wind circulation patterns in NW Iberia and the Bay of Biscay (Díaz et al. 2013). North America, considered a DSP free region, witnessed the first toxic DSP outbreaks in recent years. Azaspiracids, a group of lipophilic toxins co-extracted with DSP toxins that affect N Europe since 20-y ago is proving to be widespread. Nevertheless the identification of the causative organisms, *Azadinium spinosum*, and other *Azadinium* and *Amphidoma* species, has just started. Amnesic Shellfish Poisoning (ASP), caused by *Pseudo-nitzschia* species, was first described after a major outbreak in 1998 in Prince Edward Island, Canada, and is now a widely reported cause of short-term shellfish harvesting closure, especiallyscallops, which show a great affinity for these toxins and are hard to depurate.

Toxic (*Heterosigma akashiwo, Karenia mikimotoi, Pseudochatonella spp*) and non-toxic (i.e. spiny *Chaetoceros* spp.) high biomass fish-killing HABs may be devastating for cage salmon aquaculture in W Canada, Scandinavia, and Scotland, and for other fish species in S Iberia and W France. A major issue is to identify the exact mechanism causing fish death.

Blooms of Cyanobacteria are the main concern in brackish waters of the Baltic Sea. Finally a main concern in the last decade is the emergence of benthic HABs that were formerly restricted to tropical environments. Blooms of *Ostreopsis* spp. are associated with toxic sea-spray on Mediterranean coasts with effects on beachgoers similar to those of neurotoxic shellfish poisoning (NSP) producer *Karenia brevis* in the Gulf of Mexico; small-scale toxic outbreaks of Ciguatera Fish Poisoning (CFP) due to*Gambierdiscus* now occur amongst consumers of large carnivorous fishes in the Atlantic Islands (Canaries, Madeira, Azores) (GEOHAB 2012). Ongoing work on these emerging HABs and their toxins will be highlighted during this ICES Theme Session on "Harmful Algal Blooms in Aquaculture and Fisheries ecosystems: prediction and societal effects"

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