Harmful Algal Blooms and Climate Change

Harmful Algal Blooms and Climate Change Scientific Symposium

May 19 – 22, 2015
Göteborg, Sweden

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Symposium Organizers

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Symposium Program

Monday	**18 May, 2015**	
17:00-21:00	Registration	
19:00-21:00	Ice breaker	

Tuesday	**19 May, 2015**	**Speaker**
08:00	Registration	
08:30	Introduction, goals of the symposium	Bengt Karlson and Angela Wulff
08:45	Summary of what we may know about climate change effects on HABs	Mark Wells
09:00	Harmful algal blooms and ocean climate change: Progress on tackling a formidable predictive challenge (*Invited talk*)	Gustaaf M. **Hallegraeff**
09:30	Short-term HAB forecasting in a changing environment (*Invited talk*)	Joe **Silke**
10:00	***Coffee / Tea break, poster mounting***	
10:30	Climate warming and harmful blooms (*Invited talk*)	Theodore J. **Smayda** and Thomas J. Smayda
11:00	Toxic blooms phenology and abiotic controls in a changing world. The case of *Alexandrium minutum* in Britany (French coast)	Annie **Chapelle**, Carles Guallar-Morillo, Cédric Bacher, Martin Plus, Marc Sourisseau, Guillaume Le Gland, Valérie le Guennec and Laure Guillou
11:20	Expansion of the benthic dinoflagellate *Ostreopsis* with climate change: Health risks assessment and policy strategies for management	Elisa **Berdalet**, Magda Vila and Rafael Abós-Herràndiz
11:50	Long-term trends of harmful algal blooms in the Seto Inland Sea of Japan	Ichiro **Imai**, Keigo Yamamoto, Tetsuya Nishikawa and Satoshi Nagai
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13:30	Breakout Session 1 1a. Physical effects on HAB — Stratification due to increased temperature and runoff 1b. Physical effects on HAB — Temperature (e.g. physiology, range extension), salinity, light, etc. 1c. Grazing effects on HAB	
15:30	***Coffee / Tea break***	

16:00	Linkage to Other International Programs with an HAB Component	Stewart Bernard and Raphael **Kudela**
16:30	Red tides are more correlated with climate variability under eutrophic conditions in Hong Kong: Time series analysis	Kedong **Yin** and Jianzhang He
16:50	Response of North Sea phytoplankton blooms to changing climate conditions: A model scenario analysis	Willem **Stolte**, Anouk Blauw, Tineke Troost, Ghada El Sarafy, Hans Los, Meinte Blaas and Nicky Villars
17:10	Reports from Breakout sessions	
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Wednesday	**20 May, 2015**	**Speaker**
08:30	Cyanobacteria in future climate conditions: Time to project diversity and function, not only biomass (*Invited talk*)	Catherine **Legrand**
09:00	Climate change: The links to global expansion of harmful cyanobacterial blooms (*Invited talk*)	Hans W. **Paerl**, H. Xu, B. Qin, G. Zhu, N.S. Hall, K.L. Rossignol and J.T. Scott
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12:00	Microenvironments of *Trichodesmium* colonies – Implications for ocean acidification responses	Meri **Eichner**, Isabell Klawonn, Samuel T. Wilson, Matthew J. Church, David M. Karl and Helle Ploug
12:20	A less saline Baltic Sea promotes cyanobacterial growth, hampers intracellular microcystin production, and leads to strain-specific differences in allelopathy	Andreas Brutemark, Angélique Vandelannoote, Jonna Engström-Öst and Sanna **Suikkanen**
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16:20	Precipitation as a driver of phytoplankton ecology in coastal waters: A climatic perspective	Peter A. **Thompson**, Todd D. O'Brien, Hans W. Paerl, Benjamin L. Peierls, Paul J. Harrison and Malcolm Robb
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Oral Presentations

Tuesday, May 19

May 19, 09:00, Invited-10285

Harmful algal blooms and ocean climate change: Progress on tackling a formidable predictive challenge

Gustaaf M. **Hallegraeff**

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Responding to the predictions from IPCC physico-chemical climate models, over the past 15 yrs HAB climate science has progressed from single-factor to multistressor single-species lab and multi-species mesocosm manipulation experiments to tentative predictive modeling. Key environmental factors identified include: increased temperature, enhanced surface stratification (affecting nutrient and light availability), elevated CO_2 (stimulating photosynthesis and driving 'ocean acidification' biogeochemistry), and increased extreme precipitation and storm events. Emerging HAB climate responses include: range expansion of warm-water (e.g. *Gambierdiscus*) at the expense of cold-water species; changes in abundance and seasonal bloom window; and increased cellular toxin content of key HAB species (*Alexandrium, Pseudo-nitzschia, Karlodinium*). Developing predictive capability has been frustrated by: contradictory species and especially strain-specific responses (e.g. *Emiliania*), lack of insights into evolutionary adaptation; and into how HABs interact with the broader phytoplankton and zooplankton grazer communities; and scarcity of sustained (>30 yrs) biological data streams (except for taxon-limited CPR and microfossil records). Unexplored factor interactions may underpin differing climate responses even by different geographic ocean provinces. To progress HAB climate science we need to agree on 'best practices' experimental protocols, use of biological reference organisms and climate 'hot-spot' observer sites. Climate change is now adding a new level of uncertainty to seafood safety and HAB monitoring programs, calling for more investment in global observation systems, improved ocean sensor capabilities and integrated data management.

May 19, 09:30, Invited-10325

Short-term HAB forecasting in a changing environment

Joe **Silke**

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The provision of short term Harmful Algal Blooms (HAB) forecasts to mitigate against impacts to the aquaculture industry has been tackled by several research groups in recent years. These systems rely on observations of biological, chemical and physical pressures that promote HABs, and are used to provide risk indices to aquaculture operations. The complexity of drivers used in forecasting HABs requires the role of natural variability and human disturbance to be understood. Short term changes in HAB occurrence has been firmly linked with weather patterns, but, the linkage between long term climate variation and changes in HABs is more obscure. In some cases the knowledge that informs models used for short term forecasting HABs depends on decades of research. Successful operational or semi-operational HAB forecasts rely on a tight coupling between observation and models. The diverse group of phytoplankton that are classed as HABs do not belong to a single biological or evolutionary group, but span the majority of algal taxonomic groups. Climate variability that impact phytoplankton communities will also impact species that have harmful effects. Such impacts in response to an altered climate include shifts in the timing or magnitude of the spring bloom due to changes in sea temperature, light availability, nutrients etc. Indirect changes including altered oceanic circulation patterns or basin scale events impacting HAB occurrence and distribution. These types of change would result in different succession of HAB occurrence, range expansion/ contraction, and changes to the seasonal timing, duration and hence forecasting of HAB events.

May 19, 10:30, Invited-10328

Climate warming and harmful blooms

Theodore J. **Smayda**[1] and Thomas J. Smayda[2]

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The temperature-growth niche width for 150+ species and strains of dinoflagellates, raphidophytes and other diverse flagellates was evaluated to assess the potential effect of global warming on harmful algal blooms. The data collectively suggest the species in those phylogenies predominantly have sub-tropical to tropical evolutionary origins that pre-adapt them to elevated temperature. Species potentially most responsive to warming are those adapted to lower temperatures at or near 15^0C, and frequently occur latitudinally in coastal waters delineated by the 15^0C isotherm centered at about 45^0N and 45^0S. Prominent members of this "cold-water" flora, whose bloom behavior and distribution may be particularly vulnerable to temperature warming, include the paralytic shellfish toxin producer *Alexandrium tamarense/ catenella* complex and ichthyotoxic *Heterosigma akashiwo*. A uniform, harmful algal response to global warming is unlikely because of experimental evidence that temperature has multiple effects on cellular life history and physiological processes, including encystment, germination, chemical composition, toxin content, growth rate and motility. Those traits, the three different species growth-temperature patterns that occur, the differences in species temperature niche widths, the diversity of harmful modes, the variations in habitat conditions associated with harmful bloom and red tide outbreaks, and inadequate methodology profoundly influence current capacity to quantify and project the direct effects of temperature change in modifying harmful algal bloom behavior. Species-specific and habitat-specific based experimental and field studies are the required modeling approach, but even then the complexity of the temperature-phytoplankton relationship is a formidable impediment to quantification and prediction of temperature driven changes in harmful bloom behavior.

May 19, 11:00, Oral-10283

Toxic blooms phenology and abiotic controls in a changing world. The case of *Alexandrium minutum* in Britany (French coast)

Annie **Chapelle**[1], Carles Guallar-Morillo[1], Cédric Bacher[2], Martin Plus[1], Marc Sourisseau[1], Guillaume Le Gland, Valérie le Guennec[1] and Laure Guillou[3]

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[3] CNRS, Roscoff, France

The dinoflagellate *Alexandrium minutum* is a bloom-forming species which is distributed worldwide and frequently identified along the French coasts. It is responsible for outbreaks of Paralytic Shellfish Poisoning events that affect aquaculture industry, human health and ecosystems. Contaminations have appeared in Brittany in the late-1980s. Since then, a large time series dataset has been created which combines environmental, phytoplankton and toxicity variables from REPHY French monitoring program and other research programs. Our approach to understand *A. minutum* bloom controls and its phenology is based on *i)* statistical analysis combining the definition of environmental niche of *A. minutum* populations and the phenology of *A. minutum* events and *ii) A. minutum* numerical modelling based on physiological traits parameterization for generating emergent properties among phytoplankton functional types in the bay of Brest. Both results showed that temperature, irradiance and dilution are important factors regulating the population dynamics of this species and more especially the bloom initiation. They contribute to determine *A. minutum* ecological niche, to influence the shape of its blooms and to provide explanation of the interannual variability. These results could be later applied to local climatic scenarios in particular concerning water temperature and could integrate phenotypic variations effects.

May 19, 11:20, Oral-10312

Expansion of the benthic dinoflagellate *Ostreopsis* with climate change: Health risks assessment and policy strategies for management

Elisa **Berdalet**[1], Magda Vila[1] and Rafael Abós-Herràndiz[2]

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Ostreopsis is a tropical benthic dinoflagellate genus that produces palytoxin (PLTX) and analogues, one of the most potent non-protein marine toxins known. *Ostreopsis* species grow well in shallow waters as epiphyte, mainly embedded in a self-produced mucilage sheath covering macroalgae, corals or rocks. In tropical seas, *Ostreopsis* has been related to human intoxication -sometimes fatal- by ingestion of contaminated marine food. The data collected along the last 20 years indicate the potential expansion of this toxic organism in temperate waters, including the Mediterranean, as a result of climate warming and anthropogenic impacts in the coastal zone. Nowadays, *Ostreopsis* recurrent proliferations in these latitudes constitute a health and environmental emergent problem, which needs a strategy for management at different levels.

Here we summarize the main elements that should be considered in order to explore the future impacts of the *Ostreopsis* blooms under a climate change scenario:

-To ascertain the present distribution of the genus worldwide.
-Improve monitoring methodological limitations (early warning systems).
-Increase the understanding of *Ostreopsis* ecophysiology and toxicity.
-Ascertain risks for the environment (e.g. macrofauna mortality, food webs alteration).
-Human health risk assessment, concerning seafood intoxication, respiratory and cutaneous irritations.
-Multidisciplinary and coordination structures to elaborate prevention and mitigation plans.

May 19, 11:50, Oral-10319

Long-term trends of harmful algal blooms in the Seto Inland Sea of Japan

Ichiro **Imai**[1], Keigo Yamamoto[2], Tetsuya Nishikawa[3] and Satoshi Nagai[4]

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[4] National Research Institute of Fisheries Science, Yokohama, Kanagawa, Japan

The Seto Inland Sea is the largest enclosed coastal sea in Japan and is also a major fishing ground including aquacultures of fishes, bivalves and seaweeds. Two significant long-term changes in environments were noticed: i.e. an increase in winter water temperatures of 0.042°C year^{-1}, and a decline in dissolved inorganic nitrogen (DIN) from about 10 μM in the 1970s to ~5 μM in the late 1990s to the present due to the reduction in nutrient inputs by virtue of the regulation by law. Along with serious eutrophication in 1960s and 1970s, the red tide incidents had markedly increased in frequency and scale. The maximum incident 299 per year was recorded in 1976, and the incidents showed a clear decreasing trend to reach around 100 per year in late 1980s. However, the toxic dinoflagellate *Alexandrium tamarense* has become dominant in the Seto Inland Sea in spring, especially in Osaka Bay, and has made manila clams and oysters toxic almost every year from late 1990s. The deposition of abundant cysts of *Alexandrium* spp. in sediments indicates the establishment of *A. tamarense* in the Seto Inland Sea. There is a history of anthropogenic transfers of oyster juveniles from *A. tamarense* blooming areas (Tohoku) to the Seto Inland Sea (no *A. tamarense* blooms before 1990s), and investigations using microsatellite markers revealed the close relationships between *A. tamarense* strains of Tohoku and the Seto Inland Sea. The ecosystem resilience was disturbed by anthropogenic activities such as transferring oyster juveniles in the Seto Inland Sea.

May 19, 16:00, Oral

Linkage to Other International Programs with an HAB Component

Stewart Bernard and Raphael **Kudela**

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A brief review is presented of the partnerships between the HAB research community and international programmes of relevance to long term HAB and ecosystem observations. These include groups related to the Committee on Earth Observation Satellites (CEOS), such as the International Ocean Colour Coordinating Group (IOCCG) and the importance of these groups in realising the needs of the HAB community from an earth observation perspective. Also discussed are the relevant components of the multi-ministerial Group on Earth Observations (GEO), such as the HAB components of the Blue Planet task. The role of the Global Ocean Observing System in promoting long term HAB-related observations is also assessed. Beyond the programmatic aspects, approaches to demonstrating the economic value of the research, and the value of specialised HAB community skills to the larger ecosystem and biogeochemical focused science effort are also briefly examined.

May 19, 16:30, Oral-10292

Red tides are more correlated with climate variability under eutrophic conditions in Hong Kong: Time series analysis

Kedong **Yin** and Jianzhang He

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Climate changes have also been reported to be a factor influencing outbreaks of red tides, but evidence is rare due to lack of time series of red tide occurrences. In Hong Kong, red tides have been monitored since 1983, which offers us a great data set of 32 year time series (1983-2001) to examine the relationship between climate indices and red tides. The analysis for 1983-2014 time series shows that correlation between red tides and NPGO (North Pacific Gyre Oscillation) is significant at $p<0.01$. Correlation of red tides with MEI, the El Niño index, is not significant, but becomes significant by 7-10 months lag. The significant correlation of red tides with PDO is only significant after 7 months lag. Starting in 2001, due to sewage effluent control, water quality has been significantly improved in most Hong Kong marine waters. Consequently, the number of total red tides has been reduced from 512 during 1983-2001 to 255 during 2002-2014. The correlation analyses for 2002-2014 show that most significant correlations for 1983-2001 disappear for 2002-2014 with only a few exceptions. This demonstrates that climate variability plays an important role in setting up the conditions for the formation of red tides, particularly under eutrophic conditions caused by anthropogenic input of nutrients.

May 19, 16:50, Oral-10297

Response of North Sea phytoplankton blooms to changing climate conditions: A model scenario analysis

Willem **Stolte**, Anouk Blauw, Tineke Troost, Ghada El Sarafy, Hans Los, Meinte Blaas and Nicky Villars

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In general climate change is expected to result in higher water temperatures, more stratification and hence more potentially harmful dinoflagellates and cyanobacteria. But this pattern is likely to vary regionally. Other climate change effects such as wind and precipitation patterns and carbon dioxide concentrations further complicate regional effects of climate change.

We did a study to predict the effect of climate change on primary productivity and harmful algal blooms in the North

Sea, with a numerical model driven by IPCC scenarios combined with historical data analysis. We learned that effects were strongest in the region of freshwater influence. Here the spring bloom is expected to start earlier, blooms are more likely to occur and primary productivity is expected to increase. Dinoflagellates are expected to increase everywhere.

We identified the following knowledge gaps: Effects of enhanced stratification on harmful algal blooms at the species level; effects of climate change on river discharges, as these have a major impact in coastal waters, where HAB effects have most societal impact; Lack of monitoring data (and methods) to detect (changes in) phytoplankton concentrations below the surface mixed layer and how to disentangle climate change effects from other pressures of global change, such as eutrophication and fisheries?

We propose an integrated approach. Improve process knowledge, by experiments and data analysis. Use improved knowledge in existing models. Extensively monitor phytoplankton and supporting variables. Combine models and data analysis to keep track of changes (information system) and adapt to changes e.g. real-time forecasting.

Wednesday, May 20

May 20, 08:30, Invited-10321

Cyanobacteria in future climate conditions: Time to project diversity and function, not only biomass

Catherine **Legrand**

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In the Baltic Sea, cyanobacteria summer blooms can be harmful as they produce bioactive metabolites (including toxins) that are transferred to higher trophic levels, make water unsafe for recreation and contribute to hypoxia of bottom waters. Cyanobacteria have a long evolutionary history that confers them the capacity to be well adapted to environmental stress. They have access to various nutrient pathways, and their tolerance to high light and high temperature suggest that cyanobacteria are likely to be favoured under environmental changes linked to global warming.

The burning question is: will cyanobacteria become dominant over other phytoplankton under future climate conditions?

There is no unified picture for projected scenarios. The hypothesis for increased biomass based on physiological and growth strategies has its limitations, as trait-based measurements may change over time. Stable traits (life cycle) are also rarely included in projections. Further, it is still unclear whether future environmental changes will lead to a loss or gain of diversity and function in phytoplankton and microbial communities. Cyanobacteria are an essential part of brackish food webs due to primary production and nitrogen fixation. Yet, the differences among cyanobacterial populations are largely unknown, making it difficult to predict the future extent and development of the blooms, especially in response to changing environmental conditions.

The main difficulties in studying cyanobacteria are their morphological variability and degree of polymorphism, the variability in production of bioactive metabolites (including toxins), and their sometimes enigmatic life cycle depending on different environmental conditions. As a result the identification and characterization of cyanobacterial diversity and function is only possible using a combination of molecular, morphological and ecophysiological approaches.

Recent findings from field observations, experimental work and modeling will be presented to support that projecting future cyanobacterial blooms in the Baltic Sea needs to integrate “quantity” (biomass) and “quality” (diversity and function) aspects.

May 20, 09:00, Invited-10287

Climate change: The links to global expansion of harmful cyanobacterial blooms

Hans W. **Paerl**[1], H. Xu[2], B. Qin[2], G. Zhu[2], N.S. Hall[1], K.L. Rossignol[1] and J.T. Scott[3]

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Cyanobacteria are the Earth's oldest oxygenic phototrophs and they have had major impacts on shaping its biosphere. Their long evolutionary history (~ 3.5 by) has enabled them to adapt to geochemical and climatic changes and recent anthropogenic modifications of aquatic environments, including nutrient over-enrichment (eutrophication), water diversions, withdrawal and salinization. Eutrophication has promoted a worldwide proliferation of cyanobacterial blooms that is harmful to ecological and animal (including human) health. In addressing steps needed to stem and reverse this troubling trend, both nitrogen (N) and phosphorus (P) input constraints are likely needed. Cyanobacteria exhibit optimal growth rates and bloom potentials at relatively high water temperatures; hence global warming plays a key interactive role in their expansion and persistence. Additional manifestations of climatic change, including increased vertical stratification, salinization, and intensification of storms and droughts, play synergistic roles in promoting bloom frequency, intensity, geographic distribution and duration. Rising temperatures cause shifts in critical nutrient thresholds at which cyanobacterial blooms can develop; thus nutrient reductions for blooms control may need to be more aggressively pursued in response to climatic changes taking place worldwide. Cyanobacterial bloom control must consider both N and P loading dynamics within the context of altered thermal and hydrologic regimes associated with climate change.

May 20, 11:30, Invited-10309

The essentials of pH and the carbon dioxide system for HAB researchers

David R. **Turner**

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The continuing slow acidification of the surface ocean has resulted in an increased focus on the influence of CO_2-system parameters such as pH and pCO_2 on biological processes. Both when carrying out measurements and when calculating within the CO_2 system, it is important to have a clear understanding of the scope and limitations of the methods used. For experimental measurements, the choice of method must take into account both practical limitations, and the accuracy and precision required. Once two of the four parameters pH, pCO_2, alkalinity and total inorganic carbon have been measured, the remaining two can be calculated. However, such calculations result in additional uncertainties that need to be borne in mind. I will summarise the basics of CO_2 system chemistry in seawater, and will discuss the scope and limitations of different approaches to measurement and calculation.

May 20, 12:00, Oral-10288

Microenvironments of *Trichodesmium* colonies – Implications for ocean acidification responses

Meri **Eichner**[1], Isabell Klawonn[2], Samuel T. Wilson[3], Matthew J. Church[3], David M. Karl[3] and Helle Ploug[1]

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N_2-fixing cyanobacteria are known to form extensive, partly toxic, blooms in various ecosystems, including oligotrophic oceans as well as the nutrient-rich Baltic Sea. Previous laboratory and field studies investigating climate change effects on marine diazotrophs have found differing responses to elevated pCO_2, part of which could be explained by a modulation of responses by other environmental factors. In their natural environment, many N_2-fixers form aggregates or colonies, leading to formation of distinct microenvironments. Aiming to explore the implications of these offsets for their responses to climate change, we characterized microenvironments and small-scale fluxes in colonies of *Trichodesmium sp.* under different pCO_2 levels. Using microelectrodes, O_2, pH and redox potential were measured in colonies collected at Stn ALOHA, North Pacific Ocean. O_2 concentrations measured in the center of colonies were elevated in the light by up to 100%, with mean values of 150% and 80% O_2 saturation in light and dark, respectively. Concurrently, pH values varied within a range of 1.2 units during light and dark phases, with increasing variability in proton concentration at high pCO_2 in line with a decrease in buffer capacity. We discuss the implications of these findings for the physiological status of the cell, specifically requirements for protection of the O_2-sensitive nitrogenase and activity of carbon concentrating mechanisms, as well as potential feedbacks on ocean acidification responses of *Trichodesmium sp.* Our findings highlight the need to consider microenvironment conditions when studying responses of colony-forming phytoplankton to climate change.

May 20, 12:20, Oral-10301

A less saline Baltic Sea promotes cyanobacterial growth, hampers intracellular microcystin production, and leads to strain-specific differences in allelopathy

Andreas Brutemark[1,2], Angélique Vandelannoote[3], Jonna Engström-Öst[1,2] and Sanna **Suikkanen**[3]

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Salinity is one of the main factors that explain the distribution of species in the Baltic Sea. Increased precipitation and consequent increase in freshwater inflow is predicted to decrease salinity in some areas of the Baltic Sea. Clearly such changes may have profound effects on the organisms living there. Here we investigate the response of the commonly occurring cyanobacterium *Dolichospermum* (ex. *Anabaena*) spp. to three salinities, 0, 3 and 6. For the three strains tested we recorded growth, intracellular toxicity (microcystin) and allelopathic properties. We show that *Dolichospermum* can grow in all the three salinities tested with highest growth rates in the lowest salinity. All strains showed allelopathic potential and it differed significantly between strains and salinities, but was highest in the intermediate salinity and lowest in freshwater. Intracellular toxin concentration was highest in salinity 6. In addition, based on monitoring data from the northern Baltic Proper and the Gulf of Finland, we show that salinity has decreased, while *Dolichospermum* spp. biomass has increased between 1979 and 2013. Thus, based on our experimental findings it is evident that salinity plays a large role in *Dolichospermum* growth, allelopathic properties and toxicity. In combination with our long-term data analyses, we conclude that decreasing salinity is likely to result in a more favourable environment for *Dolichospermum* spp. in some areas of the Baltic Sea.

May 20, 16:00, Oral-10310

A climate link to the exceptional 2013 bloom of *Dinophysis* in Scottish waters and its associated diarrhetic shellfish poisoning event?

Callum Whyte, Sarah Swan and Keith **Davidson**

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During July 2013 approximately 70 people in south east England reported symptoms consistent with diarrhetic shellfish poisoning. The cases were linked to the consumption of mussels originating from the Shetland Isles Scotland. After these mussels were consumed, unusually high shellfish flesh toxin levels were detected by regulatory monitoring. The biotoxin event was linked to an exceptionally rapid increase in the abundance of *Dinophysis* sp. in west coast Shetland waters, with cell abundances reaching ~ 8000 cells L^{-1} at some sites. The speed of increase in cell numbers was such that shellfish toxicity increased from sub threshold to ~1500 µg kg^{-1} in a time scale less than the one week interval between regulatory sampling events. As a result, contaminated shellfish were marketed and consumed. The negative publicity for the shellfish industry from this event was significant, with news reports on the BBC and other outlets reducing consumer confidence in Scottish shellfish. The role of environmental factors in stimulating this bloom was investigated with analysis of wind (and water current) patterns indicating that unusual changes in the direction of the prevailing wind was related to the statistically significantly elevated *Dinophysis* densities in 2013. It was also found that similar conditions generated high *Dinophysis* abundance in Shetland in June/July 2006. Analysis of monthly means of the NAO index demonstrated a link between this potentially climate driven index and exceptional *Dinophysis* blooms. The application of this knowledge within a HAB early warning system for the Shellfish Isles will be discussed.

May 20, 16:20, Oral-10299

Precipitation as a driver of phytoplankton ecology in coastal waters: A climatic perspective

Peter A. **Thompson**[1], Todd D. O'Brien[2], Hans W. Paerl[3], Benjamin L. Peierls[3], Paul J. Harrison[4] and Malcolm Robb[5]

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Climatic change is shaping our planet's ecosystems yet our capacity to predict the consequences and prepare for the future remains rudimentary. Changes to the hydrological cycle mean that large regions of the planet are experiencing changes in precipitation. Responses by phytoplankton were assessed in three regions: 1) globally, 2) in regions that are wet and getting wetter, 3) in regions that are dry and getting drier. Using long-term time-series data the temporal variation in precipitation was compared with variation in chlorophyll *a*, diatoms, dinoflagellates, chlorophytes, chrysophytes and euglenophytes from 106 sites worldwide. The results demonstrate that phytoplankton responses to precipitation depend upon the season and region. In general phytoplankton responded more positively to increased precipitation during summer rather than winter. Increased precipitation during winter was likely to reduce chlorophyll *a*, diatoms and chrysophytes, whereas increasing precipitation in summer was likely to increase chlorophyll *a* and favor chlorophytes. Within regions that are wet and getting wetter chlorophyll *a* increased and dinoflagellate abundances were reduced in wet autumns; while diatom abundances were reduced in wet springs. In dry and drying ecosystems the abundances of chlorophytes decreased, especially during dry springs and summers. The associations between precipitation and the abundance of various, widely occurring, HAB taxa found at the 106 sites of SCOR-WG 137 database will be presented. The existence of these widespread patterns of phytoplankton abundance associated with inter annual variability in precipitation improves our capacity to predict the future composition of phytoplankton communities in receiving estuarine and coastal water bodies.

May 20, 16:40, Oral-10305

Long-term time series of phytoplankton dynamics and community composition from the Imaging FlowCytobot can reveal impacts of climate change

Lisa **Campbell** and Darren Henrichs

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Long-term time series of individual phytoplankton taxa are crucial for investigating links between climate change and harmful algal blooms (HABs). Expected alteration of environmental conditions due to climate change highlight the importance of identifying factors controlling phytoplankton community composition. Sustained and highly resolved temporal sampling will permit identification of changes in bloom phenology, predator-prey interactions, and characterization of novel species. Imaging FlowCytobot (IFCB) combines flow cytometry and video technology to capture images of individual cells which, together with machine-learning technology, enables near real-time reporting of individual phytoplankton species abundance and community composition. Two deployments of the IFCB provide examples of the utility of this high-resolution temporal approach. First, the continuous and automated operation of the IFCB in the Gulf of Mexico at Port Aransas, TX has provided successful early warning for seven HABs. Initial stages of HABs, i.e., as concentrations begin to increase above typical background levels, were detected with sufficient time for closure of shellfish harvesting to avoid human illness. Second, shipboard IFCB analyses of community composition on the Texas-Louisiana shelf were collected to examine factors contributing to interannual variability. Individual taxa distributions were mapped from the Mississippi River Delta westward to Galveston Bay. Differences in community structure between years appeared to be related to nutrient source. In 2013, dinoflagellates, including *Prorocentrum* spp., dominated the biomass at mid-salinity stations with higher urea and P-limitation, whereas in 2014, when there was no evidence of P-limitation, diatoms dominated the biomass at most stations; however, dinoflagellates dominated at stations with elevated urea.

Thursday, May 21

May 21, 08:30, Invited-10315

Exploring marine phytoplankton biogeography through theory and models: Applications to climate change studies

Stephanie **Dutkiewicz**[1], Ben Ward[2], Jeff Morris[3], Jeff Scott[1], Mick Follows[1], Sonya Dyhrman[4] and Ilana Berman-Frank[5]

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Combinations of traits (such as cell size, nutrient requirements and affinity) and consequent trade-offs mediate the fitness of phytoplankton types in different environments, and thus shape their biogeography. Climate change will alter the marine environment, for instance warmer waters, altered nutrient supplies, and lower pH. I will discuss how we use theory and global scale computer models to explore key trait combinations and controls on biogeography and how this can guide our understanding of potential responses to climate change. As a first example I will examine controls on nitrogen fixing phytoplankton (diazotroph) biogeography. A key trait, fixing nitrogen, and its trade-off, slower growth, dictates that these organism will only inhabit regions where the resource supply ratios, Fe:N and P:N, exceed a given criteria. We use a numerical model under projected 21st century conditions to show how altered supply ratios will therefore change diazotroph ranges. As a second example I will discuss how future environmental changes will alter the relative fitness of phytoplankton. Reduced nutrient supply will favour smaller phytoplankton given their lower nutrient requirements. Here we also illustrate that the relative changes in fitness due to differential response of maximum growth rate to higher pCO_2, suggested by a meta-analysis of acidification experiments, significantly alters community structure and biogeography. These examples are provided to hopefully engender discussion whether similar theoretical and model techniques could be used to constrain the controls on HABS and understand changes to their potential fitness relative to competitors in a changing climate.

May 21, 09:00, Invited-10330

Modelling harmful algal growth under climate change

Kevin J **Flynn**

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HABs are dynamic events, requiring systems dynamic approaches to modelling in order to track process that promote and dissipate their occurrence. Climate change is taking us where we have not been before, requiring models that are robust and not statistical extrapolations of past events. Models represent a simplification of reality whose construction presents a supreme test of our understanding. It is necessary to invoke elemental and biochemical (inc toxin) stoichiometry in HAB models and hence in data collection. However, we typically lack data series that are of use in modelling (i.e., C:N:P:Si:Chl, cell size etc.), relating HABs to nutrients and light, to prey fields for mixotrophy, to growth of competitors and to grazers. To these issues we now add the impacts of climate change. Temperature affects growth rates, water column stability and gas exchange rates. Ocean acidification affects the start pH for the basification that naturally occurs during bloom development, and that affects all planktonic members of the water column, including not only HAB species but prey, predators and competitors. Eutrophication and de-eutrophication impact on HAB development directly and via basification. Changes in rain fall and agriculture practice affect nutrient types, loads and ratios, water clarity, salinity and washout rates. The net result is that a far more holistic understanding is required before we can model HAB events under climate change. While we remain a long way from robust predictive models for HABs, models are powerful focal points for experiment design and data collection and should be integrated into all studies.

May 21, 11:30, Oral-10302

Shifting N:P ratios do not affect the competitive traits of dinoflagellates under present and future climate scenarios

Maarten **De Rijcke**[1], Gabriel M. Orellana[2], Julie Vanden Bussche[2], Lynn Vanhaecke[2], Karel A.C. De Schamphelaere[1] and Colin R. Janssen[1]

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Throughout history, harmful algal blooms (HABs) have never caused more food-web disruption, economic losses and human health implications than now. Yet, worryingly, these events may become even more frequent as climate change starts to take hold. To predict and prevent unprecedented environmental impacts, a profound understanding of the (future) biotic and abiotic factors that govern HAB dynamics is urgently needed. Yet while scientific consensus states that nutrient availability is crucial for HAB formation, the often cited effect of increasing N:P ratios (due to reduced anthropogenic phosphorus) is still poorly understood. How toxic dinoflagellates such as *Prorocentrum lima* and *Protoceratium reticulatum* benefit from a shift in the relative abundance of nutrients to outcompete common non-toxic dinoflagellates like *Prorocentrum micans* and *Scrippsiella trochoidea*, is hard to phantom. These dinoflagellates were therefore cultured at various N:P ratios (between 8 and 24) under current day and climate change scenarios (20 and 24°C). By sampling the cultures for over a month, it was found that higher temperatures lead to a faster onset of growth, significantly higher growth rates and changes in the average toxin content. However, as the effect of N:P ratios was comparable across all species, the results suggest that phosphate restrictions have had little to no effect on the competitive traits of HAB species. Future HABs, which benefit from increasing temperatures, are likely to be controlled by grazing, interspecific competition and allelopathic interactions. To reduce the future risk of HABs, overall nutrient levels rather than relative concentrations need to be addressed.

May 21, 11:50, Oral-10323

Long-term changes in microalgae communities on the Russian East coast with emphasis on toxic and bloom forming species

Tatiana Yu. Orlova[1], Polina A. **Kameneva**[1,2] and Tatiana V. Morozova[1]

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The results of long-term changes in microalgae communities as well as analysis of HABs dynamics in Amursky Bay (East/Japan Sea) during the period 1970-2010 were summarized. The revealed changes and trends in the composition and distribution of microalgae communities are as follows: the species richness increased; there are species-specific changes in the abundance and seasonal dynamic of HAB taxa (like *Pseudo-nitzschia* spp, *Karenia* spp., *Dinophysis* spp.); a list of species causing blooms in the bay was expanded (*Ostreopsis* spp. reveled in 2007, 3 species of *Sceletonema* spp revealed in 2013, *Prorocentrum* spp. in 2014); the biomass of the non-diatom component of the phytoplankton increased. For the last two decades some species of harmful algae (*e.g.*, toxic dinoflagellates and haptophytes benefiting from land runoff and water column stratification, warm water benthic dinoflagellates and cyanobacteria responding to increased water temperatures) became more common. The oceanographic records show alternation between periods of relative warming and cooling at the time scale in this area. However, the Sea of Japan is one of the most rapidly warming seas of the world by the sea surface temperature index. It is supposed that climate change combined with human activities, primarily through nutrient runoff, is an important factor of the increase in HABs activity in the study area.

May 21, 12:10, Invited-10290

Impact of changing physics on marine ecosystems in future coastal seas

H.E. Markus **Meier**

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In future climate water temperatures are projected to increase compared to present climate with probably significant impact on marine ecosystems. Other physical parameters like salinity, light penetration, mixed layer depth may change as well. The effects of these changes on the marine ecosystem may be either direct affecting, e.g., ecosystem functioning, or indirect affecting, e.g., nutrient fluxes by changing stratification. In low and mid-latitudes the dominant effect in projections of the open ocean is the increased vertical stratification leading to reduced nutrient levels in the euphotic zone and consequently to reduced primary production. This effect is largely absent in coastal seas. Instead, existing projections suggest differing changes in primary production arising from varying changes in mixing and advection. In this presentation we focus the discussion on indirect impacts and use the Baltic Sea as study area. Using an ensemble of coupled physical-biogeochemical models driven with regionalized data from global climate simulations we are able to quantify the influence of changing climate upon algal blooms and oxygen conditions in a sea that suffers from both eutrophication and expanding hypoxic zones. Applying various nutrient load scenarios we show that under the impact of warming hypoxic zones will very likely increase or at best only slightly decrease (in case of optimistic nutrient load reductions) compared to present conditions, regardless of the used driving climate model and greenhouse gas emission scenario. In future climate a similar expansion of hypoxia as projected for the Baltic Sea can be expected also for other coastal seas worldwide.

May 21, 16:00, Oral-10296

Towards real-time *in situ* monitoring of toxic algae

Elisa **Villa**, Carmem-Lara Manes, Jahir Orozco, Linda Medlin and Delphine Guillebault

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Harmful algal blooms represent a relevant threat to aquatic ecosystems, human health and local economies and this phenomenon is increasing globally. Rapid and reliable identification of harmful algae has therefore become a fundamental requirement in monitoring programs as an early warning system to prevent damage to humans and farmed animals. Molecular biological tools, which are faster and more accurate than conventional methods, have been developed over the past decade and have greatly enhanced the ability to identify organisms down to the species level. However, the integration of molecular techniques on a floating platform for *in situ* monitoring remains a big challenge and requires a multidisciplinary approach undertaken by scientists from different fields. The aim of the EU SMS (Sensing toxicants in Marine waters makes Sense using biosensors) project is to deliver a novel automated networked system that will enable real-time *in situ* monitoring of the chemical and ecological status of sea-water in coastal areas by the detection of a series of contaminants including a variety of toxic algae. Here we present our latest results on adapting a sandwich-hybridization approach coupled with a colorimetric assay for the detection of different species of toxic algae known to occurrences in the Mediterranean Sea.

May 21, 16:30, Oral-10331

Development of seabird based sampling strategies for the determination of plankton communities with special focus on HAB species

Bernd **Krock**[1] and Susan Waugh[2]

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The coasts of the West Antarctic Peninsula are most affected by climate change and thus are a hotspot for the study of temperature effects on plankton composition and distribution of HAB species and their associated toxins. On the other hand sampling in Antarctica is very much hampered by limited access and difficulties of getting samples due to adverse environmental conditions. In order to partly overcome both obstacles, we want to test if seabirds can be used as sampling platforms for phycotoxins and other chemotaxonomic markers for the indirect detection of HAB species or even a more general phytoplankton composition. A very promising sampling technique for this purpose is SPATT, which originally was introduced as an integrative monitoring and control tool for shellfish harvesting sites. Nowadays miniaturization of electronic sensors and the high sensitivity of mass spectrometric techniques allow for the development of very small portable devices which can be reversibly be applied to sea beards such as the little blue penguin (*Eudyptula minor*) native to New Zealand. Seabirds have the big advantage over stationary applied passive samplers, that they easily can access remote and otherwise inaccessible areas and moreover actively search areas with high primary production for feeding and thus become ideal sampling platforms. New Zealand as one of the world's biggest producers of shellfish has established a comprehensive HAB monitoring system and provides a database for the comparison of the SPATT data with the known plankton composition. Here we present the first result of such an experiment.

May 21, 16:50, Oral-10329

Integration of mobile automated monitoring systems with treatment and DSS tools for smart HAB management

Jaap **van Nes**[1], Wesley Boënne[1], Nele Desmet[1] and Piet Seuntjens[1,2,3]

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Increasing pressure on water quality e.g. by harmful algal blooms, necessitates adequate management and availability of monitoring data to detect changes, to indicate problems (early warning), to improve understanding of the water system functioning and to plan or evaluate measures. The integration of monitoring, treatment and decision support tools moves forward the enablement of smart management of scarce water resources. Historically, monitoring data were obtained by collecting samples and performing measurements at locations of interest. This approach allows for detailed information but lacks temporal and spatial resolution. Nowadays, there are plenty of instruments and technologies available on the water sensing market providing a wide range of data at very different scales and resolutions. This presentation will discuss the innovative use of automated sensors on mobile platforms for monitoring as well as the added value (especially from a user perspective) of its integration with treatment and decision support tools.

By means of recent Aqua Drone® surveys on water reservoirs suffering from algal blooms, the use of unmanned vehicles equipped with automated sensors for water monitoring and the data sets obtained by such approach will be shown. The integration of monitoring, treatment and DSS tools will be illustrated with the Dronic showcase providing insight in user requirements, system functionalities and applications.

Friday, May 22

May 22, 09:00, Oral

From GEOHAB to GlobalHAB - International Research and Coordination of HABs Leading to Improved Societal Benefits

Raphael **Kudela** and Elisa Berdalet

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GlobalHAB is an international coordinating group that facilitates and encourages cooperation on scientific research addressing Harmful Algal Blooms (HABs) in a changing world to accelerate scientific advances, leading to improved understanding, prevention, and mitigation of HABs. A follow-on to GEOHAB, the GlobalHAB programme has been endorsed by IOC, SCOR, and the IAEA. The new GlobalHAB program will address the most relevant objectives partially accomplished by GEOHAB and incorporate new pressing issues that arose with time. It will also take into consideration several recommendations posed by the international community to make the new program relevant to contemporary and future research, funding, and management priorities, continuing to privilege an international approach based on science. These issues include mitigation strategies, impacts on human health in collaboration with the medical and social experts, improve toxin detection (specially on emerging compounds), HABs dynamics under climate change scenarios or economic valuation of HABs impacts. GlobalHAB will retain a strong research-based focus, and concurrently contribute to the application of sound research to management questions in order to broaden international support.

May 22, 09:30, Oral

Developing a global harmful algal bloom and climate change monitoring network

Bengt **Karlson**

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The distribution and frequency of harmful algal blooms (HAB) are likely to be influenced by climate change effects. The most pressing reason to follow the changes is to protect human health, e.g. when toxic species occur in new areas there is a risk that previously non-toxic fish or shellfish are consumed by humans. Changes in the distribution of harmful algae that cause fish mortalities may also have serious impact of local economy in affected areas. Also other HAB, e.g. those causing problems for tourism, are affected by climate change. At present harmful algae are mainly measured as part of long term phytoplankton monitoring programs and more spatially focused efforts to detect harmful species that affect aquaculture. The latter programs are often only in operation in connection with harvesting of shellfish. Climate change related parameters such as pH, nutrients, coloured dissolved organic matter, and temperature and salinity are seldom part of the same monitoring programs. It is proposed to establish a global network for combined monitoring of phytoplankton, including HAB-species, algal toxins and climate change related parameters. The network should be based on existing long term monitoring where such exists but in several areas existing programs are missing. Thus locations for new programs should be identified in key geographical areas. The International Panel on Harmful Algal Blooms, part of the Intergovernmental Oceanographic Commission, could coordinate the program that could be directly linked to the Global Ocean Observing System. Regional organisations could contribute resources and coordinate the regional monitoring. The presentation is intended to initiate a discussion on the topic.

Late Presentation

NOAA's climate research strategy

Vera L. **Trainer**[1], Mary C. Erickson[2], Roger B. Griffis[3], Allison Allen4, Juli Trtanj5, Stephanie K. Moore[1], Robert Magnien[2], Steven R. Kibler[6], Shallin Busch[7], Libby Jewett[7], Zdenka S. Willis[8]

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NOAA's Ecological Forecasting Roadmap (EFR) is used to predict changes in ecosystems in response to environmental drivers such as climate change. The program goal is to provide early warning of these ecosystem changes on coastal systems and allow mitigation strategies to be developed. NOAA's EFR is focused on 4 priorities, the first of which is harmful algal blooms (HABs). Strategic partnerships are a necessary component of program success. The strategic plan recommends aligning complementary cross-NOAA capacity and working closely with national and international entities. Here we describe NOAA-sponsored programs that are relevant to future work on Climate Change and HABs and that share a common vision with the EFR program, including NOAA's Integrated Ocean Observing System (IOOS), the NOAA Fisheries Climate Strategy, NOAA's Ocean Acidification program, and the National Center for Coastal Ocean Science competitive research programs.

Poster Presentations

Poster-1 (10278)

Growth and antioxidant response of *Microcystis aeruginosa* (Cyanobacteria) exposed to Anatoxin-a

Mathias Ahii **Chia**[1], Micheline Kezia Cordeiro-Araújo[1,2] and Maria do Carmo Bittencourt-Oliveira[1]

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Among the toxins produced by cyanobacteria, anatoxin-a (ATX) represents one of the most commonly occurring neurotoxins. To date, most studies have focused on the toxicity of the neurotoxin on animals and aquatic macrophytes, while nothing is known about its effect on the ecology of phytoplankton species. The present study investigated the effect of ATX at environmentally relevant concentrations (5, 10, 25 and 50 μg L^{-1}) on *Microcystis aeruginosa* (Kützing) Kützing. Cell density did not significantly ($p < 0.05$) vary between the different ATX concentrations, while chlorophyll *a* content decreased. Total proteins and total microcystins (MCs) concentrations declined with increasing ATX concentrations, while antioxidant enzyme (CAT, POD, SOD and GST) activities were significantly up-regulated under the same conditions. Furthermore, internal hydrogen peroxide (H_2O_2) formation increased as ATX concentrations were increased. Significant positive correlations were observed between antioxidant enzyme activities, hydrogen peroxide production and ATX concentrations. It can be concluded that while ATX did not affect the growth of *M. aeruginosa,* chlorophyll content, MCs, total protein and antioxidant enzyme activities were significantly altered.

Poster-2 (10280)

Study on the impact of harmful algal blooms on coastal waters in Caspian Sea

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The Caspian Sea is the biggest land-locked body of salt water, bordered by Russia, Azerbaijan, Kazakhstan, Turkmenistan,and Iran. With the development of economy and the increasing population,eutrophication has become an overwhelming phenomenon in Caspian Sea and river estuary and its adjacent area. Many potentially toxic contaminants released into the Caspian Sea are lipophilic and insoluble in water. These properties increase their availability for uptake by aquatic organisms and accumulation in the food web. Previous investigations have demonstrated the occurrence of organ chlorines (OCs) and metals in Caspian seals and bony fish from Caspian Sea Recently, environmental toxic contaminants, especially persistent organochlorine compounds, have been suspected to have great impact on the health of wildlife and the ecosystems. Remediation is possible, as demonstrated by remarkable improvement of an oxygen-starved zone of the Caspian Sea, that disappeared within seven years following the decline of use of manufactured fertilizers in Central and Eastern Europe. The results indicated that there are several suggestion for solving in eutrophication problem in Caspian Sea which is consist of: 1-Curb the use of pesticides and their discharge in the rivers where they can contribute to eutrophication by killing certain classes of organisms.2-Better treatment and disposal of industrial, human and animal waste (develop waste treatment facilities and technology).3-Better use of fertilizers in farming (favor natural fertilizers) 4-Avoid land conversion, and promote the restoration of wetlands and other natural buffers (forests, grasslands) that act as reservoirs of nutrients before they reach the ocean and sea.

Poster-3 (10281)

Climate change, Phytoplankton community response and harmful algal blooms: A formidable predictive challenge

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Prediction of the impact of global climate change on marine harmful algal blooms is fraught with difficulties. Increasing temperature, enhanced surface stratification, alteration of ocean currents, intensification or weakening of local nutrient upwelling, simulation of photosynthesis by elevated co2, reduced calcification through ocean acidification, heavy precipitation and storm events causing changes in land runoff and micronutrient availability, may all produce contradictory species-or even strain-specific response. Complex factor interactions exist and simulated ecophysiological laboratory experiments rarely allow for sufficient acclimation and rarely take in to account physiological plasticity and genetic strain diversity. We can expect:

1-range expansion of warm-water species at the expense of cold water species
2-species-specific changes in the abundance and seasonal window of growth of HAB taxa
3-earlier timing of peak production of some phytoplankton
4-secondary effects for marine food webs, notably when individual zooplankton and fish grazers are differentially impacted by climate change.

The greatest problems for human society will be caused by being unprepared for significant range expansions or the increase of algal biotoxin problems in currently poorly monitored areas, thus calling for increased vigilance in seafood biotoxin and HAB monitoring programmes. Changes in phytoplankton communities provide a sensitive early warning for climate driven perturbations to marine ecosystem.

Poster-4 (10284)

Rapid kit development for harmful algal detection

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Invention of more quick, accurate, and efficient method which could have predictive and prognostic function is necessary to overcome the difficulties of conventional method for microorganisms monitoring. We have challenged to develop the immunochromatography based rapid kit for microalgae detection. As a result a rapid kit using monoclonal antibodies (mAbs) rose against α-tubulin tubulin of *Heterocapsa triquetra*, a candidate of harmful algal bloom species in the coast of Korea. The rapid kit showed a positive signal at about 5,000 cells of *H. triquetra*; 50,000 cells of *H. pygmaea* and *Cochlodinium polykrikoides*; and so on. The polyclonal antibody (pAb) against RuBisCo (Ribulose-1.5-bisphosphate carboxylase /oxygenase) large subunit of *Alexandrium tamarense*, which produces paralytic shellfish, was raised. The western blot analysis showed that the pAb detect three dinoflagellates, *A. tamarense*, *H. pygmaea*, and *C. polykrikoides*. But do not detect *Akashiwo sanguinea*. The pAb showed no signal in two diatom species, *Cylindrotheca closterium,* and *Skeletonema costatum*. Production of mAbs against *A. tamarense* RuBisCo large subunit is now under way for a rapid kit development.

Poster-5 (10289)

A study on the dense bloom of the *Heterosigma akashiwo* in a eutrophic estuary of the Sea of Marmara

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A dense bloom of the ichthyotoxic raphidophycean flagellate *Heterosigma akashiwo* (Y.Hada) Y.Hada ex Y.Hara & M.Chihara was studied together with environmental variables in a eutrophic estuary of the Sea of Marmara in 2012. The bloom of *H. akashiwo* occurred at the upper estuary in late May following an increase in diatoms in mid-May. *H. akashiwo* abundance increased gradually from the lower to the upper estuary (~0.7×10^6 to 10.4×10^6 cells L^{-1}) and reached to the highest level in the entrance of the upper estuary at the temperature of 20.2 °C and salinity of 16.4 psu. *H. akashiwo* cells were not observed in the last two stations of the upper estuary probably due to very low light availability depending on high concentrations of suspended material. The mean surface temperature increased 4.5 °C, while salinity increased 2.5 psu in late May when compared to mid-May. Secchi depth decreased rapidly from the lower to the upper estuary (6 m to 0.5 m). A remarkable increase in temperature in late May, high inorganic nutrient concentrations and low water circulation in the middle and upper estuaries may have stimulated the bloom of *H. akashiwo*. Although no fish mortality or any other harmful effects was observed during this bloom, *H. akashiwo* may pose a potentially toxic risk in the future.

Poster-6 (10291)

Climate change – Good news for toxic filamentous cyanobacteria?

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Current climate change is affecting ecosystems globally. For the Baltic Proper, the second largest brackish water basin in the world, a future business as usual (A1FI) scenario has been projected: by 2100 atmospheric CO_2 levels may rise up to 970 ppm, while precipitation will increase, resulting in a salinity decrease from 6 to 3, and a water temperature rise of 3-5°C. The projected scenario was tested on (I) a natural summer-bloom phytoplankton community, dominated by the filamentous cyanobacteria *Aphanizomenon* sp., *Dolichospermum* sp. and the hepatotoxin-producing *Nodularia spumigena* and, (II) a natural spring-bloom phytoplankton community dominated by diatoms and inoculated with cyanobacteria. We studied (I) interactive effects of elevated pCO_2 and decreased salinity and, (II) interactive effects of elevated pCO_2 and increased temperature. Initially in (I), *Aphanizomenon* sp. dominated (87% of the cyanobacterial biomass) but by the end of the experimental period, >80% of the biomass belonged to *Dolichospermum* sp., with highest biovolume in the A1FI treatment. Among the cyanobacteria in (II), only *N. spumigena* was able to match the biovolume of diatoms and dinoflagellates, but no effects of increased temperature or elevated levels of pCO_2 on any of the species or groups were observed. In conclusion, is climate change good news for Baltic filamentous cyanobacteria? Yes, at least for *Dolichospermum* sp. during summer and maybe for the toxic *N. spumigena* during spring, and possibly also for the filamentous cyanobacteria in general, resulting in even more extensive toxic blooms in the future Baltic Proper.

Poster-7 (10295)

Impact of environmental change on the dynamics of the phytoplankton population: Vegetative form and cysts of dinoflagellates

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The climatic changes impact the composition and specific structure of the phytoplankton population since its development depends directly on biotic and abiotic environmental conditions.

Because of their ability to encystement when conditions are unfavorable, Dinoflagellates are extraordinary indicators of environment change, there are also considered as climatic and oceanographic indicators.

Indeed, in this work with collaboration with the networks of coastal health monitoring, we began a phytoplankton and palynological study on Sidi Moussa Lagoon (Atlantic Moroccan coast). A seawater and deposits sample in the five stations of the lagoon of Sidi Moussa has been done monthly.

The results obtained after quantification and identification of species of dinoflagellates during the study period showed a large variability in cell abundance and plankton blooms, the most important being those of the species to *peridinium quinquicorne* with 5.10^5 C/L and *kryptoperidinium foliaceum* arriving in concentrations above 10^7 C /l, this blooms were positively correlated physicochemical parameters.

The palynologic results of the surface deposits cysts show an association which contains a large variety of species and is dominated by one of them (*Lingulodinium machaerophorum* autotrophic cyst). The heterotrophic cysts are composed of: *Polykrikos sp*, *P. kofoidii*, *Protoperidinium spp*. These are the most abundant heterotrophic taxa in our samples, and there are indicators of nutrient enrichment (V.Pospelova et al, 2010).

Poster-8 (10300)

Spatiotemporal distribution of epiphytic dinoflagellates in Korean seas

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Following the first report on the occurrence of marine epiphytic dinoflagellates (MEPDs) 5 genera from Jeju coastal waters [1], at least 15 research papers on MEPDs in Korean seas have been published. During last 4 years taxonomic papers dealing with morphology and molecular characters of one or two MEPD species in each of the 5 genera, *Amphidinium*, *Coolia*, *Gambierdiscus*, *Ostreopsis*, and *Prorocentrum*, were also published as to be new to Korea. Spatiotemporal distribution of the MEPDs indicated that three (*Amphidinium*, *Ostreopsis*, and *Prorocentrum*) of the 5 genera were relatively more eurythermal and euryhaline than the other two (*Coolia* and *Gambierdiscus*). High-abundance center of *Prorocentrum* spp. on T-S plane, however, was at higher T (22.6 °C) and higher S (34.1 psu) than that of *Amphidinium* spp. (20.3 °C, 32.0 psu) or *Ostreopsis* spp. (20.3 °C, 32.0 psu). Among the 2 stenohaline genera *Coolia* spp. exhibited the high-abundance center at higher T (22.6 °C) while *Gambierdiscus* spp. did at lowest T (19.9 °C). Vertical distribution of MEPDs at a station off an islet, Moon-seom near Jeju Island exhibited subsurface maxima in all the 4 genera, *Amphidinium* (5m, Jun), *Coolia* (10m, Oct), *Gambierdiscus* (15m, Jun), and *Prorocentrum* (5m, Oct), other than *Ostreopsis* (surface, Jun). Recent reports on spatiotemporal distribution of 'originally (sub) tropical' MEPDs in Korean seas imply that their populations are extending habitats northward owing to the regionally accelerated climate changes in the south eastern Yellow Sea. [1] HS Kim, W Yih, JH Kim, G Myung, HJ Jeong. 2011. Ocean Sci. J. 46(3):205-209.

Acknowledgments: Present work was in part supported by the facilities and equipment in Marine Biology Research & Education Center of Kunsan National University

Poster-9 (10303)

The use of the IOC-ICES-PICES Harmful Algal Event Database (HAE-DAT) to detect spatial and temporal trends in harmful algal bloom events in UK waters

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The Intergovernmental Oceanographic Commission (IOC) -International Council for the Exploration of the Sea (ICES)-North Pacific Marine Science Organisation (PICES) Harmful Algal Event database (HAE-DAT) (http://haedat.iode.org/index.php) contains records of harmful algal events from across the globe over the last 30 years. HAE-DAT data from the United Kingdom contains records of shellfish harvesting closures enforced when paralytic shellfish poisoning (PSP), diarrhetic shellfish poisoning (DSP) and amnesic shellfish poisoning (ASP) toxins exceed the limits defined by the EU Shellfish Hygiene Directive (91/492/EEC and subsequent amendments). Data on fish kills and nuisance foams have also been submitted. Analysis of HAE-DAT data accurately describes the regional distribution of harmful algal events around the UK coast but changes in the extent, duration and frequency of events may reflect environmentally driven changes in HAB dynamics (such as climate change) as well as modifications to monitoring programmes. Examples of both can be seen in the UK HAE-DAT data: a reduction in PSP events in Scotland over the last 25 years despite relatively constant monitoring effort; a reduction in the extent and duration of UK ASP events due to a change in the EU legislation introduced in the UK in 2005. The EU decision (2002/226/EC) permits end product testing of *Pecten maximus* which allows non-toxic parts of scallop flesh to be marketed and eliminated the requirement to enforce the closure of scallop fishing areas. Knowledge of changes to routine monitoring programmes as well as 'non-events' is required to interpret spatial and temporal trends in HAE-DAT data correctly.

Poster-10 (10304)

Do teratogenic carotenoids from cyanobacteria represent a link between climate change and global declines in aquatic vertebrate populations?

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A growing body of evidence supports the hypothesis that cyanobacteria (or "blue-green algae") are rapidly increasing in the environment both as part of increasingly frequent, persistent and intense freshwater algal blooms, and accelerated eutrophication of freshwater and coastal habitats. And, moreover, that these increases may be attributed to global climate changes which favor proliferation of these photosynthetic prokaryotes. Although recognized to produce a wide range of bioactive metabolites, a relatively limited number of toxic metabolites - or so-called *cyanotoxins* - are generally associated with toxigenicity of cyanobacteria. However, as part of on-going studies focused on the contribution of additional bioactive metabolites to the toxigenicity of cyanobacteria, several otherwise well-known cyanobacterial carotenoids, and specifically a series of xanthophyll glycosides, were identified as potent teratogens (i.e. developmental toxins). Moreover, it was demonstrated that these cyanobacterial carotenoids specifically act as *pro-retinoid*, giving rise to chemical variants of retinoic acid (i.e. "retinoids") with recognized developmental toxicity. As these carotenoids, unlike more phylogenetically restricted cyanotoxins, are produced by all blue-green algae, it is proposed that the toxicity of these metabolites may, therefore, widely contribute to the impacts of cyanobacteria in freshwater and coastal habitats, and particularly documented global declines in amphibian and other aquatic vertebrate populations. The contribution of cyanobacterial carotenoids to the temporally coincident - and specifically decadal scale - increases in cyanobacteria, and declines in aquatic vertebrate populations, will be discussed.

Poster-11 (10306)

Effects of nutrient concentrations, phagotrophic feeding and allelopathy on bloom dynamics of potentially harmful dinoflagellates

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Bloom dynamics of potentially harmful dinoflagellates are influenced by a variety of environmental factors, including abiotic factors such as the concentrations of dissolved nutrients, and biotic factors such as the presence of potential competitors and consumers. Many dinoflagellates have evolved particular strategies to escape competition by either phagotrophic feeding (mixotrophy) or by producing harmful secondary metabolites (allelopathy). In the present study microcosm experiments were conducted to investigate the impact of different nutrient conditions and the availability of prey organisms on growth and feeding characteristics of the bloom forming dinoflagellates *Lingulodinium polyedrum* and *Alexandrium fundyense* (previously *Alexandrium catenella*). To differentiate between the feeding impact on the prey community and potential allelopathic effects, additional tests for lytic activity were conducted with both dinoflagellates. Both of them were able to ingest the pico-phytoplankton *Ostreococcus sp.* and both had a strong negative impact on the prey population in all nutrient treatments. However, there was no benefit for the dinoflagellates from growing with prey species regarding biomass production. In the experiments testing for allelopathy, *A. fundyense* showed a strong lytic activity, while *L. polyedrum* did not. This indicates that mixotrophy can be an important competitive strategy for *L. polyedrum* by reducing competitors through phagotrophic feeding, while for *A. fundyense* allelochemicals may play a more important role for escaping competition and becoming dominant in the phytoplankton community. This study emphasizes that bloom forming dinoflagellates may use very different strategies to become dominant in a plankton community, entailing different trophic interactions leading to altered food web dynamics.

Poster-12 (10307)

Climate change: How does this influence on harmful algal blooms in the lagoon of the Baltic Sea?

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Lagoons are one of the most vulnerable to impacts of natural environmental factors. The Curonian and Vistula Lagoons are one of the largest lagoons of Europe and highly productive water bodies. The Curonian Lagoon is choking mostly freshwater, while the Vistula Lagoon is restricted brackish water. In the last decades the nutrients loading changes, warming trend and algae blooms were observed. Hydrological, chemical and biological researches were carried out monthly since 1991 to 2014. Multiple reductions of nutrients loading from the watershed area in 1990s did not result in considerable improvement of the ecological situation. Hydrological and chemical parameters are the main factors that influence on the algal blooms in these lagoons.

The Curonian Lagoon may be characterized as hypertrophic water body with “poor” water quality. Climate change in 1990s-2000s combined with other factors (freshwater, slow-flow exchange, high nutrients concentrations) creates conditions for Cyanobacteria “hyperblooms”. Harmful algal blooms in July-October result in deterioration of the water chemical parameters and death of fish. Algal toxins detected in water and biota and it may exceed safe level. “Hyperblooms” of Cyanobacteria is the most dangerous for coastal towns and tourist resorts (UNESCO National Park “Curonian Spit”).

Climate change in 1990s-2000s have been also observed in Vistula Lagoons (mean annual temperature increased by 1.4°C for 40 years), but brackish water prevent harmful algal hyperblooms. After the invasion of the filter-feeding mollusk *Rangia* water quality was significantly improved from “poor” to “satisfactory” level in 2011-2014, but productivity of the ecosystem remained at a long-term level.

Poster-13 (10308)

Effect of climate change and algal blooms on pH in the lagoon of the Baltic Sea

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Curonian and Vistula Lagoons are the largest lagoons of the Baltic Sea, where the monthly researches of the physical, chemical, biological parameters were carried out in 1981-1982 and 1991-2014. At present, averages for the water area pH change from 8.0-8.1 in autumn-winter to 9.2-9.5 in the spring-summer. In 1981-1982 average for the period April-October pH was 8.33-8.37. Climate change and more intensive warming-up of water in 1990-2000's created conditions for Cyanobacteria "hyperblooming", eutrophication and increased primary production. The highest averages for the area pH (9.13-9.55) occur in the Curonian Lagoon during harmful algal blooms, when chlorophyll amount to 208-904 mg/m^3 and primary production 9-16 gC·m^{-3}·d^{-1}. Owing to these processes, in the Curonian Lagoon average for June-September pH increased with 8.37 in 1981-1982 to 8.70 in 1991-1999, 8.73 in 2000-2005, 8.79 in 2006-2012. Maximum pH (8.82-8.93) was observed in 2006, 2011, when primary production was 578-624 gC·m^{-2}·year^{-1}. In the Vistula Lagoon, pH also increased from 8.38 in 1981-1982 to 8.61 in 1991-1999, 8.74 in 2000-2005 and 8.91 in 2006-2010. For the Baltic Sea in 2005-2006 average for the growing season surface pH was 8.07 that correspond to the average pH in the world's oceans. Thus, in lagoons the increase of algal blooms due to climatic changes can significantly increase of pH. Considerable water exchange between lagoon and sea can promote to maintain of stable state of the pH in coastal areas of Baltic Sea despite of global processes of ocean acidification.

Poster-14 (10311)

Are harmful cyanobacteria blooms increasing in frequency or intensity in Southern Portugal reservoirs?

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In the last few decades unusual cyanobacteria species were found in new environments and cyanobacteria bloom events (CyanoHAB) seem to have increased. Several authors blamed global climate change and aquatic ecosystem eutrophication for this biogeographic expansion and for growing CyanoHAB frequency. In freshwater systems, CyanoHAB occurrence and the presence of unexpected toxigenic cyanobacteria species create a complex problem to water resources management authorities, since ecological and human health impacts of cyanotoxins have been well documented worldwide and a link between CyanoHAB and higher probability of toxicity events was established. Southern Portugal reservoirs present privileged conditions, since the specificities of the Mediterranean torrential climate favor the development of many cyanobacteria species. High hydraulic residence, prolonged sun exposure, warm waters, droughts and floods alternating periods, with high nutrient loadings during floods, promote phytoplankton growth and increased turbidity favoring cyanobacteria dominance in these reservoirs. Despite claims of rising detection of CyanoHAB, multivariate analysis of phytoplankton monitoring data series for 30 major southern Portugal reservoirs did not allow any clear tendency to be established. Cyanobacteria dominate these reservoirs in terms of cell abundance, at least during the extended dry season, but rarely in terms of biomass, and extreme CyanoHAB events occur irregularly. Nevertheless, new toxigenic species (e.g. *Cylindrospermopsis raciborskii*), were growingly detected, increasing the health risks, since toxins produced by such species are not regularly screened. This well succeeded invasion calls for a better strategic approach to the CyanoHAB problem, involving water quality and public health authorities, as well as research institutes and scientists.

Poster-15 (10313)

Towards airborne imaging spectrometry of algae blooms in relation to micronutrient fluxes in Lake Victoria (Kenya) shore systems

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Nutrient enrichment as a result of anthropogenic activity concentrated along the land-lake margin is increasing eutrophication of near-shore waters across the globe. In spite of the role that such catchments serve in support of lakes food webs, hardly any studies have been conducted on heavy trace metal-mediated nutrient cycling in eutrophic lakes. Lake Victoria not only provides resources for the livelihoods of the basin (a major source of protein for over 30 million people), it is also a large and complex, dynamic repository for natural and anthropogenic hydrocyclic emissions from the catchment. Due to their environmental persistence and biogeochemical recycling, the immobilization and accumulation of heavy metals in Lake Victoria raises issues concerning the lake's water quality, algal phytoplankton dynamics, micronutrient cycling, the safety of biotic life, and the aquatic food chain as all organisms are included in a food web by trophic connections in the ecosystem. Cyanobacteria (blue-green algae), which are natural and cosmopolitan inhabitants of fresh waters, are particularly well adapted for growth in nutrient-enriched lakes. Although comparisons have been drawn between the geochemical cycling of metals in oceans and lakes, including the importance of cyanobacteria in controlling the metal levels, there is no coherent pattern with regard to metals in the lakes. The absence of correlations may reflect a lack of novel methods of data analysis, or low sensitivity of lakes to metal uptake by algae, blurring by other processes (e.g. redox cycling and scavenging by other particles), and the highly dynamic nature of lake systems. Despite the ubiquity of algal blooms in freshwater lakes, there is little information linking the chemical conditions in the environment with bloom dynamics. In view of the complexity of the interactions with environmental variables, powerful computational models are required to elucidate and predict underlying processes of algal blooms. Because airborne imaging spectrometry allows study of large areas of aquatic systems compared to the time consuming and expensive point sampling, this study will combine novel machine-learning techniques (for data mining, exploration and modeling (spatial, temporal)) with airborne imaging spectrometry and trace spectroanalysis to study algae speciation and blooms, and catchment-derived heavy metal fluxes in selected Lake Victoria (Kenya) shore systems. This will be done in order to quantify and understand the processes affecting water quality and micronutrient cycling.

Poster-16 (10314)

Spatial and temporal variability of *Noctiluca scintillans* in the highly stratified Sea of Marmara

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Noctiluca scintillans constitutes an important fraction of >200 µm fraction of net samples in the Sea of Marmara and occasionally causes dense blooms. Although many studies indicated that abundance patterns of *Noctiluca* are not associated with eutrophication, the present study points to contrary evidence with up to 10 fold higher abundance at more eutrophic or polluted regions, as inferred from high resolution spatial samplings. A 10-year long time series data showed an increase trend in *Noctiluca* abundance. The annual peak appear to follow the only phytoplankton increase in Marmara Sea occurring in December-February period, a unique characteristic of the highly stratified Marmara basin, while the secondary and less pronounced *Noctiluca* increase is observed in autumn. Cell diameters of *Noctiluca* also decreased following the diatom increase, indicating a population growth period. High and prolonged abundance of *Noctiluca* in 2004 is represented by abundance over 10^5 cells m^{-3} from January to the end of June, reaching 3.98×10^5 cells m^{-3} (May). Samplings from reported red-tides within the study period were usually wind advected patches and surface concentrations approached 1.31×10^6 cells l^{-1}. Although no adverse effect of *Noctiluca* on benthos or fish assemblages is detected in the Sea of Marmara, a significant succession with mesozooplankton is distinguished. The bottom-up and top-down control of *Noctiluca* over zooplankton might cause a reduction in fodder zooplankton biomass and decrease condition of ichthyoplankton, if the increase trend continues.

Poster-17 (10317)

Occurrence of toxic algal bloom of *Microcystis ichtyoblade* in Corumana Reservoir, Mozambique, Africa

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In recent years, cyanophyte species mainly the genus *Microcystis* appeared more frequently in the plankton of several lakes in Mozambique. During some periods of the year they produce water blooms that last for few weeks.

This communication reports a heavy algal bloom occurred in last years at Corumana Reservoir, South of Mozambique, Africa, where the lake surface was completely covered by masses of algae in a way never observed before.

Samples taken during the algal bloom revealed that the bloom was entirely composed by single cyanobacteria, identified as *Microcystis ichtyoblade*. Microcystins were analyzed and high concentrations were detected. Fisherman interviewed during the period of the heavy bloom, reported that in contact with lake water, they had skin problems but not other symptoms were reported. The lake water is used by people living in the nearest villages, not only for fish activities but also for drinking purposes, without any conventional water treatment. The high levels of microcystins observed raise concerns about the possible effects of the toxins on the health of the local people who are in their life time drinking water from this lake. These people have no knowledge regarding cyanobacteria and cyanotoxins and potential health consequences.

The result of the present study might be a contribution to the knowledge of the biogeography of toxic cyanobacteria in African countries, but also raise the need to extend the cyanobacterial education to elucidate the water managers and local people how to handle the situation when this kind of phenomenon occurs.

Poster-18 (10318)

Increase in massive blooms of the toxic dinoflagellate *Alexandrium tamarense* with warming in the eastern Bering Sea

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The eastern Bering Sea has a vast continental shelf and is mostly covered with seasonal ice during winter. Recently, a climate regime shift to warm period has been reported along with environmental and biological changes in the eastern Bering Sea shelf. The occurrences of the toxic dinoflagellate *Alexandrium tamarense* causing Paralytic Shellfish Poisoning have frequently been reported along the Gulf of Alaska to the south of Aleutian Islands, but are hardly known in the eastern Bering Sea shelf. Recently, high numbers of *A. tamarense* resting cysts were found in bottom sediments there, suggesting that *A. tamarense* blooms have occurred in the area. To evaluate relationships between climate regime shifts and *A. tamarense* blooms, we conducted inter-annual observations of *A. tamarene* densities and environmental conditions during the summers of 2004, 2005, 2006, 2009, 2012, and 2013. We observed a climate regime shift from a warm water period during 2004 and 2005 to a cold water period during 2009, 2012, and 2013, with significant differences of water temperature in surface and bottom layers between the warm water and the cold water period. The massive blooms of *A. tamarense* were found during the warm water period, with maximum cell density of 6.09×10^5 cells L^{-1}, and significantly low abundances of this species (< 500 cells cells L^{-1}) during the cold period. These results indicate that the scale of the toxic *A. tamarense* blooms will be larger with future predicted warming in the arctic and subarctic seasonal ice zones.

Poster-19 (10320)

Historical and recent biotoxin trends in Washington State: Analyzing closure days, frequency and duration

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The marine biotoxin program at the Washington State Department of Health (WDOH) has routinely collected and analyzed shellfish tissue samples for biotoxins across Washington waters since 1957. The goal of the program is to ensure that recreationally and commercially harvested molluscan shellfish is safe for human consumption. The WDOH has one of the largest sets of biotoxin data from shellfish tissue monitoring in the United States and analyzes over 3,000 shellfish samples each year. As of the end of 2014, the dataset contained over 100,000 entries with information on toxin levels for the three different biotoxins found in Washington State (Paralytic Shellfish Poison (PSP), Amnesic Shellfish Poison (ASP or domoic acid) and Diarrhetic Shellfish Poison (DSP)), various shellfish species, monitoring sites, waterbodies and collection dates. WDOH uses blue and California mussels as sentinel species to determine closures. Based on established regulatory limits, we determined historical closure dates, frequency and duration to look for site-specific and regional trends. Results show that mussel closures in several Local Health Jurisdictions (LHJ's) and waterbodies, PSP closures are occurring earlier in the year. In recent summers, multiple DSP and PSP closures occur simultaneously and extend closures. ASP closures primarily impact coastal LHJ's and have been observed in mussels and razor clams. In Puget Sound, manila clams exhibited the highest toxin level that is typically observed in mussels. This analysis provides a better understanding of historical closures and trends allowing WDOH to manage waterbodies more effectively and guide future shellfish monitoring efforts in a changing environment.

Poster-20 (10326)

The effects of several environmental and biological factors on the growth and forming of colonies of *Phaeocystis globose*

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Laboratory culturing method was used to study the the effects of varying temperature, salinity, diatom and vitamin on the growth and colony-forming of *Phaeocystis globosa* sampled from Bohai Sea of China. The results showed that temperature and salinity play an important role in controlling the growth of *P.globosa* solitary cells. The optimal temperature range for solitary cells is 15-30°C, solitary cells grew at highest specific growth rate under 20-25°C. The optimal salinity for *P.globosa* ranged from 30-35. The highest cell abundance was found at salinity of 30 under 20°C. When exposed to 15°C and 30°C, *P.globosa* grew at relative small growth rate, and the growth almost ceased when salinity decreased to 10 and 15, suggesting the ability to tolerate the extreme salinity decreased when exposed to extreme temperature. *Chaetoceros minimus* attachment to the colonies helped *P.globosa* to develop more colonies when diatom *C. minimus* and *P.globosa* co-cultured, but the size and solitary cell density of colonies were smaller than those in the independent culture of *P.globosa*. Vitamins have selective impacts on the growth and colony-forming of *Phaeocystis*. Vitamin B1 significantly enhanced the growth of solitary cells more than the forming of colonies. Vitamin B12 decreased the growth of solitary cell and inhabited the development of colonies. It suggested that *P.globosa* is vitamin auxotroph.

Poster-21 (10327)

Length of time series is crucial when evaluating the effect of Climate change on Phytoplankton communities

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The phytoplankton community is complex, often composed of many different species. Climate change is considered to be a rapid process but its effect on phytoplankton communities, and a possible promotion of harmful algal blooms, can still be difficult to evaluate due to the stochastic nature of the marine environment. Climate change may include e.g. changes in rainfall and/or wind patterns that might alter the nutrient availability in the system. Together with e.g. temperature changes in the water and ocean acidification these pressures might affect phytoplankton communities. There are multiple effect scenarios on phytoplankton communities from such climate change. The putative effects range from changes in species composition and the associated inter-relationship between species to blooms of specific species. These patterns and their effects on the phytoplankton diversity might be difficult to elucidate from short time series.

The length of the time series is therefore crucial when evaluating effects of climate change on the occurrence of phytoplankton species. The possibility that climate change leads to increased algal blooms and enhanced occurrence of toxic species is here evaluated. The Swedish national monitoring program includes over 25 years of phytoplankton data. This time series have here been evaluated to elucidate the effects of climate change on the phytoplankton community.

Poster-22 (10332)

Risk-monitoring, modelling and mitigation (M3-HABs) of benthic microalgal blooms across the Mediterranean regions

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The pan-Mediterranean project M3-HABs regarding monitoring of harmful algal blooms, with particular reference to the benthic dinoflagellate *Ostreopsis,* started in 2014 in the framework of the ENPI-CBCMED Programme. The specific objective of the project is to provide a common strategy for monitoring benthic toxic microalgae, through the development of new, more efficient and common procedures and protocols, making the process mostly cost and time effective, allowing for most efficient monitoring designs, increasing the knowledge on environmental drivers affecting *Ostreopsis* blooms and translate this into a forecasting tool, and improving the general awareness of the risks related to *Ostreopsis*. The following results are expected: a larger awareness of the risks associated with the *Ostreopsis* blooms, an appropriate diffusion of cautionary measures set up, the production of common monitoring protocols, the development of new technologies for species-specific identification and counting and the build-up of prediction models in order to prevent and reduce risk factors for the environment, human health and economic activities. The project will improve the establishment of solid networks along Mediterranean coasts to cope with *Ostreopsis* emergencies, providing the target groups common and intercalibrated protocols, in order to have comparable samplings in space and time through the Mediterranean Sea.

Poster-23 (10333)

Studies on the characteristics of morphology and distribution of Dinoflagellate cysts in China

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Spatial distribution of species and abundance of Dinoflagellate cysts in China Sea was studied in present paper, on the basis of surveys of surface sediments from 28 main bay in Bohai Sea, Yellow Sea, East Sea and South China Sea, as well as publicated papers. Analysis of similarity coefficients among communities of Dinoflagellate cysts from 9 representative sea area displayed that the tested community were no more than median similarity level, showing obvious variation of the community constitution among above sea area, which suggested that the relationship of the tested community of cysts were far. The number of species and abundance of Dinoflagellate cysts were low in Bohai Sea, with high number of species and low abundance in East Sea. While cyst exhibited high number of species and abundance in parts of Yellow Sea and South China Sea, suggesting that there were risk of outbreak of red tide of Dinoflagellate in these sea area. Interpretation were conducted on the spatial distribution of 40 common or representative species, which were favor to further researches on the monitor of shell toxin and red tide.

Poster-24 (10334)

Study on response of changes of phytoplankton composition and climate in Qingduizi Bay Chinese northern Yellow Sea

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We collected the ecological data surveyed in October 1987 for Qingduizi Bay. For phytoplankton, 79 species of diatom and dinoflagellate were identified, of which diatom included 70 species, and dinoflagellate included 9 species. Dinoflagellate species accounted for 11% of the total species. The total biomass of phytoplankton was 2.0×10^7 cell/m^3, and the ratio of N/P was 12.66:1. The average air temperature in October was 11.3°C from 1978 to 1987, whereas the mean sea surface temperature was 15.3°C from 1973 to 1982. In October 2012, the phytoplankton ecological survey for Qingduizi Bay identified 25 species. They included 21 diatom species, and 4 dinoflagellate species. Dinoflagellate species accounted for 16% of the total species. The total biomass of phytoplankton was 7.0×10^7 cell/m^3, and the ratio of N/P was 29.48:1. The mean air temperature of October was 12.1°C and the average sea surface temperature 18.2°C by using remote sensing method from 2003 to 2012. This survey identified a new record species-*Leptocylindrus minimus*. It first appeared in Qingduizi Bay, and became the dominant species. The dominance index was 76.9%. Its abundance varied between 0.06~39.94×10^7cell/m^3, with an average of 5.8×10^7cell/m^3. From 1987 to 2012, the composition of phytoplankton community in Qingduizi Bay has changed. The proportion of dinoflagellate species in the total number rose nearly 5%. These changes might be related to N/P rising from 12.66:1 to 29.48:1, and mean air temperature in October increasing by 0.8°C between 1978-1987 and 2003-2012, and mean sea surface temperature in October rising by 2.9°C between 2003-2012 and 1973-1982.

Poster-25 (10286)

A 100-year record of changing toxic algae in Scottish coastal waters relating to climate change

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HAB-forming dinoflagellates have been affected by climate change. Some species within the *Alexandrium tamarense* species complex are potent producers of PSP toxins worldwide, including Scottish waters. Routine monitoring of PSP toxins in shellfish around Scotland began in 1991, and since then there have been closures of shellfish sites almost every year. Currently, the Scottish Government is promoting the expansion of the shellfish industry to nearly double its size by 2020, but there is no mechanism to assess the vulnerability of new sites to the impacts of HABs or climate change.

Regional sea surface temperature analyses from 1880 to the present show that temperatures are increasing. However, datasets showing changes in HAB frequency and toxicity cover a much shorter time frame: along Scottish coasts, monitoring for PSP toxins started in 1991 and of *Alexandrium spp.* in 1996. To address this shortfall in data, this new project will examine dinoflagellate cyst numbers in the sediment record to show changes in species composition over time to compare with changes in climate.

Dinoflagellate cysts will also be extracted from the sediment and tested for their long-term viability. If large-scale viability is proven, cyst accumulations in certain depositional environments could be acting as seeds beds for blooms. By mapping the seed beds, it would be possible to evaluate the potential risks associated with HABs and climate change, to then inform the aquaculture industry on future siting of activities.

Poster-26 (10337)

Ostreopsis cf. *ovata* growth and toxicity in a warmer Mediterranean Sea

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The abundance of *Ostreopsis* cf. *ovata* growing on macrophytes and its toxicity was monitored during 3 years at 8 sampling sites in the southern Catalonian coast (Northwestern Mediterranean). Several strains were isolated, established in cultures, and the effect of temperature on growth and toxicity was tested. Results of multifactorial experiments conducted in cultures show that within the range of temperatures tested (19, 24, and 28ºC) growth was inhibited at 19ºC, the highest growth rates were obtained at 24ºC, and toxicity was significantly higher at 28ºC. Results on the field observations are similar to those found in cultures; average temperature during *O*. cf. *ovata* blooms was 24.48ºC. Field studies showed water temperature was the most important parameter defining the *O*. cf. *ovata* seasonal pattern and restricting the ecological niche, but within the range of temperatures where growth occurred, *O*. cf. ovata abundance did not show correlation with water temperature. A rising of sea surface temperature is currently being observed in the Mediterranean Sea; therefore the window of time for the blooming period of *O*. cf. ovata may possibly be enlarged.

Poster-27

Characterizing the surface accumulations of cyanobacteria in the Baltic Sea using remote sensing and in situ data during the period 2002-2014

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Satellite ocean color data (MODIS) have been used in order to detect surface accumulations of cyanobacteria in the Baltic Sea using an automatic classification algorithm. Spatial variations of these, sometimes toxic phytoplankton, have been mapped and calculations of duration, extent and intensity are compared to cloud cover and nutrient concentrations in the Baltic Proper. Variations were large during the study period of 2002-2014 with total area affected by surface accumulations of cyanobacteria ranging from 122,000 km^2 in 2004 to 222,000 km^2 in 2008. Regional investigation showed that although blooms were detected every year in all regions of the Baltic Sea (excluding the Bothnian Bay) regular cyanobacteria occurrence were found in the Northern Baltic Proper whilst less regular in Bothnian Sea and Arkona Basin. As an attempt to describe the annual cyanobacterial bloom with low cloud cover influence, 7-day composite maps were used to describe weak-, well- and strong-establishment of cyanobacteria presence. The cyanobacterial bloom in the Baltic Sea during the period of investigation showed recurring establishments of at least well established blooms with a peak average per date establishment on the 14th of July. Comparisons between remotely sensed data and in situ data of chlorophyll a and cyanobacteria biomass were used to develop a new summer chlorophyll a algorithm (RBA). The RBA-algorithm were then used to describe the average daily blooming intensity of cyanobacteria of which the bloom of 2005 showed much higher average daily intensities.

Poster-28

Defining emerging patterns of Harmful Algal Bloom biogeography and biodiversity associated with global regime shifts in Arctic coastal systems

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Global change mediated by sea temperature rise, enhanced ice melting and other anthropogenic influences is predicted to have a profound influence on Arctic coastal regions. Differential effects on biogeography and diversity of HABs and their associated toxins were addressed during an oceanographic expedition (ARCHEMHAB) to west Greenland with transects across the Irminger Sea to fjord systems in northwestern Iceland. In west Greenland, longshore sampling was accompanied by fjord transects to the edge of the glacier ice shelf. Field observations included physical oceanographic parameters (CTD) and bio-optical profiles, vertical net tows and Niskin bottle sampling (plankton, nutrients, pigments, DOM), and benthic sediment grabs for dinoflagellate cysts (*Alexandrium* spp.) and bivalve molluscs. We found numerous HAB taxa (*Alexandrium, Azadinium/Amphidoma*, *Dinophysis*, *Protoceratium reticulatum*, *Pseudo-nitzschia* spp.) and associated toxins, primarily gonyautoxins, spirolides C and des-methyl C, and domoic acid, with only trace levels of dinophysistoxins, pectenotoxins and yessotoxin, in the plankton from the water column. Community analysis of plankton size fractions by DNA bar-coding based upon sequencing the LSU rDNA D1/D2 region revealed comparative patterns of diversity for Disko Bay (Greenland) versus stations in an Icelandic fjord. The high species diversity in the microplankton fraction on the Greenland coast showed a strikingly high representation of cryptic dinoflagellate taxa. Although definitive linkages to HAB-relevant regime shifts could not be defined at this stage, multi-faceted comparative ecosystem studies provide the basis for developing future scenarios and modelling global change processes of HAB distribution in Arctic waters.

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Breakout Discussions

Tuesday - Breakout Session 1

1a. Physical effects on HAB — Stratification due to increased temperature and runoff

1b. Physical effects on HAB — Temperature (e.g. physiology, range extension), salinity, light, etc.

1c. Grazing effects on HAB

Wednesday - Breakout Session 2

2a. Carbon dioxide effects on HAB

2b. Cyanobacterial HABs

2c. HAB effects on fisheries and aquaculture

Thursday - Breakout Session 3

3a. Nutrient effects on HAB

3b. HAB modelling challenges

3c. Benthic HABs

Friday - Breakout Session 4

4a. Best practices manual content

4b. Future observation systems