University of Hamburg
Department of Biology

ZENTRUM FÜR MEERES-
UND KLIMAFORSCHUNG

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To whom it may concern,

Nov 12 2005

Please find enclosed our application for 42 days ship time with the R.V. Meteor in the spring of 2012. The proposed cruise will constitute a novel and much needed multidisciplinary cruise examining the dynamics of deep winter convection and its subsequent decay on the dynamics of the biological carbon pump as well as the population dynamics of key ecosystem and biogeochemical players in the North Atlantic. This cruise has goals which are clearly linked to the International IMBER (Integrated Marine Biogeochemistry and Ecosystem Research) science plan that being to assess potential links and feedbacks between ocean biogeochemistry, marine ecosystems and climate. Furthermore this cruise will contribute to the BASIN (Basin-scale Analysis, Synthesis, and Integration) International Science Program a multi national program involving the EU, USA and Canada. It is anticipated that funds for support of this cruise will be made available from a proposal co-ordinated by myself answering the January 5th 2010 call for proposals by DG environment
ENV.2010.2.2.1-1 North Atlantic Ocean and associated shelf-seas protection and management options

The call text is as follows.
There is a need to improve the understanding of the variability, potential impacts, and feedbacks of global change and anthropogenic forcing on the structure, function and dynamics of the ecosystems of the North Atlantic Ocean and associated shelf seas and on their capacity to provide services.

The project should provide new data, analyses and the models necessary to:
(1) understand and simulate the population structure and dynamics of broadly distributed, and biogeochemically and trophically important plankton and fish species; to resolve the impacts of climate variability on marine ecosystems and the feedbacks to the earth system;

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(2) develop understanding and strategies that will contribute to improve and advance ocean management (ecosystem approach). The project should develop methods to consolidate and integrate long term observations from EU and international databases for modelling and prediction of the Atlantic Ocean ecosystem and related services

This work will be achieved in close collaboration with similar initiatives in the US and Canada. The coordination and complementarities of these EU and US/Canada initiatives must be described in the proposal. This will be considered in the evaluation. The participation of scientific institutions from US and Canada is welcomed.

Funding scheme: Collaborative Project (large scale integrating project)

Expected impacts:
It is expected to reinforce the knowledge base of the impact of global changes on the North Atlantic marine ecosystems and its regions, in particular, in the European perspective, the North Atlantic marine region, and thereby contribute to a better ocean management. Given the scale of influence of global change and the added value of co-coordinating the scientific activities of the EU and North American the project is expected to reinforce cooperation and coordination of research programmes between the two sides of the Atlantic. The project should also contribute to informing policy makers at national, EU and global level.

Budget: 7 Million Euros
Deadline for Submission: January 5th 2010

Thank you for your consideration

Sincerely

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Antrag für Schiffszeit auf FS Meteor, Merian und den Mittelgroßen FS

1. Antragsteller, Adresse

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2. Wissenschaftliches **Thema der Reise**

Physical controls on the dynamics of phytoplankton biomass, carbon flux and trophic interactions in the North Atlantic during the transition from regimes of winter convection to spring stratification.

3. Projekt; Internationale Partner

EU BASIN in collaboration of MEECE and IMBER

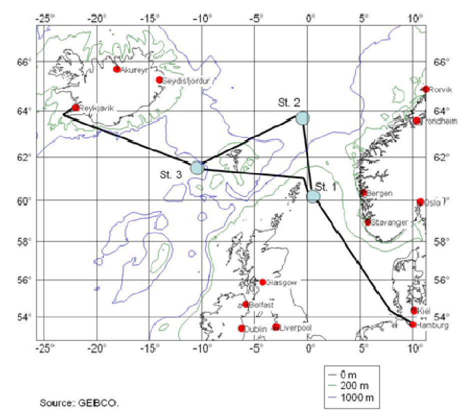
4. Kennwort

BASIN-Cruise I

5. Arbeitsgebiet und betroffene Küstenstaaten

Northern North Atlantic,
3 Stations: East of Shetlands,
Northeast of Faroer and
West of Faroer

Norway,
Great Britain, Denmark (Faroer)



6. Arbeitstage (inkl. Transfer zwischen Arbeitsgebieten)	42
7. Transfertage; Anreise zum (ersten) Arbeitsgebiet	2 1/2
8. Transfertage; Abreise vom (letzten) Arbeitsgebiet	2
9. Bevorzugter **Starthafen**	Hamburg
10. Bevorzugter **Zielhafen**	Reykjavik
11. Zeitraum	Spring 2012
12. Bordplätze	28
13. Großgeräte	ROV, VPR, 1m² Double-MOCNESS, different plankton nets, CTD with rosette, Stand-alone-pumping-systems, ADCP, sediment traps, drifters
14. Anmerkungen	Due to the goals of this study, the transition from winter convection to spring bloom is the necessary time frame for the proposed cruise, e.g., late February until early April.
15. Bevorzugtes Schiff	FS Meteor, Merian

1. General information
Application for ship time for the research vessel Meteor

1.1 Applicant

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Professor
01.01.1953, Canadian
DFG proposals: GO 556/1-1; GO 556/1-2; PE 1157/2-3
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1.2 Title
Physical controls on the dynamics of phytoplankton biomass, carbon flux and trophic interactions in the North Atlantic during the transition from regimes of winter convection to spring stratification.

1.3 Key word
BASIN-CRUISE 1

1.4 Specific field
Biological Oceanography; Physical Oceanography, Biogeochemistry, Marine Ecology (in the frame of the EU project BASIN)

1.5 Period and ship, large equipment

42 days in spring 2012, late February until early April

FS METEOR: Twenty-eight berths are needed for the participating scientists.
A Dynamic Positioning System and a Posidonia System is needed for the deployment of the ROV Mohawk. The R.V. fulfils these requirements.

Large equipment: ROV Mohawk (own winch), Video Plankton Recorder (own winch), 1m^2 Double-MOCNESS, different plankton nets, CTD with rosette, Stand-alone-pumping-systems, ADCP, sediment traps, drifters
Winches and Cables: Coax 11 mm, 4000 m; Coax 18 mm, 4000 m

1.6 Main user or secondary user
The applicant is main user of the ship.

1.7 German and English summary

Recent studies suggest that winter convection contributes to a high biomass of phytoplankton over the deep convective layer (regime one), which is in contradiction to the classical spring bloom critical depth model of phytoplankton bloom dynamics (regime two). In order to investigate the implications of these two regimes for biogeochemical fluxes and ecosystem dynamics we will assess the mechanisms influencing phytoplankton production and biomass, resolve the fate of biomass maintained during the winter convective period (i.e. flux to depth) and examine its impact on the diapause state of *Calanus finmarchicus,* a key secondary producer in this system.Upon the onset of stratification the system shifts to a classical spring bloom system dominated by large phytoplankton cells, contributing to the production of higher trophic levels, and to a second flux of carbon to the deep ocean, which is potentially mediated by higher trophic levels. In order to assess the magnitude of these fluxes throughout the course of evolution of these two regimes, the proposed multinational, interdisciplinary cruise will use state-of-the-art techniques to measure biogeochemical fluxes, and ecosystem structure and functioning. This cruise is a component of the EU contribution to the International BASIN (Basin-scale Analysis, Synthesis, and Integration) program.

Neuste Studien lassen vermuten, dass die Winterkonvektion dazu beiträgt, dass große Biomassen von Phytoplankton innerhalb der tiefen Konvektionsschicht gebildet werden (Regime 1). Diese Vermutungen stehen im Kontrast zu dem klassischen „Critical Depth Model" (Regime 2). Um die Auswirkung dieser beiden Regime auf den biogeochemischen Stofffluss und die Ökosystemdynamik zu erforschen, werden wir die Mechanismen, die Phytoplanktonproduktion und –biomasse beeinflussen, aufklären, das Schicksal des organischen Materials (z.B. Absinken) während der Winterkonvektion auflösen und die Auswirkung auf die Diapause eines der wichtigsten Sekundärproduzenten (*Calanus finmarchicus*) untersuchen.. Mit dem Einsetzten der Schichtung entsteht ein klassisches Frühjahrsblütensystem mit großen Diatomeen, das zu einer hohen Produktivität der höheren trophischen Ebenen führt und dadurch einen Kohlenstofffluss in große Tiefen generiert. Um die Größenordnung dieser Stoffflüsse während der Entwicklung der beiden Systeme zu erfassen, wird diese multinationale und interdisziplinäre Seereise die neusten Techniken anwenden, um biogeochemische Flüsse, Ökosystemstrukturen und -funktionen aufzulösen. Diese Seereise ist ein wichtiger EU-Beitrag zum Internationalen BASIN Programm.

2. State-of-the-art of science, own preparatory investigations
2.1 State-of-the-art of science

In the sub-polar gyre in the northern North Atlantic sub-polar mode water is produced by oceanic convection every winter (McCartney and Talley 1982; van Aken and Becker 1997). Mode water masses ventilate intermediate waters in sub-tropical and tropical ocean regions. In the Nordic Seas, i.e. in the polar gyre, convection contributes to the production of overflow waters which ventilate large parts of the World Ocean (Broecker 1991). The maximum extent of vertical penetration of convection during a winter sets the depth of the perennial thermocline. The depth of the convectively mixed layer (CML) in winter may undergo substantial inter-annual and longer term changes (Dickson et al. 1996). Reported extremes of convective penetration are in excess of 2000m in Labrador and Greenland Sea with typical depths in the North Atlantic rather being in the order of some hundred meters (Marshall and Schott 1999). Convection erodes and finally destroys the seasonal thermocline in autumn. During the course of a winter the convection depth at first increases then it decreases to finally form a transition to the seasonal thermocline in spring as depicted in a cartoon (Figure 1) which shows the temporal evolution of the CML including transitions to and from the seasonal thermocline.

The oceanic heat-losses which drive convection in both autumn and spring show a pronounced diurnal variability, i.e. a daytime heating and a cooling at night while in winter the cooling generally prevails during the course of a day. The atmospheric forcing which drives convection in the ocean is highly variable which in particular applies to the turbulent (i.e. latent and sensible) heat-fluxes because their magnitude is directly proportional to the wind speed. The atmospheric cooling induces instability at the surface which causes surface waters to sink. While sinking these waters displace other waters which, for reasons of continuity, must rise. Therefore, convective motions can be visualised as orbital cells (Turner 1973; Backhaus et al. 1999, 2001). The vertical orbits, in dependence on the forcing, may cover the entire convection layer. The distance separating down- and upward motions depends on the depth of convective penetration. The aspect ratio of convection i.e. horizontal versus vertical scale is about 2.5:1 according to modelling and laboratory experiments (Turner 1973). Extremes of downward motions in narrow funnels in convective plumes are in the order of 10 cm/s (Marshall and Schott 1999; Backhaus 1995; Backhaus and Kämpf 1999). Typical upward velocities are weaker, i.e. a few centimetres per second, and they cover a larger horizontal extent (Backhaus et al. 2001).

As a consequence of the diurnal character of the forcing in spring and autumn where heat-fluxes particularly depend on storm activity (i.e. via latent and sensible heat-fluxes) the lower bound of the CML might be more diffuse, i.e. more convoluted, than in winter when surface cooling prevails. This is indicated in the cartoon in Figure 1 by a convoluted depth of the convection layer. The hydrostatic pressure in the ocean varies linearly with depth. Oceanic convection, however, causes local deviations from hydrostatic pressure. The descending penetrative plumes of convection induce non-hydrostatic pressure fluctuations within and beneath the CML which vary with depth in a non-linear way (Backhaus and Kämpf 1999, Wehde and Backhaus 2000).

A vertical velocity of convection of 1 cm/s equals 864 m/day. This speed exceeds any known eigen-motion, be it sinking or swimming rates, of both zoo- and phytoplankton. It therefore can be assumed that convection must have a strong influence on motions of plankton (Backhaus et al. 2003). However, the convective vertical transport with regards to plankton so far has largely ignored.

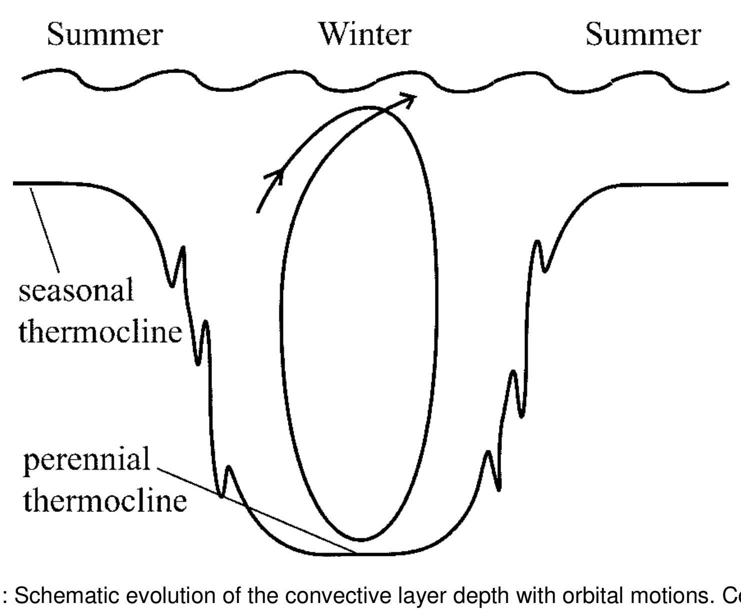
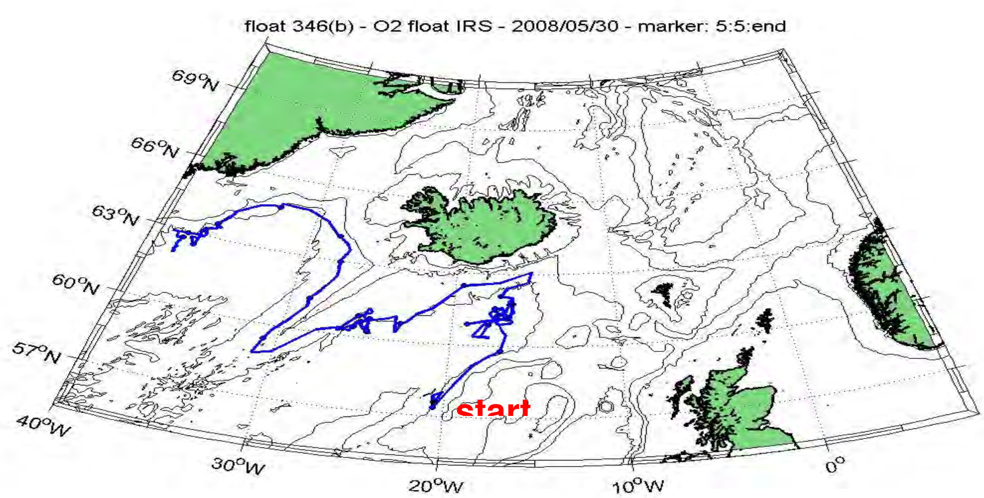


Figure 1: Schematic evolution of the convective layer depth with orbital motions. Convoluted depths in autumn and spring indicate intermittence in penetration of convection due to variations in forcing. Note: depths of seasonal and perennial thermocline are not drawn to scale.

Convection Phytoplankton and Flux

Observations in winter in the North Atlantic from the past ten years have shown the existence of a pool of phytoplankton that resides in the deep well-mixed convection layer in winter (Backhaus et al. 1999, Backhaus et al. 2003, Niehoff et al. 1999, Quadfasel pers. Com. 2008). This convection layer in the North Atlantic during winter may cover several hundred meters depending upon the characteristics of the basin and hydrography. Observations from 1999 (Backhaus et al. 2003) showed that not only water mass properties but also phytoplankton was evenly distributed over the convection layer as exemplified by a profile from the Icelandic Sea where convection had penetrated to a depth of ca. 800m. This indicates that convective mixing and transport process influences the distribution and dynamics of plankton residing in the convection layer. Typically observations of winter phytoplankton biomass, rarely examine depths below 200m. These 200 m integrated observations give estimates of phytoplankton biomass of about one order of magnitude lower than those observed at the shallow summer seasonal thermocline which has depths of only a few tens of meters. However, as convective mixing can occur to significantly greater depths (e.g. 800 meters) with phytoplankton concentrations homogeneous over the depth of convective mixing estimates of phytoplankton biomass can be significantly under estimated. An observation which is supported by Körtzinger et al (2007) who state that the onset of shallow stratification, up to one third of the mixed layer net community production during the productive season had already been accomplished. Time series of depth profiles of Chlorophyll-a obtained with an ARGO-drifter in the northern North Atlantic show that the winter pool provides the inoculum for the spring bloom in shallow convective systems of the North Atlantic while regions with deep convection in excess of 2000 m e.g. the Labrador Sea where spring phytoplankton blooms are fuelled by advection of phytoplankton cells from coastal regions (Head Pers. Comm.; Körtzinger Pers. Comm. A candidate for this production, which clearly is not a result of the spring bloom production is the phytoplankton biomass resident in the convective cells. This phytoplankton biomass in winter has largely neglected, presumably due to the low concentrations of plankton and our lack of observations both to these depths as well as due to a paucity of dedicated observational programs.

The question as to how this winter stock in a deep layer can be maintained and how plankton can reside in darkness several hundred meters beneath the euphotic layer lies in the nature of convective orbits. They not only disperse plankton evenly over the convection layer but, more importantly, allow for frequent visits to the euphotic layer for all plankton from within the layer. The intermittent supply of low PAR, apparently, suffices in supporting a production which maintains the phytoplankton stock in winter.



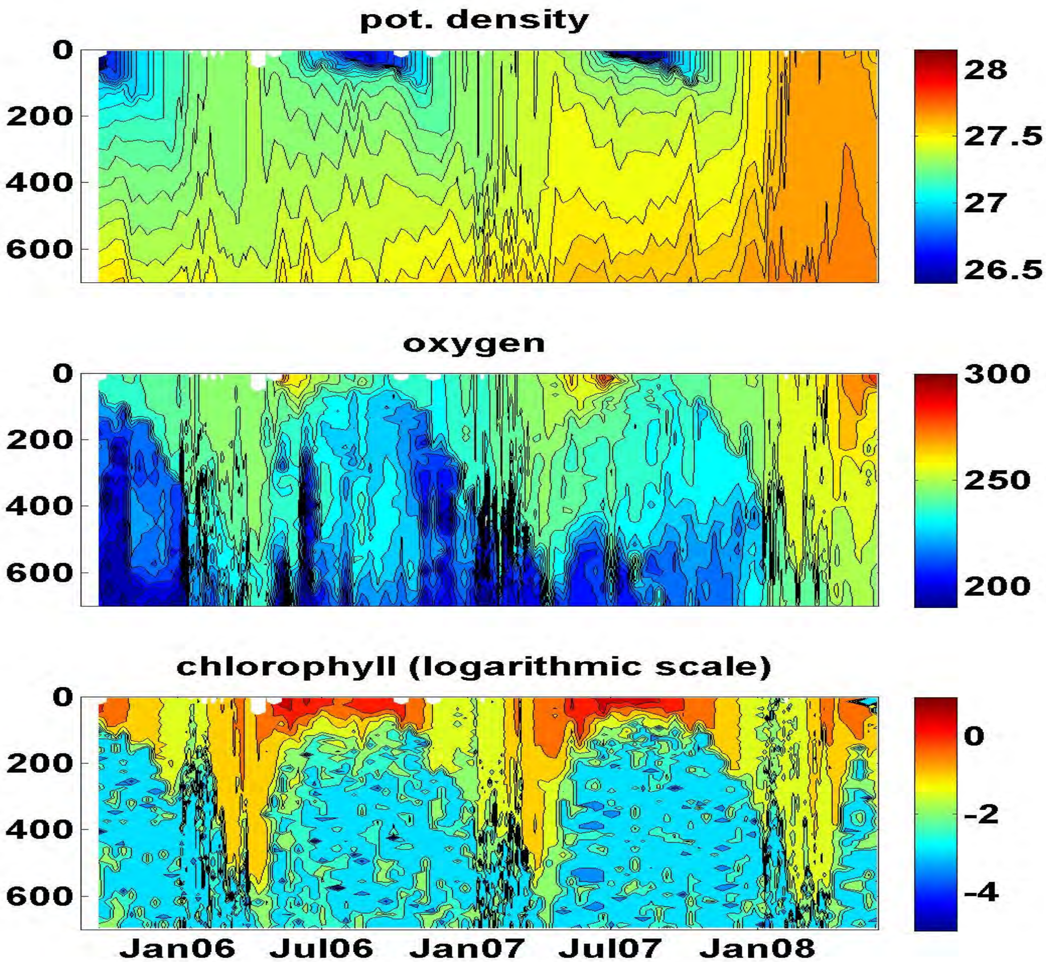


Figure 2: upper panel: Drift route of floats Quadfasel u. Latarius, pers. Komm. 2008) Lower panel: Hovmüller-Diagramm of potential density, oxygen and chlorophyll, measured with help of ARGO-Float.

With respect to the flux of carbon to the deep layer, in spring the cooling that drives convection decreases, as a result the penetration depth of convection shallows. The retreat of convection towards the surface results in the sinking of phytoplankton biomass from below the surface convective layer while within the surface layer the increasing PAR triggers the spring bloom following the classical critical depth model (e.g. Siegel et al., 2002). Indeed, increasing concentrations in a surface layer in spring are seen in the data of the ARGO-drifter (Quadfasel Pers. Comm. See figure 2). Critically, sedimentation of cells now isolated below the convective layer contribute to export production, the magnitude of which is largely unknown, as is the role of the winter plankton pool in the carbon budged of the ocean. Observations from sediment traps suggest that a peak in flux prior to that resulting from the spring bloom is often found (Richard Lampett Pers. Comm.) implicating deep convection as a mechanism influencing this flux.
With respect particle flux, the attenuation with depth is dependent on particle size (sinking rate) and quantity, and is mainly caused by bacterial remineralisation and zooplankton consumption of sinking material (Buesseler et al. 2007). These two processes have recently been estimated to be equally important in reducing the vertical flux (Steinberg et al. 2008). At present, we know that bacterial remineralisation of the flux tends to be somewhere around 10 % d^{-1} (Ploug et al. 2008). In contrast, our knowledge of the effect of zooplankton on vertical flux is very limited, although model

simulations suggest that small changes in zooplankton's activity can have a huge impact for the net downward carbon flux (Buesseler & Boyd 2009).
Small abundant copepods from genus *Microsetella* and *Oncaea* are typically found associated with sinking aggregated particles (Green & Dagg 1997), and can feed on the aggregated material, potentially at high rates (Alldredge 1972, Kiørboe 2000, Koski et al. 2005, Steinberg et al. 2008). However, at present, we neither know what governs their consumption of aggregates; nor have an idea of their proportional importance to the flux attenuation under different environmental conditions. Clearly knowledge is lacking with respect to the importance of winter convection and trophic controls on flux are essential for our understanding of seasonal and geographic changes in the efficiency of the biological pump.

Convective Controls on Zooplankton

The dominant copepod species in the North Atlantic is *Calanus finmarchicus.* This key species is linked to the production of higher trophic levels and potentially via coprophagy and or coprorhexy, vertical migration and fecal pellet flux thereby influencing the dynamics of carbon flux to deep ocean. The life history of the species involves four main phases: Overwintering at depth during winter; ascendance in late winter and spring; mating at depth and reproduction near the surface during a short growing season during spring and summer, and a return to overwintering depths during late summer and autumn (Hirche, 1996, Heath et al. 2004). There are a few winter observations of phytoplankton and *C. finmarchicus* in the North Atlantic and those that do exist provide little evidence regarding the diapause depth of *C. finmarchicus* relative to the convection layer. Convection depths in the North Atlantic vary across the basin reaching depths of more than thousand meters. Diapause beneath the convection layer would be more quiescent, and diapausing individuals would avoid contacts with predators in the surface layer as well as maintaining conditions suitable for diapause. In contrast hibernation within the convective layer would imply frequent visits to the surface within orbital motions and thus a high probability for contacts with predators as well as influencing exposure to light and density changes which could trigger emergence from diapause (e.g. Irigoien 2004). The limited information available suggests that *C. finmarchicus* is rarely found in the convection layer in winter, an exception being the Labrador Sea (Erica Head, pers. Com. 2006) where convection penetrates close to the seabed. In the Norwegian Sea, the convection layer has depths ranging between 300 and 600 m with *C. finmarchicus* diapause at depths well below 600m (Mike Heath pers. Com, 2005). Prior to the spring bloom, adult *C. finmarchicus* has been observed in surface waters (Niehoff et al. 1999) however no information on the status of deep convection was presented in this study.
The trigger for exit from diapause is as yet unresolved with a number of hypotheses under examination (for a review see Irigoien 2004). Interestingly, the shrinking convection layer in spring produces a 'rain' of recently produced viable phytoplankton cells that is left behind as explained above. Diapausing *C. finmarchicus*, will experience this phytoplankton rain which may act as a trigger to exit diapause and begin the ascent to the surface (e.g. Thorisson 2006; Krylov et al., 1996). This could explain the occurrence of adult C. *finmarchicus* at the surface prior to the spring bloom *(e.g.* Niehoff et al. 1999 and references there in*).* Whatever initiates the ascent in spring both phyto- and zooplankton reside in the convection layer prior to the spring bloom (Niehoff et al. 1999). Being separated during winter both are re-joined in the shrinking convection layer which finally transitions to the seasonal thermocline.

Trophic Interactions

To understand a plankton community and to predict its productivity requires estimation of vital rates, key process and interactions within the community. Planktonic species composition and food web links vary both spatially and temporally hence any approach to characterize interactions needs to average across these scales to smooth details and variations forming functional groups (see Zhou 2006). The questions to judge a valid approach are (i) will the averaging preserve biomass conservation and characteristics of the community structure and (ii) can those averaged variables be observed effectively in situ?
The stable isotope ratios of carbon ($\delta^{13}C$) and nitrogen ($\delta^{15}N$) provide a time-integrated measure of trophic position and have the potential to track energy or mass flows through food webs (Hobson

and Welch, 1992; Hobson et al., 1995; Post, 2002, Koppelmann et al., 2009). The istopes are differently enriched over trophic levels, with enrichment factors of 0.6-1 ‰ and 3-4 ‰ for $\delta^{13}C$ and $\delta^{15}N$, respectively. These characteristics make $\delta^{13}C$ suitable for identification of carbons sources, provided that possible carbon sources have different $\delta^{13}C$ signatures, while $\delta^{15}N$ is used to estimate trophic levels (Post, 2002). A consumer is typically enriched in ^{15}N by 3–4º/oo, relative to its diet (DeNiro and Epstein, 1981; Minagawa and Wada, 1984; Peterson and Fry, 1987; Hobson and Welch, 1992), whereas ^{13}C undergoes relatively little fractionation (<1‰) with trophic level. The $\delta^{13}C$ values can therefore provide information on an organism's major carbon sources, provided that the available carbon sources have distinct $\delta^{13}C$ signatures (Post, 2002). The weak point in this approach is the variability in trophic history of carbon at the entry point in the base of the food web. A new complementary approach (Hannides et al 2000), called Compound-specific isotope analysis (CSIA) quantifies the AA ^{15}N enrichment patterns in copepod species. This approach does not require separate analysis of prey (i.e. algae, protists) isotopic composition. Combining phytoplankton group specific fatty acid markers (St. John and Lund 1996; Dalsgaard et al. 2003) with isotopic tracers allow not only the resolution of trophic level as outlined above but allows the determination of the phytoplankton group contributing to higher trophic level production. Combining these two biomarker approaches provides as powerful tool for assessing the structure and linkages in marine ecosystems (e.g. Dalsgaard et al. 2003)

Significant progresses have been made in understanding dominant species, life histories and behavior, and in using size structured data to identify dominant species in a certain size range. Using Scanfish–CTD–OPC/LOPC data, the analysis of zooplankton community size structures, compositions and their relationships with water types has provided new insight in the population and trophic dynamics of high latitude food webs (Zhou et al in press). It has been demonstrated that biomass spectra can be used as indicators of community biomass, productivity, trophic levels and seasonal shifting of a plankton community. Following this approach, a steeper slope of the biomass spectrum for a community dominated by herbivorous species and a flatter slope for a community dominated by carnivorous–omnivorous species (Zhou 2006) occurs. In a recent study Zhou et al (in press) revealed that significant differences in biomass spectra were consistent with observed water types and current systems, even in closely associated locations such as shelf and off-shelf waters in North Norway. Characteristics of biomass spectra from a given habitat can be tracked even after being mixed with others.

The advances of biomass spectrum observations and theories have been leading to (i) efficient in situ methods to measure biomass spectra and their spatiotemporal distributions (Herman, 1988; Huntley et al., 1995; Quinones et al., 2003; Herman et al., 2004; Zhou et al., 2008), (ii) in situ process rate estimates (Edvardsen et al., 2002; Zhou and Huntley, 1997; Zhou, 2006) and (iii) community trophic structure index developed by Zhou (2006). The application of this approach for the assessment of particle flux has to date not been attempted but may however provide a powerful tool to assess the dynamics of the biological pump.

Several parameters influence the survival of species, these being loosely termed as bottom up controls primarily linking production of lower trophic levels to the physically driven access to limiting abiotic agents such as nutrients and light as well as top down controls on a population via predation. *Calanus finmarchicus* represents a key trophic player in the North Atlantic but in spite of this, only very few studies have sought to identify the main predators during the overwintering period in oceanic waters and how they are affecting the mortality rates and population dynamics of this key species. (Anderson et al. 2005, Gislason et al. 2007).

2.2 Own preparatory investigations

Professor St. John has acted as a cruise leader in over 40 cruises performed in the North East Pacific; Strait of Georgia; Baltic Sea; North Sea; North Atlantic. All of these cruises have been multidisciplinary in nature typically focused on the effects of meso-scale processes such as fronts, jets and eddies on the distribution and production of phytoplankton, zooplankton and fish. He has acted as the co-ordinator of a large EU project in this regard (LIFECO see CV) in which the seasonal dynamics of the North Sea ecosystem as influenced by H/U3 tidal mixing was assessed.

His previous research includes ecosystem modelling, development of vital rate parameterizations for zooplankton and larval fish as well as the application of trophic biomarkers to track the flow of phytoplankton biomass through marine ecosystems. For further details see the attached CV.

Professor Backhaus has covered on two cruises in February and March 1999 on board of the RV VALDIVIA (cruise leader: Jan Backhaus) a meridional transect running from southern Icelandic Sea up to the central Greenland Sea (Backhaus et al. 2000). Purpose of the cruise was to explore a hypothesized relationship between convection depth and abundance of phytoplankton. The cruise was initiated by modeling work on the Barents Sea where diatoms resting in a layer at the seabed in winter were transported back to the surface by convection and became vital with the onset of light in spring. Observations of VALDIVIA on the meridional transect revealed that living phytoplankton covered the entire convection layer over which it was as evenly distributed as temperature and salinity. Backhaus et al. (2003 MEPS) explained this finding by a vertical transport caused by convection allowing plankton to intermittently return to the euphotic layer where it receives light for growth. This led them to conclude that the entire convection layer in winter forms an incubator as opposed to the seasonal thermocline in summer. This conclusion, however, contradicts the commonly accepted picture of the compensation depth.

2.3 National and international Cooperation's

The research conducted during this proposed cruise is embedded in the EU-project "Basin-scale Analysis, Synthesis, and INtegration (BASIN)". BASIN is a cooperation between US and Canadian partners and the European Union (please view call text and letters of support). The planned work will additionally provide essential information for the validation and parameterization of models conducted by the EU-FP7 MEECE (Marine Ecosystem Evolution in a Changing Environment) project. The goals of this study are highly relevant for the international IMBER-initiative (Integrated Marine Biogeochemistry and Ecosystem Research) of the International Geosphere-Biosphere Programm (IGBP).
The project will foster the cooperation between different international groups (see 3.1 and 5.1), which will work together during the cruise.

3. Targets and working program

3.1 Targets

This cruise will solve the following questions:

- The biomass and fate of phytoplankton cells entrained in winter convective cells
- The depth of diapause of *Calanus Finmarchicus* in relation to deep convection
- Timing of the response of large phytoplankton biomass and composition to stratification in different hydrographic regimes in the North Atlantic.
- The size structure and taxonomic composition of plankton and particles in relation to the transition period from winter convection to spring stratification and subsequent response of the zooplankton community and particle aggregation.
- The vertical distribution taxonomy and size structure of phytoplankton, zooplankton, and particles over the transition from the winter convective regime to the spring bloom regime
- Individual interactions between zooplankton consumers and sinking particles, with respect to encounter and feeding rates and residence times of the key zooplankton species on different types of aggregates over the transition from convective regime to spring bloom.
- Data and parameterizations developed will be incorporated into coupled 1-D vertical biological-physical models to assess the mechanisms controlling the timing, intensity, duration and fate of phytoplankton biomass in the convective and spring bloom regimes as

well as development of an adaptive 1-D model of *Calanus finmarchicus* emergence from diapause based on the interaction between abiotic and biotic agents

- Assess the spatial variability in biomass transfer efficiencies in the convective and bloom regimes
- Identify the key predators consuming *C. finmarchicus* during diapause and ascent to the surface mixed layer.
- Assess the potential impacts of climate change on biomass transfer efficiencies and biogeochemical fluxes due to changes in plankton communities.

University of Hamburg (St John and Backhaus)

St. John: Institute for Hydrobiology and Fisheries Research, University of Hamburg
Jan Backhaus: Center for Marine and Atmospheric Sciences, University of Hamburg

As co-ordinator of the cruise the IHF team will be involved in all components of the program. Particular focus will be given to:

- Assess the dynamics of convection during transition from deep winter convection to spring bloom at the three different regimes
- Phytoplankton physiology with respect to deep convection.
- The role of deep convection on *Calanus finmarchicus* diapause depth and triggers for emergence from diapause using the Institutes Tomahawk ROV and Video Plankton Recorder as well as biochemical analyse of lipid reserves in diapausing CVs and emergent CVs and adults. Results will contribute to the development of an adaptive 1-D model of *Calanus finmarchicus* emergence from diapause based on the interaction between abiotic and biotic agents
- Application of phytoplankton group specific fatty acids to assess the algal prey of higher trophic levels in the convective and spring bloom regimes
- Zooplankton population production relative to prey type and abundance as influenced by the convective and spring bloom regimes
- The development of rate parameterizations for phytoplankton (FastTracker Photo System II activity) and zooplankton (egg production) for the parameterization and validation of coupled 3-D biophysical models.

Bjerknes Centre for Climate Research, Norway (Bellerby and co-workers)
Biogeochemistry

The Bjerkness Center will measure the full complement of carbon dioxide system variables (CT, AT, fCO_2 and pH) and oxygen from combinations of underway, laboratory and in situ methodologies. Drifters will be used to monitor fCO_2 and O_2 at main stations over short diurnal studies.
The scientific aims from their participation in the expedition will to

- determine the stoichiometry of net community biological uptake
- quantify pelagic net calcification
- constrain carbon and nutrient uptake rates of key pelagic ecosystems.
- determine the net ecosystem balance (heterotrophic/autotrophic) at key stations from in situ
- quantify the biological carbon pump across the Norwegian Continental Shelf
- assess the role of eddies in propagating biogeochemical signals across the shelf
- determine the carbon and oxygen air-sea fluxes to better constrain regional models
- continue the time-series of anthropogenic carbon and ocean acidification monitoring in the Norwegian Sea
- strengthen predictive habitat mapping capabilities through developing 3D understanding of

zooplankton life stages with respect to acidification stressors (e.g. omega saturation, pH)

Danish Technical University AQUA, Denmark (Kiørboe, Visser, Koski)
Flux studies

One aim during the cruise is to investigate the individual interactions between zooplankton consumers and sinking particles, concerning encounter and feeding rates and residence times of the key zooplankton species on different types of aggregates. These measurements will be done by using a newly-developed Sea Core sampler, which can collect undisturbed aggregates, which then can be directly observed using a video set up. Together with sinking rates of the particles and feeding rates obtained by incubations, the behavioural observations can be used to build an individual based model, describing the effect of diverse zooplankton species on sinking particles. The model estimates of aggregate degradation by zooplankton can then be evaluated against the carbon flux actually measured with sediment traps. As the cruise period covers both spring bloom and stratification, we can both expect a diverse community of zooplankton and a range of different types of sinking aggregates, which is ideal for our purposes.

Høgskolen i Bodø, Norway (Kurt Tande, with three co-workers)
Trophic interactions

The study will address the following questions:

- What is the biomass transfer efficiency between trophic levels in boreal shelf and off-shelf regions?
- Are there any spatial variability in biomass transfer efficiencies?
- What are potential impacts of climate change on biomass transfer efficiencies due to changes in plankton communities between basin and shelf systems?

Høgskolen i Bodø, Norway(Meng Zhou, with three co-workers, UMASS, USA)
Food web structure

This subproject will provide the biomass spectra of plankton communities from 1um to 35 mm across selected shelves in Europe. This will be obtained using towed platforms equipped with Laser in situ Scattering and Transmissometry Particle Size Analyze (LISST; Sequoia Scientific Instruments, Bellevue, WA), Laser Optical Particle Counter (LOPC; Brooke Ocean Technologies, Dartmouth, Nova Scotia), conductivity–temperature–depth sensors (CTD), as well as VPR. The vessel mounted Acoustic Doppler Current Profiler (ADCP) will be used to measure current up to 400 m. Size-structure data of plankton will be used to describe the community structure in the target areas backed up by limited net tow samples, and to track large scale transport and retention of plankton.
Dynamics and resilience of lower trophic food webs using the biomass-size structure approach

Marine Research Institute, Iceland (Astthor Gislason)
Top down controls

This component of the program will seek to parameterize and visualize the potential predatory regime encountered by *Calanus* during the ascent phase of the life cycle, a period when the predatory threat may be particularly significant as the animals are then migrating through the layers of mesopelagic planktivorous animals (krill, amphipods, gelatinous plankton, myctophids). The abundance and spring ascent of *Calanus*, as well as the horizontal and vertical distribution of the potential predators, will be mapped by the continuous sampling of multi-frequency acoustic data and tow-yo type VPR data. In addition, nets and pelagic trawls will be used to obtain data on diets of the potential predators from stomach content analysis and analysis of total lipids/lipid classes and stable isotopes, as well as for obtaining abundance data to which the acoustic and VPR registrations can be compared.

3.2 Working programme

Strategy of BASIN Cruise

The sea region of the 2012 BASIN Cruise has previously been surveyed regarding a hypothesized relationship between phytoplankton and convection (Backhaus et al. 2000, Backhaus et al. 2003). The survey with RV 'Valdivia' showed a pronounced difference in both convection depths and plankton concentrations between Norwegian Sea and Icelandic Basin. The sea regions are separated by the polar front which is aligned with the Greenland-Scotland Ridge. In the northern Icelandic Basin convection depths in excess of 800m were found whereas in the Norwegian Sea convective penetration rarely exceeded a depth of 500m. We have devised a triangle station pattern for the cruise that encompasses the Faeroe Islands. Each corner of the triangle stands for a different hydrographic regime. Icelandic and Norwegian Sea, the two western corners form oceanic regimes whereas the third one lies on the shelf, east of the Shetland Islands. Steaming around the triangle and doing repeated and extensive observations at each corner we intend observing the temporal evolution from winter to spring conditions in the three regimes. We expect information on how convection in differing hydrographies affects the lower trophic levels of the food web, and bio-geo-chemistry. Whereas convection in the oceanic regimes is confined to the (upper) water column on the shelf it penetrates all the way to the seabed. Thus, there even benthic communities might be affected by convection as opposed to oceanic regimes. The close proximity of the regimes around the Faeroe Islands forms an ideal setting for our investigation in terms of science but also in terms of logistics. The Faeroes offer ideal shelter in heavy weather which is abundant in the time of the year. During the cruise while passing the islands they offer a replacement or exchange of broken gear and a transfer of persons with coastal vessels.

Three locations in the eastern North Atlantic (Fig. 3) will be sampled three times to enable a temporal resolution of the data. At each station all the equipment listed in Table I will be deployed. The Video Plankton Recorder will be towed undulating down to a depth of 200 m to allow insights into the spatial resolution of zooplankton in the euphotic zone. The MOCNESS is equipped with twenty nets of 333 µm mesh size. Oblique hauls down to a depth of 1000 m will catch overwintering stages of *Calanus finmarchicus* and other zooplankton. The vertical nets will be used to catch animals and phytoplankton (Apstein net) for biochemical analyses. The CTD with rosette will deliver oceanographic data and water samples. Stand-alone-pumping-system (SAPS) can be attached to the CTD cable. These pumps will filter large amounts of water for biogeochemical analyses. The Remotely Operated Vehicle Mohawk of the University of Hamburg will be used to make high resolution pictures of the zooplankton in the water column. An attached 1200 kHz ADCP will deliver high resolution acoustic data. Additionally the ship's ADCP's will be used continuously. Drifting sediment traps will be used to sample the export flux out of the euphotic zone during the station time. We will use a newly developed digital holographic imaging (DHI) system incorporated into ARGO-style profiling drifters to obtain high-temporal and vertical distributions of taxonomic and size composition of plankton and particles, including fragile forms. These drifters also will carry CTD, fluorometer, PAR, and turbidity sensors. The drifters will be released at the beginning of the cruise at each of the three sites and recovered at the end, for a total deployment period of 6 weeks. The drifters will sample to a depth of 2000m, traveling at a vertical velocity of 0.2 m/s. Holograms of plankton and particles will be captured throughout the water column. The volume of a single hologram is 1-liter, and we will use multiple exposure holograms to obtain 10 liters of sample volume per meter of depth, or 1m^3 per 100 m depth interval. The drifters will profile twice per 24h, once at night and once during the day. Images will be extracted from the holograms in situ and saved to an on-board hard drive for further processing upon recovery.

Table I: Gears used at each station. Number of deployments and deployment time.

Gear	Time (h) per haul	Number Per station	Time total(h) per station
Video Plankton Recorde (VPR)	8	2	16
Remotely Operated Vehicle ROV Mohawk	6	2	12
1 m^2 Double-MOCNESS, oblique 1000 m	2,5	2	5
Appstein, vertical 100 m	0,5	2	1
MSN,vertical 1000 m	1	4	4
WP 2, vertical 1000 m	1	2	2
CTD with Rosette and Stand Alone Pumping System, 1000 m	3	4	12
Drifting Sediment Traps, Deployment and recovery	4	1	4
Acoustics ADCP	0	Cont.	n.a.
Drifters, Deployment and recovery	4	1	4
Total time per station:			**60**

3.2.1 Working area and station map

The working area will be covering three different hydrographic systems within the North Atlantic:

1. East of Shetlands, Station 1 60° 20' N 001° 00' E Shelf
2. NE of Faroer, Station 2: 63° 40 N 001° 00' W Norwegian Sea
3. W of Faroer, Station 3 61° 30' N 011° 00' W Iceland Basin

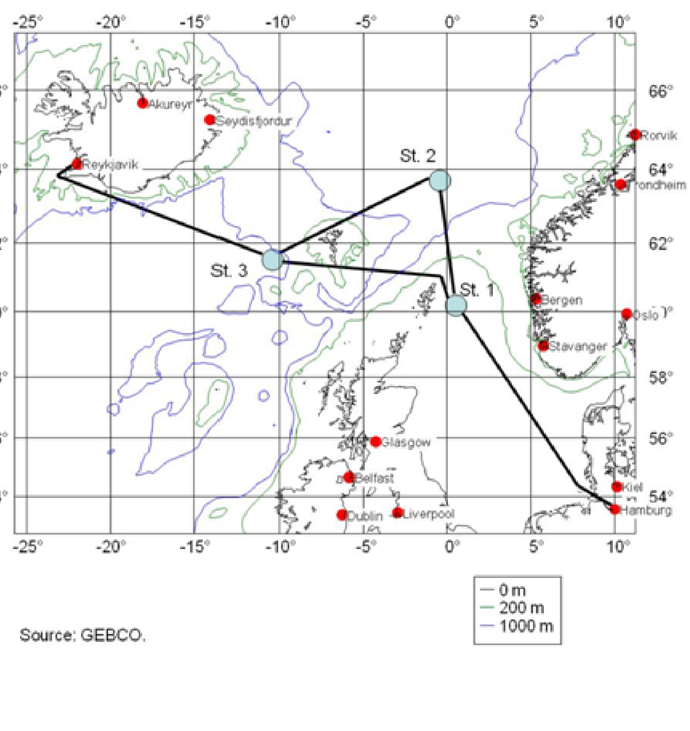


Figure 3: Station map

3.2.2 Working in foreign territories – Research authorizations

Norway, Great Britain, Denmark (Faroer)

3.2.4 Special applications

None

3.2.5 Working days

2.5 transit days are necessary to reach the first station. Since three stations shall be sampled thrice, a total of 22.5 days are necessary for station work. Additionally, 120h will be reserved for bad weather conditions. Ten days are necessary as transit time between the stations. 2 days of transit time is necessary to reach the final destination. In total 42 days of ship time are necessary.

Tab. II: Calculation of station work and transit times. St. = Station (see Fig. 3)

	Coordinates		**Dist.**	**Station**	**Trans.**
	from	**to**	**nm**	**h**	**h**
Hamburg – St. 1	53°30' N, 010° E	60°20' N, 001° E	540		60
Station Work St. 1	60°20' N, 001° E			60	
Transit St. 1 – St. 2	60°20' N, 001° E	63°40' N, 001° W	210		21
Station Work St. 2	63°40' N, 001° W			60	
Transit St. 2 - St. 3	63°40' N, 001° W	61°30' N, 011° W	310		31
Station Work St. 3	61°30' N, 011° W			60	
Transit St. 3 - St. 1	61°30' N, 011° W	60°20' N, 001° E	390		39
Station Work St. 1	60°20' N, 001° E			60	
Transit St. 1 - St. 2	60°20' N, 001° E	63°40' N, 001° W	210		21
Station Work St. 2	63°40' N, 001° W			60	
Transit St. 2 - St. 3	63°40' N, 001° W	61°30' N, 011° W	310		31
Station Work St. 3	61°30' N, 011° W			60	
Transit St. 3 - St. 1	61°30' N, 011° W	60°20' N, 001° E	390		39
Station Work St. 1	60°20' N, 001° E			60	
Transit St. 1 - St. 2	60°20' N, 001° E	63°40' N, 001° W	210		21
Station Work St. 2	63°40' N, 001° W			60	
Transit St.2 - St. 3	63°40' N, 001° W	61°30' N, 011° W	310		31
Station Work St. 3	61°30' N, 011° W			60	
St. 3 - Reykjavik	61°30' N, 011° W	64°08' N, 022° W	510		48
Bad weather reserve				120	
Total hours				**660**	**342**
Total days				**27.5**	**14.5**
Required ship time (days)					**42**

3.2.6 Start and end of the cruise

End of February 2012 to beginning of April 2012
Start Harbour: Hamburg
End: Reykjavik

4. Funds to conduct the cruise

EU- project BASIN and proposals to be submitted to DFG and BMBF

5. Conditions to accomplish the project

5.1 Working group

Table III: Working group

No	Name	Institution	Area of activity
1	Prof Dr. Mike St John	Uni HH	Biological Oceanography
2	Dr. Rolf Koppelmann	Uni HH	Biological Oceanography
3	Dr. Janna Peters	Uni HH	Biological Oceanography
4	Klas Möller	Uni HH	Biological Oceanography
5	Dr. Linda Holste	Uni HH	Biological Oceanography
6	Prof Dr. Jan Backhaus	Uni HH	Physical Oceanography
7	Dr. Andre Visser	DTU AQUA	Biological Oceanography
8	Student	DTU AQUA	Biological Oceanography
9	Dr. Marja Koski	DTU AQUA	Biological Oceanography
10	Prof. Dr. Thomas Kiørboe	DTU AQUA	Biological Oceanography
11	Student	DTU AQUA	Biological Oceanography
12	Prof Dr. Richard Bellerby	bjerknes uib	Biogeochemistry
13	Student	Bjerknes uib	Biogeochemistry
14	Dr. Richard Sanders	NOCS, Southampton	Biogeochemistry
15	Prof Dr. Kurt Tande	Høgskolen i Bodø	Biological Oceanography
16	Student	Høgskolen i Bodø	Biological Oceanography
17	Prof Dr. Torkel Gissel Nielsen	University of Aarhus	Biological Oceanography
18	Student	University of Aarhus	Biological Oceanography
19	Dr. Stéphane Pesant	MARUM, Bremen	Biological Oceanography
20	Andre Eckhard	Uni HH	Technical Support
21	Silke Jansen	Uni HH	Technical Support
22	Bettina Walter	Uni HH	Biological Oceanography
23	Prof Dr. Astthos Gislason	Marine Research Institute Reykjavik	Biological Oceanography
24	Student	University Maine	Biological Oceanography
25	Student	NOCS, Southampton	Biogeochemistry
26	Student	Virginia Institute of Marine Science	Biological Oceanography
27	Prof Dr. Cabell Davis	Woods Hole	Biological Oceanography
28	Student	Woods Hole	Biological Oceanography
Total 28			

6. Declaration

Ein Antrag auf Förderung dieses Vorhabens wurde bei keiner anderen Stelle eingereicht. Wenn wir einen solchen Antrag stellen, werden wir die Deutsche Forschungsgemeinschaft unverzüglich benachrichtigen.

7. Signature

(Prof. Dr. Michael St. John)

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8. Appendix:

- References
- C.V. Michael St. John incl. list of publications
- C.V. Jan Otto Backhaus incl. list of publications
- Letters of Support and Intent
- 1 CD ROM including:
  - Main letter
  - Proposal
  - C.V.s
  - Letters of Support and Intent
  - Call text FP7 ENV 2010
  - International Science Plan “BASIN”

6. Daten-/Probensicherung und Verfügbarkeit

Data collected during the proposed cruise will be provided and maintained to/in the database infrastructure (WDC-MARE) and information system (PANGAEA®), which forms the technological backbone for database networking and interoperability in BASIN. Furthermore, data will be used to participating actively to existing initiatives on metadata and data standardisation, such as those undertaken by the Intergovernmental Oceanographic Commission's IODE programme (http://www.iode.org/), the NERC Data Grid programme (http://ndg.nerc.ac.uk/), the SeaDataNet programme (http://www.seadatanet.org/), and the Marine Metadata Interoperability network (http://marinemetadata.org/).

7. Erklärung

"Ein Antrag auf Förderung dieses Vorhabens wurde bei keiner anderen Stelle eingereicht. Wenn ich einen solchen Antrag stelle, werde ich die Deutsche Forschungsgemeinschaft bzw. das BMBF unverzüglich benachrichtigen."

c. Die von der Senatskommission für Ozeanographie und dem Konsortium Deutsche Meeresforschung verfasste „Erklärung zu einer verantwortungsvollen Meeresforschung“ (Anhang 1) sowie der von der Kommission zum Schutz der Meeresumwelt des Nordostatlantiks (OSPAR) herausgegebene „Code of Conduct for Responsible Marine Research in the Deep Seas and High Seas of the OSPAR Maritime Area” (siehe Anhang 2) ist beachtet und deren Kenntnisnahme ist hiermit bestätigt.

Hamburg, den 30.11.2009

Michael St. John